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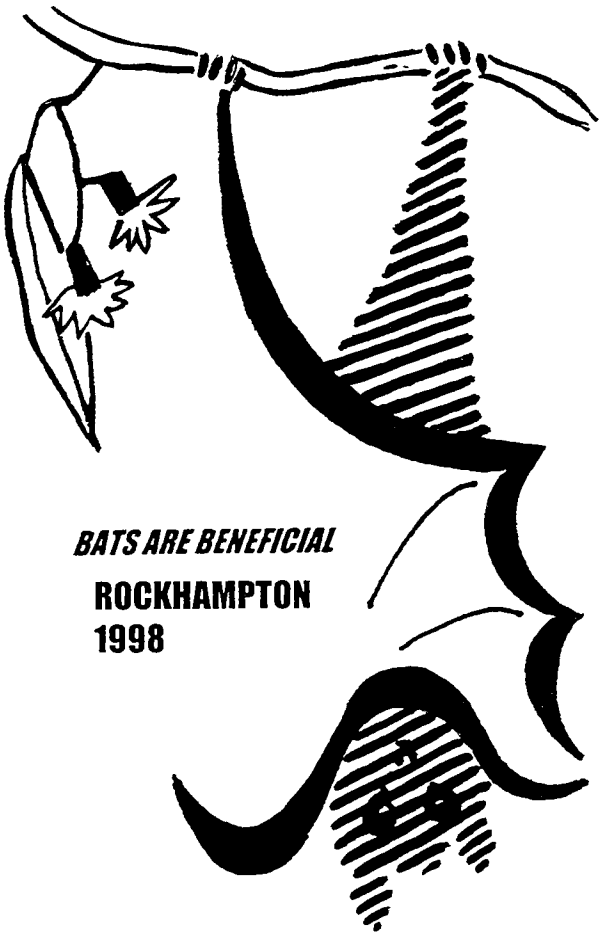

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Publisher and Managing Editor
G. Roy Horst
Bat Research News, P.O. Box 5068, Potsdam,NY 13676
Tel. 315-267-2259 FAX 315-267-3170 E-mail: horstgr@potsdam.edu.

Editor for Feature Articles
Allen Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197
Tel. 734-487-1174 FAX 734-487-9235 E-mail: bio_kurta@online.emich.edu

Editor for Recent Literature
Thomas A. Griffiths, Department of Biology, Illinois Wesleyan University, Bloomington, IL 61702
Tel. 309-536-3230 FAX 309-536-3411 E-mail: tgriff@titan.iwu.edu

Editor for Conservation Education
Patricia Morton, Texas Parks and Wildlife Department, Suite 100, 3000 IH 35 South, Austin, TX 78704
Tel. 512-912-7046 FAX 512-912-7058 E-mail: patricia.morton@tpwd.state.tx.us

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Relative Abundance of Small Tent-roosting Bats (*Artibeus phaeotis* and *Uroderma bilobatum*) and Foliage Tents (*Carludovica palmata*) in Panamá

Burton K. Lim
Centre for Biodiversity and Conservation Biology, Royal Ontario Museum,
100 Queen's Park, Toronto, Ontario, Canada, M5S 2C6,
and Department of Biology, York University, North York, Ontario, Canada, M3J 1P3

Eigteen species of bats in three families use modified foliage roosts ("tents") in over 80 species of vascular plants (Kunz et al., 1994). Eight architectural styles of tents have been described, and presumably, they are made by bats partly biting through the vein, midrib, or stem, until the leaf folds down to form an enclosed shelter. The Panama hat palm (*Carludovica palmata*) is modified into palmate umbrella tents by Peters' tent-making bat, *Uroderma bilobatum*, and Thomas' fruit-eating bat, *Artibeus watsoni* (Choe and Timm, 1985), but this palm has not been reported to be used by the very similar, pygmy fruit-eating bat, *A. phaeotis*. Only one previous study documented the frequency of different tent species used by bats, with *C. palmata* being used infrequently by *A. watsoni* (Timm, 1987). In the present study, I examined four different sites dominated by one species of palm (*C. palmata*) and compared the relative abundance of tents and of tent-roosting bats (*A. phaeotis* and *U. bilobatum*). I documented mensural variation for tents in leaves of *C. palmata*, including height above ground, distance of fold from stem, and extent of cut, in addition to other observations on tent ecology and roosting behavior.

This study was conducted from 18 to 24 February 1995, in the vicinity of Parque Nacional Soberanía and Gamboa (9°06'N 79°42'W), Republic of Panamá. Four study sites were selected, in two forest types, to compare the relative abundance of tent-roosting bats and foliage roosts. The forest types were mature second-growth within old growth humid forest along Pipeline Road, in Parque Nacional Soberanía, and isolated second-growth woodland in Gamboa (Ridgely and Gwynne, 1989).

Within each forest type, I followed 100-m transects along foot paths and streams, both of which are commonly used as flyways by bats, to survey the area for both tents and bats. Along each transect, vegetation within 5 m was inspected for tents and roosting bats. In addition, each site was surveyed for bat diversity on one evening beginning at 1830 h and ending at 2130 h. At all sites, five understory mist nets were set to a maximum height of 3 m, with one long net (12-m long) set parallel to the flyway and two long and two short nets (6-m long) set across the flyway. Reference specimens were deposited at the Royal Ontario Museum and the University of Panamá.

The disturbed woodland habitat in Gamboa was dominated by a natural ravine, with residential areas on the hilltops. A stream running through the ravine drained into a marshy area that bordered a pond adjacent to the Rio Chagres. The banks of the stream were surveyed for tents and flying bats were caught over the stream on 18 February 1995; a foot path that connected to the main trail was surveyed in a similar manner on 23 February 1995. The less disturbed, humid forest habitat was along Pipeline Road. At 4.9 km along Pipeline Road on 20 February 1995, I surveyed the Rio La Seda for tents and caught bats with nets set across the water and in the adjacent forest, from the bridge downstream to the confluence with the Rio Frijoles. In addition, a foot trail ca. 6 km down Pipeline Road, immediately past Rio Limbo, was surveyed on 24 February 1995.

To test for association between the two forests and two flyway types for small tent-roosting bats and foliage tents, Fisher's Exact Test was used (SAS Institute, 1988). This test gives the probability of observing a 2-by-2 table with as much association as the actual observations. Fisher's Exact Test is a more appropriate test of no association than the chi-squared statistic when sample sizes are small (SAS Institute, 1988).

Carludovica palmata was the most prevalent plant species that had leaves modified to form tents in the Gamboa area. It is a trunkless ground palm with fanlike leaves characterized by the same shade of green on both the upper and lower surfaces (Williamson, 1983). The only small tent-roosting bats caught during this study were *U. bilobatum* and *A. phaeotis*. *A. jamaicensis* was the only other tent-roosting species

netted, but it was excluded from the analysis because only smaller species of bats (forearm length <45 mm) have been reported to roost in *C. palmata*.

The frequency of tents and small tent-roosting bats at the four study sites (Table 1) shows a level of association between forest and flyway type for abundance of *A. phaeotis* that approached significance (Fisher's Exact Test; P = 0.08). In the more disturbed forest of Gamboa, *A. phaeotis* was more common along the foot path. In the less disturbed forest of Pipeline Road, it was more abundant along the stream flyway. Fisher's Exact Test could not be used with the data for *U. bilobatum*, because it was not netted along Pipeline Road, although it was probably present. However, *U. bilobatum* was caught most frequently in the disturbed forest of Gamboa, where it was encountered more often than *A. phaeotis* in any of the four habitats. Fisher's Exact Test suggested no association between forest and flyway type for the frequency of occurrence of *C. palmata*, or more specifically tents, but they were encountered over twice as often in more-disturbed than less-disturbed habitat. This trend was also evident for *U. bilobatum*, because it was found only in disturbed habitats.

Physical descriptions of tents in *C. palmata* were derived from the 12 foliage tents observed during the study. The outer apex of the tent was 9-35 cm (mean $\pm$ SD = 17 $\pm$ 9.5 cm) from the stem, as measured along the outer margin of the leaf. The tents ranged in height above the ground from 1.4 to 3 m (2.2 $\pm$ 0.52 m). Half the tents formed complete shelters (i.e., had the whole leaf cut), whereas others were only about one-third complete.

Of the 12 tents in *C. palmata* found during this study, only one tent, near the stream flyway in the Gamboa woodland, was occupied by bats. It contained three individuals of a small species of *Artibeus* roosting about 3 m above the ground. It is not possible to distinguish reliably between *A. phaeotis* and *A. watsoni* when they are found roosting, although only the former species was netted in the area during the study. This tent was incomplete, with the cut comprising only one-third of the leaf. The bats flew away when disturbed, and the tent remained unoccupied for at least the next 8 days. As indicated by the proportion of occupied tents found in this study (1/12), only a small fraction of suitable roosts are occupied at any given time. This was also reported by Timm and Lewis (1991) during observations on *U. bilobatum* in Costa Rica. Bats may use a number of different tents as alternate roosts to avoid predation or when disturbed (Foster, 1992). Hence, searching for bats in tents may not be the best method of determining relative abundance of tent-roosting bats.

Choe (1994) suggested that *U. bilobatum* selected young plants for roost sites, because these were usually at the bats' preferred foraging height of 2-5 m above the ground. The tents in my study ranged in height from 1.4 to 3 m. Typically, mist nets set in the understory of a rain forest reach a maximum height of 3 m, which likely encompasses the level that most small tent-roosting bats use to fly to and from their roosts. Therefore, mist-netting may provide a better indication of relative abundance of *A. phaeotis* and *U. bilobatum* than searching for tents.

In addition to the above observations, a solitary *U. bilobatum* was found roosting under a tent made in an unidentified fanlike palm in a residential area of Gamboa. It roosted there for 10 days until a disturbance caused the bat to depart. On the next day, the tent was occupied by four individuals of a small species of *Artibeus*, and eight bats roosted in the tent the following day. This observation suggests that, as a part of their daily activity, bats may actively search for suitable, alternate roost sites. Some bats do roost in vacant tents made by other species (Timm, 1987; Kunz et al., 1994).

Tents have been classified into eight architectural styles (Kunz et al., 1994). The palmate umbrella style of tent is characteristic of fan-like palms, and is the only style reported for *C. palmata*. Although there is a slight variation in tent architecture for this style, the cut region for *C. palmata* is typically polygonal in shape (Kunz et al., 1994). About half the tents observed in this study did not form a complete polygonal cut but were only about one-third complete. Tents have been observed being constructed over a number of days (Timm and Clauson, 1990), and although partial shelters may indicate tents in the process of construction, I found no intermediate forms during this study.

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I thank B. Stuchbury and G. Morton for discussion on experimental design; M. Hovorka, P. Martin, V. Morton, and P. Hogg for assistance in netting; B. Stutchbury, B. Fenton, M. Engstrom, F. Reid, C. Handley, and T. H. Fleming for constructive comments on earlier drafts of the manuscript; and the Smithsonian Tropical Research Institute for logistic support. Funding for field work was generously provided by the Reproductions Association of the the Royal Ontario Museum and the Department of Museum Volunteers through the Royal Ontario Museum Foundation, and the former Department of Mammalogy at the Royal Ontario Museum.

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Errata

In the Letters to the Editor Section of Volume 38: No. 4, in the letter from Dr. Bernard Sigé there are three errors. They occur on page 92 last line, and page 93 first line, and 4th line (6th paragraph) where the terms Paleocene and Neocene were erroneously and inadvertently substituted for the proper terms Paleogene and Neogene. Our sincere apologies to Dr. Sigé for this unfortunate error. GRH

Quoting and Spelling Names of Species from H. Kuhl's "Die deutschen Fledermäuse"

Wieslaw Bogdanowicz[1] and Dieter Kock[2]
[1]Mammal Research Institute, Polish Academy of Sciences, 17-230 Bialowieza, Poland and
[2]Forschungsinstitut Senckenberg, Senckenberg-Anlage 25, D-60325 Frankfurt a.M., Germany

In recent literature, one may note inconsistencies in the spelling of scientific names of bats and also different dates of publication for the same species. Despite official opinions of the International Commission on Zoological Nomenclature and the availability of the third edition of the International Code of Zoological Nomenclature (ICZN, 1985), no agreement apparently has been achieved on the above problems. The following example is used to help students who are not taxonomy oriented to understand why scientific names are spelled and quoted in a certain way.

Heinrich Kuhl privately published his monograph on German bats in 1817. A facsimile of this treatise, complete with all errors, was reprinted in the 1818-1819 edition of the "Annalen der wetterauischen Gesellschaft für die gesammte Naturkunde" (Annals of the Wetterauan Society for all Natural Sciences), the first part in volume 4(1) in 1818, which subsequently was considered to be volume 1 of the "Neue Annalen" (= New Annals), the second part in volume 1(2) in 1819. This monograph contained several descriptions of bats previously unknown to most scientists of the day and, for the first time, provided their binary Latin names. Although the original monograph was a rare item in libraries, many authors of the following decades correctly dated these names as 1817. However, the reprinted text of 1818-1819 increasingly became a standard reference to the scientific names introduced by Kuhl. This development required the International Commission on Zoological Nomenclature (1958) to state expressly that the correct publication date was 1817. Unfortunately, this official opinion has had no permanent effect on a constant and incorrect use of date of publication for several European bats named by Kuhl. Hopefully, the present review of the facts will help overcome this continuing confusion.

In Kuhl's monograph, 15 species were described, seven of which were new to science. These were (present generic assignment in brackets): *Vespertilio Bechsteinii* Leisler [*Myotis*], *Vespertilio Nattereri* Mihi ("mihi" is Latin for "mine," i.e., Kuhl's own) [*Myotis*], *Vespertilio Leisleri* Mihi [*Nyctalus*], *Vespertilio Schreibersi* Nattereri (1817:6 = 1818:14; "Nattereri" is Latin for "of Natterer") = *V. Schreibersii* Natterer (1817:41, 43, 66 = 1819:185, 187, 214) [*Miniopterus*], *Verpertilio Daubentonii* Leisler [*Myotis*], *Vespertilio Kuhlii* Natterer [*Pipistrellus*], and *Vespertilio mystacinus* Leisler [*Myotis*]. It is apparent that for some descriptions Kuhl quoted authors other than himself, i.e., Johann Philipp Achilles Leisler (1772-1813) and Johann Natterer (1787-1843). As Kuhl (1817:4 = 1818:12) explains, Leisler never wrote down his observations on bats, including newly discovered species. In addition, Natterer sent Kuhl several stuffed specimens of *V. schreibersii*, six of *V. discolor* [= *Vespertilio murinus* Linnaeus, 1758], and several of *V. kuhlii*, but he suggested only the names for these species and provided some notes on locality and life history. Furthermore, in 1817, Natterer started his explorations of Brazil. Thus, Kuhl is the one and only scientific authority to be quoted for all new names published in the monograph of 1817, including the one species dedicated to himself.

It remains to explain the etymology of dedication names derived from J. M. Bechstein, J. Natterer, J. P. A. Leisler, C. F. A. von Schreibers, L. J. M. d'Aubenton, and Kuhl himself. In the tradition of Latin as the language of science, the names of the above persons were first latinized to become Bechsteinius, Schreibersius, Daubentonius, and Kuhlius, but Nattererus and Leislerus. Only then was the genitive form taken as the scientific name, resulting in the correct spelling as *bechsteinii, schreibersii, daubentonii,* and *kuhlii,* but *nattereri* and *leisleri* for the respective species. The same procedure to latinize personal names was followed by those authors describing *Eptesicus nilssonii, Myotis blythii,* and *M. brandtii,* to cite European species only. In the case of dedication names that were already of a Latin form (e.g., after H. E. Nathusius and J. H. Blasius) or that ended with *-i* (e.g., after F. Capaccini and P. Savi), the genitive ending naturally was *nathusii, blasii, capaccinii,* and *savii.*

In forming a species-group name from the name of a modern man that is neither Latin, latinized, nor of Greek origin, there is a recommendation to use the genitive singular-case ending *-i*, in preference to the termination *-ii* (ICZN, 1985:195). Nevertheless, as for the existing names, the original spelling should be maintained. Articles 33c and 33d of the ICZN (1985:75) clearly state that "any subsequent spelling of a name different from the correct original spelling, other than a mandatory change or an emendation, is an incorrect subsequent spelling . . . and the use of the termination *-i* in a subsequent spelling of a species-group name that is genitive based upon a personal name in which the correct original spelling terminates with *-ii*, or vise versa, constitutes an incorrect subsequent spelling, even if the change in spelling is deliberate."

The case of *Vespertilio schreibersii* deserves further explanation. It was spelled with the ending *-i* only in the introduction, but *-ii* in the remainder of Kuhl's monograph. Article 24c of the ICZN (1985:53) provides, "If a name is spelled in more than one way in the original publication, the spelling chosen by the first reviser is the correct original spelling [Art.32b (i)], unless it is incorrect under the provisions of Articles 27 to 31." Mahoney and Walton (1988) considered Desmarest (1820) to be the first reviser of Kuhl (1817), and he used the prevalent, original spelling "*schreibersii*." However, to be a "reviser" requires that author state that there are alternatives (in this case, *schreibersii* vs. *schreibersi*) and to choose between them. Desmarest did not do this; he merely used the name *schreibersii* in the form demanded by correct latinization, followed by the correct genitive termination. Technically then he can not be called the first reviser; but he did correct an incorrect, original spelling [ICZN, Art. 32 (d) (ii)].

All the above simply means that the correct notation of bat names introduced by Kuhl (1817) are as follows: *Miniopterus schreibersii, Myotis bechsteinii, M. daubentonii, M. mystacinus, M. nattereri, Nyctalus leisleri,* and *Pipistrellus kuhlii.*

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We thank B. Petrov for bringing some problems of nomenclature to our attention, C. Smeenk and G. Storch for a discussion about the name endings, and A. J. Mitchell-Jones for commenting on an earlier version of the manuscript. The manuscript was completed while WB was a Humboldt Fellow at Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt am Main, Germany.

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Abstracts of presentations at the 8th Australasian Bat Conference April 14 - 17, 1998 University of North Queensland Rockhampton, Queensland, Australia

Abstracts are organized alphabetically by first author.

Habitat usage and foraging activity by Microchiropteran bats at Nanya in the semi-arid zone of far western New South Wales

Richard Adler and Patrick Prevett
Centre for Environmental Management, University of Ballarat, PO Box 663, Victoria, 3353

An investigation was conducted into habitat usage by bats occupying the major vegetation associations at Nanya, a remote pastoral property in the semi-arid zone of far western New South Wales. 324 hours of Anabat survey in 9 sites over three survey locations detected 10 species of microchiropteran bats. 251 bats were captured during February resulting in 96 good quality Anabat reference call files covering the 9 species captured. Comparison of foraging activity between sites located in Belah Woodland, Mallee Shrubland and Mallee Triodia showed that foraging activity was greatest in Belah Woodland. Analysis by species also showed that each species was more active in Belah Woodland with the exception of *Mormopterus planiceps*. Surprisingly 9% of calls detected were from *Chalinolobus picatus* normally considered relatively rare for this region. No significant correlation was found between the habitat variable measured and microbat activity. Variable measured included density of overstorey trees, density of understorey shrubs, foliage height diversity, and aggregation patterns of trees within vegetation units. Presumably other factors such as invertebrate abundance and diversity are more relevant to microbat distribution and warrant investigation to further assess microbat foraging preferences in the region.

Where do nectar feeding bats get their calcium?

Robert M. R. Barclay
Anatomical Sciences and Veterinary Pathobiology, University of Queensland, Brisbane, QLD 4072
and Biological Sciences and University of Calgary, Calgary, Alberta, Canada T2N 1N4.

Female bats raise their young to a large size before the pup is independent. This means that each pup is expensive to produce. I have argued that the high calcium demand on lactating females, coupled with low calcium content in insects, fruit and pollen limits reproductive output in bats and should influence diet choice by females and coevolution between bats and plants they visit. Calcium content of nectar has not been measured. I predicted that plants visited by nectar bats have higher calcium content in their nectar than do non-bat plants. I measured calcium in 13 species of bat-pollinated plants and 6 species of non-bat plants from SE Queensland. Bat plants had significantly higher calcium levels. Highest levels were present in weeping paperbark *Melaleuca leucadendra*, forest red gum *Eucalyptus tereticornis*, and spotted gum *Corymbia henryi*. These results suggest that bat-plants may have evolved higher calcium content in their nectars as an attractant for pollinating bats. Despite the difference, however, calcium levels in nectar are still relatively low and nectar is unlikely to supply all the calcium required by lactating bats. Where nectar-specialists such as *Syconycteris australis* and *Pteropus scapulatus* get their calcium remains unanswered.

Foraging behaviour of male and female *Myotis adversus* in Southeast Queensland.

Robert M.R. Barclay, Bryan J. Chruszcz, and Martin P. Rhodes.
Departments of Anatomical Sciences and Veterinary Pathobiology, University of Queensland, Brisbane, and Department of Biological Sciences, University of Calgary, Calgary, Alberta, Canada (RMRB and BJC).

Using radio-telemetry, we compared the foraging behaviour and habitat use of adult male and female *Myotis adversus* during the first lactation and post lactation periods in November and December 1997. The bats roosted in an abandoned railway tunnel near Samford, QLD. All individuals that we tracked flew 10-12

km north from their roost to forage over Lake Samsonvale, the nearest large body of water. Their commuting route occasionally followed a creek, although typically they appeared to fly directly to the lake where they began foraging. Females foraged for significantly longer than did males (mean 448 min/night vs. 371 min/night), presumably related to the increased energy demands of reproduction for females. However, there was no difference in foraging time between the lactation and post lactation periods. Rain curtailed foraging. Males and females from the same harem did not forage together, suggesting that males do not defend a foraging area for their females, or their females directly.

The distribution and composition of flying fox campsites in Brisbane and the surrounding districts, Australia

Patrina Birt and Leslie S Hall
Department of Veterinary Anatomy, University of Queensland, St Lucia, Qld 4972

Flying fox campsites in Brisbane and surrounding districts were monitored monthly between September 1996 and 1997 to record changes in numbers, species and sex-ratios. Several campsites outside the study area were also visited regularly. Occupation of flying fox campsites was found to be dependent primarily on the availability of a reliable food source with reproduction appearing to have a secondary effect. *Pteropus poliocephalus* was the dominant species throughout the year, however it was not the dominant species in all campsites with several being dominated by *P. alecto*. There was clear, stable presence of *P. alecto* in the Brisbane region compared to a more migratory behaviour of *P. poliocephalus* when food became scarce. During the summer months *P. scapulatus* was a regular visitor, however this too was dependent on the availability of a food source and the absence of this species correlated with little or no flowering. This study also found that the northern limit of *P. poliocephalus* had contracted extensively, whilst the southern limit of *P. alecto* had extended. Comparisons with previous studies also indicate that the distribution of many campsites in the study area have changed significantly over the last 60 years, with very few traditional sites remaining.

Mother-infant and nocturnal infant behaviour in *Pteropus poliocephalus.*

Nicolel Blasius and John Nelson.
Department Of Biological Sciences, Monash University, Victoria, Australia, 3168.

Mother-infant behaviour in flying foxes is similar to that seen in primates, although the reasons for this are still unknown. Some suggest that brain complexities and possible relatedness, ie close branching from the same lineage, are responsible. A series of observations were carried out on the population of flying foxes in the Melbourne Botanical Gardens. The day observations of mother-infant behaviour were undertaken from birth to 3 months. Observations for nocturnal infant behaviour began when the infants were first left alone by their mothers in the camp (approximately 2 months). These observations revealed that infants displayed independent behaviour which increased with age and a gradual increase in their adult-like behavioral repertoire. The night observations revealed an eventual increase in the amount of movement through the branches and wing flapping behaviour.

Is wild tobacco really the source of ticks for spectacled flying foxes?

Peter H. Brice. 49 Yacht St, Clontarf, 4019

Since at least 1990 spectacled flying foxes (*Pteropus conspicillatus*) on the Atherton Tablelands have suffered from paralysis caused by the Australian paralysis tick (*Ixodes holocyclus*). These incidents have been aggregated in time so that they can be seen as a large scale event occurring between about September and December of each year. This coincides with the seasonal occupation of roosts by spectacled flying foxes around the Southern Tablelands. The event also coincides with the parturition season. Large numbers of individuals (as much as several thousand) have been directly affected by tick paralysis and large numbers of dependent young have been orphaned each year.

In a 1994 study of the diet of spectacled flying foxes, it was noted that they were consuming the fruit

of wild tobacco (*Solanum mauritianum*) in large quantities. This food item was absent from their diet according to studies conducted prior to 1990. It was therefore hypothesised that flying foxes may be obtaining their tick load by visiting these relatively low growing novel food sources. This study set out to test this hypothesis. A number of wild tobacco patches growing in different situations were selected for sampling. These patches were sampled during the summer over two years at a variety of times in a variety of weather conditions. They were sampled by means of fogging, spraying and collecting cuttings.

Not one tick was found. Prima facie it seems that flying foxes are not acquiring ticks from wild tobacco. Either the flying foxes are acquiring ticks elsewhere or they are behaving in a way not yet understood to acquire ticks from nearby ground level plants via the wild tobacco. Clearly further study is necessary to understand the interaction of flying foxes and paralysis ticks in the North Queensland environment.

Echolocation and prey capture in trawling *Myotis* bats and how to tap the bat phone.

Britton, Adam R.C. and Gareth Jones
School of Biological Sciences, University of Bristol, Woodland Road, Bristol BS8 1UG, U.K.

Trawling is a hunting mode involving capturing prey from the surface of water, usually with the feet. Several *Myotis* bats around the world employ this technique very successfully, including *Myotis adversus*. Insectivorous bats use a system of ultrasonic echolocation calls to not only navigate through their environment, but also to identify and capture prey. Their role in prey capture is achieved by modifying both the structure and frequency of occurrence of these calls (creating a 'feeding buzz') as the bat approaches a potential meal, and they continue to be modified following a capture attempt. Here we describe a study aimed at elucidating the nature of these changes by manipulating and recording capture attempts in both controlled and natural conditions using high-speed video, multiple flash photography, analogue and digital echolocation recording. The results provide strong evidence that the pause following the feeding buzz ('post-buzz pause'), together with the pulse repetition rate after the pause ('post interpulse interval'), may be used to identify whether the bat caught or missed the prey. Size of the captured prey also influences these variables. Information on capture success and possibly prey size would be extremely useful in echolocation surveys which currently measure feeding rate but not feeding success in different habitats.

Summer ecology of *Myotis* bats in the interior wet-belt British Columbia, Canada

M. Carolina Caceres
Department of Biological Sciences, University of Calgary, Calgary, Alberta, Canada.

Summers in the interior wet-belt of British Columbia are characterized by cool temperatures and high rainfall. This region is home to five species of insectivorous bats of the genus *Myotis*. Two of these species, *M. evotis* and *M. septentrionalis* use gleaning as well as aerial hawking to forage. I predicted that gleaners, given their ability to feed on non-flying insects, would have a diet distinct from that of the aerial hawkers. Furthermore, I predicted gleaners would emerge later after sunset and forage later than strict aerial hawkers as their prey is less limited by ambient temperature. However, I found there was no difference in diet between gleaning and non-gleaning *Myotis* bats. Bat activity in the wet belt occurred primarily in the three hours following sunset beginning during twilight conditions. Similarly, radio-tagged gleaning bats emerged from their roost in the first half hour after sunset. 96 *Myotis* bats were captured over two summers and only 6 of 53 females captured were obviously reproductive. These numbers are considerably lower than those reported in other parts of British Columbia and elsewhere. Thus, I conclude the environmental conditions in this marginal habitat strongly influence the foraging behaviour and reproduction of the *Myotis* bats.

Vocal communication in *Pteropus poliocephalus.*

Linda S. Christesen and John E. Nelson
Department of Biological Sciences, Monash University, Clayton, Victoria 3168

Vocalizations made by the grey-headed flying fox *Pteropus poliocephalus*, Pteropodidae), have previously been placed in two broad categories, namely harsh calls and clear (tonal) calls. However, the relationship between vocalizations and physical behaviour in *P. poliocephalus* has not been investigated in any specific detail. It is known that this species produces a variety of different calls, but the function of many of them is largely unknown. We have found that the vocalizations of this species can be placed into three broad categories, namely harsh, tonal and intermediate calls. A number of distinct sub-groups occur within each category. We have also found that harsh calls occur predominantly in association with agonistic behaviours, such as fighting, chasing, and forced copulations. In the majority of cases, when harsh calls are made by *P. poliocephalus*, the vocaliser does not instigate the agonistic encounter.

These patterns are similar to those occurring in other social mammal groups. Harsh calls have been linked to agonistic behaviours in primates such as the macaque *Macaca mulatta*, and *M. nemestrina* (Family Cercopithecidae), and the squirrel monkey, *Saimiri scireus* (Family Cebidae). The presence of such a relationship suggests that vocalizations may an important component of aggressive behaviours in a number of distinct animal groups.

Preliminary observations of population size, home range and habitat use in short-tailed bats (*Mystacina sp*) in Fiordland, New Zealand

Jenny Christie[1] , C. F.J. O'Donnell[2], J. Sedgeley[1] and W. Simpson[3]
[1]Zoology Department, University of Otago, PO Box 56, Dunedin, NZ., [2]Science and Research Division, Department of Conservation, Private Bag, Christchurch, NZ., [3]Sinclair Road, RD, Te Anau.

Short-tailed bats (*Mystacina* sp.) were discovered in *Nothofagus* dominant rainforest in the Eglinton Valley, Fiordland in February 1997, representing the first records of these bats in Fiordland since 1871. This paper presents preliminary observations of population size, habitat use, activity patterns, home range size, and movements. Compared to lesser short-tailed bats (*M. tuberculata*) on Codfish and Little Barrier Islands the Fiordland bats were heavier, had larger wings and smaller ears and were sexually dimorphic. In summer, roosting groups ranged from 107-470 individuals and the bats ranged over 130 km2 of the valley. Patterns of activity and movements were similar on most nights. For example, on 10 of 12 nights a juvenile male flew down the valley from a roosting area. His nightly range averaged 16.0 km^2 (SD=7.8, range 10.4-25.0 km^2), traversing a 14 ± 2.3 km length of the valley. On two nights he flew 10-14 km to the north of the roosting area. Cluster analysis revealed that there were four separate areas within the range in which 80% of fixes were collected. These were probably foraging areas and they covered a much smaller area of the range (4.6 km^2). Most activity was within the red beech forest interior and into high altitude forest. There was less activity close to the forest edge, and few records in open grassland. Bats began emerging ca. 20 minutes after sunset and were active at the roost sites throughout the night. Radio-tagged bats from a range of sex and age classes were all active for the majority of the night even during heavy rain.

The differential utilization of forest types by insectivorous bats in far Northern Queensland wet sclerophyll forests

Chris Clague, Vision Touch and Hearing Research Centre
Department of Physiology and Pharmacology, University of Queensland, St Lucia

An ongoing study is being undertaken in tropical North Queensland investigating habitat usage by insectivorous bats. The three general forest type under investigation are Rainforest, Wet Sclerophyll (*Eucalyptus grandis*) forest and Dry Sclerophyll Forest. The Wet Sclerophyll forest is divided into four forest sub-types. These forest types have been sampled through trapping and through the ultrasonic detection of echolocation calls. Significant differences have been found between these forest types in

overall bat activity (passes per minute), species specific activity, and species composition. The tall Eucalypt dominated wet sclerophyll also provides a significant resource of 'clear air' hollows/roosts for larger bats in the area (eg. Tadarida australis). The remaining Wet Sclerophyll (*Eucalyptus grandis*) zone is currently under threat from rainforest invasion induced by changes in fire regime. If this forest type disappears it is felt that an area which may be one the most diverse for bats in Australia, and its potential role in promoting rainforest and regional diversity may also be lost.

Echolocation and social calls of *Murina florium*

Coles, RB, Clague CI, Whybird OJ* & Spencer HJ**
Dept. of Physiology & Pharmacology, The University of Queensland, Brisbane, Qld 4072.
*Present address: P.O. Box 9 Millaa Millaa Qld 4886. ** Cape Tribulation Tropical Research Station, Cape Tribulation, Qld 4873

Murina florium remains a 'rare' bat in Australia since the first record in 1981, but trapping records in and near the Wet Tropics World Heritage Area (WTWHA) have increased considerably in the last few years. One of the difficulties in studying the ecology of *M. florium* is that it appears to have a preference for roosting and foraging in the rainforest canopy. Due to the elusive nature of this species, the echolocation call has not been described and its nocturnal behaviour is poorly understood, although it seems capable of aerial insectivory, gleaning prey and nectivory. Recent survey work has resulted in the capture of individuals of *M. florium* at ground level and a range of vocalisations have been recorded from captive and released bats. The echolocation call of *M. florium* is an FM-type sweep with a frequency band (first harmonic) between 127 kHz to 54 kHz and peak energy ranges between 56 kHz to 63 kHz, depending on the flight behaviour (pulse duration 4 ms). Detecting this type of echolocation call in the field poses some serious problems for ground based survey work, especially if *M. florium* mainly forages in the tree canopy, and therefore the use of a broadband bat detector is paramount. Interestingly, *M. florium* uses an audible flight call that is distinctive (c.f. *Nyctimene* social calls) and it can be used to locate individuals, especially around the time of emergence. This social call, whose function is unclear, appears to have maximum energy in the 8-12 kHz band (duration 18 ms) but there may be ultrasonic components as well.

Problems conserving the functional role of *Pteropus poliocephalus* in the forests of South-eastern Australia

Eby, Peggy. peby@ozemail.com.au

Recent declines in species abundance and high predicted rates of extinction are of major concern to conservation planning. As a result, population viability, measured as the capacity of a population to be self-sustaining, is used throughout the world as the predominant criterion for setting conservation priorities and for measuring conservation success. However, an increasingly strong case is being presented for shifting goals away from minimizing extinction risk towards maintaining populations of sufficient size or structure to retain the ecological roles of species. For many social species the ecological implications of complex population structures remain unexplored and the resulting deficit in our understanding of the ecological roles and resource requirements of individuals is problematical for conservation planning. This problem is exemplified by differences in the habitat requirements of *P. poliocephalus* of various social ranks, and variations in their mutualistic interactions with food plants. There is a strong line of evidence that *P. poliocephalus* allocate food resources of different temporal and spatial reliability within the hierarchical social structure of the species, and that the dominance rank of an individual determines habitat use, migration characteristics and foraging ecology. These traits in turn influence the effectiveness of individuals as seed and pollen vectors.

This paper describes relationships between social rank and bat-plant interactions and explores the challenges associated with conserving this highly complex system. Particular emphasis is placed on describing the resource requirements of migratory bats and on identifying conservation priorities.

An update of Equine Morbillivirus (EMV) and Australian Bat Lyssavirus (ABL) prevalence in flying foxes in Queensland.

Hume Field, Kim Halpin, Peter Young, Barry Rodwell, Natasha Smith, Craig Smith & Tracy Briggs.
Animal Research Institute, Queensland Dept. of Primary Industries, Locked Bag 4, Moorooka, 4105.

A research team at the Queensland Department of Primary Industries (QDPI) Animal Research Institute (ARI) has been screening flying foxes for antibodies to EMV and for ABL antigen. One epidemiological objective of this research is to determine prevalence data for each virus, and to explore the influence of the host variables of species, age and location. From the preliminary results, a species effect is apparent for both EMV and ABL. For EMV, antibody prevalence for *Pteropus alecto, P. poliocephalus,* and *P. scapulatus* in south-east Queensland is 41%, 23.5% and 6.5% respectively. For ABL, disease prevalence for *Pteropus alecto, P. poliocephalus, P. scapulatus* and *P. conspicillatus* statewide is 5%, 2%, 10.5% and 1% respectively. Age-specific analysis for antibodies to EMV in south-east Queensland indicates that juvenile flying foxes have a significantly higher (P=0.06) prevalence than adults (43.5% and 30% respectively). Analysis of age-specific data for ABL is incomplete at this time. The effect of location of the prevalence of both EMV and ABL is currently underway.

Radio-telemetry studies of hand-reared flying foxes at Gordon: Behaviour and survival after release.

Denise Ford and Michael Augee
Ku-ring-gai Bat Conservation Society, PO Box 607 Gordon NSW 2072
andBiological Sciences, University of New South Wales, Sydney 2052

Until 1995 little data had been collected on the fate of hand-reared flying-foxes after release. Information on the success of hand-rearing by rehabilitators tended to be based on the non-return to care of hand-reared animals or alternatively the continuous contact by rehabilitators with hand-reared animals returning to an area to be supplementary fed. Some information has been gathered on hand-reared animals but the data has been infrequent and fragmented across many years.

A radio-tracking study on the fate of hand-reared flying-foxes after release was conducted over three years, 1995 - 1997 by the Ku-ring-gai Bat Conservation Society Inc. (KBCS) and Dr. Michael Augee from the University of NSW. The studies aimed to document the behaviour of the animals after release, whether they integrated into the wild colony successfully and how quickly this could be achieved, their survival and finally their movements within Sydney and beyond.

Results have indicated that younger animals, released earlier than previous standard practice have far higher rates of survival and are more likely to integrate into the wild colony. Independent behaviour has developed earlier with less reliance on human intervention for support feeding. Changes have now been instituted to the rearing and release procedures by the KBCS in Sydney.

Developmental abnormalities in young flying foxes.

Les Hall[1], Janine Barrett[1], Georgia Livesay[1], and Helen Luckhoff[2]
[1]Veterinary Pathology and Anatomy, University of Queensland, St Lucia, Qld, 4072
[2]PO Box 3015, Darra, Qld, 4076

There are few reports regarding developmental abnormalities in bats. In the last 13 years, 20 cases of abnormalities have been reported in newborn young and juvenile Black and Grey-headed flying foxes (*Pteropus alecto and P. poliocephalus*). The most frequent abnormalities were craniofacial and fluid on the brain (hydrocephaly, hydranencephaly, and porancephly). One case of supernumery digits (polydactyly), was also recorded.. The incidence was 2 in 1985-89, 12 in 1990, and 6 from 1991 to present. Total incidence for all abnormalities was 1 per 100 newborn young and juveniles in human care. The abnormalities were more frequent (75%) in Black flying foxes. Case histories and possible reasons for the abnormalities will be discussed. Developmental defects of the brain should be considered as a cause of neurological signs in young bats. Lyssavirus has been found in a juvenile orphan flying fox in human care. Any juvenile flying fox showing signs of central nervous system disorders, such as hind limb paralysis, lack of coordination, or mental impairment should be examined for Lyssavirus or developmental abnormalities.

The origin of New Zealand's mystacinids solved

S. Hand, M. Archer and H. Godthelp
School of biological Sciences, University of New South Wales, Sydney 2052, Australia

New Zealand's endemic mammal fauna consists of three bat species. The vespertillionid *Chalinolobus tuberculatus* as been demonstrated to be closely related to Australian congeners, but the origins and relationships of New Zealand's two endemic mystacinids, *Mystacina tuberculata* and the recently exticnt *M. robusta*, have remianed obscure. Taxonomists have variously placed them in three microchiropteran superfamilies. The issue appeared resolved when molecular data showed them to be basal members of the South American superfamily Noctilionidae(=Phyllostomoidae), their dispersal to New Zealand from South America evidently occurring more than 35 million years ago (Pierson *et al.* 1986). Recently it was suggested that on the basis of a variety of data that mystacinids are probably basal members of the cosmopolitan superfamily vespertilionidae s.l. (Simmons 1998) and that they diverged from other bat lineages more than 50 million years ago. Now the first pre-Pleistocene records for mystacinids has been found in Australia. Three Miocene species of the new genus *Icarops* are known from lower teeth and dentary ragments(Hand, Murray, Megirian, Archer and Godthelp, 1998), and more dental and very distinctive postcranial material has been recovered from at least two other Australian Tertiary localities. The fossil mystacinids, which range in age from 12 to 25 million years old, are generally more primitive than Recent taxa and suggest an Australian origin for New Zealand's mystacinids.

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The importance of the riparian zone to prairie-dwelling bats in Canada

Gillian L. Holloway
Department of Biological Sciences, University of Calgary, Calgary, Alberta, Canada

I investigated the roosting and foraging habitat of prairie bats along the South Saskatchewan River in south-east Alberta, Canada. *Myotis ciliolabrum, M. lucifugus,* and *Eptesicus fuscus* roosted in small crevices in the coulees (cliffs) of the river valley. Roosting crevices had small opening dimensions, and were typically >2m above or below flat ground, or within large crevices going into the ground. *M. evotis* roosted in narrow crevices in granite rocks. The majority of echolocation and foraging activity occurred along the river, especially around riparian trees. Very little bat echolocation activity was heard on the open prairies. Springs (standing water) near the river also had high bat echolocation and foraging activity. Insect abundance was greatest at the river and springs. This study shows that riparian habitat is critical to prairie bats, and conservation measures are needed as riparian forests are declining.

Metabolic rate as a function of ambient temperature in two fruit bats.

G. Roy Horst and Gary G. Kwiecinski
Potsdam College of State University of New York, Potsdam, NY, USA 13676
and University of Scranton, Scranton, PA, USA 18510

There appears to be much variation in thermoregulatory strategies between similar species depending on body mass, diet, geographical distribution, food availability, and other variables. We compare the metabolic response (MR) to decreasing ambient temperature (Ta) in *Artibeus jamaicensis* and *Phyllostomus discolor*, two species which have very similar diets, are of very nearly the same body mass, and are sympatric in many parts of their ranges. To reduce stress during this procedure we attempted to make the experiments as unintrusive as possible. Rather than placing the individuals being tested into exotic metabolic chambers, we designed our system so that the metabolic chamber is part of their permanent cage. The chamber is small, dark, and quiet, and the bats preferred to roost in this small extension of their cage. We determined that bats "at ease" in our chamber had basal metabolic rates (BMR) 20 to 50% lower than

bats in a "standard" metabolic chamber under similar conditions.

We also examined the difference in BMR of isolated single bats compared to groups tested together, and found that at temperatures within their thermoneutral zone there is little difference in BMR, but when tested at Ta below the thermoneutral zone, the difference between single bats and groups became ever greater with decreasing Ta. Bats tended to huddle ever more tightly as Ta declined. As Ta decreased below the thermoneutral zone, BMR increased in both species but there is a wide variation between individuals in both species. The low end of thermoneutral zone appears to be nearly the same for both species; but the variation within one species is greater than the variation between the two species. Some bats begin to increase metabolic rate at Ta 24 °C., while others wait until Ta is below 20 °C.

We are in the process of lowering Ta to the point where the bats "give up" and become heterothermic; some abandon homeothermy as early as Ta = 22 C. Others continue to maintain homeothermy Ta as low as 15 C.° P. discolor is clearly more capable of dealing with lower ambient temperatures than *A. jamaicensis*.

Something's got to be done! An ethnographic approach to resolving conflicts surrounding the presence of flying foxes in urban settings.

Peter Howard and Darryl Jones
AES Griffith University and Convener,
Suburban Wildlife Research Group, Lecturer, Griffith University

When the behaviours of urban dwelling Australian fauna have conflicted with the interests of humans, those typically called upon to resolve these conflicts have been wildlife managers and/or those with an expertise in the biology of the problem species. An alternative approach seeks resolution by identifying the human stakeholders and moderating their often conflicting interests.

Through the use of focused group discussions, in depth interviews, public meetings and newspaper database searches, the Suburban Wildlife Research Group has gathered data on conflicts involving Brush-turkeys, Torresian crows, Australian magpies and Flying-foxes. Initial analysis suggests there are considerable similarities in the nature of all these problems. By interpreting these data in the light of current Australian environmental values and by using existing theory on the development, maintenance, moderation and change of attitudes, this paper describes a set of tools and methods managers might use in their dealings with the public concerns which surround the presence of Flying-fox colonies in suburban settings.

The exclusion and subsequent re-establishment of a colony of fishing bats (*Myotis adversus*) from a bridge near Morisset, New South Wales

Glenn Hoye
PO Box 271, Belmont NSW 2280

During mid 1995, Stockton Creek Bridge near Morisset, New South Wales, was demolished and replaced with a concrete bridge. Examination of the bridge prior to its removal, revealed that a colony of at least one hundred Fishing Bats (*Myotis adversus*) were roosting during the day in splits and hollows in timber corbels supporting the main beams of the bridge. Capture and subsequent banding of bats was undertaken to assess the size of the colony utilising the bridge and to allow movements to other roosts to be identified. Bats were then progressively excluded from the bridge as demolition proceeded.

Alternative roosts for this species in the area were investigated through radiotelemetry of excluded individuals as well as examination of known roosts in the vicinity. Following erection of the new bridge, corbels from the old bridge were installed under it to provide diurnal roosting habitat. The bridge was monitored for the following twelve months to assess usage of the installed corbels by bats. Within one month, bats were recorded roosting in the corbels and breeding was noted within ? months. Numbers in the bridge fluctuated over the twelve months from a minimum of 50 adults being noted at any one time. Numbers decreased over the winter months. The pattern of use may have changed from that prior to the old bridge being demolished as high numbers were present prior to the bridge being demolished in May 1995. The reasons for these changes are not clear, but may be related to differences in microclimate within the corbels due to greater insulation from the new concrete spans as opposed to the original bitumen covered timber decking.

The operation indicates that re-establishment of roosts of the Fishing Bat is feasible in particular cases if this is necessary. Priority should always be given, however, to maintaining roosts where this is at all possible. Re-established roosts may not have the same characteristics as the original roosts. In cases where bats must be excluded from roosts, consideration should be given to reinstalling roosting elements in the new structures. Use of previously used roosting elements should be considered over the use of newly formed structures.

Monitoring insectivorous bats at an urban environment: A preliminary study in Brussels, Belgium

Nancy Irwin, Yves Laurence, Olivier Missa, Rennie-Marie Lafontaine and Perrie Devillers
Umiversity of Queensland (Irwin)

A methodology was developed to facilitate easy data collection that would be useful for designing conservation management programs. The study site covered 40km^2 which encompassed the city Centre, suburbs, parks and forest. Temperature, rainfall, sunset times and lunar phase was recorded. The sampling protocol followed, recorded bats (simultaneously) on two 1 Km transects 30 minutes after sunset. Each transect was divided into 20 recording points separated by 50m and passed through the most number of habitats feasible for that square. At each point the observer recorded bats heard on bat detectors in a 3 minute interval. Fight and frequency characteristics were recorded, as were whether the bats were feeding or beating. 26 habitat variables were also recorded. Control transects were also monitored to ascertain the effect of time and degree of seasonal variation. These were monitored to from dawn to dusk each week throughout the study period. Results to date show; there is a global and local effect of bat occurrence with specific habitat variables, and that different species utilize different habitats, and were affected differently by season.

The ecology of *Myotis macropus* in a warm water outlet tunnel at Vales Point power station on Lake Macquarie on the central coast of New South Wales

Daniel Lunney, Adele Reid, Glenn Hoye and Jan Grigg
Fly by Night Bat Surveys, Newcastle, N.S.W. (Hoye)

The aim of this study was to examine how this vulnerable species in NSW survives in a highly industrialized site. The bats occupied the warm water outlet tunnel from the power station throughout the year. The tunnel provided a warm and moist environment for roosting. The females reproduced twice during the spring-summer months. The analyses of the scats revealed a diet which included aquatic insects and some fish. The bats were observed flying nightly up to 3 km across the lake and up the tributary of the adjacent creeks and bays. Their survival and breeding will depend on the maintenance of the tunnel and the surrounding waterways and adjacent vegetation.

Wildlife careers and flying foxes: Paving the way to conservation. (Pre-liminary results of a survey of wildlife carers in eastern Australia).

Nicola Markus. Dept. of Veterinary Patho-Biology, University of Queensland, St. Lucia 4072

A two-page questionnaire was mailed to members of volunteer wildlife care groups involved with flying fox rehabilitation. The survey aimed to establish the demographics of volunteer carers (sex, age, occupation etc.) as well as their motivations for caring, their understanding of the ecological role of flying foxes and their perception of the threat of bat-transmitted disease to carers. Over one hundred carers* belonging to eighteen* care organizations responded to the survey. Pre-liminary results indicate that 88% of carers are female and 60% of carers are aged between 31-50 years. Half of all carers have full-time occupations while less than 10% are either retired or unemployed. More than 50% of carers have over four years experience and over 40% have reared over six flying foxes, with 12% having reared more than 21 bats each. Altruism, conservation and education rated most highly as motivations for caring and 81% of carers felt that hand-rearing contributed to the conservation of flying foxes in the wild. Less than half considered the bat-transmitted diseases of EMV and lyssa-virus a serious threat to carers, and less than half correctly identified the role of flying foxes in Australiaís ecology as seed-dispersers and pollinators.

Fruit farmers' perceptions of methods of orchard protection against flying foxes in far-north Queensland.

Megan McHold[1] and Hugh J. Spencer[2].

[1]School for International Training [2]Cape Tribulation Tropical Research Station, Australian Tropical Research Foundation PMB 5 Cape Tribulation Qld. 4873

Flying foxes (*Pteropus spp.*) are considered "keystone species" in many ecosystems in eastern and northern Australia, pollinating a wide range of hardwood and rainforest species and dispersing many rainforest fruits. Flying foxes have suffered from a culturally based negative image which has seen them become the subject of bounty hunting and fear-based destruction of colony sites. With the gradual loss of habitat through agriculture, particularly cane farming and urban development, flying foxes have increasingly begun to attack fruit orchards. As intelligent and opportunistic foragers, the three larger flying foxes, *P. alecto, P. poliocephalus* and *P. conspicillatus* appear to be altering their tastes to include orchard crops in preference to natural fare. Orchardists in Queensland were recommended to grow rambutans as these fruit appeared to be untouched by flying foxes, now, rambutans are very heavily attacked. Lychee orchards in Far North were devastated in December 1997 by flying foxes, primarily *P. conspicillatus*, the spectacled flying fox, which is primarily restricted to the rainforest areas in the Wet Tropics World Heritage Area centered around Cairns. Some growers lost as much as 90% of their crop.

As the spectacled flying fox population is considered to be in steep decline, especially over the last 20 years, through habitat loss and related impacts (tick infestations, killings in orchards), there is a strong push to have the IUCN status of these animals listed as vulnerable. In order for this listing to be practical, it must have the support of farmers. To this end a survey of over 100 exotic fruit growers was conducted in December 1997, to determine the effectiveness of measures, such as netting, aerial electrocution devices and other approaches to controlling flying fox damage. We determined that 28% of farmers used exclusion nets alone, and 19% used nets in conjunction with patrolling with lights and a gun. Aerial electrocution devices ("grids" or "Fyre Fox") were employed by 14 farmers, some alone, some in combination with other techniques. Other techniques - noise makers, lights, sound generators (bird-scare) etc accounted for about 6%. Nineteen percent of farmers used no protection whatsoever. Exclusion nets were regarded as reasonably effective, especially "over-canopy" netting in dry areas, but the effectiveness of the cheaper "throw-over" nets ranged from effective to totally ineffective, with the majority of farmers considering them "somewhat" effective. Farmers in lowland areas expressed strong concerns about the other impacts of netting-promoting fungus and insect attack, and the exceedingly short life of throw-over nets. Electrified grids were felt to be effective, but had to be activated early in the growing season, or else resulted in unacceptable kill rates. Patrolling was also felt to be effective, but time demanding. Both patrolling and grids require a Damage Mitigation permit from Queensland DOE, and there is pressure to discontinue this practice. Most farmers expressed a strong distaste for killing flying foxes, and felt that research on non-lethal approaches to control was essential, even though their experiences with such approaches to date has largely been negative.

An indigenous perspective on flying fox harvesting.

Charles Missi. Faculty of Aboriginal and Torres Strait Island Studies
Northern Territory University, Casuarina NT 0811

Indigenous people want to be independent from foreign cultures and to keep alive the traditions and customs which give meaning to our existence. Eating wildlife, including flying-foxes, is one of these traditions and in Australia has been a part of life for tens of thousands of years. The harvests of wildlife by indigenous people is far more sustainable than sheep, wheat or any other form of intensive farming currently under way in Australia. In the past harvests relied on harpoons, spears, throwing sticks, natural fiber nets, canoes, etc., but now a combination of old and new methods are used. This represents a natural evolution of tradition, just as the traditional Christmas turkey is no longer hunted but bought from a supermarket. Indigenous people are very interested in harvesting wildlife commercially as it would help maintain traditional diets, build on traditional knowledge and skills, and provide income and employment to poor rural communities.

A case for metapopulation structure in bats: An update on long-tailed bats in a temperate rainforest, New Zealand

Colin F.J. O'Donnell
Science and Research Division, Department of Conservation, Private Bag, Christchurch, NZ.

A study of population structure of the threatened long-tailed bat (*Chalinolobus tuberculatus*) has continued in temperate rainforest in the Eglinton Valley, Fiordland. Radio-tracking of bats (n=73) indicated that individual foraging ranges overlapped considerably. However, a banding study revealed that apparently distinct, but cryptic, social groups existed. The bats almost always associated with some of their traditional roosting companions during the day, but mixed at foraging sites during the night. Three groups were studied in detail. Of 1,886 recaptures in 65 harp-trapping sessions at communal roosts by March 1997 there were only 38 cases (2%) of individuals switching between groups. Switching only occurred for one night. Those switching were equally distributed amongst non-breeding females, pregnant females and males. Each group contained 147-182 marked individuals, with 35, 51 and 63 breeding females. Juveniles of both sexes returned to their natal group as one year olds. Results raise questions about how bat populations are defined and have implications for recommending best practice conservation management. Localised assemblages of bat populations linked through infrequent migration by a few individuals, implies that metapopulations exist. However, the long-tailed bat population did not conform to traditional 'source-sink' metapopulation models because the metapopulation occurred in homogeneous habitat extending over a large geographic area. If long-tailed bat populations are characterized by local extinction of groups in some patches of forest, and colonization of others, then loss of lowland forests could have had a significant impact on the persistence of populations in the past.

Does the presence of EMV/BPMV antibodies have any effect on heamatology, serum biochemistry and serum cortisol in conscious and anesthetised spectacled flying foxes *Pteropus conspicullatus* ?

Annabelle Olsson, BVSc.
FNQ Wildlife Rescue Assoc. Inc., 19 Purbeck Place, Cairns 4870.

The continued survival of the spectacled flying fox in far north Queensland is critical to the maintenance of rainforest floral diversity. Stress and subclinical disease, induced or exacerbated by pressure on roost sites and feeding grounds, can severely depress an animal's ability to reproduce, fight infection or cope with normal environmental adversities. Failure to recognize the effects of these stressors on animal health could have serious implications for spectacled flying-fox populations. It represents a greater threat to critically endangered exotic species.

Blood samples were taken from manually or chemically (xylazine/ketamine) restrained juvenile hand-raised spectacled flying foxes to determine a range of values for haematology, serum biochemistry and cortisol. SNT's were performed to determine EMV status. There were no apparent differences between EMV positive and EMV negative animals. No haematological or cortisol differences were apparent between anaesthetised and manually restrained bats. Some biochemical differences occurred. The limitations of this preliminary investigation, notably the small sample size and hand-reared juvenile status of the animals, are acknowledged. Research is continuing.

Acknowledgements: Dr Geoff Mitchell of Veterinary Pathology Services, Brisbane, for processing the blood samples and Hume Field of the Animal Research Institute, Brisbane, for providing EMV/BPMV antibody test results.

Habitat use of the eastern horseshoe bat in a fragemented woodland mosaic

Chris Pavey 64 Arafura Street, Upper Mt Gravatt, Brisbane, 4122, Qld.

I examined habitat use by foraging and commuting eastern horseshoe bats, *Rhinolophus megaphyllus* Gray, in a fragmented woodland mosaic at Anduramba, southeast Queensland. The species was considered to be vulnerable to habitat fragmentation because of its unique combination of wing morphology and auditory characters that are adapted to foraging in environmental clutter (i.e. close to and within vegetation). I studied habitat use by light tagging and radio tagging individuals that roosted in a colony in a large wood-

land fragment. Light tagged bats were observed foraging within an area of 105 ha composed of open habitat (grassland) (68% of area), closed habitat (woodland) (20%), and edge habitat, which was the interface of woodland and grassland and isolated clumps of trees in grassland (12%). Bats foraged in closed and edge habitat but not in open habitat, and used closed habitat significantly more often than expected by its availability. Commuting bats left the vicinity of the roost by one of two routes, both of which led into riparian woodland. One route was entirely within woodland, whereas the other route crossed 250 m of open ground. Bats were tracked up to 2.25 km (straight line distance) from the roost. The study shows that the conversion of woodland into a fragmented woodland mosaic will reduce the availability of the preferred foraging habitat of *R. megaphyllus*.

Wing morphology of Southeast Queensland microchiroptera.

Martin Rhodes
Department of Veterinary Pathology and Anatomy, University of Queensland, St.Lucia, Qld, 4072

I examined the wing morphology of Microchiroptera in southeast Queensland, using measurements from live bats (328 bats) and museum specimens (658 bats). I did this to obtain measurements of dimensions predicted from aerodynamic theory to influence flight of bats. These describe the width and length of wings, the wing area and the wing area relative to body mass. I measured wing area of live bats from tracings made around their outstretched wing, while I estimated wing area of museum specimens from lengths of their digits.

The body mass ranged from 4.1 to 127.8 g; wing span from 18 to 58 cm, and wing area from 0.006 to 0.063 m^2. The aspect ratio (relative width of wing) ranged from 4.98 to 8.25, while the wing loading (mass by wing area) ranged from 4.32 to 19.75 N/m^2. For each character describing wing morphology, most species had overlapping values with other species, while a few species had distinct wing morphology. Most overlap occurred among species with low wing loading and aspect ratio. To overcome problems with overlapping species, I divided species into groups with similar wing morphology. The similarities and differences between species suggest the flight is similar between some species and different between others.

Flight behaviour of bats: Measurement and description from field studies.

Martin Rhodes
Department of Veterinary Pathology and Anatomy, University of Queensland, St.Lucia, Qld, 4072

The flight behaviour of free-flying bats in the field can be observed with the aid of light tags. Observations made in this way can be used to characterize the flight behaviour of a species. Descriptive terms have been used previously to characterize the flight behaviour of bats, but these loosely describe the observations made, and are open to interpretation. The resulting descriptions are also not standardized for comparison between studies. To accurately characterize the flight behaviour of bat species in southeast Queensland, I measured the frequency of specific behaviours. I defined seven flight behaviours, and for each species I calculated the number of each behaviour per minute of observation. This allowed flight behaviour to be characterized quantitatively.

Species which have been described to have direct flight, such as *Nyctinomous australis* and *Myotis moluccarum*, have a high rate of 'straight' flight compared to other behaviours. Species whose flight has been characterized as maneuverable, such as *Nyctophilus gouldi*, and *Vespadelus pumilus*, have a lower rate of 'straight' and higher rate of 'turn' and 'zigzag' behaviours. In addition to providing a quantitative basis for applying different terms to species with very distinct flight behaviour, more subtle differences between species flight behaviour are indicated by quantifying behaviours. Quantifying flight behaviour should reduce the variability in behavioural recordings from an observer with time (intra-observer reliability) and between observers (inter-observer reliability).

Variation in echolocation call structure with changing clutter conditions: Problems for identification.

Rhodes, Monika and Hans-Ulrich Schnitzler
Eberhard-Karls Universitaet Tuebingen, Deaptment of Physiology,
Auf der Morganstelle 28, D-72076 Tuebingen, Germany

Tasmanian bats species can be identified from ultrasonic recordings of their echolocation calls. To obtain a repertoire of species-specific pulse characteristics for each species, calls from hand released bats were compared with calls from free flying bats to obtain a greater range of call types. The echolocation calls of the sibling species *Vespadelus darlingtoni* and *Vespadelus regulus* were not distinguished from one another as hand release recordings were not obtained from *Vespadelus darlingtoni*. Both species were described as one species-complex.

The echolocation behaviour of all Tasmanian bat species in search flight was described. The change in search signal structure and parameters (pulse interval, pulse duration, initial-, best- and end frequency and duty cycle) with changing clutter conditions in their hunting habitat was also described. The species *Chalinolobus gouldii*, *C. morio*, *Falsistrellus tasmaniensis*, *V. darlingtoni/regulus* and *V. vulturnus* are typical edge and gap bats which search for prey along edges and gaps and in open spaces. They emitted search signals which consisted of an initial FM-component followed by a QCF-component (FM-QCF-FM signal). In open spaces it was typical for these six species to emit long narrow band signals with a small FM-component, a dominant QCF-component and long pulse intervals. As bats approached vegetation (cluttered space), the QCF-component of the signal was shortened, and the FM-component increased, while pulse interval and pulse duration was decreased, *Nyctophilus geoffroyi* and *N. timoriensis*, both gleaners, produced pure FM-calls in every level of clutter.

The results presented do not fully characterize the intra-specific variation, as they stem from data sets comprising only a few individuals each. However, the established and proved knowledge of the interdependence of clutter situation and call structure enables an approach to species determination of the Tasmanian bat fauna via acoustic monitoring; i.e. considering parameters of call structure.

Significant bat results from comprehensive regional assessment fauna surveys in the south-eastern Queensland biogeographic region

Schulz, M.[1], D. Hannah[2], T. Eyre[2] and L. Hogan[1]
[1]Forest Wildlife Section, Dept of Natural Resources, [2]Forest Assessment Unit, Dept. of Environment

Bat surveys were conducted as part of the Comprehensive Regional Assessment of fauna occurring in state forests, timber reserves and national parks in the south-eastern Queensland biogeographical region between March and December 1997. Techniques used included 30 minute ultrasonic detection sessions using Anabat II detectors at all systematic sites; and harp trapping, mistnetting and triplining at selected sites. A summary of significant results, in terms of previously known distributions and habitat preferences are presented. Significant findings included the location of the little pied bat *Chalinolobus picatus* in near-coastal forests dominated by lemon-scented gum *Corymbia citriodora* and ironbarks in 10 localities. This species is normally regarded as only occurring in arid and semi-arid localities. The large forest bat *Vespadelus darlingtoni* was confined to high altitude moist tall open forest in the far south of the region. The distribution of the poorly known eastern cave bat *V. troughtoni* appeared puzzling. It was primarily recorded from escarpment areas in Kroombit Tops and Blackdown Tablelands in the far north of the region. However, searches of culverts in the selected areas in pastureland away from any rock outcrops in the far south also revealed small numbers to be present. The common blossom-bat *Syconycteris australis* is normally regarded as being confined to coastal forests and heathlands. This species was recorded from two inland sites, with the furthest site being approximately 75 km from the nearest coastline. An interesting result was the complete absence of a number of species; notably the large-eared pied Bat *C. dwyeri*. The only records of this species from the region are from high altitude sites at Lamington and Gambubal and from low altitude sites in disused fairy martin *Hirundo* aerial nests in the Wivenhoe Dam area. It appears surprising that this bat which, although rare within such a large biogeographical region, has been omitted from species to be included in the revised Bat Action Plan.

The human cost of Australian Bat Lyssavirus infection in Queensland.

Linda Selvey. Manager, Communicable Diseases Unit, Queensland Health.

In November 1996 a woman died from Australian Bat lyssavirus infection. Her symptoms and signs were very similar to classical rabies. Australian Bat lyssavirus is closely related to classical rabies and, unlike other bat lyssaviruses, the rabies vaccine has been found to be protective against Australian bat lyssavirus. Investigations are underway to see whether any previously undiagnosed cases of encephalitis were due to Australian Bat lyssavirus infection. Since July 1997, 105 people have been provided with post-exposure prophylaxis following injuries incurred by bats, predominantly flying foxes. Apart from being costly, this statistic is alarming because of the potential risk involved to the people who are exposed. This paper will discuss the rationale behind Queensland Health guidelines on the management of exposure to flying foxes and bats as well as presenting the latest findings on human infection with another bat-related zoonosis, Bat paramyxovirus or equine morbillivirus.

Cynopterus bats(pteropodidae) as agents of seed dispersal on the Krakatau Islands, Indonesia.

Louise A. Shilton
School of Biology, University of Leeds, Leeds LS2 9JT, UK.
Present address: Department of Forestry, Australian National University, ACT 0200.

The Krakatau Islands provide a special example of ecosystem re-establishment and recovery after cataclysmic volcanic eruptions completely destroyed their biota in 1883. The recolonization of these islands by plants and animals represents perhaps the best documented example of rainforest succession in the humid tropics. Pteropodids were the first bats to recolonize the islands, with more recent microchiropteran arrivals. *Cynopterus* bats are the most successful pteropodid colonists, now represented by four species, but the role of fruit bats in the recolonization of the islands by plants has received little detailed attention. This is the first study to quantify the role of fruit bats as agents of seed dispersal on these islands. Field studies include: assessment of the most important plant food resources by longitudinal monitoring of vegetation plots; capture of fruit bats for analysis of faecal seed content, flight speed and foraging distance. Retention times of seeds in the gut of captive bats have been measured and germination trials have been used to quantify the effect of gut-passage on seed viability. This information is being used to test the hypothesis that fruit bats play a key role in the re-establishment of tropical rainforests in disturbed areas.

Objective analysis of Anabat files: A worked example.

Jolly, Simon. 5 Howitt Court, Werribee, 3030 Australia

For research projects and fauna surveys it is essential that recorded calls be attributed to the correct species. Although it may not be possible to be 100% certain which species made a call, it is possible to objectively assess a call and assign a probability that it was made by a particular species.

A good collection of reference calls is essential. There must be no doubt about the true identity of each reference species, and ideally, you should have ten or so calls for each species of interest. These calls, and the unknown calls, are then processed with either Analook, Analyse or Analyze for Win 95. These programmes allow you to select parts of the call you feel are most representative, exclude abnormal pulses, and prune outlying data points. They will then extract quantitative attributes from each call (average frequency, pulse slope, pulse curvature etc.) and output them to a text file.

The resultant text file can then be imported into a statistical package (e.g. Minitab, SPSS, S-Plus). A new numerical attribute is added to the data to identify known species. If the species is not known this field is left blank. Choose the Discriminant analysis command, specifying the numeric species variable as the Grouping variable. The various quantitative attributes are designated as Independent variables. A range of statistics may be offered by the package, but for the novice, the only concern is Probability of group membership. Press the OK button and these probabilities are saved as extra variables in the worksheet. The probability of species membership will be clearly shown for each call. An unknown call might have a 2% chance of belonging to species 1, an 80% chance of belonging to species 2, and so on. That is all there is to it. Now you may say that just by looking at the call you would judge it to belong to species 2 - but I

would be skeptical. If you say that you have analysed the call and there is an 80% chance it belongs to species 2, then there is no argument.

Flying foxes: To hunt or not?

Chris Tidemann. Australian National University,
School of Resource Management and Environmental Science, Canberra, ACT 0200

Wildlife management in most of the world is dominated by the Western paradigm - wildlife is owned by the state, is conserved in protected areas, consumption of wildlife is illegal. There is growing recognition that this approach does little to conserve wildlife in the >90% of the world that will never be included in protected areas and there is growing resentment against it in the many countries that have a long tradition of wildlife use for food and medicine. Across Africa, southern Asia, Australasia and islands of the Pacific and Indian Oceans fruit bats have been traditionally hunted for food and pharmaceutical properties. Efforts to stop fruit bat consumption have failed because of limited policing resources and antagonistic community attitudes; fruit bats are continuing to decline. I argue that hunting per se is not the real problem and that if it were approved it would not only promote community involvement in conservation of fruit bats and other wildlife, but would also lessen pressure on already limiting state-funded conservation initiatives. This stance has recently been espoused by the World Conservation Union (IUCN) and the World Wide Fund for Nature (WWF), although in developed countries many conservationists continue to oppose it.

Dry season habitat use by flying foxes, *Pteropus spp.*, in Kakadu National Park: a monsoonal environment in North Australia

Christopher R. Tidemann[1], Micheal J. Vardon[1], Ronald A. Loughland[1,2] and Peter J. Brocklehurst[3]
[1]The Australian National University, School of Resource Management and Environmental Science, Canberra ACT 0200;
[2]National Avian Research Centre, PO Box 9903, Sweihan - Abu Dhabi, United Arab Emirates,
[3]Department of Lands, Housing and conservation (NT), PO Box 496 Palmerston NT 0831

We used information from Aboriginal hunters and aerial and ground survey to investigate habitat use by Black (*Pteropus alecto*) and Red Flying-foxes (*P. scapulatus*) in Kakadu National Park in the early dry season of 1992. Both species formed camps at riparian sites in dense vegetation within 5 km of one or more sites that were indistinguishable in landform, vegetation type and structure, from the occupied site; all were within adult flight range (<70 km) of another camp occupied by conspecifics. Colonies containing >1000 animals and large numbers of young were classed as main camps (n=6); camps containing <1000 animals were designated as satellite camps (n=9). Main camps of *P. alecto* (n=4) were restricted to the north of the study area whereas the main camps of *P. scapulatus* (n=2) were further inland. All were within foraging range (20 km) of large expanses of blossoming plants. Satellite camps of both species were distributed more uniformly across the landscape. Camps in dense vegetation over water frequented by crocodiles would ensure protection from most predators and a protected microclimate in which to rear young. Proximity to similar sites would provide insurance against human predation and fires.

Colony occupation by black (*Pteropus alecto*) and red (*P. scapulatus*) flying foxes in the Darwin region, North Australia

Michael Vardon and Christopher Tidemann. Australian National University,
School of Resource Management and Environmental Science, Canberra ACT 0200

Five colonies of flying-foxes (*Pteropus alecto* and *P. scapulatus*) were monitored regularly in the Darwin region between July 1994 and December 1997; other colonies were inspected opportunistically. There was a relatively consistent annual cycle in numbers of the two species and the age-sex structure of colonies. *Pteropus alecto* appeared to be a local level migrant, with the number of animals in the northernmost colony negatively correlated with numbers in the southernmost colony (p=0.06). There was an apparent southward movement of adult *P. alecto* at the end of the wet season (March - June), following

births in February and a return north in the Build-up season (September-November). Some animals were present in the northernmost colonies year round, but this was not the case in the southern colonies.

For *P. scapulatus* the colony occupation pattern was less clear, probably because the study area encompassed only a fraction of the north-south range of the species. Large numbers of *P. scapulatus* were annual visitors to the southernmost colony in July-November 1994-1997: small numbers were present in the northern colonies December-March 1995-1996 but in 1997 large numbers occupied a northern colony for most of the year.

Ecological energetics of New Zealand long-tailed bats: A pilot study.

Peter Webb. Department of Zoology, University of Otago, P O Box 56, Dunedin.

Here I report on the results of a pilot study on the ecological energetics of New Zealand long-tailed bats, *Chalinobus tuberculatus*, a small insectivorous forest bat. The study was conducted in southern beech forest (*Nothofagus spp*) in Fiordland, New Zealand, over a three week period in February 1998. Nulliparous adult females and adult males were caught in flyways or at roost exits and maintained in captivity for up to three days during which they were hand fed each evening on meal worms. Captured individuals remained euthermic during the hours of darkness but entered torpor at dawn and in most cases remained torpid through out the day. At 10°C energy expenditure when torpid was about 2% of that when euthermic. As ambient temperature increased the energetic costs of torpor and euthermy converged until they were indistinguishable at around 35°C. Periods of apnea were apparent within a few minutes of bats entering torpor. A temperature sensitive radio-transmitter fitted to a single adult male bat indicated that torpor was very prevalent in the wild but on any day could occur at any time, all day, or not at all. Torpor in this individual was noted in both solitary and communal (10-30 bats) roosts.

Sexual dimorphism and the ecolocation calls of *Hipposideros semoni.*

Whybird, Olivia J.*, R.B. Coles and C.I. Clague
Dept. of Physiology & Pharmacology, The University of Queensland, Brisbane, Qld 4072.
*Present address: P.O. Box 9 Millaa Millaa, Qld 4886.

There are six species of hipposiderid bats in Australia, similar in size (FA range 37-50 mm) with the exception of the much larger *Hipposideros diadema* (FA 68-78 mm). The sexes have not been regarded as dimorphic in size but the number of records from the rarely caught species is usually quite meagre. Recent survey work in the Wet Tropics World Heritage Area (WTWHA) and Cape York have yielded new records for *H. semoni*, and historical records have been re-examined. The results suggest that this species is actually dimorphic in size with females larger than males, and may be the only example amongst the Australian species (*H. semoni* in New Guinea show the same trend). Remarkably, recordings of the echolocation calls of *H. semoni* captured in the Cooktown region of Cape York reveal that males have a much higher CF around 98 kHz compared to females with CF around 74 kHz. This difference appears to be correlated with body size but data are preliminary. Field recordings of 'unidentified' hipposiderid-like CF-FM calls from flying bats in regions such as Black Mountain NP and the Windsor Tableland, can now be attributed to foraging female and male *H. semoni*. Female *H. semoni* from Iron Range further north, have CF around 80-82 kHz, suggesting that there may be geographical variation in echolocation call frequencies for this species, as previously reported for *H. ater* and *Rhinonicteris aurantius*, and also *Rhinolophus megaphyllus* (Coles 1993, 5th International Theriological Conference, Sydney).

Conservation status of the spectacled flying fox in the wet tropics region of Australia.

Whybird, Olivia J.[1], Stephen Garnet[2], & Hugh Spencer[3]
[1]Queensland Department of Environment, P.O.Box 2066, Cairns 4870, [2] P.O. Box 9, Millaa Millaa 4886
[3]Australian Tropical Research Foundation, PMB 5, Cape Tribulation, Qld 4873

A survey of all known Spectacled Flying-Fox colonies in the wet tropics will be undertaken in March 1998 with the assistance of volunteers. Information from this survey will be compared with historical data

on the basis of which the status of the species in Australia will be determined. A summary of issues relating to Spectacled Flying-Fox management will be presented along with suggestions for future action. The survey is being conducted as part of an integrated approach to Spectacled Flying-Fox management by fruit growers, researchers, conservation groups and the Queensland Department of Environment.

Bat Fauna of a semi-arid National Park(Idalia) in Central Western Queensland

R.A. Young and G.I. Ford
139 Nardoo St., Toowoomba, Queensland 4250 and
University of Southern Queensland, Toowoomba, Queensland 4250

Even though numerous surveys and reviews of the arid/semi-arid zone fauna have been undertaken, the bat communities have been generally ignored or poorly sampled.

In 1995 a survey was conducted at Idalia National Park, about 85 km west-south-west of the town of Blackall, in the semi-arid zone of Queensland. During the survey 14 species, representing nine genera and four families were recorded. Bats were recorded using bat traps, trip-lines, ultra-sonic call detectors, hand nets and direct observations. A sampling effort of 27 bat trap-nights and 4 tripline-hours over 15 days resulted in 859 captures of nine species. The mean number of bats captured per trap-night was 31.4 with the highest capture success being 273 bats caught in one trap set for one night.

The bat species recorded were: *Pteropus scapulatus*, two unidentified *Mormopterus* species, *Mormopterus beccari?*, *Nyctophilus australis, Taphozous georgianus, Saccolaimus flaviventris, Nyctophilus gouldi, N. geoffroyi, Chalinolobus picatus, C. gouldii, Scotorepens greyii, Vespadelus vulturnus* and *V. finlaysoni?*. The occurrence of the Little Forest Bat *Vespadelus vulturnus* at Idalia represented a northward range extension of about 500 km.

List of Attendees at the 8th Australasian Bat Conference

[all Australia unless noted otherwise]

Taj Abdullah, Dept. of Veterinary Anatomy, University of Queensland, St Lucia, Qld, 4072

Scott Antcliff, University of Western Sydney, Hawkesbury, NSW,

Kyle & Yuki Armstrong, The University of Western Australia Hackett Drive, Nedlands, W.A., 6907

Sylvia Atkinson, Wildlife Volunteers, Sunshine Coast, 13 Currawong St, Mudjimba, Qld, 4564

John Augustyn, Olsen Capricorn Caverns, MSF 250, Rockhampton, Qld, 4702

Barry Baker, Biodiverstiy Group, Environment Australia, GPO Box 636, Canberra, ACT, 2601

Marjorie Beck, Ku-ring-gai Bat Conservation Society, 134 Springdale Rd, Killara, NSW, 2071

Rolf Beck, 134 Springdale Rd, Killara, NSW, 2071

Robert Bender, Friends of Organ Pipes Nature Reserve, 8 Bailey Grove, Ivanhoe, Victoria 3079

Gillian Bennett, Wires, Clarence Valley, PO Box 157, Yamba, NSW, 2464

Patrina Birt, Dept. of Vetenary Anatomy, University of Queensland, St Lucia, Qld, 4027

Nicky Blassius, 9/17 Kemp St., Thornbury, Victoria 3071

Amanda Boardman, F.A.W.N.A. NSW Inc., 3851 Nowenoc Rd, Number One, NSW, 2424

Chris & Lyn Boston, Wildlife Volunteers Sunshine Coast, 29 Cormorant Cres, Peregian Beach, Qld, 4573

Peter Brice, 49 Yacht St, Clotaft, Qld , 4019

Janet Bronk, Orphan Native Animal Rear & Release Programme, 10 Warrambeerab Place, Mudgeeraba, Qld, 4213

Ryan Chick, Arthur Rylah Institute, 123 Brown St,(PO Box 137), Heidelberg, Vic, 3084.

Linda Christensen, Monash University, Clayton Vic. 3168, PO Box 408, Sunbury, Vic, 3429

Jennifer Christie, Zoology Dept., Otago University, C/- 15 Thomas St., Gore, New Zealand

Chris Clague, Vision, Touch & Hearing Research Centre, University of Qld, Brisbane, Qld, 4072

John Clarke, Dept. of Environment, PO Box 3130, Rockhampton Shopping Fair, Rockhampton, Qld, 4700

Cheryl Cochran, Northern Rivers Wildlife Carers, Lychee Drive, Rosebank, NSW, 2480

Roger Coles, Vision, Touch & Hearing Research Centre, University of Qld, Brisbane, Qld, 4072

Linda Collins, Flying Fox Information & Conservation Network, 123 Walker St., Helensburgh, NSW, 2508

Molly Crawford, Wildlife Preservation Society Qld, 6 Nathalie Place, Kinka Beach, Yeppoon, Qld.,4703

Max Cullen, 29 Greenwood Close, Christchurch 8001, New Zealand

Maritca De Oliveira, Dept. of Natural Resources - Forest Wildlife, PO Box 631, Indooroopilly, Qld, 4068

Janette Donovan, 49 Yacht St, Clontarf, Qld, 4019

Angela Duffy, Department of Natural Resources & Environment, 123 Brown St, Heidelberg, Vic, 3084

Peggy Eby, 12 Ashley St, Waverley, NSW, 2024

Tish Ennis, Mammal Section, The Australian Museum, 6 College St, Sydney, NSW, 2000

Hume Field, Animal Research Institute, Qld., Locked Bag 4, Moorooka, Qld, 4105

Ron Firth, 5/1498 North Rd, Clayton, Vic, 3168

Stanley Flavel, Marine Studies Programme, Univ. of The South Pacific, PO Box 1168, Suva, Fiji Islands

Denise Ford, Ku-ring-gai Bat Conservation Society, 79 Peacock St, Seaforth, NSW, 2092

Greg Ford, Univ. Southern Qld, Dept. Biological & Physical Science, PO Box 1744,Toowoomba, Qld, 4350

David Gee, David Gee Bat Consultancies, PO Box 189, Gol Gol, NSW, 2738

Rachel Geisel, University of Queensland, 4 Carnoustie Crt, Karana Downs, Qld, 4306

Helen Gormley, Orphan Native Animal Rear & Release Programme, 362 Montague Rd. West End, Qld, 4101

Henry Grezegorski, 60 Sutherland St, Calliople, Qld, 4551

Michelle Grsegorski, PO Box 7723 Bondi Beach, NSW, 2026

Suzanne Grzegorski, 60 Sutherland St, Calliople, Qld, 4551

Les Hall, Veterinary Pathology & Anatomy University of Queensland, St Lucia, Qld, 4072

Sue Hand, School of Biological ScienceSchool of Biological Science, U.N.S.W. Sydney, NSW, 2052

Katherine Harrison, 93 Wellington Rd, East Limfield, NSW 2070

Elizabeth Hartnell, Ku-ring-gai Bat Conservation Society, 32 Rosedale Rd., Gordon,NSW, 2072

Luke Hogan, Dept. of Natural Resources - Forest Wildlife Section, PO Box 631, Indooroopilly, Qld, 4068

Gillian Holloway, Dept. Biological Science, University Calvary, Calgary, Alberta, T2N IN4, Canada

G. Roy Horst, Postdam College of Sate Unviversity of New York, Postdam, New York, 13676, USA

Lynn Hoskins, Rockhampton Wildlife Rescue Association, 407 Stenhouse St, Nth Rockhampton, Qld, 4701

Peter Howard, Griffith University, AES ESE 2 Building, Natham Campus , Natham, Qld, 4111,

Glenn Hoye, Fly By Night Bat Surveys, PO Box 271, Belmont, NSW, 2280

Margaret Hoye, Fly By Night Bat Surveys, PO Box 271, Belmont, NSW, 2280

Sandy Ingleby, Australian Museum, 6 College St , Sydney, NSW, 2000,

Nancy Irwin, University of Queensland, St Lucia, Brisbane, Queensland, 4072

David Jackson, Environment Australia - Biodiversity Group, PO Box 636, Canberra , ACT, 2601

Simon Jolly, 5 Howitt Court, Werribee, Vic, 3030

Lyn Kearney, Orphan Native Animal Rear & Release Programme, 129 William Rd. Moodlu, Qld,4510

Julene King, WIRES - Sydney, 103 Reedy Rd, Maraylya, NSW, 2765

Richard Knight, Central Queensland University - Biology Dept., 11 Davis St, Rockhampton, Qld, 4700

Lyn Laskus, W.E.A.R.S., 59 Bendee Cres, Blackwater, Qld, 4717

Leanne Law, Rocky Wildlife Rescue Assn., 277 Lakes Cr Rd; Nth Rockhampton, Qld, 4701

Brad Law, State Forests of NSW, PO Box 100 Beecroft, NSW, 2119

Serena Lockwood, Wellington Zoo, Daniel St., Newtown WGTN New Zealand

Helen Luckhoff, Orphan Native Animal Rear & Release Programme, P.O. Box 3015, Darra, Qld, 4076

Dan Lunney, NSW National Parks & Wildlife Service, PO Box 1967, Hurstrill , NSW, 2220

Jackie Maisey, Northern Rivers Wildlife Carers

Nicola Markus, Dept. of Veterinary Pathology and Anatomy, University of Queensland, St. Lucia, Qld, 4072

Charlene Marshall, NSW National Parks & Wildlife Service, PO Box 91, Alstonville, NSW, 2477

Dennis Matthews, Parks & Wildlife, Finke Gorge National Park, PO Box 1046, Alice Springs, NT, 0870

Alison Matthews, NSW National Parks & Wildlife Service, PO Box 1967, Hurstville, NSW, 2220

Mary McCabe, 64 Wentworth Tc,. Rockhampton, Queensland, 4700

Shona McKenzie, Orphan Native Animal Rear & Release Programme, 1781 Mt Cotton Rd Burrank,Qld, 4156

Charles Missi, Keriba Gainau Torres Strait Island Corp N. Territory, 117 Gribbson Place, Malak, NT, 0812

Tony Mitchell, Dept. of Natural Resources & Environment, PO Box 634, Orburst, Vic, 3888

Sheryl Mitchell, Gladstone & District Wildlife Carers Assoc., 3 Berringer Lane, West Gladstone, 4080, Qld

Narelle Montgomery, Biodiverstiy Group, Environment Australia, GPO Box 636, Canberra, ACT, 2601

Brendon Neilly, 1/2 Austin St. Fairlight, NSW, 2094

Annabelle Olsson, FNQ Wildlife Rescue Assoc. Inc., 19 Purbegic Pl, Edge Hill (Cairns) Qld 4870

Nancy Pallin, Ku-ring-gai Bat Conservation Society, PO Box 607, Gordon, NSW, 2072

Chris Pavey, 64 Arafura St. Upper Mt. Gravatt, Brisbane, Qld, 4122

Carol Pountain, Ku-ring-gai Bat Conservation Society, 8 Page Ave, Wahroonga, NSW ,2076

Patrick Prevett, University of Ballarat, PO Box 663, Ballarat, Vic, 3353

Terry Reardon, S.A. Museum, North Terrace, Adelaide, SA, 5000

Linda Reinhold, Dept. of Natural Resources, GPO Box 2454, Brisbane, Qld, 4001

Martin Rhodes, Dept. of Veterinary Pathology and Anatomy, University of Qld, St Lucia, Qld, 4072

Monika Rhodes, 43 Broomfield St, Taringa, Qld, 4068

Greg Richards, Greg Richards & Associates Pty. Ltd., PO Box 3305, Belconnen, ACT, 2617

Graeme Russell, Queensland Dept. of Environment, PO Box 3130, Rockhamton, Qld , 4700

Martin Schulz, Dept. of Natural Resources - Forest Wildlife, PO Box 631, Indooroopilly, Qld, 4068

Jane Sedgeley, University of Otago, Zoology Dept., 7 Kowhai Terrane, Christchurch, New Zealand

Linda Selvey, Queensland Health, GPO Box 48, Brisbane, Qld, 4001

Louise Shilton, School of Biology, University of Leeds,Leeds LS2 9JT, United Kingdom

Jeff Simmons, WPSQ ABS, 361 Rockonio Rd, North Rockhampton, Qld, 4701

Joanne Smissen, Deakin University School of Biological & Chemical Sciences, Geelong, Vic, 3217

Heather Smith, Adelaide Zoo, Frome Rd, Adelaide, SA, 500

Leslie Smith, Rockhampton Wildlife Rescue Ass., 190 Frenchville Road, Rockhampton, Qld, 4700

Chris Smuts-Kennedy, Dept. of Conservation New Zealand, Private Bag 3072, Hamilton, New Zealand

Sonya Stanvic, Wildlife Information Rescue Service, 138 Ridgeway Crs, Valley Heights, NSW, 2777

Lynda Stevenson, 57 Richardson Rd, Raymond Terrace, NSW, 2324

Roscoe Taylor, Central Health Unit - Rockhampton, PO Box 946, Rockhampton, Qld, 4702

Bruce Thomson, Dept. of Environment, PO Box 731, Toowoomba, Qld, 4350

Chris Tidemann, Australian National University, SRMES/Australian National University, ACT, 0200

John Toop, Queensland Dept. of Environment, 150 Gair St, Nt Riton, Qld,

Maree Treadwell/Kerr, Ku-ring-gai Bat Conservation Society, 1A Narelle Ave, Pymble, NSW, 2073

Christopher Turbill, PO Box 745, Coffs Harbour, NSW, 2450

Margaret Turton, 61 Henderson Rd, Wentworth Falls, NSW, 2782

Michael Vardon, Australian National University, PO Box 530, Sauderson, NT, 0810

Dianne Vavryn, 28 Barmoya Rd., The Caves, Rockhampton, Queensland ,4701

Peter Webb, Univ. of Otago, Dept. of Zoology, University of Otago, PO Box 56, Dunedin, New Zealand

Carole West, Wires, Clarence Valley, 18 Neill St, Lawrence, NSW, 2460

Chris White, Pacific Lime, Box 5090, Central Qld Mail Centre, Rockhamptom, Qld, 4702

Olivia Whybird, University of Queensland, PO Box 9, Millaa Millaa, Qld, 4886

Ray Williams, Ecotone Ecological Consultants Pty. Ltd., 10 King St, Mt. Ku-ring-gai, NSW, 2080

Anne Williams, Ecotone Ecological Consultants Pty. Ltd., 10 King St, Mt. Ku-ring-gai, NSW, 2080

Tanya Williams, Ecotone Ecological Consultants Pty. Ltd., 10 King St, Mt. Ku-ring-gai, NSW, 2080

Amy Williams, Ecotone Ecological Consultants Pty. Ltd., 10 King St, Mt. Ku-ring-gai, NSW, 2080

Terry Williams, Pacific Lime, PO Box 5090, Rockhampton, Qld, 4700

Allan Young, 39 Nardoo St, Toowoomba, Qld.,4350

Letters to the Editor

Editor's Note: Unlike technical articles, letters are not peer-reviewed, but they are edited for grammar, style, and clarity. Letters provide an outlet for opinions, speculations, anecdotes, and other interesting observations that, by themselves, may not be sufficient or appropriate for a technical article. Letters should be no longer than two manuscript pages and sent to the Feature Editor.

Observation on the diet of *Myotis ricketti* from Lao PDR: a piscivorous bat

Mark F. Robinson and Maurice Webber
11 Newton Road, Little Shelford, Cambridgeshire, CB2 5HL, U.K.
and 88 Elliott Road, March, Cambridgeshire, PE15 8BP U.K.

It has been speculated that Rickett's big-footed bat, *Myotis ricketti*, eats fish (Allen, 1940, Francis et al., 1996), as do some other large-footed bats, such as *Noctilio leporinus, M. vivesi* (Altenbach, 1989) and *M. adversus* (Robson, 1984); however, this has not been proven. *M. ricketti* is recorded from south, east, and northeast China and Hong Kong (Corbet and Hill, 1992), and, more recently, from Lao PDR (Laos--Francis et al., 1996).

We captured 13 M. ricketti in a recent study (9 January--2 February 1998) investigating the diversity of small mammals, in particular bats, in the Khammouan Limestone National Biodiversity Conservation Area (NBCA), Lao PDR (17°26'-18°05'N, 104°25'-105°10'E). The Khammouan Limestone was one of 18 areas formally declared a NBCA in October 1993, along with an additional 11 recommended areas (Burkmuller et al., 1995). This bat was caught flying at a height of 0.3-0.5 m at two sites that were over slow-flowing open water and at a third site that was over a 10-m diameter pool in a cave entrance. Five droppings were collected from two bats that were held in clean cotton bags following capture. Observations on the droppings using a 10- and 30-power binocular microscope showed that they were comprised of ca. 97% fish scales, with small amounts of insect chitin. Although only a small number of droppings was examined, and clearly more work needs to be done, this suggests that fish is an important constituent of this bat's diet. It may be that in a region with an extended dry season, such as Lao PDR, the distribution of *M. ricketti* is governed by the presence of perennial rivers, streams, and pools. As found in this study, foraging may occur in cave systems, where water, often containing fish, is present year-round. Also, a requirement of "fishing" or "trawling" bats is the need for still or undisturbed slow-flowing water (Jones and Rayner, 1991), and consequently, this could reduce the number of suitable foraging areas further. Clearly this may have implications for the management of riverine systems within the region, if quality feeding areas are to be maintained for this and other species of bats.

We thank WWF-Thailand, the Lao PDR Department of Forestry, and the National Project Director of the Forest Management and Conservation Project (FOMAMCOP) for permission to work in Lao PDR and for organizing the Lao PDR component of the project. This project was funded by the Global Environment Facility through the World Bank to the Lao PDR government, via a contract with Burapha Development Consultants and sub-contracted to WWF-Thailand. We are grateful to A. L. Smith and R. E. Stebbings for help and advice.

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Albinism in *Artibeus intermedius*

Carmen Pozo and J. Enrique Escobedo-Cabrera

El Colegio de la Frontera Sur(ECOSUR), Museo de Zoolría. Zona Ind. No.2, Carr. Chetumal-Bacalar, A.P. 424, C.P. 77000, Chetumal, Q. Roo, Mexico

An albino female *Artibeus intermedius* was collected from a mangrove-coastal dune ecotone at 6 km south of Baca Paila(N 19° 59' 31", W 87° 28' 16") in the state of Quintana Roo in Mexico on March 30,1995. The specimen has totally white pelage, and red iris, the ears and nose leaf were yellowish, the flight membranes and uropatagium were completely white. The veins in the wing were notably red, naked areas were pink, and the nails were white. Measurements taken at time of collection (23:30 hr): head and body length is 75.5 mm, forearm length is 63.2 mm, and weight was 45 grams. It had an open vagina, prominent teats and was lactating at the time of capture. The specimen was prepared as a study skin and skull, deposited in the mammals collection (ECO) of "El Colegio de la Frontera Sur" ECOSUR, with catalog number CH-M0996. We also collected at the same time as this specimen, *Artibeus intermedius, A. jamaicensis, A. lituratus, Centurio senex* and *Dermanura phaeotis.*

Fig. 1 An albino female *Artibeus intermedius* .

The capture locality of this specimen is at the buffer zone of the Biosphere Reserve of Sian Ka'an 100 meters from the coast line. The vegetation is mangrove-coastal dune ecotone in which the main components are *Trinax radiata, Tournefortia gnaphalodes, Suriana maritima, Ambrosia hispida, Rhizophora mangle, Languncularia racemosa, Cordia sebestana, Hymenocallix littoralis, Sesuvium portulacastrum* and *Coccoloba cozumelensis.* According to the bibliography, this is the first case of albinism in the genus

Artibeus. Other cases of total or partial albinism were reported for the genus *Myotis* by Metzger(1956) and Smith (1968); *Pteronotus, Macrotus* and *Demanura* by Sánchez et al (1989); *Rousettus* by Kavim (1983); *Tadarida* by McCoy(1960); *Chaerephon, Molossus, Pipistrellus, Rhinolophus*, and *Eptesicus* by Allen (1939); and *Glossophaga, Antrozous, Myotis, Pipistrellus, Eptesicus, Lasiurus, Chaerephon* and *Molossus* by Setzer (1950).

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A REQUEST FOR ASSISTANCE

I received this communication on June 5, 1998. Perhaps some one of you can respond. GRH

Dear Dr. Horst,

Next year I'm going to investigate selection of summer roosting sites and habitat use by bats in Bialowieza Primeval Forest in north-east Poland. Until now our knowlage about ecology of tree-hole bats here in Poland is very limited. Certainly, the telemetry method for such investigation is the most suitable. Anyway I have to test the method in this season. At present most of the equipment (1 antenna and 1 receiver...) is available, but for this research I need transmitters (0.5-1g)... A. M. Hutson of The Bat Conservation Trust told me that at the recent conference you announce that you have surplus equipment for various field studies, including radiotracking. Perhaps you have some spare transmitters or know people who can endow us with them. If it's possible please contact me. I would be very obliged for any help.

Yours sincerely, Ireneusz Ruczynski, Mammal Research Institute, Polish Academy of Sciences, 17-230 Bialowieza, Poland

my e-mail is: iruczyns@ bison.zbs.bialowieza.pl

I e-mailed explaining that my radiotracking transmitters were designed for tracking mongooses and not appropriate for his use. GRH.

News from our Colleagues

from Wisconsin, U.S.A.

My undergraduate research lab has been interested in bat ontogeny and skeletogenesis coupled with summer field ecology studies. Currently, University of Wisconsin-Whitewater(UWW) student Jason Gieger is working on a project concerning histology of the calcar in *Myotis lucifugus* on the heels of a paper we presented at the 26th Annual North American Symposium on Bat Research suggesting that the proximal end and core of the calcar is composed of calcified cartilage and/or bone. Katherine Thibault, graduate of Boston College is also working on growth and development of the calcar and also continues to work with me in the summers in Colorado on a project funded by the City of Boulder concerning the roost site distribution, foraging ecology and water use patterns of the Front Range bat assemblage (a paper also presented at the 26th annual symposium). Kate spent the last six months down under. Three months involved studying parental care in tropical frogs at a remote field station in Papua New Guinea followed by three months on the southern island of New Zealand studying short- and long-tailed bat ethoecology. Another UWW student Sam Daane will accompany Scott Pedersen and me to the Caribbean island of Montserrat in June 1998 to radio-track and census bats. The Soufriere Hills Volcano has been raging for nearly three years and has destroyed about 50% of the island, much of which was prime bat habitat. We seek to quantify damage to the bat populations by comparison of this year's data with those collected by Pedersen before the eruption. Submitted by Rick Adams e-mail: adamsr@uwwvax.uww.edu

from Papua New Guinea

John Winkelmann and Frank Bonaccorso are undertaking a fifth consecutive field season studying the movements, roost selection,time/energy budgets, habitat requirements, and food habits of small pteropodid bats at the Kau Wildlife Management Area on the north coast of New Guinea. Focal species for the 1998 season are *Macroglossus minimus* (Northern Blossom Bat) and *Dobsonia minor* (Common Naked-backed Fruit Bat). Both species have remarkably small home ranges of from 1-10 hectares within the productive lowland rainforest of Papua New Guinea.

Frank's long promised field guide, Bats of Papua New Guinea. is slated for July 1998 publication by Conservation International in its Tropical Field Guides series. The book features plates with 60 species painted by Fiona Reid, Keys to the species with anatomical illustrations by Stephen Nash, and coverage of all 91 species recognized for Papua New Guinea.

The Papua New Guinea National Museum had the first ever birth of a long-eared flying fox, *Pteropus macrotis*, reported in captivity. The young male born in September 1997 was six months old before fledging. The Museum displays long-eared flying foxes, spectacled flying foxes, and bare-backed fruit bats (*Dobsonia moluccensis*) in a large free-flight mixed species enclosure simulating a lowland rainforest that includes crowned pigeons, several species of parrots and lorries, rails, birds of paradise, short-beaked and long-beaked echidnas.

A major project of the Museum in cooperation with the Department of Conservation and Environment is to map the distribution of fauna and flora of national concern in Papua New Guinea. Frank and Ilaiah Bigilale currently are compiling a database for the bats of Papua New Guinea that will be used to map all know localities by species and predict the distribution of species using the BioClim model previously used in Australia. Submitted by Frank Bonaccorso. e-mail: pngmuseum@global.net.pg

From Arkansas, U.S.A.

On February 19, the third annual meeting of the Southeastern Bat Diversity Network (SBDN)was hosted by the Ouachita National Forest in Hot Springs, Arkansas. This meeting is held in conjunction with the annual Colloquium on the Conservation of Mammals in the Southeastern United States, and actually began as an outgrowth of the colloquium whose attendees typically include a number of bat researchers. This year's meeting was attended by 130 researchers and resource managers from all over the southeast and Oklahoma and Missouri. The primary goals of the SBDN are to share information on methods, equipment and areas of research interests with the ultimate objective of producing management guidelines for bat species of concern. These guidelines are then made available to resource managers and others who have direct responsibility for habitats important to bats. This year's meeting focused on National Forest lands. As our National Forests begin to review and update their Forest Land and Resource

Management Plans, documents regarding management information take on an ever increasing importance. To help familiarize the group with forest Land Management Planning, Dennis Krusac, Endangered Species Specialist in the Regional Office in Atlanta, made a presentation entitled" Bat Conservation on Southern National Forests: Where we've been and where we're going." Dennis has been at the forefront of discussions regarding the Indiana bat and its habitat needs in the southeast and elsewhere, and provided the group with background information. Dan Nolan, Planning and Recreation Team Leader on the Ouachita, then spoke on "Land management planning on Southern National Forests: How to become involved and provide input." Dan provided a step by step discussion on how forest planning works and how bat biologists, or anyone else, may become involved in the crafting of these important documents.

Steve Schumauch gave a report on the activities of Bat Conservation International and the possibilities of an M.O.U. between the SBDN and BCI. Regional priorities regarding those bats in need of attention by the group were discussed by Mary Kay Clark who also presented a progress report on the conservation strategy for *Corynorhinus rafinesquii.*

J. D. Wilhide, Arkansas State University, Tim Carter and Alex Menzel, University of Georgia, and Hill Henry of TVA rounded out the afternoon with informative and entertaining presentations on the positive and negative aspects of using the Anabat Bat Detection system. The next day at the colloquium, 13 of the 22 presentations were on bats.

The 1999 S.B.D.N. meeting will be held in Virginia. For general information about the SBDN contact Mary Kay Clark, State Museum of Natural Sciences, Raleigh, NC 27626-0555(919-715-2599). For specific information about the 1999 meeting contact Don Schwab, Virginia Department of Game and Inland Fisheries, 5806 Mooretown Road, Williamsburg, VA 23188 (575-253-7072.

Submitted by David Saugey, U.S. Forest Service, P. O. Box 189, Jessieville, AR 71945

From New York, USA

This is not the usual item of news that one is accustomed to finding in this space, but rather a plea to any and all of you to help fill this space. I recently did an analysis of our nearly 800 subscribers and found that less than 3% of our subscribers have ever submitted a news item! Since the inception of Bat Research News 40 years ago, the underlying purpose of this publication was to provide communication with our peers in bat research about our activities. If the number of news items that reach me for each issue is any indication of the success of that purpose, then Bat Research News has failed.

I have recently completed my second decade as Editor and Publisher of Bat Research News and scarcely an issue goes by without a plea from me "send me some news!" This is not only just a bit embarrassing but also very discouraging for me and my associate editors. I find it especially peculiar that there many among us who are recognized around the world as leaders on issues related to research, conservation, education and public relations concerning bats. Yet only a very few of these "leaders" in our field have provided any kind of news about their activities. I have recently had a very good undergraduate tell me that she looked through all my issues of BRN only to inform me that, "there is almost nothing about the programs or the people I am interested in working with!" Here is a great (and free) opportunity to promote your programs, yet you are not taking advantage of it. I also receive responses from many of you who tell me that you are not "a big time academic researcher" and don't have anything interesting to report. You would be surprised by how many people are very interested in your activities or observations. Those of you in the areas of education programs about bats, whether it be in public schools, or for the general public, are surely doing things that would help and encourage the rest of us who are sometimes desperate to come up with new ideas to try in this vastly important part of our mission.

I am dedicated to rejuvenate and improve the **News** section and propose the following. With the summer issue of Bat Research News will be invitations to 50 of our subscribers from around the world, chosen at random, asking you to send an item of news in time for Volume 39: No. 3, the autumn issue, which will go to press sometime in late September. If you respond, your name will be removed from the "lottery", and you will receive the gratitude of our readers and especially from me. If you really don't have anything you consider newsworthy, then send me a note telling me that you're still interested. It would cheer me up immensely. Remember you can e-mail it to me. horstgr@potsdam.edu

If we cannot improve the **news** section of *Bat Research* ***NEWS,*** perhaps we should change our name.

Gratefully yours, G. Roy Horst, Publisher, ***Bat Research News***

Book Review

A field guide to the mammals of Central America and southeast Mexico.
Reid, F.A. 1997. Oxford University Press, New York.

This book is the very best news for anyone who is going to Central America and southeast Mexico to view or work with mammals. As a field biologist I cannot imagine a more important part of my field equipment than a really good field guide. Well, Fiona Reid's book is not just a "really good" field guide, it's excellent. Now I will explain why I hold this view.

In February 1998 I was doing field work with bats in the northeastern corner of Costa Rica. As usual, I had prepared a checklist of the bats we might encounter and a key for identifying them. But, more importantly one of our group brought along a copy of Fiona's book. Waiting for the flight to leave I was drawn to the illustrations and from there to the species accounts and the range maps. During the flight I spent a good deal of time in the bat section where 136 species are described and most of them illustrated. I wondered about artistic licence when I looked at the picture of the emballonurid *Centronycteris maximilliani*, particularly the depiction of its ear.

Two nights later I watched as one of my colleagues handled a small brownish-coloured bat just removed from a mist net and asked to have a closer look at it. I recognized the ear right away ... *Centronycteris*. My question about artistic licence was answered ... none had been used. The illustrations in the book circumvented the need for the key. Later in the trip we caught a large phyllostomine that I had omitted from the checklist and the key. The book came to the rescue ... it was *Phylloderma stenops*, another new bat for me. Whether it was one of the small stenodermines or one of the glossophagines, the book provided invaluable text and illustrations which facilitated our field identifications.

Over the course of the trip, I had occasion to use the book to identify some monkeys as well as a Tayra ... in each case the illustration and the text, coupled with the range map, made it "easy" to be sure of one's identifications.

There are 48 colour plates in the book which provides a detailed account (measurements, diagnostic features and behaviour) for 346 species of mammals. The range maps are very well done and more general maps show basic habitat types as well as political boundaries. The book provides a current view of the classification of the mammals, including, for example, *Micronycteris microtis*, previously known from the area as *Micronycteris megalotis*. There are a many citations providing the reader with access to background material, and a wealth of suggestions about where one can go to see different species.

I highly recommend this book to anyone who is interested in the mammals of Central America. The coverage is simply outstanding!

M.B. Fenton, Department of Biology, York University, North York, Ontario, M3J 1P3, Canada.

The 8th European Bat Research Symposium

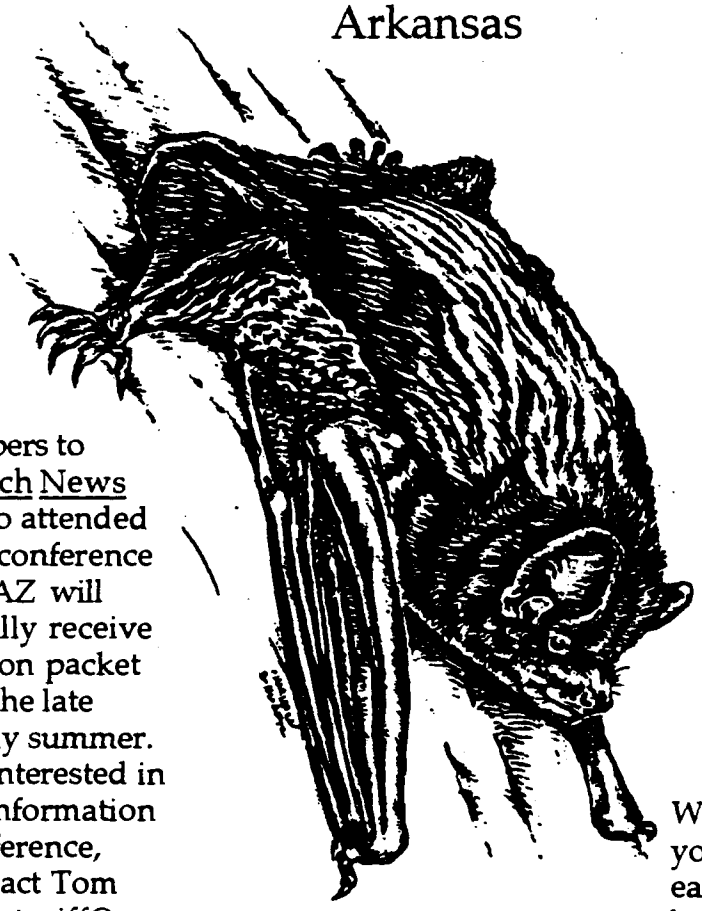
The symposium will be held August 23-27, 1999 in Kraków, Poland. The program will include plenary sessions, contributed papers and posters. Bat-detector workshops are also being planned. For additional information contact the conference host: Bronislaw W. Wolozyn, Chiropteran Information Center, Insitiute of animal systematics and Evolution, Polish Academy of sciences, ul. Slawkowska 17, 31-016 Kraków, Poland.

tel: +48-12-4226410, fax: +48-12-4224294, e-mail: VIIIEBRS@isez.pan.krakow.pl

Additional announcements and information concerning this symposium will appear in subsequent issues of Bat Research News

The 28th Annual North American Symposium on Bat Research

will be held October 28-31, 1998 in Hot Springs, Arkansas



All subscribers to Bat Research News and all who attended last year's conference in Tucson, AZ will automatically receive a registration packet by mail in the late spring/early summer. All others interested in receiving information on the conference, please contact Tom Griffiths at tgriff@titan.iwu.edu or 309-556-3230.

Hot Springs is beautiful in October, and we anticipate a large turnout!

Conference Logo: Silver-haired bat *Lasionycteris noctivagans* from "The Wild Mammals of Missouri," and courtesy of Dr. Elizabeth Schwartz and Univ. of Missouri Press

We recommend that you reserve a room early at the conference hotel: **The Arlington Resort Hotel (1-800-626-9768 or 1-800-643-1502 or 501-623-7771).** Tell them you are with the North American Symposium on Bat Research.

Conference Host: David A. Saugey, U. S. Forest Service, Jessieville AR
Program Director: Tom Griffiths, Illinois Wesleyan U., Bloomington, IL

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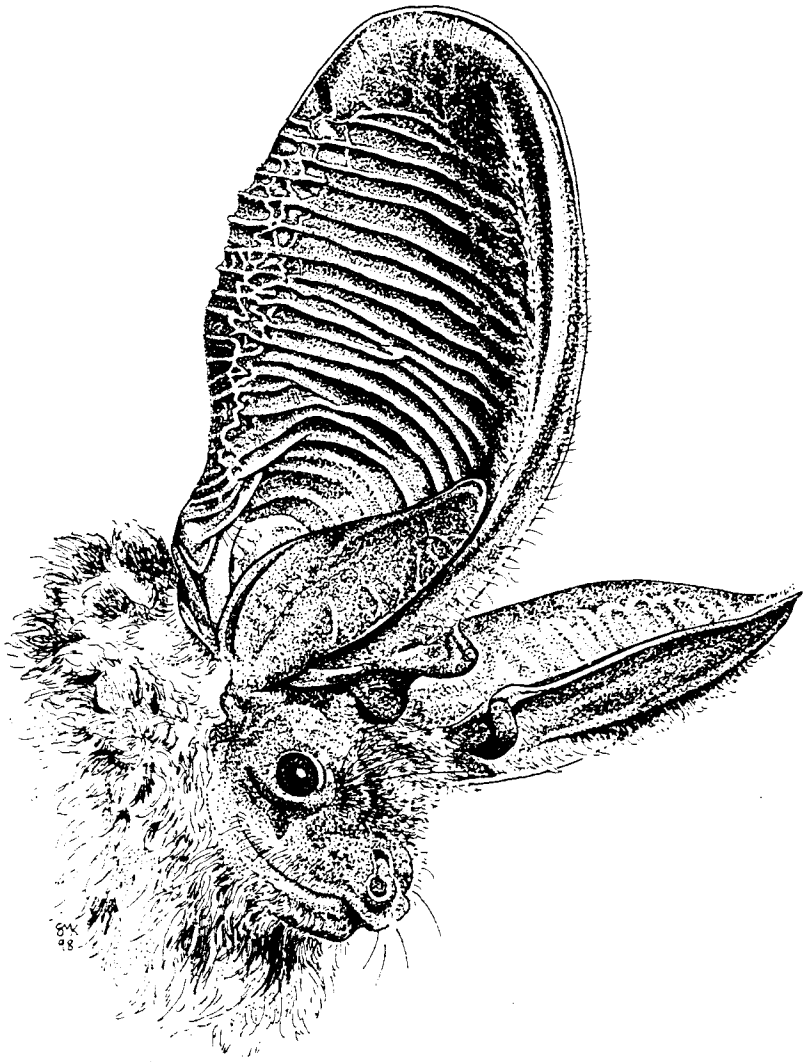
There is no recent literature section in this issue, but we promise you an expansive section in the next issue.

Front Cover

The illustration on the front cover of this issue the front cover of the 8th Australasian Bat Conference program and proceedings.

We are always looking for high quality line drawings for our front covers; if you have some good "bat-art" that you would like to share with us please send me a copy and I will contact you at the earliest opportunity. GRH

BAT RESEARCH NEWS



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BAT RESEARCH NEWS

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Publisher and Managing Editor
G. Roy Horst
Bat Research News, P.O. Box 5068, Potsdam,NY 13676
Tel. 315-267-2259 FAX 315-267-3170 E-mail: horstgr@potsdam.edu.

Editor for Feature Articles
Allen Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197
Tel. 734-487-1174 FAX 734-487-9235 E-mail: bio_kurta@online.emich.edu

Editor for Recent Literature
Thomas A. Griffiths, Department of Biology, Illinois Wesleyan University, Bloomington, IL 61702
Tel. 309-536-3230 FAX 309-536-3411 E-mail: tgriff@titan.iwu.edu

Editor for Conservation Education
Patricia Morton, Texas Parks and Wildlife Department, Suite 100, 3000 IH 35 South, Austin, TX 78704
Tel. 512-912-7046 FAX 512-912-7058 E-mail: patricia.morton@tpwd.state.tx.us

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E-mail Directory for Bat Biologists

The following e-mail directory has been compiled from several sources including registration at conferences. The prime source for addresses has been individual submission of e-mail numbers by the addressee. If you do not wish to be included in the directory please notify me to that effect and I will remove your name from the next version.

If your e-mail number is incorrect or has been changed please send your correction to me via e-mail to horstgr@potsdam.edu

Thank you for your assistance, G. Roy Horst

name	e-mail #	country
Abdullah, Taj	tabdullha@zoology.uq.edu.au	Australia
Adam, Michael	adamm@ccmail.orst.edu	USA, (Oregon)
Adams, Rick	adamsr@uwwvax.uww.edu	USA, (Wisconsin)
Agoramoorthy, G.	moorthy@mail.npust.edu.tw	Tiawan
Aguiar, Ludmilla	laguiar@guarany.unb.br	Brazil
Aguirre, Luis F.	coroagui@caoba.entelnet.bo	Bolivia
Ahlen, Ingemar	Ingemar.Ahlen@nvb.slu.se	Sweden
Albuja, Luis	lalbuja@SIS.POLI.EDU.EC	Equador
Almeida, Marilene Fernandez de	mfde_alm@uol.co.br	Brazil
Altenbach, Scott	batmine@unm.edu	USA, (New Mexico)
Ammerman, Loren	loren@uta.edu.	USA, (Texas)
Anderka, Fred	holohil@logisys.com	Canada, (Ontario)
Anderson, Kenneth W.	andersen001@mail1.gannon.edu.	USA, (Pennsylvania)
Andrews, Peter	pandrews@hep.ph.liv.ac.uk	United Kingdom
Anthony, Edythe	Eanthony@grog.ric.edu	USA, (Rhode Island)
Arita, Hector	arita@ate.oikos.unam.mx	Mexico
Arlettez, Raphael (1)	raphael.arlettaz@izea.unil.ch	Switzerland
Arlettez, Raphael (2)	rarletta@ulys.unil.ch	Switzerland
Armstrong, David M.	armstrod@stripe.colorado.edu	USA, (Colorado)
Armstrong, Kyle	kyle@cyllene.uwa.edu.au	Australia
Arnold, Andreas	arnold.a@metronet.de	Germany
Arroyo-Cabrales, Joaquin	arroyo@cervide.reduaeh.mx	Mexico
Atkinson, Sylvia	80kinsos@health.qld.gov.au	Australia
Augee, Michael	m.augee@unsw.edu.au	Australia
August, Peter	pete@edc.uri.ed	USA,(Massachusetts)

name	e-mail #	country
Aulagnier, Stephane	aulagnie@teleirgm.toulouse.inra.fr	France
Avilla, Leonardo S.	lavilla@sv.compuland.com.bre	Brazil
Azzali, Giacomo	anatnor@ipruniv.cce.unipr.it	Italy
Baagøe, Hans	hibaagoe@zmuc.lu.dk	Denmark
Baker, Barry	barry.baker@ea.gov.au	Australia
Baker, Robert J.	BSRJB@Ttacsl.ttu.edu	USA, (Texas)
Baker, Rollin	rbaker@elc.net.	USA, (Texas)
Baker, Suzzane C.	bakersc@jmu.edu	???
Baldino, Cristi	cbaldino@concentric.net	USA, (California)
Banack, Sandra	sabanack@acd1.byu.edu	USA, (California)
Banks, Don	donbanks@magnolia.net>	USA, (Missiissippi)
Baptista, Tony	96tlb@whatonma.edu	???
Barber, Diana	Diana.Barber@QMS1.life..uiuc.edu	USA, (Illinois)
Barbosa, Pat	wildlife@epix.net	USA; (Pennsylvania)
Barclay, Robert	barclay@acs.ucalgary.ca	Canada, (Alberta)
Barlow, Kate	k.barlow@bristol.ac.uk	United Kingdom
Barnard, Sue	pszoode@prism.gatech.edu	USA, (Georgia)
Baron, George	barong@ere.umontreal.ca	Canada, (Quebec)
Barratt, Elizabeth	suaaemb@UCL.AC.UK	United Kingdom
Bassett, John	microman@U.WASHINGTON.EDU	USA, (Washington)
Bat Conservaion of Michigan	76011.663@compuserve.com	USA, (Michigan)
Bat Conservation International	batinfo@batcon.org.	USA, (Texas)
Bat House	bathouse@altnews.com.au	Australia
Bat World	batworld@aol.com	???
Battersby, Jessa	j.e.battersby@sussex.ac.uk	United Kingdom
Baumgarten, Julio	morcegos@bitsnet.com.br	Brazil
Beck, Rolf	Rolf.Beck@unsw.edu.au	Australia
Bell, Mitchell	ageo@aol.com	USA, (Florida)
Belwood, Jackie	OhioBats@aol.com	USA, (Ohio)
Bender, Robert	robertb@angliss.vic.edu.au	Australia
Bergmans, Wim (1)	bergmans@nciucn.nl	Netherlands
Bergmans, Wim (2)	mail@nciucn.nl	Netherlands
Bernard, Henrico	ebernard@inpa.gov.br	Brazil
Bernard, R.T.F.	ZORB@warthog.ru.ac.za	South Africa
Bernard, Richard	zorb@kudu.ru.ac.za	South Africa
Betts, Burr	bbetts@eou.edu	USA, (Oregon)
Bhatnagar, Kunwar	kpbhat01@ulkyvm.louisville.edu	USA, (Kentucky)
Bhiwgade, Dayanand	biwgade@life.bu.net.in	India
Bihari, Zoltan	bihari@fs2.date.hu	Hungary
Birney, Elmer C.	ecbirney@biosci.cbs.umn.edu	USA, (Minnesota)
Birt, Patrina	s023082@student.uq.edu.au	Australia
Blanchette, Richard	richblan@hotmail.com	Canada, (Quebec)
Blencoe, Eric	eurobats@uno.de	Germany
Bleveans, Luanna B.	luannab@galenalink.com	USA, (Illinois)
Bloss, Joanna	jbloss@bio.bu.edu	USA, (Massachusetts)

name	e-mail #	country
Boada-Teran, Carlos Esteban	vsFlores@gaurany.unb.br	Brazil
Bodvinkin, Alexander	irina@ptichi.irkutsk.su	Russia
Bogan, Michael	mbogan@mail.unm.edu	USA, (New Mexico)
Bogdanowicz, Wieslaw	wieslaw@bison.zbs.bialowieza.pl	Poland
Bohn, Kirsten M.	bohnkirs@cwis.isu.edu	USA, (Idaho)
Bolster, Betsy C.	BBolster@compuserve.com	USA, (California)
Boughman, Janette	boughman@zoology.ubc.ca	Canada, (Brit.Col.)
Bounds, Dixie Louise	dbounds@umes-bird.umd.edu	USA, (Maryland)
Bowles, John	bowlesjb@aol.com	USA, (Texas)
Brandon, Carl	cbrandon@vtc.vsc.edu	USA, (Vermont)
Braun, Monika	100734.361@compuserve.com	Germany
Brigham, R. Mark	mark.brigham@uregina.ca	Canada, (Sask.)
Brito, Bernardo	bbrito@guarany.unb.br	Brazil
Britton, Adam	BZARCB@SSA.BRISTOL.AC.UK	United Kingdom
Brooke, Anne P.	abrooke@nh.ultranet.com	USA, (New Hampshire)
Brown, Caroline Bourque	7351.1773@compuserv	USA, (California)
Brown, Nikolle	black-catnik@worldnet.att.net	USA, (California)
Brown, Patricia	PATBOBBAT@AOL.COM	USA, (California)
Bumeururgsri, Sara	bsara@ratree.psu.ac.th.	Thailand
Bunch, Bill and Mary	billandmary@alltel.net	USA, (?)
Bunch, M. Strayer	MSTRAYER@InfoAve.net	USA, (Georgia)
Burke, Harold S.	burke_short@fuse.net	USA, (Kentucky)
Burland, Tamsin	suaatmb@ucl.ac.uk	United Kingdom
Burneo, Santiago	sburneo@uio.satnet.net	Equador
Burnett, Stephen C.	burnett.33@osu.edu	USA, (Ohio)
Buzato, Silvana	sbuzato@ib.usp.br	Brazil
Byrnes, Deanna	dpbyrnes@students.wisc.edu	USA, (Wisconsin)
Cabrera, Theresa	tcabrera@zoogate.zoo.hawaii.edu	USA, (Hawaii)
Caceres, Carolina	mccacere@acs.ucalgary.ca	Canada, (Alberta)
Cadena, Alberto	acadena@ciencias.ciencias.unal.edu.co	Columbia
Caetano Junior, Jorge	icaetnao@tba.com.br	Brazil
Cairns, Sara	SCAIRNS@MIDD.CC.MIDDLEBURY.EDU	USA, (Vermont)
Campbell, Karen	karenc@joe.alb.edu	USA, (Pennsylvania)
Campbell, Lori A.	lacampbell@ucdavis.edu	USA, (California)
Carpenter, Roger	eidolon@pop.azstarnet.com	USA, (California)
Carter, Timothy	TCC4454@owl.forestry.uga.edu	USA, (Georgia)
Cartwright, Anne	cartwrig@eos.net	USA, (Ohio)
Casseday, John H.	casseday@u.washington.edu	USA, (Washington)
Catto, Colin	Gatcontrust@qr.apc.org	United Kingdom
Cavelier, Jaime	jcavelie@cdcnet.uniandes.edu.co	???
Chapman, Brian R.	chapman@smokey.forestry.uga.edu	USA, (Georgia)
Chapman, Sandra S.	schapman@smokey.forestry.uga.edu	USA, (Georgia)
Chelsvig, Jim	jchelsvig@aol.com.	???
Chick, Ryan	r.chick@dce.vic.gov.au	Australia
Choate, Jerry	BIJC@FHSUVM.FHSU.EDU	USA, (Kansas)

name	e-mail #	country
Christensen, Linda	Linda.Christensen@sci.monash.edu.au	Australia
Chung-Maccoubrey, Alice	Alice.Chung-MacCoubrey/rmrs_albq@fs.fed.us	USA, (NM)
Churchill, Sue	bilge-rat@msn.com	Australia
Clague, Chris	Phoniscus@internetnorth.com.au	Australia
Clark, Brenda	bsclark@sosu.edu	USA, (Oklahoma)
Clark, Don	drclark@tamu.edu	USA, (Texas)
Clark, Mary Kay	mkclark141@aol.com	USA, (North Carolina)
Clarke, John	John.Clarke@env.qld.gov.au	Australia
Clawson, Rick	clawsr@mail.conservation.state.mo.us	USA, (Missouri)
Coen, Claudia	cec6@cornell.edu	USA, (New York)
Coleman, Brent	BLC32@email.byu.edu	USA, (Utah)
Coles, Roger	R.Coles@vthrc.uq.edu.au	Australia
Collins, Linda	LindaCollins@bigpond.com.au	Australia
Comeaux, Lisa	comeaux@utkux.utcc.utk.edu	USA, (Tennessee)
Corben, Chris	corben@delphi.com	USA, (?)
Cosson, Jean Francois	cosson@roazhon.inra.fr	France
Costa, Deborah Peres de	debpc@hotmail.com	Brazil
Covey, Ellen	ecovey@u.washington.edu	USA, (Washington)
Crampton, Lisa	lcrampto@acs.ucalgary.ca	Canada, (Alberta)
Cross, Steve	scross@sou.edu	USA, (Oregon)
Cruz-Neto, Ariovaldo P.	neto@life.ibrc.unesp.br	Brazil
Cryan, Paul	pcryan@UNM.EDU	USA, (New Mexico)
Cullen, Max	zephyr@southlights.gen.nz	New Zealand
Currie, Robert	RRCurie@aol.com	USA, (?)
Czaplewski, Nick	nczaplewski@ou.edu	USA, (Oklahoma)
Dalton, Virginia [Ginny]	Plecotus@aol.com	USA, (Arizona)
Davidson, Susan	susand@umich.edu	USA, (Michigan)
Davis, Kathy	tegan@ozemail.com.au	Australia
De Oliveira, Maritca	deolivm@dnr.qld.gov.au	Australia
Delahaye, Laurence	delahaye.l@fsagx.ac.be	Belgium
Dempsey, Janet L.	dempsey@stlzoo.org	USA, (Missouri)
Denault, Lisa K.	ldenault@iastate.edu	USA, (Iowa)
Denzinger, Annette	annette.denzinger@uni-tuebingen.de	Germany
Desch, Clifford	desch@uconnvm.uconn.edu	USA, (Connecticut)
Dickson, Jenny	jcizik@snet.net	USA, (Connecticut)
DiSalvo, Arthur F.	afdisalvo@juno.com	USA, (Neveda)
Ditchfield, Albert D.	trachops@amnh.org	USA, (New York)
Dobbyn, Jon(Sandy)	sdobbyn@bmts.com	???
Druecker, Jay	jdruecker@csc1.csc.edu	USA, (Nebraska)
Duffy, Angela	A.Duffy@nre.vic.gov.au	Australia
Dumont, Betsy	erd@riker.neoucom.edu	USA, (Ohio)
Dunlop, Jenna	YFSC0115@VM1.YORKU.CA	Canada, (Ontario)
Dunning, Dorothy	dunning@wvnvm.wvnet.edu	USA, (West Virginia)
Duvergé, Paul Laurent	L.Duverge@BRIS.AC.UK	United Kingdom
Dybek, Andre	uzs058@ibm.rhrz.uni-bonn.ck	Czech Republic

name	e-mail #	country
Eby, Peggy	peby@ozemail.com.au	Australia
Egar, Judith	judithe@rom.on.ca	Canada, (Ontario)
Elliot, Paul	serae@cvs.warwick.ac.uk	United Kingdom
Ellis, Susan	sellis@jersey.net	USA, (New Jersey)
England, Angela	aengland@batcon.org	USA, (Texas)
Ennis, Tish	tishe@amsg.austmus.gov.au	Australia
Entwistle, Abigail	a.entwistle@abdn.ac.uk	United Kingdom
Erkinaro, Mikko Johannes	mjerkina@cc.jyu.fi	Finland
Esberard, Carlos E.	celesb@uol.com.be	Brazil
Eskow, Jessica	Jessica_Eskowj@champint.com	???
Esser, Karl-Heinz	kalle.esser@biologie.uni-ulm.de	Germany
Fabian, Marta Elena	mfabian@vortex.ugrs.br	Brazil
Faria, Deborah	morcegos@bitsnet.com.br	Brazil
Fascione, Nina	nfascio@defenders.orgne	USA, (Maryland)
Fauna and Flora International	info@fauna-flora.org	???
Faure, Paul A.	paf2@cornell.edu	USA, (New York)
Fellers, Gary	gary_fellers@nbs.gov	USA, (California)
Fenton, M. Brock	bfenton@monkey.circus.yorku.ca	Canada, (Ontario)
Field, Hume	fieldh@prose.dpi.qld.gov.au	Australia
Finn, Laura S.	lsfinn@aol.com	USA, (Florida)
Firth, Ron	Ronald.Firth@sci.monash.ed.au	Australia
Fischer, Erich A.	efischer@nin.ufms.br	Brazil
Flavel, Stanley	Flavel_S@usp.ac.fj	Fiji
Fleming, Ted	tfleming@umiami	USA, (Florida)
Floyd, Randy	rfloyd@teleport.com	USA, (Oregon)
Forbes, Peter	prforbes/r6pnw_wenatchee@fs.fed.us	???
Ford, Greg	gford@mail.connect.usq.edu.au	Australia
Forman, Larry	GFORMAN@ROCKFORD.edu	USA, (Illinois)
Francis, Charles	cfrancis@bsc-eoc.org	Canada, (Ontario)
Freeman, Patricia	pfreeman@UNLINFO.UNL.EDU	USA, (Nebraska)
Fuhrmann, Malte	FUHRMANN.BGNATUR@T-ONLINE.DE	Germany
Fullard, James	jfullard@credit.erin.utoronto.ca	Canada, (Ontario)
Funakoshi, Kimitake	funakoshi@kkis.ac.jp	Japan
Gaisler, Jiri	gaisler@sci.muni.cz	Czech Republic
Gannon, Michael	mrg5@psuvm.psu.edu	USA, (Pennsylvania)
Gannon, William	wgannon@unm.edu	USA, (New Mexico)
Gardner, Alfred	GARDNER.ALFRED@NMNH.SI.EDU	USA, (Wash.D.C.)
Gee, David	dgee@mildura.net.au	Australia
Geisel, Rachel	R.Geisel@uq.edu.au	Australia
Geluso, Kenneth	kngeluso@cwis.unomaha.edu	USA, (Nebraska)
Gerell, Rune	rune.gerell@swipnet.se	Sweden
Giannini, Norberto	pidba@upida.satlink.net	Argentina
Giovengo, Karen	keren_giovengo@mail.fws.gov	USA, (?)
Glick-Bauer, Marian	MABMGB@aol.com	USA, (New York)
Godawa, Joanne	negodawa@cyf-kr.edu.pl	Poland

name	e-mail #	country
Gonzalez Bordon, Gloria	teju-cites@sce.cnc.una.py	Paraguay
Gordon, Lori	bcllg@ttacs.ttu.edu	USA, (Texas)
Gordon, Thomas	trux1964@life.bio.sunysb.edu	USA, (New York)
Gore, Jeffrey A.	GoreJ@gfc.state.fl.us	USA, (Florida)
Gornstein, Eric	egorn@acs.bu.edu	USA, (Massachusetts)
Gould, Edwin	edgould@erols.com	USA, (Wash.D.C.)
Graciolli, Gustavo	mingua@garoupa.bio.ufpr.br	Brazil
Graves, Shannon M.	smgraves@aol.com	USA, (Georgia)
Greg Richards & Assoc. Pty. Ltd	batman@atrax.net.au	Australia
Griffin, Donald R.	cfs@oeb.harvard.edu	USA, (Massachusetts)
Griffiths, Thomas	tgriff@titan.iwu.edu	USA, (Illinois)
Grsegorski, Michelle	minkystar@hotmail.com	Australia
Gustafson, Alvar	AGustafson@infonet.tufts.edu	USA, (Massachusetts)
Güttinger, René	rene.guettinger@bluewin.ch	Switzerland
Habersetzer, Joerg	jhaberse@sng.uni-frankfurt.de	Germany
Hall, John	jlahall@aol.com	USA, (Pennsylvania)
Hall, Leslie S.	l.hall@mailbox.uq.edu.au	Australia
Hamilton, Ian	inhamilt@acs.ucalgary.ca	Canada, (Alberta)
Hand, Suzzane	s.hand@unsw.edu.au	Australia
Handley, Charles	mnhvz036@sivm.si.edu.	USA, (Wash.D.C.)
Haraden, Tom	Tom_Haraden@nps.gov	USA, (Utah)
Harris, Arthur H.	AI01%utep.bitnet@utepvm.ep.utexas.edu	USA, (Texas)
Hart, James A.	JAHART@ARK.Ship.edu.	USA, (Pennsylvania)
Harvey, Michael, J.	mharvey@tntech.edu	USA, (Tennessee)
Haukkovaara, Olli (1)	olli.haukkovaara@vlk.fi	Finland
Haukkovaara, Olli (2)	olhaukko@freenet.hut.fi	Finland
Hayes, John P.	hayesj@fsl.orst.edu	USA, (Oregon)
Hayes, Robin L.	76011.663@compuserve.com	USA, (Michigan)
Hayssen, Virginia	vhayssen@science.smith.edu).	USA, (Massachusetts)
Hazam, Bruce	bhazam@ACS.BU.EDU	???
Heffner, Ricky	FAC2623@UOFT01	USA, (Ohio)
Heideman, Paul D.	pdheid@facstaff.wm.edu	USA, (Virginia
Heller, Klaus-Gerhard	kheller@biologie.uni-erlangen.de	Germany
Helverson, Otto	helver@biologie.uni-erlangen.de	Germany
Hendricks, William	myotis@ldd.net	USA, (Kentucky)
Henricks, Jolie	BattyCat@aol.com	USA, (Oregon)
Henry, Travis H.	thhenry@tva.gov	USA, (Tennessee)
Henson, O.W.(Bill)	owh@med.unc.edu	USA, (North Carolina)
Hermanson, John	jwh6@cornell.edu	USA, (New York)
Hernandes, Alessandra Rosado	alexbats@music.pucrs.br	Brazil
Hickey, M. Brian C.	bats@glen-net.ca	Canada, (Ontario)
Hill, David A.	d.a.hill@sussex.ac.uk	United Kingdom
Hillman, Adrian	almauric@infonews.co.th	Thailand
Hitoshi Murai	rumbat@tym.fitweb.or.jp	Japan
Hoagland, Buzz	bhoagland@foma.wsc.mass.edu	USA, (Massachusetts)

name	e-mail #	country
Hogan, Bronwyn	bchogan@ucdavis.edu	USA, (California)
Hogan, Luke	hoganl@dnr.qld.gov.au	Australia
Holland, Julian N.	jholland@fig.cox.maimi.edu	USA, (Florida)
Holloway, Gillian	ghollowa@acs.ucalgany.ca	Canada, (Alberta)
Holohil Electronics	holohil@logisys.com	Canada, (Ontario)
Holroyd, Jeffrey L.	gholroyd@compusmart.ab.ca	Canada, (Alberta)
Horner, Margaret	peggy.horner@tpwd.state.tx.us	USA, (Texas)
Horst, G. Roy	horstgr@potsdam.edu	USA, (New York)
Hosken, David	hosken@zoolmus.unich.ch	Switzerland
Houck, Becky	houck@uofport.edu	USA, (Oregon)
Howard, Peter	P.Howard@ens.qu.edu.au	Australia
Howell, Daryl	dhowell@max.state.ia.us	USA, (Iowa)
Hoye, Glenn	bigah@CCNewcastle.edu.au	Australia
Hoye, Margaret	bigah@CCNewcastle.edu.au	Australia
Hsu, Minna J. (1)	hsumin@cc.nsysu.edu.tw	Taiwan
Hsu, Minna J. (2)	hsumin@mail.nsysu.edu.tw	Taiwan
Hubbell, Joselyn	hubblej%cherryvale@boulder.lib.co.us	USA, (Colorado)
Humes, Marcia	humesm@CCMAIL.ORST.EDU	USA, (Oregon)
Hutcheon, James	hutcheon@students.wisc.edu	USA, (Wisconsin)
Hutchinson, Jeff	jthutc0@ukcc.uky.edu	USA, (Kentucky)
Hutson, Tony	thutson@bats.org.uk	United Kingdom
Ingle, Nina R.	nri2@cornell.edu	Phillipines
Ingleby, Sandy	Sandyi@amsg.austmus.gov.au	Australia
Irvine, Robert	robert.irvine@asc.gov.au	Australia
Irwin, Nancy	uoinri@abdn.ac.uk	United Kingdom
Iudica, Carlos	casaiud@flmnh.ufl.edu	USA, (Florida)
Ivanova, Teodora	Rabbits@main.infotel.bg	Bulgaria
Jackson, David	david.jackson@ea.gov.au	Australia
Jacobs, David	djacobs@botzoo.uct.ac.za	South Africa
Jarzembowski, Tomasz	doktj@univ.gda.pl	Poland
Johnson, Heather	sac27916@saclink.csus.edu	USA, (California)
Johnston, David	djohnston8@AOL.com	USA, (California)
Johnston, Georgann B.	gbatty@ix.netcom.com	USA, (California)
Jolly, Simon	JOLLYS@OZEMAIL.COM.AU	Australia
Jones, Gareth	Gareth.Jones@bristol.ac.uk	United Kingdom
Jones, Kate	katherin@MAX.ROEHAMPTON.AC.UK	United Kingdom
Juedes, Ulrich	buw@ipn.uni-kiel.de	Germany
Juste, Javier	BCJJB@ttacs.ttu.edu	USA, (Texas)
Kaipf, Ingrid	ingrid.kaipf@uni-tuebingen.de	Germany
Kalko, Elizabeth	elisabeth.kalko@uni-tuebingen.de	Germany
Kasper, Stephen	Y6KAS@ttacs.ttu.edu	USA, (Texas)
Kath, Joe	jkath@dnrmail.state.il.us	USA, (Illinois)
Kazial, Karry	kazial.1@osu.edu	USA, (Ohio)
Keegan, D. J.	djk@mweb.co.za	South Africa
Keeley, Brian	bkeeley@batcon.org	???

name	e-mail #	country
Kern, William	whk@gnv.ifas.ufl.edu	USA, (Florida)
Khabilov, Tolibjon	tolib@khgu.khj.td.silk.org	Tajikistan
Kilburn, Kerry	KILBURN@WVSVAX.WVNET.EDU	USA, (West Virginia)
Kilpatrick, Wm. C.	wkilpatr@moose.uvm.edu.	USA, (Vermont)
Kindermann, Darlene	dkinderm@hornet.livnet.edu	USA, (New York)
King, Kerensa	KerensaK@premier1.net;	USA, (Washington)
King, Mark	Mark.a.King@me.state.us	USA, (Maine)
Kirkland, Gordon	glkirk@ark.ship.edu	USA, (Pennsylvania)
Kirkpatrick, Ralph D.	Osagekirk@aol.com	USA, (Indiana)
Kirsch, John	wuzm@macc.wisc.edu	USA, (Wisconsin)
Kiser, M.	mkiser@batcon.org	USA, (Texas)
Klinghammer, Kirsten	klingham@SAGE.CC.PURDUE.EDU	USA, (Indiana)
Knight, Richard	r.Knight@cqu.edu.au	Australia
Krishna, Amitabh	akrishna@banaras.ernet.in	India
Krutzsch, Philip H.	krutzsch@aruba.ccit.arizona.edu	USA, (Arizona)
Kunz, Thomas H.	kunz@bu.edu	USA, (Massachusetts)
Kurta, Allen	bio_kurta@online.emich.edu	USA, (Michigan)
Kurta, Allen	bio_kurta@online.emich.edu	USA, (Michigan)
Kwiecinski, Gray G.	GGK301@UOFS.edu	USA, (Pennsylvania)
Laborda, Jeffrey	lslabord@scifac.indstate.edu	USA, (Indiana)
Lacki, Michael	mlacki@pop.uky.edu	USA, (Kentucky)
Lancaster, Winston	w.lancaster@liszt.zool.gu.se	Sweden
Larsen, Eric	LARSEEML@dfw.wa.gov	USA, (Washington)
LaVal, Richard	rlaval@sol.racsa.co.cr	Costa Rica
Law, Brad	bradl@ironbark.forest.nsw.gov.au	Australia
Layne, James N.	jlayne@strato.net	USA, (Florida)
Lee, Ya-fu	abramus@utkux.utcc.utk.edu	USA, (Kentucky)
Leffler, John W.	jleffler@ferrum.edu	USA, (Virginia)
Leitner, Phil	leitner@jong.com	USA, (California)
Lengas, Brad	SLXZ6@CC.USU.EDU	USA, (Utah)
Leuthold, Caroline	Caroline.Leuthold@zool.unine.ch	Switzerland
Lewis, Robert E.	relewis@iastate.edu	USA, (Iowa)
Lewis, Stephen W.	ftswl@aurora.alaska.edu	USA (AK)
Lewis, Susan E.	lewiss@carroll1.cc.edu	USA, (Wisconsin)
Lim, Burton K.	burtonl@rom.on.ca	Canada, (Ontario)
Lina, Peter H.C.	p.h.c.lina@ecnc.nl	Netherlands
Lindhard, Birgitte J.	birgitte.lindhard@post3.tele.dk	Denmark
Long, Glenis	long@physics.purdue.edu	USA, (Indiana)
Long, Emma	nhi665@abdn.ac.uk	United Kingdom
Long, Jennifer	74721.3477@compuserve.com	USA, (Massachusetts)
Lopes, Ariadna	avflopes@npd.ufpe.br	Brazil
Losey, John	jlosey@facstaff.wisc.edu	USA, (Wisconsin)
Lumsden, Lindy	L.Lumsden@nre.vic.gov.au	Australia
Lunde, Darrin	lunde@amnh.org	USA, (New York)
Lunney, Dan	dan.lunney@npws.nsw.gov.au	Australia

name	e-mail #	country
Machado, Ricardo Bomfim	rpacheco@guarany.cpd.unb.br	Brazil
MacLeod, Brent	batboy@cadvision.com	???
Marco Aurelio Ribeiro de Mello	marm@acd.ufrg.br	Brazil
Marimuthu, G.	ANIMBEHAV@pronet.xlweb.com	India
Marinho-Filho, Jader	jmarinho@guarany.unb.br	Brazil
Marks, Cynthia	flabats@aol.com	USA, (Florida)
Markus, Nicola	n.markus@mailbox.uq.edu.au	Australia
Marques, Rosane Vera	rosenbat@music.pucrs.br	Brazil
Marshall, Charlene	charlene.marshall@npws.nsw.gov.au	Australia
Mashburn, Kris	BatsRGr8@aol.com	USA, (California)
Masters, W. Mitchell	masters.2@osu.edu	USA, (Ohio)
Matt, Felix	fxmatt@BIOLOGIE.UNI-ERLANGEN.DE	Germany
Matthews, Alison	alison.matthews@npws.nsw.gov.au	Australia
Matthews, Dennis	d2m.nmdl02.ncom.nt.gov.au	Australia
Mayer, Frieder	fmayer@server.biologie.uni-erlangen.de	Germany
McAney, Kate	mcaney@iol.ie	Ireland
McCarthy, Timothy	mccarthyt@cplgh.org	USA, (Pennsylvania)
McCracken, Gary	gmccrack@utk.edu	USA, (Tennessee)
McDaniel, V. Rick	vrmcdanl@Quapaw.astate.edu	???
McDonnell, Jo	jmmcdonn@unity.ncsu.edu	USA, (North Carolina)
McFarlane, Donald A.	dmcfarla@JSD.CLAREMONT.EDU	USA, (California)
McGowan, Emily	emmcg@ix.netcom.com	USA, (New York)
Medellin, Rodrigo	medellin@miranda.ecologia.unam.mx	Mexico
Menzel, Michael	MAM6648@owl.forestry.uga.edu	USA, (Georgia)
Meritt, Dennis	dmeritt@condor.depaul.edu	USA,)Indiana)
Merriman, Cathy	cmerriman@wwfcanada.org	Canada, (Ontario)
Mickleburgh, Simon	info@fauna-flora.org	United Kingdom
Mies, Rob	OBCBats@aol.com	USA, (Michigan)
Milam, Mindy	Eptesicus@aol.com	USA, (Alabama)
Miller, Bruce W.	galljug@btl.net	Belize
Miller, Jack W.	75372,475@compuserve.com	USA, (California)
Miller, Peter	Peter_Miller_at_CAS-ADMIN@casmail.calacademy.org	
Miller, Ray	rmmbats@snowcrest.net	USA, (California)
Miner, Karen	kminer@parks.ca.gov	USA, (California)
Mistry, Shahroukh	smistry@olg.com	USA, Wash. D.C.)
Mitchel-Jones, Tony	tony.mitchell-jones@english-nature.org.uk	United Kingdom
Mitchell, Tony	t.mitchell@nre.vic.gov.au	Australia
Mobley, Emily	oldbat@albany.net	USA, (New York)
Moeschler, Pascal	pascal.moeschler@mhn.ville-ge.ch	Switzerland
Molinari, Jesus	molinari@ciens.ula.ve	Venezuela
Montana, Susan	eryops@earthlink.net	USA, (?)
Montgomery, Narelle	narelle.montgomery@ea.gov.au	Australia
Morell, Tom	tmorrell@wp.bsu.edu	USA, (Indiana)
Morris, Karen	Karen.Morris@state.me.us	USA, (Maine)
Morton, Patricia	patricia.morton@tpwd.state.tx.us	USA, (Texas)

name	e-mail #	country
Muller, Eileen	Epmuller@aol.com	USA, (Pennsylvania)
Munoz, Mariana	mariana@ciens.ula.ve	Venezuela
Murai, Hitoshi	rumbat@tym.fitweb.or.jp	Japan
Myers, Phil	pmyers@umich.edu	USA, (Michigan)
Navo, Kirk	kirk.navo@state.co.us	USA, (Colorado)
Nebzydoski, Mark	MHN1@tiger.uofs.edu	USA, (Pennsylvania)
Neilly, Brendon	critter@IDX.com.au	Australia
Nelson, John	john.nelson@sci.monash.edu.au	Australia
Neuweiler, Gerhard	neuweil@zi.biologie.uni-muenchen.de	Germany
Nogueira, Marcelo R.	mrn@ufrrj.br	Brazil
Nordquist, Gerda	gerda.nordquist@dnr.state.mn.us	USA, (Minnesota)
O'Donnell, Colin	mohua@voyager.co.nz	New Zealand
O'Farrell, Michael J.	mikeof@accessnv.com	USA, (Neveda)
O'Shea, James E.	jeoshea@cyllene.uwa.edu.au	Australia
Ochoa, Jose	jochoa@reacciun.ve	Venezuela
Oh, Yung Keun	batmanoh@dragon.yonsei.ac.kr	Korea
Ohio Bat Program	OhioBats@aol.com	USA, (Ohio)
Okimoto, Ben	hnzoovet@hgea.org	USA, (Hawaii)
Oliveira, Edny Rocha de	eros@acd.ufrj.br	Brazil
Oliveira, Paulo E.	poliveira@ufu.br	Brazil
Organization for Bat Conservation	obcbats@aol.com	???
Ormsby, Pat	orms@rio.com	USA, (Oregon)
Owen, Robert (1)	LAQUINO-CITES@SCE.CNC.UNA.PY	Paraguay
Owen, Robert (2)	BCRDO@TTACS.TTU.edu	USA, (Texas)
Pagels, John	jpagels@saturn.vcu.edu	USA, (Virginia)
Pallin, Nancy	pallin@bigpond.au	Australia
Palmeirin, Jorge	palmeirim@fc.ul.pt	Portugal
Parry-Jones, Kerryn	wambina@ozemail.com.au	Australia
Pavey, Chris	cpavey@ecn.net.au	Australia
Pease, Charles	cpease@bslnet.com	USA, (Arizona)
Pedersen, Scott	Bathead@u.washington.edu	USA, (Washington)
Pedro, Wagnar Andre	wagnerpedro@regra.com.br	Brazil
Perkins, J. Mark	batsrus1@stsna.com	USA, (Utah)
Perlmeter, Stuart	sperlmet@sps.lane.edu	USA, (Oregon)
Petersen, Christine	CPetersen-Clark@calacademy.org	USA, (California)
Pettersson, Lars	pettersson@bahnhof.se	Sweden
Philpott, Wendy	Amoenus@aol.com	USA, (California)
Pierson, Elizabeth (Dixie)	Edpierson@aol.com	USA, (California)
Pine, Ron	pine@imsa.edu	USA, (Illinois)
Pinheiro, Eliana C.	liapinhe@unb.br	Brazil
Pir, Jacques B.	eherjpir@pt.lu	Luxembourg
Pirie, Lucia de la Ossa	priba@cariari.ucr.ac.cr	Costa Rica
Pozo de la Tijera, Carmen	cpozo@nicte-ha.ecosur-qroo.mx	Mexico
Prevett, Patrick	p.prevett@ballarat.edu.au	Australia
Racey, Paul A.	nhi173@abdn.ac.uk	United Kingdom

name	e-mail #	country
Racine, Denyse	denyseracine@compuserve.com.	USA, (California)
Rainey, Wm. (Bill)	WEREDP@aol.com	USA, (California)
Rainho, Ana	dep@icn.pt	Portugal
Ramsey, Marikay A.	ramseyma@juno.com	USA, (New Mexico)
Rayner, Jeremy M. V.	J.M.V.Rayner@bristol.ac.uk	United Kingdom
Reardon, Terry	treardon@zoology.adelaide.edu.au	Australia
Redondo, Rodrigo A.F.	redondo@mono.ufmg.br	Brazil
Rehak, Zdenek	rehak@sci.muni.cz	Czech Republic
Reinhold, Linda	Linda.Reinhold@dnr.qld.gov.au	Australia
Reis, Nelio Roberto dos	nrreis@sercomtel.com.br	Brazil
Reiter, Guido	Guido.Reiter@sbg.ac.at	Austria
Rensel, Eric	parkerdam.sp@DCNR.state.pa.us	USA, (Pennsylvania)
Revelo, Igor Castro	museon@isacha.ecx.ec	Equador
Reyes, Jorge Ortega	jortega@miranda.ecologia.unam.mx	Mexico
Reynolds, Scott	smbdsr@worldnet.att.net	USA, (Massachusetts)
Rhodes, Monika	anl86027@student.uq.edu.au	Australia
Riba, Pablo	priba@cariari.ucr.ac.cr	Costa Rica
Ribeiro de Mello, Marco A. (1)	marm@acd.ufrj.br	Brazil
Ribeiro de Mello, Marco A. (2)	jacyrmarco@ibm.net	Brazil
Ribeiro, Tatiana Texeira	bergallo@uerj.br	Brazil
Richards, Greg	batman@atrax.net.au	Australia
Richardson, Bruce	BruceR2738@aol.com	USA, (?)
Rodriguez-Moran, Armando	arodrig@ns.inter.edu	USA, (Puerto Rico)
Rodriquez-H, Bernal	bernalr@cariari.ucr.ac.cr	Costa Rica
Romero-Almaraz, MA.Lourdes	romero@cib.uaem.mx	Mexico
Romijn, Phyllis Catharina (1)	phyllis.lba@pesagro.com	Brazil
Romijn, Phyllis Catharina (2)	phyllis@openlink.com.br	Brazil
Roth, Stan	jroth@falcon.cc.ukans.edu	USA, (Kansas)
Ruedi, Manuel	manuel.ruedi@izea.unil.ch	Switzerland
Rupprecht, Charles	cyr5@cdc.gov	USA, (Georgia)
Russ, Jon	j.russ@qub.ac.uk	United Kingdom
Russ, Stephen	sruss@ix.netcom.com	USA, (California)
Sanchez-Hernandez, Cornellio	cornelio@servidor.unam.mx	Mexico
Sasse, Blake	blakes@flinet.com	USA, (Florida)
Saugey, David	dsaugey/r8_ouachita_jessieville@fs.fed.us	USA, (Ark.)
Schedvin, Natasha	n.schedvin@nre.vic.gov.au	Australia
Schilling, Stephen	Stephen_Schilling@umit.maine.edu	USA, (Maine)
Schilling, Steven	SCHILLING.STEVE@EPAMAIL.EPA.GOV	USA, (Maine)
Schmidt, Sarah	sschmidt@U.Arizona.EDU	USA, (Arizona)
Schulz, Martin	shulzm@dnr.qld.gov.au	Australia
Schutt, William	desmodus@yahoo.com	USA, (New York)
Schwellenbach, Kathy	kathy.schwellenbach@stpaul.gov	USA, (Minnesota)
Scott, Christine	forbats@batnet.com	USA, (California)
Scott, Mike	mgscott@utk.edu	USA, (Tennessee)
Sedgeley, Jane	mohua@voyager.co.nz	New Zealand

name	e-mail #	country
Seidman, Victoria	victoria@humboldt1.com	USA, (California)
Selvey, Linda	selveyl@health.qld.gov.au	Australia
Senulis, Joe	senulis@acm.org	USA, (Wisconsin)
Seyjagat, John	lubee@aol.com	USA, (Florida)
Sherwin, Rick	ressh@utw.com	???
Shilton, Louise	Louise.Shilton@anu.edu.au	Australia
Sidner, Rhonda M.	sidner@U.Arizona.EDU	USA, (Arizona)
Sige, Bernard (1)	sige@isem.isem.univ-montp2.fr	France
Sigé, Bernard (2)	ferriere@cirad.fr	France
Simmons, James	james_simmons@brown.edu.	USA, (Rhode Island)
Simmons, Nancy B.	simmons@amnh.org	USA, (New York)
Simons, Diana	batflap@aol.com	USA, (California)
Singer, Stephen W.	SWSingerMS@aol.com	USA, (California)
Singh, Udai Pratap	akrishna@banaras.ernet.in	India
Slough, Brian G.	bslough@yknet.yk.ca	Canada, (Ontario)
Smissen, Joanne	jsmiss.en@deakin.edu.au	Australia
Smith, Elizabeth	libby@nvi.nvi.net	USA, (Ohio)
Smith, Jerome	caspyr@aristotle.net	???
Smith, Leslie	leslies@pronet.net.au	Australia
Smith, Macklin	Macklin.Smith@UM.CC.UMICH.EDU	USA, (Michigan)
Smith, Suzanne E.	ses4@axe.humboldt.edu	USA, (California)
Smuts-Kennedy, Chris	c.smuts-kennedy@doc.govt.nz	New Zealand
Soroka, Doug	DSOROKA@ARSeRRC.GOV	USA, (Pennsylvania)
Soubihe, Edmon Antonio R.	edmon@base.com.be	Brazil
Spaulding, Raymond (Rick)	RLSpaulding@OEES.com	USA, (California)
Speakman, John	nhi158@ABERDEEN.AC.UK	United Kingdom
Spears, Ronnie	so94906@GSVMS2.CC.GASOU.EDU	USA, (Georgia)
Spencer, Hugh (1)	Hugh@altnews.com.au	Australia
Spencer, Hugh (2)	Hugh.Spencer@altnews.com.au	Australia
Stanvic, Sonya	fstanvic@ozemail.com.au	Australia
Stern, April	DNAstern@bigfoot.com"	???
Stevenson, Lynda	Koalahos@tpgi.com.au	Australia
Stewart, Joanne	jostew1234@aol.com	???
Stihler, Craig	cstihler@dnr.state.wv.us	USA, (West Virginia)
Stoddard, John	gstoddar@UXA.ECN.BGU.EDU	USA, (Illinois)
Stoner, Kathryn	kstoner@cariari.ucr.ac.cr	Costa Rica
Storch, Gerhard	gstorch@sng.uni.frankfurt.de	Germany
Storz, Jay	storz@bio.bu.edu	USA, (Massachusetts)
Strickler, Timothy	stricklt@gvsu.edu	USA, (Michigan)
Stroo, Arjan	stroo@rulrhb.leidenuniv.nl	Netherlands
Studier, Eugene	myotis@umich.edu	USA, (Michigan)
Surlykke, Annemarie	ams@dou.dk	Denmark
Swanson, David A.	bob.stoll@dur.ohio.gov	USA, (Ohio)
Swartz, Sharon	Sharon_Swartz@BROWN.EDU	USA, (Rhode Island)
Szabo, Erika	szaboe@fs2.date.hu	Hungary

name	e-mail #	country
Szewczak, Joeseph M	joe@wmrs.edu	USA, (California)
Tague, Thomas	104774.565@compuserv.com	USA, (Pennsylvania)
Tatarian, Gregory & Trish	tatarian@pacbell.net	USA, (California)
Tavares, Valeria da Cunha	valtabat@mono.icb.ufmg.br	Brazil
Taylor, Peter	petert@durban.gov.za	South Africa
Taylor, Roscoe	taylorer@health.qld.gov.au	Australia
Teeling, Emma	e.teeling@qub.ac.uk	United Kingdom
Thierry, Kervyne	thierry.kervyn@student.ulg.ac.be	Belgium
Thomas, Don	d.thomas.courrier@usherb.ca	Canada, (Quebec)
Thomas, Steven P.	thomas@duq3.cc.duq.edu	USA, (Pennsylvania)
Thompson, Elizabeth	elizabetht@sgccvb.sunygenesee.cc.ny.us	USA, (New York)
Thompson, Laureen	lthompso@delta.dfg.ca.gov	USA, (California)
Thompson, Neville	n.thompson@dial.pipex.com	United Kingdom
Thomson, Bruce	bruce.thomson@env.qld.gov.au	Australia
Tidemann, Chris	chris.tidemann@anu.edu.au	Australia
Tigner, Joel	joel.tigner@pn.nettuno.it	USA, (North Carolina)
Titley, David	titley@nor.com.au	Australia
Toop, John	John.Toop@env.qld.gov.au	Australia
Tracy, Dianna	dtracy@oakland.edu	USA, (Michigan)
Tranjano, Eleonara	etrajano@usp.br	Brazil
Trierveler, Fernanda	trier@prp.via-rs.com.br	Brazil
Trimarchi, Charles	trimarch@wadsworth.org	USA, (New York)
Trombulak, Steve	trombulak@midd.cc.middlebury.edu	USA, (Vermont)
Tschapka, Marco	motschap@biologie.uni-erlangen.de	Germany
Tupinier, Yves	Yves.Tupinier@wanadoo.fr	France
Turton, Margaret	turtonm@acay.com.au	Australia
Twente, John	JohnTwente@webtv.net	USA, (Missouri)
Tyrell, Karen	karen_tyrell@msn.com	USA, (Tennessee)
Uieda, Wilson (1)	uieda@botunet.com.br	Brazil
Uieda, Wilson (2)	wuieda@ibb.unesp.br	Brazil
Utzurrum, Ruth	utzurrum@bio.bu.edu	USA, (Massachusetts)
Vavryn, Dianne	vavryn@networx.com.au	Australia
Venable, Morgan	cruzbat@aol.com	USA, (California)
Verbeek, Joost	verbeekj@wxs.nl	Netherlands
Verkem, Sven	verkem@ruca.ua.ac.be	Belgium
Vernier, Edoardo	giulini@civ.bio.unipd.it	Brazil
Villa-R., Bernardo	bvilla@planet.com.mx	Mexico
Vogel, Stefan	roland.eberwein.univie.ac.at	Austria
Vonhof, Martin	mvonhof@acs.ucalgary.ca	Canada, (Alberta)
Walker, Steven M.	swalker@batcon.org	USA, (Texas)
Walsh, Allyson	enquines@bats.org.uk	United Kingdom
Webb, J. Warren	web@ornl.gov	USA, (Tennessee)
Webb, Peter	peter.webb@stonebow.otago.ac.nz	New Zealand
Weinstein, Bret	fruitbat@biology.LSA.umich.edu	USA, (Michigan)
Weller, Ted	tjw4@axe.humboldt.edu	USA, (California)

name	e-mail #	country
Whitaker, John	LSWHITAK@SCIFAC.INDSTATE.EDU	USA, (Indiana)
Whitman, Joseph	bats@cosnet.net	USA, (Oregon)
Whitman, Kimberly	whitman.kimberly@phillyzoo.org.	USA, (Pennsylvania)
Wiles, Gary J.	gwiles@ns.gov.gu	Guam, (USA)
Wilhide, J.D.	JDWil@Osage.astate.edu	USA, (Arkansas)
Wilkes, Melody Bell	Wwilkes@MODS.org	USA, (Florida)
Wilkinson, Jerry	wilkinson@zool.umd.edu	USA, (Maryland)
Williams, Daniel F.	dwilliam@s2.sonnet.com	USA, (California)
Williams, Terry	Terry.WilliaMs.@qcl.com.au	Australia
Wilson, Don E.	WILSON.DON@NMNH.SI.EDU	USA, (Wash.D.C.)
Wilson, Nixon	nixon.wilson@uni.edu	USA, (Iowa)
Winchell, Jane	Janey_Winchell@PEM.org	USA, (Massachusetts)
Wing, Steven M.	swing@scsn.net	USA, (South Carolina)
Winklemann, John	jwinkelm@gettysburg.edu	USA, (Pennsylvania)
Winnington, Andrew	apwinnington@hotmail.com	New Zealand
Winter, York	ywinter@biologie.uni-erlangen.de	Germany
Winters, Patricia	batmam@aol.com>	USA, (California)
Woloszyn, Bronislaw	WOLOSZBR@isez,pan.krakow.pl	Poland
Woodford, Michael	mwood@sun.science.wayne.edu	USA, (Michigan)
Wunder, Laurie	wundelaw@dfw.wa.gov	USA, (Washington)
Yamamoto, Terumasa	CXJ13576@niftyserve.or.JP	Japan
Young, Bob	BCSC@cadvision.com	Canada, (Alberta)
Zbinden, Karl	karl.zbinden@phil.unibe.ch	Switzerland
Zippilli, Gail	gailbat@email.msn.com	USA, (Pennsylvania)
Zortea, Marlon (1)	mzortea@sigma.tropical.com.br	Brazil
Zortea, Marlon (2)	mzortea@npd.ufes.br	Brazil

If your e-mail number is incorrect or has been changed please send your correction to me via e-mail to: horstgr@potsdam.edu

If you are not included and would like to be, please send your e-mail address and your mailing address to: horstgr@potsdam.edu

We are contemplating making this directory available on disc in format compatable with MacIntosh and IBM for a reasonable price (probably less than $15.00 US.plus shipping). We need to determine whether there is enough demand to justify the effort. If you might be interested in purchasing a copy please e-mail me to that effect (this is only an expression of interest, not a request to purchase). If there is sufficient interest in an electronic version, we will proceed with its preparation. Thank you for your assistance, G. Roy Horst

More Abstracts from the Australasian Bat Conference

The Managing Editor wishes to express his sincere apologies for the omission of the following abstracts from the previous issue of Bat Research News(Vol. 39: No.1) which included the abstracts of papers presented at the 8th Australasian Bat Conference in April, 1998, in Rockhampton Australia. These abstracts made up the section of the conference entitled "Roosting Ecology" and was chaired by Robert M. R. Barclay of Calgary Canada. This oversight arose from the editor's marginal skills in computer composing and in no way was an "editorial" decision (merely another one of his many screw-ups). Again apologies all around.

GRH, Managing Editor.

Continuing results from bat roosting boxes at Organ Pipes National Park, Victoria

Robert Bender and Robert Irvine
11 Mudie Avenue, Sunbury 3429 Victoria and 9 bailey Grove, Ivanoe, 3079 Victoria

There is minimal published research in Australia on roost boxes for bats however it is known that bats will not roost in natural regrowth forests. Artificial roosts are essential in encouraging bats back to new growth forest lacking in natural hollows. Since 1988 harp trapping for bats in Organ Pipes National Park has consistently shown seven species present in the park. 10 artificial roost boxes were installed in 1992, and started showing signs of use by bats late in 1994, with Gould's Wattled Bats (*Chalinolobus gouldii*)being captured during box inspections. For the following two years, only the one species was found using the boxes. In an effort to attract a wider variety of species the Friends group has experimented with designs involving larger and smaller internal volumes, multiple compartments, and smaller entrance slits, in 15 additional boxes installed in 1996 and 1997. The smaller entrance slits have been intensively chewed by Sugar Gliders (*Petaurus breviceps*), unsuccessfully attempting to gain entrance. The newer boxes with small entrance slits have proved much more popular with Gould's Wattled Bats. In 1997, boxes were installed with even smaller entrance slits and internal volume and for the first time, Large Forest Bats (*Vespadelus darlingtoni*) have been found using these. Experiments will continue in an attempt to design roosts for the other 5 species are prepared to use. e-mail: robert.irvine@asc.gov.au & robertb@angliss.vic.edu.au

The roosting behaviour of the lesser long-eared bat *Myctophilus geoffroyi* and Gould's wattled bat *Chalinolobus gouldii* in a fragmented landscapein Northern Australia

L. F. Lumsden[1] and A. F. Bennett[1,2]

[1]Arthur Rylah Institute for Environmental Research, 123 Brown St., Heidelberg Victoria, 3084

[2] Current address: School of Ecology and Environment, Deakin University - Rusden Campus, 662 Blackburn Rd., Clayton, Victoria, 3168.

Roosting behaviour of *Nyctophilus geoffroyi* and *Chalinolobus gouldii* were investigated during a study of the roosting ecology of insectivorous bats in a fragmented landscape in northern Victoria. A total of 45 individuals of *N. geoffroyi* and 27 *C. gouldii* were fitted with transmitters, resulting in the location of 139 roosts used by *N. geoffroyi* and 89 roosts for *C. gouldii*, at which behaviour could be observed. Both species shifted roost sites frequently, with 67% of *N. geoffroyi* roosts and 50% of *C. gouldii* roosts occupied for only a single day. There was no significant difference between males and females in how often they shifted, and lactating females shifted roosts as frequently as non-breeding females. One lactating female *N. geoffroyi* used eight different roosts over an 11 day period, moving her young to each new roost. When individuals shifted to a new roost it was usually to another nearby. Both species were faithful to a defined roost area, returning there consistently from foraging activities considerable distances away, but frequently shifting roost trees within that area. Three-quarters of all roosts for both species were within 300 m of the preceding roost. The majority (88%) of roosts occupied by male *N. geoffroyi* contained only a single animal, while for females this figure was 38%. Female roosts contained significantly more individuals during the breeding season than the non-breeding season (18.3 ± 15.0 vs 2.4 ± 2.0 individuals). *C. gouldii* roosts contained more individuals than *N. geoffroyi* roosts(8.7 ± 7.9 vs 3.5 ± 7.2 individuals),

with a maximum colony size of 29 individuals recorded. *C. gouldii* emerged from their roosts early in the dusk period, while *N. geoffroyi* emerged approximately 25 minutes later when it was fully dark.
e-mail: L.Lumsden@nre.vic.gov.au

Roost use by *Chalinolobus tuberculatus* and *Mystacina tuberculata* in temperate nothofagus forest.

Jane Sedgeley
Department of Conservation, Private bag, Christchurch, New Zealand
and Department of Zoology, University of Otago, PO Box 56, Dunedin, New Zealand.

Seventy three long-tailed bats (*Chalinolobus tuberculatus*) were radio-tracked during the summers of 1993-1997 to 304 day roosts in 291 different trees. 95% of these roosts were located in mature, open-structured lowland forest and were within 500 metres of the forest-grassland edge. Roost tree and roost cavity characteristics were compared with those of 596 random trees and 187 random cavities. Bats preferentially roosted in trees which had a significantly lower canopy closure, larger stem diameter, were taller, had larger trunk surface areas and greater numbers of cavities than available trees. In comparison with random cavities, roost cavities were higher from the ground (median = 15 m, n=161) and had relatively uncluttered entrances (mean distance to nearest vegetation = 16 m, n=116). They had relatively small entrance holes (median = 69 cm2, n=120) and internal dimensions (median = 289 cm2, n=72), tended to have a vertical interior orientation (where height exceeded depth) and were dry. Preliminary analysis indicates unoccupied long-tailed bat roost cavities are thermally more stable than similar sized non-roost cavities. Generally, oscillation in unoccupied roost air temperatures mimicked those of external air temperatures, though were of a much lesser amplitude and showed a lag of 6 - 12 hours such that roosts were at their warmest during the night. e-mail: mohua@voyager.co.nz

Roosting and foraging ecology of the eastern forest bat *Vespadelus pumilus* under two disturbance histories.

Bradley Law and Jason Anderson
Research Division, State Forests of NSW, PO Box 100, Beecroft, NSW, 2119.

Little is known about the habitat requirements of Australian bats, however this information is needed to make intelligent management decisions when systems are disturbed. This study contrasts the roosting and foraging ecology of *Vespadelus pumilus* between two sites of differing disturbance history on the mid-north coast of NSW. Lorne Flora Reserve (182 ha) is primarily old growth forest surrounded by logged forest and eucalypt plantations, while Swan's Crossing consists primarily of regrowth and eucalypt plantations established on an old dairy farm. A total of 38 bats were tracked at the two sites. Roost preferences were determined by comparing trees used with those randomly available, while foraging bats were triangulated from fixed stations at night. Bats tracked at Lorne Flora Reserve typically roosted in hollows within large mature trees and showed a strong preference for roosting and foraging within the Reserve. Bats at Swan's Crossing did not have this option. Instead hollows in understorey trees and remnant rainforest trees within a gully were the typical roosts. Bats caught in this forest also foraged there. Home ranges were relatively small, averaging 5.3 ha (n=10). Implications for management will revolve around preferences for the size and species of roost trees, topographical position and distance from gully lines as well as the ability to forage in disturbed forests. These data will be discussed in relation to current management prescriptions. Compared with long-tailed bats, recent results suggest that a greater proportion of short-tailed bats (*Mystacina tuberculata*) occupy trees that are at higher altitudes and a greater distance from the forest edge. Roost cavities tend to be relatively lower to the ground, have larger entrances and greater internal height. e-mail: bradl@ironbark.forest.nsw.gov.au

RECENT LITERATURE

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Mosquito feeding by bats

John O. Whitaker, Jr. and Rachael Long
Department of Life Sciences, Indiana State University, Terre Haute, Indiana 47809
and University of California Cooperative Extension, 70 Cottonwood St., Woodland, CA 95695

There are many statements in the popular literature that bats feed heavily on mosquitoes, and bat conservationists often use this presumed habit as a reason to encourage people to protect bats. However, it has long been the position of the senior author that bats have little or no impact on mosquito control when it does occur. Therefore bat conservationists should not place emphasis on protection of bats because of their presumed habit of feeding on mosquitoes.

This position was brought into question recently during a study of the diet of Indiana bats, *Myotis sodalis*, from a swamp in southern Michigan (Kurta and Whitaker, in press). Numerous mosquitoes were unexpectedly observed in the guano throughout much of the season. The immediate thought was that some species of mosquito must swarm as chironomids often do. A swarm is a large number of flying insects that remain in a tight unit, often in one place, often for the purpose of mating. The purpose of this paper is to review mosquito feeding by bats in an attempt to put it into proper perspective, especially in its relation to bat conservation.

Some previous records of North American bats feeding on mosquitoes follow. Anthony and Kunz (1977) found mosquitoes in 77.4% of their samples from *M. lucifugus* from New Hampshire. Zinn and Humphrey (1981) examined 4, 65, and 24 scats of *M. austroriparius* from Florida and reported volumes of mosquitoes as 10, 27.6, and 46.2%. Mosquitoes formed about 3% of the volume of the contents of 100 scats of *M. lucifugus* from Alaska (Whitaker and Lawhead, 1992). A total of 6 mosquitoes was found among 340 prey in one little brown myotis (Buchler, 1976). Whitaker has examined hundreds of scats and stomachs of bats and found mosquitoes as follows: 2% of the volume in 15 silver-haired bats (*Lasionycteris noctivagans*), 3.2% of the volume in 31 California myotis (*Myotis californicus*), 0.4% of the volume in 67 little brown myotis, and 0.7% of the volume in 23 eastern pipistrelles (*Pipistrellus subflavus*). In one hoary bat stomach, Poole (1932) found a single mosquito. Long et al. (1998) reported mosquitoes in the diet of *M. yumanensis* and *Tadarida brasiliensis*. Clearly, bats do eat mosquitoes, although not routinely and not commonly by the bats that fly around our houses, and we could cite many studies where no mosquitoes were taken.

It has been suggested that a small *Myotis* is capable of catching 600 or more mosquitoes in an hour under laboratory conditions (Griffin et al., 1960). Under field conditions, however, bats seldom eat mosquitoes, not because of any aversion to them, but presumably because mosquitoes do not usually fly, in numbers, at the heights where bats are feeding, and because mosquitoes are small and females do not swarm. Therefore, it is energetically inefficient for bats to pursue individual mosquitoes. We found that much of the mosquito feeding by bats is 1) early in the season, when relatively little food is available; 2) in the high latitudes (Barclay, 1985; Rydell, 1986; Whitaker and Lawhead, 1992), where dipterans, especially mosquitoes, are perhaps much more abundant and other groups, such as beetles and true bugs, are perhaps much less common than at lower latitudes; and 3) in other areas where mosquitoes are large and very abundant and swarm, such as in Florida (Zinn and Humphrey, 1981).

Swarming of male mosquitoes has been known for some time (Charlwood and Jones, 1980; Nielsen and Haeger, 1960; Yuval and Bouskila, 1993; Yuval et al., 1993, 1994) and apparently occurs in many species of mosquitoes. Mating often occurs in swarms, but there are few females present in swarms and most mating occurs as pairs leave during mating. Nielsen and Haeger (1960) found that swarming is rhythmical and induced by twilight, and that it occurs within narrow spatial limits and at definite hours, usually dusk and often dawn. Males swarm every night, except perhaps on their first days of life or in inclement weather, and swarming takes place at the same location night after night. There are several kinds of swarms (Nielsen and Haeger, 1960), and in many species, the swarms remain attached to "swarm markers," perhaps rocks or stubs, but the upper part of the swarm may be blown about by the wind. Swarms sometimes include more than one species, in which case the swarm takes on the characteristics of the dominant species. Swarming generally occurs at heights of 1-3 m, but may extend higher.

Although females are seldom present in swarms, swarms of males function as a site for females to select a mate (Charlwood and Jones, 1980; Yuval and Bouskila, 1993). Yuval and Bouskila (1993) observed females entering swarms, finding mates, then leaving the swarm, often in copulo. On 19 evenings of observation of male swarms of
Anopheles freeborni in California, these authors observed 2,724 copulating pairs leaving swarms. Yuval et al. (1993) found that larger males were the more successful ones, and smaller males were more apt to swarm early in the evening. Swarms last 30-35 min and up to thousands of individuals may participate, 90-100 percent of them males.

Yuval and Bouskila (1993) observed 1,351 cases of predation on mosquitoes in male swarms, all by two species of dragonflies. Predation occurred near dusk (during the first 15 min after the swarm had formed), whereas most copulations occurred later. No cases of predation by bats were observed by these researchers, but further observations of swarms using bat detectors would clearly be of interest.

We suspect that most of the time when significant numbers of mosquitoes are eaten by bats, that the mosquitoes are mostly of males from swarms that the bats have located by echolocation, and that the mosquitoes are taken by flying back and forth through the swarms to capture their prey, as when feeding on midges (Chironomidae). The bats would get very few females during this process, because there are so few females available in a swarm at any one time.

Bats take numbers of mosquitoes, even males, relatively infrequently. We believe that this is because much or most of the swarming is near dusk and dawn, whereas most of the foraging of bats is after dusk, although some species are night- or day-feeders. Even though bats might take fairly large numbers of mosquitoes at times, the mosquitoes are presumably mostly males, and males do not take blood meals, feeding on plant juices instead. Only by feeding on appreciable numbers of female mosquitoes would bats make much impact on mosquito populations.

Based on the above information, we do not think it is appropriate to encourage protection of bats because they feed on mosquitoes. However, the failure of bats to focus on mosquitoes does not lessen their value to us. Much more information is needed on bats feeding on specific pest species, but the numbers of crop-harming and disease-carrying insects eaten by big brown and evening bats such as spotted cucumber beetles, scarabaeid beetles, stinkbugs, and leafhoppers are phenomenal (Whitaker, 1992, 1993, 1995). Other bats eat great quantities of moths, such as cutworm moths, the larvae of which are important crop pests. Bats deserve all the protection and help we can give them. If for no other reason, we clearly should protect insectivorous bats because they are the major predators of night-flying insects. Protection of bats, therefore, will help maintain the balance of nature and should help control numerous pest species. Protection of bats will not aid in mosquito control and we should not state or imply that it will. We should continue to protect bats because they and nighthawks are the major predators of nocturnal insects, probably including many agricultural pests.

Further work is needed to determine if bats are indeed feeding on male swarms, and if the mosquitoes being eaten by bats are primarily males. We encourage observation of male mosquito swarms, using night-vision equipment and bat detectors in areas where bats are abundant, to obtain information on possible bat predation there. We also encourage netting of bats and guano collection to determine whether the mosquitoes eaten by bats are all or mostly males, perhaps using the antennae or mouth parts, because females have piercing/sucking mouthparts, whereas males do not.

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Assessment of foraging activity using Anabat II: A cautionary note

Ted J. Weller, Victoria M. Seidman, and Cynthia J. Zabel
U. S. Forest Service, Redwood Science Lab, Arcata, CA 95521, and Wildlife Department, Humboldt State University, Arcata, CA 95521

Recent availability of low-cost and easy-to-use bat detectors, such as Anabat II (Titley Electronics, Ballina, Australia), has made assessment of bat activity accessible to an increasing number of researchers and land managers. Researchers using bat detectors have attempted to identify species assemblages (e.g., Fenton et al., 1983; O'Farrell et al., in press) or compared bat activity between areas or among habitats (e.g., de Jong and Ahlen, 1991; Hayes and Adam, 1996; Walsh and Harris, 1996*b*). Researchers also have used bat detectors to compare relative amounts of foraging activity between areas (Brigham et al., 1997; Crampton and Barclay, 1996; Erickson and West, 1996; Krusic et al., 1996; Thomas, 1988; Vaughan et al., 1997; Walsh and Harris, 1996*a*).

Earlier investigators separated echolocation calls of bats into three phases: search, approach, and feeding buzz (e.g., Fenton and Bell, 1979; Griffin, 1958; Simmons et al., 1979). These three categories are still used and can be visualized in the field when bat detectors are connected to oscilloscopes (e.g.; Fenton and Bell, 1979) or laptop computers (e.g., O'Farrell et al., in press). Most researchers that attempt to assess feeding activity in the field using the audio output of bat detectors, describe their methods as "foraging activity was recognized by high pulse repetition rates, or feeding buzzes, associated with attacks on prey" (Griffin, 1958). However, no recent studies have been published that test the validity of this methodology, using modern equipment, such as the Anabat II. It had been stated that the feeding activity can be unambiguously assigned from the audio output of the QMC mini-detector (Fenton et al., 1983). These statements imply that the sound of a feeding buzz is equally apparent to all researchers, and that this sound is actually produced by a bat in the act of feeding. To test the former, we conducted a survey in which we asked bat researchers to categorize prerecorded bat calls.

Our goal was to evaluate the variability among observers in categorizing bat calls using the audio output of bat detectors. Our null hypothesis was that categorization of bat calls is an objective task repeatable by other researchers. If classification of bat calls is objective, calls should be classified similarly by different observers, and experience of the observer should not significantly affect how calls are classified. If categorization of calls is objective, but difficult to learn, there should be greater variability among inexperienced observers on how calls are categorized compared to experienced researchers.

Materials and Methods

We recorded calls of *Myotis* spp. in the Pilot Creek watershed in Six Rivers National Forest, ca. 50 km east of Eureka, California. Calls were identified as *Myotis* spp. by viewing the time-frequency structure of the calls using the Anabat II Zero-Crossings Analysis Interface Module, Anabat 5 software, and a laptop computer (e.g., O'Farrell et al., in press).

Recordings were made along stream channels within mature Douglas-fir (*Pseudotsuga menziesii*) forest between June and August 1996. We used the Anabat II bat detector, in conjunction with the Anabat II delay switch and a Realistic minisette-20 tape recorder to record remotely calls in the field (Hayes and Hounihan, 1994). These materials were similar to those used in previous studies that passively monitored bat activity (e.g., Hayes, 1997; Krusic et al., 1996; Parker et al., 1996).

Ten calls were subjectively selected for inclusion on an audio tape to assess variability among observers in identification of call type. The first two calls were intended to orient the listener to the quiz process while listening to calls that were easy to categorize. The first was one that we agreed had no feeding component, i.e., a search-phase call. The second was a call that we agreed was an obvious feeding buzz. Calls 3-10 were

ambiguous calls that we disagree among ourselves as to whether they were approaches or feeding buzzes. The quiz tape was not meant to approximate 10 calls that one would acquire during a night of field recording.

Respondents were surveyed at the North American Symposium on Bat Research in Tucson, Arizona, between 9 and 11 October 1997. First they were asked to report their years of experience with bat detectors, the Anabat system, and whether they regularly distinguished among call types. Next they listened to the tape of 10 calls through headphones and attempted to categorize each call as search, approach, or feeding buzz.

Many respondents placed calls into more than one category. Since we were most interested in whether respondents detected a feeding buzz, we used only the respondents' highest level of categorization in our analyses. For example, if the call were categorized as having both a search phase and an approach phase, we used an approach in the analysis. Respondents were segregated into two groups: experienced (≥3 years of bat detector experience) and less experienced (≤3 years experience). We pooled the identifications and used chi-squared contingency table analysis to test for association between experience level and how calls were classified.

Results

Twenty-six researchers responded to the survey, resulting in 252 identifications of the 10 calls (eight calls were not identified). Mean experience with bat detectors was 4.5 years (range: 1 month to 21 years), and mean experience with Anabat detectors was 1.3 years (range: 1 month to 4 years). Eighty-four percent of respondents reported that they regularly distinguished between search and feeding calls, and 21% regularly distinguished between approaches and feeding.

Categorization of bat calls was highly variable. Hereafter, our results refer to a respondent's highest level of categorization for a particular call. None of the calls was identified the same by all 26 observers. Six of 10 calls were identified the same by ≥50% of the respondents, and only one (call 2: the obvious buzz) was placed in the same category by >68% of the respondents (Fig. 1). All ten calls were identified as either an approach or feeding buzz by a majority (≥58%) of the respondents. However, only three calls (2, 3, and 5) were identified as either an approach or feeding buzz by ≥95% of the respondents.

Of the 252 identified calls, 14.7% were identified as a search, 36.1% as approach, and 49.2% as feeding buzz. There was no significant association between observer experience and identification of call type (X^2 = 4.21, P = 0.12, $d.f.$ = 2) or assignment of the feeding buzz call type (X^2 = 0.01, P = 0.92, $d.f.$ = 1; Fig. 2).

Discussion

Our null hypothesis was rejected, and we concluded that categorization of bat calls based on recorded audio output of Anabat detectors is subjective. There was great variability in classification of the 10 calls, and there was no association between the observer's experience with bat detectors and how calls were classified. If calls could be reliably identified from recorded audio output of bat detectors, then one type of call would dominate for each of the ten calls in Fig 1. The variability among observers in identification of call types is cause for concern to those who attempt to infer foraging activity from the audio output of divide-by-n bat detectors, such as Anabat II.

We expected a great deal of variation in identification of calls as either approach-phase calls or feeding buzzes, because these types of calls can be difficult to distinguish even when analyzing time-frequency graphical displays (Kalko, 1995; Parsons et al., 1997). The number of respondents who identified calls as searches was unexpected. Since the calls on the quiz tape were primarily chosen for their ambiguity, all calls may not be this difficult to categorize. However, we included two calls that we assumed would be easy to categorize. The original intent of these two calls was to demonstrate that most researchers would agree on obvious call types. Call two met these expectations, but call one, which we considered to be a typical search call, was identified as an approach (42.6%) and even a feeding buzz (11.5%) instead of a search (42.3%). This demonstrates the subjectivity inherent in audio determination of calls. Given that calls of ambiguous type exist, in practice they are probably subjectively assigned to a category. It is likely that a test asking researchers to categorize randomly selected calls would display variability similar to that presented here.

Our survey was conducted using recordings of *Myotis* spp. made with the Anabat II system in forested habitat. Our results and conclusions are limited to these species, in this habitat, using this recording system. Experience levels were reported as years of bat-detector use. We realize that use rates within a year vary appreciably among respondents. Also, the survey was conducted in the lobby outside a scientific meeting that presents different conditions than the relative quiet of the laboratory. Nevertheless, despite several uncontrolled parameters in this study, the observed trends are not encouraging.

A majority of researchers surveyed attempt to identify foraging activity, defined by most researchers as occurrence of "feeding buzzes" (e.g., Krusic et al., 1996; Thomas, 1988) in the field. Our data indicate that categorization of feeding buzzes based solely on recorded audio output of Anabat II detectors may be subjective and not repeatable. Only call 2, which we identified a priori as a feeding buzz, achieved ≥95%

concurrence on its categorization. Frequent calibration in identifying feeding buzzes among researchers on a particular study may allow for relative comparisons of foraging activity among habitats. However, this method may not accurately estimate the actual amount of foraging in an area. To complicate matters further, some insectivorous bats may not use echolocation to capture prey (Fenton, 1990).

Alternatively, foraging activity could be defined as the presence of either approaches of feeding buzzes. Since approach-phase calls occur when the bat is pursuing prey (Kalko, 1995), the detection of an approach-phase call would indicate foraging activity. However, during our survey, in only three of 10 cases did researchers achieve ≥95% agreement that the call was either an approach or feeding buzz.

Calls have been successfully assigned to one or more of these phases by qualitatively assessing changes in call design, using time-frequency displays of the echolocations on oscilloscopes, and while observing behaviors of the bats (e.g., Fenton and Bell, 1979; Fenton et al., 1983; Kalko, 1995). Call type has been quantitatively assessed for *Chalinolobus tuberculatus* but required the use of digital, signal-processing equipment and multivariate analysis to separate calls into search and terminal-buzzes (Parson et al., 1997). Despite the technology and effort expended, approach calls could be recognized but not quantitatively distinguished from feeding buzzes (Parson et al., 1997). Most respondents to our survey did not attempt to distinguish approach calls in the field but did attempt to identify feeding buzzes. Passive monitoring of activity with bat detectors and later listening to the audio output does not allow consistent determination of call type. While it has been suggested that the human brain may be the most effective tool for analyzing sounds (Fenton, 1988), our data indicate that the audio determinations of call type are subjective, even at a level that separates approaches and feeding buzzes from searches.

Acknowledgments

We thank the participants in our survey, without whom this note would not be possible. T. A. Griffiths graciously offered space at the North American Symposium on Bat Research and encouragement for the quiz. M. Gannon, J. R. Waters, and W. Z. Zielinski offered helpful suggestions that greatly improved the manuscript. This study was supported by Redwood Science Laboratory, Pacific Southwest Forest Experiment Station, United States Forest Service, United States Department of Agriculture.

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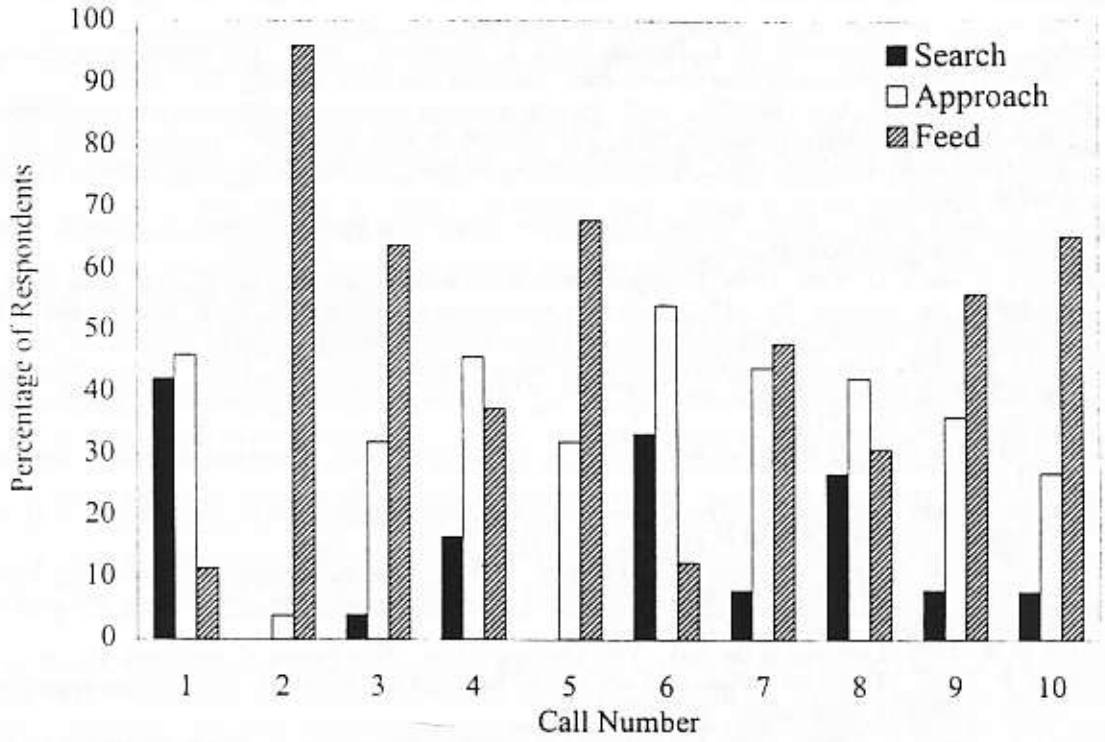

Figure 1. Identification of bat call types by researchers. 26 respondents listened to the same 10 calls.

Weller, et al continued...

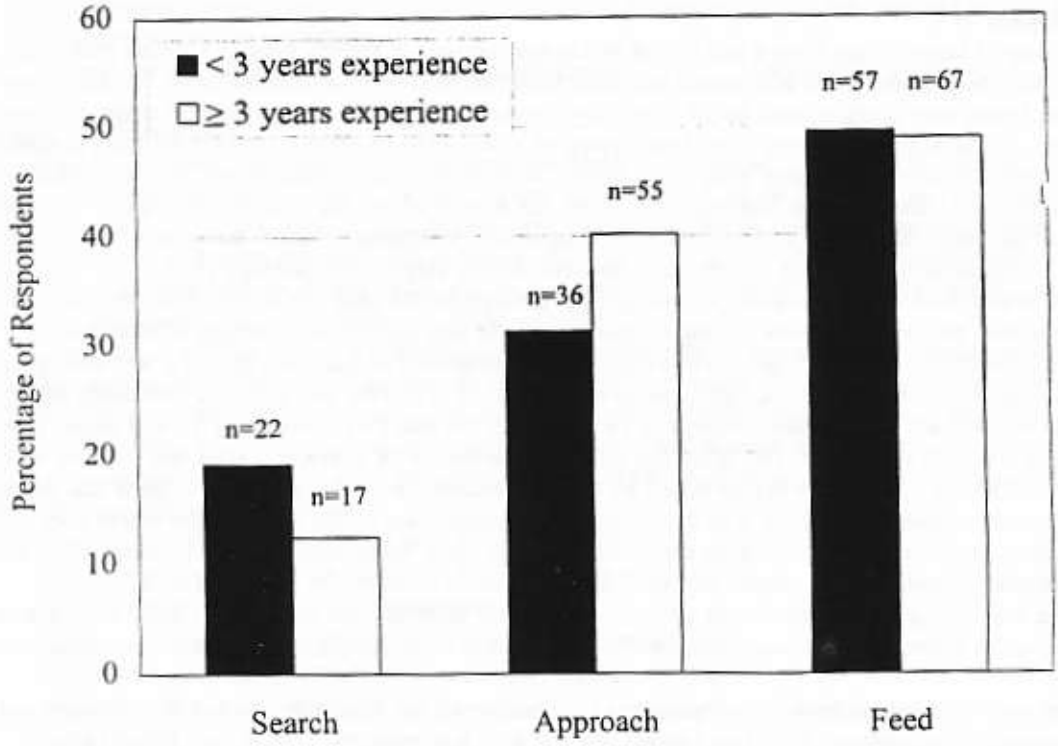

Figure 2. Identification of final phase of a call as a "feeding buzz" by experienced compared to less experienced researchers (experienced,n=14: less experienced n=12).

* * * * * * *

VIIIth European Bat Research Symposium
Kracow, Poland in August 23 - 27, 1999.

The VIIIth European Bat Research Symposium will be held in Kracow, Poland hosted by the Chiropterological Information Centre of the Institute of Animal Systematics and Evolution, Polish Academy of Sciences. The symposium will be held at one of the conference centres in Kracow and will run from Monday 23 August to Friday 27 August, 1999.

The provisional programme will consist of four plenary sessions, four oral presentation sessions and four poster sessions. Plenary sessions will include systematics and evolution, ecology, behaviour and conservation. Although we are expecting a large number of participants, we hope to avoid having concurrent sessions. The number of oral presentations will be limited to about 40. Thus we encourage as many of you as possible to present poster papers. The official language of the conference will be English. All papers, posters and communications should be prepared in English.

A second circular will be sent in late 1998 to all who contact the host (address below) . The second circular will contain the outline of the programme for the Symposium, the formal call for papers, and forms for registration, hotel accomodationss and the submission of abstracts. Registration costs have not been determined as of this date but there will be a reduced registration fee for students.

Address all communications to:

Professor Bronislaw W. Woloszyn, Chiropterological Information Centre,
Institute of Animal Systematics and Evolution, Polish Academy of Sciences,
ul. Slawkowska 17, 30-016 Krakow Poland
e-mail address: woloszbr@ isez.pan.krakow.pl or: VIIIEBRS@isez.pan.krakow.pl
Tel. +4812/422-64-10 or +4812/422-19-01 FAX +4812/422-42-94

News from our Colleagues

from Japan

By way of introduction, I am a zoo keeper at Toyama Municipal Family Park in Toyama Prefecture, Japan. I have been interested in hibernation and daily torpor of insectivorous bats for about 5 years. Since that time, I have been doing reserch on the type of daily torpor in *Myotis macrodactylus* in a tunnel in my free time. At the beginning of my study from spring of 1996 to fall of 1996, once each month I counted the number of bats and measured body weight(Bw), body surface temperature(Tbs), and wall surface temperature(Tws) and ambient temperature(Ta) in the tunnel where the bats were resting. *Myotis macrodactylus* used this tunnel from late March to August this year(perhaps before the onset of the mating season). In midsummer(July and August) the bats were in daily torpor; their average Tb was 14 °C. This tunnel was also used by *Rhinolophus ferrumequinum* throughout the year. In midsummer, *Rhinolophus ferrumequinum* moved in and flew around in this tunnel. In this period, the averages of their Bw were increasing slowly. In April, average Tb was higher than average of Tws and average of Ta, and average of Tws was higher than average of Ta. All of these measurements (Tb, Tws, and Ta) were increasing slowly from April to August. But in May, average of Ta crossed to Tbs and Tws. Average of Ta was higher than average of Tbs and average of Tws after this month. Fluctuation of average of Tbs was parallel with average of Tws. All Tbs were higher than Tws that I measured during this research. I think that when *Myotis macrodactylus* most likely is in daily torpor, the temperature of the wall surface where they are resting may be an important factor in the fluctuation of their body temperature, because when *M. macrodactylus* are resting, their ventral surface is in very intimate contact with the tunnel wall.

I am continuing this research and collecting the same kind of data concerning daily torpor and hibernation in *Rhinolophus ferrumequinum*, for comparison of these phenomena between these two species.

I am very interested in hearing the opinions of the readers of Bat Research News of this research and will welcome any suggestions as to how I might proceed with this research. Thank you, Hitoshi Murai

202 High-corp Shiroyama, 3264-7 Yoshizukuri, Toyama City, Toyama PRF JAPAN 930 - 0142
e-mail is: rumbat@tym.fitweb.or.jp

from Texas

Plastic bat houses designed by Marvin Maberry, a Research Associate in BCI's North American Bat House Research Project, have successfully attracted four species of bats. Mexican free-tailed bats, evening bats, and big brown bats have used plastic houses in Texas, and little brown bats have used them in Wisconsin and Pennsylvania. Maberry has two designs, a nursery house, and a smaller, insulated model. The nursery house design is the only one in Texas in which free-tailed bats have been documented to rear young. Up to 700 free-tails have been found in this model. A colony of 65 Big brown bats used a pair of insulated houses in northeast Texas as a maternity roost during summer, and several bats overwinter in them as well. To order these bat houses, or for more information, contact Marvin Maberry at Unique Homes, 1407 Maberry Road, Daingerfield, TX 75638, (903) 645-7780. Submitted by Mark Kiser, Coordinator, North American Bat House Research Project, BCI, PO Box 162603 Austin, TX 78716, tel. 512-327-9721 e-mail: mkiser@batcon.org

from Wisconsin

Being a caver (I now work for the DNR in a non-wildlife capacity), most of my work has been with bats that hibernate in the caves and mines in Wisconsin. I also hear a bit of what goes on elsewhere in the state. Biannual censuses in the southwestern part of the state show that populations (of mostly *Myotis lucifugus*) have been holding stable. Temperature monitoring of the Neda mine in south-central Wisconsin has been ongoing since just before gating two years ago and early data show that the gates have not affected the internal temperature. We recently retrieved the data loggers from last winter and will see if El Nino has had an effect. In northwest Wisconsin, I hear that the Bay City mine is now gated to protect the bats. On the other hand, DNR wildlife managers and others around the state have noticed not seeing as many bats this summer. There is no data to go with this as we currently have no summer monitoring programs, but I

have heard it from enough places that it is not to be discounted. Finally, there are plans to erect wind-powered electical generating farms. Work is starting on understanding how this will affect bats. While there has been a history of research on bird interactions with these windmills, we have had little luck so far in finding work on bats and windmills.

Submitted by Joe Senulis. e-mail: senulis@acm.org or senulj@dnr.state.wi.us

from Washington

The Washington State Bat Working Group has recently been formed. This group is a sub-group of the larger Western States Bat Working (WSBWG) Group. The vision of the WSBWG and it's member state groups, including the WABWG, is that all interested and responsible individuals, agencies, interest groups and businesses will work cooperatively to ensure that bats are conserved throughout their existing ranges and within suitable historic ranges. Bats will be preserved for the sake of biological diversity, ecological integrity and for the benefit of present and future humanity.

The purpose of both groups is to facilitate communication among interested parties and reduce risks of species decline or extinction. Recognizing that time and resources are limited, we hope to provide a mechanism by which current information regarding bat ecology, distribution, and research techniques can be readily accessed. We envision a forum in which conservation strategies can be discussed and education programs encouraged and advocated. Involvement in the WABWG is entirely voluntary. Anyone interested in bats is encouraged to participate.

For more information, please contact any of the following:

Eric Larsen at (360) 902-2618 or LARSEEML@dfw.wa.gov

Scott Pedersen at Bathead@u.washington.edu

Kerensa King at (360) 677-2414 or KerensaK@premier1.net

Jessica Eskow at (253) 770-7838 or eskowj@champint.com

Peter Forbes at (509) 653-2205 or prforbes/r6pnw_wenatchee@fs.fed.us

submitted by Kerensa King

from Erlangen, Germany

York Winter has send us this very comprehensive "news" about the Programs of Bat Research at Erlangen University in Erlangen, Germany

Bat research at the Institute of Zoology, Erlangen University, under the auspices of Prof. Dr. Otto von Helversen, Dr. York Winter, Dr. Marco Tschapka, Dr. Frieder Mayer and Dr. Roland Aubauer is centered around the following main topics:

Ecology and physiology of nectar-feeding bats (Glossophaginae, Phyllostomidae)

Our work is centered around (1) our animal keeping facilities at Erlangen University with four tropical greenhouses dedicated to our currently 200+ individuals of nectar-feeding bats which we have been keeping and breeding since 1982 (*Leptonycteris curasoae, Choeronycteris mexicana, Glossophaga soricina, G. commissarisi, Hylonycteris underwoodi, Lonchophylla robusta* and *Anoura geoffroyi*) and our laboratories which include flight cages with a fully automated nectar-feeding (with computer operated pumps) and activity monitoring system. (2) The lowland tropical rainforest at La Selva Biological Station, Costa Rica and (3) Ecuador.

Marco Tschapka, Ph.D., 1998, summarized in his thesis the results from his more than two year stay at La Selva Biological Station in Costa Rica where he studied flower resource use mainly by *Glossophaga commissarisi, Hylonycteris underwoodi, Lonchophylla robusta* and *Lichonycteris obscura* and established the phenologies of the bat-pollinated plants.

Felix Matt is working on his PhD research in Ecuador to elucidate bat - plant interactions at this tropical rainforest site.

Jorge Lopez joined us from Guatemala on a DAAD (Deutscher Akademischer Austauschdienst = German Academic Exchange Service) doctoral fellowship. He works on the sensory physiology (vision and hearing) of glossophagine bats. During previous work for his Master's thesis he investigated the seed dispersal by frugivorous bats at La Selva Biological Station in Costa Rica.

Brigitte Pink carries out her doctoral research on social interactions between mother and young *Glossophaga soricina* using IR-video in our colonies of captive individuals.

from Germany continued...

Christian Voigt Ph.D., 1998, studied the energetics of pregnancy and lactation in glossophagine bats (using DLW in collaboration with Tom Kunz), the cost of hovering flight in glossophagine bats, and the relevance of calcium for nectar-feeding bats.

Dagmar von Helversen, together with her husband she has documented the first case of an 'acoustic nectar guide' in a flower. The vexillum of flowers of the glossophagine-pollinated vine *Mucuna holtonii* acts like an acoustic triple mirror that reflects echolocation calls with high intensity to advertise open flowers.

York Winter's main activities have focussed on elucidating the energetic parameters which are of relevance for the ecology and competitive species interactions in glossophagine bats. These include measuring the cost of level forward and hovering flight in glossophagine bats and daily energy expenditure and aspects of foraging and nectar-feeding. Several flight tunnels (14 to 50 m) with an automated feeding system serve to study aspects of flight and foraging behavior (flight speeds, kinematics of flight using high speed filming in collaboration with U. Norberg). A wind-tunnel has now been completed to establish(hopefully) the flight power to flight speed relationship in small nectar-feeding bats. For this work on energetics he also developed a new technique of constructing miniature electrocardiogram transmitters (350-450 mg) for implantation in small bats. In collaboration with W. Nachtigall (100-point anemometer) and R. Dudley, U of Texas, (Heliox) he hopes to learn more about the biomechanics of hovering flight. In the search to elucidate the mechanisms explaining sympatric occurrance of the two sibling mouse-eared bats (*Myotis myotis* and *M. blythii*), he recently, with Raphael Arlettaz, examined the flight behavior of individuals of these two species while they were flying up and down a 50-m flight tunnel with an obstacle course between two automatic mealworm dispensers. Reprints can be obtained as electronic photocopies by entering

"HYPERLINK ftp://server.biologie.uni-erlangen.de/pub/winter-lit/winter-lit.txt
ftp://server.biologie.uni-erlangen.de/pub/winter-lit/winter-lit.txt" into Netscape.

Social organization and harem maintenance in the neotropical bat *Saccopterix bilineata*

Christian Voigt Ph.D., 1998, marked, observed and radio-tracked individuals of *Saccopteryx bilineata* in the harem roosts around La Selva Biological Station in an effort to understand the mechanism behind the peculiar harem organization of this species.

Gerald Heckel is continuing for his doctoral research the work initiated by C. Voigt by using DNA-analysis (with Frieder Mayer) to establish patterns of relatedness and reproductive success in this harem bat.

Population genetics of bats

This work is centered around our DNA lab for performing molecular analyses of relatedness. A variety of genetic techniques are used including multi-locus DNA fingerprinting, analysis of microsatellites and sequencing of mitochondrial DNA in order to study relationships on the individual, population or phylogenetic level.

Frieder Mayer, studied paternity of twins of the noctule bat *Nytalus noctula* and is interested in sperm competition of bats. He is also interested in the phylogeny of bats. As the 'backbone' of the DNA-lab he is also involved in the other studies that are performed here.

Eric Petit, Ph.D.,1998, who joined us as a doctoral student from France, completed his dissertation on the genetic structure of European populations of the noctule bat *Nyctalus noctula*.

Gerald Kerth, Ph.D., 1998, now at the University of Zurich, is studying the microgeographic population structure and relationships among individuals of *Myotis bechsteini*. He is interested in the evolution of group living and social behavior in bats.

In a comparative approach female philopatry and its consequences on geographic population structure is being studied in several species including *Myotis myotis* (Renata Paszkiewicz, University of Worclaw, Poland), *Pipistrellus pipistrellus* (Sandra Huttenbugel, University of Marburg, Germany) and *Miniopterus schreibersi* (Peter Gombkete, University of Debrecen, Hungary).

Echolocation and flight behavior of European bats

Roland Aubauer, an electronic engineer specialized in acoustics, joined the Erlangen group in 1998 after a two year post-doctoral study in Hawaii where he studied the sonar system of dolphins. Formerly, he has developed an 8-microphone array which provides the sensory input for a cross-correlation analyzer to

from Germany continued...
automatically track the flight paths of echolocating bats. He is now modifying his phantom-echo system, which he developed in Hawaii, for studying bat echolocation.

Marc Holderied is using for his doctoral research the 8-microphone array in the field for a combined study of the flight behavior and echolocation of European bats.

Conservation mangagement of Southern German bats

Mathias Hammer is currently the coordinator for conservation and management activities of North Bavarian bats, a programme funded by the Bavarian Agency for Environmental Protection (LfU).

A recent event

On July 23, 1998, The Faculty of the Natural Sciences of Erlangen University conferred the degree of 'Doctor honoris causa' (Dr. h.c.) on Jorgen Gebhard, Basel, Switzerland, in recognition for his research on the biology and social behavior of the noctule bat *Nyctalus noctula*.

Submitted by York Winter, Institute of Zoology II, Erlangen University, Staudtstrasse 5, 91058 Erlangen, Germany. e-mail: ywinter@biologie.uni-erlangen.de

From Seattle, Washington

The following letter was sent to me in response to, "send us some news about what you are doing with bats these days". It really is addressed to all of us. GRH

Dear Roy:

In response to your "plea" to subscribers of Bat Research News for more current news about ongoing bat research, I would like to suggest another potential category of interesting news for BRN to present. I suspect that many of your subscribers, myself included, are not currently involved in research on bats. We did do such research at one time, but due to the twists of fate that happen to all of us, we have had to leave research altogether or change to other areas of biology. We still maintain an intellectual interest in bats, as demonstrated by or subscription to Bat Research News, but have moved on to other things in order to pay mortgages, grocery bills and college tuition.

Members of this subset of Bat Research News subscribers are currently engaged in other interesting areas of biological research or in other pursuits. I would be interested in learning what other members of the group of bat "alumni" are doing now, and more importantly, how they got from bats to where they are now. I think such information would be valuable for your student readers given the current direction of biology toward the molecule and gene and away from the organism and environment. A significant portion of these students will have to move away from bats(and all intact organisms) if they are to make a living studying life and living systems. Explicit descriptions of how others have accomplished this transition should aid the next generation of biologists in meeting this challenge when they are confronted by it.

Now that I have proposed the idea, I guess it is my duty to bare my past for all to see. My initial interest in bats focused on the physiology and physiological ecology of temperate, insectivorous bats. My interest in mammalian hibernation soon expanded to include renal function and water balance in these animals. I completed a Ph.D. thesis on that subject in 1977 and moved to a postdoctoral position with plans to learn the techniques to study the physiology of cardiovascular fluid balance(the Starling Forces and Equilibrium) in hibernating animals. This area of physiology is concerned with how we keep water in the cardiovascular system and out of tissues over time(i.e., how to prevent edema formation).

In retrospect that move began my transition from studying bats per se to studying microvascular physiology. From that point on in my career, I have studied primarily the control of microvessels (arterioles, capillaries and venules) and the exchange of materials across capillary walls. My first interest in microvascular physiology was the control of the microvessels of the bat wing. The double layer of skin which propels the bat also contains a vascular bed which can be observed repeatedly at up to a thousand-fold magnification without harming the animal. The bat wing remains the only unanesthetised, nonsurgically-prepared microvascular model available.

I moved on from in vivo studies of the bat wing to in vitro studies of smooth muscle mechanics and

pharmacology in cerebral penetrating arterioles(20-50 μm in diameter) utilizing a cannulation technique. After these studies, I returned to the intact organism to study the exchange of protein and water across the vessels of synovial lining of joints. The effects of both acute and chronic inflammation on these processes are of great clinical importance today. As our population ages, the incidence of arthritis of all types increases along with the cost of treating these patients. My current work on microvessels examines the exchange of small molecules across the capillaries of coronary circulation. We employ multiple indicator dilution techniques in conjunction with computational biology to study the biochemistry of cardiac adenosine metabolism. Adenosine is a vasodilator currently suspected of being the long-sought control molecule that links tissue metabolism to local blood flow.

My career has not been as well planned as those of some of my contemporaries. Like most things in life, it has progressed by taking advantage of opportunities which presented themselves at points of transition. I hope my idea of requesting the "alumni" of bat research to explain how bats got them started on their current endeavors expands the pool of news available for BRN, even if it is not about current bat research per se.

Best wishes. John E. Bassett, Ph. D. John's e- mail is: microman@U.WASHINGTON.EDU

Studbook for the Rodrigues Fruit Bat *Pteropus rodricensis*

The North American Regional Studbook for the Rodrigues fruit bat *Pteropus rodricensis*has been published. This is the second edition of the studbook and data is current throught 31 December 1997.

The studbook was established in 1993 to help North American Zoos manage this endangered species in captivity. This is currently the only managed endangered species held in captivity. It is hoped that this species will serve as a model species for group management.

There are currently 290 (154.128.8) Rodrigues fruit bats in 8 institutions in North America. This population is part of a world population which originated from the Black River Aviaries, Mauritius and the Jersey Wildlife Preservation Trust, Channel Islands.

For more information contact: Steven M. Wing, Studbook Keeper, Riverbanks Zoo, PO Box 1060, Columbia, SC 29212-1060, USA or e-mail: swing@riverbanks.org

New Books on Chinese Mammalogy

I have received the following announcements from Yan Yuanliang at the Huayu Center for Environmental Information Services in Beijing, China concerning three new books about mammals in China. It is not likely that these works will be widely advertised world-wide, so I include the following information for those who may be interested. GRH

THE FOSSIL ANIMALS OF CHINA [Chinese-English-Japanese]

Chief Editor: Guan Jian , Published in 1998. 197 pages, about 550 color pictures.

ISBN: 7-5027-4487-8 Price: US$ 120 , Postage US$10, Total US$130

Introduction: In recent years, many revolutionary discoveries from China have been adding to and rewriting the history of evolution. Examples include evidence of the bio-explosion of early Cambrian-Chengjiang fauna; new discovery of earliest(580 million years ago bio-fauna from Guizhou) abundant dinosaur fossils in different areas of China; ancient birds from Liaoning; discovery of and research on the Miocene mammals of northwestern China; and the new human fossil discoveries such as Hexian Man and Tangshan Man. These discoveries bring illumination and hope for paleontologists during a difficult time.

This book outlines the kinds of fossil animals discovered in China. The latest fossil discoveries are highlighted including early Cambrian invertebrate fossils from Chenjiang, Yunnan, Shunosaurus fauna from Sichuan, late Jurassic primitive bird, and Rehe fauna from Liaoning, late Jurassic sauropod fauna from Yunnan, and fossil mammals from northwestern China. In coordination with philadelphias*s Dinofest*s 98 and the exhibition at the Lake Biwa Museum, this book supplements the materials on display including Lufeng prosauropod fauna from Yunnan. Miocene Mammalian fauna from Ningxia and the most recent bird discoveries

DISTRIBUTION OF MAMMALIAN SPECIES IN CHINA

(Chinese-English Ed.) Chief Editor: Zhang Rongzu

Published in 1996. 328 pages. Hardback/US$150 +Postage US$15 = US$165

The volume is a systematic information on mammal distribution of China. Substantially, it is an atlas of distribution maps with detailed records at county level. It includes all the mammals known in China, comprising 506 specie, which are classified as 51 families and 14 orders. This volume is in Chinese-English bilingual. The lists and maps are followed by texts arranged in order of taxonomic system. Each species included the following items: (1)nomenclature, including scientific names, Chinese names and English names; (2)subspecies and their main ranges; (3)distribution records in China; (4)habitat; (5)brief account of range abroad. The chief author Professor Zhang Rongzu is one of the most active pioneers of zoogeography in China. He has conducted field work practically in the whole country for the past two decades. He has been enthusiastic about wildlife conservation and is a member of IUCN.

WILDLIFE OF CHINA (English Edition)

Edited by China Wildlife Conservation Association. 133 pages, 230x300mm

Published by China Forestry Publishing House. More than one hundred color photographs

US$80+Postage 10 = US$90

China is a vast country which from north to south extends across the equatorial belt, the Torrid Zone, sub-tropical zone, Temperate zone and the Frigid Zone; while stretching westward from the eastcoast to the hinterland of the Asian continent. Wildlife abounds in such favorable geographical conditions and climates. The fauna of mainland China belongs to Palaearctic and Oriental Zones. Not only does China possess various kinds of wild animals of economic value, it also has more than a hundred species of world-famous rare and precious animals. To disseminate and popularize the knowledge of wild life, many scientists and cameramen have , in the past years, risked their lives against hardships, all for the purpose of photographing wildlife in their natural habitats. We have chosen more than a hundred photographs from their large collection to the prepare this book for readers.

Order any of these three books from:

Huayu Center for Environmental Information Services, P.O. Box 4088, Beijing 100001 P.R. China.

Fax Order: +86-10-68575909, E-mail: hceis@ mx.cei.gov.cn

We shall mail the book and invoices to you on receipt of you order.

The 28th Annual North American Symposium on Bat Research

will be held October 28-31, 1998 in Hot Springs, Arkansas

All subscribers to Bat Research News and all who attended last year's conference in Tucson, AZ will automatically receive a registration packet by mail in the late spring/early summer. All others interested in receiving information on the conference, please contact Tom Griffiths at tgriff@titan.iwu.edu or 309-556-3230.

Hot Springs is beautiful in October, and we anticipate a large turnout!

Conference Logo: Silver-haired bat *Lasionycteris noctivagans* from "The Wild Mammals of Missouri," and courtesy of Dr. Elizabeth Schwartz and Univ. of Missouri Press

We recommend that you reserve a room early at the conference hotel: **The Arlington Resort Hotel (1-800-626-9768 or 1-800-643-1502 or 501-623-7771).** Tell them you are with the North American Symposium on Bat Research.

Conference Host: David A. Saugey, U. S. Forest Service, Jessieville AR
Program Director: Tom Griffiths, Illinois Wesleyan U., Bloomington, IL

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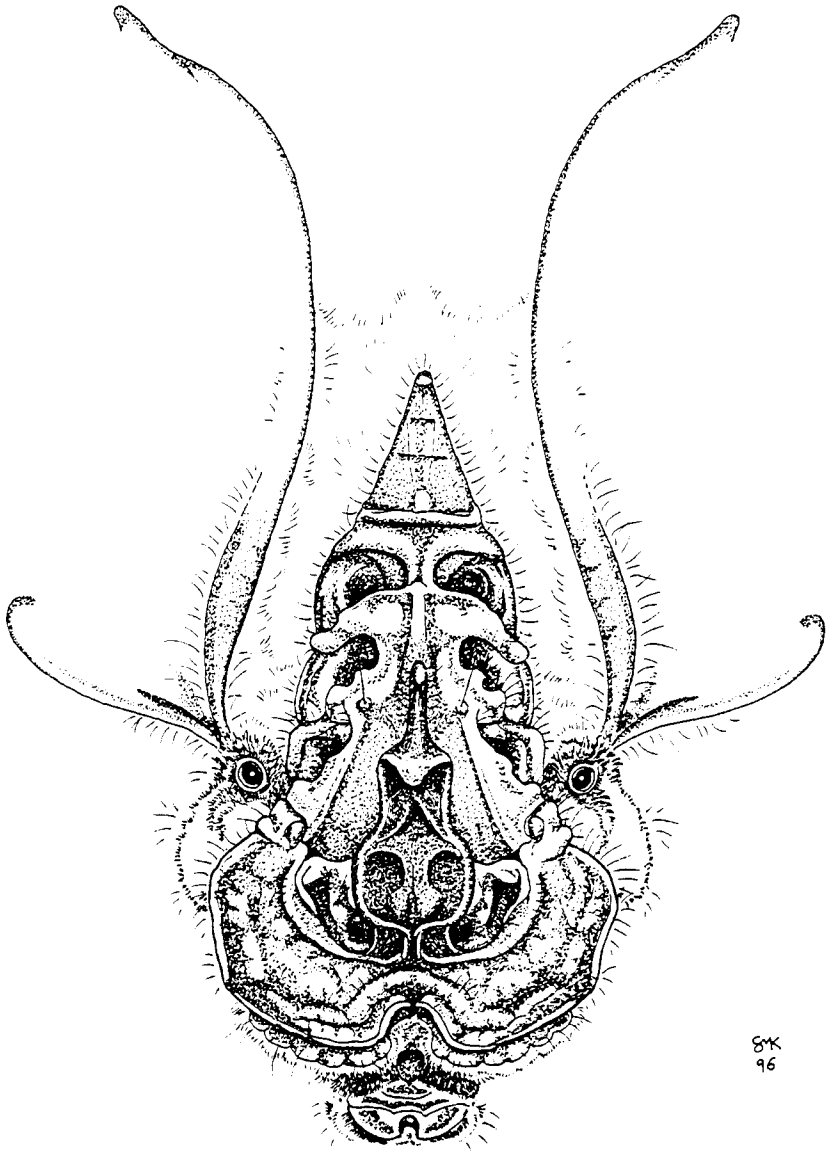
Front Cover

The lovely line drawing of the brown long-eared bat *Plecotus auritus* , is the artistic work of Sheelagh Kerry, who resides at 1, Bettws Cottage, Abergavenny, Gwent, Wales, United Kingdom NP7 7LG.

If you have an illustration of a bat (or bat-related object) that you would like to see on a future cover, please send it to us for our consideration. If it appears on an issue, you will receive one year of Bat Research News in return. Line drawings are best, photos are often difficult to reproduce well. GRH

BAT RESEARCH NEWS



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G. Roy Horst
Bat Research News, P.O. Box 5068, Potsdam, NY 13676-5068 U.S.A.
Tel. 315-267-2259 FAX 315-267-3170 E-mail: horstgr@potsdam.edu.

Editor for Feature Articles
Allen Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197
Tel. 734-487-1174 FAX 734-487-9235 E-mail: bio_kurta@online.emich.edu

Editor for Recent Literature
Thomas A. Griffiths, Department of Biology, Illinois Wesleyan University, Bloomington, IL 61702
Tel. 309-536-3230 FAX 309-536-3411 E-mail: tgriff@titan.iwu.edu

Editor for Conservation Education
Patricia Morton, Texas Parks and Wildlife Department, Suite 100, 3000 IH 35 South, Austin, TX 78704
Tel. 512-912-7046 FAX 512-912-7058 E-mail: patricia.morton@tpwd.state.tx.us

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BAT RESEARCH NEWS

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11th International Conference on Bat Research
August 2 to 6, 1998
Pirenópolis, Brazil

Following are the abstracts of the presentations to the 11th International Conference on Bat Research, held August 2 to 6, 1998 at Hotel Pousada dos Pireneus, in Pirenópolis, Brazil and sponsored by The University of Brasilia. The Convenors of the Conference were Jader Marinho-Filho, Ludmilla Aguair and Wilson Uieda. In the past we have presented conference abstracts in alphabetical order by the first author. The abstracts appeared in the program grouped by subject matter and rather than rearrange the very large number into alphabetical order with the possibility of introducing error or omitting one or more, they are arranged here by subject, as they were in the program. To facilitate finding the abstract of a given author there is an index following the abstracts. GRH

BATS AND HEALTH

EVOLUTION OF RABIES IN VAMPIRE BATS THROUGH THE ANALYSIS OF EPIZOOTY OF BOVINES FROM THE STATE OF RIO DE JANEIRO FROM 1984 TO 1997

da Silva, M.V., de Oliveira, A.N., de Moura, W.C.[1] and de Figueiredo, M.J.

Instituto Municipal de Medicina Veterinária "Jorge Vaitsman". [1]Fundação Oswaldo Cruz

Farm animals, like cattle and horses are last in the chain of the rabies cycle. The disease is maintained in the vampire bat population. In 1986 a serious outbreak started in the bovine population in the southern end of the state. By analyzing the geographic distribution of the cases confirmed in the laboratory by immunofluorescence and mouse inoculation tests, it was possible to define five different regions that showed outbreaks at different times. The epizooty shows the following pattern: it starts in an area and stays there for a varied period, after that, the outbreak starts in a region bordering the former. Following this pattern, the epizooty started in the southern end of the state in 1987. In 1990 it went to the mountainous region. In 1993 it arrived in the northern regions of the state. This bovine epizooty clearly advances with bat migration. It is possible to follow the rabies epizooty in vampire bats and discover the infected individuals before the outbreak in bovine population. At the same time, more effective control strategies to reduce vampire bat populations could be improved in the areas bordering the epizooty.

RABIES IN NON-HEMATOPHAGOUS BATS IN RIO DE JANEIRO CITY SINCE 1983 TO 1997

da Silva, M.V., de Oliveira, A.N., de Moura, W.C.[1] and de Figueiredo, M.J.

Instituto Municipal de Medicina Veterinária "Jorge Vaitsman". [1]Fundação Oswaldo Cruz

Little is known about rabies in wild mammals of Brazil. In general the virus is detected only after a rabies outbreak in the bovine herd. This is directly related to the disease in the vampire bat population. The rabies laboratory of the IMM''JV is responsible for all the exams from the city. During a 15 year period, 11,484 mammalian brain samples were analyzed. Only 77 (0.67%) were bats and all of them were non-hematophagous. Four were positive. The last two cases had strong histories of attack on humans in residential flats of the 6th and 7th floors. Each were sited in different places, but both locations being

densely populated. Geographic distribution revealed that the majority of the samples came from populous areas. This fact could raise the likelihood of bites. Besides, the bat attack was the main reason why people brought in the animal for diagnostics.

IDENTIFICATION OF NON-HEMATOPHAGOUS BATS SUBMITED TO RABIES LABORATORY

da Silva, M.V., de Oliveira, A.N., de Moura, W.C. [1] and de Figueiredo, M.J.
Instituto Municipal de Medicina Veterinária "Jorge Vaitsman". [1]Fundação Oswaldo Cruz

Bats belonging to 14 genera had their brains removed for rabies diagnostics via direct immufluorescence and mouse innoculation tests. The species and results are: one *Anoura caudifer*, two *Artibeus lituratus*, one *Artibeus sp.*, one *Carollia perspicillata*, two *Pteronotus personatus*, one *Chiroderma villosum*, three *Glossophaga soricina*, one *Histiotus sp*, two *Molossus ater*, five *Molossus molossus*, and one *Myotis nigricans* were negative. One Phyllostomidae, one *Phyllostomus hastatus*, two *Promops nasutus*, one *Sturnira lilium*, three *Tadarida laticaudata* and one *Vampyrodes caraccioli* were positive.

ORAL MICROBIOTA OF BATS IN PUERTO RICO

Archila-Diaz, L., Cruz, D.B. , Perez Jimenez, J., Vasquez Torres, R. and Rodriguez-Duran, A.
Dept. of Natural Science and Mathematics Interamerican University, Bayamon, Puerto Rico

Among the most abundant microorganisms in the oral cavity of mammals are bacteria and fungi. The most predominant bacteria in the mouth are cocci and filamentous bacteria. The most common fungi are yeast. In this study a different situation was found: rods and filamentous bacteria are predominant in bat oral cavities. Growing interest in speleology and ecotourism have increased the frequency of contact between people and bats. Therefore it is important to understand the possible consequences of such encounters. Studies of microbial populations in bats could allow us to understand their role in the environment and its potencial applications. Seven of the thirteen known bat species on the island of Puerto Rico were studied. The species differ in their feeding habits and choice of roost, as well as morphological and physiological aspects. Samples of eight individuals of the seven species were collected using sterile swabs and properly diluted prior to cultivation. Microbial isolates were studied on the basis of macroscopic characteristics of colony and microscopic structures. Bacterial isolates were initially classified using selective biochemical tests. Molds were identified using taxonomic keys by microscopic examination. Our results demonstrate a microbial diversity in the mouth of bats. Grampositive coccus, Grampositive and Gramnegative rods, and filamentous bacteria have been found in all species. The most prevalent mold is *Penicillium*. Biolog and API Systems were used to discriminate among the isolates. Through the analysis of the data we noticed that there is a possible relationship between the feeding habits of bats and their oral microbiota.

SURVEY ON ANTI-LEPTOSPIRA AGGLUTININS IN CHIROPTERA SERA IN BOTUCATU REGION, SÃO PAULO STATE, BRAZIL

Gimenes-Bosco, S.M., Souza, L.C. , Meireles, L.R., Gottschalk, S., Langoni, H. and Carreira, R.C.
Departamento de Higiene Veterinária e Saúde Pública, Faculdade de Medicina Veterinária e Zootecnia - UNESP/Botucatu, 18618-000 - Rubião Junior, São Paulo - Brazil,

Leptospirosis is a worldwide disease of man and numerous species of wild and domestic animals; it is caused by a great variety of Leptospira serotypes. A total of 83 sera samples of chiroptera from the Botucatu region were examined by the microscopical serum agglutination test (MSA). The sera were obtained by heart venopunction and they were frozen at -20°C till the moment of being processed. Twenty-four serotypes of *L. interrogans (australis, autumnalis, bratislava, butembo, bataviae, brasiliensis, castelonis, canicola, copenhageni, cynopteri, djasimam, grippotyphosa, hardjo, hebdomadis, icterohaemorrhagiae, javanica, panama, pomona, pyrogenes, sentot, shermani, tarassovi, wolffi, whitcombi)* and 5 serotypes of *L. biflexa (andamana, illini, patoc, garcia, nazare)* were used. Seven (8,40%) sera samples of *Carollia perspicillata* specie (3 females, 42,85% and 4 males, 57,15%); 09 (11,00%) *Mollossus mollossus* (9 males, 100,00%); 01 (1,20%) *Nyctinomops laticaudactus* (1 male, 100,00%); 01 (1,20%) *Glossophaga soricina* (1 male, 100,00%); 01 (1,20%) *Anoura caudifera* (1 male, 100,00%) and 64 (77,00%) *Desmodus rotundus*

(19 females, 29,69% and 45 males, 70,31%) were analyzed. All of the 83 sera samples turned out to be negative of MSA. Despite that these results were negative, the role that these animals represent in the epidemiology of this disease must be considered, since these groups of animals may be a natural reservoir or accidental host of *Leptospira* sp., and, possibly, transmitters of this important zoonosis. These are preliminary results from research in evolution.

SURVEY ON DIMORPHIC PATHOGENIC FUNGI IN CHIROPTERA FROM THE BOTUCATU REGION, SÃO PAULO STATE, BRAZIL

Gimenes-Bosco, S.M., Souza, L.C., Gottschalk, S., Meireles, L.R., Langoni, H. & Bagagli, E.[1]
Departamento de Higiene Veterinária e Saúde Pública Faculdade de Medicina Veterinária e Zootecnia - UNESP/BOTUCATU 18.618-000 - Rubião Júnior, SP - Brazil
[1]Departamento de Microbiologia e Imunologia Instituto de Biociências - UNESP/Botucatu

Pathogenic dimorphic fungi have been recovered from feces and soil enriched with bat feces. Besides the soil, some species of fungi had already been isolated from bat organs, such as: *Candida* sp., *Cryptococcus neoformans*, several species of dermatophytes, *Coccidioides immitis, Histoplasma capsulatum, Cladosporium* sp., *Sporotrichium* sp., *Paracoccidioides brasiliensis* and *Blastomyces dermatitidis*. Botucatu is an important endemic area of paracoccidioidomycosis and, based on this fact, we started this survey using, till the moment, 15 bats of *Desmodus rotundus* (6 females, 40% and 9 males, 60%) and 2 *Carollia perspicillata* (2 males, 100%) caught in this region. The animals were sacrificed and their organs (lung, liver and spleen) were aseptically collected. Fragments of the organs (0,2-0,3 mm) were cultivated on Saboraud (plus cloramphenicol) and Mycosel (plus gentamicin) agar plates and incubated at 35°C for 6 weeks. In these respective media we evaluated 559 and 561 liver fragments; 70 and 69 spleen fragments; and 161 and 157 lung fragments. No *P. brasiliensis* nor *H. capsulatum* were isolated from these animals. The growth of the contaminating fungi was observed in 49 lung fragments cultivated on Saboraud agar. Since bats mainly have arboreal habits, these results confirm some previous findings which point out soil as a major reservoir of pathogenic dimorphic fungi. More studies of fungi isolation from soils with bat feces (guano) are necessary for a better comprehension of the role of these animals in the epidemiology of these mycoses.

LEPTOSPIRES IN BATS FROM SÃO PAULO, BRAZIL

Santos, M.G.S., Dias, M.A.G., Berardis, E.G. and Almeida, M.F.
Centro de Controle de Zoonoses - Rua Santa Eulália, 86 - Santana - SP - SP - Brasil, CEP 02031-020

In two municipals of São Paulo State, Jundiaí and São Paulo, blood samples of 71 non-hematophagous bats were collected, 50 being from *Molossus molussus*, 8 from *M. ater*, 5 from *Eumops auripendulus*, 2 from *Eptesicus brasiliensis*, 2 from *Artibeus lituratus*, 1 from *Nyctinomops laticaudatus*, 01 from *Eumops perotis*, 01 from *Carollia perspicillata* and 1 from *Glossophaga souricina*. Serum was tested by a microscopic agglutination test against 20 live antigens for leptospirosis. It was shown that two (2.8%) of the 71 bats had antibodies to soro group pyrogenes 1:100, being one of the *Molossus molossus* and one *M. ater*. This is the first time that the presence of leptospiral agglutinins in non-hematophagous bats has been detected in São Paulo State.

LABORATORY DIAGNOSIS AND RESEARCH OF RABIES ANTIBODIES IN BATS IN THE SÃO PAULO STATE, BRAZIL

Almeida, M.F.[1], Aguiar, E.A.C.[1], Martorelli, L.F.A.[1], Nunes, V.F.P.[2]
[1]Centro de Controle de Zoonoses - São Paulo - SP. Rua Santa Eulália, 86-Santana-CEP 02031-020
[2]Divisão De Controle De Zoonoses - Jundiaí - SP

Between 1992 and 1997, the Center of Zoonosis Control of São Paulo city received 1605 specimens of bat rabies diagnosis by FA-Fluorescent Antibody and MIT-Mouse Inoculation tests. Blood samples were collected from the 653 of the 1605 bats and the sera were analyzed by RFFIT-Rapid Fluorescent Focus Inhibition Test for research of rabies antibodies. Seven bats were positive for rabies in FA and MIT tests (0,44%). The prevalence of the antibodies was 4,3% (28/653) using 0,5IU/ml like cut-off, but 248 speci-

-mens showed titers higher than 0.1IU/ml indicating previous contact with the rabies virus. The insectivorous bats (85.9%) and *Molossus molossus* (68.8%) constitute the majority of the samples and females were predominant (69.2%). The majority of the bats were captured from the ceilings or attics of houses and empty spaces of buildings in São Paulo and Jundiaí cities (92.8%) The proximity between humans and bats imply a potential danger of exposure to rabies for humans and pets.

PATHOGENIC FUNGI IN BATS OF THE JUNDIAÍ CITY, BRAZIL

Matos, D.[1], Almeida, M.F.[2], E.A.C.[2] & Martorelli, L.F.A.[2]

[1]Instituto Adolfo Lutz-São Paulo-SP

[2]Centro de Controle de Zoonoses-SP, Rua Santa Eulália, 86-Santana-CEP 02031-020

Ninety two bats (30 males and 62 females) of different species, the majority (91.5%) being insectivorous, and 73% being the specie *Molossus molossus*, were captured inside urban buildings. Liver, spleen and intestine tissues were collected from the bats, resulting in 276 biological samples, that were conserved in PBS-lincomicin, at 3°C/24h. until processing. The samples were macerated, having one aliquot seed in Sabouroud Agar-chloranphenicol and incubated for 30 days at 30°C. Identifications were made according to physiological, biochemical and morphological models. Six biological samples (2.2%) of five bats had fungi potentially pathogenic to humans. One female *M. molossus* showed three species: *Candida famata, Candida guilliermondii* and *Candida parapsilosis* in her spleen; one male *M. molossus* had *Candida famata* in his spleen; one female *Glossophaga souricina* presented *Candida ciferri* from the intestine; one female *M. molossus* had *Cryptococcus laurentii* in the spleen and one female *M. molossus* had *Histoplasma capsulatum* in the liver and in the spleen. This study revealed different fungi species from the group of bats analyzed, which cause human mycosis and have an opportunistic potential.

RABIES IN HUMAN BEINGS TRANSMITTED BY VAMPIRE BATS IN APORA AND CONDE, STATE OF BAHIA, BRAZIL

Gonçalves, M.S. [1,3], J. Sá-Neto, R.[1], Brazil, T.K.[1] and Uieda, W.[2]

[1]Depto. Zoologia, IB, Universidade Federal da Bahia, Salvador, BA. [2]Depto. Zoologia, IB, Universidade Estadual Paulista, Botucatu, SP, Brazil, and [3]Bolsista PIBIC/CNPq

Nowadays, hematophagous and non-hematophagous bats are known as the second major rabies transmitter to human beings in Brazil. In the state of Bahia, cases of rabies upon humans transmitted by vampire bats (*Desmodus rotundus*) have been occasionally related. We record here two outbreaks of human rabies at villages of Aporá (1991) and Conde (1992), which killed five people (four children and one adult). Both counties had 16,000 inhabitants and many small ranches with few heads of cattle. Data obtained from city health services show that 308 cases of attacks upon humans by vampire bats were related during 1991 in Aporá, and 63% of them occurred between February and April. The three deaths by rabies in Aporá (two children and one adult from different families) occurred in the middle of 1991. In Conde, only five attacks were recorded in 1992 (one in January, three in October and one in November), and two people (children from the same family) died of rabies in October. Even though those aggressions upon humans by vampires were already known by health technicians, prevention actions (rabies vaccines to people and vampire control) were taken just after the human rabies transmitted by *D. rotundus*.

BAT RABIES IN THE NETHERLANDS

Lina, P.H.C. Reference Center for Bat Conservation, 2300 AV Leiden, The Netherlands

Reference Centre for Bat Studies and Conservation - P.O. Box 835, 2300 AV Leiden, the Netherlands

The first evidence of the presence of rabies in the Netherlands was found in 1987. Since then, 3,286 bats, collected from 1984 to 1997, and belonging to 11 species, have been examined for rabies. Rabies was found in 219 Serotines, *Eptesicus serotinus*, and in five Pond bats, *Myotis dasycneme*. Approximately 20% of the submitted Serotines were diagnosed as being rabies positive. The majority of the infected animals were found north of the rivers Rhine and Meuse The incidence of rabies in the Serotine in the Netherlands is similar as found for this species in Denmark and in the German federal states Schleswig-Holstein and Lower-Saxony. The present known data about rabies in European bat species make it likely

that rabies is endemic in at least several populations of the Serotine, and scarce or probably absent in other European bat species. The Serotine is mainly a building dwelling species. However, there are no evidences that rabies in this species is a serious risk for public health.

STUDY OF A COLONY OF *DESMODUS ROTUNDUS* AT THE FAZ. SANTA CARLOTA, CAJURU, SÃO PAULO

Hertz, F.S.

Fac. Filos. Ciênc. Let. Rib. Preto - USP. Av. Bandeirantes 3900, Ribeirão Preto, SP, Brasil, 14040-901

The behavior of a colony of *Desmodus rotundus* was studied while testing observation techniques in a water drainage tunnel at the Fazenda Santa Carlota, Cajuru, State of São Paulo (21°20' to 21°27' S, 47°18' to 47°14' W). The most efficient observations within the tunnel were made with infrared night-vision equipment, as opposed to visible light with a red filter. It was also found that a mist-net was easier to manipulate and transport than a harp-trap for external collecting; inside the tunnel a hoop net proved to be highly efficient. Success of collection effort was strongly and negatively influenced by both natural or artificial external illumination, particularly during the full-moon. The number of captured individuals varied, peaks occurring during rainy season. Recapture rates were slightly lower than others reported in the literature, probably due to a larger population size in the study site or to more frequent movement between shelters by the bats. They occupied more than one roosting site inside the tunnel and more than one roost site in the study area. Four periods of colony activity were distinguished and observed as to respective time expenditures: rest (25%); feeding (29%); returning to roost (21%) and finally, cleaning/settling (25%). Analysis of the reproductive state of captured animals clearly demonstrated a polyoestrous aseasonal cycle for *D. rotundus*.

SILVER-HAIRED BAT-ASSOCIATED HUMAN RABIES IN THE UNITED STATES

Hunt, L. A.[1] & Bhatnagar, K.P.[2]

[1]Departments of Microbiology & Immunology and [2]Anatomical Sciences & Neurobiology, University of Lousville School of Medicine, Louisville, Kentucky 40292, USA.

A variant of rabies virus associated with *Lasionycteris noctivagans* and recently reported to be associated with *Pipistrellus subflavus* (CDC, MMWR 47:1-5,1998) has been identified as the major source of human cases acquired by exposure within the U.S. since 1980. Of these 24 cases, 15 are associated with the *Lasionycteris / Pipistrellus* variant, six with variants from *Eptesicus fuscus, Tadarida brasiliensis* and *Myotis* species, and three with coyote or skunk variants. The identification of bat-associated variants of rabies virus has been based upon genetic and antigenic analyses of human brain tissue performed at the CDC, Atlanta, rather than known or suspected exposure to rabid bats. Because wildlife rabies has been diagnosed in much higher numbers in racoons and skunks, bats as the major source of human rabies in the U.S. is unexpected. Only one case had a documented bat bite or scratch, and there was no known exposure to bats in nine of these bat-associated cases. Unique characteristics of this bat variant of rabies virus and/or distinctive characteristics of bats may be responsible for rare cases of virus transmission from bat to human that seem to occur with only limited physical contact.

STRUCTURIZATION FOR THE IMPLANTATION OF OFFICIAL LOCAL BASES FOR PERMANENT RABIES CONTROL - RJ/BRASIL

Romijn, P.C.[1], Cattaneo, C.A.M.[2], daSilva, M.V.[3] and Oliveira, A.N.[3]

[1]Empr. Pesq. Agropecuaria RJ - PESAGRO-RIO

[2]Secr. Est. de Agric., Abast. e Pesca - CDSA/SDS/SEAAP

[3]Inst. Mun. Med. Vet. Jorge Vaitsman - IMMVJV

With the main objective of human rabies eradication, outbreaks of the disease in domestic mammals are controlled/avoided through periodical vaccinations, the virus circulation thus becoming restricted to wild mammals. The risk of rabies and other Lyssavirus transmission by contact between humans and wild animals, including bats, is a matter of great concern for Public Health. The identification of several bat species with these viruses, in different parts of the world, which may even be in latency, makes it necessary

to monitor the disease and agents in nature, through the most sensible techniques available. PESAGRO-RIO, after promoting training courses (1992) and meetings (1992 to 97) for professionals on rabies epidemiology, prophylaxis and carrier control, during the past two years has been working together with State Animal Health officials on educational campaigns, training local groups on the control of rabies in an ecologically responsible way. The biological samples collected through the trained local, regional and state structures are used in monitoring and typifying the different Lyssavirus through molecular biology, with the co-operation of other national and international research institutes.

THE COMMON VAMPIRE BAT IN URBAN AREAS OF LARGE CITIES FROM BRAZIL

Uieda, W.[1], Cezári, A.[2] and Esberard, C.E.L.[3]

[1]Depto. Zoologia, IB, UNESP, 18618-000, Botucatu, SP

[2]Secretaria Estadual de Saúde, Belo Horizonte, MG

[3]Fundação Rio-Zoo, 20940-040 Rio de Janeiro, RJ, Brasil

Because its main food source is livestock, the common vampire bat is habitually found in countryside areas. Occasionally this vampire could occur in villages, towns, and even on the outskirts of large cities. Nowadays, we have recorded its presence in well-urbanized residence areas of large cities, such as São Paulo, Belo Horizonte, Rio de Janeiro and Salvador, Brazil. In big cities, humans, dogs and zoo-animals have been bled by *Desmodus rotundus*, and this situation deserves attention from the public health services because of its role in rabies' transmission. Rabies on livestock is frequently recorded nearby those Brazilian cities. The major obstacles to night activities of urban *Desmodus* are the heavy traffic in the first half of the night, the delayed resting of its potential preys (humans) and artificial night illumination. To avoid those problems, the urban vampires fly high, over four meters height, and feed after midnight, usually between 1 and 2 AM (when most people are already resting and the urban environment is quieter). *D. rotundus* changes its behavior drastically for exploring urban areas and their resources, becoming more light-tolerant, foraging higher, feeding later and on unusual preys. In some places, like Pelourinho, Salvador, humans are the only prey explored by vampires.

ECOLOGY AND EPIDEMIOLOGY OF ATTACKS UPON HUMANS BY THE COMMON VAMPIRE BAT

Schneider, M.C.[1] and W.Uieda, W.[2]

[1]Private Consultant in Epidemiology, 4 Northrop Court, Rockville, MD, 20850, USA

[2]Departamento de Zoologia, IB, UNESP, Botucatu, SP, 18618-000, Brasil

People bled by vampire bats (*Desmodus rotundus*) are not rare phenomenon in many Latin American countries. This constitutes a potential risk for human rabies and outbreaks of rabies transmitted by vampires were been frequently reported. The most of investigated cases occurred in the small Amazonian villages with difficult access, without post-exposure rabies preventive treatment. The changing of productive process generally has been observed at those areas, like mining for gold, cutting down trees and elimination of animals. Human beings usually are a secondary food source to vampires, when the main source is out, perhaps because human is harder prey than livestock. In the wild, wild mammals and birds are the main food source to vampires, but in many areas, the elimination of those animals and/or the introduction of domestic ones took to changing the behavior of vampires. Today, vampire bats are more common and versatile, and their geographic distribution is wider. To feed upon humans, vampires approach later in the night, land on subtract (bed or hamac), walk and/or jump toward the victim and bite the distal parts of the body (feet, hands and head). With the objective of analyze some factors associated with bat biting in one of these communities and simulate some actions of control for this problem, a cross-sectional survey was conducted in Mina Nova (160 inhabitants), a village of gold prospectors in the Amazonian region of Brazil. One hundred twenty-nine people in 35 households were interviewed. Bats were captured near people's houses and sent to a lab to be examined. Seventy-four percent of the households reported having someone bitten by vampires. Forty-one percent of the people had been attacked by vampires at least one time. Ninety-two percent of the bites were located on the lower limbs. Through a logistic regression, it was found that adults were bitten around four times more often than children (OR=3.75, IC:1.46-9.62). Males were bitten more frequently than females (OR=2.08, IC:0.90-4.76). Through a simulation with the

mathematical model created, it is also suggest that the best action of control for areas of high risk of humans rabies transmitted by *D. rotundus*, without access to the Health System, it is the combination of pre-expousure treatment with control of bats population. Many of the outbreaks investigated it is possible to suggest that some environment problem it is going on related an economical issues. There should also be more research on how changes in the natural ecosystem it is affecting the relationship between men and vampire bats.

BEHAVIOR AND COMMUNICATION

FEEDING BEHAVIOUR OF *DIPHYLLA ECAUDATA* IN CAPTIVITY

daSilva, M.V., deOliveira, A.N., Andrade, M.C.R.[1], deMoura, W.C.[1] and deFigueiredo, M.J.
Instituto Municipal de Medicina Veterinária "Jorge Vaitsman"
[1]Fundação Oswaldo Cruz

Four *Diphylla ecaudata* were kept in a large cage measuring 1.80 x 1.50 x 1.00 m. It was built outdoors and covered by a roof. A wired cage measuring 0.40 x 0.25 x 0.15 m with the bottom opened and the outside covered by cardboard was used for a diurnal roost. White Leghorn chickens were offered as prey. Due to the gentle behaviour of these bats, we tried to make close observations of the biting and feeding behaviour. Two bats were transferred to the laboratory. One chicken was held by hand and placed over the table. The bat promptly came to the cloaca and was rapidly covered by feathers. It was impossible to describe the actual biting other than that feeding was successfully observed. By carefully manipulating the feathers on the cloacal region, the head of the bat was uncovered and a feeding behaviour similar to that of *Desmodus rotundus* was revealed. After biting, the bat extended the tongue and remained licking the wound. This behaviour was registered on video and observed several times without disturbing the bat. The wound inspection in the cloacal region sometimes revealed that the bite did not completely remove the piece of flesh and that crater wounds were not produced.

AREA UTILIZATION BY MALES AND FEMALES OF *TADARIDA BRAZILENSIS* IN A DIURNAL SHELTER IN AN URBAN ENVIRONMENT

Marques, R.V. and Pacheco, S.M.
Laboratório de Mastozoologia, Museu de Ciências e Tecnologia,
PUCRS. Av. Ipiranga, Porto Alegre, RS, Brasil.

A group of *Tadarida brasiliensis* has been studied for two years in the roof of a building in downtown Porto Alegre, southern Brazil. Weekly or fortnightly observations have been made. The temperature and luminosity were measured inside the diurnal shelter using a maximum-minimum thermometer and a luximeter. Bats have been found in 16 different places inside the shelter. Luminosity and the number of bats have been controlled in each place. One hundred fifty males and one hundred ninety females had one of their wings marked with blue and pink bandettes, respectively. Marked bats were released at the same place where they had been caught. Predominant luminosity inside the shelter was 0.1 lux and inside the roosts it was zero lux. Temperatures varied between 9°C in the winter and 39°C in the summer. The number of bats inside the shelter changed from 5 (April / 1997) to 1,500 (December / 1996), including nestlings. During spring and summer, the period of birth and nestling growth (November to January), the place named "nestling's wall" (place 7) has sheltered adult bats, especially females, and nestlings. That place was not occupied or had few bats during the rest of the year. Roost 4 has sheltered females throughout the whole year, but there were also males during May, June and July. During the last two months, there were fertile bats. Roost 9 has sheltered males throughout the entire year, but there were few females in July and August and from November to February. Fertile bats were observed during the first two months; during the other months, there were births and lactation. Roost 11 has sheltered mostly females, but there were a few males during all of the year. There were no significant differences between frequencies of males and females for the other places inside the shelter

AGGRESSIVE BEHAVIOUR IN THE BRAZILIAN LONG-NOSED BAT *RHYNCHONYCTERIS NASO*

Zortéa, M.[1], Rodrigues, M.M.P.[2] and De Marco Jr., P.[3]

[1]Universidade Federal de São Carlos - PPG. Ecologia e Recursos Naturais Museu de Biologia Prof. Mello Leitão, Santa Teresa-ES, 29650-000 - Brasil, [2]Universidade Federal do Espírito Santo - PG. Psicologia - Brasil

[3]Universidade Federal de Viçosa - Lab. Ecol.Quantitativa - DBG - Brasil

The Brazilian long-nosed bat is a small emballonurid species widely ranged in Central and South America. During two months (mid-march to mid-April and July) we observed three colonies of *R. naso* roosting under a bridge in the north of Espírito Santo state, southeast Brazil. The observations were carried out diurnally paying special attention to one colony. Aggressive behaviour was a common interaction between members of the groups. Nevertheless this behaviour didn't produce physical injuries to the animals. We recorded 149 aggressive events of marked individuals where males and females were equally aggressive, although the males preferentially attacked other males. The females aggression were preferentially pointed to other females. These differences were statistically significant. We also created a index to assess the aggressiveness degree amongst the colonies individuals, where the biggest values were assigned to the females group.

MATING SYSTEMS IN BATS

McCracken, G.F.

The University of Tennessee, Knoxville, TN 37996 U.S.A.

Early descriptions of bat social systems, mostly of temperate vespertilionids, described unstructured interactions and mating systems that were believed to be promiscuous and random. Many later studies, mostly of phyllostomids and pteropids, described polygynous mating systems. The evolution of mating systems was generally described by what males could defend; either groups of females or resources needed by females. Information is now available on the mating systems of 64 species of bats in 10 families. The best represented families remain the Vespertilionidae (16 species), Pteropodidae (15 species), and Phyllostomatidae (10 species). Over half of these species (i.e. 33) mate in single-male/multi-female groups. Harems have been suggested for 32 species, and most have been attributed to male behaviors of "female defense" or "resource defense". In all but 5 of these species females frequently move among males. The frequent movements of females and behavioral observations suggest that female choice and polyandry are underappreciated in many supposed "harem" mating systems. This is supported by limited molecular data. Fifteen species mate in multi-male/multi-female groups. Where details are available, these mating systems are highly structured. Many bats are promiscuous (mates have no continuing relationship outside of mating) but there is no evidence that any bat mates at random. Monogamy is reported for 16 species. Only 5% of known mammalian mating systems are monogamous, and monogamy is evidently more common in bats than in most other mammals. Target species and future directions for mating system research will be suggested.

THE ROOSTING BEHAVIOUR OF TWO SPECIES OF VESPERTILIONIDS IN SOUTHERN AUSTRALIA

Lumsden, L.F., Bennett, A.F., and Silins, J.E.

Dept. Natural Resources and Environment, 123 Brown St., Heidelberg, Victoria 3084, Australia

Roosting behaviour of two species of vespertilionids *Nyctophilus geoffroyi* and *Chalinolobus gouldii* were investigated during a study of the roosting ecology of insectivorous bats in southern Australia. A total of 45 individuals of *N. geoffroyi* and 27 *C. gouldii* were fitted with transmitters, and followed for a total of 504 bat-days, resulting in the location of 220 roosts. Both species shifted roost sites frequently, with 67% of *N. geoffroyi* roosts and 50% of *C. gouldii* roosts occupied for only a single day. There was no significant difference between males and females in how often they shifted, and lactating females shifted roosts as frequently as non-breeding females. Several theories relating to roost site fidelity were examined. There was no significant difference in the frequency at which bats shifted when the roost was under bark or in a more permanent hollow, or if the roost was solitary or communal. When individuals shifted to a new roost it was usually to another nearby. Both species were faithful to a defined roost area, returning there

consistently from foraging activities up to 12 km away, but frequently shifted roost trees within that area. Three-quarters of all roosts were within 300 m of the preceding roost. The majority (88%) of roosts occupied by male *N. geoffroyi* contained only a single animal. Female roosts contained significantly more individuals during the breeding season than the non-breeding season (18.3 ± 15.0 vs 2.4 ± 2.0 individuals). *C. gouldii* emerged from their roosts early in the dusk period, while *N. geoffroyi* emerged approximately 25 minutes later when it was fully dark, consistent with the theory that faster flying species emerge earlier than gleaning species.

EFFECTS OF THE DOMINANT MALE REMOTION IN THE *ARTIBEUS JAMAICENSIS* POLYGYNOUS MATING SYSTEM

Ortega, J.R. and Arita, H.T.
Departmento de Recursos Naturales, Instituto de Ecología, UNAM, México, D. F. 04510.

In a polygynous environment, a single male can monopolize several females, accessible and clustering, to obtain the majority of the copulas, and have the best reproductive success in the next generation. The Jamaican fruit-eating bat, *Artibeus jamaicensis*, has a polygynous mating system with a single dominant male in small groups and two males in big ones (> 13 females). This second male does not make the same defending activities as the dominant male, but is tolerated in the group. The goal of this study is to estimate the role of the secondary male when the dominant male is absent and to determinate the presence of a satellite adult male in the colony. Plastic rings were used to identify all individuals in the colony; control groups and experimental groups with similar characteristics (e.g. equal number of females, presence or absence of the secondary male, etc.) were selected for a removal experiment. The experiment had eight replicates for the single groups (one male) and four for the complex groups (two males). The dominant was retained for three days and the substitution was recorded. We compared the time, presence/absent and defending position of the newly arrived male with the controls. Our results show than the latency (first visiting male after removal of dominant) was less for the control dominant male than experimental (t student p=0.003), probably because the satellite male or the secondary male needs time to be accepted as dominant in the group. In all cases where the group had a secondary male, this male always assumed the vacant position, but in seven cases of the simple groups, a satellite male took the dominant role and in another the disruption caused a group segregation. Even though the secondary male is recognized as part of the group, the time for it to occupy the empty place was the same as that for satellite males (Mann-Whitney U, p=.109). The time spent by a control male in the group was larger than for the experimental males, but the difference is less obvious by the third day. In all cases, when the experimental dominant males were released they returned to the original group and expulsed the supplant male, thus restoring the previously existing hierarchy. With this experiment, we searched for the presence of adult males without groups; aside from the largest groups, where the secondary male always takes the vacant place; the groups exhibit a defined hierarchy between the dominant males.

ON SOME UNEXPECTED ABILITIES OF THE VISUAL SYSTEM IN PHYLLOSTOMID BATS

Schmidt, U., Hessel, K. and Wiesemann, A.
Zoological Institute, Poppelsdorfer Schloss, D-53115 Bonn, Germany

Although all bat species have functional eyes, the optical sense is often thought to be of minor importance in Microchiroptera. Nevertheless, in a variety of investigations on multimodal orientation bats rely on vision, even when the echolocation system gives contradictory information. There is only sparce knowledge about the efficiency of the visual system in bats. We investigated the efficiency of phyllostomid bats to respond to moving visual patterns and the ability to differenciate colours. In a rotating drum with equidistant vertical stripes the electrooculogram (EOG) was recorded in *Carollia perspicillata, Phyllostomus discolor, Desmodus rotundus* and laboratory mice. The visual acuity was determined by altering the width of the stripes under light intensities between 70 lx and 5x10-7 lx, and velocities of the moving target between 0.25°/s and 400°/s. An optokinetic nystagmus was found beyond 5x10-5 lx (*Desmodus*) and 5x10-4 lx (*Carollia, Phyllostomus*, mouse) respectively; an EOG was only recordable in a distinct range of velocity (*Carollia, Phyllostomus* : 5°- 320°/s; *Desmodus*: 10° - 240°/s; mouse: 1°- 20°/s). The maximum visual acuity (*Phyllostomus*, mouse: 2° - 3°; *Carollia, Desmodus*: : 3° - 4°) was found in a medium

intensity range; bright illumination and low light reduced the visual acuity. Visual performance was also dependent on the velocity of the optokinetic stimulus. The pursuit movement, in which the velocity of eyes and target matches, is different in the species investigated. Whereas *Phyllostomus* follows the movement of the stripes up to 60°/s, *Carollia* 40°/s, *Desmodus* 20°/s and mice 2°/s. In a triple-choice flight arena 3 *Carollia* were trained to respond to a green light plate (550 nm) for food reward. In the critical tests the bats were able to discriminate this positive stimulus from a red light plate (605 nm). Colour discrimination was independent of the light intensity (both colours were presented in a variety of different intensity combinations). To ensure that both colours were visible to the bats, the reaction thresholds were determined. The results indicate that *Carollia* has at least two photopigments and is capable of dichromatic vision.

THE MATING SYSTEM OF THE MEXICAN FREE-TAILED BAT *TADARIDA BRASILIENSIS MEXICANA*

Nicklaus, A.T.H.[1] and Keeley, B.W. [2]

[1]Southwest Texas State University, San Marcos, Texas, U.S.A.

[2]Bat Conservation International, Austin, Texas, U.S.A.

The mating season of the Mexican free-tailed bat *Tadarida brasiliensis mexicana* lasted in central Texas in 1998 from March 18 through April 6, with the greatest mating activity occurring between March 21 and April 1. Copulations were documented in major maternity roosts, small maternity roosts, and night roosts. Focal animal sampling using an infrared video camera and direct visual observations revealed multiple copulations by both males and females. Males employ two distinct copulatory strategies. During aggressive copulatory acts the male separates a female from a roost cluster, restricting her movements during mating while emitting characteristic calls. During passive copulatory acts the male moves very slowly on top of a female which is roosting in a tight cluster. Copulation occurs without the female showing any reaction and without male vocalizations. This study indicates indiscriminate promiscuity to be the mating system of the Mexican free-tailed bat.

TENT-MAKING BATS - A STUDY IN SOCIAL ARCHITECTURE

Weinstein, B.

University of Michigan, Ann Arbor, MI 48109-1079, USA

Tent-making has envolved at least three times in bats, each time in small, canopy-feeding frugivores. This suggests a possible link between size, feeding ecology and the evolution of this remarkable roosting habit. It is clear that canopy fruits exist in fluctuating patches wich are spacio-temporally predictable. Tree species wich fruit seasonally provide a predictable resource on an annual time scale, and all species, including the asynchronously fruiting figs, provide a resource that is predictable on the shorter time scale of fruit development. It has further been demonstrated that flight costs per gram go up as mass decreases in bats. I therefore hypothesize that tent-production is an adaptation that reduces commuting costs for small fruitbats by allowing them to produce dry, safe roosts close to rich fruit sources. I present radio-telemetry data on two species of stenodermatine tent-bats on Barro Colorado Island, Panama. The Hypothesis is reviewed in the context of these data, wich describe extremely small nightly foraging ranges. Infrared video is also presented from the first observations of actual tent-production by a neotropical bat since the phenomenon was discovered in 1932. This work was done in collaboration with Elisabeth Kalko and Charles Handley as part of an ongoig effort to document the behavior of bats and the nature of the bat community on Barro Colorado Island.

ECOLOGY AND BEHAVIOR OF *DIAEMUS YOUNGI* AND *DIPHYLLA ECAUDATA*

Schutt Jr., W.A.[1] and Ueda, W.[2]

[1]Department of Mammalogy, American Museum of Natural History, New York, NY 10024 USA and Division of Natural Science, Bloomfield College, Bloomfield, New Jersey, 07003 USA.

[2]Departmento de Zoologia, Instituto de biociências, UNESP, 18618-000 Botucatu, SP, Brazil.

Because of their widespread distribution, high population densities, and easy maintenance in captivity, the vast majority of information on vampire bats has been concerned with the common vampire bat,

Desmodus rotundus. Relatively little has been reported on the biology of the white-winged vampire bat, *Diaemus youngi*, and the hairy-legged vampire bat, *Diphylla ecaudata*. Both of these genera are considered rare in the wild and feed primarily on birds. Information on the ecology and behavior of these genera is reviewed and instances of interspecific vatiation are detailed. These include differences in feeding behavior (e.g., bite location) and the effects of predation on prey species (i.e., bird deaths from predation by *Diaemus youngi* have not been documented). Because of their unique biology and rarity in the wild, and because they do not cause significant economic loss to farmers, we strongly believe that conservation efforts should be initiated to preserve these genera.

CONSERVATION

BAT DIVERSITY IN THE CAFURINGA ENVIRONMENTAL PROTECTION AREA, FEDERAL DISTRICT, MID-WESTERN BRAZIL

de Sá, H.B.P. and Araújo, A.F.B.
Departmento de Ecologia, Instituto de Biologia, Universidade de Brasilia

The Cafuringa Environmental Protection Area (EPA) is located in the northwest of the Federal District, mid-western Brazil and is dominated by Cerrado vegetation. Its bat community was sampled from June 1996 through February 1997 using mist nets placed along flight routes, day roosts or food plants. The Cafuringa EPA is composed of a diversity of landscapes, including cattle farms, native savannas, forest remnants and caves, which provide food and roosting sites for bats. We provided a brief review of the currently acknowledged species occurring in the Cerrados region and in the surrounding Federal District. We have collected 318 individuals belonging to 29 species of 24 genera representing six different families. The calculated Shannon-Weaver diversity index (2.5) was compared to other studies from the Amazon and Atlantic forest and proved to be one of the highest ranking. *Desmodus rotundus*, the common vampire bat was the most frequent species. The community exhibited a pattern of few abundant species and several rare ones. Its functional diversity was also assessed. A principal components analysis (PCA) was performed to test for habitat preference. The results showed no clear preference for any category, but that a somewhat unique bat fauna could be found in the cave regions. We discuss the importance of the caves, forest remnants and human induced habitat diversification in the process of bat community construction. Strategies and important considerations concerning the conservation of the bats for the area are presented.

DIVERSITY OF BATS IN FOREST FRAGMENTS

dosReis, N.R.[1], Peracchi, A.L.[2], Sekiama, M.L.[3] & deLima, I.P.[1]
[1]Dept. Biologia e Vegetal, Univ. Estadual de Londrina, Londrina, PR - 86051-990 Brasil
[2]Depto. Biologia Animal - Instituto de Biologia, UFRRJ, Rio de Janeiro, RJ - 23851-970 Brasil, [3](?)

The bay of the Tibagi river, a place which experiences rapid environmental alterations due to its agriculture and cattle raising potential, with 25,000 km2, has three forest fragments: the "Floresta Nacional do Irati" (3,572 ha), the "Reserva Biológica da Klabin" (11,116 ha) and the "Parque Estadual Mata dos Godoy" (680 ha). Here, *Myotis ruber* and *Chiroderma doriae* can be found. These are bats threatened by extinction, as are *Pygoderma bilabiatum, Myotis levis* and *Rhogessa tumida* presumably threatened species. Using the same capture effort in the 3 areas, it was stated that the "Floresta Nacional do Irati" with little vegetation diversity, showed the lowest diversity with nine species of bats. The "Parque Estadual Mata dos Godoy", although it is five times smaller, revealed 15 species. We came to the conclusion that a big reserve, without good conditions would house a lower number of species. A small reserve with adequate resources and great vegetational diversity presents a greater number of niches, housing a higher number of species. Attention is called to the fragmentation of habitats, which continuously occurs in response to economic growth, and will cause the rare and more sensitive species which are of great importance to the ecosystem to disappear.

POPULATION DYNAMICS OF HOUSE-DWELLING BATS IN HUNGARY

Bihari, Z.
Agricultural University of Debrecen; 4032 Debrecen, Böszörményi ut 138, Hungary

Several projects were carried out with the aim of researching the population dynamics of the 26 bat species which have been found in Hungary in recent years. Church rooves are the primary roosts of some species in Hungary. One very important question is how colony sizes and locations change temporally. In the course of my investigation I tried to answer these questions with the help of a long-term (10 years) monitoring program. The results of the project are the following: I have found a drastic decline in the numbers of *Plecotus austriacus*, but in contrast a significant increase in the case of *Myotis myotis*. The reason for the observed changes during the 10 years is, in many cases, the change of characteristic features of the roost. We can not know the exact reasons in some cases, we just consider it probable with the loss of foraging habitats and the draining of wetlands. Very interesting changes were detected in the distribution of different colonies. The number of *M. myotis* colonies have been decreasing, while the size of each remaining colony has been increasing, since numerous small colonies have moved together and many bats have moved into the study area from distant parts of Hungary. This grouping is advantageous from the point of view of energetic balance, but not for the protection of this species, in that large colonies are more vulnerable and more sensitive to humamn influences. The bats in the known colonies stay in churches only in summer while in winter they move to distant Slovak and Hungarian caves. In Hungary among the most endangered 'house-dwelling' bat species are *Myotis dasycneme* and *Myotis emarginatus*.

FORAGING AND FEEDING ECOLOGY OF THE SEROTINE BAT *EPTESICUS SEROTINUS*

Kervyn, T., Brasseur, J., Motte, G. and Libois, R.
Zoogeographical Research Unit, Zool. Institute, Univ. of Liège, B-4020 Liège, Belgium

We carried out a two year study regarding the serotine bat, an endangered species in Western Europe. Radiotracking, censusing with ultrasound detector and diet analysis allowed us to determine the foraging and feeding ecology of this species. Two colonies separated by 3 Km from each other and comprising 40 adult females were studied in detail in Belgian Lorraine. From May to July, the serotine bat exploits forest edges. This habitat allows them to feed on large insects such as cockchafers (Coleoptera, Melolonthidae), tipulids (Diptera Tipulidae) and ophionids (Hymenoptera, Ichneumonoidea, Ophionidae). After this period, they switch their habitat choice towards grassland (pastured or mowed). The diet changes also towards Coleoptera Scarabaeidae Aphodius sp. and Trichoptera in pastures along rivers. The diet and habitat changes are closely related to prey emergence and availability. Our results make a sound basis for a conservation policy of this species in Belgium, namely as to that which concerns the management of feeding areas.

HIBERNATING BATS IN FLANDERS; FACTORS INFLUENCING THE NUMBERS AND SPECIES COMPOSITION

Verkem, S. and Verhagen, R.
University of Antwerp, RUCA, Evolutionary Biology, Groenenborgerlaan 171, B-2020 Antwerp, Belgium.

For more than 20 years hibernating bats have been counted in Flanders, Belgium. Of the 18 indigenous species 7 are found regularly (*Myotis daubentoni, M. mystacinus/brandtii, M. nattereri, M. dasycneme, M. emarginatus, Pipistrellus pipistrellus* and *Plecotus sp.*), 5 others are rare (*M. myotis, M. bechsteinii, Nyctalus noctula, Eptesicus serotinus* and *Barbastella barbastellus*). The other species are not found in hibernacula. Since 1975 the numbers of most species are increasing. This increase is most pronounced for *M. daubentoni, M. mystacinus/brandtii* and *M. nattereri*. Three main types of hibernacula are distinguished: old fortifications, limestone caves and small objects such as ice-cellars. The highest numbers of bats are found in the forts and limestone caves. In these large hibernacula all species are found, but Daubentons bat and the Whiskered bat are the most common species. In the small objects only four species of bats (*M. daubentoni, M. mystacinus, M. nattereri* and *Plecotus sp.*) are found regularly. These species are known to be well resistant to low temperatures which regularly occur in these small objects. In order to design adequate protection plans we investigated the effect of humidity, disturbance and wall structure on the number of hibernating bats in the different types of hibernacula. In small objects humidity has a significant effect (Anova, $F=22.8$; $df=567$; $p<0.001$) while the degree of disturbance has no effect. In forts and limestone caves both humidity and disturbance have a significant effect (Anova, $F=14.9$; $p<0.001$

and F=28.1; p<0.001). The structure of the wall could only be investigated in the small objects. More bats were found in hibernacula with many cracks or rough brick walls compared to hibernacula with smooth walls but this was not significant (Anova, F=0.09; df=718; p=0.9).

THE CHEMICAL CONTROL OF HOUSE BATS IN RIO DE JANEIRO COUNTY: A PRELIMINARY EVALUATION

Pol, A., Nogueira, M.R. and Peracchi, A.L. .
Inst. de Biologia - UFRRJ. Seropédica – Rio de Janeiro, Brasil. CEP: 23851-970.

In Brazil, bats are protected by federal law, with any practice related to controlling native populations being subject to approval by specific government agencies. During a series of studies regarding the use of human constructions as refuge by bats in Rio de Janeiro county (Rio de Janeiro State, Brazil), we noted evidence of irregular activity by firms which combat vectors and other harmful animals in controlling house bats, motivating an investigation whose results are herein presented. Between December 1997 and February 1998, we requested bat control service for a colony of *Molossus molossus*, located in the roof of the first author's residence, from 75 firms advertising in the Rio de Janeiro Yellow Pages 1998. Many of the consulted firms (54.67%) intended to do the service, from which we obtained information about the use of the following products: insecticide (41.46%); repellent (26.83%); rodenticide (7.32%); vampiricide (4.88%); a combination of insecticide and rodenticide (4.88%); a combination of insecticide and repellent (2.44%); and uncertain products (12.20%). The indiscriminate use of chemical products against bats, besides being an illegal activity, confers risks to public health. This study has the proposal of alerting researchers from other regions about the illegal practice of professionals in the control of house bats and of raising a discussion on the validity of the employment of chemical repellent for such purpose.

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ENVIRONMENTAL EDUCATION IN SOME DISTRICTS OF PORTO ALEGRE CITY: CHIROPTERA DEMYSTIFICATION

Pacheco, S.M. & Hernandes, A.R.
Mastozzology Laboratory of Museu de Ciências e Tecnologia da PUCRS.
Av. Ipiranga, 6681, Cx. Postal 1429. CEP 90619-900, Porto Alegre, RS, Brasil.

A study about "the myth of bats" has been conducted from July 1997 to April 1998. The objective this work was to investigate the community's knowledge of bats. We used a set of questions for 40 residents of Aberta dos Morros district and the same question for 40 persons of others districts of Porto Alegre City. The study was divided in two phases: I. questions administered without previous knowledge of bats; II. questions given after receiving information about these mammals. The districts chosen were the central, southern and northern zones, along with a district near the rural area of the city. The persons were of different social classes, having up to college and university degrees. The ages were between 10 and 70 years old. The following questions were presented: 1. Have you seen any bats? 2. Do you know if there are any bats living in your district? 3. Where? 4. What do you do when you see a bat? 5. What's the importance of bats in nature? The first results showed that 80% of the people had seen bats and 40% affirmed that they had seen bats in their own houses or in places nearby trees. About 37% of the people surveyed answered that they used to kill bats in their houses, and 10% answered that they never did anything with the bats. Only 10% of people answered that bats are responsible for pollination of some flowers or capture and use insects as food. Later, we sent them a paper with information about the biology and ecology of the order Chiroptera. After 20 days, we again asked the questions from step I. The results showed that 81% of the people had lost fear of these mammals, and that 60% knew about the feeding habits and the importance of bats in nature. The question which showed the greatest difference in percentage between the first and second polls was number 4, in that 80% of those questioned would not kill bats, but would encourage them to fly away or use other manners to remove bats from their houses. We believe that with basic information, it is possible to change the prejudice and false ideas or concepts in relation to the wild fauna, principally bats.

DISTRIBUTION OF THE BATS OF COSTA RICA

Rodríguez-H., B.[1] and Wilson, D.E.[2]

[1]Museo de Zoología Universidad de Costa Rica, San José Costa Rica

[2]National Museum of Natural History, Mammals, Washington DC 20560 USA.

We divided the country into four geographic regions: Northwest (N), Southwest (S), Caribbean (C), and Central Valley (CV). Geographical criteria (e.g., rivers, cordilleras) already established as well as climatic features (following Holdridge 1967) were used to establish the limits of such geographical regions. Each region, except CV, was subdivided into altitudinal zones: 0-400 m (lowland [ll]), 400-1500 m (middle land [ml]), and >1500 m (highland [hl]). In order to assign the bat species to their corresponding geographical regions and altitudinal zones, we reviewed the Costa Rican collections housed at the University of Costa Rica, National Museum, and Institute of Biodiversity, and the collection of the National Museum of Natural History in Washington D. C. In addition, data from literature and personal observations were also utilized to complete the information needed. In Costa Rica, there are 107 species of bats. The distribution of these species into the geographical regions and altitudinal zones is as follow: 84 species in N (67 ll, 45 ml, and 34 hl), 69 species in SW (56 ll, 37 ml, and 14 hl), 86 in C (72 ll, 58 ml, and 17 hl), and 44 species in CV, all of them in ml. We compared the species richness, using Jaccard index (N vs. P = 66%, N vs. C = 68%, N vs. VC = 43%, C vs P = 61%, C vs. VC = 41%, and P vs. CV = 47%). The richest geographical regions are the Caribbean and Northwest. Yet this result may be a consequence of the greater sampling effort that has been carried out on these two regions. The percentage of species in common is very similar among regions, except for the CV that presented less species due to the fact that only middle land was sampled.

GLOBAL ACTION PLAN FOR MICROCHIROPTERAN BATS

Hutson, A.M.[1], Mickleburgh, S.P.[2] and Racey, P.A.[3]

[1]The Bat Conservation Trust, 15 Cloisters House, 8 Battersea Park Road, London SW8 4BG,

[2]Fauna and Flora International, Great Eastern House, Tenison Road, Cambridge CB1 2DT,

[3]University of Aberdeen, Department of Zoology, Aberdeen, AB24 2TZ, (all United Kingdom)

In 1992, *Old World Fruit Bats. An Action Plan for their Conservation* was published. This proved to be a great stimulus to work on this group of bats and many of the highest priority projects in that Plan have been undertaken. To follow this success a Global Action Plan for Microchiropteran Bats has been compiled to assess status and threats to almost 820 species. The project was again a collaborative project between the authors and the IUCN-SSC Chiroptera Specialist Group and others. Over 120 of the world's experts have contributed to this Plan which is seen as a stepping stone to more detailed documents looking at conservation issues on a national or regional basis or concentrating on particular bat families. The Plan reviews the major threats to bats on a global and regional scale. Around 20 species Action Plans have been compiled. The species chosen were those that best represented the range of issues facing bats worldwide. The Plan also includes a full species list for all microchiropteran bats with status assessments using the latest IUCN criteria and distributions. The authors have worked with The Natural History Museum in London to look at hotspots for bat biodiversity on both a global and regional basis. This will greatly assist in the targeting of funds for conservation work. Finally, there are detailed recommendations for conservation action including country by country accounts detailing the threatened and endemic species. The Plan will be circulated widely to key individuals and institutions and governments worldwide and hopefully will stimulate a similar degree of interest and action to ensure the long-term survival of threatened microchiropteran bats and their habitats.

REDISCOVERY OF *GLISCHROPUS JAVANUS* (VESPERTILIONIDAE), FROM THE KRAKATAU ARCHIPELAGO, INDONESIA

Lumsden, L.F.[1], Hand, S.[2], Schedvin, N.K.[1] and Gibson, L.[3]

[1]Dept. Natural Resources and Environment, Heidelberg, Victoria 3084 Australia [2]University of NSW, Kensington, NSW 2033 Australia [3]Australian Museum, College St, Sydney NSW 2000 Australia

Glischropus javanus (Chasen, 1939) was described from a single specimen collected from west Java,

Indonesia, in 1934. Chasen suggested that *G. javanus* may be a subspecies of the more widespread *G. tylopus*, but described it as a full species on the basis of differences in skull morphology. Since its original description no further specimens have been collected, and the taxonomic and conservation status of the species have remained unclear. During an expedition to the Krakatau Archipelago, Indonesia in 1996, 14 *G. javanus* were trapped. The Krakatau Archipelago consists of an active volcano surrounded by three islands that have revegetated since total sterilisation during a massive volcanic eruption in 1883. *G. javanus* was trapped on two of these islands, which are 180 km west of the type locality at Mt Pangrango, Java. Three previous expeditions to Krakatau in 1985, 1986 and 1992 did not detect this species. Lactating females were trapped in 1996, indicating the presence of a resident population. This species has a number of external and skull features midway in structure and/or size between those of *G. tylopus* and members of the genus *Pipistrellus*, to which *Glischropus* has often been linked. These intermediate features include partially enlarged thumb and foot pads, less displaced I2, small and extruded P2, short diastema between I2 and C1, and indistinct metalophs on M1 and M2. A feature unique to *G. javanus* is a gland on the dorsal surface of the rump. In males long fur protrudes from the gland, however in females it is bare.

PRELIMINARY EVALUATION OF THE STATE OF KNOWLEDGE AND STATUS OF CONSERVATION OF BOLIVIAN BATS

Aguirre, L.F.
Investigador Asociado, Colección Boliviana de Fauna, Casilla 994, La Paz, Bolivia.

In 1996 a workshop was conducted in order to establish the status of conservation of Bolivian vertebrates. Because of the lack of systematized information on Bolivian bats, none of them were considered for the resulting publication. In Bolivia, bats represent almost a third of the mammal fauna, with 107 species currently recognized. Primarily using the information of Sydney Anderson on Bolivian mammals and specimens stored in Bolivian collections, I examine the preliminary status of conservation of Bolivian bats. To do so, I plotted the distribution of bats against maps of Bolivia with information regarding land conservation, land use, status of conservation of Bolivian ecological regions, as well as an analysis of patterns of distribution, biology, degree of habitat adaptation, rarity and others. With this information, a program for the conservation of Bolivian bats, considering potential areas in which bats are in most danger and where some environmental education is needed and is planned to be created.

ROOST-SITE SELECTION BY *CHALINOLOBUS TUBERCULATUS* AND *MYSTACINA TUBERCULATA* IN TEMPERATE NOTHOFAGUS RAINFOREST, NEW ZEALAND: IMPLICATIONS FOR FOREST MANAGEMENT

Sedgeley, J.
Department of Zoology, University of Otago, PO Box 56, Dunedin, New Zealand

Roosting ecology of the New Zealand long-tailed bat *Chalinolobus tuberculatus* was studied during the summer months of 1993 - 1997. This study was expanded in 1997 to include a sympatric population of short-tailed bats *Mystacina tuberculata*. Characteristics of 291 *C. tuberculatus* roost trees and 169 roost cavities were compared with those of 596 random trees and 187 random cavities. Bats actively selected roost trees that had a significantly lower canopy closure (median = 80%, n = 117), larger stem diameters (mean = 105 cm, n = 237), were taller (mean = 31 m, n = 236) had larger trunk surface areas (median = 50 m2, n = 109) and a greater number of cavities (median per tree = 3, n = 107) than available trees. Roost cavities were higher from the ground (mean = 17 m, n = 185) and had relatively uncluttered entrances (mean distance to nearest vegetation = 16 m, n = 116). They had relatively small entrance holes (median = 69 cm2, n =120) and internal dimensions (median = 289 cm2, n = 72). Unoccupied roost cavities tended to be thermally more stable than similar-sized non-roost cavities. Generally, oscillations in unoccupied roost air temperatures mimicked those of external temperature, though were of a much lesser amplitude and showed a lag of 6 - 12 hours. Thus roosts were at their warmest during the night. Although sample sizes are small, in comparison with C. tuberculatus, roost cavities of *M. tuberculata* were significantly lower to the ground (median = 9 m, n = 19), had more cluttered entrances (mean = 6 m, n = 13) and entrance holes (median = 264 cm2, n = 12) and internal cavity height (median = 100 cm, n = 15) were larger. Bats selected to roost in the largest trees in the forest, trees of the size targeted for removal by most timber extraction techniques. Selection of highly specialised roost sites, high levels of roost lability and low levels of roost reuse

indicate bats need large areas of unmodfied forest. Habitat of this type is seldom found in forests managed for timber production.

BATS AS INDICATORS OF ENVIRONMENTAL INTEGRITY IN THE RAINFOREST OF MEXICO

Medellín, R.A.[1], Equihua, M.[2] and Amin, M.A.[1]

[1]Inst. de Ecología, UNAM, AP 70-275, Mexico, D.F. [2]Instituto de Ecología, A. C., Xalapa, Veracruz, México

Bats are the second largest order of mammals, but they are probably the most plastic group of mammals in terms of their ecology. They use a wide variety of resources, inhabit many ecosystems, and present a wide range of morphotypes. These characteristics affect the way they respond to environmental variability such as disturbance. We sampled 15 bat communities along a disturbance gradient in the Lacandon Rainforest of southern Mexico, from active cornfields to pristine forest. Here we report on the findings of the differences in bat community composition and structure. Bats respond in two main ways to disturbance: first, there are certain species that disappear altogether from disturbed areas. These are termed sensitive or fragile species. In this case, the community is affected by the sheer number of species present and by the identity of those species that are absent from the disturbed areas. There is a second community parameter affected by disturbance. The single dominant species in any one site is also an indicator of disturbance or environmental integrity. This is probably related to the vegetation structure and composition depending on the successional or disturbance stage and to the intrinsic characteristics of the common bat species that always include a set of 4-5 species. Given their ecological plasticity, the presence of generalist and specialist species, their great abundance and diversity in rainforests, and the relative ease in sampling them, bats may well be considered a useful indicator group to evaluate environmental integrity.

SPECIES COMPOSITION, DISTRIBUTION AND CONSERVATION OF BATS IN CENTRAL ASIA

Khabilov, T.K.

Khudjand State University, 735700 Khudjand, Tajikistan

Central Asia (regions of the former Soviet Union), is one of the most representative areas in species composition and quantity of bats. Twenty-five species belonging to three families are known from this region. Bats are rather numerous in Central Asia, outnumbered only by rodents. This makes the bats an important component of both natural and cultivated landscapes. Feeding on cotton plant pests, [the cotton plant is the main crop of Central Asia], bats constitute a very important component of biological control and need protection. Twenty years of research in Central Asia indicate diminished populations of some species. Some mountainous populations, such as *Rhinolophus ferrumequinum, R. euryale, R. blasii, R. bocharicus, Myotis blythi, M. emarginatus,* and *Minopterus schreibersi*, have all vanished. *Myotis frater* is now extinct. Measures must be taken to protect the remaining species. Fourteen extant species are registered in the Red Book and are in need of overall protection. Tajikistan is the first region in the former Soviet Union where eighteen micro-reserves have been organized.

MONITORING BAT POPULATIONS FOR CONSERVATION: THE UK NATIONAL BAT MONITORING PROGRAMME

Walsh, A. & Catto, C.

The Bat Conservation Trust, 15 Cloisters House, 8 Battersea Park Road, London, SW8 4BG. U.K.

Trends in bat population numbers over time are poorly understood, yet of particular importance to bat conservation. In the UK, quantitative population data is available for very few species and methods used to collect data remain unverified. In 1996, the UK government commissioned The Bat Conservation Trust to run a five-year programme of research - the UK National Bat Monitoring Programme - with the overall goal of developing an effective monitoring strategy for resident UK bat species. The programme is designed to help meet obligations to the conservation of bats under national legislation and international treaties to which the UK is party. It is expected to provide data of value to broader conservation actions and help meet the expectations of the Chiroptera Specialist Group of the IUCN/SSC. The principal aim of the programme is to develop standard monitoring methodologies and produce baseline population data for

selected bat species in a framework that will enable the investigation of possible causes of population change. Eight species of bat have been selected for which at least two counting methods are being applied from the three most commonly used methods - observation at summer maternity roost sites, observation at winter hibernation sites and summer field survey using bat detectors. To cross-validate roost counting schemes which suffer from potential biases, an intensive area-based roost count study is also being applied. All methods rely upon the large network of volunteers that exists in the UK and we are indebted to their generous support.

MOTIVATIONS AND COSTS IN THE REHABILITATION OF AUSTRALIAN FLYING FOXES (MEGACHIROPTERA: PTEROPODIDAE)

Markus, N.
Dept. of Veterinary Pathology and Anatomy, University of Queensland St. Lucia, QLD 4069, Australia

The rehabilitation for release of orphaned and injured flying foxes in Australia is supported by an extensive network of volunteer wildlife carers. Although carers represent an important interface between man and flying fox, little is known about the nature of caring. Members of wildlife care groups along Australia's east-coast were surveyed via a postal questionnaire during the 1997/98 breeding season of three native species of flying fox. In addition to questions about demography and experience, carers were asked to outline their motivations and the difficulties encountered in the care of flying foxes. Responses from 119 carers showed altruistic aspects to be the prime motivations for caring. Conversely, the time demand of caring was the single biggest challenge, potentiallMarkus, N.y preventing 29% of carers from continuing with the care of bats in the future. While all carers were aware of the recent discovery of two potentially fatal, bat-transmitted diseases (Bat paramyxovirus and Australian Bat lyssavirus), 52% felt that carers were not at risk of infection if appropriate precautions such as hygiene and vaccinations were taken.

SHADED CACAO PLANTATIONS AND BAT ASSEBLAGES IN THE ATLANTIC RAINFOREST OF SOUTHERN BAHIA STATE,BRAZIL

Faria, D.[1] and Baumgarten, J. [2]
[1]Universidade Estadual de Campinas and [2]Universidade Estadual de Santa Cruz

As a traditional, and being the most important crop of southern Bahia, Brazil, shaded cacao plantations seem to be suitable habitat for birds and terrestrial mammals, and are pointed out as important habitats for the local biological communities. Here we propose to investigate the potential role of this traditional crop system for bat conservation in southern Bahia, establishing the extent to which shaded cacao may support local bat assemblages. Using mist nets, we compared the bat community structure in fragments, continuous forest tracts, and shaded cacao plantations. Capture rates on cultivated areas of cacao were much higher than those obtained for forest tracts. Shaded cacao also harbored an extremely high number of bat species, including a vast array of forest dwellers such as gleaners insectivorous bats. Even isolated plantations, kilometers away from forest tracts, were also rich in bat species and trophic guild structures. The higher success found on shaded cacao plantation compared with forest tracts may be due to a less cluttered, although still stratified, forest habitat provided by this traditional crop system. In spite of comprising only a small fraction of the original forest vegetation, shaded cacao plantations are suitable habitats for bat faunas, that seem to use these modified and disturbed areas as an extension of their forested habitats. These results have practical implications for bat conservation on a local scale.

DO BATS BELIEVE IN THE WILDLIFE CORRIDORS HYPOTHESIS?

Downs, N.C., Racey, P.A. & Weller, N.C.
Department of Zoology, University of Aberdeen, Aberdeen, Scotland

Although the creation of vegetation corridors, particularly treelines, has attracted significant grant funding in Europe, there is little rigorous proof of its value to many groups of wildlife. This study has provided such proof with regard to pipistrelle bats *Pipistrellus pipistrellus*. Extensive use has been made of automatic bat monitoring stations positioned pairwise next to and away from wildlife corridors. In addition, suction traps were used to quantify the food resources provided by the corridors. Although pipistrelles commute along corridors and sometimes feed while doing so they occasionally fly across open spaces.

CONCERVATION MANAGEMENT OF BATS IN AN URBAN ENVIRONMENT: A PRELIMINARY STUDY IN BRUSELLS, BELGIUM

Irwin, N.[1], Missa, O. [2], Laurence, Y.[2], Lafontaine, R.M.[2] and Devillers, P.[2]

[1]Zoology Dept.University of Queensland, St. Lucia, Brisbane, Q 4072, Australia

[2]Institute Royal des Sciences Naturelle de Belgquie, Rue Vauiter 29, B 1000, Bruxelles, Belgique

Conservation of bats requires specific management programmes; focal areas are chosen to reduce cost, but where to concentrate that effort in urban environments is typically based on sparse, dissimilar data. Efforts are compounded as very few data exists on the effects of management. This project is part of a large long term multi-disciplinary programme for the Brussels region. The aims were to standardise methodologies, assess the bat species composition, relative abundance and habitat utilisation within the region and create a predictive model. A survey protocol was developed where data was collected on a point basis; this enabled analysis to be performed using both standard multivarient statistics and GIS techniques. Preliminary results presented here will discuss the effects of streetlights, degree of urbanisation, presence of water and vegetation types on bat species composition and relative abundance. The applications of such an approach to monitoring are discussed. Long term project aims are to actively maintain and increase the bat fauna of the region by increasing public awareness, identifying colonies and to establish a predictive model approach for resource management. With the co-operation of bat groups, this model will be used to predict and verify bat species composition and relative abundance in other urban areas.

THE RECOVERY OF POPULATIONS OF *PTEROPUS SAMOENSIS* AND *P. TONGANUS* FROM HURRICANES AND HUNTING IN AMERICAN SAMOA

Utzurrum, R.C.B.

Department of Marine and Wildlife Resources, Government of American Samoa, American Samoa

The numbers of two species of fruit bats found in American Samoa declined drastically in response to a series of hurricanes between 1987 and 1991. A hunting ban (protecting both species of fruit bats, and three species of pigeons and doves) was instituted in 1992 to aid in population recovery. *P. samoensis* surveys on Tutuila Is. from 1995-1997 show a recovery and relatively constant populations in the last three years. Significant variability in numbers was, however, found among survey sites, and within a year. The lack of interannual variation and the dampening of oscillations in growth rates suggest that the populations may be reaching an asymptote, or are near-equilibrium. Population counts over the last 10 years, and in relation to occurrences of hurricanes and hunting activities suggest that *P. samoensis* were being impacted by hunting. Conversely, the data strongly suggests that the recovery process has been favored by the hunting moratorium. *P. tonganus* populations are still below the pre-hurricane levels, but population growth rate trajectories and trends in numbers since 1991 suggest a slow recovery. Unlike *P. samoensis*, the hurricanes may have had a more direct impact on *P. tonganus*. The temporary hunting ban will expire in 1998. Regardless of whether this protection is lifted or not, long-term population monitoring should continue for management and conservation purposes.

IMPACT OF NATURAL TREE FALL GAPS ON THE UNDERSTORY BAT COMMUNITY OF PRIMARY FORESTS IN CENTRAL AMAZONIA

Bernard, E.

Biological Dynamics of Forest Fragments Project - INPA/SI, Caixa Postal 478 Manaus - AM 69011-970 Brazil

Tree fall gaps are one of the most frequent disturbance events in tropical forests. Canopy openings by tree falls cause a series of changes in the physical characteristics around the gaps, and a mosaic of new microhabitats is produced. Little is known about the relationship between bat communities and gap processes in tropical regions. To investigate the impact of natural gaps on the understory bat community, 17 gaps (70 to 240 m2) and 14 control points were sampled during one year (2.323 mist-net-hours). I captured 539 individuals, belonging to 5 families, 23 genera and 36 species. Using Mantel Test on the 16 most common species, I verified that there was no significant difference between captures inside and outside gaps ($p = 0.470$). I also verified that species classified by other authors as closed forest users were captured inside gaps. I concluded that small tree fall gaps, originated by one to three fallen trees, do not represent a significant disturbance for bats which use the forest understory habitat. CNPq - Brazil; BDFFP- INPA/SI; Bat Conservation International.

PRESERVING GENETIC DIVERSITY WITHIN NEW ZEALAND NATIVE BATS POPULATIONS

Winnington,A.[1,2] ; Spencer,H.[2] and Lambert,D.[1]

[1] Section of Ecology, College of Sciences, Massey University, Private Bag 11-222, Palmerston North

[2] Department of Zoology, University of Otago, PO Box 56, Dunedin

New Zealand has two species of microbat; the Short-tailed Bat *Mystacina tuberculata* and the Long -tailed Bat *Chalinolobus tuberculatus*. Despite having special significance as being New Zealand's only native terrestrial mammals, the short- and long-tailed bat are both currently under threat. We were contracted, by the Department of Conservation, to collect genetic information on New Zealand's native bats and to provide management recommendations to assist in the preservation of the genetic diversity found within populations of wild bats. Bat researches and Department of Conservation staff collected a total of 389 tissue samples from twelve populations of both long- and short-tailed bats throughout New Zealand and sent them to Molecular Ecology Laboratory at Massey University. DNA analysis indicated that at least two distinct populations of long-tailed bat are present in New Zealand, with a marked degree of genetic difference occuring between North Island and South Island samples. In case of short-tailed bats, Hauturu (Little Barrier Island) and Northland populations of the smaller kauri forest short-tailed bat are genetically distinct from other larger short-tailed bats found in the mainland beech forest and from the short-tailed bats on Whenua Hou (Codfish Island). Populations of the larger mainland short-tailed bat were shown to differ genetically, with increasing geographic distance. The Whenua Hou population of short-tailed bats represents a genetically distinctive remnant. Molecular markers were located within the mitochondrial DNA of long- and short-tailed bats to allow an individual of unknown origin to be reliably ascribed to a particular geographic region. Consequently, in order to preserve this genetic diversity we recommend that populations of native bat should be given their separate conservation status.

PROGRAM FOR THE CONSERVATION OF MEXICAN AND NORTH AMERICAN MIGRATORY BATS

Arroyo-Cabrales, J.[1], Medellín, R.A.[2], Navarro, L.[2] and Walker, S.M.[3]

[1]Laboratorio de Paleozoología, INAH, Col. Centro, 06060 México, D. F.; [2]Instituto de Ecología, UNAM, Ciudad Universitaria, Apartado Postal 70-275, 04510 México, D. F., and [3]Bat Conservation International, Inc., PO Box 162603, Austin, Texas 78750

Migratory bats are those bats which spend part of the year in a region, and the other part in a different area. Many of North America's most ecologically and economically important bats migrate seasonally across the United States-Mexico border. The Mexican free-tailed bat *Tadarida brasiliensis* forms colonies ranging from several hundreds to millions of individuals; each night these insectivorous bats fly to areas with high numbers of insects, consuming several tons of animals, including in many cases crop pests. Unfortunately, their populations have declined dramatically in several areas where they were formally abundant. Two other species, the greater and lesser long-nosed bats *Leptonycteris nivalis* and *L. curasoae* are pollinators of several important plants, including those well-known agaves that produce the raw material for the important tequila industry; these bats are already listed as endangered. In 1994, a unique consortium led by Bat Conservation International, the Asociación Mexicana de Mastozoología, A. C., and the Instituto de Ecología, UNAM, formed the Programa para la Conservación de Murciélagos Migratorios de México y Estados Unidos de América (PCMM), otherwise known as the Program for the Conservation of Migratory Bats of Mexico and the United States. With strong government, private, and academic support in both countries, PCMM is implementing a multi-faceted program of research, education, and conservation action designed to reverse the alarming declines in migratory bats and establish a new conservation ethic among citizens in Mexico and the United States. An international PCMM steering committee of leading scientists, educators, and conservationists meet bi-annually to set short- and long-term goals, to ensure maximum integration of program components, and to monitor and evaluate overall program effectiveness. The program is composed by three major components: Research, Environmental Education, and Cave Conservation. The main objective of the research is learning in detail the natural history of the bat species being protected in order to address their conservation needs more throughoutly. Research programs focus on monitoring population trends, studying bat / plant relationships, analyzing foraging and mating behavior,

learning on the migratory routes, and documenting the economic values of these bats. Populations research has been undertaken at several caves in the Mexican states of Nuevo León, Tamaulipas, Michoacán, Puebla, Hidalgo, and Chiapas, among others. The project, Bats Aloft, will allow to have strong data regarding the feeding behavior and diet of the free-tailed bats, to evaluate their economic importance for agriculture. A highly successful education initiative targets rural communities and schools near key roosting caves in northern and central Mexico, and is coordinated with detailed management plans to permanently protect these sites through formal legislation and local community stewardship. Also, general environmental education for the Mexican people is being developed. In order to develop a general environmental educational program, a test project was undertaken nearby a cave where a drastic diminishing of bat populations has occurred within historical times, the Cueva de La Boca, Municipality of Santiago, State of Nuevo León. Previous to the beginning of the test program, a preliminary study of the present status of cave and bat populations was conducted, as well as a socioeconomical survey among the people living in the communities nearby the cave. Such information was used to develop both a school pilot program assayed at four rural schools, and a temporal exhibit to provide to basic information about bats, and the damage to their populations by human activity in Cueva de La Boca, especially to the free-tailed bat *Tadarida brasiliensis*. The exhibit was produced in long-lasting materials that could be fastly set up, and with nice photographs, and concise texts, for attracting kids and young people. Other utilized materials included actual bat specimens for showing the main characters in the real animal, as well as pointing on the variety of bats. Also, there are plans for trying to incorporate the migratory bats educational program in the text books for elementary schools. Finally, based on the previous experiences, educational materials have been enhanced in order to be applied to any community with a few adjustments depending on the socioeconomical picture in the region. A large amount of effort within the past three years, since the program was established, has been dedicated to the Environmental Educational Program. An initial pilot program was implemented for securing the free-tailed bat populations at Cueva de La Boca, Nuevo León. The program included both a temporal exhibit, and three-day scholar activities at the elementary schools nearby the cave. Materials created for this program are top-quality, and should be useful, with required adjustments, for undertaking the educational program in other regions in México. At present those materials have been applied in the rural communities nearby Gruta de Quintero, Tamaulipas, another roosting cave for *Tadarida brasiliensis*. The next cave focused by the environmental education program is La Gruta, Ciudad Hidalgo, Michoacán, where populations of both species of *Leptonycteris*, and *Tadarida* occur during the year. Also, plans are being developed for a program that will deal with urban communities and bats living in cities. In terms of cave protection, we have been successful in lobbying at the Ministry level for adding to the Environmental Protection Law an addenda stating that caves are sites that could be protected. In doing so, we are using Cueva de La Boca as an example of how to proceed in terms of legislation requirements. We are developing the Management Plan for the cave, and we have started to train secondary school students for local community stewardship. PCMM's organization and programs provide an excellent model for other Latin American countries with limited financial resources, and expansion plans are already underway. The program's recently completed Spanish-language educational materials and its successful grass-roots conservation approaches will be shared with other North and South American countries where bats, and the ecosystems that depend on them, remain threatened.

EDUCATIONAL PROGRAMS AND CONSERVATION OF VAMPIRE BATS

Educational Programs and Conservation of Vampire Bats

Walker, S.M. & Ochoa, J.

Bat Conservation International, Inc., P.O. Box 162603, Austin, Texas 78716

The threat of rabies is a constant concern for Latin American cattle owners. To protect their livestock, some ranchers exterminate all bats they find. This approach rarely eliminates the vampire bats that prey on cattle, but instead kills bats that consume agricultural pests, disperse seeds, or pollinate vital plants. Several educational programs have been developed to address this problem. For example, in 1993 Bat Conservation International (BCI) worked with Dr. Rexford Lord and Dr. Victor Sancho to produce the video, "Control del Murcielago Vampiro y La Rabia Bovina." Dr. Lord spent two years using the video to educate veterinarians and cattle associations across South America. In 1994, BCI, the Asociacion Mexicana de Mastozoologia, A.C., and the Instituto de Ecologia, UNAM, formed the Programa Para a Conservacion de Murcielagos Migratorios (PCMM). With strong government and private support, the PCMM has imple-

-mented a multi-faceted program of research, education, and conservation action designed to reverse alarming declines in bats attributable to misguided vampire control efforts. This year, BCI, the U.S. Fish and Wildlife Service, and the Asociacion Venezolana para la Conservacion de Areas Naturales, led by Dr. Jose Ochoa, convened a group of biologists and rabies experts to develop a vampire control training program that can be distributed to public health officials throughout the range of vampire bats. All of these programs provide excellent models for countries with limited financial resources.

THE AIMS, FUNCTIONS AND ACHIEVEMENTS OF THE INTERGOVERNMENTAL *"AGREEMENT ON THE CONSERVATION OF BATS IN EUROPE"*

Blencowe, E.
EUROBATS, Martin Luther King Str. 8, D-53175 Bonn, Germany

The EUROBATS Secretariat administers the Agreement on the Conservation of Bats in Europe. The Agreement was set up under the aegis of the Convention on the Conservation of Migratory Species of Wild Animals. This Convention is also known as the Bonn Convention, because it was an initiative of the West German Government which led to its conclusion in 1979. The Convention itself was a result of one of the recommendations following the United Nations Conference on the Human Environment in 1972. The Bonn Convention recognises that endangered migratory-species can be properly protected only if activities are carried out over the entire migratory range of the species. Because many of these species migrate over the international boundaries within the continents and even beyond, the need for an international Convention was paramount for this process to be carried forward. The Bonn Convention allows for the conclusion of individual agreements covering particular species or groups of species within a geographically limited migratory range. The Agreement on the Conservation of Bats in Europe was the third of these concluded, and came into force in its five signatory countries in January 1994. The first Meeting of Parties took place in Bristol in July 1995, and by this time there were nine parties. Since then, and at the time of writing, a further four countries (among them Poland) have ratified or acceded to the Agreement, making a present total of thirteen countries, from all over Europe. The first Meeting of Parties agreed on the need to establish a permanent secretariat to administer the Agreement, and to co-ordinate international activities between the Parties to the Agreement, and to encourage others to join. A budget of just under half a million German Marks was agreed upon for the period between January 1996 and December 1998, to be funded by the individual Parties according to their position on the United Nations Scale of assessments. The EUROBATS Secretariat - comprising a half-time Executive Secretary and a half-time Administrative Assistant - started work at the beginning of January 1996. Its particular functions are to: facilitate the exchange of information and assist in the co-ordination of international research and monitoring activities, including seeking financial support for these; arrange and service Meetings of the Parties, including those of an intersessional Advisory Committee established by the first Meeting of Parties to carry forward research and monitoring work, and to discuss priorities for further activities on the international level, between Meeting of Parties; and stimulate proposals for effectiveness of the Agreement, including attracting more Non-Parties to join the Agreement. The Secretariat arranged the first meeting of the Advisory Committee in April 1996. The Meeting considered the tasks laid before it by the first Meeting of the Parties, and particularly concentrated on international activities and monitoring. Members agreed to carry out a pan-European analysis of the currently available information on the migratory habits of certain species, and to assess the effectiveness of various methodologies for monitoring certain species. The Secretariat was charged with analysing the reports of the Parties on their implementation of the Agreement, to find strengths and weaknesses and to report back to the Advisory Committee with a digest of the reports and proposals for improving the reports in the future. All these matters were considered at the second Advisory Committee meeting, which took place in January 1997 in Kraków, Poland. The third Advisory Committee meeting took place in March 1998. The second session of the Meeting of Parties will take place from 1-3 July 1998. The Secretariat also attended the Seventh European Bat Research Symposium in the Netherlands in August 1996. The Secretary of the Agreement gave a presentation on the Agreement to research scientists and amateur bat enthusiasts from all over Europe. Its purpose was first to emphasise the importance of the Agreement to the Conservation of bats in Europe, and to offer advice and assistance to researchers in developing proposals for the conservation of certain populations of specific species of bats occurring within Europe, particularly where these populations migrated at least partially over international borders. Such a project is being carried forward co-ordinated by Hungary and the Secretariat for *Miniopterus schreibersii*, whose populations in

Hungary have been suffering a drastic decline over the past few years. Hungary will be working with Austria, the Republic of Macedonia, Slovakia, Slovenia, the Republic of Yugoslavia, Romania and Ukraine on the Project. In this way, the Secretariat will continue to try to encourage active support of the Agreement, and through the Agreement the research work essential for the survival of the European bat species. The Secretariat has also circulated publicity materials throughout Europe, addressing some of the myths about bats, and trying to promote reason when bat species are considered in town planning or agricultural questions. In this respect the Secretariat has benefited from much media interest both in Germany and elsewhere. In addition, the Secretariat co-ordinated the first European Bat Night on 20 September 1997. Five countries participated (France, Germany, Poland, United Kingdom and Ukraine), with 12,000 people attending the German event alone. European Bat night well be held again on 29 August 1998, and up to now 12 countries will be participating. The EUROBATS Secretariat liaises with Parties, Non-Party Range-States, Non-Governmental Organisations and individual researchers and bat enthusiasts, and is working towards the establishment of the Bat Agreement as the vehicle for reversing the downward trends in bat population within Europe.

ECHOLOCATION AND FEEDING ECOLOGY

FOLIVORY IN URBAN *ARTIBEUS LITERATUS* FROM BRASILIA

[1]Uieda, W., Bredt, A.[2] and Pinto, P.P.[2]

[1]Universidade Estadual Paulista, Botucatu, SP

[2]Instituto de Saúde do Distrito Federal, Brasilia, DF, Brazil

Folivory in bats has already been reported in at least 17 species of Old World megabats and in just 4 New World microbats, including the big fruit bat *Artibeus lituratus* (Phyllostomidae). This frugivorous species lives in small groups and frequently can be found in the Brazilian sub-urban and urban habitats. In Brasilia, *A. lituratus* was observed ingesting leaves of *Sapindus saponaria* (Sapindaceae) and *Mangifera indica* (Anacardiaceae), two common trees in this city. Leaf fragments and pellets of both species and of *Ficus insipida* (Moraceae), *Persea americana* (Lauraceae) and *Erythrina velutina* (Leguminosae) were found on the floor beneath 236 of the 2005 night roosts studied between 1994-1997. The 4 former species and 2 former families represent additions to the plant list already known as leaf sources for the bats. The leaf was removed from a plant and taken to the feeding roost, located in another tree. After landing on a branch, the bat manipulated the leaf between its thumbs, biting and removing part of the leaf; it chewed it several times and discarded the pellets. The bat ingested just the liquid part of the leaf. Our data show a seasonal difference, highly significant ($c2 = 7.566$; $p < 0.01$), of the folivory for urban *A. lituratus*, with a larger consumption of leaves in the dry season.

FRUGIVORY IN URBAN *ARTIBEUS LITERATUS* FROM BRASILIA

Uieda, W.[1], Bredt, A.[2] and Pinto, P.P.[2]

[1]Universidade Estadual Paulista, Botucatu, SP

[2]Instituto de Saúde do Distrito Federal, Brasília, DF, Brazil

The big fruit bat *Artibeus lituratus* is one of the largest members of the genus *Artibeus* and very common in several regions of Brazil. It has also been frequently found in urban areas of several cities. In Brasília, this bat is the most common among the phytophagous bats and it uses several trees from the city arborization as food sources and as feeding and day shelters. During 1994-1997, we observed *A. lituratus* visiting plants and ingesting fruits in feeding roosts. We examined the food remains found on the floor beneath 2,005 feeding roosts from urban area of Brasilia. In this city, the bat fed on fruits from 23 species, with just five of them being (*Terminalia catappa*, *Calophyllum brasiliensis*, *Eugenia jambos*, *Holocalyx balansae* and *Syagrus romazoffiana*) requently consumed by bats. *T. catappa* was particularly important to the diet of urban *A. lituratus* as its fruits, both ripe and unripe, were consumed in every month. This plant is used a lot in the arborization of many Brazilian cities and, may be the main source of attraction for *A. lituratus* to urban environments. This species used a monthly average of 11.7 different fruit types in its diet, a high diversity, when compared with studies developed in other areas. In spite of this, no more than half (53.8%) of its feeding roosts contained just one fruit type in any one night.

USE OF WATER HOLES BY STENODERMATINAE BATS IN WESTERN AMAZONIAN BRAZIL

Nogueira, M.R., Pol, A. and Peracchi, A.L.
Instituto de Biologia, São Paulo, Seropédica, RJ. CEP: 23851-970. Brazil

In 1974, M. D. Tuttle published a report documenting an unusual drinking behavior of some Stenodermatinae bats that were attracted in large numbers to particular water holes in Amazonian Venezuela. In spite of the apparent peculiarity of this phenomenon, new data has not appeared in the literature. During a survey of the chiropteran fauna conducted on July 1996 and March 1997 in the Parque Nacional da Serra do Divisor (PNSD), in the state of Acre, in extreme western Amazonian Brazil, new evidences on this concern were obtained. Despite the proximity of available water resources, phytophagous bats of the cited subfamily were seen drinking muddy water in small pools of puddle areas located not only in primary dense forest, but also close to houses of riverine natives, where water with organic and inorganic residues is discarded. In accordance with natives, this is a common behavior in the region, especially in undisturbed forests where particular water holes ("barreiros") also attract larger mammals in "search for salt". Captures with mist-nets demonstrated that a higher number of individuals and species visit the water holes in undisturbed vegetation. While *Mesophylla macconnelli* and *Vampyressa pusilla* were the most frequent species in this type of habitat, the first with 42 individuals sampled in a single site in 3 net/hours, *Platyrrhinus helleri* was predominant in water holes close to houses. Seasonality doesn't seem to constitute a determinant factor in the use of this resource, since such visits were observed in both dry and wet seasons. A single sample of the water used by bats, collected from a water hole not directly influenced by human residues, showed a high concentration of sodium (51 ppm), an element which can be selectively exploited as a nutrient. Nets set over water holes were extremely efficient in sampling Stenodermatinae bats, with 16 of the 18 species recorded in PNSD captured in this way. Financial support: USAID.

FLIGHT CAGE OBSERVATIONS OF FORAGING MODE IN FOUR NEOTROPICAL FLOWER-VISITING BATS

Giannini, N.P.[1] and Villalobos, F.B.[2]
[1]Cátedra de Vertebrados-PIDBA, Miguel Lillo 205, 4000-Tucumán, Argentina.
[2]Escuela de Biología, Universidad de Costa Rica, Costa Rica.

At La Selva Biological Station, Costa Rica (Feb. 1998), we studied the foraging and flying behavior of individuals of two *Phyllostomus* (*P. discolor* and *P. hastatus*) and two specialized nectarivores (*Glossophaga commissarisi* and *Lonchophylla robusta*). In a flight cage, we observed the response (i.e. foraging method, reaction and foraging time, nectar removal) of individual untrained bats to the presence of a banana inflorescence with controlled volumes of nectar per flower. Each trial lasted 30 min. The specialized bats showed a highly variable behavior, whereas the two *Phyllostomus* were stereotyped, and took longer to react. The *P. hastatus* that successfully contacted the inflorescence (3 out of 6) landed only once, then alternated between probing a single flower and scanning the surroundings until the nectar was exhausted. *P. discolor* (10 out of 21) briefly landed, probed a single flower, flew and returned to the flower, doing this for an average of 10 contacts. *L. robusta* (2 out 4) began by hovering, contacting several flowers each time, and subsequently landing and behaving in a similar way to *P. discolor*. *G. commissarisi* (6 out of 10) was highly variable, using and suddenly changing among foraging methods. We interpret these observations as a continuous gradient from fully landing to hovering, that could be a real feature of the flower-bat interactions at the assembly level. Basic aerodynamic measurements paralleled the behavioral trends.

NECTAR PRODUCTION AND SCENT IN TWO BAT POLLINATED *PASSIFLORA* SPECIES

Varassin, I.G.[1] and Sazima, M.[2]
[1]Museu de Biologia Prof. Mello Leitão/Brasil and [2]Universidade Estadual de Campinas/Brasil

The passionflowers *Passiflora galbana* and *P. mucronata* (Passifloraceae) are both bat-pollinated species. The first is probably visited by *Glossophaga soricina* and the second by *Anoura caudifer, Carollia perspicillata* and *G. soricina* (Glossophaginae). They occur in sand-dune formations in southeastern Brazil and are synchronopatric, flowering from March to September. The flowers of both species are very similar, being whitish, zigomorphic and erect. At the begining of anthesis, they are already scented. The anthesis of

P. galbana lasts from 17:00 to 06:00h, and the nectar secretion occurs during the first part of anthesis, showing a maximum rate (70 - 161 µl) between 19:00-22:00h. Nectar reabsorption starts at 24:00h. Three hours later, most flowers of *P. galbana* are nectarless, but remain opened and producing odour. The anthesis of *P. mucronata* starts at 03:00h, when the total amount of nectar (300 µl) has already been secreted. The nectar is not reabsorbed and may be present until the end of the anthesis at 11:00h. Therefore, there is a shift on the nectar source from one species to the other, the first offering nectar during the beginning, and the other at the end of the night. No morphological trait could function as a distinctive signal in these species but their scent profiles are very different, perhaps working as a signal to the bats and allowing them to recognize the nectar producing species. Nectar presentation at different periods should be advantageous to the bats and could reduce interespecific pollination. (CNPq).

PREY OF THE COMMON VAMPIRE BAT FROM MID-WEATERN BRAZIL

Cardoso, M.M. & Uieda, W.
UNESP, São Paulo, Brazil.

The prey of the common vampire bat is generally recognized through observations of attacks upon different animals and by checking wounds on a prey's body. Both observations are difficult to make and much field work time is needed. Moreover, we can not get information concerning individual use of different prey by bats. A fast and simple methodology to get that information is serological analysis of gut contents. However, we know only four studies concerning this subject, and none of them were carried out in Brazil. Using the precipitin test by capillarity, we analyzed 183 stomach contents of vampire bats captured in 16 caves of Mid-western Brazil, during 1992-1994. The anti-sera of the following possible prey species were employed: bovine, equine, swine, chicken and humans. The Mid-western Brazil vampire bats fed upon the following prey, in decreasing order, bovine, equine, swine and chicken. The most frequent use of mammal blood by the common vampire bat was evident, in the ratio of 10:1 stomachs, as cited in the literature. Feeding by vampire bats was not the same between individuals of different reproductive stages nor between males and females. Reproductive and inactive males used more bovine and unidentified prey species (probably wild preys), respectively. Non-pregnant females mainly fed from bovines. On the other hand, pregnant females did not show differences in prey utilization.

DYSSOCHROMA VIRIDIFLORA, A BAT-DEPENDENT PLANT

Sazima, M.[1], Buzato, S.[2] & Sazima, I.[1]
[1]Universidade Estadual de Campinas and [2]Universidade de São Paulo, Brasil

Few plants are known to depend on the same kind of animal both for pollination and dispersal, and most of the recorded instances are related to birds as the agents in these two phases of a plant's reproductive cycle. We found that *Dyssochroma viridiflora* (Solanaceae), an epiphyte endemic to the Atlantic rainforest in southern Brazil, is both pollinated and dispersed by phyllostomid bats. The greenish flowers open at night and are visited by nectar-feeding glossophagine bats, whereas the yellowish fruits are sought by fruit-eating carolliine and stenodermatine bats. We studied this plant at the lowland rainforest in Ubatuba (about 50 m elevation), and at the highland rainforest in Campos do Jordão (about 1600 m). In the lowlands, we recorded the ubiquitous *Glossophaga soricina* visiting the flowers, whereas in the highlands we recorded the also ubiquitous *Anoura caudifer*, the only glossophagine found in the area. The fruits were eaten away by *Carollia perspicillata* and *Sturnira lilium* in the lowlands, whereas in the highlands only the latter bat was recorded as a visitor to solanaceous fruits (we have no actual records for frugivorous bats feeding on *D. viridiflora* in the latter area). Other bat-pollinated solanaceous plants, such as species of the genus *Markea*, may prove to be bat-dispersed as well. This is almost certainly the case for *Dyssochroma longiflora*, the second species of the genus.

WHAT FLORAL FEATURES FAVOR BATS AS VISITORS TO *ENCHOLIRIUM VOGELII*?

Christianini, A.V. & Buzato, S.
Universidade de São Paulo, Brasil

Encholirium species are erophytic, terrestrial Bromeliaceae, pollinated mainly by bats. *Encholirium vogelii* is an endemic species of "Serra do Cipó", MG, southeastern Brasil (ca. 19° S, 43° W), growing in

rocky montain fields called "Campos Rupestres". This species shares several flower features with chiropterophilous and ornithophilous syndromes, which motivated us to conduct this study. *E. vogelii* blossoms during January-February, releasing 180 cm tall inflorescences that contain ca.150 flowers, opening 5-22 flowers per day. Flowers are light green and anthesis lasts 48 hours. Average nectar volume and sugar concentration in nectar are 34.8 µl and 17.6 %, respectively. During the day, flowers were visited by several hummingbird species and at night, flowers were visited by the glossophagine bat, *Lonchophylla bokermanii*. This bat hovers very briefly in front of the flowers while lapping nectar and pollen, visiting 1-7 flowers per plant in each visit. The pollen is located on hummingbird's bill and bat's snout. *E. heloisae*, other synchronopatric species of *Encholirium*, has similar flower features, but, in contrast with *E. vogelii*, is not visited by bats. We believe that this selective visiting behaviour of bats in relation to *E. vogelii* is probably related to the higher position of flowers on the inflorescence, wider corolla and larger amounts of nectar available when compared with *E. heloisae*. These subtle differences on the attributes of both species may be responsible for the absence of bats on *E. heloisae* flowers. Additional controlled experiments are programmed to further test our hypothesis.

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BAT POLLINATION: PATTERNS OF ENERGY FLOW AND RESOURCE USE

Otto von Helversen
Institut für Zoologie II, Universität Erlangen, Germany

From the point of view of a pollinator, nectar is a high energy nutrient but costly to find and to exploit; on the other had, producing conspicuous flowers and secreting nectar is not a negligible cost for a plant. As costs for the pollinator include searching and localizing a flower, the plant may save energy by a trade-off between costs of nectar production and costs of making flowers conspicuous and easy to detect. Conspicuous flowers are also advantageous because they are favoured by more visits in competition with other plants; low rewards increase visit numbers, by causing pollinators to return repeatedly. For both parts of the system, plants and pollinators, competition with other individuals, of the same or another species, plays an important role in determining the pattern of energy transfer. These ideas will be discussed, comparing examples of bat pollinated rain forest flowers with the behaviour and energy requirements of their pollinators.

COEXISTANCE AND RESOURCE USE IN A COMMUNITY OF FLOWER-VISITING BATS IN ANEOTROPICAL RAINFOREST

Marco Tschapka
Institut für Zoologie II, Universität Erlangen, Germany,

Neotropical rainforests support guilds of nectarfeeding bats (Phyllostomidae: Glossophaginae). What mechanisms permit the coexistence of these species? The high level of transparency in energy flow for nectarivore communities permits quantitative assessment of both resource production and use. Bats were captured (8/94-1/97) in lowland forest at the La Selva Biological Station, Costa Rica. Food plants were determined by analysis of pollen loads and fecal samples. Four Glossophagines were found to co-occur at La Selva: two permanent residents (*Glossophaga commissarisi, Hylonycteris underwoodi*) and two species that occurred in small numbers only during seasonal periods of nectar superabundance (*Lichonycteri obscura, Lonchophylla robusta*). The two resident species differed in their temporal feeding strategies: after the main flowering peak, *G. commissarisi* shifted to a more frugivorous diet, while the smaller population of the apparently more specialized *H. underwoodi* fed on the few remaining bat-flowers. Throughout the annual cycle *H. underwoodi's* diet principally consisted of plants that provided only low energy density (kJ/ha/day), as revealed by phenology, flower density and nectar values. Body size and wing proportions support the idea that *H. underwoodi* is better adapted to exploiting low densities of flowers in energy-efficient flight than *G. commissarisi*, which primarily feeds on more concentrated flower resources.

DIET OF THE INDIANA BAT *MYOTIS SODALIS* IN MICHIGAN

Murray, S.W.
Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197

The Indiana bat, *Myotis sodalis*, has been listed as an endangered species in the United States since 1973, and despite the protection of major hibernacula, its overall population is still declining at an alarming rate. This suggests that the decrease in numbers is occurring during the summer, so it is important to document the roosting and foraging requirements of this species. The habitats and the trees that Indiana bats utilize vary between the central part of their range and the northern part of their range. Also, preliminary data suggest that in more southern states the diet of this bat is dominated by non-aquatic insects, and by aquatic insects in the north. For example, dietary studies in Indiana have found that typically 50% of the prey items are Lepidoptera, whereas a preliminary study in Michigan found 80% of the diet consisted of Trichoptera and Diptera. This difference in prey type, non-aquatic versus aquatic insects, could be due to Indiana bats selecting different foraging areas or prey items in the northern part of its range. Another possibility is that the results from this one Michigan site, are just a local phenomenon and not representative. To help determine if the diet and possibly foraging areas differ depending on range, I examined the diet of the Indiana bat at another site in Michigan. Over 50% of the diet consisted of Trichoptera and Diptera. The next important prey items were Coleoptera and Lepidoptera consisting of approximately 30% of the diet. These results suggest that Indiana bats in the northern part of their range are feeding on prey items different from what is considered typical. To properly manage this species, the variation in feeding ecology across the species' range must be taken into consideration.

MOTH SPECIALIZATION IN THE TRIDENT BAT, *CLEOTIS PERSIVALI*

Jacobs, D.S.
Department of Zoology, University of Cape Town, Private Bag, Rondebosch 7701, South Africa.

The allotonic frequency hypothesis proposes that some bat species are able to overcome the defense systems of tympanate insects by using echolocation calls with constant frequencies (CF) above or below the insects' hearing range. A major prediction of this hypothesis is that as the CF component of the echolocation call increases the incorporation of moths in the diet should also increase. It is possible that the short-eared trident bat, *Cloeotis percivali*, which has an echolocation call with a CF component at 212 kHz may have evolved to become a super predator on moths. Such a predator would have three characteristics. a) It should form rare components of bat communities so that it contributes very little to the selection pressure on moth hearing. b) It should feed almost exclusively on moths. This should be reflected in its skull morphology as well as its diet. c) Most of the energy of the call should be concentrated in the CF portion of the call to enable it to overcome moth hearing. These predictions were tested on a community of insectivorous bats which included *C. percivali, Hipposideros caffer, Rhinolophus simulator, Miniopterus schreibersii,* and *Scotophilus borbonicus. Cloeotis percivali* displayed all three characteristics of a super predator. It was the rarest bat in this and other communities, never comprising more than 1% of the total bat population. Although the diets of the other bat species included moths and beetles, the diet of *C. percivali* was comprised exclusively of moths. Principal component analysis indicated that C. percivali had a relatively larger gape and relatively smaller dimensions in skull features (e.g. height of the coronoid process) associated with the mastication of hard-bodied insect prey such as beetles. This suggests that its skull is specialized for the greater utilization of soft-bodied insect prey such as moths. Lastly, most of the energy of its echolocation calls was concentrated in the CF component of its call. *Cloeotis percivali* thus appears to have won the arms race against moths.

INTRASPECIFIC VARIATION IN WINGSPAN AND ECHOLOCATION CALLS AFFECTS HABITAT USE BY THE INSECTIVOROUS BAT, *MINIOPTERUS SCHREIBERSII*

Jacobs, D.S.
Department of Zoology, University of Cape Town Private Bag, Rondebosch 7701 S. Africa

On the basis of its long narrow wings, the insectivorous bat, *Miniopterus schreibersii*, has been characterized as a species which uses rapid flight to forage in uncluttered spaces. Until now observations of this bat's foraging behaviour supported this view. However, long narrow wings in this species is combined with relatively low wing loading suggesting that this bat might be capable of the slow manoeuvrable flight

characteristic of bats that forage in cluttered habitats. During recent trapping at the De Hoop Nature Reserve in South Africa this species was trapped in dense vegetation as well as in open spaces. This study investigated the morphological basis for this bat's ability to utilize both kinds of habitat. The wing parameters and echolocation calls of individuals that foraged in open spaces were compared with those of individuals that foraged in dense vegetation. This species used rapid less manoeuvrable flight in open spaces and slower more manoeuvrable flight in vegetation. There were no differences in wing area (open 141.31(10.39cm2); cluttered 138.26(11.11cm2) and wing loading (open 8.76(1.05 Nm-2; cluttered 8.66(0.84Nm-2) between bats foraging in open and cluttered spaces. However, individuals that foraged in clutter had shorter wingspans (open 31.03(1.57cm; cluttered 29.79(0.98cm), and therefore lower aspect ratios (open 6.82(0.47; cluttered 6.44(0.46) than individuals that foraged in open habitat. A shorter wingspan enables greater manoeuvrability in the confined spaces of cluttered spaces. In accordance with theoretical predictions, individuals foraging in open spaces increased the duty cycle of their echolocation calls by increasing call duration (open 4.38(1.70ms; cluttered 2.25(0.90ms). Increasing the duty cycle of the call enhances the bat's detection of beating wings of insect prey. Individuals foraging in open spaces also used echolocation calls of lower mean maximum frequency than those used by bats foraging in cluttered spaces (open 51.59(8.68kHz); cluttered 69.51 (11.56kHz). Since atmospheric attenuation increases with frequency, fast flying bats use lower frequency echolocation calls to increase their detection range of insect prey, giving them more time to react. The use of both open and cluttered spaces in this species is thus based, in part, on high intraspecific variation.

BAT DETECTORS AS TOOLS FOR FIELD IDENTIFICATION OF BATS IN SOUTHERN AFRICA

Taylor, P.J.
Durban Natural Science Museum, P.O. Box 4085, Durban, 4000 S. Africa

In many countries in Europe, North America and Australia, ultrasonic bat detectors are routinely used for conducting species surveys of bats. Because of the diversity of southern African bats, and the relative paucity of echolocation data for local species, such an approach has not hitherto been applied locally. Multivariate analysis was used to summarise new echolocation data obtained, using a Petterson D980 bat detector with digital tape recorder, from 25 bats representing 17 microchiropteran species recorded in a variety of situations: free-flying on release, handheld, flying in a room, flying naturally in search phase outdoors, and tethered outdoors. The new data were used to:1) assess the potencial of echolocation data (and hence, bat detectors) for species identification; and 2) to test the effect of environmental variables on echolocation call structure. The results showed a good taxonomic separation at the family level, based on a combination of body size and echolocation parameters. While species identification appears most feasible in narrow-bandwidth, constant-frequency call (CF) bats, more overlap was evident in broad-bandwidth frequency -modulated call (FM), particularly in smaller species of the Family Vespertilionidae which tend to have very broad signals. Species identification based on echolocation parameters in FM bats was further complicated by the observation of significant intraspecific variability in the four species in wich more than one individual was analysed. Nevertheless, where unknown calls were recorded at a locality, most of these calls could later be matched to known species with reasonable certainty, based on comparisons of sonograms. It seems likely that, together with field observations of flight patterns, foraging behaviour, habitat, distribution and relative body size, and once a more extensive sound library becomes available (documenting as many calls as possible for each species), bat detectors will prove valuable in the routine identification of the more dominant (commoner) species within a particular community. The effectiveness and accuracy of bat detectors for species recognition will be much greater when used in conjuction with a recording and analysis system capable of producing sosnograms. For the time being at least, corroboration of species identity should be carried out wherever possible, using mistnetting and collection of bats from day-time roosts.

ROBUSTNESS OF SKULL VS. HARDNESS OF INSECT PREY IN TWO NEOTROPICAL GENERA OF MOLOSSID BATS

Molinari, J. & Muñoz, M.
Universidad de Los Andes, Mérida, Venezuela

We studied skull morphology and diet in 13 species of bats of the genera *Eumops* and *Molossus*. To classify these bats morphologically, we carried out a Cluster Analysis of the species based on their scores on the second and subsequent factors of a Principal Components Analysis which considered cranial, mandibular, and dental measurements. In this way, we obtained four groups of bat species differing in skull robustness. To study food habits, we identified insects (to order) found in stomach contents and feces of over 150 individual bat specimens belonging to these skull robustness groups. We assigned each insect order to one of five levels of hardness of chitinous exoskeleton, ranging from soft to hard-shelled, and used this categorization to determine the distribution of hardness levels of prey collectively taken by members of each bat group. In agreement with a previous prediction (Freeman 1981), we found an overall direct relationship between robustness of bat skulls and hardness of insect prey. However, the distribution of prey hardness levels is bimodal in the four bat groups. We interpret this as indicating that other morphological and behavioral characteristics of bats besides skull robustness are involved in the selection of soft- or hard -shelled prey. For example: (1) a larger skull may facilitate the consumption of harder prey; and (2) by affecting flying speed and maneuverability, both body mass and wing shape may influence the efficiency of bats in the pursuit and capture of certain kinds of insects.

POLLINATON BY BATS IN SOUTHEASTERN BRAZILIAN FORESTS: AN OVERVIEW

Buzato, S. [1], Sazima, I. [2] and Sazima, M.[2]
[1]Universidade de São Paulo and [2]Universidade Estadual de Campinas, Brasil

Studies on bat pollination in Brazil concentrate in the southeast, and most of them comprise case histories focusing on one or a few plant species. To gain a broader insight on the interactions between flowers and bats we gathered field data on bat pollinated assemblages at two sites in different mountain ranges covered by the Atlantic rainforest in São Paulo, southeastern Brazil. The lowland site (about 50 m elevation) harbours 10 chiropterophilous plant species, pollinated mostly by three glossophagine bat species. The highland site (about 1600 m) harbours seven plant species, pollinated by a single glossophagine species. Bromeliaceae accounts for about 30% of the bat-pollinated species at each site. The plant populations bloom annually and both communities present staggered continual flowering patterns. Tube and brush type shapes, and yellowish and greenish colours prevail in the bat-flowers at both sites. Corolla length averages 26.8 and 37.2 mm, sugar concentration in nectar averages 15.0 and 18.1%, and nectar volume averages 150.8 and 167 µl at the lowland and the highland site respectively. The flowers are pollinated mostly during hovering visits by glossophagine bats, the plants being visited in the trap-line foraging pattern. The patterns that emerged from our study are consistent with those found for plant species pollinated mostly by glossophagine bats at other rainforest sites in South America.

STUDIES ON BAT POLLINATION IN BRAZIL: A HISTORICAL PERSPECTIVE

Sazima, M. and Sazima, I.
Universidade Estadual de Campinas, Brasil

In Brazil, as for the rest of South America, the foundations of knowledge about bat pollination were laid down by St. Vogel in the late nineteen fifties and early sixties. After two long journeys across the country, he published extensively on his field observations. Vogel established a well ordinated scheme on chiropterophily in Brazil (and South America as well), comprising about 50 bat-pollinated plant species in 30 genera and 27 families, an impressive figure for any tropical country. Several of these were presumed to be bat-pollinated based on floral syndromes, and subsequent studies revealed that Vogel was right in almost all of his assumptions. In 1969 he anticipated that a chiropterophilous species would be found in the Passifloraceae, and bat visits to *Passiflora mucronata* were recorded in 1978. In fact, most studies on bat pollination in Brazil followed the forecasts left by St. Vogel. (Exceptions are a study on some Amazonian plants by C.T. Carvalho in 1960, and another study on the genus Parkia by H.C. Hopkins in 1984).

Studies on bat pollination in Brazil gained a new impetus in the seventies, when G. Gottsberger and

I. Silberbauer-Gottsberger, and M. and I. Sazima independently published on the genus. From then on, some "novelties" appeared (all of them, however, foreseen in some way by Vogel), and the number of recorded bat-pollinated species is still increasing. Presently several Brazilian authors study bat pollination in the Amazon (R. Gribel, E.A. Fischer), the northeast (I.C.S. Machado), west (P.E. Oliveira), and southeast (M. and I. Sazima, S. Buzato) to mention some. A few present studies on bat pollination in Brazil focus on communities and conservation, a highly desirable trend for a tropical country with a still alarming deforestation rate.

BAT POLLINATION OF CERRADO PLANTS

deOliveira, P.E.A.M.
Dept. Biociências. Universidade Federal de Uberlândia, Uberlândia, Brazil

The cerrado formerly occupied one fifth of the Brazilian territory. These neotropical savanna areas are characterized by a rich herbaceous layer and a woody layer of shrubs and trees whose density defines gradients from open grasslands to dense cerradão woodlands. The woody flora, which extends into the cerrado region as gallery forests along river valleys and drainage lines, is related to the rain forest formations. The cerrado woody flora and forest trees share in common a great diversity of pollination systems along with a prevalence of obligatory allogamy due to dioecy and self-incompatibility. Bat pollinated species represent less than 5% of the total flora, but some of them are very common and widespread elements of the cerrado. They have relatively less specialized flowers and are visited and pollinated both by Glossophaginae and diverse frugivorous bats. *Lafoensia pacari, Caryocar brasiliensis* and *Hymenaea stigonocarpa* produce copious amounts of nectar in robustly built brush flowers which are visited by a similar bat fauna, although they flower in different times of the year. *Bauhinia spp.* and *Pseudobombax spp.* have more specialized flowers with protected nectar chambers accessible only to bats with long and specialized tongues, and in the case of *Bauhinia*, to those able to hover in front of the relatively fragile flowers to reach for the nectar. Bat pollinated cerrado trees are related with congeneric forest species sometimes occurring nearby and pollinated by the same bats. Bats seems to fly freely from forest to cerrado and these formations constitute a mosaic of resources which may help to maintain a greater diversity and number of flower visiting bats. (CNPq)

CANOPY TREES POLLINATED BY BATS IN THE RESERVA DUCKE, CENTRAL AMAZON

Fischer, E.A.[1] and Sazima, M. [2]
[1]Universidade Federal do Mato Grosso do Sul and [2]Universidade Estadual de Campinas

The neotropical bat-pollinated flora is mainly pollinated by Glossophaginae or Phyllostominae bats. To compare plant traits between species pollinated by Glossophaginae and species pollinated by Phyllostominae, we studied canopy trees in old-growth Amazon "terra firme" forest. From April 1996 to March 1997, flowering trees were monthly sampled in 14.8 ha. Density, size, flowering season, flower production and visitors were registered for nine tree species. Species pollinated by Phyllostominae (n = 5) were most frequent in elevated soils distant from watercourses and presented large, uppermost trees in the forest canopy. Otherwise, tree species (n = 4) pollinated by Glossophaginae were smaller and common along watercourses. Flowering seasons were short (2-3 mo) and sequential among species pollinated by Phyllostominae, whereas species pollinated by Glossophaginae flowered during 2-10 mo with overlapping seasons. The means for number of blossoms produced per tree, number of blossoms open daily per tree and nectar production per blossom, were all significantly higher for species pollinated by Phyllostominae than for those pollinated by Glossophaginae. Groups of 5-30 Phyllostominae bats constantly visited focal trees throughout the flower lifetime, and vocalizations and aggressive encounters were common among these bats. Glossophaginae bats visited trees singly or in pairs, and in short visiting bouts interspersed with intervals of no visits. Differences found between species pollinated by Phyllostominae and those pollinated by Glossophaginae support the occurrence of two general categories of neotropical bat-pollinated tree species.

MONITORING ECHOLOCATION CALLS OF NEOTROPICAL BATS: AN EFFECTIVE TOOL TO ASSESS DIVERSITY OF AERIAL INSECTIVORES

Kalko, E.K.V.[1,2,3], Molinari, J.A.[4], Sampaio, E.M.[1], Staden, D.v.[1] & Handley Jr., C.O.[3]

[1]Animal Physiology, University of Tuebingen, Germany [2]Smithsonian Tropical Research Institute, Panama
[3]National Museum of Natural History, Washington DC, USA [4]Universidad de los Andes, Mérida, Venezuela.

Neotropical bats are highly speciose. To assess patterns in diversity and to provide a firm basis for conservation-oriented programs, detailed knowledge about species composition of local and regional bat faunas is crucial. Development of efficient inventory techniques such as combining mistnetting with acoustic monitoring (i.e., identification of bats based on echolocation calls) now permit comprehensive inventories to be made. Whereas New World leaf-nosed bats (Phyllostomidae) can be sampled well with mistnetting, this metod is ineffective for others, i.e., for the large portion of aerial insectivores which make up 30-50% or more of local faunas. By studying bats in Central and South America, we are currently developing an acoustic identification key for neotropical bats. We found, based on characteristic call parameters, that many of the aerial insectivores including heath-tailed bats (emballonuridae), free-tailed bats (Molossidae), leaf-chinned bats (Mormoopidae), buldog bats (Noctilionidae), and evening bats (Vespertilionidae) can be identified to genus and most to species level. However, acoustic monitoring requires appropriate equipment and adequate knowledge about how to record, analyse, and interpret bioacoustic information. We outline methodological considerations, report results of ongoing field studies, and suggest recommendations how to standardize recording and analysis procedures to allow comparison between studies.

IS THERE A PHYLOGENETIC SIGNAL IN BAT ECHOLOCATION CALLS?

Simmons, N.B.[1] & Kalko, E.K.V.[2]

[1]Dept. of Mammalogy, American Museum of Natural History, New York, USA
[2]Animal Physiology, University of Tuebingen, Tuebingen, Germany,
and Smithsonian Tropical Research Institute, Panama.

Most microchiropteran bat species and genera are characterized by taxon-specific echolocation calls, and call structure is generally assumed to reflect the ecological habits of the bat. In this study we investigated the possibility that echolocation calls structure also contains phylogenetic information. We scored 25 features of call structure in over 90 genera representing all extant microchiropteran families. Features considered included number of harmonics, bandwidth, peak frequency, presence and structure of initial and terminal FM components, presence of a CF component, and presence and structure of terminal phase calls. In some cases, call characteristics employed in different habitats (open space versus cluttered habitats) were scored separately to accommodate call variability seen in some taxa that use multiple habitats. Analyses of our data indicate that many families are characterized by specific types or combinations of echolocation calls that differ from those seen in most other families. We conducted a cladistic analysis of family-level taxa using only echolocation call characters and compared the resulting tree with a recent phylogeny of bats based on morphological and molecular characters. Our poorly-resolved echolocation-only tree contained some groups that appear to be linked by convergent call structure, but it also identified clades congruent with those found in previous phylogenetic studies. We combined our echolocation call characters with the morphological and molecular data set found that inclusion of the echolocation data did not change the structure of the single most-parsimonious tree. However, inclusion of the echolocation data did significantly increase the decay and bootstrap support for several clades. The results suggest that echolocation calls do contain important phylogenetic information that may be useful for reconstructing the evolutionary history of microchiropteran bats.

COMPARATIVE FEEDING ECOLOGY OF THE AERIAL INSECTIVOROUS BATS *EUMOPS GLAUCINUS* AND *E. AURIPENDULUS*

Muñoz, M. & Molinari, J. Universidad de Los Andes, Mérida, Venezuela.

Eumops glaucinus and *E. auripendulus* are widely sympatric in the neotropics. Both have medium-sized ears, but differ in body mass (41 g and 29 g, respectively), skull (that of *glaucinus* is less robust),

and appendage proportions (*glaucinus* has shorter wings and larger interfemoral membrane). Previous research has proposed: (1) a more robust skull to imply a diet including an increased variety of insects, and based on insects with harder exoskeletons; (2) a higher body mass to likewise imply a diet including an increased variety of insects; and (3) shorter wings to augment speed/maneuverability, and a larger interfemoral membrane to facilitate contacting flying insects, thus improving capture of soft-shelled and more elusive prey, especially Lepidoptera. Accordingly, the skull of *glaucinus* should lead to less varied and, on the average, softer-shelled prey. However, the body mass of this bat would partially debilitate such trend by promoting more prey variety, whereas the appendages would partially reinforce it by easing the capture of softer-shelled prey. We analyzed stomach contents and feces of *E. glaucinus* and *E. auripendulus* from throughout Venezuela. Results are: (A) the diet of *glaucinus* includes less prey variety; (B) both *Eumops* species take soft-shelled and intermediate prey; (C) hard-shelled prey is important only for *auripendulus*. This suggests that, for these bat species, skull robustness and appendage proportions are more important than body mass in determining different feeding habits.

FORAGING BEHAVIOUR OF *POLECOTUS AURITUS* AND *MYOTIS DAUBENTONI* IN SYMPATRY

Zukal, J.[1], Andreas, M.[2], Reiter, A.[3] & Brenda, P.[4]

[1] Institute of Vertebrate Biology, Academy of Sciences of CR, Kvetna 8, CZ-60365, Brno,

[2] Institute of Applied Ecology, Czech Agriculture University, CZ-26831, Kostelec nad Cernymi Lesy,

[3] South Moravian Museum, Premyslovcu 6, CZ-66901, Znojmo,

[4] National Museum, Vaclavske nam. 68, CZ-10000, Praha, (ALL Czech Republic)

The research was carried out on the bat community at the locality Ledové sluje caves near Vranov nad Dyjí, SE Czech Republic. Bats were netted and recorded by means of ultrasound detectors. The collected fecal pellets were analysed and particular food taxa were identified. Presented paper is aimed at the foraging behaviour of the most abundant species - *Plecotus auritus* and *Myotis daubentoni*. We observed two peaks in seasonal dynamics of flying activity (April and August, September) of both studied species, but *P. auritus* is more abundant in early spring months. The level of *M. daubentoni* foraging activity was relatively stable. The differences in seasonal body weight changes are also the most apparent in the beginning of season. The body weight growth of *P. auritus* is quicker after the end of hibernation. In general, we can conclude that *P. auritus* seems to be much more successful in foraging during early spring than its congener. It has much more opportunistic and flexible foraging strategy, changing the main food items from April to May.

ECOLOGY

WING MORPHOLOGY OF BATS OF THE BRAZILIAN CERRADO: INSIGHTS ON THE CONSEQUENCES OF ASSEMBLAGE FEATURES

Oliveira, E.R. de & Oliveira, L.F.B.

Depto. de Vertebrados, Museu Nacional - UFRJ, Quinta da Boa Vista, 20940-040, RJ, Brazil

Flight has opened up many ecological opportunities for bats because it permits foraging over large areas to otherwise inaccessible places. Such an expensive mode of locomotion should demand a strong selection to minimize its cost. A wing design which minimizes the work needed to fly at optimal speeds for the animals, may be favored by natural selection. The type of habitat of bats and the optimal way of exploiting them are related to the combination of morphological, ecological and behavioral attributes of the species. Considering that wing morphology is phylogenetically constrained, the demands of flight and the great variability of habitats in the Cerrado landscape may be responsible for the assemblage features. The recent landscape disruptions resultant from anthropic activities may drastically affect the bat assemblages over large areas, thus rarity or local extinction may be partially phylogenetically determined. Four assemblages of bats from the Alto Tocantins Region (State of Goiás, Brazil) are studied. Aspect-ratio (shape of the wing) and wing-loading (body weight and wing size relationship) components are examined by Factor Analysis. The wing design is recognized to be related to the manner of use of space (sustained

foraging flights, locomotion among vegetation, slow and fast fliers). The designs of the species are phylogenetically constrained but the habitats are drastically variable in a short time scale. The consequences of the abrupt changes in the landscape of the Cerrado, due to anthropogenic activities, certainly will have a strong impact in favoring or reducing species richness in local bat assemblages. CNPq, CAPES, NATURAE

FEEDING HABITS OF FRUIT BATS IN AN URBAN RESIDENTIAL AREA OF CAMPINAS, SP, BRAZIL

Soubihe, E.A.R. & Setz, E.Z.F.
Depto. Zoologia, IB, UNICAMP, Campinas, SP, Brazil

Despite their high diversity and ecological importance, bats are poorly understood by urban man. Due to the ease of detecting feeding roosts along streets, this reality can be changed. The aim of this study was to determine feeding habits and seasonality of fruit bats through the observation of left-overs from feeding roosts in the J. Guanabara neighborhood of Campinas, SP, Brazil. Areas under feeding roost were cleaned of trash and the following morning, food left-overs discarded by the bats were collected and the number of fruits per plant species was noted. In April 1998 (n = 32 roost-nights), 5 species (*Holocalyx glaziovii* = HG, *Terminalia catappa* = TC, *Myrciaria sp* = MS, *Syagrus romanzoffiana* = SR and undetermined, in decreasing order of number of fruits) from 4 families (Fabaceae, Combretaceae, Myrtaceae, Palmae, respectively) appeared under 4 roosts. Three species are native (HG, MS and SR) and one exotic (TC). These species are frequent along streets (HG, TC and SR) and in gardens (MS) in Campinas. On average, each feeding-roost presented 2 to 38 left-over fruits per night (min. 1- max. 101). Left-overs consisted of isolated seeds (HG, TC, SR and IN) or peels with seeds (MS). These preliminary results confirm the importance of ornamental plants in fruit bat subsistence and their potential as educational tools in an urban context.

VARIATIONS IN AGE STRUCTURE AND SEX RATIO OF A *CAROLLIA PERSPICILLATA* POPULATION IN AN ATLANTIC FOREST FRAGMENT IN SOUTHEASTERN BRAZIL

Ribiero de Mello, M.A. & Fernandez, F. A. S.
Departmento de Ecologia, Universidade Federal Soubihe, E.A.R. do Rio de Janeiro

Population dynamics of bats have been studied since July 1997 at a fragment (15 ha) of Atlantic Forest at Poço das Antas Biological Reserve, Southeastern Brazil. Among eleven bat species captured, *Carollia perspicillata* (Phyllostomidae: Carollinae) was dominant. On the whole, the sex ratio was significantly biased towards females (M = 0.42, F = 0.58; log-likelihood ratio, G = 6.65, 1 df, $p < 0.01$). The proportion of females did not differ significantly among months (G = 5.80, 5 df, $0.25 < p < 0.50$). The distribution of the individuals in age classes (juveniles, subadults and adults), separated by degree of ossification of patagium fingers' epiphysis, did not differ significantly between sexes for the study as a whole (G = 2.52, 2 df, $0.25 < p < 0.50$). Nevertheless there was a highly significant variation in the age structure among months (G = 53.63, 10 df, $p < 0.001$). There were no juveniles from July to December 1997, but juveniles and later subadults appeared in January-February 1998. In March 1998 the population was maturing again. These patterns can be explained by breeding starting in the late dry season-early wet season (August -September), coupled with aging, as the time span of the juvenile class is short.
(FAPERJ, Fundação O Boticário de Proteção à Natureza, FUJB).

NATURAL HISTORY OF THE VAMPIRE BAT *DESMODUS ROTUNDUS* ON THE COAST OF JASLISCO STATE, MEXICO

Sánchez-Hernandez, C.[1], Romero-Almaraz, M.L.[2] & Flores-Oviedo,A.[1]
[1]Instituto de Biología, UNAM, A. P. 70-153, 04510, México, D. F.
[2]Centro de Investigaciones BiológiRibeiro de Mello, M.A.cas, UAEM, Av. UniversidadFernandez, F.A.S. 1001, Col. Chamilpa, 62210, Cuernavaca, Morelos, México

The vampire bat *Desmodus rotundus* is one of the most abundant and best studied of the three blood feeding bat species. This is the principal vector of rabies to the cattle in the tropical regions of the American continent. For appropriate control procedures, it is necessary to know the natural history, ecology

and behavior of this bat. The study was conducted in the proximity of Chamela, a biological station of the Instituto de Biología, UNAM, located in the state of Jalisco, at 60 meters above sea level. This area is characterized by rolling plains and with hills rising no more than 500 m. The climate is characterized by a pronounced dry-wet season. Tropical deciduous and semi-deciduous forest predominate on the hillsides and along the water courses respectively. The phenology changes extensively between the dry and rainy seasons. The field work portion of this study began in December 1996 and the observations were carried out every 35 to 40 days. All captured bats were examined and marked with collars for later identification. The questions we sought to answer to were: How do the density, sex ratio, reproduction and age structure of *Desmodus rotundus* vary temporally?, Which of the following factors determine the bat's home-range: sex, age or reproduction? The research has recorded that bat density varied from 57 to 14 individuals in the refuge and the sex ratio ranging from 0.56 to 1.5 females per male. We have found pregnant females and juveniles in almost all the collection periods. We make the description of postnatal growth.

NEW RECORDS OF BATFLIES (DIPTERA, STREBLIDAE) ON PHYLLOSTOMID BATS IN THE FAR SOUTH OF BRAZIL

Graciolli, G.[1] and Rui, A.M.

[1]Postgraduate Course in Entomology, Universidade Federal do Paraná

[2]Postgraduate Course in Ecology, Universidade de Brasília

This study presents the first data of batflies of the Phyllostomidae family in the southernmost part of Brazil. The collection of the material was made in northern Rio Grande do Sul (Planície Costeira) in an area which was originally covered by forest (Floresta Ombrófila Densa). The batflies were collected from five species of phyllostomid bats. Eight species of batflies were identified, all of which belonged to the Streblidae family. *Anastrebla modestini* and *Exastinion clovisi* were found on *Anoura geoffroyi* and *Trichobius parasisticus* on *Anoura caudifer*. It was observed that *Megistopoda proxima* and *Trichobius sp* were parasites of *Sturnira lilium*. *Paratrichobius longicrus* and *Megistopoda aranea* were found on *Artibeus lituratus* and *A. fimbriatus*. *Metelasmus pseudopterus* was found only on *A. fimbriatus*. *Paratrichobius longicrus* is the most abundant batfly species which is a parasite of the two species of *Artibeus*. The sex ratio was calculated for the three species of batflies most frequently collected, the results showing a larger proportion of males in the populations. In relation to *P. longicrus* (n = 24), the sex ratio is equal to 1 male: 0,71 females, for *M. aranea* (n = 18) being 1 male: 0,64 females and for *M. pseudopterus* (n = 11) 1 male: 0,73 females.

MIGRATION OF THE NATHUSI'S PIPISTRELLE ALONG THE BALTIC COAST

Jarzembowski, T. & Stepniewska, A.

Universytet Gdanski, 80-441 Gdanski, Poland

Migration of the Nathusi's pipistrelle *Pipistrellus nathusi* was studied between 1996-1997 on the Wistula Split. To observe the bats' east-west movements along the coastline, two methods were used:

1. recording with two Petterson D100 bat detectors connected to stereo systems; 2. monitoring movements between bat boxes and changes in bat numbers in the study area. From the beginning of May, significant eastern movements of bats ($p < 0.005$ Wilcoxon test, 235 ind.) were observed to dominate. The peak was observed in the middle of the month. At this time the first male bats started to occupy boxes on the study area. From mid-July until the end of August, bats going west outnumbered bats going east (195 ind.). During this period, females joined males in the boxes and formed mating groups. On the basis of these facts, spring migration, in May, may be described as shorter and more intensive than autumn, from the end of July until the end of August.

VERTICAL STRUCTURE OF BAT COMMUNITIES IN TREE FALL GAPS IN CENTRAL AMAZONIAN PRIMARY FORESTS

Bernard, E.
INPA/SI - Caixa Postal 478 Manuas - AM - 69011 - 970. Brazil

I investigated the vertical stratification of bat communities that use as habitat small tree fall gaps in primary forests of Central Amazonia (80 km north of Manaus) using capture nets in the canopy (17 to 30 meters high) and in the understory (from 0 to 2.5 meters). Seventeen small natural tree fall gaps (70 to 240 m^2) were sampled during one year (3,398.5 mistnet.hours). I captured 936 individuals, belonging to 6 families, 27 genera and 51 species. Utilizing Non Metric Multidimensional Scaling (NMMDS), I verified a marked vertical stratification between the communities. These showed an heterogeneous distribution between the understory and the canopy, with canopy being a intense utilized region. Species of the sub -family Stenodermatinae were more abundant at canopy level. Carollinae and Phylostominae utilized more frequently the understory, as did sub-families Glossophaginae and Lonchophyllinae. Sturnirinae was equally distributed between canopy and understory. The family Mormoopidae utilized the understory, as did Thyropteridae. Members of the families Emballonuridae and Vespertilionidae were equally abundant in the understory and in the canopy, while Molossidae mostly utilized the region above the canopy, with sporadic incursions to the interior of the gaps.

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BATS FROM PEDRA BRANCA STATE PARK - I, PAU DA FOME REGION, RIO DE JANEIRO STATE - FOOD HABITS AND REPRODUCTIVE PERIODS

Silva, S.S.P. da[1], Dias, D.[2], Cruz, A.P. da[2] & Peracchi, A.L.[3]
[1]Fundação Instituto Estadual de Florestas/IEF.
[2]Biologia Animal - UFRRJ - Faculdades Integradas Maria Thereza
[3]UFRRJ, Antiga Rod. Rio-São Paulo, Km 47, Seropédica, Itaguaí, RJ, 23851-970.

Food resource utilization and reproductive periods of 26 bat species occurring in Pedra Branca State Park were studied during the period from March 1994 to June 1997. The bats were caught in mist-nets. A total of 593 specimens belonging to Phyllostomidae, Vespertilionidae and Molossidae families were captured. The feces and gastrointestinal contents of bats were examined in the laboratory for separation and identification of food items. The family most represented was Phyllostomidae, with 574 individuals. The frugivorous phyllostomids showed preference for Cecropiaceae, Piperaceae and Solanaceae fruits. Utilization of Leguminosae, Bombacaceae, Myrtaceae and Malvaceae pollens were also detected in the study site. Our data indicate that the diet of some species varies throughout the year according to food availability, while other species show restricted food preference. In this study, the occurrence of *Artibeus cinereus* is emphasized, which constitutes the first record of this species for the city of Rio de Janeiro. Vespertilionidae (n=11) and Molossidae (n=8) were also sampled during the study. It was observed that reproduction occurs mainly during the periods from March to May and July to November. The most common species showed seasonal poliestry with bimodal peaks. The reproductive periods of bat species are likely related to food availability.

COMPARATIVE STUDY OF THE RENAL STRUCTURE OF PUERTO RICAN BATS

Rivera-Marchand, B., Rivera Peracchi, A.L. & Rodriguez-Duran, A.
Department of Natural Science and Mathematics, Interamerican University-Bayamon, Puerto Rico

The only endemic terrestrial mammals on the island of Puerto Rico are bats. There are thirteen known species, which differ in their feeding habitats and choice of roost, as well as morphological and physiological aspects. The majority of these species live in caves where temperatures vary between 21°C -40°C. The difference in feeding habits and roost suggests a possible difference in the mechainsm for reabsorbing water and concentrating urine Studying the renal structure in bats, the ability to concentrate urine can be evaluated. The ratio between the size of the renal medulla and the size of the cortex was determined using normal hystological methods The higher the value of the ratio, the more concentrated is the urine. The medulla cortex ratio varied among the species Feeding habits and roost were considered to

compare and explain these differences. For example, the waste produced by the consumption of insects requires more water for excretion. The type of roost is another factor that could influence the ability to concentrate urine. We found that the species which live in hot caves have a better ability to concentrate urine.

BATS OF THE RIO PARDO BASIN OF THE SPELEOLOGICAL PROVINCE, SOUTHERN BAHIA/BRAZIL

Soares-Santos, B.
State University of Santa Cruz - UESC, Bahia, Brazil

The Atlantic Forest of Southern Bahia represents one of the most important priorities for conservation in the Neotropics. The Rio Pardo basin represents an area of 2500 km^2 near the Pau Brasil County at the extreme south of Bahia State. It is characterized by the presence of limestones and dolomites. There are at least 15 caves ranging from 60 to 300m long. From May 1997 to April 1998, I visited 10 caves twice a month (except for the months of December '97 and January '98) representing an effort of 620 hours. After November '97 I started to use numbered plastic necklaces to tag the bats. I captured 21 species belonging to four families (Natalidae, Thyropteridae, Phyllostomidae and Vespertilionidae). Seemingly, at least for the most common species such as *Carollia perspicillata* and *Desmodus rotundus*, the size of the colonies are constant. Some species did not show fidelity to the shelters, as it was observed for *Crotopterus auritus* and *Diphylla ecaudata*. For all caves visited, quite diverse bat faunas were observed. However, for those caves located near pasture areas I mostly recorded hematophagous and insectivorous populations, while carnivorous, frugivorous and nectarivorous species were more abundant in caves close to forest fragments or "cabrucas" (shaded cocoa plantation). This work constitutes the first record of *Thyroptera tricolor* in caves.

STUDYING BAT COMMUNITIES OR FRUGIVOROUS BATS?

Aguiar, L.[1] and Marinho-Filho, J.[2]
[1]Programa de Pós-Graduação em Ecologia - Departamento de Ecologia, UnB, Brasília - DF - Brazil.
[2]Departamento de Zoologia - Universidade de Brasília - ICC Ala Sul - 70910-900. Brasília - DF - Brazil.

Studies on bat communities are scarce all over the world. In Brazil they are very recent. Analyzing the current literature and some unpublished material covering most of the studies on bat community structure in Brazil, from 1983 to 1995, some patterns seem common to all of them: latitudinal variation in richness of species, low equitability of species, primary vegetation holding more species than secondary, similarity of frugivorous guilds independent of geographical location, seasonal variation in species composition and diets of bats. Reproduction usually occurs in the period of greater availability of food and it varies geographically. However, despite the fact that aproximately 60% of the Brazilian bat fauna is composed of insectivorous bats, almost all available data comes mainly from frugivorous species, easily caught with mist nets. I argue the necessity of new methodologies and technologies on bat community studies in Brazil.

ECTOPARASITES OF BATS FROM THE DISTRITO FEDERAL AND THE STATE OF GOIÁS, MID-WESTERN BRAZIL

deSouza, J.L. and Bredt, A.
Instituto de Saúde do Distrito Federal, Brasília, DF, Brasil.

Several arthropod groups parasitise exclusively on bats, living in close association with their hosts at their roosts, either natural or artificial. We studied the ectoparasites from 41 bat species form the following families Emballonuridae, Mormoopidae, Phyllostomidae, Natalidae, Furipteridae, Vespertilionidae and Molossidae. Between 1989 and 1997, the bats were captured in caves, buildings, flyways, pastures and orchards. Mites belonging to the families Argasidae (4 spp.), Chirorhynchobiidae (1), Ixodidae (2), Listrophoridae (1), Macronyssidae (17), Myobiidae (1), Sarcoptidae (1), Spelaeorhynchidae (1), Spinturnicidae (12), and Trombiculidae (6) were found. Insects belonging to the families Streblidae (35 spp.), Nycteribiidae (4), Ischnopsyllidae (3), Pulicidae (1) and Polyctenidae (2) were also found in Mid -Western Brazil. Spinturnicid and trombiculid mites were found on every bat family studied. Macronyssid mites were more frequently associated to phyllostomid bats, followed by the molossids and vespertilionids.

Streblid flies were found mainly in association to phyllostomids, while nycteribiids were more often found on vespertiolionids, followed by molossids. Fleas and polyctenid hemiptera were found exclusively on molossids (Grant by FAPDF, Proc. 190.000.280/94)

THE BATS OF THREE DIFFERENT DISTURBED AREAS IN ATLANTIC FOREST, SOUTHEASTERN BRAZIL

Melo, G.[1], Jucá, N.[1], Enrici, M.A.[2], Alvarez, C.A.B. [1], Ribeiro, T.T.L.[1], Costa, D.P.[1], Peixoto, F.[1], Esberárd, C.E.L.E[3] and Bergallo, H.G.[1]

[1] Setor de Ecologia, Inst. de Biol. Roberto Alcântara Gomes, Universidade do Estado do Rio de Janeiro

[2]Setor de Zoologia, IBRAG / UERJ and [3]Fundação Rio-Zoo.

We studied the Chiroptera species composition, richness and diversity in three areas with different disturbance levels. The study was carried out in the Atlantic forest at Ilha Grande, district of Angra dos Reis, Rio de Janeiro State, Brazil. Two of the areas (Trilha do Cachadaço and Trilha da Parnaioca) are covered with secondary forest one of them being close to a small village, Trilha da Parnaioca, consequently suffering a major anthropic influence. The third area, Jararaca, is at the hillside of the mountain with little habitat alteration. Monthly, from September 1997 to March 1998, two mist-nets (12 m) were opened in each area for six hours. The animals captured were identified, weighed, sexed and measured, and released after the trap-night period. The total number of bats captured up to now includes 290 individuals, belonging to 16 species: *Carollia perspicillata, Sturnira lilium, Phyllostomus hastatus, Artibeus jamaiscensis, A. obscurus, A. fimbriatus, A. lituratus, Chiroderma doriae, Platyrrhinus lineatus, Trachops cirrhosus, Tonatia bidens, Desmodus rotundus, Anoura caudifer, Glossophaga soricina, Myotis nigricans* and *M. albencens*. The most common species in the three areas were *C. perspicillata, S. lilium, A. obscurus* and *A. fimbriatus*. The species diversity was higher at Trilha da Parnaioca (H'= 3,307) followed by Trilha do Cachadaço (H'= 2,807) and Jararaca (H'= 2,562), which may be a result of a greater effort in the first area, necessitating an increase in the number of samples in the other areas.

TENTS USED BY *VAMPRESSA PUSILLA* IN SOUTHEAST BRAZIL

Zortéa, M.[1] & de Brito, B.F.A. [2]

[1]Universidade Federal de São Carlos - PPG. Ecologia e Recursos Naturais and Museu de Biologia Prof. Mello Leitão, Santa Teresa-ES, 29650-000 - Brasil

[2]Universidade de Brasília - PG. Ecologia - Brasil

A few species of bats in the world are known to use special diurnal roosts called tents. A Neotropical frugivorous bat, *Vampyressa pusilla* (Phyllostomidae), is one of those species which use this kind of roosts. In this study we present a new data on the utilization of tents by this species. Two Atlantic Rain Forest reserves located at the southeast Brazil were inspected with the aim of finding these tents. At the Biological Reserve of Duas Bocas were observed *V. pusilla* in modified leaves of *Heliconia* (Heliconiaceae). However at the Santa Lúcia Biological Station, where Heliconia are less common, *V. pusilla* was observed in modified leaves of *Simira aff. eliezeriana* (Rubiaceae). The *Simira's* tents have a similar shape as the one observed for *Pentagonia donnell-smithii* (Rubiaceae) and used by *V. nymphaea* in Costa Rica. The *Heliconia's* tents have a mixed pattern of architecture, that differ from the other tents used by bats of the genus *Vampyressa* in other regions.

TROPHIC STRUCTURE OF THE PHYLLOSTOMID ASSEMBLY AT BARRO COLORADO ISLAND, PANAMA

Giannini, N.P.[1], Kalko, E.K.V.[2,3,4], Handley Jr., C.O. [4] and Tejada, S.[3]

[1]Cátedra de Vertebrados, Facultad de Ciencias Naturales, 4000-Tucumán, Argentina.

[2]Animal Physiology, University of Tübingen, 72076, Tübingen, Germany.

[3]Smithsonian Tropical Research Institute, P.O. BOX 2072, Balboa, Panamá.

[4]National Museum of Natural History, Washington DC, 20560, USA.

We studied the trophic structure of phyllostomids on Barro Colorado Island (BCI, 1600ha), a tropical,

semideciduous lowland forest, in Panamá. Most data derive from a long term project (1976-1985), with more than 4000 dietary samples from 30 species of bats. To examine multivariate structure and to test for the presence of meaningful subsets of sp. we analyzed the whole data matrix, and subsets thereof, with Correspondence Analysis and Multidimensional Scaling. Animalivores were well separated from plant-eaters. An ordination of the latter distinguished *Piper*-eating Carollinae from *Ficus*-eating Stenoderminae, and bats with more than 40% of pollen in the diet (Glossophagines and Phyllostomus). Fig-eating bats spanned a long gradient, in part related to the size of the bat and the fig, though some variation unexplained remained. In this group, an ordination based upon captures under fig trees and of the actual diet yielded the same results. Among the animalivores, available data from different sources are highly variable due to small sample sizes, and biases in analytical techniques. Overall, we conclude that in spite of some overlap and seasonal variability, the main trophic structure of phyllostomids on BCI constitutes of the two major, clearly separated groups of animalivorous and plant-eating bats, the latter forming a triad composed of mainly *Ficus*-eating, *Piper*-eating and nectar- and pollen-eating bats.

DIET AND ALTITUDINAL HABITAT SELECTION IN THREE SYMPATRIC SPECIES OF *STURNIRA* IN AN ANDEAN RAIN FOREST

Giannini, N.P.
Cátedra de Vertebrados, Facultad de Ciencias Naturales, 4000- Tucumán, Argentina

Diet and habitat choice of 3 sympatric species of *Sturnira* (Chiroptera:Phyllostomidae) were studied in a montane seasonal wet forest in NW Argentina. Mist nets (10) were used on 2 nights, monthly (16 mo., Dec. 1994-April 1996) at 3 sites (800, 1200, 1600m). Species roughly segregated altitudinally, one common at lower sites, one dominant at upper sites, and the other one rare everywhere. Captures correlated with number of plants visited by bats, over time, at the 2 lower sites, but not at the upper site. Diet (552 samples of *S. erythromos*, 44 of *S. lilium* and 2 of *S. oporaphilum*) was dominated by *Solanum* and *Piper* (>97%, 17 or less sp. out of 96 sp. of fleshy fruits found in the area, with 4-5 sp. that comprised 15% or more of the total diet each) at all sites and for all bats studied. Relative proportion of these 2 main food items followed the increase in number of *Solanum* species and the decrease of *Piper* densities, altitudinally. Locally bats eat the same fruits in similar frequency. Fruits showed chiropterochorous traits, and an extended phenology over several months. Together with Central American data, these results strongly support the observation that *Solanum* and *Piper* are core fruits for *Sturnira*, and do not support the influence of body size on habitat and diet selection. Altitudinal capture rate can be related to the continental distribution of sp. within the genus (lowland vs. montane forests). Large scale, neotropical patterns seem to explain local trends in *Sturnira*, both in fruit and habitat use.

BAT FAUNA FROM AN ENVIRONMENTAL PROTECTION AREA IN SOUTHEASTERN BRAZIL

Morelli-Alves, G., Cardoso, M.M., M.M., Hayashi, M.M., Nogueira, Y.L. and Uieda, W.
UNESP, São Paulo, Brazil

The Atlantic Forest has suffered a degradation process primarily accelerated by agriculture and urban expansion. Flora and fauna investigations in the remnant natural areas are extremely important to support the Atlantic Forest conservation. A study of the bat fauna was carried out at the Environmental Protection Area–Fazenda Intervales a remnant Atlantic Forest area of the state of São Paulo. A total of 235 bats belonging to 24 species of 4 families were caught by us between 1995 and 1997, and by Manço et al. (unpublished report), during 1989-1990. The Family Phyllostomidae was represented by 63% of the species, and the most common bat was *Sturnira lilium* (42%), followed by *Lonchorrhina aurita* (14%), *Anoura caudifer* (13%), *Desmodus rotundus* (8%), *Carollia perspicillata* (7%), *Artibeus lituratus* (6%), *Anoura geoffroyi* (4%), *Diphylla ecaudata* (2%), *Trachops cirrhosus* (1%) and *Chrotopterus auritus*, *Glossophaga soricina*, *Phyllostomus hastatus*, *Pygoderma bilabiatum*, *Sturnira tildae* and *Tonatia bidens* (0.6%). The Family Vespertilionidae was represented by *Myotis nigricans* (49%), *Histiotus velatus* (36%), *Myotis ruber* (7%), *Lasiurus ega argentinus* (4%), *Eptesicus brasiliensis* and *Lasiurus blossevillii* (2%). Three other species, *Tadarida brasiliensis*, *Peropteryx macrotis* and *Furipterus horrens* were found there, being from the families Molossidae, Embalonuridae and Furipteridae, respectively.

OBSERVATIONS ON PHYLLOSTOMID BATS VISITING FIG TREES

Esberárd, C.E.L., Chagas, A.S.., Luz, E.M. and Martins, L.F.S.
Projeto Morcegos Urbanos, Fundação RIOZOO, Rio de Janeiro, Brasil.

Fruits of fig trees are an important food source for bats. Figs vary in their color, size, time of ripening and availability. There are numerous species of figs known from the Atlantic Forest of southern Brazil. The richness and the diversity of frugivorous Phyllostomid bats (subfamilies Glossophaginae, Carollinae and Stenodermatinae) were studied for 2 species of *Ficus*. These data were collected by catching bats with mist nets opened overnight, for two nights, near each species of *Ficus*. The sampling was conducted at Reserva Rio das Pedras, a private reserve near Mangaratiba, Rio de Janeiro State, southern Brasil (km 115 of Br-110 Road, 22.9066°S and 044.1009°W). *Ficus citricifolia*, an hemiepiphytic species, of 3.5 meters in height, produces small fruit (5 grams). *Ficus gomelleira*, an arboreal species of 10 meters in height produces large fruit, which weigh on average 15 grams. Near *Ficus citricifolia*, 13 frugivorous bat species were netted (N= 84 captures, mean of forearm length = 56.42 mm) with a total biomass of frugivorous bats equal to 4.032 kg, with an average of 47.43 grams per bat and a diversity index (Shannon-Wiever) of H' = 1.5475. Only 8 species of frugivorous bat species were netted near *Ficus gomelleira*, with a biomass of frugivorous bats totalling 5.765 kg, with an average of 52.57 g per bat (N = 114 captures, mean of forearm length = 61.60 mm) showing a diversity index of H'= 1.7038. These results suggest that (1) larger *Ficus* fruits were visited by larger bats and support a higher biomass of frugivorous species; (2) Smaller *Ficus* fruits were visited by more bat species and (3) Small frugivorous species rarely netted (such as *Chiroderma doriae* and *Pygoderma bilabiatum*) were only captured near *Ficus citricifolia*.

NEW RECORDS OF *LONCHOPHYLLA BOCKERMANNI*

Baptista, M. & de Oliviera, J.A.
Museo Nacional-UFRJ, Quinta da Boa Vista s/n, São Cristóvão - 20940-040, RJ, Brazil

Lonchophylla bockermanni(Chiroptera, Lonchophyllinae) was described from Serra do Cipó, Cordilheira do Espinhaço (19° 02' S - 46° 26'W), Minas Gerais and since then has been reported from Ilha Grande, in the state of Rio de Janeiro, hypothetically being restricted to southeastern Brazil and regarded as an endangered species. Here we report two new localities for *Lonchophylla bockermanni* from Central and Northeastern Brazil, which considerably enlarge the known range of the species. The voucher specimens are deposited at Museu de Zoologia, Universidade de São Paulo (MUZUSP), and Museu Nacional, Universidade Federal do Rio de Janeiro (MN), and are as follows: MN 37197, adult female, skull and body in fluid, from Alto Tocantins, Goiás (c.a. 14(01'47''S, 048(18'55''), a typical Cerrado area, now to a great extent under the recently filled reservoir of the "Serra da Mesa" hydroelectric complex, which covers an area of 170,000 km^2, collected in 1993 by Duke S. Rogers; MZUSP 14170, adult female, body in fluid, skull missing, MZUSP 14173, young male, skull and body in fluid, and MZUSP 14174, adult female, skull and body in fluid, the three last from Cocorobó, Bahia, (09° 53'S - 39° 02'S), near one of the most arid regions of Northeastern Brazil. Collector unknown.

PRELIMINARY SURVEY OF THE BAT FAUNA IN THE ECOLOGICAL CONTEXT OF THE UNIVERSITY CAMPIS OF PICI-UFC FORTELAZA, CEAR´A, BRAZIL

Machado, D.A.N.,[1,2] Otoch, R.[1] and Bezerra, C.L.F.[1,3]
[1]Instituto Cearense de Ciências Naturais (ICCN), Parquelândia, Fortaleza, Ceará, Brasil
[2]Universidade Federal do Ceará, Laboratorio de herpetologio, Campus do Pici, Fortaleza, Ceará, Brasil
[3]Universidade Federal do Ceará, Depto. de Biologia, Campus do Pici, Fortaleza, Ceará, Brasil

The university campus of Pici is in Fortaleza, Ceará, Brazil, comprising a total area of 232 ha. It is located in a zone of "tabuleiro pré-litorâneo" (plain relief near the coast), drained by tributaries of the Maranguapinho river sub-basin, one of these originating from the Santo Anastácio reservoir, in the campus area. The current vegetation is an ecological relic of great relevance, because the flora and the fauna corresponds approximately to the biotic structure of the old semideciduous "tabuleiro" forest that once covered the whole coast of the state, including the campus, and is now reduced to a few hectares, representing refuge and survival area for many of the remaining species. Besides, it is fundamental to the environmental stability of the campus and adjacent ecosystems. The campus presents a diversity of ecol-

-ogical systems: the remaining forest, the reservoir and flooded areas outlying its dam, and areas in the process of natural regeneration. The preservation of these natural stocks, which can be used in environmental education, will help teaching and the development of researches involving the environment, like Zoology, Botany, and Ecology. Captures were accomplished using mist-nets and hand nets, and seven bat species were found: *Saccopterix leptura* (Emballonuridae), *Noctilio leporinus* (Noctilionidae), *Glossophaga soricina* (Phyllostomidae; Glossophaginae), *Artibeus lituratus, A. planirostris, A. jamaicensis* and *Platyrrinus lineatus* (Phyllostomidae; Stenodermatinae).

LOCAL ABUNDANCE AND BODY MASS RELATIONS OF BATS IN FRAGMENTED AND REFORESTED HABITATS FROM BRAZIL

Pedro, W.A.Pedro, W.A.[1,2] and De Marco Jr., P.[3]

[1]PPG-ERN/UFSCar

[2]Departamento de Apoio, Produção e Saúde Animal, UNESP, Araçatuba, SP, 16050-680, Brasil

[3]Departamento de Biologia Geral, Universidade Federal de Viçosa, Viçosa, MG, 36570-000, Brasil

The bat diversity in reforested and fragmented habitats was studied in 15 locations in Brazil, and an analysis of these data served as a test for the hypothesis that body mass affects the relative abundance in species in communities of sympatric bats. For a set of 87 bat species encountered in this study, rarity was not correlated with body mass. The lack of a significant relationship between size and rarity may reflect the overall small size and mobility of bats. The potentially high dispersion ability of bats and their longevity may allow species to persist even in small populations.

TAXONOMIC ASSEMBLAGE OF BATS FROM A REMNANT FRAGMENT OF ATLANTIC FOREST IN THE CITY OF SÃO PAULO.

Pedro, W.A.[1,2], Geraldes, M.P.[3], Lopez, G.G.[3] and Alho, C.J.R[1]

[1]PPG-ERN/UFSCar

[2]Departamento de Apoio, Produção e Saúde Animal, UNESP, Araçatuba, SP, 16050-680, Brasil

[3]Departamento de Zoologia, Universidade de São Paulo

The bat community of a 120 ha remnant of the Atlantic forest, in the city of São Paulo, southeastern Brazil, was studied over two years, from the standpoints of species composition and abundance in relation to habitat fragmentation and seasonality. Bats were sampled monthly using mist nets extended during a period of six hours after sunset. We caught 243 bats representing 7 seven species: six Phyllostomidae (*Sturnira lilium* 117, *Artibeus lituratus* 41, *Glossophaga soricina* 12, *Desmodus rotundus* 11, *Platyrrhinus lineatus* 9, *Pygoderma bilabiatum* 8) and one Vespertilionidae (*Histiotus velatus* 45). No seasonal patterns were detected for the relative abundance of the species (Kolmogorov-Smirnov, D=0.571, p>0.05), suggesting that climatic factors of the dry and rainy seasons did not significantly affect the species composition and abundance during the study period. Habitat loss and fragmentation appear to have been responsible for the low species richness, since we encountered only about 10% of the Chiroptera fauna typical of the Atlantic forest - the biome which in the past dominated that region.

PRELIMINARY ASSESSMENT OF ASPECTS RELATED TO THE DIET AND WING MORPHOLOGY OF BAT COMMUNITIES IN A RESERVE IN SOUTHEAST BRAZIL

Tavares, V.C.[1], Perini, F.A.[2] and Lombardi, J.A.[3]

[1]Programa de Mestrado em Ecologia, Conservação e Manejo de Vida Silvestre-ICB/UFMG Av. Antônio Carlos, 6627, CP 486, 30161 970, Belo Horizonte, M.G. Brazil.

[2]Curso de Ciências Biológicas da UFMG and [3]Departamento de Botânica-ICB/UFMG

The morphology and feeding behavior of bats are strongly correlated. Indexes relating wing shape and size of noseleaf were used to characterize phyllostomid communities and the diet of the species was analyzed. The research was conducted in the Parque Estadual do Rio Doce, the largest preserved area of Atlantic Forest in the state of Minas Gerais, Southeast of Brazil (19° 48' S and 42° 28' W). Bats were

sampled with mist-nets set to a maximum height of 3 meters in forests of primary (P) and secondary growth (S) and in an open area (O). We related the data on diet with the morphological indexes and the three types of habitat. *Cecropia spp.* and *Ficus spp.* were the most consumed in "O", *Piper spp.* and *Cecropia spp.* dominated the fruit bat's fecal samples in "P", and *Vismia spp., Cecropia spp.,* and *Piper spp.* were well represented in "S". Bats of the sub-family Phyllostominae were only captured in primary forest or in their roosts. New records of species for the area were found by means of roost search and by net capture.

BATFLIES (STREBLIDAE AND NYCTERIBIIDAE) PARASITES OF BATS FROM THE "PARQUE ESTADUAL DO RIO DOCE", EAST OF MINAS GERAIS, BRAZIL

Azevedo, A.A. [1], Linardi, P.M. [1], Tavares, V.C. [2] and Souza, J.L. [3]

[1]DepartaTavares, V.C.mento de ParasitoPerini, F.A.logia ICB/UFMG

[2]Programa de Pós-graduação em ECMVS - ICB/UFMG, CP. 486, CEP 30161-970, Belo Horizonte, MG

[3]Laboratório de morcegos, ISDF/GCZ, CEP 70620-000, Brasília, DF

There are few records of ectoparasites for Brazilian bats, despite the great species diversity of these hosts. The present information deals with the geographic distribution of some species of batflies and records of the host-parasite relationships. Captures were performed during 1997, in the "Parque Estadual do Rio Doce" (19o48'-19o29'S and 42o38'- 42o28'W), the largest preserved area of Atlantic rainforest of the state of Minas Gerais. Sixty-one bats were examined, representing three families and 15 species. Each of six species of Streblidae batflies infested a particular species of phyllostomid bat : *Aspidoptera falcata* and *Megistopoda proxima* on *Sturnira lilium; Strebla wiedemanni* on *Desmodus rotundus; Trichobius longipes* on *Phyllostomus hastatus; Trichobius lonchophyllae* on *Glossophaga soricina; Strebla guajiro* on *Carollia perspicillata.* The species *Paratrichobius longicrus*, was recorded on *Plathyrrhinus lineatus* and *Artibeus spp.*, while *T. joblingi* was collected on three species of bats (*C. perspicillata, D. rotundus* and *Artibeus sp.*). *Basilia sp.* (Nycteribiidae) was collected only on *Myotis nigricans* (Vespertilionidae). The infestation, related to sex and age of the phyllostomid hosts, is as follows: males (46.2%), females (29.0%); young (53.8%) and adults (31.8%).

INTERELATIONSHIPS BETWEEN ACARI AND BATS IN THE "PARQUE ESTADUAL DO RIO DOCE", EAST OF MINAS GERAIS, BRAZIL

Azevedo, A.A.[1], Linardi, P.M.[1], Coutinho, M.T.Z.[1], Tavares, V.C.[2] and Souza, J.L.[3]

[1]Departamento de Parasitologia

[2]Programa de Pós-graduação em EMCVS-ICB/UFMG, CP 486, CEP 30.161-970, Belo Horizonte, MG

[3]Laboratório de Morcegos, ISDF/GCZ, CEP 70620-000, Brasília, DF

There is little biogeographical and ecological information available on ectoparasites of Brazilian bats. Bats were captured from April to November 1997, at the "Parque Estadual do Rio Doce" (19048'-19029'S and 42038'- 42028'W), the largest preserved area of Atlantic rainforest of the state of Minas Gerais. Rates of parasitism, according to sex and age of hosts, were recorded. Host-parasite relationships are presented. Sixty bats representing three families (Phyllostomidae 12 spp.; Molossidae and Vespertilionidae: 1sp. each), were examined. Fifty seven percent of these bats were parasitized by at least one mite species. The ectoparasites found were: *Chiroptonyssus haematophagus, Collicus sp., Eudusbabekia sp., Fonsecia sp., Macronyssoides kochi, Macronyssoides sp., Paralabidocarpus sp., Parichoronyssus crassipes, Perigliscrus iheringi, Perigliscrus ojasti, Perigliscrus sp., Perissopalla sp., Radfordiella desmodi, Radfordiella sp., Steatonyssus sp.*, and one unidentified species of the family Laelaponyssidae, with an average of 3.63 parasites per host. Most of the bats were infested by only one species of mite. However, some associations of mites and chiggers were also recorded. Adult bats were more infested than young ones, and males more infested than females.

VARIATION IN FUR COLOR OF *DESMODUS ROTUNDUS* IN THE PARQUE ESTADUAL DO RIO DOCE, EAST OF MINAS GERIAS, SOUTHEAST BRAZIL

Redondo, R.A.F.[1], Tavares, V.C.[2], & Marcos, M.H.[3]

[1]Curso de Ciências Biológicas - UFMG and [2]Programa de Mestrado em ECMVS - UFMG

From January to October 1997 29 individuals of *Desmodus rotundus* (Geofroy St. Hilare (Phyllostomidae: Desmodontinae)were netted in the Parque Estadual do Rio Doce. They showed two distinct fur color patterns. The majority of the population had a golden-reddish color (79%) while the remaining were gray (31%). The golden-red specimens showed a darker dorsal coloration, with some individuals tending towards brown, and a lighter colored abdomen. Individual variation in fur color tones were also observed in the *Desmodus rotundus* reddish population. Two individuals with the red pattern also had white stripes on the head. Gray individuals did not show any kind of tone variation in fur color. The forearm length of the golden-reddish individuals (n=20) showed a significant difference ($p< 0,001$) from the gray ones (n=9). However, the predominance of females (n=13) among the golden-reddish sample was probably responsible for this difference, since females showed a forearm length greater ($p<0,001$) than males (n=7), and there was no significant difference between forearm length ($p<0,05$) in gray (n=8) and golden-reddish males. Sexual dimorphism found in *D. rotundus*, with females being larger than the males, has already been described by others authors.

TROPHIC RELATIONSHIPS IN A NEOTROPICAL BAT COMMUNITY: A PRELIMINARY STUDY USING CARBON AND NITROGEN ISOTOPIC SIGNATURES.

Gerardo Herrera, M.L.[1], Fleming, T.H.[2] and Sternberg, L.S.[2]

[1]Depto de Zoología, Insto. de Biología,Universidad Nacional Autónoma de México, Mexico, DF

[2]Department of Biology, University of Miami, Miami Florida

We used stable isotope techniques to determine the nitrogen and carbon isotopic composition of 21 species of neotropical bats (17 phyllostomods, 2 mormoopids, 1 molossid, and 1 emballonurid) representing a diverse array of feeding habits (e.g., frugivory, nectarivory, insectivory, carnivory, and sanguinivory). We also determined the isotopic composition of plants and insects presumably ingested by the bats. Samples were collected in Calakmul, Mexico, in the Spring of 1995. We found trophic enrichment of both ^{13}C and ^{15}N. Our data indicate that most species of frugivorous bats examined have a mixed diet of fruits and insects, and that only *Centurio senex*, *Artibeus lituratus*, and *Dermanura watsonii* appear to be exclusively frugivorous. One species of insectivorous bat, *Tonatia brasiliensis*, apparently relies on fruits as part of its diet. Although preliminary, our results indicate that stable isotope methods can be used to quantify the importance of different dietary classes in the diets of bats. Current research on the trophic dynamics of tropical communities of bats using the isotopic approach is conducted by the senior author.

URBAN BATS FROM THE DISTRITO FEDERAL, MID-WESTERN BRAZIL

Caetano Júnior, J.[1], Bredt, A.[1], Uieda, W.[2], Massunaga, P.N.T.[1] and Paranahyba, K.M.[1]

[1]Instituto de Saúde do Distrito Federal, Brasilia, DF

[2]Universidade Estadual Paulista, Botucatu, SP, Brazil

Since 1989, the Center of Zoonosis Control of the Distrito Federal has investigated the presence of bats in urban areas, their food and available roosts, rabies prevalence, and other interactions between bats and humans. In the region of the Distrito Federal, 45 bat species were found and 47% of them were observed in urban environments. Concerning their feeding habits, 26.7% are insectivorous (with prevalence of *Molossus molossus*), 8.9% are frugivorous (with prevalence of *Artibeus lituratus*), 4.4% are nectarivorous (with prevalence of *Glossophaga soricina*), and just 2.2% are omnivorous and sanguivorous (*Phyllostomus hastatus* and *Desmodus rotundus*). Buildings are the main kind of roosts used by bats (62%), but foliage of plants can also be used (14%) by them. Our data show that two species are more frequently found in urban areas of the Distrito Federal: *M. molossus* living in buildings and *A. lituratus* feeding on fruits and roosting on foliage of urban trees. Ten species entered the buildings through the window or door

during their night activity, and this problem was more common in the hot and rainy season. Species found to be entering buildings were mainly *M. molossus* and *Nyctinomops laticaudatus*. No rabies infected bats were found in the Distrito Federal.

NATURAL HISTORY AND POPULATION BIOLOGY OF *LONCHOPHYLLA DEKERSERI*

Coelho, D.C., Barata,C. & Marinho-Filho, J.
Department de Zoologia, Universidade de Brasília

Lonchophylla dekeyseri is a Cerrado endemic bat species and its biology is very poorly known. It seems to roost exclusively in caves in calcarious formations which, in central Brazil, are associated with semideciduous dry forests. This study presents information on the natural history and ecology of this species in the region of Brasilia, Federal District, Brazil. From September/97 to April/98, monthly capture sessions were realized in each of three caves: Fenda, Dois Irmãos and Saúva. Nets were opened on 37 nights from 1800 to 0600 of the next day. A total of 150 individuals were captured, banded and released. The time of capture, sex, reproductive condition and age (young or adult) were recorded. Feces were collected as well as pollen samples from the fur and wings of the bats. Twenty- three individuals were re-captured, none of them more than once. The peak of roost emergence was in the first hour after sunset and most individuals went back to the caves by the very end of the night. The mean sex ratio (male:female) was approximately 1:4, varying from 1:3 at Saúva and Dois Irmãos caves to 1:6 at Fenda Cave. Pollen of five species was found on the fur of *L. dekeyseri*. Field observations confirmed visitation to flowers of *Bauhinia sp* and *Lafoensia pacari*. Seeds and fragments of insects were found in the fecal samples, indicating that this species, as most nectarivores, utilizes a wide range of food items. In March no bats were caught in any of the three caves, but, at the end of April, two pregnant females were caught. The strongly female biased sex ratio, suggests some sexual segregation at the roosts or a polygynic mating system for this species.

EFFECTS OF FOREST FRAGMENTATION ON THE DIVERSITY AND STRUCTURE OF BAT COMMUNITIES IN CENTRAL AMAZON

Sampaio, E.M.[1], Kalko, E.K.V.[1,2] and Handley Jr., C.O.,[2]
[1]Animal Physiology, University of Tuebingen, Germany
[2]National Museum of Natural History, Washington DC, 20560, USA

We studied the effects of forest fragmentation on composition and guild structure of the bat community in the unflooded areas of the BDFFP (Biological Dynamics of Forest Fragments Project) near Manaus in Central Amazon (Brazil). We compared different sizes of forest fragments (3 x 1 ha; 3 x 10 ha) with plots in continuous forest (2 x 1 ha; 2 x 10 ha) during January/1996-May/1998, including rainy and dry season. We used mistnets in standardized transects in all fragments and plots. The preliminary analysis show clear differences in guild composition between fragments and continuous forest. The fragments were dominated by large numbers of understory frugivores. The continuous forest is characterized by a higher number of species than the fragments, however, relative abundance of most species is rather low. It appears, that understory frugivores are using the secondary growth around the forest fragments, which is mostly composed of *Vismia* (Clusiaceae), *Cecropia* (Cecropiaceae) and Melastomataceae, as food resource. In contrast, gleaning insectivores, which are rich in species in continuous forest, seem to occur in much lower numbers of species and individuals in the fragments or are even absent. The results show a clear effect of the forest fragmentation on the local bat communities whereby species diversity declines in fragments and local abundance of species changes dramatically.

ROOSTING ECOLOGY AND SOCIAL ORGANIZATION IN THE TENT-MAKING BAT *ARTIBEUS CINEREUS*

Kunz, T.H.[1] & McCracken, G. F.[2]

[1]Departmant of Biology, Boston University, Boston, MA 02215 U.S.A

[2]Department of Ecology and Evolution, University of Tennessee, Knoxville, TN 37966 U.S.A.

Artibeus cinereus (Phyllostomidae: Stenodermatinae) roosts in tents constructed from leaves of eight species of plants in Trinidad, West Indics. Among these are two members of the family Palmae (*Cocos nucifera* and *Manicaria saccifera*), six members of the family Araceae (*Philodendron fragmantissimum, P. ornatum, P. simsii, Anthurium jenmanii* and *Xanthosoma undipes*), and one member of the family Polygonaceae (*Cocolaba latifolia*). Tents were most commonly constructed at heights rnaging from 2 to 3 meters above the ground. Leaves used for tent construction were selected independently of their vertical position within a clump, angular position, or leaf size. The volume of uncluttered space beneath a leaf appears to be the most important criterion used by these bats for tent construction. Roosting groups of *A. cinereus* ranged from 2 to 5 individuals. Preliminary analysis of allozyme data indicates that *A. cinereus* is highly variable in six out of eleven electrophoretic loci examined. This variability was evident both within and among populations. These results suggest that there is no geographic population structuring of this species in Trinidad and that roosting groups are genetically random subsets of the adult population.

ROOSTING ECOLOGY OF THE NORTHERN BAT *MYOTIS SEPTENTRIONALIS*

Kurta, A. & Foster, R.W.

Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197 U.S.A.

During 1993 and 1994, we radiotracked 11 adult female and juvenile northern bats (*Myotis septentrionalis*) in southhern Michigan. We tracked the bats to 32 roost trees, of which 18 were silver maples (*Acer saccharinum*), one was red maple (*A. rubrum*), and 13 were green ash (*Fraxinus pennsylvanica*). Fifty-three percent of the trees were living; 52% of the roosts were in crevices or hollows, and the remainder were under exfoliating bark. The bats appeared to select against small elms (*Ulmus americana*), but in general, characteristics of roost trees were similar to a random sample of trees. Northern bats changed roosts every 2 days, and distance traveled varied from 6 to 2,000 m. Up to 60 adults were found in a single tree, making this the largest summer aggregation ever reported for the species. Compared to Indiana bats (*Myoris sodalis*) previously studied at the same site, northern bats moved greater distances between roosts and roosted more often in maples, in cavities, in living trees, and in areas with high canopy cover.

HOME RANGE SIZE, MOVEMENTS AND NIGHTLY ACTIVITY PATTERNS OF A TEMPERATE RAINFOREST BAT IN NEW ZEALAND

O'Donnell, C.F.J.

Science and Research Division, Department of Conservation, Private Bag, Christchurch, New Zealand

Sixty radio-tagged long-tailed bats (*Chalinolobus tuberculatus*) ranged over 117 km2 of Nothofagus rainforest and indigenous shrubland in the Eglinton Valley, Fiordland, during summers 1993-1996. Bats were followed for an average of 11.9±6.4 days and a range of age and sex classes were sampled. Calibration and fix error estimates will be explained. Ranges varied significantly between different groups. Post -lactating females had the largest ranges (median=18 km2), although the largest individual range (56 km2) was of an adult male. Lactating females had significantly smaller ranges than post-lactating and non -breeding females and adult males. Lactating females and juveniles had average range widths of 2.6-4.3 km while other bats travelled much greater distances to their foraging sites (max 19 km) including trips to forage over indigenous shrublands. Juveniles <2 weeks out of the roost had the smallest ranges (median=1.6 km2) but thes- increased significantly after c.2 weeks, and the largest juvenile range was c.29 km^2. The bats averaged 4 foraging and 2 roosting bouts per night (n=76 nights). Duration of bouts did not vary between sex and age classes. Roosting averaged 34 minutes regardless of time of night, but the first foraging bout was longer (median=143 min) than subsequent bouts, which became shorter through the night. Despite the large range sizes all bat groups had relatively small core areas in which they spent most

of their time. The ranges presented provide a brief snapshot of home range patterns, largely because transmitters remained attached for a relatively short time. Thus the range sizes are likely to be underestimates of seasonal, annual, and life-time range requirements.

FEEDING BEHAVIOUR OF THE LONG-TONGUED FRUIT BAT *MEGALOGLOSSUS WOERMANNI* AND ITS ROLE AS POLLINATOR IN THE FRICAN RAIN FOREST

Grünmeier, R.
Mühlstr. 23, D-55270, Schwabenheim, Germany
former address: Institute of Specific Botany and Botanical Garden, University of Mainz, Germany

The tiny fruit bat *Megaloglossus woermanni* (Megachiroptera, Macroglossinae) is the only highly specialized blossom bat in Africa. It is a lowland forest species and appears to be rare. So far, there is very little direct evidence about its feeding ecology and its role as pollinator within a rain forest community. Field studies carried out in the primary and secondary rain forest of Cameroon, exhibited that the chiropterophilous flowers are visited and pollinated by a number of different fruit bats: such as large and middle-sized species of the genus *Rousettus, Lissonycteris, Myonycteris* and *Nanonycteris* with more or less frugivorous feeding habits as well as *Megaloglossus* supposed to be predominantly nectarivorous. Information is provided on the flying periodicity, the foraging behavior in the trees and on the flowers, and on the diet including examined pollen samples from the fur, alimentary canal and faeces of the bats. The flower-visiting bats differ profoundly in their ability to utilize these flowers as a nectar and pollen resource and in their way of acting as pollinators. Without doubt, the fruit-eating bats have a high influence in the pollination, but *Megaloglossus woermanni* visits the flowers more frequently and effectively. This long-tongue fruit bat is the most important pollinator for a large number of native forest trees and lianas, and also for some introduced neotropical plant species. These findings also show that this species feeds almost exclusively on nectar and pollen.

EVIDENCE FOR A DETERMINANT ROLE FOR THE REPRODUCTIVE CYCLE IN COLONY SITE USAGE BY THE GREY-HEADED FLYING FOX *PTEROPUS POLIOCEPHALUS*

Pasyrry-Jones, K.A.[1] & Augee, M.L.[2]
[1]School of Biological Sciences, The University of Sydney, Sydney 2006 Australia
[2]School of Biological Sciences, The University of New South Wales, Sydney 2052 Australia

Previous authors have reported that *Pteropus poliocephalus* (Pteropodidae) colony sites are occupied in response to blossom availability. However in this study we report that at the Gordon site in suburban Sydney, Australia, colony occupation patterns are not correlated with food use but are correlated with events in the reproductive cycle of *P. poliocephalus*. As well, in contrast to reported occupational patterns of other colony sites where flying-foxes migrate away from the site during winter and early spring, the Gordon site was occupied by substantial numbers of flying-foxes throughout the entire period of the study: a period of 62 months from 1985-1990. As a result of the introduction of plants native to other parts of Australia and exotics from other continents, there is a variety of food available throughout the year in the Sydney region in comparison with less urbanised areas. This food supply permits the occupation of the Gordon colony site during winter and spring and reduces the migratory behaviour of its flying-foxes throughout the year, however flying-foxes do move in and out of the site in response to reproductive imperatives. We conclude that the occupational pattern of any colony of *P. poliocephalus* is based on the reproductive requirements of the species modified by the vagaries of the local food supply.

NECTAR PRODUCTION IN NATIVE AUSTRALIAN FOREST TREES VISITED BY FLYING FOXES

Birt, P.
Department of Veterinary Pathology and Anatomy, University of Queensland, St. Lucia Q 4072, Australia

The volume of nectar secreted by the flowers of several commercially valuable native Australian forest trees visited by flying foxes was measured over 24 hours to observe whether they conform to the criteria of 'bat-pollinated' flowers. In *Corymbia citriodora, C. henryi* and *C. tessellaris*, large volumes of nectar were secreted during the night with little, if any, secreted during the day. Nectar secretion in *Melaleuca leucadendron* was high throughout the day and night, however larger volumes were secreted during the night. Concurrently, approximately 80% of flowers opened during the night with the remaining 20% opening during the day. Subsequently, pollen was released primarily during the night. This study suggests that several species of native Australian forest trees utilized by the timber industry are endeavoring to attract nocturnal pollinators. In combination with the majority of these trees relying on cross-pollination for maximum fruit set and seed viability, the ability of flying foxes to transport pollen over vast distances suggests they may be one of the most valuable agents for pollen dispersal of these trees. Implications for the timber industry include effective management of forest resources that will maintain viable populations of flying foxes so that they continue to perform their role as pollinators and seed disperses.

FEEDING ECOLOGY OF THE MADAGASCAR FRUIT BAT *PTEROPUS RUFUS*

Long, E. & Racey, P. A.
Department of Zoology, University of Aberdeen, Aberdeen, Scotland, U.K.

Pteropus rufus is the largest of the three species of endemic megachiropterans in Madagascar. Little is known about its feeding ecology, pattern of resource use and role in seed dispersal and data is being collected on these subjects in a 250 ha remnant of gallery forest in South East Madagascar which contains a colony of up to 2000 bats. *P. rufus* appears to be an opportunistic generalist frugivore feeding on both introduced commercial crops (particularly sisal flowers) and native fruits. Its role in seed dispersal is being examined through the use of germination trials, of seeds from faeces, ejecta and ripe fruits collected from traps laid out at intervals along transects around selected fruiting figs.

A MULTIVARIATE ASSESSMENT OF GEOGRAPHIC VARIATION IN PARAGUAYAN BAT SPECIES ASSEMBLAGES

Owen, R.D. , Willig, M.R. , Presley, S.J. and López-González, C.
Department of Biological Sciences, Texas Tech University, Lubbock, TX 79409-3131.

Little is known about geographic variation in the local composition of South American mammalian assemblages, or the factors that may produce such variation. This is particularly important in Paraguay because the country occurs at the interface of a number of phytogeographic regions, including Cerrado, Upper and Lower Chaco, Interior Atlantic Rainforest, and Pantanal, and is the point at which many temperate species reach their northern limits or tropical species reach their southern limits. Based on two years of intensive field work throughout the country, we document the species composition of bat assemblages at 25 sites. In addition, we estimate the similarity among sites based on a variety of indices sensitive to the presence and absence of species, or to the rank abundance of species. Using UPGMA algorithms, we cluster sites and species based on these indices, and interpret resultant patterns with respect to geographic distances among sites as well as their associations with particular phytogeographic zones. Considerable variation in species composition characterizes sites, and geographic distance accounts for little of that variation. Faunal assemblages do not correspond to the six distinct phytogeographic zones in the country; rather, strong differences exist between sites east (mesic) and west (xeric) of the Río Paraguay. Generally, these differences are related to dominance by molossids and verspertilionids in dry regions, versus phyllostomids in mesic regions.

TWENTY YEARS OF BAT RADIO-TELEMETRY: PROGRESS AND PITFALLS

Brown, P.E. and Berry, R.D.
Physiological Science Department, UCLA, Los Angeles, CA 90095-1606
and Brown-Berry Biological Consulting, Bishop, CA 93514

The technology of radio-telemetry has improved since our first study in 1978 of pallid bats *Antrozous pallidus* using 2 gram transmitters and FM radios as receivers. The current crystal-controlled 0.5 gram transmitters and receivers with scanners make telemetry easier on the bats and the researchers. This evolving technique has provided data on roosting and foraging habitat, home range, activity patterns and social interactions. For example, pallid bats have been found roosting in mud cracks in the ground, and California leaf-nosed bats *Corynorhinus townsendii* on Santa Cruz Island feed over native vs. exotic vegetation. In one study, a fringed myotis *Myotis thysanodes* commuted nightly over 12 km from a cliff face in dry chaparral to forage in the same patch of pine/oak woodland. In 14 studies on 11 species in the United States, Japan and Australia, we have learned that to avoid weight loss or death, transmitters should be 5% or less of body weight. Telemetry on females during late pregnancy and lactation can alter their foraging behavior and efficiency, and the added burden of the transmitter may result in their death or that of their infant. The method of foraging also affects the ability of the a bat to carry a transmitter, and aerial insectivores may be impacted more than gleaning species.

ECOLOGICAL ASPECTS ABOUT THE GHOST FACED BAT *MORMOOPS MEGALOPHYLLA* AT SAN ANTONIO DE PINCHINCHA

Boada, C., Burneo, S. & Tirira, D.
Museo de Zoología de Vertebrados, Departmento de Ciencias Biológicas
Pontificia Universidad Católica del Ecuador, Apto 17-01-2184 Ecuador

San Antonio de Pichincha is located 20 km northwest from Quito. There are 2 small artificial caves that harbor a *Mormoops megalophylla* colony of approximately 4700 individuals. It is the southernmost location of this species' distribution in Ecuador, but may also be found in northern Peru. In Ecuador *Mormoops megalophylla* is found in three other locations: Gruta de la Paz and Rumichaca in the Carchi province, and Nono in the Pichincha province. Patzelt (1978) discovered this species in Ecuador when he visited the cave at San Antonio 15 years ago at which time the species was unknown for Ecuadorian fauna. The ghost faced bat's name comes from the Greek mormo, that means frightening thing that causes panic and opps, which means face. Despite its wide distribution, *M. megalophylla* has not been well studied. It is, however, known that this species is insectivorous. We chose San Antonio as the primary location for this research due to its proximity to Quito. It has the largest colony and the easiest entrance. The field study began in February of 1996 and finished in March of 1998. We made 44 visits to the San Antonio cave and 4 visits to the Gruta de la Paz and Rumichaca. We observed the activity cycles and the frequency of departure as related with temperature, rain and cloudiness. We estimate the number of individuals that make up the colony. We caught 388 individuals to get the sexual information, following the methods of Tirira (1994) in his study about ecological aspects in *Noctilio alvibentris affinis* in the Ecuadorian Amazon basin, and morphometric data. Seventeen individuals were sacrificed for stomach analysis and we collected excrement samples directly from the animal or from samples deposited on the ground for laboratory analysis. We analyzed the specimens from the MEPN (Museo de la Politécnica Nacional) and Q-CAZ (Museo de Zoología de la PUCE). The average number of individuals forming a colony was 4684 (4515 - 4803). Of the 388 individuals caught and the 37 individuals from museums, 38 (9 %) were females and 387 (91 %) were males. We caught 4 females in lactation on January 5 and 22, March 4 and October 28. From the museums, we observed pregnant females on November 11 (Albuja, 1982) and 1 on May 15. The total length for males n = 25 : 63.5 (57.7 - 77.5). For females : n = 8 65.2 (55.8 - 73). The forearm for males n = 77 : 58.4 (54.7 - 66). For females n = 9 : 57.7 (54.6 - 61.8) The weight for males n = 43 : 22.5 (19.5 - 25) and for the females we didn't find enough data. The first cave departure time registered was at 18:40 hours. The highest frequency of departure was at 20:15 hours (53 per minute) The last departure was recorded at 23:10 hours. The bats began returning to the cave at 02:10 hours and the last record of an individual entering was at 04:18 hours. We found that when the night is very rainy, or very moonlit, all activities started later.

BAT FAUNAL INVENTORY METHODS AND RESULTS: AN EXAMPLE FROM PARACOU, FRENCH GUIANA

Simmons, N.B. and Voss, R.S.
Department of Mammalogy, American Museum of Natural History, New York, USA

It is well known that the Neotropics support more bat species than any other zoogeographic region, but the extent of Neotropical bat diversity at the level of local communities remains to be determined. Range maps suggest that 90-100 bat species could be expected at many Amazonian rainforest localities, but collections rarely exceed 50-60 sympatric species and little is known about how capture methods can bias estimates of diversity patterns and community structure. The address these and other issues, in 1991 -1994 we conducted an inventory of bat species diversity at Paracou, a forestry research station in French Guiana. Working within a 3 km sampling radius, we documented 78 bat species in 168 days using ground -level mistnets, elevated mistnets, and collecting at roosts. Although we recorded over 3100 bat captures, several statistical diversity estimators suggest that we encountered only about 90% of the local bat fauna. Most of the local species missing from our inventory are probably aerial insectivores, gleaning insectivores, or nectarivores. The apparent percentage of frugivores (Carollinae and Stenodermatinae) in the known fauna decreased dramatically over time as continued collecting progressively increased representation of other guilds in our faunal list (e.g., frugivores comprised over 70% of the fauna after 14 collecting days, but constituted only 22% of the documented fauna by the end of our study). A quantitative analysis of faunal similarity among 14 rainforest localities clusters the Paracau faunal list with others previously reported from the Guiana subregion of Amazonia, next with lists from elsewhere in Amazonia, and lastly with Central American faunal lists. Almost 50% of the bat species in the Paracou fauna are essentially pan-Neotropical in distribution; true Amazonian endemics constitute only a minor fraction of the fauna.

PHYSICAL AND CHEMICAL PROPERTIES OF FRUITS EATEN BY OLD WORLD FRUIT BATS (FAMILY PTEROPODIDAE)

Dumont, E.R.[1] & Irvine, A.K.[2]
[1]Department of Anatomy NEOUCOM Rootstown OH, USA
[2]CSIRO-Tropical Forest Research Centre Atherton QLD, Australia

Pteropodid communities often are composed of species that are divergent in body size, anatomy, physiology, and behavior. This diversity is a striking indicator of resource partitioning at work within these assemblages. While variation among fruit consumers is one side of resource partitioning, variation among available fruits is an equally important component of the resource partitioning puzzle. This study presents a survey of fruit variables (size, mass, color, puncture resistance, presentation, pH, and sugar content) that are predicted to be associated with patterns of resource use among Old World fruit bats. Fresh fruits from 40 plant species (34 native fruits) were surveyed from sites in Australia (Queensland) and Papua New Guinea. Bat fruits exhibit a wide range of morphologies/chemistries for each of the sampled variables. For example, the mean puncture resistance of fruits ranges from <15 to 2,095 g/mm^2, and mean fruit pH ranges from 2.9 to 6.3. Fruit color ranges from white through blue, but most fall into a yellow/orange to red category. The majority of fruits are exposed on the external surfaces of plants. Overall, the picture of fruit diversity mirrors the complexity of the pteropodid assemblage and may be an important factor in resource partitioning.

DISPERSION OF SEEDS BY A BAT COMMUNITY AND AVAILABILITY OF RESOURCES IN A TROPICAL DRY ENCLAVE OF COLOMBIA

Alvarez, J. and Cadena, A.
Instituto de Ciencias Naturales, Universidad Nacional de Colombia, A.A. 7495 Santafe de Bogota, Colombia

The processes of seed dispersion and pollination by a bat community in the arid enclave of the Patia River at 630m of altitude were established.. Between October-96 and July-97, 185 individuals pertaining to 14 species were captured in 688.6 net/ hrs. Samples of feces and pollen from the pellage were collected. Columnar cacti density as well as the availability of flowers and fruits were considered. Bat species foraging on pollen and nectar in the region include *Artibeus jamaicensis* (35.1%), *Carollia perspicillata*

(28.2%), *Phyllostomus discolor* (20.4%), *Anoura geoffroyi* (5.7%), *Micronycteris megalotis* (2. 5%) and *Choeroniscus godmani* (2.0%). The diet was made up of 77% fruits, 13% insects and 10% nectar-pollen. Twelve types of pollen were identified as consumed by the community. Pollen grains of columnar cacti (*Stenocereus griseus* and *Pilosocereus sp*) and *Ochroma pyramidale* were the most important for five species of bats. *M. megalotis* consumed only pollen of *O. pyramidale*. Other pollen grains belong to the Acanthaceae (*Trichanthera gigantea*), Fabaceae, Euphorbiaceae (*Alchornea sp.*), Compositae, Malvaceae (*Abutilon sp.*), Urticaceae and Convolvulaceae (*Evolvulus sp*). The community consumes fruits of Solanaceae, Piperaceae and Moraceae throughout the year. *P. discolor, A. geoffroyi* and *A. jamaicensis* consume fruits of S. *griseus* and *Pilosocereus sp* at times that correspond to the fruiting peaks. Both species of cactus flower continuously, with a sharp peak in the second dry period for *Pilosocereus sp.* and two peaks, coincidental with seasonal transitions for *S. griseus*. In this arid zone, phenology and reproductive cycles are similar to other northern arid regions but there is no specific pollinator for columnar cacti.

CONVERGANCE OF EXTRINSIC AND INTRINSIC SPATIAL INFORMATION ON THE VAMPIRE BAT *DESMODUS ROTUNDUS*

Schlangen, M., Höller, P. & Schmidt, U.
Zoological Institute, Poppelsdorfer Schloss, D-53115 Bonn, Germany

Bats are known for their extraordinary spatial memory, which has been shown to be partially based on idiothetic orientation. On the other hand bats possess highly developed allothetic orientation sytems (echolocation, vision, olfaction). In this paper we demonstrate the ability of the common vampire bat, *Desmodus rotundus*, to make use of idiothetic and allothetic information, and a combination of both respectively. In a quadrant shaped flight arena the bats were trained to proceed directly from a defined starting point to a defined landing site, which was marked by a yellow LED (visual landmark) and a solid plastic block (20x5x3cm; echoacoustic landmark). The alignment of the starting box was adjustable. To check for the importance of landmark orientation and dead reckoning respectively, series of standard flights were randomly intermitted either by flights with shifted landmarks („LM") or by flights with the starting alignment of the bats shifted („S") or a combination of both („LM+S"). The distance between the landmarks as well as the relative position to each other (LED: left side, block: right side) was always kept the same. During critical experiments the bats were rewarded at the landing sites indicated by the altered setup-parameters and the standard landing site. In a frame-by-frame video analysis we examined the following parameters: 1. landing position of the bat; 2. flight path; 3. direction of the head during flight; 4. repetition frequency of echolocation sounds; 5. location and alignment of the head during sound emission. In experiment „LM" the bats shifted their flight route towards the direction of the moved landmarks, indicating that the bats did use them for navigation. Remarkably, none of the bats hit the new landing site between the shifted landmarks exactly, but all of them landed between the alternative and the standard target location. In experiment „S" several parameters of the flight showed that the shifted starting alignment affected the bats choice of the landing area (idiothetic component of orientation). Nevertheless all bats started correcting manoeuvres shortly after their take off, resulting in a heading for the standard landing site. Functional convergence between idiothetic and allothetic orientation became evident in experiment „LM+S". The effects of shifting both landmarks and starting alignment were superposed, resulting in a heading of the bats towards the alternative landing site. For a second test series the standard setup was slightly modified in order to impede the use of the visual and the echoacoustic landmark for flight navigation (enlarged distance between LED and echo block). Confronted with the new standard conditions, further shifting of the landmarks no longer influenced the flight behaviour. For critical experiments the side walls of the arena were then shifted towards the centre of the arena (10°). As a result the bats individually changed their flight route accurately, according either to the position of the left or the right wall. The results obtained lead to the following conclusions: 1. If landmarks are available, *Desmodus* makes use of them in order to find a target. 2. If in a well known environment the spatial conditions are stable, *Desmodus* in addition uses idiothetic orientation. 3. Allothtetic and idiothtetic information are combined, resulting in a compromise course. 4. Changes in the landmark configuration induce the bats to look for new reliable landmarks.

BAT FLOWERS AND THE HISTORY OF MAMMALIAN POLLINATION

Vogel, S.
Institute of Botany, University of Vienna, Austria

An attempt is made to reconstruct the evolution of chiropterophily, based on structural features, geography, and taxonomic distribution. Nectar feeding likely has its roots in mammalian frugivory which accompanied the diversification of angiosperms beginning in the upper Cretaceous. Fruits and flowers associated with mammals have certain features in common. Adaptation of recent plants to pollen transfer by non-flying, mainly frugivorous mammals appears in some cases to be relictual, revealing relationships that preceded chiropterophily. Preadapted flowers may thus have been available when bats evolved, a process subject to geographical isolation. Fruit-eating bats developed, presumably from a common insectivorous stock, independently: Megachiropterans in the Paleotropics, and phyllostomatid Microchiropterans in the Neotropics. Each group gave rise to specialized nectar-feeders by the mid Tertiary. Both groups arose in environments previously established by ancient (Gondwanian) floral elements that were exploited for nectar by respective precursors. Compared to their Old World counterparts, nectar-feeding Neotropical bats reached a higher degree of perfection, using sonar localization of flowers and feeding while on the wing. Although there is a striking overall coincidence of floral style, those differences in handling flowers by bats correspond to structural modifications of the respective chiropterophilous flowers. In the Paleotropics large brush-type and bell-shaped bat flowers prevail, both suited for landing, while in the Neotropics also small corollas developed, accessible only to hovering bats. Most Paleotropic bat-pollinated taxa belong to genera poor in species, are of more ancient affinity, and are trees. Neotropical chiropterophily, in contrast, also involves herbaceous and species-rich genera of advanced, sympetalous families. The advent of Paleotropic chiropterophily seems to have preceded that of the herbaceous life form, while in the Neotropics it coincided with strong speciation of herbs from the Miocene onward, resulting in a total number of bat-flowered species about four times as large as in the Paleotropics.

BAT POLLINATION IN "CAATINGA" AND ATLANTIC FOREST IN NORTHEASTERN BRAZIL

Machado, I.C. and Lopes, A.V.
Universidade Federal de Pernambuco-Brazil

The Northeast of Brazil presents a varied sort of vegetation, but it is mainly dominated by the Caatinga vegetation which covers approximately 60% of its extension. A preliminary study concerning pollination syndromes of Caatinga species in Pernambuco showed that chiropterophily occurs in about 17% of the species, and it has been found among the families Cactaceae, Bombacaceae, Capparaceae, Bromeliaceae, Malvaceae, and so on. One case history was done with *Pilosocereus catingicola* (Cactaceae) and visits of *Glossophaga soricina* were frequently observed, including to flowers of very low individuals, ca. 50 cm from the ground. In two other studies developed in Atlantic forests, with *Irlbachia alata* (Gentianaceae) and *Abutilon scabridum* (Malvaceae), the only bat pollinator observed was also *G. soricina*, performing amazingly acrobatic flights when visiting flowers of *I. alata*, a herbaceous species. *Abutilon scabridum*, a species from the Abutilon-Bakeridesia complex, presents an intermediary syndrome between chiropterophily and ornithophily, like other species of this genus studied in southeastern Brazil. In *A. scabridum* there is a major tendency for chiropterophily in relation to floral features, anthesis period, frequency and behaviour of visitors. *G. soricina* presented a trap-line behaviour in all three studied species, and it was the only bat species which was registered as a pollinator in Caatinga as well as in Atlantic forest in Pernambuco. Actually, *G. soricina* is the most abundant nectarivorous species in the Caatinga. In a list of 38 species of bats registered in the Caatinga and Cerrado areas in the Northeast, three species are referred to as being primarily nectarivorous: *Anoura geoffroyi*, *G. soricina* and *Lonchophylla mordax*. Concerning the Atlantic forest of this region, there are only limited lists. Despite the few existing studies, the preliminary data of the pollination syndromes in the Caatinga species suggest the occurrence of chiropterophily in various interesting genera such as *Harpochilus* (Acanthaceae), *Capparis* (Capparaceae), and *Pavonia* (Malvaceae). Intensifying studies in the Northeast of Brazil may identify different pollination patterns by bats and may permit comparisons with other Brazilian ecosystems.

REPRODUCTIVE ASPECTS OF SOME GUILDS OF ECUADORIAN BATS

Burneo, S., Boada, C. and Tirira, D.
Museo QCAZ de Vertebrados, Pontificia Universidad Católica de Quito, Ecuador

This paper is a pioneer work for Ecuador, in which the information from Natural History museums of the world is classified and analyzed for comparisons with meteorological data from representative spots from our region. Ecuadorian bats have been divided into guilds using the dietary and geographic information, resulting in the following guilds: eastern tropics insectivores, eastern tropics frugivores, eastern tropics nectarivores, eastern tropics carnivores, and these dietary divisions are applied in other geographic regions such as eastern subtropics, Andean, western subtropics, western tropics, and Galapagos regions, if applied (for example in the Galapagos islands there are only insectivores). I n some cases with excessive taxonomic differences we had to subdivide the guilds. The information was gathered from the most important museums in Ecuador, such as the Museo de Vertebrados de la Pontificia Universidad Católica de Quito (QCAZ), Museo Ecuatoriano de Ciencias Naturales (MECN) and Museo de la Escuela Politécnica Nacional (MEPN), and from other museums of the world such as the United States National Museum (USNM), the American Museum of Natural History (AMNH), the Field Museum of Natural History (FMNH), the Michigan State University Zoology Museum (MSU) and the British Museum of Natural History. In our museums we could analyze the field data for possible errors and we classified the animals according to their sexual age and sexual state following the criteria of Tirira (1994). Males and females were classified into one of the following categories: fetus, infant, juvenile, sub-adult, adult I (non-reproductive at time of capture) or adult II (reproductive at time of capture). Males were considered to be in one of the following sexual states (which we use to estimate their respective phase of sexual development): TE – scrotal testicles; TSE – sub-scrotal testicles; or, TI – abdominal testicles. Females were classified into the following categories: LA – lactation, GE – pregnant, MD – developed breasts, CA – carrying infant. The meteorological data was analyzed by: the average monthly rainfall in millimeters (from 1980 to 1996, and from 1990 to 1996 to avoid differences due by the 1983 El Niño phenomenon); the month's average total number of rainy days; the monthly average minimum, maximum and median temperature in Celsius degrees; the monthly average relative humidity in percentage and the cloudiness in eighths. Consulting various studies concerning the relationship between seasons and food productivity (for insects, flowers and fruits), we diagram the annual productivity cycle for each region and compare it with the museum data for each guild (using the adults I and II, the fetuses and infants) to examine the degree of coincidence between these graphs. We also use the information gathered to calculate male-female ratios, time to adulthood, and evaluate the duration of parental care in different species.

POLLEN MORPHOLOGY OF BAT POLLINATED PLANTS

Arjan Stroo
Comparative Morphology Section, Rijksherbarium, Leiden, The Netherlands

Angiosperm pollen is structurally very diverse. Transport by different kinds of pollinators is one of the factors that may have been responsible for the origin of this diversity. The objective of this study was to find out to what extent pollination by bats has acted as a selective force on pollen morphology. Based on literature, two hypotheses were formulated; 1) Pollen from bat pollinated plants is bigger than that of relatives with other pollination syndromes; 2) The exine ornamentation is rougher in pollen grains of bat pollinated species. These were tested on a set of 32 species taken from 21 different plant families. The results showed that the pollen grains of bat pollinated plants are big, 64.3 m on average, and significantly bigger (14%) than that of their relatives ($p<0.01$). For ornamentation no clear correlation was found, perhaps partly because of the methodology used and the selection of the taxa under study. Future studies will incorporate better phylogenetic information, more flower morphological data and partly focus on developments in more specific groups.

TEMPORAL AND SPATIAL ACTIVITY OF *EPTESICUS SEROTINUS* IN THE AGROCOENOSES

Pokorny, M. & Zukal, J.
Institute of Vertebrate Biology, Academy of Sciences, Kvetna 8 CZ-60365, Brno, Czech Republic

The nursery colony of *Eptesicus serotinus* (Schreber, 1774) was studied by radiotelemetry during reproduction period of 1996 and 1997. Radiotracking was conducted by means of two stationary and one movable observers. The control series of locations was carried out before the final research. Foraging activity of *Eptesicus serotinus* was registered during all night between sunset and sunrise. Typically, activity was divided to three foraging bouts, and the first one together with the last one accounted 85% of the overall foraging time of radiotracked bats. Lactating females shortened the length of the first foraging bout and also the total foraging time most probably due to energetically expensive parental care. Total activity of studied individuals was two-peaked with the highest level shortly after sunset. The lower peak was recorded before sunrise. Bats were foraging longer time during warm and cloudless nights. The total home range area covered by serotine colony varied between 1431 and 2037 ha and the individual home ranges were approximately 450 ha. The maximum commuting distance between the foraging area and the roost was 3.2 km. During all season the bats preferred the habitats close to the water bodies and meadows. When foraging in rural habitat than they used the surroundings of street lamps as foraging places. Only exceptionally the bats used the windbreaks in the fields and they absolutely avoided vineyards. Significant temporal changes in habitat preference were recorded. The foraging around the water bodies and the patches of woods was registered at the beginning and the end of nights. During the rest of night the females foraged mainly in the rural habitats. In general, temporal and spatial activity of *Eptesicus serotinus* is in close relation to the activity of their prey and it seems to be an non-specialized bat species well adapted to an antropically influenced landscape.

OBSERVATIONS ON THE POLLINATORS OF SYNTOPIC MARCGRAVIA SPECIES IN A LOWLANDRAINFOREST: BATS AND OPOSSUMS

Marco Tschapka & Otto von Helversen
Institut für Zoologie II, Universität Erlangen, Germany

The bizarre architecture of the inflorescences of the neotropical genus *Marcgravia* (Marcgraviaceae) has, for a long time, inspired curiosity among pollination ecologists. We observed the visitors of four species from the lowland rainforest at La Selva Biological Station in Costa Rica: *Marcgravia nervosa, M. serrae, M. mexicana* and *M. nepenthoides*. All received visits by small nectar-feeding bats (Phyllostomidae: Glossophaginae). *M. nepenthoides* also attracted two species of opossums (*Caluromys derbianus, Didelphis marsupialis*). The nectaries of *M. nepenthoides* are extremely large (mean vol. > 2,500µl) when compared with the other species (< 250µl) indicating an adaptation towards these big visitors. Judging from inflorescence size and architecture, bats are probably inefficient pollinators of this species and merely exploiting the mutualistic plant-opossum system. Simultaneously flowering species deposit the pollen on different body parts of bats: *M. serrae* on the underside of wings and body, *M. nervosa* on the snout and throat. *M. nepenthoides* may under certain conditions deposit pollen on the upper part of the head. The fourth species, *M. mexicana*, follows the same pattern as *M. serrae*, but is temporally separated. Our results from La Selva together with preliminary observations on two more species from montane rainforest (*M. pittieri*: Rara Avis, Costa Rica; *M. spec. nov.*: Estación Cientifica San Francisco, Ecuador) suggest that the interaction between bats and *Marcgravia* is not uncommon.

EVOLUTION AND SYSTEMATICS

THE STATUS OF *RHINOLOPHUS BOCHARICUS* IN CENTRAL ASIA

Khabilov, T.K. .
Khujand State University, 735700 Khujand, Tajikistan.

Rhinolophus bocharicus (Kast. et Akimov 1917)is endemic in the former Soviet Central Asia, and known outside of this area only from North Afganistan and North-Easten Iran (Khabilov,1992). This species is morphologically very alike to a Greater Horseshoe Bat (*R. ferrumequinum*), whom they co -inhabit in a larger part of area. Length of forearm of *R. bocharicus* is always less than 53 mm unlike *R. ferrumequinum*. N.A.Bobrinkskii (1926) and S.N. Ognev (1928) considered *R. bocharicus* as subspecies of *R. ferrumequinum*. In the former Soviet zoological literature *R. bocharicus* was regarded as sibling species with *R. ferrumequinum*. On the other hand only small details of its morphology of nostrils, zygomatic width and a big reduction of P1 make *R. bocharicus* differ from *R. mehelyi* (Strelkov, 1963). Allen (1959) propposes that *R. bocharicus* should be considered as a subspecies of *R. clivosus* , widespread in Arabia, and on the African coast of the Red Sea. Corbet and Hill (1992) recognized *R. bocharicus* as a distinct species, but Koopman (1993) included *bocharicus* as a subspecies of *R. clivosus*. Nevertheless, a new morphemetic analysis (CVA) carried out to date (Thomas, 1995) and our research has recognized *R. bocharicus* as a distinct species.

BATS FROM PARQUE NACIONAL DA SERRA DO DIVISOR, ACRE, BRAZIL

Nogueira, M.R. , Pol, A. ., Peracchi, A.L. . Silva, A.M. da , and Rocha, C.P.H.
Instituto de Biologia - UFRRJ. Km 47 da antiga Rio-São Paulo, Seropédica, RJ. CEP: 23851-970.

The Parque Nacional da Serra do Divisor (PNSD) is situated in northwestern Acre state, forming the westernmost extremity of Amazonian Brazil, along the Peruvian border. It encompasses approximately 605.000 ha, and comprises several distinct vegetational physiognomies where botanical and faunistic inventories were developed as part of the "Projeto para Conservação do Parque Nacional da Serra do Divisor" under the auspices of S.O.S. Amazônia, The Nature Conservancy, and IBAMA. Preliminary results of the chiropteran survey, conducted from 8-28 July 1996 (dry season) in northern PNSD along the Rio Moa, and 11-29 March 1997 (wet season) in southern PNSD along the upper Rio Juruá, confirmed the presence of 55 species identified based on 855 bats captured. The sampling was carried out essentially with mist-nets placed at ground level, in localities at about 250 m elevation. *Sturnira magna* and *Promops centralis* are recorded for the first time in Brazil, as is *Vampyressa pusilla* in Amazonian Brazil. 39 species mentioned are new for the state of Acre. Represented in Brazil by scarce records and probably restricted to the western Amazon, *Carollia castanea*, *Artibeus andersoni* and *Platyrrhinus infuscus* were frequently sampled in PNSD. The list reported here, including 3 Emballonuridae, 2 Noctilionidae, 14 Phyllostominae, 4 Glossophaginae, 5 Carolliinae, 18 Stenodermatinae, 3 Desmodontinae, 1 Thyropteridae, 3 Vespertilionidae, and 2 Molossidae, seems to constitute a record in bat species richness for Brazilian conservation units. Data on habitat and reproduction of the cited species are also provided. Financial support: USAID.

FIRST RECORD OF *HISTIOTUS MACROTUS* FOR A BRAZILIAN TERRITORY

Pol, A., Nogueira, M.R. and Peracchi, A.L.
Instituto de Biologia - UFRRJ Km 47 da antiga Rio-São Paulo, Seropédica –
Rio de Janeiro, Brasil CEP: 23851-970.

The current geographic distribution of *Histiotus macrotus* (Poeppig, 1835) is based on scattered reports, covering great expanses of Argentina, Chile, Bolivia and Peru. The scarcity of specimens deposited in museums, and chiefly the lack of related studies on its taxonomy, makes the identification of this species a difficult task, resulting in the uncertainty about the limits of its geographic distribution. In may 1996 during a faunistic survey promoted by Furnas Centrais Elétricas and Fundação Riozoo, on Cerrado vegetation areas under the influence of UHE Corumbá's reservoir, located at Ipameri county, state of Goiás,

central Brazil, we succeeded in capturing an adult male of the referred species. Externally, the specimen could be identified by its large oval ears joined by a well-developed connecting-band, a high and broad tragus, forming nearly half of the auditory pavilion. The antitragus was small, not well differentiated, and rounded. The wing membranes were comparatively light, pale and more or less translucent gray. The ears and tragus were slightly yellowish in tone in relation to the membranes. Five external and thirteen cranial morphometric measurements coincide with the diagnosis supplied for the species by the few available references. With this record we included this rare species in the Brazilian Chiropteran fauna, considerably enlarging the limits of its geographic distribution.

BAT COMMUNITY IN A CAVE FROM EASTERN BRAZIL, INCLUDING A *LIONYCTERIS* SPECIES PREVIOUSLY KNOWN ONLY FROM AMAZONIA

Trajano, E. and Gimenez, E.A.
Dept. Zoologia, Inst. Biociências da USP, São Paulo, Brazil

A cave bat community from a semiarid region in eastern Brazil was studied during the dry season. A high diversity was observed, with thirteen species recorded. Except for *Micronycteris minuta* and *Lionycteris spurrelli*(Phyllostomidae, Glossophaginae), such bats were also found in other Brazilian karstic areas. The commonest species were the hematophague *Desmodus rotundus*, the omnivore *Carollia perspicillata*, and the insectivore *Natalus stramineus*. These bats form itinerant colonies, moving frequently inside the cave. *L. spurrelli* was previously known from Amazonia, usually associated with evergreen forests. The present record extends its range 1600 km to the south. A disjunct distribution explains some morphological differentiation between Amazonia and Olhos d'Água cave populations. The latter may be a relict of former continuous forest vegetation, which has been fragmented after the climatic optimum. Dispersion through Cerrado gallery forests is also possible.

QUATERNARY BATS FROM SERRA DA MESA (GOIAS, BRAZIL)

Salles, L.O.[1], Avilla, L.S. [1], Czaplewski, N.J. [2], Simmons, N.B.[3] and Sahate, V.A.[1]
[1]Depto. de Vertebrados, Museu Nacional - UFRJ, Quinta da Boa Vista, s/n. Rio de Janeiro, RJ, 20940-040, Brazil;
[2]Oklahoma Museum of Natural History and Dept. of Zoology, University of Oklahoma, Norman, OK 73019 USA;
[3]Dept. of Mammalogy, American Museum of Natural History, New York, NY 10024.

The South American Tertiary fossil record of Chiroptera is poorly known, being largely limited to the Miocene of La Venta (Colombia) and to the Quaternary of Lagoa Santa (Brazil). As part of the research program "Mamíferos do Quaternário do Brasil", in 1995-1997 the Museu Nacional organized three short paleontological expeditions to a group of four calcarium caves (Igrejinha and Nossa Senhora da Aparecida from the Bambuí-Group, and Carneiro and Itambé from the Araxá-Group) located in the Region of Serra da Mesa, Alto Tocantins (State of Goias). From the Quaternary deposits of these caves a somewhat diverse fauna of microvertebrates is revealed, including lizards, frogs, snakes, marsupials, rodents and bats. The bat fauna is represented by many well-preserved fragments of maxilla and lower jaws as well as some nearly complete skulls. Thus far we have identified what appear to be remains of 22 species representing 14 genera and 4 families (Mormoopidae, Phyllostomidae, Vespertilionidae, and Natalidae). This assemblage includes *Pteronotus parnelli, Pteronotus sp., Mimon sp.1, Mimon sp.2, Micronycteris sp., Tonatia sylvicola, Tonatia n. sp., Trachops sp., Phyllostomus hastatus, Phylloderma n. sp., Glossophaga sp., Carollia sp., Stenoderminae insertae sedis, Artibeus sp.1, Artibeus sp.2, Artibeus sp.3, Sturnira sp., Desmodus rotundus, Desmodus sp., Myotis sp., Natalus stramineus, Natalus n. sp.* Undoubtedly they represent one of the richest bat fauna of the South American Tertiary. Granted by: CNPq.

BATS FROM HUMAITA, AMAZONAS: A FIRST SURVEY

Taddei, V.A.[1] & Pedro, W.A.[2,3]
[1]Depto. de Zoologia, UNESP, São José do Rio Preto, SP, 15054-000, Brasil [2]PPG-ERN/UFSCar
[3]Depto. de Apoio, Produção e Saúde Animal, UNESP, Araçatuba, SP, 16050-680, Brasil

The bats from Humaita and vicinities, southwestern Amazonas (nearly 7° S and 63° W), were studied between February, 1981 to February, 1986. Bats were sampled with mist nets and hand nets, in forest and

urban environments. We caught 1567 bats representing 48 species. *Carollia perspicillata* (Phyllostomidae) was the dominant species (43% of captures), followed by *Molossus molossus* (Molossidae)(21%) and *Artibeus planirostris* (Phyllostomidae)(9%). Some of the species in the samples are rare in collections from the Brazilian Amazon, including: *Anoura caudifer, Carollia castanea, Platyrrhinus helleri, P. brachycephalus, Artibeus anderseni, A. gnomus, A. concolor, V. pusilla, Furipterus horrens* and *Myotis simus.*

TESTING A MOLECULAR HYPOTHESIS WITH MORPHOLOGICAL DATA: A REVISION OF THE GENUS *TRACHOPS*

Ditchfield, A.D.
Dept. Mammalogy, American Museum of Natural History, New York, NY10024.

Trachops (Gray, 1847)(Chiroptera, Phyllostomidae) is a genus currently considered to be monotypic. However, I previously found unexpected large sequence divergence values for the mitochondrial cytochrome b gene in *Trachops cirrhosus* (Spix, 1823). This molecular variation is highly structured, allowing identification of five distinct, geographically defined clades in the range of the species. To test whether or not this is a composite species, I surveyed the morphological variation in the genus. Preliminary analyses of ~1400 Trachops specimens from Mexico to SE Brazil revealed considerable though subtle variation in size and craniodental morphology. There are probably three and perhaps as many as six species in the complex presently identified as *"Trachops cirrhosus."* This study of species/subspecies limits combining molecular and morphological approaches has implications for many fields of research, from systematics to animal behavior. For example, bat predation could be an important factor in the evolution of frog vocalizations in the Neotropics, but one must first determine if *Trachops* species in other areas outside Panama also feed on frogs. Brazil is an excellent region to explore this issue, since it may harbor as many as three species of *Trachops.*

PIPISTRELLES: POPULATIONS AND PUZZLES!

Barratt, E.M.[1]., Gottell, D.[1], Jones, G.[2] and Racey, P.A.[3]
[1]Zoological Society of London, Regents Park, London, NW1 4RY, U.K.
[2]School of Biological Sciences, University of Bristol, Bristol, BS8 1UG, U.K.
[3]Department of Zoology, University of Aberdeen, Aberdeen, AB24 2TX Scotland, U.K.

The pipistrelle bat *Pipistrellus pipistrellus* is common in the UK but vulnerable across the rest of its range and has until recently been considered a single species. In 1993 Jones and van Parijs identified two groups of pipistrelles with different echolocation frequencies (45 or 55 kHz). We present the results of a molecular study of the taxonomic status of these two phonic types, using both mitochondrial and nuclear markers, which demonstrate that each is a distinct species and that cryptic speciation has occurred within the pipistrelles. We also present the results of a microsatellite study which investigates the population structure of the two species across Europe, and discuss the implications for future conservation policy.

BASAL METABOLIC RATE IN PHYLLOSTOMID BATS: INFLUENCES OF BODY MASS, PHYLOGENY AND DIET

Cruz-Neto, A.P. & Abe, A.S.
Departamento de Zoologia, IB, UNESP, CP 199, CEP 13506-900, Rio Claro, SP.

Variation of the basal metabolic rate (BMR) in bats has been mainly associated to differences in body weight. When this variable is controlled for, a residual variation which can be associated to diet and phylogeny remains. We tested this by analyzing the effects of body weight, diet and phylogeny on the variation of BMR in 20 species of bats belonging to the family Phyllostomidae. An allometric equation between BMR and body weight was derived, and the result indicates that 70% of the variation in BMR can be explained by differences in body weight. However, the extension to which body weight influences BMR in these species differs from those hitherto reported for other species of mammals, and the possible causes for such difference are discussed. An exploratory analysis, based on phylogenetic relationships among the species, indicated no effect of phylogeny on the residual variation of BMR. Accordingly, we were not able to detect any relationship between diet and the residuals of BMR among the studied species. Assuming a

relation between BMR and thermogenic capacity, these results also suggest that the plasticity in the patterns of thermal and energy homeostasis observed for these species has an adaptative feature in response to recent factors. The possible causes for these results were discussed and other factors that could be causing the residual variation in BMR were suggested.

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A NEW SPECIES OF *TONATIA* FROM THE BRAZILIAN SAVANNAS AND ITS PHYLOGENETIC INTERRELATIONSHIPS

Avilla, L.S.[1], Salles, L.O.[1] and Simmons, N.B.[2]

[1]Depto. de Vertebrados, Museu Nacional - UFRJ, Quinta da Boa Vista, s/n. Rio de Janeiro,

[2]Dept. of Mammalogy, American Museum of Natural History, New York, NY 10024.

Tonatia (Chiroptera, Phyllostominae)is a diverse group of small to medium-sized phyllostomid bats that presently includes seven species. Based on a new sample of extant and fossil bats from the Brazilian Savannas (Cerrado) in the Region of Serra da Mesa (Alto Tocantins, State of Goias), we recognize a new species of *Tonatia*. This taxon is diagnosed by a number of derived characters including the presence of a well-developed flange on the mastoid process, angulation of the anterior portion of the rostrum, enlarged and laterally expanded occipital condyles. To evaluate relationships among *Tonatia*, we assembled a data set of 49 potentially informative characters including external, craniodental, and skeleton features. Preliminary parsimony analyses (branch and bound, PAUP 3.1) resulted in a single fully resolved most-parsimonious tree with the following structure: ((*Tonatia n. sp.* (*T. bidens T. saurophila*)) (*T. brasiliense* ((*T. carrikeri T. schulzi*) (*T. sylvicola T. evotis*))). Several clades in this tree are very well-supported with 10 or more synapomorphies. Based on our results, we propose a new subgeneric classification for this group. Granted by: CNPq.

A MOLECULAR PHYLOGENETIC PERSPECTIVE ON HIGHER LEVEL SYSTEMATICS OF CHIROPTERA

Teeling, E., Waddell, V. & Stanhope, M.

The Queen's University of Belfast, School of Biology & Biochemistry, Belfast BT9 7BL, Northern Ireland

The interfamilial phylogenetic relationships of Microchiroptera are examined via sequence analysis of a number of coding and noncoding loci from both the mitochondrial and nuclear genomes. The possibility of a sister group relations hip of the superf amily Rhinolophoidea and the Megachiroptera, suggested by some earlier DNA hybridization data, is examined from the perspective of amino acid and nucleotide sequence data.

PHYLOGENETIC ANALYSIS OF TWO-LINED SAC-WINGED BATS BASED ON ND3-4 MTDNA RESTRICTION CUT SITES

Lim, B.K. & Engstrom, M.D.

Centre for Biodiversity & Conservation Biol., Royal Ontario Museum, Toronto, Ontario, Canada, M5S 2C6

An hypothesis of evolutionary relationship within the two-lined sac-winged bats (Saccopteryx) has been hindered because *S. gymnura* was known only by the type specimen collected over 120 years ago near the Amazon River at Santarem, Para, Brasil. Our recent "re-discovery" of this enigmatic species in the Iwokrama Reserve of central Guyana has enabled us to use a molecular approach to investigate its phylogenetic relationships relative to its congeners (*S. bilineata, S. canescens,* and *S. leptura*) including the recent hypothesis that *S. gymnura* is the sister taxon to *S. canescens*. A phylogeny was constructed based on a parsimony analysis using mapped cleavage sites from 12 restriction endonucleases within the 2,400 basepair ND3-4 mtDNA gene region. Outgroup taxa included *Balantiopteryx plicata, Centronycteris maximiliani, Cormura brevirostris, Peropteryx macrotis,* and *Rhynchonycteris naso* which represent all genera traditionally included in the subfamily Emballonurinae.

WIN SOME, LOSE SOME: CONSEQUENCES OF MICROCHIROPTERAN PARAPHYLY FOR THE EVOLUTION OF ECHOLOCATION

Hutcheon, J.M. & Kirsch, J.A.W.
University of Wisconsin Zoological Museum, Madison WI 53706, USA

Recent molecular work on bat phylogeny calls into question the long-accepted subordinal dichotomy between Megachiroptera and Microchiroptera, suggesting instead that rhinolophoid microbats may be specially related to Pteropodidae. This provisional finding implies that many microbat characters, in particular those involving echolocation, were either lost in megabats or convergently evolved in rhinolophoids and other microbats. The main objection to loss is the apparent usefulness of this complex suite of anatomical/physiological features. But loss occurs frequently when characters are no longer useful, or when others that replace them are more so. On the other hand, if echolocation is so valuable, its multiple evolution is not unlikely. Convergence among echolocators might be discounted because of the intricacy of anatomical adaptations for bat echolocation, their long evolutionary history, and their many physiological correlates. Yet echolocation is in fact implemented quite differently in rhinolophoids and most other microchiropterans, while also being constrained by flight and body size. We conclude that the notion of microbat paraphyly and its uncomfortable consequences for the evolution of echolocation are not as absurd and unlikely as they first appear.

THE SCALING OF FLIGHT AND ECHOLOCATION IN MICROCHIROPTERA: A PHYLOGENETIC PERSPECTIVE

Arita, H.T. & Uribe, J.
Instituto de Ecología, UNAM, Apartado Postal 27-3; CP 58089, Morelia, Michoacán, Mexico

Flight and echolocation in Microchiroptera can be viewed as two manifestations of the same adaptive complex. At least in some aerial insectivorous bats, wing flapping and echolocation pulse production are coupled to save energy, so about one echolocation call is generated per wingbeat during the search phase. As outlined by G. Jones (1994, Functional Ecology 8:450-457), both pulse repetition rate (PRR) and wing -beat frequency (WBF) scale with body mass with negative exponents because of morphological and functional constraints. If PRR and WBF are completely coupled, one might expect the scaling lines with body mass to be identical for both parameters to produce PRR/WBF ratios equal to one. However, the allometric equations show variations among taxonomic groups that suggest an additional phylogenetic constraint that limits the possible set of values for flight and echolocation parameters. We used the tools of the comparative method to trace the evolution of the coupling of flight and echolocation among Microchiroptera. We calculated allometric equations for some taxonomic groups to assess the variation among bats and analyzed the evolution of PRR, WBF, and the associated wing morphology along an evolutionary tree of bats based on recent phylogenetic hypotheses. Our results suggest the existence of a phylogenetic constraint that indeed limits the gamut of possible combinations of considering both parameters as a single adaptive complex.

MORPHOLOGY AND ECOLOGY OF EOCENE BATS FROM MESSEL

Habersetzer, J.[1], Storch, G.[1] and Bogdanowicz, W.[2]
[1]Forschungsinstitut and Naturmuseum Senckenberg, Senckenberganlage 25,
D-60325 Frankfurt am Main, Germany and [2]Museum and Inst. of Zoology,
Polish Academy of Sciences, Wilcza 64, P.O. Box 1007, 00-950 Warszawa, Poland

Early middle Eocene bats of Messel (W-Germany) represent the oldest known bat community, providing a broad spectrum of information for taxonomic and functional morphological studies. These bats are known from relatively complete skeletons but the use of two new radiological techniques (including exact three-dimensional orientation under real-time X-ray control) developed in our study, permitted the collection of new data on the dental, wing, and pectoral girdle morphology. Morphometric analyses of the wing form showed where and how all the species differ and revealed that Messel bats represented a biologically balanced fauna and occupied specific flight niches similar to those of Recent tropical bats. The small-sized, broad-winged *Palaeochiropteryx tupaiodon* hunted close to the ground. The *Archaeonycteris* species were characterized by average body size, low aspect ratio, and moderate wing loading; their flight

style seems to be rather unspecialized. The medium or large-sized, narrow-winged *Hassianycteris* species flew very fast and were well adapted to exploit free spaces. The functional significance of the shoulder joint morphology is also discussed and viewed in terms of adaptive radiations during the early evolution of bats.

FOSSIL VAMPIRE BATS: AN UPDATE

Arroyo-Cabrales, J.

Laboratorio de Paleozoología, INAH, Moneda 16, Col. Stanhope, M.Centro, 06060 México, D. F.,

It has been 10 years since the last comprehensive review of what it was known on Paleontology about vampire bats was conducted by Ray et al. in1988. Since then, several new findings have appeared in the literature, including the formal description of two new species. This paper tries to bring the knowledge about fossil vampire bats up-to-date. Several papers have discussed the fossil record of vampire bats in recent years. Morgan et al., described two new species of fossil vampire bats. The extinct vampire bat *Desmodus archaeodaptes* was described based on a skull and a few isolated postcranial bones; it was similar in size to the common vampire bat, *D. rotundus*, and known from the early to middle Irvingtonian of northern peninsular Florida (USA), ranging approximately from the late Pliocene to middle Irvingtonian, 1.9 to 0.8 million years. *Desmodus draculae* was described based on two incomplete skeletons, and a few isolated elements, from an undated deposit at Cueva del Guácharo, State of Monagas, Venezuela. This is the largest known vampire bat species, and at present it has also been recorded from one locality in México, and several localities in Brazil. Morgan extensively described the vampire bats bones from Florida fossil sites, including two species: *Desmodus archaeodaptes* and *D. stocki*. The comparisons between the extinct species bones and those of the common vampire bat are noteworthy. Some inferences on why vampire bats are found in Floridan Pliocene-Pleistocene sites are explored, as well as a proposal that *D. archaeodaptes* or its progenitor probably reached Florida via Middle America as an early participant of the Great American Interchange in the late Pliocene (late Blancan) around 2.5 million years ago. Trajano and de Vivo documented the presence of *Desmodus draculae* as far south as Santana Cave, near Iporanga, Sao Paulo State, southeastern Brazil. It is an incomplete skull, without mandibles and very-poorly preserved; a relatively recent date is suggested for the specimen, and in fact, the possibility of finding the species alive has been considered. It was also pointed out that there could be a closer relationship between *D. draculae* and *Diaemus youngi* due to the presence in both of a second upper molar, but this was considered more like a plesiomorphic character state, and an apomorphic character state shared by both species was not found, while *Diaemus* has a distinct dental autamorphy, the loss of the vestigial lingual basin of the upper premolar, being present in *Desmodus rotundus* and *D. draculae*. The FAUNMAP Working Group recorded seven localities containing vampire bat remains, including six for *Desmodus stocki*, and one for *Desmodus sp.* with dates ranging between 10,000 and 120,000 years BP; however, two localities had narrower date ranges, i.e. U-Bar Cave, New Mexico (25,000-40,000), and Daisy Cave, California (10,700-35,000). A review of all of the fossil vampire bat remains from localities in México showed the presence of four species of vampire bats within the Quaternary Period (Pleistocene and Holocene). *Desmodus cf. D. draculae* was identified based on two partial humeri collected in stratigraphically-controlled excavations in Loltún Cave, México; an actual date is not assigned, but the sediments correspond to the Pleistocene-Holocene interface (approximately 10,500 years BP). The common vampire bat *Desmodus rotundus* was found in late Pleistocene deposits, older than 28,400 years BP in Loltún Cave, Yucatan. In the same cave, from Pleistocene-Holocene interface sediments, there are remains of the hairy-legged vampire bat, *Diphylla ecaudata*. The Pleistocene vampire bat *Desmodus stocki* is recorded from four localities in México, including the type locality, San Josecito Cave, Nuevo León State. Qualitative and quantitative comparisons between *D. stocki* and *D. rotundus* are provided, as well as some inferences about the presence of both sexes in the fossil material of *D. stocki*, and the age range of 9920 and 7040 years BP for one of the Mexican localities, while for the others it can just be said that they are late Pleistocene. Renewed excavations in San Josecito Cave have allowed to collect more *D. stocki* bone material from a radiocarbon-dated stratum at approximately 28,000 years BP. Cartelle and Abuhid recorded from the late Pleistocene-Holocene from the State of Bahia, in Brazil, a skull of *Desmodus rotundus* from Toca da Boa Vista, and one pertaining to *D. draculae* from Toca dos Ossos, associated with *Equus (Amerhippus) neogeus*. The authors pointed out that there are small differences between the Brazilian specimens and those of the type series from Venezuela, like the sagittal crest being slightly more developed, and the presence of a minute M2 on the specimens from Sao Paulo and Bahia; however, the presence or absence of M2 does not necessarily have

an evolutionary significance, as it seems to be with *Diaemus youngi*, in which some specimens have and some do not this characteristic. Czaplewski and Cartelle reported the occurrence of two species of Pleistocene vampire bats in Bahia, Brazil, including *Diphylla ecaudata*, and an additional braincase of *Desmodus draculae* from Toca da Boa Vista. This specimen differs by the lower profile of its braincase, and having more prominent bulges on either side of the back of the braincase, from those other specimens from Bahia, Sao Paulo, and Venezuela. However, all that variation is attributed to intraspecific variation. Lastly, they mentioned the collection of a skull of D. rotundus associated to a sloth coprolite (*Nothrotherium maquinense*) dated by AMS radiocarbon assay to 12,200 + 120 years BP. Grady et al. recorded the northernmost finding of the Pleistocene vampire bat from New Trout Cave, West Virginia, USA, specimens that were tentatively assigned by Ray et al., to *Desmodus draculae*, but with further study showing that they pertained to *D. stocki*. Three of the four specimens are assigned to sediments older than 29,400 years BP, and so it supports assignment of these vampire bats to pre-Pleniglacial stage. Five species of vampire bats are known for the Tertiary and Quaternary of the Americas and the Caribbean region, including three that are extinct, *Desmodus archaeodaptes, D. draculae,* and *D. stocki,* and two extant ones, *D. rotundus* and *Diphylla ecaudata*. Most of them, but *D. archaeodaptes*, were collected from Pleistocenic and/or Holocenic sediments, while the Floridan vampire bat was obtained from late Pliocene/early Pleistocene (Blancan/Irvingtonian). Few radiometric controls are associated with vampire bat remains, and those that are being assigned to ages between 9,000 to 40,000 years BP for D*esmodus stocki*; 12,200 to 30,000 years BP for *D. rotundus*; and 11,000 to recent for *D. draculae*. For the fossil record, *Desmodus draculae, D. rotundus,* and *Diphylla ecaudata* have the largest distribution ranges from southern México to southeastern Brazil, while *Desmodus stocki* is known from northern US to central Mexico, and *D. archaeodaptes* only from Florida. *Desmodus draculae* and *D. rotundus* occurred together in, at least, two localities, i.e.: Loltún Cave and Toca da Boa Vista, while *D. stocki* seems to be allopatric to the other species of the genus. Little has been commented on their phylogenetic relationships, but it seems that *Desmodus archaeodaptes* is a more-primitive species than the other three known species of the genus *Desmodus*, while there are doubts about *D. draculae* or *D. stocki* as being less envolved than *D. rotundus*.

FUNCTIONAL MORPHOLOGY

WING MORPHOLOGY IN THE BAT COMMUNITY OF YUCATAN, MEXICO

Santos, M., Guerrero, G., Uribe, J. and Arita, H.
Instituto de Ecología, U.N.A.M. Morelia, Michoacán, Mexico

The use of morphological analysis has had a relevant role in the study of ecological relationships among species, in determining ecological-morphological correlations and how this correlation is affected by the behavior and performance of organisms. Wing morphology in bats has been addressed using two main approaches: (1) The measurement of morphological parameters (wing loading (WL), aspect ratio (AR), and tip shape index (Itip)) using wing outlines drawn from living individuals; (2) The estimation of the same morphological parameters using museum specimens. The main purpose of this study is to make comparisons of bat wing shape using the two mentioned methods in order to search for morphological arrangements in the bat community of Yucatan, Mexico. We gathered wing measurements using both living animals (23 out of 31 species) and museum specimens to estimate WL, AR, and Itip ; in the former, the morphological parameters were obtained using a digital planimeter, abling us to estimate the plagiopatagium and chiropatagium areas. In the other one, using the same 23 species (museum specimens), we estimated the wing area starting with measurements of the length of the 3th and 5th digits, as well as measurements of the forearm. Once all the measurements were obtained for each method, we plotted the species on bivariate graphs and conducted a cluster analysis using WL, AR and Itip values. This approach allowed us to know how bat species are grouped in morphological space. Our results show that species in the Yucatan community form consistent groups, regardless of the method used to estimate wing -morphology parameters. This suggests that in the absence of field data, the use of museum specimens is a convenient option. Being as such, for the rest of the analysis we incorporated the whole bat community of Yucatan (n=31 species). We obtained four different morphological groups in the bat community of Yucatan. All species for each group had similar foraging habits and diet types. The clearest morphological arrangement were obtained among members of the Molossidae family (n=5). All these species belong to the

same guild (feed on insects), and have narrow, large, and pointed wings that allow them to perform high-speed flights over open areas. However, Phyllostomid members were grouped due to differences between WL rather than in differences among diet habits, since this family has members that feed on fruits, nectar and blood. The third group included members of the families Vespertilionidae, Mormoopidae, Natalidae and Emballonuridae, all of them feed on insects following differents hunting strategies. The last group is formed by a combination of members from three different families (Noctilionidae, Vespertilionidae and Molossidae). The incorporation of phylogenetic analysis, the use of the comparative methods, and behavioral observations on the field, are necessary to establish a more and complete scenario.

WING MORPHOLOGY AND FLIGHT MODE IN RECENT BATS: A GEOMETRIC MORPHOMETRICS APPROACH

Bogdanowicz, W.

Museum and Inst. Zool., Polish Academy of Sciences, Wilcza 64, PO Box 1007, 00-679 Warszawa, Poland

Previous descriptions of bat wing form were based either on univariate or standard multivariate analyses of traditional measures of lengths and areas. Each of these methods has its own strength, but they do not fully describe differences in shape and usually overlook the covariation of points in different regions of the wing. To avoid these problems I depicted the wing morphology by means of thin-plate spline (TPS) of 22 homologous landmarks. The use of partial and relative warps, derived from decomposition of TPS, provided the power to discriminate among various, even "sibling" taxa, and segregated 17 families of Recent bats into several groups with generalized wing shape and flight characteristics. The relationships between wing morphology and flight behaviour of these groups are analyzed, and discussed in the context of phylogenetic constraints on the evolution of flight structures in Chiroptera.

PHYSIOLOGY

EFFECTS OF FASTING ON CARBOHYDRATE METABOLISM IN FRUGIVOROUS BATS

Pinheiro, E.C.[1], Resano, N.M.Z.[2], Garófalo, M.A.R.[2], Oliveira, J.R.[2], Taddei,V.A.[2], Migliorini, R.H.[3] and Kettelhut, I.C.[3]

[1]Depto. Ciências Fisiológicas - UnB, Brasília, DF, Brasil, [2]Depto. Zoologia - Unesp, SJ Rio Preto

[3]Depto. Bioquímica, FMRP - USP, Ribeirão Preto, Brazil

We investigated, in two species of frugivorous bats *Artibeus lituratus* and *A. jamaicensis*, of both sexes, parameters of carbohydrate metabolism and the adaptive changes induced by 24, 48, 72, 96 h and 6 days of fasting. To this end plasma levels of glucose and lactate, liver and muscle glycogen, rates of gluconeogenesis and its enzymes activities in the liver were determined. Plasma glucose concentration did not differ significantly in fed animals. Fasting induced a decrease in plasma glucose levels after 24 hours in female and 48 hours in male bats. Plasma levels of lactate were extremely high in fed and decreased in fasted bats. Liver glycogen content was markedly high in fed bats, but was reduced to extremely low levels after 24 hours of fasting. Muscle glycogen content was also reduced in fasted bats. The expected increase in gluneogenesis during fasting was seen only after 48 hour of fasting in male animals. The activities of liver glucose-6-phosphatase, fructose-1,6-biphosphatase and phosphoenolpyruvate carboxykinase were not affected by food deprivation. It seems that in 24 h of fasting, neoglicogenesis from alanine does not contribute significantly for glycemic homeostasis in frugivorous bats.

LIPID METABOLISM IN FRUGIVOROUS BATS

Pinheiro, E.C.[1], Resano, N.M.Z.[2], Garófalo, M.A.R.[2], Oliveira, J.R.[2], Taddei,V.A.[2], Migliorini, R.H.[3] and Kettelhut, I.C.[3]

[1]Depto. Ciências Fisiológicas - UnB, Brasília, DF, Brasil [2]Depto. Zoologia - Unesp, SJ Rio Preto

[3]Depto. Bioquímica, FMRP - USP, Ribeirão Preto, Brazil

The aim of the present study was to investigate in two species of frugivorous bats, *Artibeus lituratus*

and *A. jamaicensis*, parameters of lipid metabolism and the adaptive changes induced by several periods of food deprivation. We evaluated in fed and 24, 48, 72, 96 h and 6 days fasting male and female bats, the plasma levels of free fatty acid (FFA), the liver and carcass lipid content and in vitro rates of lipolysis in fragments of abdominal adipose tissue. Fasting induced a striking increase in plasma levels of FFA that was accompanied by a marked increase in the amount of liver fat and by a progressive decline of carcass lipid content. In vitro rates of lipolysis were increased in tissues from fasted bats. Taken together, the data indicate that the adaptive metabolic changes in lipid metabolism induced by fasting in bats are qualitatively similar to those found in other mammals, but differ quantitatively in some aspects. Especially noteworthy is the striking increase in FFA mobilization induced by fasting from lipid depots, in the first 24h fasting from abdominal stores and after that, from carcass stores. Finally, it seems that the liver has a central role in the control of the metabolic pathways involved in the caloric homeostasis.
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GAS EXCHANGE, BODY TEMPERATURE, AND EVAPORATIVE WATER LOSS IN THE VAMPIRE BAT, *DESMODUS ROTUNDUS*

Cruz-Neto, A.P. and Abe, A.S.
Departamento de Zoologia, IB, UNESP, CP 199, CEP 13506-900, Rio Claro, SP, Brazil

Gas exchange (VO2 and VCO2), body temperature (Tb) and evaporative water loss (EWL) were measured in the vampire bat, *Desmodus rotundus*, as a function of environmental temperature (Te). Between 30° and 35° *D. rotundus* responds with a typical homeothermic pattern, with Tb ranging between 35° and 37°C. In this range of Te, our values for VO2 were below those hitherto reported for this species. At 35 °C, EWL accounts for more than 60% of the total metabolic heat production (MHP), a value below those reported for other bats. At 30°C, the contribution of EWL to MHP was equal to those reported for other bats. Below 30°C *D. rotundus* showed two different thermoregulatories strategies. Homeothermic *D. rotundus* maintained Tb below those commonly reported for phyllostomid bats. Rates of EWL in these bats did not varied between 5° and 25°C, being about 17% lower when compared with other normothermic bats. It seems that homeothermic *D. rotundus* actively control EWL at low Te. The decrease in rates of gas exchange, Tb and EWL is still more substantial when these bats entered into torpor. During torpor, energy savings amounts to 44% with a reduction in EWL of 37% compared with homeothermic bats. Below 20°C, torpid vampire bats kept rates of EWL and Tb fairly constant. This results suggest that this species is able to down regulate these variables and to kept them constant in a level that differ from those normally found in homeothermic animals. Financial Support: FAPESP (grants 1994/6026-9 and 97/02731-8)

HISTOLOGICAL AND HISTOCHEMICAL ASPECTS OF THE GASTRIC AND DUODENAL MUCOSA OF THE VELVETY FREE-TAILED BAT

Rozensztranch, A.M.S.[1,2], Apfel, M.I.R.[2] & Salles, L.O.[1]
[1]Departamento de Vertebrados, Museu Nacional – Rio de Janeiro, RJ - 20940-040
[2]Laboratório de Histoquímica - Depto. de Histologia e Embriologia - UERJ, Rio de Janeiro, RJ - 20551-030

Histological and histochemical aspects of the stomach and gastroduodenal junction of *Molossus molossus* (Pallas) was examined. Six stomachs were fixed by immersion in Bouin's fixative (24 h) processed and embedded in Paraplast media. Sections of 6µm thickness were stained in H-E, Mallory's trichrome, PAS, Alcian blue (AB) pH 2.5 and Toluidine blue (TB). The mucosa shows gastric glands with deep pits and short secretory regions in the cardiac and pyloric regions. In the fundic region an inverse disposition of the glands were found in comparison to the cardia and pylorus. Parietal cells are mostly found in the isthmus and neck of fundic glands. In the cardiac glands they were scarce. These cells have a weak reaction to PAS technique, however in the cardia a slight positivity was observed. The surface epithelial cells presented metachromasia to TB, and positivity to AB only in the cardia and fundus. In the cardiac region the pits also presented positivity to AB. Chief cells were restricted to the gastric glandular base. Glands of Brunner, found only in duodenal submucosa, presented negativity AB reaction and weak reaction to PAS. The histochemistry showed regional differences in relation to the distribution of proteoglycans and cellular glycoproteins. The reaction to AB method was strong in the cardia but it became progressively weaker with proximity to the pylorus. The PAS technique showed histochemical differences between parietal cells, but no other difference were shown along the mucosa. Granted by: FAPERJ.

COMPARATIVE DIGESTION AND ASSIMILATION OF THREE BLOOD TYPES BY THE COMMON VAMPIRE BAT *DESMODUS ROTUNDUS*

Coen, C.E.
Section of Ecology and Systematics. Cornell University, Ithaca, NY 14853

Desmodus feeds on mammalian blood, while *Diaemus* and *Diphylla* feed on avian blood. The hypothesis is that different genera of vampire bats are physiologically adapted to their respective diets and *Desmodus* will perform differently on mammalian vs. avain blood. An experiment was conducted to determine the comparative digestion and assimilation of different blood types by *Desmodus*. Six adult, non-pregnant females and 5 adult males were housed individually in digestion chambers. Chicken (avian), cow (mammalian, ruminant) or pig (mammalian, monogastric) blood was offered ad libidum to males and females randomly assigned to diets. Quantitive collection of food (blood) and excreta (urine+feces) were taken daily for 7 days. Data were analized by T-test at P20.05. Mean consumption was significantly higher on chicken (31.37g ± 11.8) than cow (17.59g±4.7) or pig blood (17.53g±2.68). Mean consumption as a percent of body mass was significantly higher in chicken (99%) than cow (56%) or pig blood (57%). Mean excretion values followed the pattern for consumption values. There were significant differences in consumption between males and females on chicken and cow blood but not pig blood. These data suggest there is a difference in digestion and assimilation of avian vs. mammalian blood by *Desmodus* but not between the two mammalian blood types. Feed and excreta samples are being chemically analyzed for differences in nutrient assimilation including protein, fat, CHO, macro-and microminerals.

A REGIONAL VAMPIRE BAT MANAGEMENT AND EDUCATION PROGRAM FOR THE CAUCA VALLEY, COLOMBIA

Coen, C.E. [1] and Valencia, D.[2]
[1]Section of Ecology and Systematics. Cornell University, Ithaca, NY 14853.
[2]Instituto Colombiano Agropecuario (ICA), Palmira, Colombia.

This program was iniciated due to concerns associated with increasing outbreaks of vampire bat related paralytic rabies in cattle in the Cauca Valley. Very little is known about the status of vampire bat related rabies and population dynamics in this region. There are no population size estimates, no data on the economic impact of vampire bats on cattle production and no long term program for the management and monitoring of the vampire bat populations and vampire bat related rabies in the valley. In response to this lack of information and the need for a long term management and control strategie we designed and developed a comprehensive program in collaboration with other ICA stations in the Cauca Valley and the Department of Health. Our plan integrates: information regularly gathered by government agencies; a mark/recapture program to study distribution and abundance of vamipre bats and their movement patterns in the valley; determination of economic impact of vampire bat in the region; continued response to rabies outbreaks; rabies testing; extention, development and trainning of locals and; an intensive program of laboratory studies designed to provide information on aspects of vampire bat biology and physiology that will assist us in managing this animals in an ecologically sound way. The objectives of this preliminary report are to: (1) outline the Regional Vampire Bat Management and Education Program and (2) report the preliminary results of the Economic Impact Study of vampire bats on milk production by dairy cattle.

HEMATOLOGICAL VALUES OF THE PANAMANIAN FRUGIVOROUS BAT *ARTIBEUS JAMAICENSIS* AND ITS ECOLOGICAL IMPLICATIONS

Samudio Jr., R.
Department of Zoology, University of Florida, Gainesville, FL and Smithsonian Tropical Research Institute.

Artibeus jamaicensis is one of the most studied bats in the Neotropics. It has a wide distribution in lowland forests, it is locally common and very abundant suggesting that it is well adapted to its environment. This study analyzes *A. jamaicensis'* blood elements, its responses to low environmental temperature and discusses its ecological implications. Fifty one bats were captured at Parque Nacional Soberanía, Panamá: 30 were tested at standard conditions and 21 at 11°C for 6 h. Animals were anesthetized and euthanazied, after 2ml of blood were taken from the heart. Values were established for WBC, RBC, Hb, Hm, [G] , and Tb, and compared with values reported from other bat studies. There were no significant

differences in Hb and Hm between the two conditions. For WBC and RBC differences resulted from hemopathologies in standard condition. Glucose concentration [G] and Tb showed differences after hypoglycemic values were eliminated in standard condition. It is concluded that hematological values in Panamanian *A.j amaicensis* are within the range reported for neotropical bats. It seems common to observe hemopathology in neotropical bats. Blood elements did not decrease but [G] and Tb decreased at low Ta. Blood physiology shows interactions with thermoregulatory, nutritional, inmunological and reproductive processes on bats.

CALCIUM HOMEOSTASIS IN BATS REVISITED: WHAT IS THE ROLE OF VITAMIN D?

Kwiecinski, G.G. [1], Chen, T.C. [2] and Holick, M.F. [2]

[1]University of Scranton, Scranton, PA and [2]Boston University School of Medicine, Boston, MA.

Vitamin D is an essential precursor of 1,25-dihydroxyvitamin D, the steroid hormone required in most terrestrial vertebrates for bone development and growth, and for intestinal calcium absorption, bone remodeling and calcium homeostasis throughout life. Vitamin D is acquired in diets or by conversion of cholesterol after skin exposure to solar UV radiation. Most bats are nocturnal and avoid direct sun exposure, and dietary preferences appear to be vitamin D and calcium poor. Bat milk analyses indicate calcium is limited and may not meet requirements for neonatal growth and maintaining normal calcium balance of mother and pup, yet these animals do not show any signs indicative of vitamin D deficiency or hypocalcemia. It has been shown in some bats that extensive bone remodeling occurs during times of limited calcium availability. Another study has indicated that calcium absorption in the intestines is by a passive mechanism and not by active transport. Our recent studies show dorsal skin from *Artibeus jamaicensis* synthesizes previtamin-D following exposure to UV radiation and circulating 25-dihydroxyvitamin D, the major plasma form of vitamin D, are normally low or non-detectable. We also fed bats diets supplemented with vitamin D and found that it took up to one year to clear excess vitamin D from the plasma and regardless of vitamin D status, no significant variations in plasma calcium occurred. These results suggest that bats function optimally at low levels of vitamin D, they rely upon a highly efficient, passive mineral uptake system that is adequate to meet mineral requirements, and that mineral homeostasis may not be regulated at the level of the intestine, but rather by manipulating bone and teeth reservoirs.

REPRODUCTION

COPULATION BEHAVIOUR OF *NOCTILIO LEPORINUS*

Marques, R.V. and Pacheco, S.M. .

Laboratório de Mastozoologia, Museu de Ciências e Tecnologia, PUCRS. Av. Ipiranga, 6681, Cx Postal 1429, CEP 90619-900, Porto Alegre, RS, Brasil.

A colony of *Noctilio leporinus* (Linneaus,1758) has been observed on a small farm outside of the city of Porto Alegre, southern Brazil. The opening of the shelther, in a hollow tree, is at a height of 3.0m. However, bats were positioned, in general, at a height of 4.0m. There were about six bats in the colony. It was not possible to be sure about number of bats, because the most of them used the higher part of the hollow tree, where it was difficult to see them. This colony has been observed since 1997, always between 17h and 22h. The bats which stayed in the lower positions were observed, filmed and photographed. Mist nets were used to catch bats that were flying near the tree. These bats were measured, photographed and afterwards released. Wind velocity, atmospheric humidity, temperature and luminosity of the external environment were measured with specific instruments. On the night of March 28, 1998 (autumn), two copulations were observed and filmed. The first one occurring at 20h 18 min and the second one at 20h 58 min. One male copulated with two females. It was not possible to see the beginning of the first copulation. During the second copulation, the female positioned herself in front of and between the body of the male and the trunk of the tree. Thus, the male was able to copulate with her. The first copulation was observed for 3 min 05 sec and the second one proceeded for 3 min 15 sec. The male stayed upon back of the female with thumbs resting upon her shoulders in both copulations. The bats remained suspended, head down

hanging inside the hollow tree. The females stayed hanging in the tree by one foot, while using the claws of the other to frequently rub their own body. All the while the male hung by both feet in the tree. The females moved their closed wings many times during copulations, but the male did not release them. The male rubbed his nose on the back of females for a few seconds throughout the copulations. At the end of the second copulation, the bats separated and rubbed one foot on their own pubic region.

REPRODUCTION OF *ARTIBEUS LITORATUS* AND *A. FIMBRIATUS* IN THE FAR SOUTH OF BRAZIL

Rui, A.M.[1], Michalski, F.[2], Fabián, M.E. [3] and Garcia, S.M.L.[4]

[1]Postgraduate Course in Ecology, Department of Ecology, Universidade de Brasília

[2]Postgraduate Course in Animal Biology, Universidade Federal do Rio Grande do Sul - UFRGS

[3]Department of Morphological Sciences, UFRGS, and [4]Department of Zoology, UFRGS

Artibeus lituratus (Olfers, 1818) and *A. fimbriatus* (Gray, 1838) are the species of the genus *Artibeus* which present the most southern distributions. Such species occur in the southernmost region of Brazil, in the state of Rio Grande do Sul. Studies on the reproduction of *A. lituratus* have shown variations in its reproductive pattern according to different geographic areas, whereas nothing is known about the reproduction of the *A. fimbriatus*. The aim of this research is to collect information on the reproduction of *A. lituratus* and *A. fimbriatus* in the State of Rio Grande do Sul, Brazil. A hystological analysis of male and female gonads was carried out. Data obtained thus far suggest that both species present bimodal polyestrous reproductive patterns. The first estrous occurs between June and July (winter), and the first birth peak, between October and November (spring). Right after the first births, estrous post partum takes place and the second parturition peak occurs about February and March (summer). The occurrence of estrous right after birth became evident as there were females that were simultaneously pregnant and lactating. Pregnancy in both species seems to last about three or four months. Only one embryo per gestation is produced. There is no reproductive synchronism between females of the population studied, which may be ascribed to individual characteristics, especially age.

REPRODUCTION AND MATERNAL CARE IN BRAZILIAN LONG-NOSED BAT

Zortéa, M.[1] and Rodrigues, M.M.P.[2]

[1]Universidade Federal de São Carlos - PPG, Santa Teresa-ES, 29650-000 - Brasil

[2]Universidade Federal do Espírito Santo - PG. Psicologia - Brasil

Some aspects of the biology and behaviour of *Rhynchonycteris naso* were studied in the southeast Brazil. Three colonies were observed diurnally at two periods (summer and winter) in 1997. Occasional observations were carried out in previous years. The females had two synchronic reproduction periods in this area with an interval of 6 months. All the females gave birth in the period of 4 weeks. The two birth peaks were at the end of summer (March-April) and spring (October). During the first 20 days, the offsprings stayed full time with their mother and then the young gradually started to separate from them. After 30 - 35 days the young were no longer observed clinging to their mothers. There were no attempts to protect the progeny that were attacked by other bats of the colony. When the young were alone, their most frequent activities were grooming and stretching wings.

PRELIMINARY ULTRASTRUCTURAL OBSERVATIONS ON THE CHORIOALLANTOIC PLACENTA AND THE HEMATOMA OF *TAPHOZOUS LONGMANUS*

Bhatnagar, K.P[1]. and Karim, K.B[2]

[1]Dept of Anat. and Neurobiol., Univ of Louisville Sch. of Med., Louisville, KY 40292 USA

[2]Dept of Zoology, Inst of Science, Nagpur 440 001 India

Light and electron microscopic examination of placenta and hematoma of the emballonurid *T. longimanus* revealed the three regions of the placental disc: (a) intricate convoluted tubules lined by discontinuous flat endothelial cells form nearly half of the placenta. Detached endothelial cells were seen in the maternal capillary lumen. A thick homogeneous eosinophilic layer lies deep to the endothelial cells and in the regions devoid of such cells. A PAS - positive, highly reticulate, and discontinuous interstitial

membrane is embedded in the thickness of the homogeneous layer, outer to which is the trophoblast; the other half of the disc comprises, (b) the sac-like hematoma resulting from the extravasated maternal blood surrounded by chorionic epithelium undergoing disintegration; chorionic epithelium with engulfed RBCs and regions with intact chorionic epithelium, and (c) next to the hematoma lies the shriveled gland-like yolk sac splanchnopleure with remnants of the yolk sac lumen and hypertrophied endodermal and mesodermal cells. The three components (placenta, hematoma, and yolk sac splanchnopleure) are separated from each other by fibrous partitions. The junctional zone contains multinucleate giant cells. The umbilical cord is attached below the hematoma. The interhemal membrane shows transition from endotheliochorial to hemochorial. The interstitial membrane is reticulate, electron dense and discontinuous. Either or both layers of the trophoblast may persist. The hematoma comprises ruptured maternal capillaries with free floating endothelial cells, extravasated blood, and free floating cytoplasmic organelles of endothelial and chorionic epithelial cells. RBCs are seen engulfed within disintegrating epithelial cells. The chorionic epithelial cells are phagocytic, exhibiting large round mitochondria, coated vesicles in large numbers, RER, free ribosomes and some unusual organelles. Indented nuclei show conspicuous chromatin. Some vesicular structures are seen filling the nuclei.

RETARDED EMBRYONIC DEVELOPMENT AFTER IMPLANTATION IN *HIPPOSIDEROS LANKADIVA LANKADIVA*

Karim, K.B. and Khan, N.A
Dept. of Zoology, Int. of Science, Nagpur 4400 001, India.

In *Hipposideros l. lankadiva* (Kelaart) preimplantation stages of an embryo were observed until the second week of September, after which the blastocyst implants at the cranial end of the uterus in a preformed implantation chamber anatomically appeared as a swollen bulb. By mid-October the bats become semitorpid until mid-March, a period of about 5 months. The bulb size does not increase from September to December, but afterwards there is gradual but slight growth and by mid-March, the arousal period of bats from semitorpor, there is significant increase, reaching maximum at term. The implanted bilaminar blastocyst remains at the embryonic disc stage throughout semitorpor, exhibiting retarded embryonic development. The diffuse trophoblastic placenta occupies half of the thickness of the endometrium and consists of a syncytiotrophoblastic shell amidst which lie maternal capillaries lined by distinct endothelium. The undifferentiated cytotrophoblast marks its fetal boundary. The endometrium beyond the syncytiotrophoblastic shell is compact with cut ends of distal segments of the uterine glands. The epiblast embryonic disc during October-December is in contact with the basal cytotrophoblast. During January-February formation of trophoepiblastic cavity is visible, and enlarges by March. In January the cytotrophoblast becomes active - its cells divide and form hillocks and by March they penetrate the syncytiotrophoblastic shell. After mid-March development accelerates and by the 2nd of April advanced stages of pregnancy are noticed. The primitive streak develops about 7 months postcoitally. Deliveries take place during late May or early June.

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11th International Bat Research Conference

A Compact and Flexible Method for Mist-netting Bats in the Subcanopy and Canopy

Marco Tschapka
Institut für Zoologie II, Universität Erlangen, Staudtstraße 5, 91058 Erlangen, Germany

Most studies involving capture of bats utilize nets, set on the ground, with a height of less than 4 m. Due to the high ecological diversity of species, this potentially generates a huge sampling bias (Kalko et al., 1996). When studying insectivorous bat communities, it presents a major problem, because several species of aerial-hawking bats forage exclusively in or above the canopy and may never be caught in ground-based nets. Similarly, obtaining species-specific data on interactions in the canopy between bats and flowers or fruits of trees, epiphytes, and lianas poses severe problems. Only rarely is it possible to identify the bat species visiting a plant by observation--a consequence of the bat's nocturnal activity and the often great similarity between species. Catching bats while approaching a particular food-plant is one of the few possibilities for obtaining this type of information.

Access to the canopy has been achieved by canopy walkways, single-rope techniques, cranes, balloons, rafts, and by various methods for pulling nets up into the crown (e.g., Kunz and Kurta, 1988; Munn, 1991). While working on a study of bat-flower interactions at La Selva Biological Station, Costa Rica (Tschapka, 1988), I developed a simple technique to raise mist nets into the subcanopy and canopy and employed it successfully during more than two years of fieldwork. I placed nets from 8 m to higher than 20 m in the canopy and netted a multitude of species during the study period, ranging from tiny 5-g *Ectophylla alba* to 90-g *Phyllostomus hastatus*. Advantages of this netting system include: 1) lightness and flexibility, because the system can be carried and operated by a single person, 2) the proposed method allows a fair degree of horizontal adjustment after it is raised, and 3) the technique allows mist-netting in the center of larger gaps or clearings rather distant from supporting structures.

The Basic Technique

Materials needed include a pair of flexible poles, a mist net of appropriate size, lead weights, and string of sufficient length for the height at which the net will be used. To support the net, I used aluminum poles from a dome tent. The pole consisted of nine elements, each ca. 11 mm in diameter and 45-cm long, for a total length of ca. 4 m. Fiberglass poles were both too heavy and too flexible.

First, I shot a weight attached to a lightweight, monofilament fishing line over suitable branches of two trees, using a slingshot or a compound bow, depending on height. Next, I replaced this lightweight line on both sides with a heavier line to raise the net. Fishing line made from nylon monofilament should not be used for raising or holding the net, because it tends to cut into the bark of trees as weight is applied, and, therefore, the net easily gets stuck. For raising the net, I used a braided fishing line, intended for use with larger fish; this second line was purchased in rolls of 100 m at a hardware store.

The net is first set up on the ground with the poles lightly pushed into the ground. Due to the elasticity of the poles, tension on the net will not be very high. Secure the loops that attach the net to the poles by wrapping the upper and lower loops several times around the pole, and center the net on the poles. Attach a pull-up string a few centimeters above the middle of each pole. Centered placement of strings on the poles aids in distribution of the tension over all guide-lines. To make sure that the net poles hang in a vertical position once in the air, tie a small lead weight near the bottom of each pole. A weight of 50 g per pole is sufficient, even for 12-m nets, and the weights that I used were simply sinkers used for fishing.

Once everything is in place, a single person setting up the system must alternate between each side to pull on the strings, thus raising the net from the ground. Increased tension on these lines will stretch and tighten the net once it is above ground. The whole structure should resemble a vertically hanging hammock (Fig. 1a). Trees supporting the line may be close together, just slightly farther apart than length of the net, or quite distant from each other, e.g., at each border of a large gap (Fig. 1c). Limits are mainly set by the length of the available line.

Because the net and poles are extremely light and this weight is often insufficient to overcome friction between lines and the bark of the tree, attach another string at the same point as the main line to one pole as a safety line for pulling the net down. This additional line also facilitates steering the net around obstacles, such as branches.

Additional Hints and Tricks

If the net is placed higher than 15-20 m, it may be difficult to notice when small bats become entangled. However, because the net and poles are extremely lightweight, even the movements of a very small animal (<10 g) will cause the entire net to move. A piece of reflecting tape attached to the end of the poles makes it easier to see when the net moves and a bat is caught. Alternatively, movements may also be felt by touching the safety line.

Although I employed this method in open areas with nets up to 12 m long, I mostly used shorter nets. Because of the horizontal degrees of freedom, it was possible to reach places that were blocked by branches from below by first raising the net above the obstructing layer of vegetation and then moving the net horizontally to the desired location (Fig. 1b). Depending on the type of vegetation, I used nets as small as 3 m in length. This small size was not necessarily a disadvantage, especially when the flight path of the bats was rather predictable, e.g., while approaching a potential food-source or coming out of a tree-roost. This technique is generally better suited for netting in places where few individuals are expected. It is more useful for obtaining data on the identity of animals visiting particular flowers/fruits or emerging from an otherwise inaccessible tree-hole, rather than as a method for netting large numbers of animals.

Due to the loss in tension when nets are pulled down, animals have a tendency to become more entangled compared to those caught in ground-operated nets. Larger, more "destructive" bats are a problem for most canopy-techniques (and this technique is, unfortunately, no exception), because it always takes some time to lower the net, and the animals generally do not hesitate to work on destroying the mesh in the mean time.

While I used this technique only for bats, it could also be used for birds. As a welcome side-benefit, the tent-poles are also extremely versatile for many netting situations. Their lightness and collapsibility make them very useful when working in remote or mountainous areas that require access on foot and they also are convenient to transport on airlines.

Acknowledgments

I thank A. P. Brooke, O. v. Helversen, and Y. Winter for their comments. Graphics were provided by F. Brunken and G. Tschapka. Financial support was from DFG and DAAD (HSPII-AUFE).

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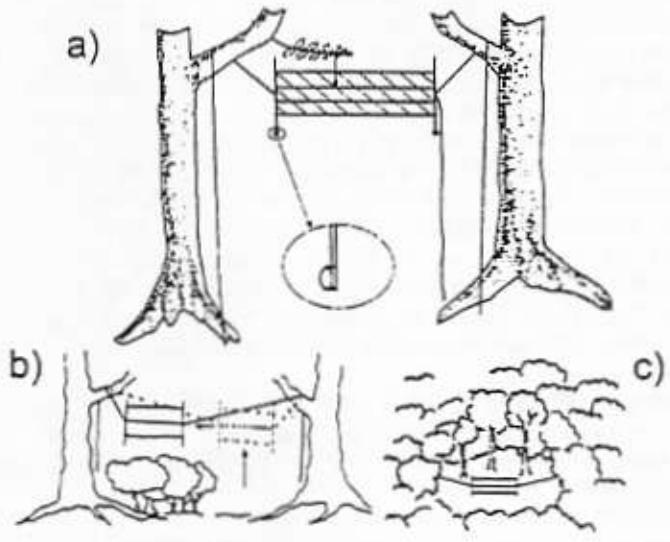

Fig. 1. Netting technique and examples of use. a) Net hanging in front of an epiphytic plant. Note the additional safety line tied to one of the poles. Insets show lead weights attached to poles. b) Nets may be raised at an unobstructed location and then pulled horizontally to the appropriate place. c) Large nets may hang in the middle of gaps.

Letters to the Editor

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Artificial Roosts and Diet of Some Insectivorous Bats in the Parque Estudual do Rio Doce, Brazil

Valéria C. Tavares and Marina Anciães
Programa de Pós Graduação em Ecologia, Conservação e Manejo de Vida Silvestre
ECMVS / UFMG, CP 486 CEP 30 161 970, Belo Horizonte, Minas Gerais, Brazil

Demonstrating their flexibility, some species of bats have adapted themselves to artificial roosts. The availability of refuges and the bats' ways of using them may influence the size of their colonies, dispersal of individuals, foraging strategy, and social behavior. In this paper, we report a peculiar roost occupation by bats in and near the Parque Estudual do Rio Doce, Brazil, and provide preliminary information concerning the diet of these bats.

The Parque Estudual do Rio Doce is in eastern Minas Gerais, southeast Brazil, and comprises an area of 35,974 ha. The vegetation is semideciduous tropical and consists of a mosaic of primary and secondary forests. There are nearly 40 lakes, and elevations vary between 230 and 515 m. Average annual temperature is 20-22°C, and average rainfall is 1,500 mm (J. R. Stallings et al., 1987, Revista Brasileira de Zoologia, 7:663-677).

Rhynchonycteris naso (Emballonuridae), *Macrophyllum macrophyllum* (Phyllostomidae) and *Myotis albescens* (Verspertilionidae) occupied roosts located in two houses ("palafitas") at a lake, the Lagoa da Barra. Palafitas are houses built above lakes, near shore, and supported by wooden posts that are fixed in the floor of the lake. One large palafita simultaneously sheltered colonies of *R. naso* (80-85 bats) and *M. albescens* (>50 bats), as well as small bachelor groups of M. macrophyllum (6-8 bats in each group). *M. albescens* roosted in a crevice formed by two horizontal beams that supported the floor of the house and in small crevices and holes in the underside of the floor. *R. naso* occupied both the outer and inner walls of the house; these bats were solitary and roosted away from each other (15 cm). A smaller palafita also sheltered colonies of *R. naso* (28-30 bats) and *M. macrophyllum* (46-48 bats). The former species occupied all walls, and the latter formed one large cluster at the back of the roost.

We examined fecal pellets from two *M. albescens* and from two *R. naso*; three to four pellets were obtained from each bat. In addition, we examined the stomach contents of an additional two individuals from each of these species. *M. albescens* and *R. naso* are believed to be aerial insectivores, and our data are consistent with that belief (B. K. McNab, 1971, Ecology, 52:352-358). In pellets of *R. naso*, we found four nematoceran eyes, one coleopteran tergite, one intact platygasterid, and plant fragments. In pellets of *M. albescens*, we found one coleopteran sternite, one cecidomyid, one chironomid antenna, and five nematoceran eyes. We also found plant fragments in a stomach of *R. naso*, and a part of the basal abdomen of a dolichopodid was found in one stomach of *M. albescens*. Our preliminary data suggest that both species of bats have similar diets, feeding on semi-aquatic insects. Our observations also indicated that *M. albescens* starts foraging later than *R. naso*, which might minimize competitive interactions. *R. naso* began foraging about 1700 h, well before sunset (1800 h), whereas *M. albescens* did not begin until 2000 h.

Although roost availability rarely seems a limiting factor for Neotropical bats, the continuing devastation of the Atlantic forest may eventually modify this situation. Depletion of natural refuges has been diminishing or modifying roost diversity and availability in the Neotropics (e.g., E. Trajano, 1995, Chiroptera Neotropical, 1:19-22). Use of artificial bat houses may be one way to protect riparian colonies in Parque Estudual do Rio Doce and to reduce the presence of bats in human habitations. Riparian areas also must be carefully protected since they might have a crucial importance, offering optimal conditions for roosting and feeding for insectivorous bats.

We are grateful to CNPq, CAPES and IEF. We thank J. A. Lombardi, W. A. Pedro, J. Marinho-Filho, and W. Ueda for critical readings of early drafts of the manuscript. Many thanks to D. A. Yanega, for carefully analyzing fecal samples. We are indebted to V. A. Taddei, who identified the vouchers, and C. Handley for valuable suggestions.

Hibernation of a Little Brown Myotis in a Building

John O. Whitaker
Department of Life Sciences, Indiana State University, Terre Haute, IN 47809

The big brown bat, *Eptesicus fuscus*, has adapted to man both summer and winter. Its maternity colonies are mostly in buildings, and most big brown bats hibernate in buildings (J. O. Whitaker, Jr. and S. L. Gummer, 1992, J. Mammal., 73:312-316), although many individuals hibernate in caves and mines as well. That the species uses buildings both summer and winter suggests that its ancestral habitat was hollow trees in both summer and winter.

The little brown myotis, *Myotis lucifugus*, also has adapted to man in summer in that most maternity colonies are now in buildings, probably indicating that their maternity colonies previously were in hollow trees. This species, however, generally hibernates only in caves and mines, undoubtedly indicating caves to be its ancestral winter habitat.

During a six-year study of big brown bats hibernating in buildings in Indiana, all bats found were big brown bats (1,572 observations), except one male little brown bat found hibernating in an old school building in Dubois County, Indiana, on 25 January 1989. There were an estimated 160 little brown myotis in this building on 19 October 1988. We know of only one other record of a little brown myotis hibernating in a building. P. F. Conner (1960, N.Y. State Museum and Science Service Bull., 382:1-84.) reported a "fresh," dead, male little brown bat that was found at the Farmers Museum in Cooperstown, Otsego County, New York, on 7 February 1957. Conner thought it had died and fallen from the rafters above because of unsuitable hibernating conditions.

Use of Natural Gas Well Sites and Pipeline Corridors by Tree Bats in Northwestern Pennsylvania

Scott L. Bearer[1], Peter Dalby,[1] and Merlin J. Benner[2]
[1]Department of Biology, Clarion University, Clarion PA 16214
[2]Pennsylvania Department of Conservation and Natural Resources, Harrisburg, PA 17105

During June 1994, a cooperative project between the National Fuel Gas Company, Pennsylvania Bureau of Forestry, and Clarion University of Pennsylvania began with the Callen Run section of the Clear Creek State Forest. Within the next decade, National Fuel Gas will widen 10 km of existing pipeline and construct 31 km of new pipeline, as part of the construction of a storage field for natural gas. Also, several well-site clearings will be created/enlarged from 0.2 ha to 0.4 ha. Approximately 120 ha of forest will be cleared to create linear rights-of-way for pipelines and 0.2-ha clearings for well sites.

Habitat alterations associated with the expansion of well sites and widening of pipeline corridors may have various consequences on wildlife. These potential consequences include introduction of predators, a change in species composition, an alteration of resource proximity and associated travel routes, and a change in roosting, foraging, and/or reproductive habitats. To ascertain the effects of widening the pipeline corridor and the expansion of well-site clearings on tree bats in north-central Pennsylvania, the present study was conducted to: 1) determine use of the corridors for foraging or traveling routes compared to the surrounding forest, 2) determine whether there is a corridor-width effect by comparing habitat usage within the narrow and wide pipeline corridors, 3) determine use of well sites for foraging compared to the surrounding forest, and 4) provide baseline data that may be useful in evaluating how tree bats may be affected by eventual creation of larger well clearings and wide pipeline corridors after National Fuel Gas Company has constructed its storage field.

Ultrasonic detectors were used at all sites to identify species and assist in interpreting presence and habitat use. Field work started in May 1998, with biweekly detecting at each of the following study sites: three well-site clearings, two wetland areas (one pond, one Clarion River), and six interior forest sites. Detection times, 15 min in duration, were randomly chosen for each site.

As of the end of July 1998 and after 75 min (five 15-min periods) of monitoring at each of the 20 sites, preliminary results showed 430 passes in the three well-site clearings, 363 passes over the two wetland areas, 122 passes on the three wide pipeline sites, 3 passes on the three narrow pipeline sites, 11 passes through the six interior forest sites, and 4 passes along the stream corridor. These results indicate *prima facie* that bats are using wide pipeline corridors for foraging and traveling routes significantly more than the surrounding forest. However, neither the narrow pipeline corridor nor the stream corridor are used more frequently than the interior forest. Well-site clearings had a significantly higher number of bat passes than the interior forest; also, the number of feeding passes in well-site clearings compared closely to the number of passes along the pond and riverside, indicating that these habitats may be important in foraging activity of bats.

Possible Gleaning Behavior in *Lasiurus borealis*

Jeffrey T. Hutchinson and Michael J. Lacki
Department of Forestry, University of Kentucky, Lexington, KY 40546

Some species of bats may glean prey from the ground more often than expected (M. B. Fenton, 1990, Canadian Journal of Zoology, 68:411-422), but these behaviors are difficult to observe and cannot be documented using most standard methods for monitoring bats, such as radiotelemetry, mist-nets, or bat detectors. Night-vision equipment can permit the behavior of individual bats to be observed, but the investigator must have some idea of which species he or she is looking at beforehand, because it is normally difficult to distinguish among the various species of bats that occur in a given area with such equipment. However, when bats forage in the vicinity of street lights, the behavior of individual bats can be visually observed. With some species, such as the red bat (*Lasiurus borealis*), bats can be identified to species without the aid of specialized equipment. Reports of red bats foraging around street lights are common in the literature (e.g., M. B. C. Hickey et al., 1996, Journal of Mammalogy, 77:325-334), but to our knowledge, there are no reports of red bats landing on the ground while foraging around street lights.

During July and August 1996, one of us (JTH) observed red bats landing on the ground on seven different nights, while these bats were feeding around a street light adjacent to a camping site, near Sandy Hook, Elliot County, Kentucky. While standing 20 m from the light, JTH observed red bats periodically dropping to the ground, where they landed with their wings outstretched. Bats remained on the ground for ca. 2-3 seconds before taking flight. On two occasions, two and three red bats were observed on the ground within 1 m of each other. Whenever JTH approached within 20 m of the street light, no bat landed on the ground, and all bats remained foraging in the air, above the light. On three evenings red bats were observed through binoculars, but no red bat was seen on the ground with a prey item in its mouth. Further, attempts to capture bats in mist nets on two nights were unsuccessful.

Although a clear explanation for these behaviors is unavailable, dietary studies show that red bats eat flightless crickets (Gryllidae), suggesting that red bats occasionally feed on the ground (G. A. Feldhamer et al., 1995, Transactions Illinois Academy of Science, 88:139-143; J. O. Whitaker, Jr., 1972, Canadian Journal of Zoology, 50:877-883). Further, D. A. Saugey et al. (in press, Journal of the Arkansas Academy of Science) discovered red bats hibernating in forest-floor debris in Arkansas, providing empirical evidence that red bats do land on the ground.

Crickets were commonly heard chirping and were frequently seen on the ground, beneath the street light, at the site where bats were observed. However, there appeared to be plenty of other food available for red bats, because moths (Lepidoptera), beetles (Coleoptera), and other insects (Homoptera and Diptera) swarmed around the street light, so an explanation for why red bats would land on the ground to feed is not clearly evident. It is possible that red bats were chasing prey or searching for wounded prey that dropped to the ground, but the frequency with which red bats were observed landing on the ground does not lend credence to this explanation. An alternative possibility is that red bats were drinking beads of water off the surface of the grass. Most of the present observations were made between 0200 and 0500 h. In eastern Kentucky, the humidity is high during the summer months, and moisture often accumulates on vegetation during the cool, early morning hours. We believe this explanation improbable though, because a permanent pond (25 by 20 m) was within 125 m of the street light. It seems more reasonable to us that the red bats that landed on the ground were preying on flightless crickets or other insects.

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Request for Assistance

Dear Dr. Horst,

I wish to inform readers of BRN about a small conservation project commissioned by the World Bank to the State Herbarium (Rijksherbarium) in Leiden, the Netherlands. The project aims at a report on the economic values of the biodiversity of limestone mountains, hills and caves in East Asia (i.e. for this report including Mongolia, China, Burma eastward to Papua New Guinea, and the Philippines). Limestone is often quarried, regardless of the biodiversty associated with it, for road and dam construction. The report must point out that this is a threat to many species and ecosystems, and to the economic values represented by them (sadly enough, the only really valuable argument in the 'development' world). I have been asked to fill in a small chapter, of only a few pages, on bats. Because of the limited space, it will focus on *Eonycteris speleaea* and *Tadarida* (or *Chaerephon*) *plicata* (although the other species are also considered). It will be distributed among World Bank people, consultants, and the cement sector in the region. Simultaneously, a database is being produced on known caves and their biodiversity.

My question to readers of BRN is, if they have knowledge of limestone caves in the 'East Asia' region considered, where the mentioned bat species or other bat species have been observed. There is actually rather little exact data on this subject to be found in the literature, which is not unexpected, as meny bats are collected outside or even far away from their caves. The obvious economic values of bats are the Megachiropteran pollination and seed dispersal of economically important tree species, and the Microchiropteran predation on harmful insects and the production of guano. We also pay attention to rare species, the biodiversity value of which is more easily generally understood than that of the more common species. So, I should appreciate data (also: on museum specimens) on caves (with geographical coordinates, if possible) and their bat populations. As there is little time available, I hope that those who possess some data they wish to share, do so quickly. I thank you in advance for your help. The project will conclude with a workshop in Vietnam by the end of January. With kind regards, Sincerely, Wim Bergmans.

address: Wim Bergmans, Pieter Pauwstraat 10, 1017 ZJ Amsterdam, The Netherlands
e-mail: bergmans@nciucn.nl or mail@nciucn.nl

FUTURE MEETINGS

The 29th North American Symposium on Bat Research
will meet October 27 to 30, 1999 in Madison Wisconsin. John Hutcheon, Host

The 30th North American Symposium on Bat Research
will meet in October, 2000 in Miami, Florida. Ted Fleming, Host

The 31st North American Symposium on Bat Research
will meet in October, 2001 in Victoria, British Columbia. Mark Brigham, Host

The 12th International Bat Research Conference
will meet in August 2001 in Malaysia

The Ninth Australasian Bat Conference
will meet in New South Wales in April, 2000

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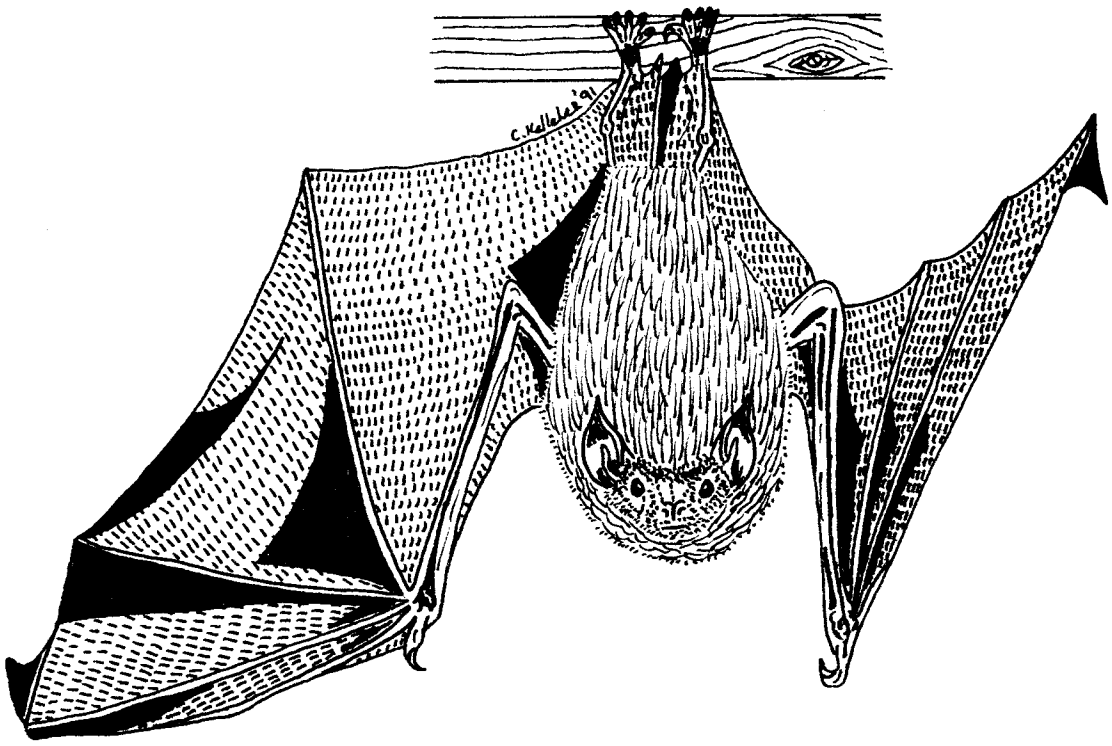
FRONT COVER

The fine illustration on the front cover depicting a "fierce face" image of a lessor horseshoe bat *Rhinolophus hipposideros* was generously provided by Sheelagh Kerry, who resides at 1 Bettws Cottage, Abergavenny, Gwent, Wales, U. K.

BAT RESEARCH NEWS



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Bat Research News, P.O. Box 5068, Potsdam, NY 13676
Tel. 315-267-2259 FAX 315-267-3170 E-mail: horstgr@potsdam.edu.

Editor for Feature Articles
Allen Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197
Tel. 734-487-1174 FAX 734-487-9235 E-mail: bio_kurta@online.emich.edu

Editor for Recent Literature
Thomas A. Griffiths, Department of Biology, Illinois Wesleyan University, Bloomington, IL 61702
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Editor for Conservation Education and Book Reviews
Patricia Morton, Texas Parks and Wildlife Department, Suite 100, 3000 IH 35 South, Austin, TX 78704
Tel. 512-912-7046 FAX 512-912-7058 E-mail: patricia.morton@tpwd.state.tx.us

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A Passive Monitoring System for Anabat II Using a Laptop Computer

Michael J. O'Farrell. O'Farrell Biological Consulting,
2912 North Jones Boulevard, Las Vegas, NV 89108

Introduction

Anabat ultrasonic detection and analysis equipment (Titley Electronics, New South Wales, Australia) provides a relatively inexpensive way to examine the time-frequency structure of echolocation calls that have been recorded using a low-cost tape recorder. A number of studies have used such equipment to monitor activity of bats (Hayes and Adam, 1996; Humes et al., in press; Krusic et al., 1996; Lance et al., 1996; Mills et al., 1996); however, these workers reported an inability to identify all species recorded, particularly those of the genus Myotis. Additionally, tape recordings generally resulted in sequences of few usable calls, many of which were fragmentary (Mills et al., 1996).

An alternate approach incorporated the use of a laptop computer as a substitute for the tape recorder (O'Farrell et al., 1999). Digitally storing calls as binary computer files eliminated distortion due to differential tape speed and general background noise inherent in inexpensive tape recorders. In the past, use of the computer required the presence of an investigator to save files manually. This active approach (investigator present) was beneficial because it allowed the investigator to examine calls in real time, make adjustments to sensitivity to reduce echoes and other noise, and selectively save high-quality sequences. However, need for the investigator's presence limited the number of sites that could be monitored simultaneously.

Newer versions (5.7 and higher) of the Anabat software provide an "automatic save" capability that places a sequence of calls into memory about 5 seconds after incoming sounds terminate. An investigator, therefore, can implement the automatic save function, leave the computer to tend mist nets or traps, and not lose acoustic information. With a computer and zero-crossings analysis interface module (ZCAIM), separate sites can be monitored simultaneously. Over the past year, I experimented with passive monitoring (investigator absent) techniques using the automatic save mode. The purpose of the present paper is to describe various methods used, including modifications that allow safe monitoring during inclement weather.

The System

I used the passive system to monitor areas over stock tanks, earthen impoundments, riparian or riparian-scrub corridors, and along rocky hillsides. One must select an area that is secure from vandalism yet allows for orientation of the equipment to cover the most likely flight path of bats. To date, I have not experienced vandalism or damage by animals. Although many configurations are possible, I used the following materials and arrangement.

A 53-liter plastic container (Rubbermaid Roughneck) held all equipment, including the Anabat detector, ZCAIM, laptop computer, and external battery (Fig. 1). The system also used a piece of electrical conduit made from polyvinylchloride (PVC) and having a diameter of 5 cm; the conduit was an "elbow joint" manufactured with a curved 90° turn. The conduit was fitted through one end of the container and adjusted to orient the external opening of the elbow at about 45° to the ground. The detector microphone was placed in the other opening. The microphone end of the conduit was modified by making a slanted cut, starting 10.2 cm from one end on the inside bend and extending to 11.5 cm from the end on the outside bend; this allowed the detector to fit into the conduit with the lid of the container closed. A small hole (10-mm diameter) was drilled at the bottom of the turn to allow drainage of water. A 4-l, rectangular, plastic container (Rubbermaid) was used to hold an AC adapter and inverter for the computer. Three holes (38-mm diameter) were cut along each of the long sides of the 4-l container to provide ventilation and egress of the power cord to the battery and computer. Once set up and all electrical connections made, the computer was turned on and placed in automatic save mode using Anabat software.

The lid of the computer should then be closed. Closing the lid automatically turns off some computers thereby reducing energy consumption and increasing battery life. If the screen does not automatically turn off upon closure, the ZCAIM cannot be placed directly on the lid of a laptop because electrical noise is generated by continued operation of the computer screen. Separating the ZCAIM from the computer lid with a ca. 6 cm of foam rubber allowed use of even these computers.

This system was tested during high wind and rain in Wyoming on 13-16 June 1998 during conditions that were severe enough to rip a rainfly off a backpacking tent. The passive monitoring setup was secure, all equipment remained dry, and good sequences of echolocating bats were recorded during periods throughout the night. Since then, the setup has been used during a variety of weather conditions, including cool nights with heavy condensation, and has provided complete protection for all electrical components.

The capacity of the battery to operate a laptop for more than one night depends on size of battery used. The current that is drawn is highly variable from one model of laptop to another. Older refurbished machines tend to be less efficient and draw more current. For example, the variation in my current laptop computers is as follows: Clincher notebook, 2.33 amps; IBM Thinkpad 360CSE, 4.13 amps; Toshiba Satellite T2130CS, 1.65 amps. Closing the computer decreased draw on the Toshiba to 1.02 amps but had no effect on the draw of the two older computers. If there is access to AC power, recharging batteries on a daily basis is accomplished easily. However, difficulty arises at remote locations, and use of a small generator may be required. I am currently experimenting with use of a RAM drive to decrease current draw even further, and preliminary results indicate a draw of only about 0.8 amps when the hard drive is shut down.

I originally used a deep-discharge marine battery (Astro Lite 24EV, 85 amp-h, weighing 21.1 kg). With this battery, the Clincher notebook could be powered for 25 h. I more recently incorporated the use of a more lightweight, wheelchair battery (Guardian DG 12-32, 32 amp-h; 11.6 kg) that provided 12 h of use by the IBM Thinkpad. Greater ease in transporting the smaller battery compensated for the shorter duration of use. A 6-amp automatic charger completely charged the wheelchair battery in less than 8 h.

Effect of Conduit on Detector Response

Difference in response for an unenclosed detector microphone and one placed in the conduit was tested in two ways. First, distance and angle of response was determined using an electronic tape measure (Radio Shack, Catalog #63-645, Tandy Corporation, Fort Worth, TX). This device produced pulses that roughly oscillate from 47-49 kHz. Technical specifications stated the range of the tape measure at 15 m, and electronic pulses were detected up to that distance. Electronic pulses were detected consistently within a 45° cone of reception regardless of whether the microphone was exposed or within the conduit. Occasional pulses were detected beyond 45° but probably represented echoes from nearby trees.

Second, quantity and quality of echolocation calls was determined by recording bats simultaneously with two detectors--one exposed and the other in the conduit. The two-part test was conducted at Grapevine Spring, Clark Co., Nevada, on 15 September 1998. Each detector was attached to a separate ZCAIM and laptop computer. To test for differential in response between detectors (Test 1), the two detectors were strapped together, oriented at a 45° angle, and used simultaneously to monitor bat activity for 0.5 h. To test the effect of collecting sounds by an exposed vs. an enclosed detector (Test 2), one detector was placed in the conduit (Fig. 1), and the other was strapped to the outside of the conduit so that the microphone was even with the extended opening of the conduit. Simultaneous monitoring continued for another 0.5 h.

Approximately equal numbers of files were collected during each test (Table 1). Four species of bat were detected during Test 1 (*Pipistrellus hesperus, Myotis californicus, M. ciliolabrum,* and *M. thysanodes*). Two additional species were detected during Test 2 (*Antrozous pallidus* and *M. volans*). Detector 1 collected significantly more individual calls than Detector 2 during both tests, with and without use of the conduit (Wilcoxon Signed-Rank tests, $P < 0.01$). However, the proportion of calls collected by Detector 1 compared with Detector 2 remained constant between tests, suggesting that the conduit had no effect on response of the detector.

During Test 1, Detector 1 collected three files that were not recorded by Detector 2, and Detector 2 collected one file that Detector 1 did not. The same species were detected by both detectors, and no apparent difference in ability to identify species existed between recordings produced by the two detectors.

During Test 2, each detector collected one file not recorded by the other machine. At 1948 h, Detector 2 recorded 13 calls of *M. thysanodes*, whereas Detector 1 did not record any file. At 2008 h, Detector 1 recorded two calls of *M. californicus*, but no file was recorded by Detector 2. In addition, Detector 2

collected one file that consisted of unidentifiable noise, during the time that the other detector recorded 24 calls of two species. Enclosed and unenclosed detectors generally recorded the same species; however, Detector 2 (in the conduit) was the only one to record M. thysanodes during Test 2. Visually, there were no apparent differences in clarity of the time-frequency structure between calls recorded by unenclosed or enclosed (conduit) detectors.

Field Use

Since July 1997, I have used the passive setup over metal tanks in open pinyon-juniper woodlands (Shingle Spring, Lincoln Co., Nevada; Summit Spring, Washington Co., Utah), along riparian corridors (Virgin River, Clark Co., Nevada; Lake Perris State Park and Sycamore Canyon Wilderness Park, Riverside Co., California; Henry's Fork, Sweetwater Co., and Boysen State Park, Fremont Co., Wyoming), over large earthen ponds (Volcan Mountain Wilderness Preserve, San Diego Co., California), and along rocky hillsides (Lake Perris State Park, Riverside Co., California; Lower Sage Creek, Sweetwater Co., Wyoming). The percentage of files that contained sequences of calls that were of sufficient quantity and quality to identify species was generally high and similar whether the conduit was used or not (Table 2). The low percentage of usable sequences at Simmons Flat (66.5%) appeared associated with the open nature of the site.

To obtain sequences of calls of sufficient quality and quantity for species identification, it is necessary to orient the microphone to maximize the time a bat remains within the cone of reception. This can be accomplished by orienting the equipment to cover areas suspected of concentrated bat activity. Thus positioning the microphone to point over a pond or water tank, along the edge of a riparian corridor, and within a flight path have resulted in more identifiable sequences than orienting the unit straight up or perpendicular to vegetation edges. Placing the detector within 30 cm of the ground and oriented at a 45° angle provides a cone of reception that will sample bats well from the ground to directly overhead at a distance of 2 m or greater from the microphone. Use of the automatic save function in Anabat software (versions 5.7 and higher) with a laptop computer provides a greater ability not only to monitor bat activity remotely but also to identify the species of bats. The current availability of inexpensive, refurbished laptop computers provides an economical option for passive monitoring.

Acknowledgments

C. Corben provided invaluable assistance in design of hardware, software, and testing of the system. B. Luce made helpful suggestions for the final design of the holding container. T. M. O'Farrell, B. Luce, J. M. Priday, R. M. Faught, and J. B. Alpert provided field assistance. C. Corben, W. L. Gannon, J. P. Hayes, and B. W. Miller provided comments on an earlier draft of the manuscript.

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Table 1. Summary of mean number of calls recorded with both detectors unenclosed (Test 1) and a combination of one unenclosed and the other placed in a conduit (Test 2). N = number of files collected.

	TEST 1		TEST 2	
	Detector 1	Detector 2	Detector 1	Detector 2
	Unenclosed	Unenclosed	Unenclosed	In conduit
n	29	29	27	27
Mean	35.1	29.6	23.0	19.7
SE of Mean	5.93	4.96	4.43	3.66
Range	4-130	2-111	4-118	0-96

Table 2. Summary of total number of files recorded during passive monitoring with the number of files containing sequences of calls that were inadequate for identification of species (non-usable) and the percentage of files with identifiable sequences (% usable).

Location	Total	Non-usable	% Usable
A. With Conduit			
Lake Perris State Park, CA	193	42	78.2
Sycamore Canyon Wilderness Park, CA	22	2	91.0
Simmons Flat, Volcan Mtn., CA	272	91	66.5
Virgin River, NV	150	21	86.0
Shingle Spring, NV	2,357	298	87.4
Summit Spring, UT	495	0	100
B. Without Conduit			
Ferguson Pond, Volcan Mtn., CA	982	100	89.8
Boysen State Park, WY	49	10	79.6
Lower Sage Creek, WY	28	1	96.4
Henry's Fork, WY	175	22	87.4

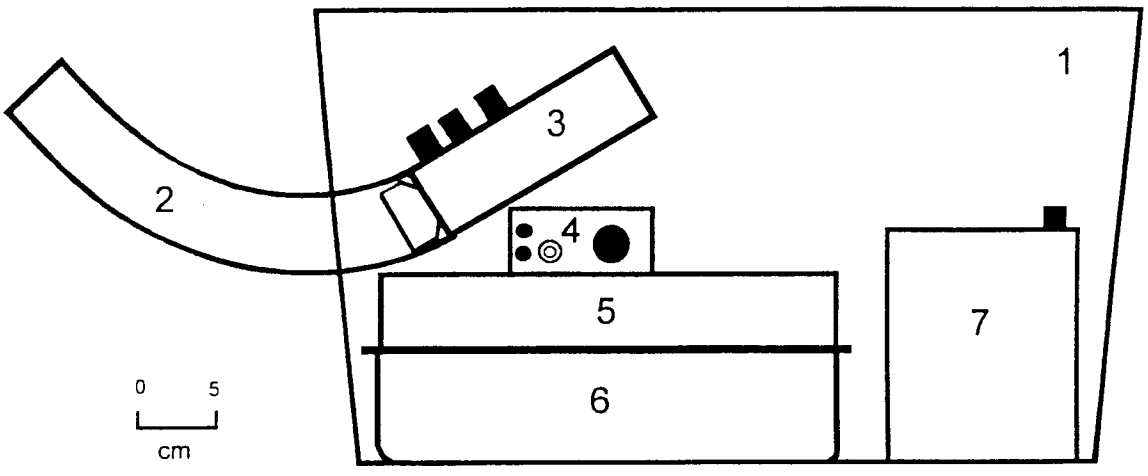

Figure 1. Diagram showing arrangement of passive-monitoring system. 1 = 53-l container; 2 = 5-cm diameter electrical conduit with 90° bend; 3 = Anabat detector; 4 = ZCAIM; 5 = laptop computer; 6 = 4-l container; 7 = 12-volt sealed battery.
xxxxxxxxxxxx

RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths, Dept. of Biology, Illinois Wesleyan Univ., Bloomington, IL. 61702-2900, U.S.A.) for inclusion in this section. If reprints are scarce, please send a complete citation (including complete name of journal and mailing address) to **tgriff@titan.iwu.edu** by e-mail. Receipt of reprints is preferred at it will facilitate complete and correct citation. Our Recent Literature section is based on several bibliographic sources and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome.

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Abstracts of Presentations at the 28th Annual Symposium on Bat Research

Abstracts are listed in alphabetical order by first author.

Timing of Visitation to Waterholes by a Coloradan Bat Assemblage: Is There Pattern?

Rick A. Adams and Katherine M. Thibault, University of Wisconsin, Whitewater, WI

Data on species-specific visitation times to waterholes of a Coloradan bat assemblage were gathered from 1995-1998. More than 800 individuals of 10 species were mist-netted over a four-year period and captured individuals were tagged with colored, numbered forearm bands. Bands fitted with colored, reflective tape were used to code species for observation while in flight. Waterholes with highest species diversity (nine species captured) evenness, and density were small in diameter (< 7 m), located along small streams in relatively cluttered riparian habitat near rocky areas. Larger ponds (approx. 10-20 m in diameter) located in open Ponderosa Pine (*Pinus ponderosa*) habitat had lower species diversity (1-5 species captured) species evenness, and species density, than observed at smaller, streamside pools. Species-specific patterns of visitation varied among sites. At smaller waterholes with high species diversity, patterns of visitation were predictable and discrete, whereas at larger waterholes located in open areas with lower species diversity, species-specific visitation times were not as predictable or as discrete. Order of species capture also differs between large and small waterholes and this does not appear to be a function of distance from roost sites. However, Chi Square tests for general overlap showed significant differences among species visitation times at all waterholes ($Gadj = 0.584$, $V = 385$, $p = 0.23$). In addition, some species such as *Myotis evotis*, utilize a generalist pattern by coming to waterholes in small groups (4-5 individuals) throughout the night (no recaptures indicates different visiting individuals), whereas other species, such as *M. lucifugus*, tend to arrive at waterholes in large groups (usually > 20 individuals) all at once and do not return in large numbers throughout the remainder of the night.

Analysis of Hair Structure of Twenty Colorado Bat Species

Brian R. Amman, University of Southern Colorado, Pueblo, CO

Hair is a common characteristic among mammalian species and hair structure can vary greatly among genera with bats being no exception. In this study, hair structure will include scale type, scale width and length, total length of the filament, and coloration. Hair structure also includes medulla type but this aspect of hair structure analysis is absent in both the Vespertilionidae and Molossidae and therefore is not included in this study. The objective of this study is to determine if hair structure can be used as a supplemental taxonomic tool to identify the bats of Colorado to genera and even species. Hair samples were taken from 58 specimens that included three of each species occurring in Colorado or with a possibility of occurrence in Colorado. The exception is *Idionycteris phyllotis* in which only one specimen was obtained. These samples were taken from the dorsal area between the scapular region on all of the specimens. An additional area was sampled on *Euderma maculatum* to obtain both color types. Light microscopy was used to take the 6,680 measurements of scale length and width, both of which were taken at three places along the filament, and filament length. The means of these measurements will be compared to determine differences. Scanning electron microscopy was used to obtain detailed micrographs of scale type. The scale types described by Benedict (1957) will be used to separate genera and species if possible. Some preliminary examinations of the micrographs of scale types indicate a great deal of variance between the Vespertilionidae and Molossidae and some variance within the Vespertilionidae.

New Phyllostomid Bats from the Quaternary of Serra da Mesa (Goias, Brasil)

Leonardo S. Avilla, Leandro O. Salles, Nancy B. Simmons, and Victor A. Sahate
Museu Nacional -UFRJ, Rio de Janeiro, Brasil; Universidade Santa Úrsala, Rio de Janeiro, Brasil, and American Museum of Natural History, New York, NY

The South American Cenozoic fossil record of Chiroptera is poorly known. As part of the research program "Mamíferos do Quaternário do Brasil," four calcarium caves - Igrejinha and Nossa Senhora da Aparecida from the Bambuí-Group, and Carneiro and Itambé from the Araxá-Group - located in the region of Serra da Mesa (Goias, Brasil) were explored. After screenwashing large amounts of Quaternary deposits from these caves a somewhat diverse fauna of microvertebrates was revealed, including frogs, lizards, snakes, birds, and mammals. The bat fauna is represented by many well-preserved fragments of maxilla and lower jaws as well as some nearly complete skulls. Thus far we have identified remains of 27 species

representing 16 genera and 4 families (Mormoopidae, Phyllostomidae, Vespertilionidae, and Natalidae). This assemblage includes *Pteronotus parnellii*, *Pteronotus* sp., *Micronycteris* sp., *Macrophyllum* n. sp., *Phyllostomus hastatus*, *Phyllostomus* sp., *Mimon bennettii*, *Mimon* sp., *Phylloderma* n. sp., *Trachops* sp., *Tonatia sylvicola*, *Tonatia* n. sp., *Desmodus* (sp. 1 and sp. 2), *Glossophaga* sp., *Carollia perspicillata*, *Artibeus* (sp. 1, sp. 2, and sp. 3), *Sturnira lilium*, Stenodermatinae (sp. 1, sp. 2, sp. 3, and sp. 4) incertae sedis, *Myotis* sp., *Histiotus* sp., *Natalus stramineus*. Undoubtedly it represents one of the richest bat fauna of the South American Cenozoic. Interrelationships within Vampyrinae and Phyllostominae are reviewed in an attempt to interpret the phylogenetic context of the three new phyllostomid species referred as part of the genera *Tonatia*, *Phylloderma*, and *Macrophyllum*. Granted by: FURNAS (Geabrasil and Naturae) and CNPq.

Calcium and Fruit Bats: Where Do Australian Flying Foxes Get Their Calcium?

Robert Barclay and Les Hall
University of Calgary, Calgary, Alberta, and University of Queensland, Brisbane, Australia

In previous work, it has been suggested (Barclay 1994) that reproductive female bats face a problem meeting their calcium requirements. This is caused by low calcium availability in insects, fruit and nectar, combined with high calcium demand due to the large size of young bats at weaning. Figs have recently been shown to contain relatively high levels of calcium, suggesting that they may be important sources for bats. However, the availability of the calcium is unknown as it may be bound in the seeds and other solid material not ingested by fruit bats. We investigated the importance of figs and other fruits as a source of calcium for flying foxes (*Pteropus* spp.) in the vicinity of Brisbane, Australia. We collected fruits and rejecta from the field and measured calcium content via atomic absorption spectrophotometry. In addition we fed captive grey-headed flying foxes (*Pteropus poliocephalus*) known amounts of fruit and collected rejecta, feces and urine to determine calcium retention rates. While figs of various species had significantly higher calcium content than other fruits commonly eaten by flying foxes, much of the calcium was contained in the portion spit out by the bats, most likely the seeds. Thus, measures of calcium content from whole fruits are misleading. None-the-less, figs still provide significantly more calcium than do other dietary items (fruit or nectar) and should be a particularly important component of the diet of reproductive female frugivorous bats. These results suggest that the co-evolution of bats with figs may have involved figs incorporating calcium in fruits as a means of attracting bats for the purposes of seed dispersal.

Sex Discrimination and Roostmate Recognition Using Olfactory Cues in Two African Free-tailed Bats, *Mops condylurus* and *Chaerephon pumilus* (Chiroptera: Molossidae)

Sylvie Bouchard, York University, Toronto, Ontario.

The existence and/or function of olfactory signals in the lives of bats is poorly known. The ability of two species of African bats (Angola free-tailed, *Mops condylurus* and little free-tailed, *Chaerephon pumilus*) to distinguish sexes and roostmates from strangers in scent-choice experiments was tested. During this study I tested 345 bats in the field at Hoedspruit South Africa, between 6 October and 8 December 1997. Experiments were conducted in a translucent plastic arena and test individuals were naive adults. I collected scent by rubbing a bat's glandular area with a microscopic slide. Three experiments were performed with both sexes of each species. First, I tested whether they showed discrimination between the sexes by running two experiments in which time spent on each side of the arena represented choice. In the first one, the interaural skin of a male and a female were rubbed and presented to the test subject. In the second experiment, the muzzle of a male and a female served as source of odor. In both cases, the test subject was presented with chemical signals from bats of their own colony. Second, I ran one more experiment to see if these bats could recognize a roostmate from a stranger. I collected scent from the interaural gland of a female roostmate of the test individual, and of a female from a different colony and presented the scents to the tested bat. Both male and female *M. condylurus* can discriminate sexes based on odors collected in the interaural area, whereas only male *C. pumilus* showed recognition when the muzzle was the source of odor. Female *M. condylurus* from an intermediate size colony (ca. 200-600 individuals) distinguished a female roostmate from a stranger. Time spent on the roostmate's side varied inversely with test-subject colony size which suggests that recognition is individually based. The different results with the two species and between sexes illustrate the need for further research on these bats olfactory communication.

Vertical Use of Habitat by Insectivorous Bats in Temperate Coastal Old-growth Forest

Paul A. Bradshaw and R. Mark Brigham, University of Regina, Regina, SK Canada

Bats are considered to be sensitive to levels of structural clutter encountered during flight. Small interspecific differences in wing morphology have been shown in some instances to have important implications for maneuverability, agility, and energetic costs of flight, and may thus be reflected in differences of microhabitat selection. Old-growth forest exhibits greater structural heterogeneity and vertical complexity than younger forest, and can be viewed as a heterogeneous habitat volume that contains a range of vegetation densities. We generated predictions, based on wing morphology and vegetation density, regarding vertical microhabitat selection by insectivorous bats within three old-growth forest stands of differing vertical structure, on Vancouver Island, British Columbia. Predictions were tested using ultrasonic detectors set at three sampling heights, corresponding to the canopy, understory, and shrub levels. Vertical microhabitat associations of bat species (or species groups), identified from echolocation calls, were inferred from relative measures of bat activity. Bat activity was sampled on 65 nights during the summer of 1996 resulting in a total of 2285 bat passes recorded. Bats were found at all levels of the forest stands studied, although vertical patterns of activity differed between sites. We found strong evidence that bats use forest strata such as the sub-canopy, and canopy, which is contrary to findings from previous studies in temperate forests. However, there was little evidence for high rates of foraging activity within the forest at any sampling level. Our predictions of microhabitat association based on wing morphology were not supported by the data collected. The vertical distribution of bat activity could not be consistently explained from an ecomorphological perspective, that is, fine scale functional links between bat wing morphology and microhabitat structure were not apparent.

Molecular Systematics of Plecotine Bats: A Reevaluation of Proposed Hypotheses

Jorge Salazar Bravo, Mathew Garcia, Jerry Dragoo, and Terry L. Yates
The University of New Mexico, Albuquerque, NM

The systematics and composition of the tribe Plecotini has recently received a great deal of attention. Several papers have used selected data sets to propose alternative hypotheses of phylogenetic relationships. In this paper, we use the complete sequence of the cytochrome *b* gene in the mitochondrial DNA of putative members of this tribe, and a set of selected outgroups, to test the phylogenetic hypotheses proposed. Because previous analyses have heavily relied upon chromosomal and morphological data sets, we included them in a Total Evidence analysis. We conclude that the tribe is monophyletic, and probably Palaearctic in origin.

Acoustic Identification of Bats in Missouri

Eric R. Britzke, Derek W. Bossi, and Lynn W. Robbins
Southwest Missouri State University, Springfield, MO

Mist nets, Tuttle traps and visual counts in caves have been the standard methods for monitoring bats in an area. However, mist nets and Tuttle traps may not catch all of the species in an area, may be difficult to use in some situations, and are hard on the bats. Therefore, a non-invasive means to accurately determine bat presence in an area needed to be devised. In this study, the echolocation calls were used in an attempt to determine species identification. Bats were captured by mist net and Tuttle trap in southern Missouri, visually identified, light tagged, and released. While the light tagged bats foraged, recordings of search phase calls were made with the AnabatII bat detector and AnabatV software. We recorded the echolocation call sequences of eight species. We used Analook to manually remove background noise from the sequence, select typical search phase calls, and send the values of the 10 measured parameters to a text file. We identified species on each call sequence in three ways. First we used a qualitative approach where we simply looked at the call sequence and identified species based on our own previous experience. We then constructed a key based on the 99.99% confidence intervals of the measured parameters. We also used a linear discriminate function that assigned species identification based on a library of known identity calls. These three methods were tested with known calls that were not used in the construction of the key or model. The efficiency of these three methods in determining species identification was compared. With the Anabat system, there is now a method that provides the ability to determine all species of bats present in an area, without the need to handle any bats for identification purposes.

Distribution, Territoriality, and Sociality of a Solitary Flying Fox, *Pteropus samoensis*

Anne Brooke, Newfields, NH

The Samoan flying fox, *Pteropus samoensis*, is an endemic of the Samoan and Fijian archipelagos. It is one of few species that are routinely active during the day. Small population size, limited range, and overhunting during the 1980s and early 1990s has caused concern about the species survival. Although little is known of the natural history, territoriality has been proposed as the basis of habitat division among the widely spaced, monogamous pairs and may contribute to lower population densities. During 33 months, 1994-1996, I investigated the distribution, activity patterns, foraging areas, social organization, and territorial behaviors of *P. samoensis* in American Samoa. Local densities varied in 6 study valleys with forest quality and the amount of hunting. Two individuals, radio tracked for 2 months, were active both diurnally and nocturnally although both foraged over a greater area at night. Most observations of roosting bats were of a single individual or a female with a juvenile. Individuals returned to the same roost branches for months or years. Aggregations of 4-11 bats, larger than an immediate family group, were seen occasionally, and an aggregation of ca. 60 bats, seen once, may have been a response to fruit abundance. The timing of mating varied somewhat each year, with most mating activity in 1994-1996 between Sept.-Nov. Young, born the following year between April-June were volant when ca. 3 months old. Both juveniles and males followed or pursued females. These "follows" were distinct from the "chases" of bats defending food resources. Bats vigorously defended fruiting or flowering trees and actively drove trespassers away. Defending bats wingclapped and regularly chased intruders in an aerial pursuit. Chases frequently ended when the defender bit the feet or back of the intruder. Some chases ended after both animals fell for several meters through the air with their feet locked together. Only rarely were bats seen defending roost sites. *Pteropus samoensis* is a "solitary" species but individuals are loosely social. Like colonial pteropodids, the Samoan flying fox is highly territorial of food resources. I found no evidence that pairs were monogamous but long-term studies of marked bats and genetic testing of family groups would be needed to fully explore this possibility.

Twenty Years of Bat Radio-Telemetry: Progress and Pitfalls

Patricia E. Brown and Robert D. Berry.
Physiological Science Department, UCLA, Los Angeles, CA 90095-1606;
Brown-Berry Biological Consulting, 134 Wilkes Crest Road, Bishop, CA 93514

The technology of radio-telemetry has improved since our first study in 1978 of pallid bats Antrozous pallidus using 2 gram transmitters and FM radios as receivers. The current crystal-controlled 0.5 gram transmitters and receivers with scanners make telemetry easier on the bats and the researchers. This evolving technology has provided data on roosting and foraging habitat, home range, activity patterns and social interactions. For example, pallid bats have been found roosting in mud cracks in the ground, California leaf-nosed bats Macrotus californicus forage primarily in dry desert washes, and Townsendís big-eared bats Corynorhinus townsendii on Santa Cruz Island feed over native vs. exotic vegetation. In one study, a fringed myotis Myotis thysanodes commuted nightly over 12 km (and over 600 meters elevation gain) from a roost in a cliff face in dry chaparral to forage in a patch of pine/oak woodland. In 14 studies on 11 species in the United States, Japan and Australia, we have learned that to avoid weight loss or death, transmitters should be 5% or less of body weight. Bats should be weighed prior to transmitter attachment, and recaptured and weighed again at the end of the study whenever possible. Telemetry on females during late pregnancy and lactation can alter their foraging behavior and efficiency, and the added burden of the transmitter may result in their death or that of their infant. The method of foraging also affects the ability of the a bat to carry a transmitter, and aerial insectivores may be impacted more than gleaning species. Telemetry can impact the individual animal, and possibly provide misleading behavioral results. For these reasons, proposed telemetry studies should be balanced between the costs to the bats versus the potential knowledge gained.

Bat Habitat Enhancement and Preservation on Managed, Fire-Damaged, and Urban Forests

Timothy K. Brown, T. K. Brown and Associates, Bellevue WA

Old growth forests provide habitat for wildlife in snags, deep crevices, hollows, and fallen woody debris. However, with the rapidly shrinking old growth forests and loss of habitat due to urban development, these habitats are rapidly disappearing. Second growth, even-aged stands, while providing timber resources for the future, provide poor habitat for bats and many other species (wildlife trees) because

of the relative lack of tree form and heterogeneity. Urban forēsts have also altered populations of bats and wildlife. Thoughtful habitat development using mechanical means to create wildlife trees and forest floor structures, will markedly improve the chances for recovery of endangered and threatened species. Rather then destroying habitat, chain-saws can be wielded to enrich (or replace) habitat by means of modifying live and dead trees (bat slits, bat flanges, bat hollows) to offer a wide range of roost types and microclimafic variables for bats to utilize. I will discuss my twenty-five years of designing, creating, and monitoring wildlife trees in Alaska, Canada, and the Western U.S., and the accumulation of a tremendous volume of data relating (1) which species of bat inhabit which type of modification, (2) the species, health and size of tree, (3) elevation, latitude, and growing season, prevailing winds, and (4) the type of natural tree-damage (lighting, freeze, fire, wind, heart and stem rot).

Flying Mice? Flying Primates? Flying Foxes? ...Desperately Seeking Sister-groups!

Deanna G. P. Byrnes, University of Wisconsin, Madison, WI

The superorder Archonta currently includes Chiroptera, Primates, Scandentia, and Den-noptera. However, the validity of this group has recently been challenged. The morphological affinity of bats to flying lemurs, and the neuro-anatomical evidence supporting a close alliance of megabats with primates and Dermoptera, is contradicted by various molecular data sets placing the whole of Chiroptera outside the traditional archontan clade. Various DNA-hybridization experiments conducted in our laboratory have found bats to be very close to Ferungulata (sensu Simpson). This result is not peculiar to our work, as other molecular analyses (published and yet unpublished) also point to a close association among bats, ferungulates, and possibly edentates. I have combined DNA-hybridization data collected in our laboratory over the past half-dozen years and analyzed them in light of the new question: "Are flying mice and flying foxes really just foxes?"

The Summer Ecology of Long-eared Myotis Species Bats in the Interior Wet-Belt of British Columbia

M. Carolina Caceres, University of Calgary, Calgary, AB

Summers in the interior wet-belt cedar-hemlock forests of British Columbia are characterized by cool temperatures and high rainfall. The study area encompassed two national parks which contained large stands of mature cedar-hemlock forests. This region is home to five species of insectivorous bats of the genus *Myotis* including a provincially red-listed (endangered) species, *Myotis septentrionalis*. Two of the wet-belt species, *M. evotis* and *M. septentrionalis* use gleaning as well as aerial hawking to forage. I predicted that gleaners, given their ability to feed on non-flying insects, would have a diet unlike that of the aerial hawkers. I also predicted gleaners would emerge later after sunset, forage later and forage in different habitats than strict aerial hawkers. I further predicted that the foraging advantages of gleaning in cooler enviromnents may allow for more gleaning individuals to reproduce. However, I found there was no difference in diet and temporal foraging activity between gleaning and non-gleaning *Myotis* bats, although there was evidence of spatial partitioning. Over two summers, 96 *Myotis* bats were captured and only 6 of 53 females were obviously reproductive: These numbers are considerably lower than those reported in other parts of B.C. and elsewhere. Thus, I conclude the envirom-nental conditions in this marginal habitat strongly influence the foraging behaviour and reproduction of the *Myotis* bats. I examined the roost preferences of the gleaning long-eared species. Roost trees had similar characteristics to those chosen by other forest-dwelling bats. However, *M. evotis* also used tree stumps and rock crevices for roosting whereas *M. septentrionalis* only used trees in the national parks. Despite the poor climatic conditions of the interior wet-belt, the national parks may provide abundant roosts for *M. septentrionalis*.

Bats and Education: Teaching about the Process of Science

Karen A. Campbell, Albright College, Reading, PA

One of the great benefits (or perhaps hazards) of working with bats is that we are often called upon to give "bat talks" to different groups, ranging from school children of various ages to conservation societies to practically any other community group imaginable. It is relatively easy to capture the interest and attention of people of all ages with information about bats, and as a result bat programs can be a window to a larger view of science. Given current concerns over the low level of scientific literacy of the average citizen, these talks provide an opportunity for us, as scientists, to advance the public understanding of science as a process. It is important to remember that as people who have developed an understanding of

the method of scientific discovery, we represent a small proportion of the population in general. Much curricular reform at all levels of scientific education is aimed at removing the impression that science learning is a process that sifts from the masses of students a select few deemed suitable for scientific inquiry. Initiatives to improve the learning of science include efforts to ensure that science is taught as a process in which all citizens are engaged at some level. Our casual encounters with school and community groups provide an avenue to model the ways in which scientific research is conducted and used to address real problems. Rather than presenting simply a collection of neat "bat facts," we can use public presentations to package the same information as stories that allow our audiences to gain an appreciation for the kinds of questions that science asks. Interactive programs, even if limited to stories which allow us to pose questions for the listeners to consider, allow people with virtually no scientific background to build an understanding of how a scientist gathers and analyzes data or tests hypotheses in search of answers that give meaning to life. This also allows us to personalize the scientific process, to show how science is work done by people caught up in the process of discovery. In this way, our audiences learn not only about bats, which are admittedly fascinating on their own, but gain some insight into the spirit of scientific inquiry which defines who we are.

Bats of the Delaware Water Gap National Recreation Area

Karen A. Campbell, Jason Schwenk, Bryan Thompson, Trinh Pham, Jason Stumhofer, Anthony Valeriano III, Lawrence Ward and Jeffrey Sensenig, Albright College, Reading, PA

Plans for trail development within the Delaware Water Gap National Recreation Area (DWGNRA) include efforts to determine the status of bat populations within the park, with particular attention to the federally endangered Indiana bat, *Myotis sodalis*. We conducted a two-year study, in the summers of 1997 and 1998, to assess bat activity within the DWGNRA, to increase our knowledge about the summer habitat use by bat populations in the park, and to provide a guide to future park developments. The population was sampled at a total of 23 sites over the two-year period, with 16 sites sampled on the Pennsylvania side of the park and 7 sites sampled in New Jersey. At each site, the population was sampled using 3-tiered (7m high) mist nets and/or lm-square harp traps, during late spring (end of May) and mid-summer (end of July). Bat activity was also monitored acoustically using ANABAT 5 and tunable broadband detectors. A total of 148 bats were captured over the two seasons, representing 5 species (*Myotis lucifugus, M. septentrionalis, Pipistrellus subflavus, Eptesicus fuscus,* and *Lasiurus borealis*). Hoary bats, *Lasiurus cinereus*, were detected acoustically at several sites, but were not captured. *M. sodalis* was not captured at any site. There was evidence that the park provides suitable habitat for reproductive activity of some bat species. Large maternity colonies of *M. lucifugus* and *E. fuscus* were identified in several permanent structures. Reproductive roost sites were not identified for other species, but pregnant and lactating female *M. septentrionalis* were captured early in each season. Post-lactating *L. borealis* and *P. subflavus* females were also captured during the summer sampling periods, but these bats may have been transient. Data obtained using radio-telemetry of post-lactating *M. septentrionalis*, captured at two sites within the park, suggest that these bats forage over an extensive area following lactation. There was considerable foraging activity over the Delaware River, but the activity we monitored was patchy both over the length of the river sampled and throughout the season. Intensive foraging activity apparently coincides with the emergence of insects at different points during the season, with foraging becoming more widely dispersed throughout the park between emergences. The DWGNRA clearly provides useful summer habitat for several bat species, and plans to develop specific areas of the park will continue to be shaped by the potential effects of habitat disturbance on the bat community.

The Pathway of Water Transport in Leaves of *Heliconia pogonata* and *Manicaria saccifera* Modified by Roosting Bats to Serve as Tents

Ewa Cholewa, Sylvie Bouchard and Maarten Vonhof
University of Waterloo, Waterloo, Ontario, and York University, North York, Ontario, Canada

This study elucidates the pathway of water movement through vascular system of *Manicaria* sp. and *Heliconia* sp. leaves altered by roosting bats. The bat *Ectophylla alba* modifies mature leaves of *Heliconia* sp. by severing the leaf lamina on both sides of the midrib in two 33-cm-long cuts. Following these cuts, the *Heliconia* sp. leaf collapses on both sides of the midrib, and creates a secluded site for diurnal roosting. Another bat, *Arbiteus watsoni* modifies the apical lamina of *Manicaria* sp. leaf into a J-shaped tent by cutting the lamina 10 cm from the leaf edge, and by severing upper ridges, the major sites for mechanical support of the leaf lamina. The weakened lamina droops downward while the detached sides fold underneath,

forming a dark roosting site. To maintain the viability of the leaves the plant must sustain continuous water transport to the modified areas and overcome the severe vascular damage caused by the bats. Water movement within modified leaves was visualized using red-colored, water-soluble tracer Safranine O. Detached areas of the leaf lamina are supplied with water via minor transverse veins branching from the first major parallel vein that remains intact above the cut. Transverse veins conduct water through a single xylem element previously believed to function only in local water transport, supplying cells in their close vicinity. Our observations show that the transverse veins can conduct water and refill severed major parallel veins, keeping the leaf-tent alive for up to several months.

* Foraging and Thermoregulatory Behaviour of Long-eared Bats *Myotis evotis* in South-eastern Alberta

Bryan Chruszcz, University of Calgary, Calgary, Alberta

I studied the foraging and thermoregulatory behaviour of long-eared bats (*Myotis evotis*) in the Badlands of the South Saskatchewan river valley during the summers of 1997 and 1998. In 1997 I radio-tagged eight pregnant and four lactating females. In 1998 I radio-tagged four pregnant and seven lactating females. Predominately, bats foraged in the cottonwood trees along the river and in the sagebrush meadow between the cottonwoods and the coulees where they roosted. Bats foraged for most of the night, periodically roosting in the trees or coulees for brief periods. Bats roosted in ironstone rocks in the coulees. The structure and thermal regime of roosts differed between pregnant and lactating females. For pregnant females, the roosting crevice was typically in a horizontal plane under pieces of rock that had flaked off the top of the ironstone. For lactating females, the roosting crevice was typically in the vertical plane where the rock had split in two. Lactating roosts had smaller daily temperature ranges than pregnant roosts at the same time during both pregnancy and lactation stages of the breeding season. All bats used torpor everyday, but the use of deep torpor occurred more frequently in pregnant as opposed to lactating females. These results suggest that pregnant and lactating females may have different energy requirements.

* Bryan Chruszcz received ***The Bat Research News Award*** for this presentation.

Roosting and Foraging Activities of *Corynorhinus rafinesquii* and *Myotis austroriparius* in the Francis Beidler Forest in South Carolina

Mary Kay Clark, Adam Black, and Mark Kiser,
North Carolina State Museum of Natural Sciences, Raleigh, NC; 3D/International Inc., Cincinnati, OH; and Bat Conservation International, Austin, TX

The purpose of this study was to gather roosting and foraging data on two rare bat species, *Corynorhinus rafinesquii* and *Myotis austroriparius*, that appear to be closely-linked to a declining habitat, cypress-gum swamp forest. The studies were conducted in the Francis Beidler Forest, a National Audubon Society sanctuary that contains the largest stand of original growth bald cypress (*Taxodium distichum*) and tupelo gum (*Nyssa aquatica*) in the United States. Between May and October 1996 a total of sixteen bats were radio-tracked in the sanctuary. More data were obtained for *C. rafinesquii* than for *M. austroriparius* because the latter species proved difficult to track. We located a total of 37 day roosts all within the swamp forest. Thirty-six of the day roosts were in living tupelo gum trees (*Nyssa aquatica*) and one was in a swamp gum (*N. biflora*). Individuals regularly switched roosts and roost trees were often found in clusters. For *C. rafinesquii* the maximum distance between roost trees was 575 m. The majority of the trees used for day roosting had large basal cavities, but some trees used by *C. rafinesquii* had only small openings at the base or no basal cavity at all. Additionally, one *C. rafinesquii* night roost was located in a dead cypress tree. Barclay, Vonhof and Brigham (1996) proposed a general hypothesis that "forest-roosting bats of various species require a large number of dead trees of specific species, in specific (early) stages of decay, that project above the canopy in relatively open areas." They stated that this hypothesis should be evaluated for other species in other locations to test its generality. For the most part, this hypothesis does not fit *C. rafinesquii* and *M. austroriparius*. Our data show that these two species prefer to roost in closed canopy forests in living trees that do not project above the canopy, however, they do require a number of roost trees and they do show a preference for a single tree species. Composite home ranges were delineated for nine *C. rafinesquii* and two *M. austroriparius*. Difficulty tracking *M. austroriparius* resulted in only 4 tracking nights and less than 30 triangulation fixes. The most accurate delineation of home range sizes for *C. rafinesquii* were from three individuals that were tracked from 9 to 11 days. Their home ranges were delineated using from 154 to 252 triangulation fixes. Home range sizes for these three individuals ranged from 64 hectares to 89 hectares. For these three bats the maximum distance travelled from a roost to the edge of the range varied from 718 meters to 919 meters. Although it is

possible that bats may have flown outside the range of the receivers it appears that *C. rafinesquii* concentrate their foraging, activities near roosts.

Bat Species Abundance and Diversity in a Southern Bottomland Hardwood Swamp

Shawn M. Cochran, Vernon Hoffman, J. D. Wilhide, and V. R. McDaniel
Arkansas State University, State University, AR

From May 1997 to August 1998, bat species abundance and diversity were surveyed in botton-land hardwood habitats of the Rex Handcock Black Swamp Wildlife Management area of northeastern Arkansas. We mist netted 7 different sites over eighteen nights in 1997 and twenty-five different sites over a period of thirty-five nights in 1998. Mist nets were placed at water holes, road ruts, sloughs, and along forest edges. Four hundred and fifty-two bats of 7 species, including two species of concern (*Myotis austroriparius, Corynorhinus rafinesquii*) were netted during the 1997 and 1998 field surveys. Species capture success ranged from 0-5 species per site. The total number of bats captured per night ranged from 0-55 bats. *Myotis austroriparius, Nycticeius humeralis*, and *Corynorhinus rafinesquii* were the most often captured species (>50% of the time), while *Lasiurus borealis, Eptesicus fuscus, Pipistrellus subflavus*, and *Myotis lucifugus* were the least captured species (<50%.of the time).

Paternity Exclusion for a Captive Colony of *Pteropus pumilus*: A Comparison of Microsatellite and RAPD Analyses

Lisa B. Comeaux, University of Tennessee, Knoxville, TN

In recent years, it has been necessary to bring several species of flying foxes into captivity in order to ensure their survival. A major goal of captive management is to design breeding programs based on accurate pedigree information in order to minimize the loss of genetic variation due to inbreeding. Parentage, especially paternity, can be difficult or even impossible to ascertain solely from observation of mating behavior in colonial or promiscuous species, like many flying foxes. Genetic markers, particularly microsatellites, have proven effective for paternity exclusion in many species. For this study, using only three microsatellite loci, I was able to exclude all potential sires except one (the true father) among seven possible candidates for nineteen of the twenty-three *Pteropus pumilus* pups born in captivity at the Lubee Foundation, Inc. For the remaining four pups, I have narrowed the field of potential sires to two, one of which will be excluded when more microsatellite loci are identified. A similar data set was constructed for seven of the twenty-three *P. pumilus* pups using RAPDs. Although numerous precautions were taken to ensure repeatability and prevent contamination, the presence of non-parental bands confounded paternity analysis. Different RAPD loci yielded conflicting results with different sires being implicated by several loci. In addition, exclusions performed using RAPDs were in conflict with results obtained from microsatellite analysis at 92% of informative RAPD loci. For these reasons, I believe that RAPD analysis is not a reliable indicator of parentage and should be used with caution in studies of comparative genetic diversity and phylogeny.

Evolution of Mormoopid Bats

Tenley Conway and Nancy B. Simmons
American Museum of Natural History, New York, NY

Mormoopidae is a small family of Neotropical bats that presently contains 2 genera and 8 species. These bats are of interest to biologists because of their unusual morphological traits (e.g., leaf-like chin flaps), geographic distributions (e.g., some pan-Neotropical, others with restricted ranges in the Caribbean), and diverse echolocation calls (e.g., most low duty cycle FM, one species with high duty cycle CF calls). Previous phylogenetic analyses were either completed in a pre-cladistics context, or used only a limited set of morphological characters and were unable to resolve relationships within the genus *Pteronotus*. We collected morphological data from all eight mormoopid species as well as three outgroups (representatives of Phyllostomidae, Noctilionidae, and Mystacinidae). Our data set included 70 characters of the skull, dentition, postcranial musculoskeletal system, wing membranes, pelage, vibrissae, pinnae, and dermal structures of the face. We conducted a phylogenetic analysis to find the most-parsimonious tree(s). Our most-parsimonious tree was congruent in most respects with J. D. Smith's hypothesis, with the exception of the placement of *Pteronotus personatus* as the sister taxa to the clade containing *P. quadridens* and *P. macleayii* in our tree. Monophyly of Mormoopidae, *Mormoops*, and *Pteronotus* was strongly supported, as well as a sister relationship between *P. gymnonotus* and *P. davyi*. There was moderate support for *P.*

parnellii as the sister taxa of a clade containing all of the other species of *Pteronotus*. and a sister taxa relationship between *P. quadridens* and *P. macleayii*, with *P. personatus* as the sister taxon of this clade. Geographic patterns were evaluated by mapping geographic range data on the shortest tree. A broad Central and South American origin seems to be primitive for species of Mormoopidae. Three independent invasions into the Greater Antilles are indicated: one by *M. blainvillii* , one by *P. parnellii*, and another by the common ancestor of *the P. macleayii* and *P. quadridens* clade.

*** Variability in the Vocal Repertoire of the Neotropical Bat *Saccopteryx bilineata***

Susan M. Davidson, University of Maryland, College Park, MD

Saccopteryx bilineata, a common Neotropical bat, is widely distributed, ranging from tropical South America north to southern Mexico. Male *S. bilineata* defend roost sites year round within the buttresses of large trees. Up to eight females may roost within an individual male's territory. Male *S. bilineata* are philopatric whereas female juveniles disperse from the natal roost. Males produce complex song-like vocalizations most frequently in the early morning and then periodically throughout the day. The presence of male philopatry predicts that these vocalizations should be more similar within colonies than between colonies. To investigate this, I recorded male calls at several colonies on the island of Trinidad, WI, in June, 1997 and July/August, 1998. First, I will present the range of different call types of male *S. bilineata*. Then, to determine the scale at which the dispersal patterns influence the variability of male vocalizations, I will compare acoustical features of male calls from several individual males at four colonies in Trinidad. I also will compare calls from Trinidad to additional calls recorded in Panama, Costa Rica, and Belize.

* Susan M. Davidson received ***The Karl Koopman Memorial Award*** for this presentation.

A Concordance of Ear Shape and Echolocation Call Structure in Three Species of Vespertilionid Bats

Tagide N. deCarvalho, William L. Gannon, and Luis A. Ruedas
University of New Mexico, Albuquerque, New Mexico

Among the many dramatic differences displayed by vespertilionid bats of the southwestern United States is their variety of ear size and shape. Bats that surface glean have larger ears, those that aerially hawk insects have relatively smaller ears; their echolocation calls also are quite distinct. We chose two ecologically similar bat species to determine if subtle differences in ear morphology would be reflected as subtle differences in echolocation call structure. We compared two small Myotis bats, *Myotis californicus* and *M. ciliolabrum*, with a large, more generalist bat, *Eptesicus fuscus*. In order to note differences between echolocation calls and morphological differences, we examined seven cranial characters, four measurements from each of both ears and tragus, and five echolocation call characters. In all, we measured ear and cranial characters from 80 *Myotis californicus*, 74 *M. ciliolabrum*, and 82 *Eptesicus fuscus*. Echolocation calls also were measured from each of these three species. The data were analyzed with ANOVA multiple range test and multivariate techniques. We found that between *Myotis californicus* and *M. ciliolabrum* there is a statistically significant difference in the size of the ears but not the tragus. The skull measurements were analyzed in the same way, showing some overlap in the two Myotis species which contrasted with the more dissimilar *Eptesicus fuscus*. A total of 240 echolocation calls were measured from each of the three species. The species differed significantly, suggesting that morphological and echolocation call characters are correlated. We then measured morphology and echolocation calls from 20 of each Myotis in the field. We found significant dfffferences between both Myotis species in both morphological and echolocation characters. Measuring cranial and echolocation characters from the same individuals confirmed patterns determined from museum specimens. Small differences in ear shape and size correlate with a change in the range of frequency between the two Myotis species. Implications of this study are that two apparently morphologically similar bats segregate the sonic environment, thereby reducing interspecific competition.

Using the "TreeTop Peeper II™" Video Camera to View Cliff-dwelling Bat Roosts

Michael T. Dixon and Jana L. Higginbotham
Texas Wesleyan University, Fort Worth, TX, and University of Texas at Arlington, Arlington, TX

We observed bat roosts located in cliff crevices on Tornillo Creek, Big Bend National Park, Texas with a TreeTop Peeper II (Christensen Designs) infrared video camera on 25 May 1998. This unit comprises a probe containing an infrared video camera and light source mounted on the top of a 50-foot extendible fiber-

glass pole. Near the base of the pole is a video monitor with jacks to attach a video cassette recorder. A belt with a 12-volt battery supplies power. The TreeTop II allowed us to inspect bats at the periphery of four crevices up to 55 feet above ground level that we could not have otherwise observed. We were able to confirm their identification as *Nyctinomops femorosaccus* and check for bands. Individuals were mostly clumped in distribution. We saw no evidence that the narrow crevices opened up to larger chambers. Some bats that were observed from the ground with binoculars were not observed with the video camera. It was obvious that some individuals were disturbed and made an effort to flee the probe. In one crevice we saw no bats with the camera but observed 9 bats emerge later that evening suggesting that these individuals were deeper in the roost than we had access. The unit does have a few shortcomings. It is difficult to maneuver a 50-foot high pole into small crevices (we attached guy lines) but most of the roosts were still too high to be accessible. We were unable to view many crevices because the probe was too large to fit. We got it stuck trying. Maneuvering the camera is tricky. The desired camera angle must be set on the ground and then any adjustments require collapsing the pole and then re-extending it. Positioning the camera sometimes requires turning it upside down or sideways. This is disorienting when watching the image on the monitor and made it difficult to make fine adjustments to the camera angle. Overall, we found the TreeTop Peeper II to be a valuable field tool. Remote aiming of the camera would be a helpful improvement.

The North American Bats and Mines Project: Continuing Partnerships to Conserve Mine-roosting Bats

Sheryl Ducummon, Bat Conservation International, Austin, Texas

The North American Bats and Mines Project is a partnership led by BCI and the Bureau of Land Management. It includes many government and mining industry partners and has helped save over two million mine-roosting bats in the United States, Canada, and Australia. In its fifth year, demand for Mine Assessment for Bats Workshops remains high, and over 700 wildlife and mine-land managers have received training on mine survey and bat-compatible closure techniques. Our *Bats and Mines* handbook was recently revised and reprinted, and continues to be distributed widely to mine industry and agency partners. The Mining for Habitat initiative, a BCI partnership program with the mining industry, continues to expand, with partners such as BHP Copper, Echo Bay Minerals, Homestake Mining Company, Phelps Dodge, Solutia Inc., and others joining forces. Our goal is to prevent the listing of additional endangered species by developing proactive bat conservation and management plans, including creation of artificial roosts during mine reclamation. The North American Bats and Mines Program continues to support conservation actions through our grant program, with over $80,000 spent to date on site protection for mine-roosting bats. This funding is frequently matched 10 to 1 by our partners, greatly improving our conservation efforts. Current areas of focus include mine assessment for bats prior to closures in Michigan's Upper Peninsula and construction of bat-compatible gates at important mines throughout North America. The Australian Bat Society is also joining this project, establishing a Bat and Mine Subcommittee there to produce an Australian *Bats and Mines* handbook, and to set priorities for conservation of mine-roosting species. The Jack Gordon Mine, located in Queensland's Cape York Peninsula, was recently gated in a project jointly sponsored by BCI and the Queensland National Parks and Wildlife Service. This large mine complex houses six Australian bat species, five of which are rare or endangered.

The Effect of Fruit Hardness on Feeding Behavior in Pteropodid Bats

Elizabeth R. Dumont, Northeastern Ohio Universities College of Medicine

Recent data demonstrate that the hardness of fruits used by pteropodid bats varies significantly. Moreover, there is evidence that different sized bat species use fruits with different hardness values. While small and medium sized bats appear to emphasize relatively soft fruits, large bats utilize fruits with a wide range of hardness values. Unfortunately, the relationship between bat size and fruit hardness is confounded by a significant correlation between fruit hardness and mass ($r = 0.79$, $p < 0.001$, $n = 28$). To unravel these associations, a series of controlled feeding experiments was conducted to isolate and examine the impact of fruit hardness on feeding behavior within and among pteropodid bat species. Individuals of *Syconycteris australis* (n = 2), *Nyctimene albiventer* (n = 2), *Paranyctimene raptor* (n = 3), *Dobsonia minor* (n = 3), and *Pteropus conspicillatus* (n=3) were video taped while feeding on both hard and soft fruits. Pieces of ripe apple and papaya carved to the same size and shape (roughly 25 mm spheres) were used to represent hard and soft fruits, respectively. The puncture resistance of the apple pieces used in this study was 221 g/mm^2. Papaya was much softer with a puncture resistance value of 31 g/ mm^2. By using the same sized pieces of apple and papaya for all feeding trials, intra- and interspecific variation in feeding behavior attributable to

fruit hardness was highlighted. Based on observations of feeding behavior made from video tape in the laboratory, both inter- and intraspecific variation in aspects of feeding behavior were analysed. Variables for which bats differ include the biting strategies used during feeding, the number of individual bites taken to detach a bolus of fruit, and the number of chews used to process a bolus of fruit. Preliminary results indicate that fruit hardness impacts feeding behavior both within and between species. This suggests that fruit hardness is an important factor influencing patterns of food resource use within pteropodid communities. This research was supported by an NSF grant (IBN 9507488).

Old World Bat Fruits: Diversity and Implications for Pteropodid Ecology

Elizabeth R. Dumont and Anthony K. Irvine, Northeastern Ohio Universities College of Medicine and CSIRO - Tropical Forest Research Centre, QLD, Australia

Studies of frugivore communities often look to interspecific differences in body size, anatomy, physiology and behavior for clues to resource partitioning strategies. However, an important perspective on resource partitioning can be gained by investigating variation among the fruits that are eaten. In particular, characteristics of fruits that influence bat's abilities to process fruits effectively may be critical in the selection of fruits by different bat species. In addition, because bats are essential seed dispersal agents for many fruits, fruit characteristics that attract bats may be particularly important to plants. To more closely inspect the relationship between Old World bats and plants, two different data sets are examined and discussed. One data set presents a survey of two fruit variables (mass and hardness) that appear to be associated with patterns of resource use among Old World fruit bats. Fresh fruits were measured from plants surveyed from sites in Australia (Queensland) and Papua New Guinea (n = 44 species). By combining these data with dietary data for three bat species, an association between bat size and fruits hardness and size becomes apparent. Small bats seem to be limited to small, soft fruits while large bats consume fruits with a broad range of size and hardness values. A similar association between bat size and fruit size has been reported among phyllostomid frugivores. The second data set describes fruit color and presentation. Fruits in our survey tend to be light (40%) or medium (36%) in color and clearly displayed on the external surfaces of tree canopies or trunks (75%). Fruit color and presentation are significantly correlated ($r = 0.28$, $p < 0.05$, $n = 62$). Contrary to our expectations, light colored fruits are more clearly displayed than are dark fruits. The light coloration and exposure of Old World bat fruits stands in contrast to New World bat fruits, which are often dull colored and hidden by foliage. Overall, these data indicate that fruit size and hardness are important factors mediating relationships between bats and plants. Nevertheless, the differences between New and Old World bat fruits raise the question of whether a limited suite of characteristics can be used to adequately describe all bat-dispersed fruits.

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Bat Conservation International's Student Scholarship Program: Growth of Program and Implications for Conservation

Angela England, Bat Conservation International, Austin, TX

The BCI Student Scholarship Program was established to fund field research that is relevant to the conservation of bats. Since 1995 this program has supported 48 student projects, in 20 countries, including 8 Old World and 12 New World countries. The number of project submissions has increased four-fold since 1995 and the amount of money granted annually has grown to over $40,000. The Student Scholarship Program relies on a formal and impartial review process to award funds to the best designed and conservation-relevant projects. Reviewers are chosen from an international pool of respected researchers and academicians, representing broad expertise in bat biology and conservation. The knowledge gained from funded projects is often of immediate use to conservation and protection of bats. BCI Scholars have an impressive record of continuing conservation achievements.

Habitat Use: Roost Selection and Foraging by the Vespertilionid *Otonycteris hemprichii*

M. Brock Fenton, Benny Shalmon, and David Makin, York University, Toronto, Ontario, Canada; Israel Mammal Information Center, Field Study Center, Eilat, Israel; Kfar Hayyim, Israel

Using temperature-sensitive radio transmitters, we monitored habitat use by *Otonycteris hemprichii*, a medium-sized bat (forearm 63-66 mm; mass 19.5 to 23 g) near Sapir in the Arava Valley in southern Israel. We followed four radio-tagged bats (3 post-lactating females; one adult male) for a total of 14 bat days, mon-

itoring roost selection by the bats, temperatures of flying and roosting bats, as well as >10 h of contact with foraging animals. The radio-tagged bats invariably roosted in cliff faces associated with mesa-like formations within 3 km of their foraging areas. The bats' body temperatures were consistently higher than ambient whether they were flying or roosting. There were significant differences in temperatures between the roosts the bats used. Bats alternated roosts 7 of 10 possible times. Radio-tagged *Otonycteris* emerged from their roosts about one h after sunset, at least 15 min after two other species of vespertilionids which roosted in the same sites (*Pipistrellus bodenheimeri* and *Eptesicus bottae*). Radio-tagged *Otonycteris* flew continuously while foraging, apparently taking prey from the ground. On two occasions foraging flights lasted about 3 h in one night and there was no evidence of the bats using night roosts or feeding perches. Most of the foraging occurred over the valley floors (wadis) and springs, the areas with vegetation. Analysis of feces (18 pellets from 6 bats) indicated that the bats fed on terrestrial arthropods, mainly on beetles and hymenopterans.

The Energetics of Long Distance Migration in *Leptonycteris curasoae*

Theodore H. Fleming and Wilfried Wolff, University of Miami, Coral Gables, FL

The lesser long-nosed bat, *Leptonycteris curasoae*, is one of three species of nectarivorous migratory bats in Mexico. In the spring, thousands of pregnant females migrate from as far south as Jalisco into northwestern Sonora and southwestern Arizona to form maternity colonies. In this paper, we present calculations on the minimum energetic cost for females to migrate 1,500 km and the number of cactus flowers they need to visit to obtain this energy. Our calculations indicate that this migration requires ≥271 kJ supplied by ≥602 visits to ≥120 cactus flowers. A maternity roost of 100,000 *L. curasoae* will need ≥12 x 10^6 cactus flowers to fuel their migratory travel. We propose that females use fat reserves to fuel at least part of this migration and that females have a maximum migration range of about 480 km on 3 g of stored fat. Females probably need to stop over at at least two roosts to rebuild their fat reserves before reaching their maternity roosts. Protection of caves and feeding grounds along the migratory route is absolutely essential for the conservation of this species. Near the northern end of their spring migration, bats initially encounter low densities of cactus flowers. In early April around Bahia Kino and elsewhere in coastal Sonora, flower densities typically are <10 per ha. At this time, some bats must commute >30 km from their day roost to find enough flowers to meet their energetic needs. Long distance migration and long nightly commute flights when flower densities are low have selected for fast, efficient flight in *L. curasoae*.

Netting Results for Taï Forest, Côte d'Ivoire

Thomas T. Gordon, SUNY at Stony Brook, Stony Brook, NY

The Parc National de Taï in Côte d'Ivoire is the last substantial stand of West African lowland rainforest. This UNESCO designated World Heritage Site is home to several endemic species and is likely the last refuge for other West African forest species. However, to date very few studies have addressed the chiropteran fauna of Taï in any detail. As part of a study of the hammer-headed bat, *Hypsignathus monstrosus*, I opened mist nets on 111 nights over a two year period at four different locations near the Institut d'Ecologie Tropicale on the western edge of the park. A total of 486 bats were captured, measured, and identified. Unfortunately, several of the microchiropterans could only be identified to genus level. Eighty percent of these were caught in the forest proper while the remaining twenty percent were caught during four nights of netting along a border zone between coffee plantations and the park. The overall distributions of megachiropterans to microchiropterans was 301:185; however these numbers are heavily biased by the 90 megachiropterans caught in the park border zone. The netting effort was also biased towards the months of September through February, and this too may have had an effect on the results. These biases make it difficult to assess possible migration patterns reflected in the data. However, the results are interesting and there were several notable captures worthy of mention. One is the capture of three *Scotonycteris ophiodon*, a previously unrecorded species for Taï Forest and Côte d'Ivoire. The second is the presence of *Micropteropus pusillus* inside the forest, a rare, though not unknown event. Even more remarkable is that on several nights both *M. pusillus* and its assumed high forest counterpart, *Scotonycteris zenkeri*, were captured.

Seasonal Calling Patterns in a Population of Non-lekking *Hypsignathus monstrosus*

Thomas T. Gordon, SUNY at Stony Brook, Stony Brook, NY

The hammer-headed bat, *Hypsignathus monstrosus*, was intensely studied in Gabon in the early 1970s. This species showed a pronounced seasonality in its mating behaviors which correlated to the local dry seasons. The primary mating activities involved males performing ritualized calling behaviors in small, strongly defended territories which were tightly clustered with the territories of many other males. These patterns led Bradbury (1977) to classify the mating system of the *H. monstrosus* as a "classic" lek mating system and this species of bat has since become one of the most cited examples of a lekking mammal to be found in the literature. However, leks have only been reported from a limited region of Central Africa despite the fact that the rangè of this species encompasses most all the wet forests of West and Central Africa west of the rift valley. If *H. monstrosus* do not lek in some portions of their range, then what form does the mating system take? I have been studying a non-lekking population of *H. monstrosus* at Parc National de Taï in western Côte d'Ivoire in part to answer this very question. By employing a transect censusing type method, I could monitor male calling activities over a region of forest encompassing approximately 45 km^2. Although males can be found calling all months of the year, there was a marked increase in calling activity during the wet seasons. In addition, males were usually encountered calling as single individuals in an apparently random spatial distribution in the study area. Rarely were more than four calling individuals found within hearing distance of one another. Finally, most calling locations were ephemeral, being occupied for relatively short periods lasting from an hour to less than a week.

Calling Site Characteristics for Non-lekking Male *Hypsignathus monstrosus*

Thomas T. Gordon and Inza Koni, SUNY at Stony Brook, Stony Brook, NY
and Université de Cocody, Abidjan, Côte d'Ivoire

The hammer-headed bat, *Hypsignathus monstrosus*, is probably best known for its mating system. Intensely studied by Bradbury (1977) in Gabon, the species has become almost synonymous with the concept of the classic lekking animal. However, the population of *H. monstrosus* at Taï Forest in western Côte d'Ivoire demonstrates no evidence of classic lekking behavior. In fact, males rarely call in groups and appear to call in an almost random distribution throughout the forest. Bats could occupy calling sites for a duration lasting from less than an hour to almost a week. In an attempt to understand this pattern, we looked at possible environmental factors which could be influencing male *H. monstrosus* choice of calling site. Seven "long term" (> 2 nights) calling sites were identified and analyzed for general forest structure, presence or absence of fruits and flowers, and canopy gaps. An identical analysis was undertaken for seven "non-calling" sites which were chosen at random within the research area. Comparisons were made both within and between the two types of sites. No significant differences were found between calling and non-calling sites in terms of the structural characteristics of the forest. However, calling sites had significantly more food resources than non-calling sites and additionally had a higher presence of large canopy gaps. These data suggest that the male *H. monstrosus* are employing a resource based strategy to attain copulations and that the apparent random and ephemeral calling patterns recorded at Taï Forest are actually a reflection of the fruiting patterns of the dominant food trees used by this species of bat.

A Comparison of the Laptop Computer and Tape Recorder in Recording Echolocation Calls from an Anabat Bat Detector

Brad M. Hadley, Eric R. Britzke, and Lynn W. Robbins,
Southwest Missouri State University, Springfield, MO

Anabat bat detectors have recently come into wide use. These units are able to compile a large amount of data relatively easily. The system works well when attached to a laptop computer, but when placing these units in the field it may not be practical to place computers in some locations. This may be due to the fact that there is a relatively large expense for the computer or the environment is not suited for its placement there (i.e., having bat detector suspended in a tree). However, tape recorders may have some problems inherent to their operation including: effects of battery life on tape speed, tape quality, and possible introductions of internal or external background noise. With the ability to quantitatively distinguish species based on echolocation call, the need to determine what effects the use of the tape player has on the analyses of recordings is imperative. We tested the precision of the tape recorder against the computer for recording call sequences. We placed two detectors side by side and attached one to a laptop computer and the other to a delay switch and tape recorder. The call sequences recorded by both methods

were analyzed using Analook and the averages of all of the parameters from a call sequence were compared between the two methods.

Urban Bats

Sarah Hartje, Eric R. Britzke, Kevin L. Murray, and Lynn W. Robbins,
Southwest Missouri State University, Springfield, MO

Little is known about the ecology of insectivorous bats in urban areas. The purpose of this study is to determine which species have adapted to these unnatural environments, where the bats roost, forage and how urbanization has otherwise altered these bats' behaviors. Urbanization in Springfield, Missouri created a mosaic of habitats, such as isolated wooded areas, fields, man-made ponds, parks, well-lighted parking lots, and residential areas. The Anabat II system was taken to each of these habitats where foraging bat echolocation sequences were recorded. Species that have been found within the city limits of Springfield include: *Lasiurus borealis*, *Myotis grisescens*, *M. lucifugus*, *Pipistrellus subflavus*, *Eptesicus fuscus*, and *Nycticeius humeralis*. For two of these species, *L. borealis* and *N. humeralis*, no roost sites have yet been found. Future studies include collecting of bats at their roost sites and using chemiluminescent light tags and Anabat II bat detectors to determine travel routes and additional foraging areas.

Arkansas Endangered Bat Status and Management

Michael J. Harvey, Tennessee Technological University, Cookeville, TN

Three Arkansas cave bat taxa are listed as endangered: gray bat, *Myotis grisescens*, Indiana bat, *M. sodalis*, and Ozark big-eared bat, *Corynorhinus townsendii ingens*. All occur primarily in the Ozark Plateau region of the northwestern and northcentral part of the state. Population monitoring and ecological studies of endangered bats inhabiting important hibernation, summer, and transient caves have been conducted annually since 1978. Through the efforts of several federal, state, and private agencies and organizations, as well as numerous private landowners, 14 important bat caves have been gated or fenced to protect bat colonies from human disturbance. Several additional caves have been afforded protection by intrusion alarm systems, control of access roads, and/or cooperative management agreements. An estimated 450,000 gray bats hibernate in five Arkansas caves. Approximately 200,000 inhabit 20 Arkansas caves during summer, while others migrate to summer caves in Missouri, Oklahoma, and Kansas. Gray bat numbers have increased during recent years. Approximately 2800 Indiana bats hibernate in seven Arkansas caves, decreasing from ca. 6000 during the past 15 years. Only a few males have been reported from the state during summer. Approximately 200 Ozark big-eared bats hibernate in two Arkansas caves, while ca. 300 are known to inhabit two maternity caves. Ozark big-eared bat numbers in Arkansas have decreased by more than 50% during the past 20 years.

A Tent Mist Net Set for Capturing Bats

Michael Herder and Jennifer G. Jackson, USDI BLM Arizona Strip, St. George, UT

Developed wildlife waters known as catchments or guzzlers are common throughout the arid Southwest. Most were designed to provide water for big game species, though non-target species often are more frequent users. Many of the smaller, more maneuverable bat species will use these waters to drink and/or forage. Developed wildlife waters typically incorporate a trough or drinker that is regulated by a float valve and supplied by a storage tank. Drinkers can be virtually any size and shape, though a 2 ft. by 4 ft. rectangular trough is in common use in the Southwestern U. S. These small, ground-level drinkers pose some challenges for mist netting bats. A single net stretched across the drinker is easily avoided by most species. Paired nets on the sides allow bats to pass between. Mist nets set in a box shape often forced bats to leave the drinker without watering. The authors developed a free-standing box-shaped mist net system that, when properly positioned, was successful in capturing bats. The system consists of cutting a standard mist net to fit a rigid frame built from PVC poles. The net is wrapped around four upright poles and the excess is laid over the top. This tent-like set may be positioned such that four to six inches of water is exposed in front of the net. Bats swooped down to water level to drink and came up inside the tent structure. The side panels of the mist net were taut against the top bars, but not fastened, so that researchers could reach inside the tent structure from above and remove captured bats. The assembly costs approximately $60 U. S. to build.

The Chiropteran Community Structure, Activity Patterns and Seasonal Dynamics within the Desert Lowlands of Big Bend National Park, and Notes on *Lasiurus xanthinus* in Texas

Jana L. Higginbotham, Loren K. Ammerman and Michael T. Dixon, University of Texas at Arlington, Arlington, TX; and Texas Wesleyan University, FortWorth, TX

A mist netting survey conducted in Big Bend National Park, Brewster County, Texas from March, 1996 to September, 1998 yielded a total of 1977 mist-net captures of 18 species. We netted 93 nights at 18 different sites located primarily within lowland desert. Specific sites were monitored year-round beginning in March, 1997. Observations regarding community structure and seasonal activity at these sites will be discussed. We analyzed population trends of all bat species in Big Bend by comparing our results to those obtained thirty years ago by another investigator. Four *Lasiurus xanthinus* (western yellow bat) were captured from October, 1996 to September, 1998 representing the first reports of this species in the state of Texas. All four *L. xanthinus* were captured at the same spring-fed pool along an intermittent creek on the eastern side of the park at an elevation of 850 meters. We attached a radio transmitter to an adult male yellow bat captured on 4 September, 1998. This individual was tracked for the next two days and subsequently found 22.4 km from the capture site. It was found roosting within the "skirt" of dead leaves formed around the trunk of a giant dagger yucca (*Yucca carnerosana*) at an altitude of approximately 1100 meters. The site was on a hillside dominated by giant dagger yucca. The roost measured 3.3 meters tall and was growing out of the ground at a 60° angle. To our knowledge this is the first report of a bat using yucca as a roost site.

Roost Tree Selection of Female *Myotis austroriparius* and *Corynorhinus rafinesquii* in a Bottomland Hardwood Forest

Vernon Hoffman, Shawn Cochran, J. D. Wilhide, and Sammy King, Arkansas State University, State University, AR and U. S. Geologic Survey, National Wetlands Research Center, Lafayette, LA

During the summers of 1997 and 1998 pregnant or lactating *Myotis austroriparius* (southeastern myotis) and *Corynorhinus rafinesquii* (Rafinesque's big-eared bat) were tagged with 0.52 g Holohil transmitters. Work was conducted in the Rex Hancock/Black Swamp Wildlife Management Area on the Cache River in eastern Arkansas, a primarily bottomland hardwood forest. In 1998, four *M. austroriparius* and five *C. rafinesquii* were radio tagged. One *M. austroriparius* was tracked to two tupelo trees. Both trees were in a cypress-tupelo swamp, which borders the Cache River, approximately 500 meters from site of capture. Both trees were alive, with tops intact and triangular openings in the base. An exit count of the first tupelo on June 28, 1998 was 104 and an exit count on the second tupelo on July 10, 1998 was 22. Two *C. rafinesquii* were tracked to three tupelo trees. One *C. rafinesquii*, which was tracked to two trees, used one, which was basically a stovepipe design with a large triangular opening in the base and the top broken out. The second tree used also had a broken top, but the damage was much less severe, but had an approximately 8 cm round hole at four meters high. The stovepipe tree contained approximately 15 bats and an attempt to perform an exit count on the second roost was unsuccessful. Both trees were on the banks of the river and approximately a mile and a half from the site of capture. The third *C. rafinesquii* roost was similar to the second in all manners except that it was about 1200 m from the river and about 500 m from the site of capture.

The Importance of the Riparian Zone to Prairie-dwelling Bats

Gillian L. Holloway, University of Calgary, Calgary, Alberta, Canada

I investigated the roosting and foraging habitat of prairie bats along the South Saskatchewan River in south-east Alberta, Canada. *Myotis ciliolabrum*, *M. lucifugus*, and *Eptesicus fuscus* roosted in small sandstone crevices in the coulees and cliffs of the river valley. Roosting crevices had small opening dimensions, and were typically >2 m above or below flat ground, or within large crevices going into the ground. *M. evotis* roosted in narrow crevices in granite rocks. The majority of echolocation and foraging activity occurred along the river, especially around riparian trees. Very little bat echolocation activity was heard on the open prairies. Springs (standing water) near the river also had high bat echolocation and foraging activity. Insect abundance was greatest at the river and springs. This study shows that riparian habitat is critical to prairie bats, and conservation measures are needed as riparian forests are declining.

Status, Distribution and Natural History of *Myotis austroriparius* in Texas and the Carolinas

Peggy Horner, Katy Mirowski, Mary Kay Clark, and Jo McDonnell, Texas Parks and Wildlife Department, Austin, TX (PH, KM); N. C. State Museum of Natural Sciences, Raleigh, NC (MKC); and N. C. State University, Raleigh, NC (JM)

The southeastern myotis, *M. austroriparius*, considered to be rare throughout its range, is known predominately as a cave bat, but much of its range is devoid of caves. Surveys conducted between 1994 and 1998 in North Carolina, South Carolina and Texas have yielded much new information on the distribution, status and natural history of this species in noncave habitats. Many new roost sites were located in trees and man-made structures (culverts and bridges) and most of these sites have been regularly monitored since their discovery. All roosts were in close proximity to lakes or bodies of slow-moving water (rivers, creeks, swamps) and all tree roosts had large bases with triangular-shaped cavity openings. In tree roosts, bats clustered in large numbers (50-100) at the apex of the cavity, sometimes overflowing down the sides of the cavity. Roost switching was also documented for several colonies suggesting that the availability of multiple roosts is an important habitat feature. (Two *M. austroriparius* that were radio-tracked for nine days used seven different tree roosts.) Our surveys demonstrate that *M. austroriparius* is more prevelant in the southeast than previously thought. Prior to survey efforts in east Texas *M. austroriparius* was known from only nine counties, but information obtained in the last four years has extended the range in Texas 100 miles west and the bat is now known from 22 counties. In North Carolina bridge surveys and mist-netting in floodplain forests have demonstrated that this species is found throughout the coastal plain whereas it was known from less than five counties prior to 1990. While encouraging, these new records should be viewed with caution in regards to the conservation status of *M. austroriparius*. Trees with characterisitics suitable for use by this species are rare and the forest types that contain potential roost trees are facing development pressures. Man-made sites are subject to actions that may render them unsuitable for use by bats and the fact that large numbers of bats concentrate in man-made structures makes this species vulnerable to disturbance and vandalism.

Inter-specific and Intra-specific Aggression in Captive Populations of *Eidolon helvum*, the Straw-colored Fruit Bat and *Pteropus rodricensis*, the Rodrigues Fruit Bat

Becky Houck and Laura Fredenburg, University of Portland, Portland, OR

Megachiropteran fruit bats show complex intra-specific and inter-specific aggressive behavior when maintained in a mixed species captive colony. Forms of aggressive behavior and levels of aggression vary between species and also vary with gender. In this study, displacements both at feeding stations and away from feeding stations were studied in two species of megachiropteran fruit bats maintained together in a mixed species exhibit in 1996 at the Oregon Zoo (Portland, OR). Sex ratios in the two species were almost identical (*Eidolon helvum*: 17.10, *Pteropus rodricensis*: 16.10 at the time of the study). In both species, intra-specific displacements were more common than inter-specific displacements, and the majority of aggressive interactions did not occur near feeding stations. Overall levels of aggression per bat were significantly higher in *Eidolon helvum*, the straw-colored fruit bat than in *Pteropus rodricensis*, the Rodrigues fruit bat. This statistically significant difference may reflect a stronger dominance hierarchy in *P. rodricensis*.

Echolocation as Epiphenomenon

James M. Hutcheon and John A. W. Kirsch, University of Wisconsin, Madison, WI

Recent molecular systematic studies have called into question many long-standing notions about bat systematics, including certain within-bat relationships, bat monophyly, and the outgroup of the Chiroptera. Among the most controversial of these results is the suggestion that the Old World fruit bats (Pteropodidae) and the Old World leaf-nosed bat superfamily (Rhinolophoidea) might, in fact, be sister-groups. Not the least of the implications of this phylogenetic hypothesis is that posed for the evolution of a number of chiropteran characters, especially echolocation. Indeed, the acceptance of this hypothesis demands either the loss of echolocation in the pteropodid lineage or its convergent evolution by rhinolophoids and other microbats. But any phylogenetic hypothesis, whether correct or not, which is at odds with the received wisdom can provide an opportunity for the re-evaluation of features. In particular, echolocation may represent a "character" of dubious merit. Although seemingly a good synapomorphy for Microchiroptera, due both to its complexity and uniqueness, we argue that this character-complex is not always associated with a unitary suite of features and might in fact not be homologous in all bat taxa. Thus, although

parsimony demands the evolution of echolocation as a single event, we submit that the loss or convergent gain of laryngeal sonar in Chiroptera might not be as unlikely as is often assumed. We suggest that, irrespective of the systematic controversy, microbat paraphyly provides an ideal opportunity to examine other aspects of bat evolution which have gone largely unquestioned.

Population Fluctuations in Mexican Free-tailed bats *Tadarida brasiliensis* in Central California. Do Some Bats Migrate?

Dave Johnston. H. T. Harvey and Associates. P.O. Box 1180. Alviso,California. 95002

Although populations of Mexican free-tailed bats *Tadarida brasiliensis* migrate seasonally north and south through many south central U. S. states, this species is not known to migrate seasonally in Arizona and California. Past observations in California suggested that *Tadarida brasiliensis* are resident throughout the year, being active during the warm months but only intermittently active during cool winter months.Eight surveys of the bats at Lemoore Naval Air Station covering 18,000 acres in the San Joaquin Valley of California were made from June 1997 through May 1998 at approximately one month intervals. For surveys, a portable macro-mistnet (20 ft. by 100 ft.) was set in each of four habitat areas. Acoustic surveys were made using the ANAbat 5 Titley Electronics bat detector system connected to a Toshiba laptop PC, and base buildings were visually inspected for roosts. Twelve roosts were identified, although one large roost was destroyed by pest control operators, and therefore excluded from statistical analysis. Most roosts were located on the north sides of buildings and under metal flashing against concrete. Bats found in two roosts numbered about 100 whereas numbers for the other 10 roosts were never greater than 16 individuals each (mean =6.32). Based on day roosting data, population size was significantly greater during the spring and fall seasons (mean = 5.1 + SE 1.14) than the summer and winter seasons (mean = 1.5 + SE 0.48), although the differences between the roosting populations during summer compared with the fall or spring only approached significant differences. The activity levels (number of passes/30 min.) based on ANAbat data matched those of the population data from roost sites (for spring and fall, mean = 26.9 + SE 4.92; and for summer and winter, mean = 4.5 + SE 2.78). The 12 month study suggested that large numbers of *Tadarida brasiliensis* migrated through the study site located in San Joaquin Valley of California during spring and fall seasons, and a smaller number occurred as residents during the summer and winter periods. As the alternative to long distance, north-south migrations, unpublished banding data from Phil Leitner suggested these "migrations" may be due to local seasonal movements within the Sacramento and San Joaquin Valleys, or short, east-west migrations across the Sierra Nevada Mountains.

Distribution of Activity and Roosts of Bats in High Elevation Forests of Coastal British Columbia

M. Kellner and A. Harestad, Simon Fraser University, Vancouver, BC

I examined species composition and distribution of the bat community in the montane zone (> 600 m) of temperate rainforests in coastal British Columbia, Canada. *Myotis volans*, *M. californicus*, *M. lucifugus*, *M. yumanensis*, *M. evotis/keenii*, and *Lasionycteris noctivagans* were caught in mist nets. To examine elevational and temporal gradients in relative activity levels, I conducted monthly surveys using Anabat detectors at ponds from valley bottom (300 m) to subalpine (1200 m). Bats were present at snow-covered high elevation sites when I began sampling in mid-May. Activity of *Myotis* species at mid and high elevations increased as the summer progressed, with extensive use of upper elevation sites by *Myotis* species in July and September. The capture of pregnant or lactating females, or of juveniles, indicated that 4 species (*M. volans*, *M. californicus*, *M. lucifugus*, *M. evotis/keenii*) were likely reproducing in the montane zone. Most bats that were captured and radio-tagged at high elevations roosted in snags at high elevations, in patches of old growth forest. In spite of the cool, damp weather in the coastal mountains, high elevation forests are widely used for foraging and roosting by bats.

Why *Mystacina tuberculata* Gray, 1843 is Not, and What Must be Done About It

John Kirsch, Gregory Mayer, James Hutcheon, François-Joseph Lapointe, and Jacinthe Gingras, University of Wisconsin-Madison and UW-Parkside, WI; and Université de Montréal, Québec

The lesser New Zealand short-tailed bat, sometimes known as *Mystacina tuberculata* Gray, 1843 was, for 14 years after its description, confounded with the New Zealand long-tailed bat, *Vespertilio* (now *Chalinolobus*) *tuberculatus*, the name of which has been variously ascribed to Gray, G. Forster, or J. R. Forster. The confusion can be traced to Gray's original account, in which he used the name *Vespertilio*

tuberculatus, attributing it to G. Forster, for a species of bat for which he then proposed the new genus *Mystacina*, regarding these names as pertaining to but a single species. While it is clear that Gray's account did not make available two species-group names, two other interpretations are possible, depending on who is considered to be the author of the five words used to describe *V. tuberculatus*. If the words are Gray's, *Mystacina tuberculata* Gray is a composite species (including both *Chalinolobus tuberculatus* and *Mystacina tuberculata* of current usage), in which case the name must be settled on one part of that composite. Alternatively, if the words are G. Forster's, Gray's generic name *Mystacina* is based on a misidentified type species, and there is no *Mystacina tuberculata* Gray. In that case, the specific name must be replaced by the next (and in this instance first) available name, which is *velutina* Hutton, 1872, and current usage of *Mystacina* may be preserved by choosing the zoological species before Gray as its type species. We recommend this latter course of action because G. Forster is more likely the author of the description of *Vespertilio tuberculatus*. Implementation of this judgment (1) allows a type specimen of known locality to be selected for *Mystacina velutina*, (2) preserves current subspecific classification of *Mystacina*, and (3) maintains *Mystacina* and Mystacinidae in their familiar applications. The valid name of the lesser New Zealand short-tailed bat is therefore *Mystacina velutina* Hutton, 1872, and we select Hutton's specimen from the Hutt Valley (near Wellington, North Island, New Zealand) as its lectotype.

Artificial Roosts for Bats: Bat Houses and Beyond

Mark Kiser, Bat Conservation International, Austin, TX

More than 1,750 participants in 49 states, eight Canadian provinces, the Virgin Islands, and 11 other countries participated in the North American Bat House Research Project this year. Together they provided roosts for approximately 77,000 bats of ten different species. Of the houses that met BCI's minimum success criteria of height, color and sun exposure, an impressive 75 percent were occupied by bats. Results from the North American Bat House Research Project indicate that bat house success continues to improve. The overall number of occupied bat houses increased from 31% in 1995, 37% in 1996, to 53% in 1997. Some of the improvement reflects the fact that many bat houses are not used until the second or third years, but advances in knowledge of bat roosting needs, improved designs, and installation techniques are also important. In 1997, 58% of all houses installed for at least one year were occupied. Bat houses mounted in groups averaged 21% more successful than those installed alone, and back-to-back pairs were more successful than those mounted side by side. Nursery-style houses were 19% more successful than smaller designs. High occupancy rates were reported for all designs mounted on poles or on masonry or wooden structures, though only 23% of tree-mounted bat houses were used by bats. Several new designs for extra-large bat roosts have been developed and are being field-tested in 1998. BCI is currently working with bat house manufacturers to improve designs and installation instructions through a "Bat Approved" certification program.

Leptin and Reproduction in Free-ranging Little Brown Bats (*Myotis lucifugus*)

Noga Kronfeld, Brian A. Silvia, Patrick T. Mathews, Eric P. Widmaier, and Thomas H. Kunz
Boston University, Boston, MA

During pregnancy and lactation the energetic and nutritional requirements of mammals increase, as does food intake. The mechanisms that enable mammals to maintain appropriate body mass and fetal viability during these periods are not well understood. During the non reproductive periods, leptin, the product of the *ob* gene, serves as a feedback controller of appetite and energy balance, thus affecting body mass. Leptin is produced and secreted by adipocytes, and its levels in the plasma are highly correlated with body adiposity. Recently it was demonstrated that leptin is also synthesized by the placenta in rodents, and thus may play a role in the maintenance of pregnancy and lactation. We quantified plasma levels of leptin during different stages of pregnancy and lactation in free-ranging little brown bats (*Myotis lucifugus*) in Massachusetts. Stage of pregnancy was estimated from the mass of the embryo. Stage of lactation was determined by assessing the developmental age of the pup from each mother/pup pair, based on regression equations previously published for this species. Plasma levels of leptin progressively rose during pregnancy, and decreased within 2-5 days following parturition, as was previously found in humans and rodents. These results suggest a potential role for leptin in the maintenance of pregnancy. The high circulating leptin levels found during pregnancy are not consistent with the accepted action of leptin in suppressing appetite, because appetite typically increases during pregnancy. To determine the relative contribution of fat and placental tissue secretion to the plasma leptin levels found during pregnancy in *Myotis lucifugus*, we measured leptin secretion rates from fat and placental tissue *in vitro* during pregnancy in this species. We

also measured leptin secretion *in vitro* from fat tissue during lactation. Leptin secretion (ng·g dry fat^{-1}) increased until mid-pregnancy and then decreased. Leptin secretion from the placenta increased throughout pregnancy. These results suggest that: (1) Both the placenta and adipose tissue are sources of circulating leptin during pregnancy; (2) The postpartum decline in leptin results from both the loss of placental leptin, a decline in fat content and a decrease in the secretion rate of adipose tissue; (3) Leptin may serve as a reproductive hormone that plays a role in maintenance of pregnancy and/or preparation for lactation in *M. lucifugus*.

Roosting Ecology and Social Organization in the Tent-making Bat *Artibeus cinereus*

Thomas H. Kunz and Gary F. McCracken
Boston University, Boston, Massachusetts; University of Tennessee, Knoxville, Tennessee

Artibeus cinereus (Phyllostomidae: Stenodermatinae) roosts in tents constructed from leaves of eight species of plants in Trinidad, West Indies. Among these are two members of the family Palmae (*Cocos nucifera* and *Manicaria saccifera*), six members of the family Araceae (*Philodendron fragmantissimum*, *P. ornatum*, *P. simsii*, *Anthurium jenmanii*, *Xanthosoma undipes*, and *X.* sp.), and one member of the family Polygonaceae (*Coccoloba latifolia*). Tents were most commonly constructed at heights ranging from 2 to 3 m above the ground, and were found in the lowest tier of leaves. We found no significant differences in the size of leaves used by bats for tent construction among those available, and no significant difference in angular position of leaves chosen for tent construction. The width of leaves and volume of uncluttered space beneath a leaf appears to be the most important criterion used by these bats for tent construction. Roosting groups of *A. cinereus* ranged from 2 to 5 individuals. Preliminary analysis of allozyme data indicates that *A. cinereus* is highly variable in six out of eleven electrophoretic loci examined. This variability was evident both within and among populations. These results suggest that there is no geographic population structuring of this species in Trinidad and that roosting groups are genetically random subsets of the population.

Temporal Distribution of Evening Emergence and Morning Return of *Tadarida brasiliensis mexicana*

Ya-Fu Lee, University of Tennessee, Knoxville, TN

Temporal distribution patterns during evening emergence and morning return by different age, sex, and reproductive classes of *Tadarida brasiliensis mexicana* from a large maternity colony were assessed at Frio Cave, Uvalde, TX. Each night, I sampled bats at an interval of 10 to 15 minutes at the cave entrance during the entire emergence and return periods. Age, sex, and reproductive status of bats were examined immediately on site, and then bats were released. Sampling times and the relative proportions of different classes of bats at each sampling were recorded. Preliminary results suggested that reproductive (pregnant and lactating) females and adult males did not emerge from or return to the cave at random. Higher proportions of reproductive females appeared in earlier times of evening emergence and in later times of morning return. The opposite pattern was observed in adult males and non-reproductive females. This discrepancy between adult bat classes may be a consequence of balancing the degree of hunger, energetic demands, and avoiding the risk of predation. Juveniles did not show clear trends, however, their returns apparently ended at earlier times than adult bats.

Characteristics and Seasonal Occurrence of Michigan Big Brown Bats *Eptesicus fuscus* Submitted for Rabies Testing

Julie Lemson, Michigan State University, East Lansing, MI

Even though there are nine species of bats native to Michigan, the big brown bat (*Eptesicus fuscus*) is the primary species submitted to the Michigan Department of Community Health (MDCH) for rabies testing. In 1997, over 90% of all bats submitted were again the big brown bat. Concurrently, 100% of all bats testing positive for rabies in 1997 were also big brown bats. With the cooperation of the rabies lab at MDCH, all bats received for testing in 1997 were examined. In addition to determining the species of each specimen, each bat was examined for gender, reproduction status, extent of tooth wear, and approximate age of sub-adults based on forearm joint development. From the submission record of each bat, it was also recorded as to the date the animal was tested, which county the animal came fiom and the circumstances surrounding the capture and ultimate submission. A comparison is then possible between all species testing positive for rabies and all those testing negative to see if any commonalties exist within each group, thereby revealing if a trend or pattern exists for either non-rabid bats or those having the rabies disease.

Analysis is also planned on characteristics of big brown bats submitted during the different seasons. As there is commonly an increase in submissions in August and September, age range determination could reveal if a significant portion of the bats are juveniles. Deduction of the data analysis will be presented at the meeting.

The Western Bat Working Group - What, Where, Why, When, and How

Lyle Lewis, Bureau of Land Management, Idaho State Office, Boise, Idaho

The Western Bat Working Group (WBWG) comprises agencies, organizations, and individuals interested in bat research, management, and conservation from 13 western states. The goals of the WBWG are to: 1) facilitate communication among interested parties and reduce risks of species decline or extinction; 2) provide a mechanism by which current information regarding bat ecology, distribution, and research techniques can be readily accessed; and 3) develop a forum in which conservation strategies can. be discussed, technical assistance provided, and education programs encouraged. The WBWG grew from an effort in 1994-96 to develop a range-wide conservation strategy for the Townsend's big-eared bat as part of a proactive conservation approach to preclude a formal listing of the species as threatened or endangered. The first informal meeting to discuss formation of the WBWG was held in January 1996 as part of the Four Corners Regional Bat Conference sponsored by the Colorado Bat Society. The WBWG Workshop held in Reno. The objective of the workshop was to provide states, provinces, federal land management agencies, and interested organizations and individuals a better understanding of the overall status of a given bat species throughout its western North American range. In completing this exercise, the importance of a single region or multiple regions to the viability and conservation of each species would become more apparent. This would also provide a means to prioritize and focus population monitoring, research, conservation actions, and the efficient use of limited funding and resources currently devoted to bats.

Roost Site Selection of Bats in a Temperate Old-growth Forest, Clayoquot Sound, British Columbia

Tanya Luszcz, Ruth van den Driessche and Trudy Chatwin
Ministry of Environment and Lands, Nanaimo, B.C.

Clayoquot Sound on the west coast of Vancouver Island, is an area of high profile land-use conflict. In 1995, local scientific and management groups recognized bats as an important component of forest ecosystems. Due to the remote location and wet conditions in Clayoquot Sound, almost no information existed for bats in this area. We began studies of bat populations in 1996 under direction from the Clayoquot Scientific Panel and a local planning team, with the goal of identifying critical habitat for forest-using bats. Between the months of May - August, 1997 and 1998, we mistnetted bats to determine species presence and to catch bats for radio-tagging. Radiotelemetry was used to track bats (*Myotis evotis/keenii* [endangered in British Columbia], *Myotis lucifugus/yumanensis* and *Lasionycteris noctivagans*) to their day roost sites. To date, eight bats have been radio-tagged and nine day roost sites have been located. Five roosts were in western red cedar trees which ranged in diameter from 1.12 to 3.17 m and have dead tops and extensive cracks leading to interiors decayed by heartrot. One bat was in a rock crevice on a southeast-facing broad cliff band at 900 m in elevation and one was found in a sheltered pocket in a south-facing sea cliff. In addition, two general roost areas were located on steep and sparsely treed cliff bands at 400 to 450 m in elevation. Although there are six species of trees in Clayoquot Sound within the diameter range of the roost trees found, bats were only found roosting in western red cedar trees. These results suggest that bats in Clayoquot Sound have a preference for western red cedar trees as roost sites.

Recent Reproductive Records for the Eastern Small-footed Bat *Myotis leibii* in Kentucky, with Notes on a Maternity Colony Located in a Concrete Bridge

John R. MacGregor and James D. Kiser, USDA Forest Service, Daniel Boone National Forest, Winchester, Kentucky and EcoTech Wetlands Consultants, Frankfort, Kentucky

Mistnet surveys for bats that we have conducted across Kentucky during the past 8 years have resulted in captures of reproductive female and newly volant juvenile Eastern small-footed bats at several locations within Mammoth Cave National Park in west-central Kentucky, near the western edge of the Cumberland Plateau in east-central Kentucky, and in the Cumberland Mountains of extreme southeastern Kentucky. Virtually all captures of reproductive individuals of this species in the Cumberland Plateau and Mountains have been in nets set over small ridgetop ponds and water filled road ruts adjacent to massive sandstone

cliffs. At Mammoth Cave, lactating females were taken over a natural pond on a broad ridge and post-lactating females and juveniles were caught over a well-used trail near a cave entrance. In May, 1997, we discovered several pregnant female small-footed bats that were roosting in narrow concrete crevices along the sides of a bridge spanning the Rockcastle River near the western edge of the Cumberland Plateau. We made several visits to this bridge during the summer months in 1997 and 1998 and were able to document small clusters of up to 5 females with young in these crevices, with as many as 31 bats observed using the bridge at one time. The bridge was exposed to full sun on a daily basis and the concrete became quite warm to the touch on many days. We placed HOBO Temp temperature dataloggers (Onset Computer Corporation) in the maternity crevices to record temperatures at 4.8 hr intervals through the summer months during both years. Our new mistnetting records represent the first reports of reproduction in *M. leibii* in Kentucky, and our concrete bridge apparently represents the first documented maternity colony for the species in the Eastern United States.

Effects of Experimental Cave Tours on Behavior of *Myotis velifer*

Sherry L. Mann, Robert J. Steidl, Virginia M. Dalton. School of Renewable Natural Resources, University of Arizona, Tucson.

We assessed responses of a maternity colony of about 1,000 Myotis velifer to experimental cave tours at Kartchner Caverns in southern Arizona. We used a completely randomized design with factorial structure to investigate three aspects of tours on bats: size of tour groups (small or large), whether tour groups were talking or not talking, and intensity and color of lights (half white, full white, and full red) used to illuminate tour trails. We recorded bats with a night-vision video system consisting of a camcorder, night-vision scope, objective lens, and infrared light source. From tapes, we quantified four behavioral parameters: number of takeoffs, number of landings, activity level (% of colony active), and vocalization intensity. Both number of landings into the colony ($P = 0.0060$) and takeoffs out of the colony ($P = 0.0766$) were highest when full white light was used to illuminate trails. The interaction of group size and voice intensity ($P = 0.0410$) also influenced the number of landings: when tour groups were talking, the number of landings was higher when groups were large than when groups were small, but when tour groups were not talking, the number of landings was higher when groups were small than when groups were large. The interaction of group size and voice intensity ($P = 0.0276$) influenced activity level of the colony: when tour groups were not talking, activity level was higher when groups were large than when they were small, but when tour groups were talking, activity level was higher when groups were small than when they were large. The interaction of voice and lighting ($P = 0.0110$) also influenced bat activity level: in full white and red lights, activity level was higher when tour groups were talking than when they were not talking, and in half white light, activity level was lower when tour groups were talking than when they were not talking. Finally, the interaction of lighting and group size ($P = 0.0862$) influenced the intensity of bat vocalizations: in full white and red lights, vocalization intensity was higher when tour groups were large than when they were small, but in half white light, vocalization intensity was higher when tour groups were small than when they were large. These complex behavioral responses suggest that designing cave tours to minimize short-term effects on bats will require careful consideration of all tour options.

Fruit Farmers' Perceptions of Orchard Protection Against Flying Foxes in Far North Queensland

Megan McHold,
Mount Holyoke College, and the School for International Training, Cape Tribulation, QLD, Australia

Flying foxes in northern Queensland are important in rain forests because of their seed dispersal habits. Little is known about their population size, but scientists suggest that *Pteropus conspicillatus*, the spectacled flying fox, as well as other species are declining. When flying foxes leave the rain forest due to a lack of food, they do a lot of damage to local fruit crops. In the past, the Department of Environment (DOE) has issued permits allowing farmers to exterminate a certain number of bats per season. In 1996, the DOE said that there would be a "phase-out" of lethal methods, and promised to research nonlethal methods. Part of the purpose of this study was to pressure the DOE to keep their promise, by doing or funding research on nonlethal methods. The study also aimed to map suspected colony sites for population research, to hear what methods farmers thought should be researched, to assess the effectiveness, expense, and practicality of each method, and to investigate how much lethal methods were reducing an unknown population size. Ninety-seven farmers in north eastern Queensland agreed to answered a detailed survey over the phone. The

survey asked about experiences with different types of orchard protection, the numbers of bats they saw and killed, the situation of neighboring fruit farms, the location of bat colonies, and hopes for future research. Presently, the options for crop protection against flying foxes are limited. Over canopy netting was 100% effective, though too expensive for most farmers. Draped netting and "Fyre Fox" grids were equally effective, but the electric grids were more practical and lasted longer. Patrolling, and audio and visual deterrents were impractical and ineffective. It was hard to estimate population damage because farmers' average kill per night was so varied, and because they were suspicious of me. Still, it was obvious that farmers contribute to flying fox's population decline as they killed between 1-600 bats a night. The report was sent to the DOE, several farmer associations, and to The Bat Research Station in hopes that the three groups will work together to develop practical nonlethal methods of orchard protection, including those recommended by farmers, like olfactory deterrents, and an auditory system which sounds like a natural predator and reacts according to a motion detector.

* Comparison of Altitudinal Activity and Distribution in the Endangered Hawaiian Hoary Bat*Lasiurus cinereus semotus*

Theresa C. Menard, University of Hawaii, Honolulu, Hawaii

The Hawaiian hoary bat--the only extant bat in the tropical Hawaiian Islands--inhabits a wide altitudinal range (i. e., primarily from sea level to 7,500 ft) on the island of Hawaii. The purpose of this study was to examine data on the bat's activity and distribution for evidence of altitudinal movements. I collected data on bat activity at low (sea level to 2,500 ft), mid (2,500 to 5,000 ft) and high (5,000 to 7,500 ft) altitude sites between Feb 1996 and Jun 1998. The Hawaii Natural Heritage Program (of The Nature Conservancy of Hawaii) compiled data on the bat's distribution from a variety of sources, including published articles, unpublished surveys, and museum specimens. Using the Hawaii Natural Heritage Program's data, I created a set of six maps showing the bat's altitudinal distribution by reproductive period: 1) Jan-Feb (pre-breeding), 2) Mar-May (ovulation\pregnancy), 3) Jun (parturition), 4) Jul (lactation), 5) Aug (weaning), and 6) Sep-Dec (post-breeding). Both the observed activity pattern and the mapped distribution support the following altitudinal movements: 1) bats move out of low altitudes from Jan to Feb, 2) bats extend their range to include low altitudes from Mar to May, 3) bats concentrate at mid altitudes in Jun, and 4) bats extend their range to include low altitudes in Jul. In addition, the distribution data suggest that in Aug bats extend their range to include high altitudes and from Sep to Dec bats move to low altitudes.

* Theresa C. Menard received ***The Speleobooks Award*** for this presentation.

The Effects of Group-selection Timber Harvest in Bottomland Hardwoods on the Spatial Activity Patterns of Bats

Michael A. Menzel, Timothy C. Carter, and Brian R. Chapman, Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA

The effects of forest management practices on the spatial activity patterns of bats are poorly understood. We determined the effect of a group-selection timber harvest on the spatial activity patterns of bats below the canopy at the Savannah River Site, Aiken Co., South Carolina using the Anabat system. We monitored the effect of the silvicultural treatment on feeding and foraging activity at 3 spatial scales: among habitats within a landscape, within the harvested stand, and within an individual gap. Habitats examined included Carolina bays, bottomland hardwoods that had not been recently harvested, a stand of bottomland hardwoods in which a group selection harvest had occurred, and stands of upland hardwoods and pines. Within the harvested stand, we compared the level of foraging and feeding activity among large patch cuts (gaps), small gaps, skidder trails, and forested areas. At the within-gap scale, we compared activity among the center and edge of the gap and the surrounding forest in which the canopy was intact. Six species of bats including Eastern red (*Lasiurus borealis*), Seminole (*L. seminolus*), eastern pipistrelle (*Pipistrellus subflavus*), evening (*Nycticeius humeralis*), Brazilian free-tailed (*Tadarida brasiliensis*), and big brown (*Eptesicus fuscus*) bats were detected in the study area. Levels of bat activity differed among stands, with more activity occurring in the bottomland stand in which the harvest had occurred and around Carolina bays than in unharvested stands of bottomland hardwoods and upland hardwoods and pines. Levels of bat activity also differed among harvested and unharvested areas within the stand and among different positions within gaps and the surrounding forest. At the within-stand scale, activity was concentrated in forest gaps and along skidder trails. Within gaps, activity was concentrated along the edge between the gap and the forest. The spatial activity patterns also depended on the species of bat. These results suggest the inclusion of gaps in bottomland hardwoods not only increases the total level of foraging and feeding activity of bats below the canopy, but

also the amount of time bats spend foraging in a gap is affected by its size. They also suggest that the distribution of foraging among gaps of different sizes and among different locations within a gap depend on the species of bat.

"Bats--The True-Story" Educational Video

Rob Mies and Kim Williams, The Organization for Bat Conservation, Williamston, MI

"Bats--The True Story" includes footage of over 20 different species of bats from regions around the world. This 30 minute video includes interviews with bat researchers and experts in the bat field. Chuck Ruprecht, the nation's authority on bats and rabies, shatters harmful myths about bats and rabies. Susan Barnard, bat rehabilitator and author from Basically Bats, addresses how to help injured and orphaned bats. Cyndi Marks and Dr. Bill Kern, bat house experts from The Florida Bat Center, show a properly-designed bat house occupied by thousands of Mexican free-tailed bats. Kim Whitman, Species Survival Plan coordinator at the Philadelphia Zoological Gardens, discusses the zoo's role in saving endangered bats. John Seyjaget of the Lubee Foundation explains how their facility works with threatened and endangered Megachiroptera. Biologist Dr. Allen Kurta from Eastern Michigan University, demonstrates current research techniques used to track and study bats. The video also highlights The Organization for Bat Conservation's efforts in education, and focuses on conservation of all bat species and the contributions of zoos, bat organizations, government agencies, and scientific researchers. It is geared for all ages.

Anabat: How You Use It Determines What You Learn About Bat Communities

Bruce W. Miller and Michael J. O'Farrell, Wildlife Conservation Society, Bronx, NY and O'Farrell Biological Consulting, Las Vegas, NV

Active monitoring with the Anabat II system has proven to be invaluable in the study of Neotropical non-phyllostomid bat communities. Mist-nets and double-frame harp traps capture different species, thus presenting different views of the community structure. Acoustic survey methods, using the Anabat II system, alleviate much of the mist-net and harp trap induced sampling bias. Acoustic surveys do not sample "whispering" bats (e. g., phyllostomids). The detection of species depends on where and how one samples with the Anabat. We found that fixed site surveys provided data on activity and species composition of bat communities for a discrete area whereas driving transects allowed less detailed information but for a much wider area. Fixed site surveys within forests provided data for understory species, whereas in open habitats, sampling encompassed species that utilize edges, forage above the canopy or high above open areas. Driving transects sample the same microhabitats but provide a landscape-scale examination. A complete examination of community structure requires multiple methods including mist nets, double frame harp traps, and focused acoustic sampling with fixed and mobile components.

Roosting Ecology of the Southeastern Myotis (*Myotis austroriparius*) and Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*) in East Texas

Katy-Marie Mirowsky, Peggy Horner, and Steven A. Smith, Texas A&M University- Kingsville (K-MM, SAS); Texas Parks and Wildlife Department (PH)

The southeastern myotis (*Myotis austroriparius*, federal species of concern) and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*, federal and state species of concern) are rare bats of the southeastern United States whose westernmost ranges occur in the bottomland hardwood forests of east Texas. These bats, although normally considered cave dwellers, are found in many caveless areas where roosting strategies have not been well documented. Thirteen (8 tree and 5 structural) roosts were located for both species by radio telemetry and visual searches. Seven of the eight occupied roost trees (88%) were live trees in the genus *Nyssa* with triangular, basal openings and chimney-like cavities. Diameter at breast height and interior cavity height were significantly greater ($P<0.05$) in occupied roost trees than in unoccupied trees. Occupied roosts were more thermally stable than unoccupied trees. Roost trees were in or near ephemeral water and within 1 km of a large permanent body of water. Bats switched roosts frequently and a seasonal component to roost occupation was observed.

Population Dynamics of the Mexican Long-nosed Bat (*Leptonycteris nivalis*) in Relation to Flowering Agaves in Northern Mexico

Arnulfo Moreno-Valdez, Rodney L. Honeycutt and William E. Grant
Texas A&M University, College Station, Texas

A variety of biotic and abiotic factors can potentially limit the abundance of animal species; however, the availability of food is often singled out as the most important. Food limitation is particularly important in highly mobile endotherms feeding on energy rich food like nectar. However, little is known about the population dynamics of nectarivorous bats in relation to food availability. In this study we analyze the population dynamics of the migratory and nectarivorous Mexican long-nosed bat (*Leptonycteris nivalis*), in relation to food abundance and environmental factors (temperature and humidity). A two year (1997-1998) study is conducted in the Mexican State of Nuevo Leon, particularly at El Infierno cave and surrounding area. Estimations of bat densities and the number of blooming agaves are done by month. Temperature and humidity are recorded each 4.5 hrs inside and outside the bat roost. Bat densities are visually estimated and the numbers of blooming agaves are counted in 70 fixed plots of 100 m radius, each plot is 1 km apart. First year (1997) data indicate that Mexican long-nosed bat abundance at El Infierno cave is correlated with the number of blooming agaves (r^2= 86.6%; $p<0.003$), and has no relation to temperature (r^2= 16.2%; $p>0.5$) or humidity (r^2= 1.9%; $p>0.8$). These findings have tremendous conservation and management implications for this federally endangered bat species. For conservation, it is necessary to protect large areas with wild agave patches, and reduce the use of wild agaves for human consumption. For management, it is necessary to incorporate agave counts at the same time that bat censuses are conducted. This is to discriminate between bad flowering years and real bat declines caused by human disturbances or other mortality factors.

Microchiropteran Diversity in Southern Missouri: A Comparison Between Mist Nets and the Anabat II Bat Detector System

Kevin L. Murray, Eric R. Britzke, Brad M. Hadley, and Lynn W. Robbins
Southwest Missouri State University, Springfield, MO

A survey of bat species was conducted in southern Missouri during the summer of 1998. Both mist nets and the Anabat II bat detector system were used to sample microchiropteran diversity in this area. Mist nets provide valuable information about the vertical stratification, the species diversity, and the relative abundance of bat communities. However, mist nets have several drawbacks. They are often difficult and time-consuming to erect and may cause undue stress to captured bats. In addition, because potential net sites are limited by the type of habitat and accessibility, nets can yield biased samples of bat community activity. The use of ultrasonic bat detectors, like Anabat II, can ameliorate some of these problems in that they are relatively easy to set up, require no direct contact with bats and, in general, can sample a wider variety of habitats. To test the relative merits of these two methods, we set up mist nets over ponds, streams, and flyways in southern Missouri and, at each site, set up an Anabat II bat detector system. This allowed the simultaneous sampling of bat community activity required for this comparison. To further evaluate the utility of mist nets, a comparison was made between 10, 20 and 30 foot nets. Ten foot nets had the highest diversity index, followed by 30 and 20 ft. nets, respectively, indicating that the specific habitat sampled by the mist nets may be more critical than vertical net coverage. Species presence and diversity indices will also be determined for data obtained from the Anabat II system, with recorded echolocation calls identified to the species level using discriminate function analysis.

Nocturnal Activity Patterns of the Indiana Bat, *Myotis sodalis*

Susan W. Murray, Eastern Michigan University, Ypsilanti, Michigan

It is essential to document all the areas an animal utilizes to aid in the conservation of suitable habitat. The goal of this study was to document the activity pattern of individual Indiana bats across the entire night. The study was conducted in southern Michigan, from May to August, 1998. Each bat was tracked for 2-4 full nights, noting when it was flying or roosting, and the habitat that it used. A total of 10 bats were radio-tracked: 5 pregnant, 3 lactating, and 2 juveniles. Pregnant and lactating bats foraged mostly in forested wetlands or riparian areas, although one individual foraged in an upland surrounded by wetlands. The data also suggest that the bats only flew in the cover of trees when flying from one area to another. At least eight different foraging areas were used by pregnant and lactating females, and individual bats often visited the same area or group of areas on consecutive nights. Also, individuals used anywhere from one to four different foraging areas in any one night. Pregnant females night-roosted presumably by themselves, from zero to six

times in each night. Night-roosts were located within the foraging areas, and the bats usually roosted for 10 minutes or less, although some roosted for up to 30 minutes. Lactating bats also night-roosted in their foraging areas, although less often than during pregnancy. Night-roosting by lactating females is in addition to the time they spent at the day-roost with their young. Two juvenile bats were radio-tracked, and they tended to forage and night-roost in the vicinity of their day-roost. They made short trips outside of their day-roosting area, but never stayed in one place for long. Also, juveniles did not use the same flyways or foraging areas that the adults had used, which suggests that the adults might not fly with the young. These results indicate that Indiana bats in Michigan rely on forested wetlands for foraging and night-roosting, and forested flyways are necessary for this commuting to these foraging areas.

* Nutritional Consequences of a Change in Diet from Native to Agricultural Fruits for the Samoan Fruit Bat

Suzanne Nelson, Martin Miller and Edward Heske, The University of Illinois, Urbana, Illinois, and The Illinois Natural History Survey, Champaign, Illinois

Samoan fruit bats (*Pteropus samoensis*), the endemic flying foxes that inhabit the Samoan archipelago, prefer to forage on native fruit species. They have recently been subjected to extreme population threats including hunting and severe storms, as well as large-scale habitat degradation. If habitat destruction continues at its present rate, *P. samoensis* may be forced to forage more within an agricultural matrix. In this study, we analyzed sixteen species of native fruits and four species of agricultural fruit for five organic components and eight mineral nutrients to evaluate whether native fruits provide a higher quality diet or more varied diet than agricultural fruits. We paid particular attention to four species of figs, because figs are often considered an important food item for tropical frugivores. Overall, native fruits provided more variation among fruit species and had higher average values for several nutrients than agricultural fruits. Native fruits were especially high in the biologically important minerals calcium, iron, and sodium, and provided up to 44 times more calcium, 10.5 times more iron, and 8 times more sodium than agricultural fruits. Therefore, *P. samoensis*, which may be feeding as a sequential specialist, may be better able to adjust their diet to obtain higher levels of minerals when consuming a variety of native fruits than if they were restricted to the consumption of only agricultural fruits. Figs were found to be a rich source of nutrients, particularly for calcium. These findings suggest a need to preserve native habitat and to create parks to provide for the long term health and viability of *Pteropus samoensis*.

* Suzanne Nelson received ***The Lubee Foundation Award*** for this presentation.

An Experimental Analysis of Feeding Performance in a Nectarivorous Bat, *Syconycteris australis*

C. W. Nicolay and E. R. Dumont, Northeastern Ohio Universities College of Medicine, Rootstown, OH

Nectarivorous bats possess cranial morphology attributed to adaptations for penetrating flowers and feeding rapidly with the tongue. The long snouts and tongues of nectar-feeding bats appear to be associated with the deep, narrow corollas of many bat-pollinated flowers. If this is the case, then flower shape may influence feeding performance in these bats. An experimental analysis of the effects of feeder shape on feeding behavior and performance was conducted using the nectarivorous species *Syconycteris australis* (Pteropodidae: Macroglossinae) captured at Kau Wildlife Refuge, near the town of Madang, Papua New Guinea. Five bats were observed at each of two feeders that differed in the size of the cone-shaped opening that must be entered to access the 15% honey-water solution. Thirty-one successful feeding bouts were observed at cone-shaped feeders, 25 mm long, constructed with wide (27 mm) or narrow (15 mm) openings. The duration and amount of nectar taken were recorded for each feeding bout. Rate of nectar extraction was calculated from these data. There was variation in individual success at the different feeder types -- three bats readily fed from both feeders, two never successfully fed from the narrow feeder. Perhaps because bats were unfamiliar with the feeders, the duration of the first feeding bout was exceptionally long compared to subsequent bouts. Consequently, data from the first bout were omitted in the following analyses. Bats showed a significantly higher rate of nectar extraction at the wide feeder than the narrow feeder (Mann-Whitney $U = 30.0$, $p = 0.01$). Taken individually, neither the duration nor the amount of nectar extracted per visit differed significantly between feeders. Non-parametric Kruskal-Wallace ANOVA tests among the three individuals that fed successfully at both feeders demonstrated significant ($p < 0.05$) differences between individuals in time spent at the feeder and total amount of nectar extracted, but not in rate of nectar extraction. These results suggest that differences in feeder shape influence feeding performance (rate of extraction) for *S. australis*. Among individuals, differences were observed in behavior (time spent feeding and maximum amount of nectar taken) but not performance. This research was supported by NSF grant (IBN 9507488) to ERD.

A Passive Monitoring System for Anabat II Using a Laptop Computer

Michael J. O'Farrell and Chris Corben,
O'Farrell Biological Consulting, Las Vegas, NV and Rohnert Park, CA

The Anabat II system provides the means to monitor and record bat activity without the presence of an investigator (passive monitoring). This is usually accomplished with an inexpensive tape recorder. However, sequences of calls saved on tape are usually of poor quality due to distortion and extraneous noise making identification of species difficult at best. Recent modifications to Anabat 5 software include the ability to passively save echolocation calls of bats as digital files directly to a laptop computer. We describe the equipment configuration we use for passive data collection, including modifications for use in inclement weather. Both passive systems provide coverage within a cone of reception (45°-angle at 10 m).

The Distributions, Geographic and Secondary Sexual Variation, and Reproduction of Three Species of *Artibeus* (Chiroptera: Phyllostomidae) in Paraguay

Robert D. Owen, Celia López-González, and Gloria González-Bordon, Texas Tech Univ., Lubbock, TX (RDO, CLG); Univ. Nacional de Asunción, San Lorenzo, Paraguay (RDO, GGB); and Oficina de la Autoridad Cientifica, CITES-PY, Asunción, Paraguay (GGB)

Bats of the genus *Artibeus* are considered to be primarily or entirely frugivorous, and although they have been reported to consume a variety of fruit species, they often are captured carrying the fruits of figs (*Ficus* spp.). Although 2-4 species of *Artibeus* are found sympatrically in many regions of the Neotropics, little is known about the potential competitive interactions of these congeners in areas of sympatry. Competition might occur for food, roost sites, or other resources, and might be expressed as spatial or temporal partitioning in feeding or reproduction, as increased displacement of feeding-related characters (i. e., morphology of jaw and dentition, or perhaps wings) in areas of sympatry, or as some combination of these factors. These effects might be more pronounced near the distributional limits of the species, where resources might be more limited (both in abundance and diversity), and more patchily distributed. Three species of *Artibeus* (*A. lituratus*, *A. fimbriatus*, and *A. jamaicensis planirostris*), are at or near their southern or southwestern distributional limits in Paraguay. All three species occur primarily in the eastern half of the country, where they appear to be generally sympatric, although *A. j. planirostris* is less abundant than the other two species. Based upon two years of collecting in Paraguay, and examination of many existing museum specimens, this study evaluates more precisely the distributions of these three species within Paraguay. Based upon a suite of cranial, dental, and wing measurements, we tested for morphometric differences among the species, and for geographic and secondary sexual variation in each of the three species. Although a 2-way Analysis of Variance (ANOVA) shows all characters to vary significantly among species, a Principal Component Analysis (PCA) indicates considerable overlap between *A. lituratus* and *A. fimbriatus*. However, the 2-way ANOVA also shows a significant species-by-sex interactive effect in five of the nine wing characters, and 1-way ANOVAs for sexual dimorphism in each species confirm that *A. lituratus* differs markedly from *A. fimbriatus* in the extent of sexual dimorphism. *A. fimbriatus* exhibits no sexual dimorphism in any character, whereas *A. lituratus* shows sexual dimorphism in all wing characters and in three of the 13 cranial/dental characters evaluated. *A. j. planirostris* is sexually dimorphic only in forearm length. Finally, we examined reproductive cycles in these three species. Although data are inadequate for firm conclusions (especially for *A. j. planirostris*), it appears that at least *A. lituratus* and *A. fimbriatus* exhibit bimodal reproductive cycles through the year, with both species having largest embryo lengths in January-February and again in August-September. There does not appear to be temporal (seasonal) partitioning of reproductive effort between these two species, nor does there appear to be a high degree of synchronicity within either species.

Structural Characteristics of Buildings Used by Bats in Waukesha County, WI: What Factors Should Be Considered?

Deana Pavwoski and Susan Lewis, Carroll College, Waukesha, WI

Waukesha County is one of the fastest growing counties in the state of Wisconsin. As the landscape changes from rural to suburban to urban,the types of buildings available as potential roosting sites for bats also change. In this project, we will investigate the characteristics of buildings occupied by bats in the county through a questionnaire survey sent to the owners of bat-occupied buildings. We will compare these characteristics to those of a randomly-selected set of buildings in order to determine whether the bats demonstrate preferences for particular types of construction or other roost characteristics. Characteristics of interest are likely to include age, type of construction, type of siding, height of building, and location

relative to potential foraging areas or water. The purpose of this preliminary poster is to share our project design and generate discussion about specific factors we should include in the survey.

Bats of Montserrat, BWI: Twenty Years in the Belham Valley

Scott Pedersen and Rick Adams
University of Nebraska, Lincoln, NE and University of Wisconsin, Whitewater, WI

The small British Crown Colony of Montserrat has been battered by hurricanes, notably Hugo, and since 1995, pyroclastic flows from its active volcano have reduced the southern half of the island to an ecological wasteland, destroying roost sites and 70% of the island's foraging habitat. Six surveys spanning 20 years have produced a database including 1200 captures of ten species from 45 locations (275 net-nights). The one site common to all six surveys, the Belham River drainage, had been reduced to an acidic trickle of water by pyroclastic/mud flows as of summer 1998. Crude approximations of the bat population were made using "bat captures per net-night - BNN." These data were then partitioned into three time frames: [Pre-Hugo][post-Hugo + pre-volcano][post-volcano]. If all surveys, species, and locations are considered together, the population reads: [28.5][2.4] [1.5] BNN. As a subset of these, ninety-five net-nights in the Belham yielded 703 captures, or [49.5][3.4][1.8] BNN. More specifically, the composition of the frugivore guild has shifted from being dominated by *Artibeus* and *Monophyllus* (91% of frugivore captures) to a post-volcano frugivore guild composed predominantly by two "frugivore-omnivores," *Ardops* and *Brachyphylla* (60% of frugivore captures). Indeed, the *Brachyphylla* population is doing exceedingly well with population estimates being 3-4 times those recorded in 1994. These 20 years of capture data for *N. leporinus*, *M. plethodon*, *S. thomasi*, *C. improvisum*, *A. jamaicensis*, *A. nichollsi*, *B. cavernarum*, *N. stramineus*, *T. brasiliensis*, and *M. molossus* will be discussed within the contexts of biodiversity and island biogeography. However, it is clear that both Hurricane Hugo and the ongoing volcanic eruptions have had significant impacts on the bat populations of Montserrat. The effects of these two natural disasters are underlined by the disappearance of three species: *Chiroderma*, *Sturnira*, (last seen '78 and '94 respectively, both having been endemics previously known only to Guadeloupe), and *Noctilio* (not found in '98 despite extensive mist-netting, spot-lighting, and echolocation detection efforts).

Neural Processing of Target Distance in the Mustached Bat

Christine V. Portfors and Jeffrey J. Wenstrup, Northeastern Ohio Universities College of Medicine, Rootstown, OH

In the central auditory system of many echolocating bat species, neurons sensitive to the delay between the bat's emitted sonar signal and returning echoes provide a representation of target distance. In the mustached bat, these delay-sensitive neurons are called FM-FM because they respond to the frequency-modulated (FM) sweeps in the pulse and echoes. These FM-FM neurons are different from delay-tuned neurons in other bats because they respond to two different frequency components of the sonar signal; the first harmonic FM sweep (FM1, 24-29 kHz) in the emitted pulse and a higher harmonic FM sweep in returning echoes. We are examining the physiological properties of FM-FM neurons in the inferior colliculus (IC) to understand the mechanisms underlying target distance analysis. FM-FM neurons are found in the tonotopic regions of the IC that represent frequencies within the second FM (FM2, 48-59 kHz), third FM (FM3, 72-89 kHz), and fourth FM (FM4, 96-119 kHz) harmonics of the sonar signal. In the FM3 tonotopic area, at least 50% of neurons are facilitated by the presentation of signals within the frequency range of the pulse FM1. These facilitated FM-FM neurons are tuned to pulse-echo delays of 0-20 ms, corresponding to target distances up to 3.4 m. However, the greatest' proportion of neurons are tuned to pulse-echo delays less than 10 ms, corresponding to target distances up to 1.7 m. This suggests that the mustached bat has a relatively short operational range for echolocation. The high proportion of neurons sensitive to pulse-echo delay in the IC suggests that a representation of target distance already exists at this level of the ascending auditory pathway. The IC projects to many premotor areas (e. g. superior colliculus), thus target distance information may be available at short latency, providing the rapid motor responses necessary for intercepting insect prey.

Status and Population Trends of Bats in the Gila National Forest of Southwestern New Mexico: Preliminary Patterns

Marikay A. Ramsey, U. S. Forest Service, Gila National Forest, Silver City, NM

The 33,000 hectare Gila National Forest encompasses a variety of life zones from desertscrub and semi-desert grassland at lower elevations, to subalpine grassland at the highest. Bats form one of the most diverse vertebrate assemblages in the Gila, with at least 19 species found in the area. Ten are species of concern (former Category 2 Candidates). Bats were sampled using mist nets on more than 40 nights beginning in June 1996. At 17 different sites, over 400 individuals representing 18 species were captured. When compared with previous work, similar numbers of species were detected during current surveys. Relative abundances based on total numbers of individuals captured were comparable, with the exception of five species. *Lasionycteris noctivagans* and *Myotis auriculus* were three and 15 times more abundant, respectively, in this study than earlier observed proportions. However, only a fraction of *M. volans*, *M. evotis*, and *Idionycteris phyllotis* were observed in the current study. Eight species (*M. lucifugus occultus*, *M. thysanodes*, *M. volans*, *M. auriculus*, *Eptesicus fuscus*, *L. noctivagans*, *Lasiurus cinereus*, and *Tadarida brasiliensis*) were captured in a broader range of habitats than previously documented. Diversity at each site did not directly correspond to habitat type or elevation, but instead appeared to be related to structural differences in vegetation and water sources. Sites that exhibited greater bat diversity tended to possess open flyways, and relatively large pools. Six species of bats were captured during winter surveys (*E. fuscus*, *L. noctivagans*, *M. volans*, *M. californicus*, *Pipistrellus hesperus*, and *Antrozous pallidus*). Multiple regression analyses were used to examine environmental parameters favoring bat winter activity, and the onset of increased activity in the spring and summer.

Changes in Body Composition during Reproduction and Postnatal Growth in the Little Brown Bat, *Myotis lucifugus* Using Direct and Indirect Analytical Techniques

D. Scott Reynolds, Boston University, Boston, MA

To better understand the costs of reproduction in small temperate mammals, the body composition of the little brown bat, *Myotis lucifugus* was determined. The changes of the major components of body composition (water, lean dry, and fat mass) during the breeding season were analyzed in adult females as well as during postnatal growth of the young. The reduction of lean dry and fat mass in adult females suggest mineral and fat stores are mobilized to maintain high postnatal growth rates of pups. However, the changes in body composition were small relative to the level of reproductive effort, suggesting that most of the increased costs of reproduction are not met by depletion of body reserves. Further, changes in the GI tract of adult females suggest that most of the increased energy demands of lactation are met through increased food storage capacity. In the pups, a two-week period of postnatal linear growth was followed by a rapid transition from growth to maturation of body composition and maintenance. Both direct (solvent extraction) and indirect (total body electrical conductivity: TOBEC) techniques were used to measure the body composition of little brown bats, *Myotis lucifugus*. TOBEC measurements explained a large portion of the variation in total body water (81%) and lean dry mass (87%), but was least effective at explaining variation in total body fat (46%). Predictive equations generated from body shape and TOBEC indices had a much higher level of explained variation for young bats relative to adult females. Further, mass-specific body composition models (water content, fat index, and percent lean dry mass) had lower explained variation and higher percent error than mass-independent compartments (total body water, total body fat, and lean dry mass).

Obtaining Known Search Phase Call Sequences for Use in the Identification of Unknown Bats

Lynn W. Robbins, Eric R. Britzke, and Derek W. Bossi
Southwest Missouri State University, Springfield, MO

Many recent studies using the Anabat II bat detector and the associated zero-crossing analysis system in conjunction with a laptop computer have shown the utility of this system in studying a wide array of ecological and distributional questions. Many users have purchased this system with the hope that they will now be able to identify bats under natural conditions without the need of disturbing them (i. e., mist-nets, traps, or hand captures). This identification process begins with the realization that all species in the study area must be recorded for later comparison with calls from unknown individuals. The highly variable nature of intraspecific echolocation calls, even under natural conditions, requires that all sequences used for comparative purposes be made under natural conditions. Although extensive familiarity with the bats in a

particular area is an absolute requirement if identification is made using the qualitative "looks like species A" approach, quantitative methodology is possible if more care is taken to obtain complete call sequences from known bats and then use only those calls that show the least amount of variation under natural conditions (search phase calls). It needs to be understood that the majority of call sequences cannot be reliably used for species identification. However, with consistent methodology, bat identification to species will be possible for those who need to have this information, but who are not able to spend the amount of time required to use the qualitative approach.

What Bats Fly When

Scott M. Robertson, Eric R. Britzke, Kevin L. Murray, and Lynn W. Robbins
Southwest Missouri State University, Springfield, MO

Many studies present the fact that bat activity may be staggered throughout the night. In a preliminary study conducted during the summer of 1998, the Anabat II bat detector was used to determine species present throughout the night at multiple sites in southwest Missouri. The data collected show 56.48% of all activity before 1:00 AM occurred within the first 90 minutes after sunset, at an average of 0.67 passes per minute. After a decrease in activity of approximately thirty minutes, activity returned at the average rate of 0.31 passes per minute, and tapered off after 150 minutes. Based on these findings we will simultaneously monitor different habitat types within a given area during August and September. Individual species activity will be examined for both temporal and spatial partitioning within and among the bat communities in various areas.

Methods for Estimating Colony Size of Mexican Free-tailed Bats Roosting in Carlsbad Cavern, New Mexico

William T. Route, David M. Roemer, Val Hildreth-Werker, and Jim C. Werker, International Wolf Center, Ely, MN; Carlsbad Caverns National Park, Carlsbad; & Southwest Composites Photography, Tijeras, NM

Carlsbad Cavern hosts a colony of several hundred thousand Mexican free-tailed bats (*Tadarida brasiliensis mexicana*). Colony size, behavior, and roost geography have all been problematic for obtaining accurate abundance estimates. Past methods have varied from gross ocular counts to complex calculations using video and still photography. No method has provided a measure of precision nor has any method proven valuable as an index to trends. We investigated the use of reflective infrared photography (RIP) for routine monitoring of this colony. The RIP method involves taking repeated infrared still-photographs from fixed points in the roost. Colony size is then estimated from the area of cave ceiling covered by bats. Using a roost density of 2,153 bats/m^2 and the mean area of ceiling covered with bats, we estimated there were 353,000 (+/- 22,000) resident bats roosting in Carlsbad Cavern in fall 1996. We believe that immigration and emigration contributed to increasing trends in area estimates in spring 1996 and 1997, and a decreasing trend in fall 1997. Thus, only the fall 1996 estimate was representative of the resident colony. We argue that with refinements, including monitoring flight noise, developing ceiling contour maps, and carefully timing photography, this method will provide valid estimates of annual trends.

Wallace's Malay Archipelago 140 Years Later: New Biological Explorations in Sulawesi

Luis A. Ruedas, University of New Mexico, Albuquerque, NM

Alfred Russel Wallace, during his travels and travails throughout the Malay Archipelago (1854 - 1862) spent one year on the island now called Sulawesi (September to November 1856; July to November 1857; and June to September 1859). At that time, the island's mammalian fauna was thought to consist of 14 species of non-volant species, as well as seven species of bats. Today, we recognize on the same island 128 described species of mammals, including 71 endemic species; its bat fauna is constituted by at least 53 species, including 13 endemic species. During the period of 14 May - 30 June 1998, I was able to sample some of this fauna as part of a vertebrate biodiversity research project supported by the National Geographic Society. I sampled primary mid-montane forest, highly disturbed coastal habitats, and primary lowland forest. I report herein on the more salient findings, including: a new, distinct, allopatric population of *Thoopterus nigrescens*; a new locality for *Nyctimene cephalotes*; possible presence of *Harpyionycteris celebensis* on the Eastern Peninsula; and indirect evidence for competitive interactions between the widespread *Rousettus amplexicaudatus* and its endemic congener, *R. celebensis*. I discuss these and additional findings in light of past and present conservation exigencies in Sulawesi. The initial results of this research

maintain our current understanding that Wallace's Line is an ecological construct of varying location for different major taxa, rather than a hard and fast line invariably set between biogeographic realms.

Radio Tracking Bats at Night by Airplane Can Be Done Safely, Successfully, and Cost Effectively

Stephen Russ, Oakland, CA

Radio tracking bats at night by airplane can be performed safely, successfully and cost effectively, but it takes careful planning and good communication. There are many essential elements that a primary investigator must identify and address before each flight. The princial investigator must understand the challenges and limitations facing the aviator. The pilot may be flying at night in almost total darkness and instrument conditions. He must avoid unseen mountains. He must locate and track bats that are flying at a fraction of his own speed. He must talk to or monitor air traffic control on one radio and the biologist on another radio, while following the faint beeps of a transmitter from a bat on still another radio. In addition, government regulations, cost, liability, and safety must also be taken into account. This paper describes these elements and how principal investigators should take them into account when using an airplane to track bats at night.

Genetic Structuring of Migratory and Non-migratory Populations of Brazilian Free-tailed Bats *T. b. mexicana* and *T. b. cynocephala*

Amy L. Russell, University of Tennessee, Knoxville, TN

Brazilian free-tailed bats, *Tadarida brasiliensis*, are common throughout the southern United States and Mexico. Within the United States and north-central Mexico, *T. brasiliensis* is presently divided into two subspecies: *T. b. cynocephala* which is located east of Texas to Florida and the Carolinas, and *T. b. mexicana* which is located from Texas west to the Pacific coast and south into Mexico. The main basis for this division is their behavioral differences in migration, hibernation, and roosting habits. *T. b. mexicana* generally roosts in caves in colonies of several million individuals and migrates to winter roosts in Mexico. However, non-migratory populations of this subspecies also exist in western Arizona, Nevada, California, and Oregon. *T. b. cynocephala* roosts primarily in trees and man-made structures in colonies not exceeding several thousand individuals and spends the winter months in hibernation. Because of these differences, *T. b. mexicana* and *T. b. cynocephala* have been classified as subspecies. Some authors have suggested that they warrant recognition as separate species. The putative taxa are not clearly differentiated by morphology, although *T. b. cynocephala* is, on average, slightly larger than *T. b. mexicana*. Schmidley et al. examined populations of *T. brasiliensis* in east Texas using morphological measurements. They found a population with traits intermediate between those expected for the two subspecies, and proposed that hybridization was occurring. McCracken and Gassel, 1997, using allozyme markers found an average genetic similarity of 0.96, a value typical of that found between geographically distinct populations of the same subspecies. They also found that the migratory and non-migratory populations of *T. b. mexicana* could not be distinguished genetically (Nei's genetic identity $I = 1.000$). McCracken and Gassel's data also suggested a possible zone of hybridization between *T. b. mexicana* and *T. b. cynocephala* in Arkansas; however, their study sampled only one population from this purported hybrid zone. I am engaged in a more rigorous and geographically extensive examination of population structuring in *Tadarida brasiliensis* focusing especially on the area of hybridization. This study will use variable microsatellite DNA markers combined with an analysis of DNA sequence variation in a hypervariable region of the mitochondrial DNA d-loop. I hypothesize that this species underwent a geographic retreat into southern Florida and Mexico during the Pleistocene ice age, then expanded its range during the Holocene Era, leading to the current zone of hybridization where the subspecies' ranges overlap. Although an abundant species, the life history and demography of the Mexican free-tailed bat make their populations highly vulnerable. In order to intelligently manage this fragile species, we must have a clear understanding of the genetic structuring of the populations of this species.

Social Organization of the Big Brown Bat, *Eptesicus fuscus*, Based on Microsatellite DNA Analysis

Rebecca A. Russell, Suzanne M. Ambs, Michael D. Sorenson, and Thomas H. Kunz, Boston University, Boston, MA

As part of a larger study on mating systems and social organization in temperate bats, microsatellite DNA variation was assessed to determine paternity in a colony of the big brown bat, *Eptesicus fuscus*. This

species forms maternity colonies in North America, ranging from a few dozen to several hundred individuals, in which each female usually gives birth annually to twins in its eastern range. Wing biopsies were taken from a total of 45 bats (mothers and pups) from a maternity colony located in central Massachusetts, to answer two questions: 1) Does *E. fuscus* have a polygynous mating system, in which young bats are fathered by few or many males? and 2) Are pups from the same litter fathered by the same or different males? DNA was extracted from wing biopsies for each animal. Primers designed for *Nyctalus* for two microsatellite loci were provided courtesy of Frieder Mayer. These two loci were highly variable, with 13 and 14 alleles found in loci Er 115 and Mu 438, respectively. Preliminary results from the microsatellite data suggest that pups within this maternity colony are fathered by at least two or more males. Further microsatellite analyses from other loci will help establish paternity and allow an evaluation of single versus multiple paternity in twins.

Indiana Bat (*Myotis sodalis*) Population Genetic Study

L. R. Saidak, G. F. McCracken, and R. R. Currie
University of Tennessee, Knoxville, TN; and U. S. Fish & Wildlife Service, Asheville, NC

The Indiana bat (*Myotis sodalis*) was federally listed as endangered in 1967. Since then the species has continued to decline over the total range, but some colonies have increased or remained stable. Most mating occurs mid-August to late October at hibernation sites, and it has been suggested that gene flow may be restricted between hibernation colonies. Because most major hibernacula are protected, the loss of summer roosting and foraging habitat may be responsible for the continued decline of the species. In cooperation with federal, state, and private researchers, Indiana bats are being captured by mist-netting from summer foraging habitats and winter hibernation roosts. Two wing-punches 3 mm in diameter taken from each bat provide the DNA for genetic analyses. One goal of this study is to use nuclear microsatellite DNA markers to survey the gene pool of several hibernation colonies and populations using summer habitat sites. If genetic structuring is indicated by this analysis, it will confirm that gene flow is restricted between colonies, as is suggested by behavioral observations. Currently, seven nuclear microsatellite markers have been successfully amplified in Indiana bats. A second goal of this study is to analyze mitochondrial DNA sequence variation among these same populations. Mitochondrial DNA is only passed from mothers to offspring, and sequence variation may allow identification of individual groups belonging to different female lineages. Links between winter roosts and summer maternity colonies will further clarify the potential for and/or existence of gene flow between populations. A DNA fragment thought to represent about six copies of an 82 base pair repeat unit from the D-loop of Indiana bat mitochondrial DNA has been amplified in Indiana bats using primers developed for the large mouse-eared bat (*M. myotis*). This fragment will be sequenced to look for variation between individuals and to identify female lineages. The ultimate goal of this project is to use genetic information to associate declining versus stable or increasing hibernating populations with specific geographic summer habitat areas. Summer habitat factors associated with declining populations may then be identified, leading to management recommendations geared toward reversing declines and recovery of the species.

Roosting and Feeding Behavior of *Diphylla ecaudata*, the Hairy-legged Vampire Bat: Field Observations Using Infrared Videography

William A. Schutt, Jr., Wilson Uieda, and Angelika Bredt, American Museum of Natural History, New York, NY and Bloomfield College, Bloomfield, NJ (WAS); Instituto de Biociências, UNESP, SP, Brasil (WU); and Gerência de Controle de Zoonoses, Instituto de Sadúe do Distrito Federal, Brasília, DF, Brasil (AB)

Most information on vampire bat ecology and behavior has been concerned with the common vampire bat, *Desmodus rotundus*. For example, until now there has been no video record of the feeding behavior of the hairy-legged vampire bat, *Diphylla ecaudata*. Our observations were made over a three night period (Aug 8-10, 1998) at two farms in Midwestern Brazil: Cristal Farm, Padre Bernardo County, Goias State and Grotao-SF Farm, Planaltina County, Distrito Federal. An infrared video camera (SONY TRV-85) was used to record the behavior of *Diphylla ecaudata* at a day roost in Morro Cave, at the Padre Bernardo site. Here, evidence was obtained that *Diphylla* does indeed employ its unique, digitiform calcar as an opposable digit during quadrupedal locomotion thus supporting the hypothesis proposed by Schutt and Altenbach (1998). Additionally, infrared videography was used to record the feeding behavior of *Diphylla* on domestic poultry perched in trees. Observations included: a pre-feeding "fly-by" which directly preceded a landing by the bat on to the posterior ventral region of the prey, feeding behavior (including bites on the digits and cloacal region), prey reaction to the feeding bat (including aggressive attempts to dislodge the bat), termination of feeding,

and flight initiation. This study provides new information on vampire bat feeding and roosting behavior, shows the value of low-cost infrared videography as a tool to study behavior in bats, and further supports the concept that vampire bats should be studied and treated as three separate and very different species.

Temperature Profiles of the Neda Mine Bat hibernaculum

Joseph A. Senlius and James A. Reinarz
Department of Natural Resources and Univeraity of Wisconsin, Milwaukee, WI

The Neda Mine, in south-central Wisconsin, is one of the largest hibernacula for *Myotis lucifugus* in the upper midwest, with a winter population estimated to be in the tens to hundreds of thousands. The mine is very shallow and complex. Collapses which occurred since the mine was abandoned early in the century created nine entrances to the mine. In 1996, the nine entrances were gated or sealed to keep the public out and to protect the hibernating bats. Only five of the nine entrances were used by substantial numbers of bats; these five entrances in the northern third of the mine were fitted with bat-friendly gates. The other four openings were backfilled with boulders or blasted so that coarse rock would block the entrance to humans, but preserve some level of air flow. One of the gated entrances was a cage over a 9 m deep vertical air shaft, three were gates at collapses and one was a gate across a 1.5 m diameter, 27 m long culvert that was placed in a reconstructed adit to the mine. Twenty temperature loggers were placed in the northern two-thirds of the mine at the start of January 1996, at or near the ceiling. The southern third was too unstable for entry at that time. Outside temperature and relative humidity were recorded near the adit and air shaft entrances. Anemometers were placed in the adit and air shaft entrances. Most of the eastern edge of the mine has standing water; in parts of the middle third the water depth is over 4 m. Humidity loggers were placed in the mine, but they all failed because the relative humidity was above their 95% limit. Entrance closure was done the following summer. Environmental monitoring has continued since then. Because of the extensive and complex nature of the mine, we expected that even if changes to the entrances caused local changes in microclimate, there would be enough variety to provide other suitable sites for hibernation. Despite air flow being restricted at a number of entrances and increased drastically at the adit, the internal temperature means and variation were quite similar before and after gating. The hibernation season runs from September until early May. Temperatures ranged between 3 and 9^{o} C which is quite suitable for *M. lucifugus* and has enough latitude so that mean annual temperature shifts will probably not result in the mine being unsuitable.

Wintering Behavior in Nearctic Insectivorous Bats in New Mexico

Jason P. Sexton, John B. Kendall, and William L. Gannon
University of Montana, Missoula, MT (JPS) and University of New Mexico, Albuquerque, NM (JBK, WLG)

For as long as the temperate North American microchiropterans have been studied, they have, for the most part, been considered animals which are adapted to winter resource decline in one of two ways: migration or hibernation. Recent data, as well as various historical anecdotes, illustrate the ability of insectivorous bats to resist constraints and maintain flight and/or foraging activity during winter at temperatures approaching, and in several cases, dropping below 0^{o} C. Thirty-seven nights of mist netting and acoustic sampling using ANABAT resulted in capture of sixty-four individual bats of nine species during the months of January and February 1996, and November 1997 through March 1998: *Antrozous pallidus*, *Corynorhinus towndsendii*, *Idionycteris phyllotis*, *Eptesicus fuscus*, *Lasionycteris noctivagans*, *Myotis californicus*, *Myotis ciliolabrum*, *Pipistrellus hesperus*, and *Tadarida brasiliensis* were captured. Of these species, six are previously undocumented as being active during winter. Here we: 1) document winter activity; 2) correlate this activity with prevailing ambient temperatures; and 3) correlate activity with site characteristics. Bat wintering may have profound effects on the structure of bat community dynamics throughout the year. The prevailing dogma of bat inactivity during the winter should be reevaluated in light of these results.

Leptin Secretion during Pregnancy in Free-ranging Big Brown Bats (*Eptesicus fuscus*)

Brian A. Silvia, Noga Kronfeld, Patrick Mathews, Eric P. Widmaier, and Thomas H. Kunz
Boston University, Boston, MA

Leptin, the product of the *ob* gene, is produced and secreted by adipose tissue and is considered to play an integral role in energy balance in mammals. Leptin has been implicated in the suppression of appetite and stimulation of metabolism by acting upon receptors in the hypothalamus. During non-reproductive periods, circulating plasma leptin levels are significantly correlated with body adiposity. However, leptin levels in maternal plasma have been observed to rise during pregnancy followed by a return to baseline after parturition in mice, humans, and bats. The increase during pregnancy is not correlated with body fat content nor is it associated with suppression of appetite. On the contrary, hyperphagia and a decrease in body fat content are observed during this period. These results, in combination with the discovery of leptin mRNA in placental tissue, suggest that leptin might be secreted from tissues other than adipose tissue and it may play an important role in reproduction. It is likely that the changes in maternal plasma leptin concentrations reflect the role of leptin in the maintenance of pregnancy and the onset of lactation. This study was designed to investigate the relative contributions of adipose and placental tissue secretion toward circulating plasma leptin levels during pregnancy. We evaluated the basal secretion rates, in vitro, of both adipose and placental tissues from the big brown bat (*Eptesicus fuscus*). Leptin secretion from placental tissue increased throughout pregnancy, consistent with the time course of the rise in maternal plasma leptin concentrations. Leptin secretion from adipose tissue (per gram dry fat), however, was observed to decrease as pregnancy progressed. The secretion of leptin from both adipose and placental tissue in early pregnancy may account for the rapid increase in maternal plasma leptin concentration during this period. A more moderate increase is observed from mid- to late-pregnancy, which may reflect decreasing secretion of leptin by adipose tissue and a less profound increase in placental tissue secretion at this stage. The sudden loss of leptin secretion from placental tissue following birth may explain the dramatic decline in maternal plasma leptin concentrations seen shortly after the onset of lactation. These results suggest that both placental and adipose tissue are potentially significant sources of leptin during pregnancy in *E. fuscus* and that the relative contributions of each tissue may change as pregnancy proceeds.

Efficacy of Faunal Inventory Methods in the Neotropics: An Example from French Guiana

Nancy B. Simmons, Robert S. Voss, and Elisabeth K. V. Kalko, American Museum of Natural History, New York (NBS, RSV); University of Tuebingen, Tuebingen, Germany and Smithsonian Tropical Research Institute, Panama (EKVK)

The Neotropics support more bat species than any other zoogeographic region, but the extent of bat diversity at the level of local communities remains to be determined. Range maps suggest that 90-100 bat species could be expected at many Amazonian rainforest localities, but collections rarely exceed 50-60 sympatric species and little is known about how capture methods can bias estimates of diversity patterns and community structure. To address these and other issues, we conducted a four-year inventory of bat species diversity at Paracou, a forestry research station in French Guiana. Working within a 3 km sampling radius, we documented 78 bat species in 168 days using ground-level mistnets, elevated mistnets, and collecting at roosts. The majority of species were captured in ground-level mistnets, but eight species (mostly molossids) were captured only in elevated nets, and five species (mostly emballonurids) were captured only at roosts. The apparent percentage of frugivores (Carolliinae and Stenodermatinae) in the known fauna decreased dramatically over time as continued collecting progressively increased representation of other guilds in our faunal list (e. g., frugivores composed over 70% of the fauna after 14 collecting days, but constituted only 22% of the documented fauna by the end of our study). We supplemented our survey with auditory sampling (recording echolocation calls), and detected four additional taxa (all aerial insectivores) that we did not capture during our inventory. Comparisons of efficacy of sampling methods suggest that frugivorous and gleaning phyllostomids are most effectively sampled with ground-level mist nets, while emballonurids, thyropterids, and furipterids are more easily captured at roost sites. Aerial insectivores (particularly high-flying molossids and vespertilionids) cannot be adequately sampled without use of elevated nets. Auditory sampling holds great promise, but identification of species from recording data is often difficult and requires reference to documented voucher specimens and recordings. Complete (or near-complete) inventories of bat species diversity in Neotropical forests requires prolonged use of multiple sampling methods.

Bats: A Model for the Incorporation of Experiential Education with Emerging Science and Technology Curricula

Jason Taylor, York University, Toronto, ON

Bats provide unique potential as an educational tool. People tend to have extreme positive or negative perceptions toward bats but are very responsive to educational programs. By using this fascination and focussing on the extraordinary aspects of bats, it may be possible to dispel many of the negative myths and attitudes while promoting positive aspects such as conservation. On a broader scale, I think that bat education can be used as a model to help demystify science and nature. Across North America education agendas are heading toward strict science and technology curricula. Bats are an excellent example of the often-overlooked interdisciplinary processes that make up science and society. To name a few examples, there are the social issues relating to myths and misconceptions, the history and physics of echolocation, the biology of hibernation, and the natural history of distribution. All of these attributes can be used to focus the attention of people and show how one animal in nature can be perceived from many different directions. Thinking about the different aspects of bats can help tell us about the interaction of science, technology, and society. This study is examining, through qualitative research methods, how merging holistic environmental education ideals and new science and technology curricula affect perceptions toward animals and nature. I am looking at how experiencing key animals, specifically bats, might be utilized in new science and technology curricula. The goals are to introduce multiple ways of knowing animals, increase awareness about the mechanisms of science, and promote conservation issues. Preliminary findings revealed that educators see live animals as imperative in the development of children's sense of responsibility and respect toward nature. The incorporation of animals in school situations was also seen as an important tool in increasing awareness of the inquiry method and science. Utilizing experiential education with the emerging science and technology curricula appears to be important in promoting environmental and conservation issues.

Roost-site Selection and Habitat Use Versus Availability of the Long-legged Myotis *Myotis volans* in the Managed Forests of the Eastern Cascade Range

Jeffrey A. Taylor, Michigan State University, East Lansing, MI

In 1993, the Northwest Forest Plan was created to balance the needs of wildlife while still meeting the mandate for continued timber production on federal lands of the Pacific Northwest. Private timber companies in the northwest are currently in the process of creating Habitat Conservation Plans that will manage for "species of concern" on their ownerships. However, for many of the species of concern there is very little information available about their habitat requirements. One such species of concern in this region is the long-legged myotis (*Myotis volans*). In 1997, I began a two-year study in cooperation with the Mt. Adams Ranger District of the Gifford Pinchot National Forest and Champion Pacific Timberlands, Inc. to study roost-site selection and habitat use of the long-legged myotis on the east slopes of the Cascades Range. The goals of this study were to assess the specific roost-site attributes that were selected by this species, assess localized habitat use versus availability of this species, and to compare habitat use versus availability across an entire landscape. As this area is in the rainshadow of the Cascades, precipitation declines at a rate of over 1" per mile. Therefore, I selected two sites approximately 15 miles from each other which receive 15-20" difference in precipitation. By comparing these sites, one can determine whether habitat preferences of this species shift across the landscape. The results of this study indicate that bats at the wetter westside site choose very large grand fir snags located in dense mature grand fir/douglas fir stands. These bats never selected any of the retention snags left in harvest areas. The drier eastside bats used significantly smaller grand fir snags located in younger, more open canopy forests of ponderosa pine, grand fir, and douglas fir. Some of these bats were even found in retention snags left in clear-cuts. This seems to indicate that at these drier sites they show more flexibility in the types of snags they will select. This species may very well prefer dense mature forests when given the opportunity, but may be able to deal with younger, more open stands if snag densities are adequately high. The results of this study show that habitat preference appears to shift across the landscape and that decisions on how to manage for this species on the eastside of the Cascades should be based on the particular precipitation regime of the landowner.

Diet and Community Structure of Sonoran Desert Bats

Adrian Tejedor, J. Nathaniel Holland, and Theodore H. Fleming, University of Miami, Coral Gables, FL

We studied the diet and community structure of bats at Organ Pipe Cactus National Monument (ORPI) in spring 1997. We captured 196 individuals of 11 species at 4 water holes, a permanent pond, and a swimming pool. Bats ranged in size from the 3.5 g *Pipistrellus hesperus* to the 63 g *Eumops underwoodi*. *Myotis velifer* was the most commonly captured species whereas two uncommonly captured species, *Plecotus townsendii* and *Eptesicus fuscus*, occurred at the greatest number of sites. We determined bat diets from fecal samples and compared diets with insects caught at a light trap at our netting sites. In general, bats were sampling different insects than our light trap. For example, homopterans appeared in bat feces more frequently than in light trap samples. Dietary analysis revealed three functional groups of insectivorous bats: a group of beetle specialists (*P. hesperus*, *M. velifer*, *E. fuscus*, and *Antrozous pallidus*), a group of moth specialists (*Macrotus californicus*, *P. townsendii* (?)), and a group of dietary generalists (*Myotis californicus*, *Tadarida brasiliensis*). *Leptonycteris curasoae* is a nectarivore/frugivore. We obtained too few fecal samples to classify *Nyctinomops femorosacca* and *Eumops underwoodi* to functional group but noted that both species ate moths and beetles. Among the beetle specialists, *P. hesperus* appeared to be concentrating on species of Tenebrionidae whereas *M. velifer* appeared to concentrate on species of Scarabidae. We ordinate the insectivorous bats of ORPI by morphology and diet and compare species packing in this bat community with that of other insectivorous bat communities.

Use of Rock Crevices as Day Roosts by the Bats of Boulder, Colorado

Katherine M. Thibault and Rick A. Adams, University of Wisconsin, Whitewater, WI

During the summer of 1998, we initiated a study of day roost sites of the nine species of bats that inhabit our study area in the eastern foothills of the Rocky Mountains of Boulder County, Colorado. This study is part of a larger investigation into the relative utilization of resources, especially water, by a bat assemblage. The only known roost site in the study area prior to 1998 was a cave occupied by a maternity colony of *Corynorhinus townsendii* and a colony of *Eptesicus fuscus*. A total of eight bats, representing five species, was equipped with radio-transmitters (Holohil Systems, Inc.) between 1 June 1998 and 6 August 1998; five of these were successfully tracked to their day roosts, including two *Myotis thysanodes* females, one male and one female *M. lucifugus*, and one female *M. ciliolabrum*. All roosts were in rock crevices in south-facing rocks, surrounded by saxicoline brush habitat, and located from 100 to 2000 m from the capture site. The use of rock crevices by female *M. thysanodes* is evidently unusual and, therefore, unexpected in our study area, due to the seemingly high availability of potential roost trees, predominantly Ponderosa pine and Douglas Fir, species used as roosts in other parts of the Rocky Mountains. Since roost sites are believed to be a major limiting factor for temperate bat populations, utilization of similar roosts by sympatric bat species could increase competition and potentially limit population sizes. The apparently high demand for rock crevices on south-facing slopes by the bats of Boulder County is also of concern in terms of conservation, because rock climbing is extremely popular in this area and the human population is growing rapidly.

Progress Report on the North American Bat Conservation Partnership

Merlin D. Tuttle and Steven W. Schmauch, Bat Conservation International, Austin, TX

In its first year, the North American Bat Conservation Partnership awarded $50,000 of grant support to the 17 conservation, education, and research projects rated most important by an independent review panel, and these funds were matched at more than a 10 to 1 ratio by
collaborating partners. In addition, project biologists assisted with more than 48 conservation initiatives and sponsored two workshops on bat monitoring and cave roost protection that were attended by 33 participants from 5 government and 12 private agencies and organizations. The highest current priority is development of a comprehensive, continent-wide strategic plan for bat conservation. The plan will be based on the recommendations of regional working groups and bat research and conservation colleagues in collaboration with a network of more than 150 organizational partners. It will document historic causes of bat decline, set standards for land management activities affecting bats, establish bat research protocol, set broad, continent-wide and regional goals, develop site-specific local and species priorities, and be reviewed and approved by the Partnership's Advisory Counsel of distinguished bat biologists from Canada, Mexico, and the United States. It is scheduled for completion in early 1999 and will be revised biannually.

Post-hurricane Dynamics of *Pteropus samoensis* Populations in American Samoa

Ruth C. B. Utzurrum, Government of American Samoa, American Samoa

The dynamics of populations of *Pteropus samoensis* on Tutuila Island in American Samoa were systematically monitored through monthly visual surveys beginning in 1995 following exposure to successive hurricanes in 1990 and 1991. Spatio-temporal patterns in numbers were examined using multivariate analysis and autoregression techniques. In general, the species appears to have recovered from declines associated with pre-hurricane hunting and hurricanes. However, the increases have apparently reached a stable asymptote in the last 4 years. Despite the lack of interannual variation, significant geographic differences in numbers are seen across the island. This spatial variation is accompanied by significant annual variability. The intra-annual fluctuations, however, lack a clear temporal signal (i. e., no defined seasonality), or correspondence among sites (i. e., largely asynchronous across space). Ecological (e. g., flowering and fruiting phenology) and demographic (e. g., reproduction) correlates of these patterns are currently being investigated in an effort to craft a sound management program for the species.

Habitat Selection by Bats in Temperate Old-growth Forests, Clayoquot Sound, British Columbia

Ruth van den Driessche and Trudy Chatwin, Ministry of Environment and Lands, Nanaimo, B.C.

Clayoquot Sound on the west coast of Vancouver Island, is an area of high profile land-use conflict. In 1995, local scientific and management groups recognized bats as an important component of forest ecosystems. With almost no existing information for this area, we began studies of the bat community with the goal of identifying important bat habitat. Identification of the important habitat will provide forest managers with guidelines that may minimize impacts of forest harvesting on indigenous bat populations. In 1996 and 1997, Anabat II bat detectors were used to survey the relative flight and feeding activity of bat species in a variety of forest stands. Higher numbers of bat passes were found in open forests at lower elevations and lower slope angles. In addition, more bat activity was recorded in stands dominated by western hemlock and amabilis fir compared to western red cedar or yellow cedar stands. In 1998, we used these results to identify topographic, forest structure and species components to predict which stands would have more bat activity and would be most significant in managing forests to maintain bat populations in Clayoquot Sound. To assess roost sites as an aspect of important habitat, we radiotracked male and female bats to their roosts. We radiotagged eight bats and followed them to both cliff and tree roosts. Of the six main tree species in Clayoquot Sound, all five tree roosts were in western red cedar trees suggesting this is an important species for roosting bats. Roost tree diameters ranged from 1.12 to 3.17 m and were characterized by dead tops and extensive cracks in trunks that led to hollow interiors. To evaluate the usefulness to bats of proposed leave strips around riparian areas, we placed bat detectors at the water's edge and at discreet distances into the forest from creeks and lakes. Although significantly more foraging activity was detected over water than in the adjacent forest, the amount of activity did not decrease with distance from water's edge as we had hypothesized. This suggests we should be wary of presenting a simplified picture of bat use of riparian zones and emphasizes a need for further research to guide management of forests in Clayoquot Sound.

*** Social Organization of the Neotropical Disk-winged Bat, *Thyroptera tricolor***

Maarten J. Vonhof, York University, Toronto, ON, CANADA

The neotropical disk-winged bat, *Thyroptera tricolor*, commonly roosts in young, tubular leaves of several genera of plants in the order Zingiberales, including *Heliconia*, *Calathea*, and banana plants. Roosts of this type are only available as roost-sites for a short period of time, because the leaf generally opens quickly, and therefore individuals must search for a new roost-site each day. However, potential roost-sites may be locally abundant, as suitable plants often occur at high densities in secondary habitats. Because of the abundance of potential roost sites and the high potential for mixing relative to bats that can come back to the same roost-site day after day, I predicted that groups of *T. tricolor* would not be stable and be composed mostly of non-related individuals. I studied *T. tricolor* at the Cano Palma Biological Station, located between Tortuguero National Park and Barra del Colorado Wildlife Refuge on the Caribbean coast of Costa Rica. At intervals between February 2 and May 28, 1998, I searched areas of secondary forest for roosts used by *T. tricolor*. By keeping track of the number of potential roost-sites searched in a given area, I was able to calculate both the density and occupancy rate of suitable leaves. Bats were captured at roost-sites, sexed, aged, measured, and outfitted with individually-numbered plastic split-ring bands. In addition, I took two 2 mm punches from the wing membranes of each individual for genetic analysis. To determine how long leaves were available to *T. tricolor*, I followed the growth of 20 leaves of each of the five species of suitable plants

in the study area (*H. irrasa*, *H. latispatha*, *H. pogonatha*, a *Calathea* sp., and banana), by measuring the diameter of the opening and the length of the tube twice daily until the leaf opened. I will present preliminary data on the density and longevity of potential roost-sites, group stability, and timing of reproduction, as well as plans for future research.

* Maarten J. Vonhof received ***The Bat Conservation International Award*** for this presentation.

High Altitude Movements of Mexican Free-tailed Bats and Migratory Insect Pest Populations as Assessed by Doppler Weather Radar

John K. Westbrook, Gary F. McCracken, Wayne W. Wolf and Jim D. Ward, USDA, ARS, SPA, College Station, TX; The University of Tennessee, Knoxville, TN; USDA, ARS (retired), College Station, TX; and USDC, NOAA, NWS, New Braunfels, TX

The U. S. network of WSR-88D Doppler weather radars (NEXRAD) detects weather patterns from the movement of precipitation in the atmosphere. Large numbers of Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) flying above south central Texas reflect about the same radar energy as a hail storm, and the bats are unavoidably detected during the normal operation of NEXRAD. Detection of populations of smaller objects, such as corn earworm (*Helicoverpa zea*) moths, is similar to that of light rain or aerosol particles of clouds. The question is whether NEXRAD can distinguish the movement patterns of large populations of migratory insect pests from normal weather activity. If so, NEXRAD may be a powerful tool for coupling insect movement patterns with bat movements, and documenting the interception of major insect pest migrations by millions of bats. The aerial abundance of corn earworm-size targets, as measured with mobile entomological radar, was compared to the base relectivity measured by NEXRAD. These calibrations, and comparison of the radial component of the true wind velocity with the base (radial) velocity measured by NEXRAD, indicate good potential for areawide detection of insect dispersal flights. The NEXRAD radar at Brownsville, Texas documents the northward dispersal of billions of corn earworm-size targets from 500,000 acres of fruiting corn in the Lower Rio Grande Valley of northeastern Mexico and southern Texas. Concurrently, the NEXRAD radar at New Braunfels, Texas, documents flights of millions of bats from large cave roosts in south-central Texas.

Ontogeny of the Basicranium in the Indian False Vampire Bat *Megaderma lyra*

John R. Wible and Dianne L. Davis

Carnegie Museum of Natural History, Pittsburgh, PA and University of Louisville, Louisville, KY

Basicranial characters have long played a significant role in assessments of higher- and lower-level phylogeny within Mammalia. Chiroptera, however, is one order in which basicranial characters have traditionally had little impact. Accounting for this in part is the sutural fusion encountered in adult chiropteran skulls, which masks the identity of basicranial elements. To avoid this pitfall, the study of ontogeny provides an additional level of analysis for understanding adult morphology. As part of an on-going project on basicranial ontogeny in Chiroptera, we report here on serially-sectioned prenatal specimens and adult skulls of the megadermatid *Megaderma lyra*. We focus on those features that traditionally have been used in phylogenetic analyses of other mammalian groups, i.e., the components of the tympanic roof and floor (auditory bulla), and the basicranial vasculature. Without access to the prenatal specimens, we would have been unable to fully comprehend the components of the adult tympanic roof and floor. Regarding the tympanic roof, as in all bats studied to date, *Megaderma lyra* has an anteroventral process of the tegmen tympani that forms the medial wall of the epitympanic recess and provides attachment for the tensor tympani muscle. Moreover, as in all microchiropterans studied to date, this process fuses with the enlarged cartilage of the auditory tube. Regarding the tympanic floor, as in all bats studied to date, *M. lyra* has two entotympanics, rostral and caudal, and as in other microchiropterans, an expanded ectotympanic. Regarding the basicranial arteries, the overall pattern in *M. lyra* with a well-developed stapedial system resembles that reported previously for vespertilionids, rhinolophids, and phyllostomids, but differs dramatically from that in megachiropterans in which the stapedial artery is absent in the adult. *M. lyra* also exhibits a number of unusual or potentially unique basicranial features as well: for example, a foramen in the tegmen tympani transmitting a branch of the stapedial artery, a rostral entotympanic that does not contribute to a canal for the internal carotid artery and that forms earlier than the caudal entotympanic, and an alisphenoid canal. Evaluation of the phylogenetic valence of these features awaits similar observations from additional relevant taxa.

Phylogeography of the Big Brown Bat *Eptesicus fuscus* in North America

Bronwyn Williams, Thomas H. Kunz, Virginia Hayssen, and Michael D. Sorenson
Smith College, Northampton, MA (BW, VH), and Boston University, Boston, MA (THK, MDS)

The big brown bat (Eptesicus fuscus) is widely distributed in North and Central America, where it occupies many different habitats and forms relatively discrete breeding colonies in buildings and hollow trees. Strong female site fidelity suggests the potential for significant phylogeographic structure in mitochondrial DNA (mtDNA) and the opportunity to explore the historical relationships among big brown bat populations and subspecies. We extracted DNA from wing and/or muscle biopsies from samples representing various regions across the North American continent and sequenced the RhypervariableS 5U end of the mtDNA control region. Preliminary analysis of samples from Massachusetts, New York, Wisconsin, Idaho, and California reveals substantial differences in mtDNA sequences between eastern and western populations and in the number of repeat units (~82 base pairs each) in the control region. Sequencing of additional samples from other localities is in progress.

Microsatellite Analysis of Mating Systems and Genetic Variability in Straw-colored Fruit Bats *Eidolon helvum*

Jan M. Zinck, Portland State University, Portland, OR

One of the primary concerns of species conservation is the retention of genetic variation. Maintaining genetic diversity in captive populations is therefore an important goal of breeding plans. Captive propagation programs provide opportunities to test the efficacy of molecular techniques for determining relatedness and parentage. Genetic analysis of captive populations can also be used in support of zoo breeding programs because knowledge of their relatedness is critical for effective management. Group-housed animals such as bats are difficult to manage because paternity, and sometimes even maternity, is unknown. The current captive population of Eidolon helvum in American Zoological Association (AZA) institutions was founded by seven individuals and has grown to 204 individuals in fourteen zoological parks. In addition to determining the captive mating system, the presence of these founders and the subsequent generations make the AZA populations of E. helvum an excellent model for assessing the use of genetics in management. Eight microsatellite loci, developed in the laboratory of Dr. Gary McCracken for Old World fruit bats of the genus Pteropus, were tested for applicability in E. helvum. Primer sequences for all eight microsatellites are present in E. helvum. Variability within several of the microsatellite loci has been detected in E. helvum. Comparison of the genotypes of known mother/pup pairs have shown the microsatellite markers to be heritable, and has allowed for identification of sires by exclusion. Analysis of parentage in the AZA breeding colonies is being used to determine the captive mating system of E. helvum and to monitor any loss of genetic variability in these colonies. Use of molecular techniques to identify parentage will greatly enhance zoos' abilities to maintain genetically healthy, self-sustaining captive populations, and can be used to test the effectiveness of these techniques for use in wild populations.

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Local Chair's "After the Meeting" Comments

Greetings from the beautiful Ouachita National Forest, host to the 28th North American Symposium on Bat research this past October in Hot Springs, Arkansas. I hope you had to opportunity to attend the Symposium, but if not, enjoy the abstracts of the presentations (above). Fortunately for all of us, we have been blessed with Roy Horst whose tireless efforts allow us to have this information in one handy volume of Bat Research News. But long before these abstracts reached your mailbox, Program Co-directors Margaret and Ton Griffiths had worked long, hard hours sending out the meeting announcement and call for papers, making arrangements for facilities, hotels and coordinating endless details with the Local committee. Once they received the preregistration packets and abstracts, the fun really began with organizing and printing the program, the bookkeeping and on and on. I like to refer to Margaret, Tom and Roy as the "Dynamic Trio." I am also honored to call them my friends. So the next time you see these characters, pat them on the back and thank them for providing us with " the symposium", with an outstanding outlet for news about bats and wonderful memories of great "bat meetings". Perhaps more

importantly, remember they do it because they want to, not because they have to. As Local chair for the 28th symposium, I am forever indebted to Margaret and Roy and the other members of the Local Committee, Robin Vaughn, Randy Nichols, Lori Short, Lydia Wilborn, and Samuel Larry for a successful and memorable meeting.

David Saugey, Local Committee Chair, Ouachita National forest

Twenty-eighth Annual North American Symposium on Bat Research

Thomas A. Griffiths, Program Director, NASBR
Dept. of Biology, Illinois Wesleyan University, Bloomington, IL 61702

The twenty-eighth annual North American Symposium on Bat Research met at the Hot Springs, Arkansas, Convention Center and at the Arlington Hotel in Hot Springs from October 28-31, 1998, sponsored by the United States Forest Service, Ouachita National Forest. David Saugey was the conference host, ably assisted by the members of his Local Committee: Robin Vaughn, Randy Nichols, Lori Short, Lydia Wilborn, and Samuel Larry. There were 231 registered participants (not counting the educators who attended the special Bat Conservation Workshop on Saturday morning). In terms of numbers of participants, the 28th annual symposium is tied with the 23rd annual symposium in Gainesville as the second largest regular (non-international) North American meeting ever held (Horst, 1995; Griffiths, 1996, 1997). Only the 27th annual meeting in Tucson, with 269 registered participants, has been larger. One hundred and two scientific papers were presented at the Hot Springs meeting, not counting the special presentations for teachers made during the Saturday morning workshop. Thirty-five of these were poster presentations. According to the official records of the symposium (Horst, 1995; Griffiths, 1996, 1997), this number of presentations ties for first place with the Tucson meeting for the largest number ever given at a regular meeting.

Following a long-standing tradition, graduate and undergraduate student participants were invited to enter their presentations (both platform papers and posters) in a competition which judged their merits. A special committee headed by Roy Horst judged twenty-two student platform papers and four student posters. Four cash prizes of $250 each were awarded at the Friday evening banquet. Maarten J. Vonhof of York University won the Bat Conservation International prize, Bryan Chruszcz of the University of Calgary won the Bat Research News prize, Suzanne Nelson of the University of Illinois won the LuBee Foundation prize, and Susan M. Davidson of the University of Maryland won the very first Karl F. Koopman prize. For the second year in a row, a special SPELEOBOOKS merchandise prize was awarded to Theresa Cabrera Menard of the University of Hawaii for the best poster (nice going, Theresa). Generous monetary donations from Roy Horst at Bat Research News, Roger Haagenson and John Seyjagat of The Lubee Foundation, and Emily Davis Mobley of SPELEOBOOKS made the first three prizes possible. Donations from a number of individuals (many requesting anonymity) made the Karl F. Koopman Prize possible.

Pat Knighten of the Arkansas Game & Fish Commission, Pat Morton of Texas Parks and Wildlife, and Janet Tyburec of Bat Conservation International organized and ran the special bat education workshop on Saturday morning of the conference. It was very well attended by Arkansas teachers, conservation workers, and other local persons interested in the conservation of bats. This was the third year in a row that we have run this workshop in conjunction with the NASBR. We hope to do this again in the fall at Madison, Wisconsin and annually thereafter. I thank Pat K., Pat M., and Janet for their efforts which made the workshop possible.

Finally, let me extend David Saugey's and my special thanks to Dianne Saugey (David's wife), Margaret Griffiths (my wife), and Roy Horst (the Founder of our "feast") for all the hard work they did to make this meeting a rousing success.

Literature Cited

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------. 1997. Twenty-seventh annual North American Symposium on Bat Research. Bat Research News, 38: 145-146.

Horst, G. R. 1995. A brief history of the annual North American Symposia on Bat Research. Bat Research News, 36: 129-132.

The Hot Springs Teacher Workshop: GUANO HAPPENED!

Thirty-five teachers attended the 1998 workshop held in association with the North American Symposium on Bat Research in Hot Springs, Arkansas. Thanks to local coordinator, Pat Knighten, from Arkansas Game and Fish Commission most of the participants recruited were ProjectWild facilitators. These folks are specially trained educators who give teacher workshops in Arkansas on a regular basis. Our investment in these men and women will be multiplied many times over. The other person who made a big difference with every aspect of the workshop was the symposium co-chair, David Saugey, who found sponsors, donated handouts, supplied ten microscopes, and gave us the best (and only completed) rooms in the new convention center! With Saugey-facilited donations from the Arkansas Chapter of The Wildlife Society, Arkansas Field Office of The Nature Conservancy, Arkansas Game and Fish Commission, Arkansas Game and Fish Foundation, Arkansas Academy of Sciene, the National Forest Foundation, Weyerhaeuser Corporation, and Speleobooks, we were able to provide each teacher with a generous packet of classroom materials and activities including books, videos, posters and curriculum guides. Bat Conservation International was kind enough to supply many of the materials at wholesale cost which made our donation dollars go farther. Many thanks to our faculty who gave presentations to the educators: Pat Knighten (Arizona Game & Fish), Mick Harvey (Tennessee Tech University); Stuart Perlmeter (Thurston Senior High School, Oregon); Janet Tyburec (Bat Conservation International); and Pat Morton (Texas Parks & Wildlife). By the way, guano did happen. One of Perlmeterís contributions to the workshop was a packet of Oregon bat guano for each teacher that was used in a classroom activity of examining guano under a microscope to identify insect parts. Other workshop topics included bats of Arkansas (Harvey), a bat get-acquainted activity (Morton), a demonstration of the new BCI Discover Bats! curriculum (Tyburec), a bat feeding activity (Knighten) and a slide show on bats of the world (Tyburec). Arkansas Game and Fish also provided a fine lunch for everyone and there were enough donated door prizes for everyone. Thanks to everybody who had a part in making this a truly superb workshop! A very special thanks to sponsors. With their help the bat conservation message is now reaching many learning institutions across the state of Arkansas. Plans are already underway for the 1999 workshop in Madison, Wisconsin. Please let me know if you have a classroom activity you would like to present. Pat Morton (patricia.morton@tpwd.state.tx.us).

Two of the Teacher Workshop participants identifying insect remains in guano samples.

List of Participants

28th Annual North American Symposium on Bat Research, Hot Springs, AR

Rick A. Adams, Univ. of Wisconsin-Whitewater, Asst. Prof., 800 W. Main St., Whitewater, WI 53190-1790, adamsr@uwwvax.uww.edu.

Julie Alpert, EcoVentures California, Senior Wildlife Ecologist, P.O. Box 2084, Julian, CA 92036, EcoVenture@aol.com.

Sybill Amelon, U.S. Forest Service, Wildlife Biologist, P.O. Box 291, Houston, MO 65483.

Brian Amman, University of Southern Colorado, Grad. Student/Lecturer, 3704 Elmwood Cr, Pueblo, CO 81005, parbo@fone.net.

Loren K. Ammerman, Dept. of Biology, Univ. of Texas at Arlington, Arlington, TX 76019, loren@uta.edu.

Fred W. Anderka, Holohil Systems Ltd, President, 112 John Cavanagh Rd., Carp, Ontario, Canada K0A 1L0, HOLOHIL@LOGISYS.COM.

Patricia Angehrn, Holohil Systems Ltd, Secretary-Treasurer, 112 John Cavanagh Rd., Carp, Ontario, Canada K0A 1L0, HOLOHIL@LOGISYS.COM.

Brady Baker, Arkansas State Univ., 1400 Elmdale Apt. B, Jonesboro, AR 72401, Batfinkx@aol.com.

Suzanne Baker, James Madison University, Assoc. Prof., Dept. of Psychology, JMU, Harrisonburg, VA 22807, bakersc@jmu.edu.

Kathleen Bander, 5208 45th Ave. SW, Seattle, WA 98136.

Robert Barclay, Univ. of Calgary, Dr., Biological Sciences, Calgary, AB, Canada T2N 1N4, barclay@ucalgary.ca.

Sue Barnard, Zoo Atlanta, Assist. Curator/Herpetology, 6146 Fieldcrest Dr., Morrow, GA 30260, Suebarnard@juno.com.

Jacqueline Belwood, Ohio Biological Survey, 4949 Tealtown Rd, Milford, OH 45150, OhioBats@aol.com.

Robert Berry, Brown-Berry Biological Consulting, 134 Wilkes Crest Rd, Bishop, CA 93514, Bobpatbat@aol.com.

Burr Betts, Eastern Oregon Univ., Professor of Biology, 1410 L Ave., La Grande, OR 97850-2899, bbetts@eou.edu.

Kunwar Bhatnagar, Univ. of Louisville, Professor, 2651 Kings Hwy, Louisville, KY 40205, kpbhat01@ulkyvm.louisville.edu.

Frank Bonaccorso, Papua New Guinea National Museum, Chief Curator, P.O. Box 6055, Boroko, Papua New Guinea, pngmuseum@global.net.pg.

Sylvie Bouchard, York Univ., Ph.D. Student, Dept. of Biology, 4700 Keele St., Toronto, ON, Canada M3J 1P3, sylvie@yorku.ca.

Tina Bowen, Ouachita Baptist Univ., 611 N. 12th St., Arkadelphia, AR 71923, TinaBowen@mailcity.com.

John Bowles, Bat Conservation International, Research Assoc., P.O. Box 162603, Austin, TX 78716-2603, jbbowles@centuryinter.net.

Mark Brigham, Biology, Univ. of Regina, Assoc. Professor, Regina, SK S4S 0A2, Mark.BRIGHAM@uregina.ca.

Eric Britzke, Southwestern Missouri State Univ., 901 S. National, Springfield, MO 65804, erb167s@nic.smsu.edu.

Anne Brooke, Migration Specialist, Box 102, Newfields, NH 03856, abrooke@nh.utranet.com.

Patricia Brown, Dept. of Physiological Sciences, UCLA, 134 Wilkes Crest Rd, Bishop, CA 93514, Patbobbat@aol.com.

Timothy K. Brown, T. K. Brown & Assoc., P. O. Box 6252, Bellevue, WA 98008.

Steve Burnett, Ohio State Univ., Dept. of Evolution, Ecology, & Organismal Biology, Grad. Teaching Assoc., 1735 Neil Ave., Columbus, OH 43210, burnett.33@osu.edu.

Deanna G. P. Byrnes, Dept. of Zoology & Univ. of Wisconsin Zoological Museum, Grad. Student, 430 Lincoln Dr., Madison, WI 53706, dpbyrnes@students.wisc.edu.

Carolina Caceres, Univ. of Calgary, Student, 2000 University Dr., Calgary, Alberta, Canada T2N 1N4, mccacere@acs.ucalgary.ca.

Karen A. Campbell, Albright College, Chair & Assoc. Prof., Biology Dept., Reading, PA 19612-5234, Karenc@ joe.alb.edu.

Polly Campbell, Museum of Southwestern Biology, 1002 Central Ave. S.W. Apt. A, Albuquerque, NM 87102, Polly@sevilleta.UNM.EDU.

Participants, 28th NASBR continued

John J. Christensen, Christensen Designs, 349 Scenic Place, Manteca, CA 95337, John@PeeperPeople.com.

Bryan Chruszcz, Univ. of Calgary, Student, Dept. of Biology, 2500 University Dr., Calgary, Alberta, Canada T2N 1N4, bjchrusz@acs.ucalgary.ca.

Mary Kay Clark, N. C. State Museum of Natural Sciences, Curator of Mammals, P.O. Box 29555, Raleigh, NC 27626, mkclark@ncdial.net.

Phillip D. Clem, Univ. of Charleston, Asst. Professor of Biology, 2300 MacCorkle Ave., Charleston, WV 25304, pclem@uchaswv.edu.

Shawn Cochran, Arkansas State Univ., Grad. Student, P. O. Box 1675, State University, AR 72467.

Lynn Cole, Museum of Discovery, Curator of Life Science, 500 E. Markham, Suite 150, Little Rock, AR 72201, slcole@amod.org.

Lisa B. Comeaux, Univ. of Tennessee, Grad. Student, 569 Dabney Hall, Knoxville, TN 37996, lcomeaux@utk.edu.

Tenley Conway, American Museum of Natural History, Scientific Asst., Central Park West @ 79th, New York, NY 10024, conway@amnh.org.

Theresa J. Cross, Univ. of Memphis, Grad. Student, Dept. of Biology, Memphis, TN 38152-6080, tjcross@cc.memphis.edu.

Betty Crump, USFS Ouachita National Forest, Wildlife Biologist, 912 Smokey Bear Ln, Glenwood, AR 71943, bcrump/r8_ouachita_caddo@fs.fed.us.

Robert R. Currie, US Fish & Wildlife Service, Fish & Wildlife Biologist, 160 Zillicoa St., Asheville, NC 28801, Robert_Currie@fws.gov.

Ginny Dalton, Univ. of Arizona, Adjunct Faculty, Wildlife & Fisheries Science, 1468 N. Westridge Ave., Tucson, AZ 85745, PLECOTUS@AOL.COM.

Marcia Daniels, 34 Madeira Dr., St. Augustine, FL 32084.

Liliana Dávalos, AMNH, Central Park West at 79th St., NY, NY 10024, davalos@amnh.org.

Susan Davidson, Univ. of Maryland, Grad. Student, Dept. of Biology, UMD, College Park, MD 20742, sd113@umail.umd.edu.

Tagide deCarvalho, Museum of Southwestern Biology, Student, Univ. of New Mexico, Albuquerque, NM 87131, monkey1@unm.edu.

Dina Dechmann, Swiss Federal School of Polytechnics, Eschwiesenstr. 18, Zurich, Switzerland 8003, ddechmann@hotmail.com.

Scott DeMers, Eastern Michigan Univ., Grad. Student, 1307 University, E. Lansing, MI 48823.

Carl W. Dick, Texas Tech Univ., student, Dept. of Biological Sciences, Lubbock, TX 79409-3131, BCRDO@TTACS.TTU.EDU.

Michael Dixon, Texas Wesleyan Univ., Assoc. Professor, 1201 Wesleyan St., Fort Worth, TX 76105, mdixon@flash.net.

Sue Dotson, 118 Washington St., Frostburg, MD 21532, sdotson@mindspring.com.

Sheryl Ducummon, Bat Conservation International, North American Bats & Mines Project Director, P.O. Box 162603, Austin, TX 78716, sducummon@batcon.org.

Betsy Dumont, N. E. Ohio Univ., College of Medicine, 4209 State Route 44, Rootstown, OH 44240, erd@riker.neoucom.edu.

Johan Eklöf, Dept. of Zoology, Göteborg Univ., Grad. Student, Box 463, Göteborg, Sweden SE-405 30, johan.eklof@zool.gu.se.

Angela England, Bat Conservation International, P.O. Box 162603, Austin, TX 78716, aengland@batcon.org.

Jamie Ewing, Arkansas Natural Heritage Commission, 1500 Tower Building, 323 Center Str., Little Rock, AR 72201, jamie@dah.state.ar.us.

Robert Faught, EcoVentures California, Senior Wildlife Ecologist, P.O. Box 2084, Julian, CA 92036, EcoVenture@aol.com.

Brock Fenton, York University, North York, Ontario, Canada M3J 1P3, bfenton@circus.yorku.ca.

Laura Seckbach Finn, Fly By Night, Inc., President, 431 Sheryl Dr., Deltona, FL 32738, LSFINN@AOL.COM.

Judy L. Fisher, Tri-State Grotto, Chair, P.O. Box 276, Berkeley Spgs., WV 25411, jcf@access.mountain.net.

Theodore H. Fleming, Univ. of Miami, Professor, Dept. of Biology, Coral Gables, FL 33124, tfleming@umiami.ir.miami.edu.

Steve Ford, Pittsburg State Univ., Prof., Pittsburg, Kansas 66762, SFord@Pittstate.edu.

Participants, 28th NASBR continued

Suzanne Foxworth, Texas Wesleyan Univ., 1201 Wesleyan St., Ft. Worth, TX 76105, Foxysuzi@aol.com.

Trish Freeman, Univ. of Nebraska State Museum, Professor, W-436 Nebraska Hall, Lincoln, NE 68588-0514, pfreeman@unl.edu.

William L. Gannon, Museum of Southwestern Biology, Univ. of New Mexico, Albuquerque, NM 87131, wgannon@unm.edu.

Sharon Gill, York Univ., Biology Dept., 4700 Keele St., Toronto, Ontario Canada M3J 1P3, sagill@yorku.ca.

Tom Gordon, S.U.N.Y. Stony Brook, Stony Brook, NY 11794, trux1964@life.bio.sunysb.edu.

Jeff Gore, Florida Game & Fish Commission, Wildlife Biologist, 6721 Highway 2321, Panama City, FL 32409, GoreJ@gfc.state.fl.us.

Margaret A. Griffiths, Univ. of Illinois at Urbana-Champaign, Dept. of Food Science & Human Nutrition, 905 S. Goodwin Ave., Urbana, IL 61801, griffith@ux1.cso.uiuc.edu.

Thomas A. Griffiths, Illinois Wesleyan Univ., Dept. of Biology, P.O. Box 2900, Bloomington, IL 61702-2900, tgriff@titan.iwu.edu.

Paul Gritis, Paul Gritis Books, Owner, P. O. Box 4298, Bethlehem, PA 18018.

Roger Haagenson, Lubee Foundation, Executive Director, 800 E. Broward Blvd., Ft. Lauderdale, FL 33301.

Brad Hadley, Southwestern Missouri State Univ., 901 S. National, Springfield, MO 65804, bmh@cnas.smsu.edu.

Grayson Harding, 2321 Grove Ave., Falls Church, VA 22046-2204, exhibitcentral@JUNO.com.

Harry Harnish, Devil's Den State Park, Park Interpreter, 11333 W. AR HWY 74, Westfork, AR 72774.

Sarah Hartje, Southwestern Missouri State Univ., Grad. Student, 901 S. National Ave., Springfield, MO 65804-0095, SarahHartje@Juno.com.

Mick Harvey, Tennessee Tech. Univ., Box 5063 TTU, Cookeville, TN 38505, mharvey@tntech.edu

Ginny Hayssen, Smith College, Assoc. Prof. Biology, Northampton, MA 01063, vhayssen@science.smith.edu.

Steve Hensley, U.S. Fish & Wildlife Service, Fish & Wildlife Biologist, 222 S. Houston Suite A, Tulsa, OK 74127, steve_hensley@fws.gov.

Michael Herder, USDI BLM Arizona Strip, Wildlife Biologist, 345 E. Riverside Dr, St. George, UT 84790, mherder@az.blm.gov.

Jana Higginbotham, Univ. of Texas at Arlington, Grad. Student, Dept. of Biology, Box 19498, Arlington, TX 76013, Jana@uta.edu.

Katy Hinman, SUNY at Stony Brook, Student, 50 Douglaston Rd., Sound Beach, NY 11789, khinman@life.bio.sunysb.edu.

Vernon Hoffman, Arkansas State Univ., Grad. Student, P. O. Box 599, State University, AR 72467, Vern_and_lydia@yahoo.com.

Gillian Holloway, Univ. of Calgary, 2500 University Dr., Calgary, Alberta, Canada T2N 1N4, ghollowa@acs.ucalgary.ca.

Jenny Holmes, 706 Allen St., Syracuse, NY 13210, JENNIFER.HOLMES@CARRIER.UTC.COM.

Peggy Horner, Texas Parks & Wildlife Dept., 3000 IH35 South, Ste. 100, Austin, TX 78704, peggy.horner@tpwd.state.tx.us.

G.Roy Horst,Publisher,Bat Research News, P. O. Box 5068, Potsdam, NY 13676-5068, horstgr@potsdam.edu.

Becky Houck, Univ. of Portland, Professor, 5000 N. Willamette Blvd., Portland, OR 97203-5798, houck@up.edu.

Daryl Howell, Iowa Department of Natural Resources, Endangered Species Coordinator, Wallace State Office Bldg., 900 East Grand, DesMoines, IA 50319-0034, dhowell@max.state.ia.us.

Jeff Huebschman, Univ. of Nebraska State Museum, Grad. Student, W436 Nebraska Hall, Univ. of Nebraska State Museum, Univ. of Nebraska, Lincoln, NE 68588-0514, jhuebsch@cwis.unomaha.edu.

Tracy Hurst, KY Dept. for Surface Mining Reclamation & Enforcement, Environmental Biologist, #2 Hudson Hollow, Franfort, KY 40601, thurst@nrdsmnt1.nr.state.ky.us.

James M. Hutcheon, Univ. of Wisconsin, Dept. of Zoology, Grad. Student, 430 Lincoln Dr., Madison, WI 53706, hutcheon@students.wisc.edu.

Jennifer Jackson, USDI BLM Arizona Strip, Wildlife Technician, 345 East Riverside Dr., St. George, UT 84790, bjackson@infowest.com.

Ronald A. Javitch, R. A. Javitch Natural Science Rare Book Foundation, Curator, P.O. Box 67 - Station H, Montreal, P. Québec, Canada H3G 2K5, javitch.herpetology@sympatico.ca.

Participants, 28th NASBR continued

Dave Johnston, H. T. Harvey & Assoc., Ecologist II, P.O. Box 1180, Alviso, CA 95002, djohnston8@AOL.com.

Jeff Joy, 598 Millstream Lake Rd., Victoria, B.C., Canada V9E1E7, Jeffrey_Joy@bc.sympotico.ca.

David Kabelik, Univ. of Toronto, Student, 17 Ross St., Toronto, ON, Canada M5T 1Z8, kabelik@zoo.utoronto.ca.

Joseph Kath, Illinois DNR, Endangered Species, Project Manager, 524 S. Second St., Springfield, IL 62701-1787, jkath@dnrmail.state.il.us.

Karry Kazial, Ohio State Univ., Dept. of Evolution, Ecology, & Organismal Biology, Grad. Research Assoc., 1735 Neil Ave., Columbus, OH 43210, kazial.1@osu.edu.

Mandy Kellner, Simon Fraser Univ., Grad. Student, Burnaby, BC, Canada V5A 1S6, akellner@sfu.ca.

Jim Kennedy, Bat Conservation International, NABCP Asst. Director, P.O. Box 162603, Austin, TX 78716-2603, jkennedy@batcon.org.

Bill Kern, Univ. of Florida, 11970 72nd Way No., Largo, FL 337733.

John Kirsch, UW Zoological Museum, Director, 250 N. Mills St., Madison, WI 53706, UWZM@MACC.WISC.EDU.

James Kiser, Eco-Tech Inc., Biologist, 1003 E. Main St., Frankfort, KY 40601.

Mark Kiser, Bat Conservation International, NABHRP Coordinator, P.O. Box 162603, Austin, TX 78716, mkiser@batcon.org.

Selena Kiser, Bat Conservation International, Research Asst., 500 Cap. of TX Hwy N, Bldg. 1, Austin, TX 78746.

Al Kisner, P.O. Box 8186, LaCrescenta, CA 91224-0186.

Kristin Knoepfli, Univ. of Toronto, Student, 3166 Hampton Ct., Burlington, Ontario, Canada L7N 1C2, K.Knoepfli@sympatico.ca.

Rachel Kowalski, Bat Conservation International, NABCP Staff Biologist, P.O. Box 162603, Austin, TX 78716-2603, rkowalski@batcon.org.

Noga Kronfeld, Boston Univ., Postdoctoral Fellow, 5 Cummington St., Boston, MA 02215, kronfeld@bu.edu.

Gregg Krumme, Southwestern Missouri State Univ., Grad. Student, Dept. of Biology, Springfield, MO 65804.

Dennis L. Krusac, USDA Forest Service, Endangered Species Specialist, 1720 Peachtree Rd. NW, Atlanta, GA 30101, dkrusac/r8@fs.fed.us.

Philip H. Krutzsch, Univ. of Arizona, College of Medicine, Professor, 1145 E Via Entrada, Tucson, AZ 85718, KRUTZSCH@ARUBA.CCIT.ARIZONA.Edu.

Tom Kunz, Boston Univ., Professor, Dept. Biology, Boston, MA 02215, kunz@bu.edu.

Allen Kurta, Eastern Michigan Univ., Professor, Dept. of Biology, Eastern Michigan Univ., Ypsilanti, MI 48197, bio_kurta@online.emich.edu.

Dierdre Schultz Larson, Hennepin Parks, Interpretive Naturalist, 5819 Louis Ave., Minnetonka, MN 55345-6629, didj@scc.net.

Ya-Fu Lee, Univ. of Tennessee, Graduate Student, 569 Dabney Hall, Knoxville, TN 37996-1610, abramus@utkux.utcc.utk.edu.

Julie Lemson, 1165 Jolly Rd, Okemos, MI 48864, LEMSONJU@PILOT.MSU.EDU.

Lyle Lewis, Bureau of Land Management, Wildlife Biologist, 400 E Ave. B, Jerome, ID 83338, llewis@id.blm.gov.

Susan Lewis, Carroll College, Asst. Professor, 100 North East Ave., Waukesha, WI 53186, lewiss@carroll1.cc.edu.

Kim Livengood, Univ. of Missouri, Grad. student, 302 ABNR, Univ. of Missouri, Columbia 65211, c754279@showme.missouri.edu.

Mark Ludlow, Florida Park Service, Biological Scientist, 3345 Caverns Rd., Marianna, FL 32446, some.day.

Tanya Luszcz, Ministry of Environment and Lands, Biologist, 1092 Fraser St., Kamloops, B. C., Canada V2C 3H7, tluszcz@hotmail.com.

Gail Lutowski, Stephen F. Austin State Univ., Grad. Student, Rt. 3, Box 17A, Timpson, TX 75975, lutowskigg@titan.sfasu.edu.

Linda Maberry, Maberry Centre Bat Homes, Partner, 1407 Maberry Rd., Daingerfield, TX 75638-2512, maberrybat@aol.com.

Marvin Maberry, Maberry Centre Bat Homes, Owner, 1407 Maberry Rd., Daingerfield, TX 75638-2512, maberrybat@aol.com.

Participants, 28th NASBR continued

John MacGregor, USDA Forest Service, Threatened/Endangered Species Specialist, 1700 Bypass Rd, Winchester, KY 40391.

Steve Massa, Arkansas State Univ., 1009 Glendale #5, Jonesboro, AR 72401, SMASSA@NAVAJO.ASTATE.EDU.

Christina McCain, 924 Kentucky S.E., Albuquerque, NM 87108, cmccain@sandia.net.

Gary F. McCracken, Univ. of Tennessee, Professor, 569 Dabney Hall, Knoxville, TN 37922, GMCCRACK@UTK.EDU.

Mark McGimsey, 207 Alexander, Columbia, MO 65203, batsurveys@aol.com.

Megan McHold, Mount Holyoke College, Student, P.O. 3097, South Hadley, MA 01075, momchold@mtholyoke.edu.

Lisa A. McWilliams, Auburn Univ., Graduate Student, Dept. of Zoology and Wildlife Science, Auburn University, AL 36849, 105451.2450@compuserve.com.

Theresa Menard, Univ. of Hawaii, Graduate Student, 1480 Pukele Ave., Honolulu, Hawaii 96816, tcabrera@hawaii.edu.

Michael A. Menzel, Univ. of Georgia, Grad. Student, 365 University Dr., Athens, GA 30605, Mam6648@owl.forestry.uga.edu.

Rob Mies, The Organization for Bat Conservation, Director, 2300 Epley Rd, Williamston, MI 48895, obcbats@aol.com.

Steve Mighton, U.S. Forest Service, Regional Wildlife Biologist, 310 W. Wisconsin Ave., Milwaukee, WI 53203, smighton/r9@fs.fed.us.

Katy Mirowsky, Texas A&M University-Kingsville, Graduate Student, 4329 Belfast Dr., Corpus Christi, TX 78413, kmirowsky@hotmail.com.

Emily Davis Mobley, Speleobooks, Owner, P. O. Box 10, Schoharie, NY 12157, oldbat@albany.net.

Arnulfo Moreno, Texas A&M Univ., College Station, TX 77843-2258, amoreno@wfscgate.tamu.edu.

Tom Morrell, Ball State Univ., Dept. of Biol., Muncie, IN 47306, tmorrell@WP.BSU.EDU.

Pat Morton, Texas Parks & Wildlife, Outreach Coordinator, Endangered Resources, TPWD, 3000 IH 35, South, Suite 100, Austin, TX 78704, patricia.morton@tpwd.state.tx.us.

Kevin Murray, Southwestern Missouri State Univ., Grad. Student, 901 S. National, Springfield, MO 65804.

Susan W. Murray, Eastern Michigan Univ., Grad. Student, Dept. Biology, EMU, Ypsilanti, MI 48197, smurray@online.emich.edu.

Suzanne Nelson, Univ. of Florida/The Lubee Foundation, Ph.D. Student, 303 Newins-Ziegler, Box 110430, Gainesville, FL 32611, snelson@ufl.edu.

Chris Nicolay, NEOUCOM/Kent State Univ., 4209 State Route 44, Rootstown, OH 44272-0095, cnicolay@kent.edu.

Michael J. O'Farrell, O'Farrell Biological Consulting, 2912 N. Jones Blvd., Las Vegas, NV 89108, mikeof@accessnv.com.

Barbara J. Ogaard, Sarvey Wildlife Ctr., Naturalist/Rehabber, 20311 45th Dr. SE, Bothell, WA 98012.

Pat Ormsbee, U.S. Forest Service, Wildlife Ecologist, 211E 7th St., Eugene, OR 97404, orms@rio.com.

Robert D. Owen, Texas Tech Univ., Assoc. Professor, Dept. of Biological Sciences, Lubbock, TX 79409-3131, BCRDO@TTACS.TTU.EDU.

Krista Patriquin-Meldrum, Univ. of Calgary, Dept. of Biological Sciences, Univ. of Calgary, Calgary, AB, Canada T2N 1N4, kjpatriq@ucalgary.ca.

Deana Pavwoski, Carroll College, 100 North East Ave., Waukesha, WI 53186, dpavwosk@carroll1.cc.edu.

Scott C. Pedersen, Univ. of Washington, Res. Assoc., 357448-UW Box, Seattle, WA 98195, Bathead@u.washington.edu.

Mark Perkins, PNW Bat Research Team, 2217 E. Emerson Ave., Salt Lake City, UT 84108, batsrus1@sisna.com.

Stuart Perlmeter, Springfield Public Schools, Teacher/Researcher, 2311 Alder ST., Eugene, OR 97405, sperlmet@sps.lane.edu.

Toni Piaggio, San Francisco State Univ., Grad. Student, 2101 Sacramento #504, San Francisco, CA 94109, Batchaser2@aol.com.

Elizabeth (Dixie) Pierson, 2556 Hilgard Ave., Berkeley, CA 94709, Edpierson@aol.com.

James T. Popham, Little Rock AFB, Natural Resources Manager, 314 CES/CEVA, 528 Thomas Ave., Little Rock AFB, AR 72099-4987.

Participants, 28th NASBR continued

Christine V. Portfors, N. E. Ohio Universities, College of Medicine, Dr., 4209 State Route 44, Rootstown, OH 44272, CVP@NEOUCOM.EDU.

William (Bill) Rainey, Univ. of California-Berkeley, 2556 Hilgard Ave., Berkeley, CA 94709, WEREDP@aol.com.

Marikay A. Ramsey, U. S. Forest Service, Biologist, P.O. Box 92, Silver City, NM 88062, mramsey@zianet.com.

Ron Redman, Arkansas Game & Fish Commission, 345 Hickory Grove-Haskell, Benton, AR 72015, batman@up_link.net.

Fiona A. Reid, Royal Ontario Museum, 100 Queens Parr, Toronto, Ontario, Canada M1M 2A4, FIONAR@GLOBALSERVE.NET.

Scott Reynolds, Boston Univ., Grad. Student, 27 Temple St., West Boylston, MA 01583, smbdsr@worldnet.att.net.

Dan Riskin, York Univ., 4700 Keele Str., North York, Ontario, Canada M3J 1P3.

Lynn W. Robbins, Southwestern Missouri State Univ., Professor, 901 S. National, Springfield, MO 65804, LYNNROBBINS@MAIL.SMSU.EDU.

Scott Robertson, Southwestern Missouri State Univ., Dept. of Biology, Springfield, MO 65804.

Armando Rodríguez-Durán, Inter American Univ., Professor & Dean of Arts & Sciences, Dept. Natural Sciences, Bayamón, P. R. 00957, arodrig@ns.inter.ed.

Zac Roehrs, University of Nebraska State Museum, Res. Asst., 2233 Heather Lane, Lincoln, Nebraska 68512, 00082224@bigred.unl.edu.

David Roemer, Carlsbad Caverns National Park, Resource Management Specialist, 3225 National Parks Hwy., Carlsbad, NM 88220, dave_roemer@nps.gov.

Debra Rosas, Univ. of New Mexico, MS, Dept. of Biology, Albuquerque, NM 87131.

Maureen Rowe, Wisconsin Dept. of Natural Resources, Wildlife Biologist, 1210 N. Palmatory, Horicon, WI 53032, rowem@dnr.state.wi.us.

Jim Rowell, Chicago Zoological Society, Senior Keeper, Chicago Zoological Park, Brookfield, IL 60513.

Luis A. Ruedas, Museum of Southwestern Biology, Research Assist. Prof., Univ. of New Mexico, Albuquerque, NM 87131-1091, lruedas@sevilleta.unm.edu.

Stephen Russ, 484 Lake Park Ave. #141, Oakland, CA 94610, SRUSS@IX.NETCOM.COM.

Amy Russell, Univ of Tennessee, Grad Student, 569 Dabney Hall, Knoxville, TN 37996, arussel3@utk.edu.

Rebecca Russell, Boston Univ., Student, 5 Cummington St., Boston, MA 02215.

Leslie Saidak, Univ. of Tennessee, Research Technician, Dept. of Ecology & Evolutionary Biology, Knoxville, TN 37922, LSAIDAK@UTK.EDU.

David Saugey, U. S. Forest Service, Ouachita National Forest, Wildlife Biologist, P.O. Box 189, Jessieville, AR 71949, dsaugey/r8_ouachita_jessieville@fs.fed.us.

Steve Schmauch, Bat Conservation International, NABCP Director, P.O. Box 162463, Austin, TX 78716, schmauch@batcon.org.

William A. Schutt, Jr., American Museum of Natural History, & Southampton College of L. I. U., Scientist/Assoc. Prof., Natural Science Division, Southampton College, Southampton, NY 11968, Desmodus@yahoo.com.

Kathy Schwellenbach, Como Zoo & Conservatory Education, Education Specialist, 1325 Aida Place, St. Paul, MN 55103, Kathy.Schwellenbach@StPaul.gov.

Jason Schwenk, Albright College, c/o Bio. Dept., Reading, PA 19612-5234.

Jan Self, Ozark National Forest, District Wildlife Biologist, P.O. Box 427, Jasper, AR 72641, j.self/r8_ozark@fs.fed.us.

Joe Senulis, Wisconsin Dept. of Natural Resources, ET/8 Technical Support Specialist, 101 S. Webster St., Box 7921, Madison, WI 53707, SENULJ@DNR.STATE.WI.US.

John Seyjagat, Lubee Foundation Inc., Director, 1309 NW 192 Ave., Gainesville, FL 32609, lubeebat@aol.com.

Valerie Shafer, Stephen F. Austin State Univ., Grad. Student, P.O. Box 4068, SFASU, Nacogdoches, TX 75962, z_shaferVM@TITAN.SFASU.edu.

Rick Sherwin, Univ. of New Mexico, Dept. of Biology, Albuquerque, NM 87131-1091, rsherwin@unm.edu.

Brian Silvia, Boston Univ., Student, 5 Cummington St., Boston, MA 02215, Silviab@bu.edu.

Participants, 28th NASBR continued

Nancy B. Simmons, American Museum of Natural History, Assoc. Curator, Central Park West @ 79th, New York, NY 10024, simmons@amnh.org.

Diana Simons, P.O. Box 461031, Los Angeles, CA 90046-9031, batflap@aol.com.

Sue Smith, Humboldt State Univ., P.O. Box 4756, Arcata, CA 95518, SES4@AXE.HUMBOLDT.EDU.

Lorraine Standing, York Univ., 4700 Keele Str., North York, Ontario, Canada M3J 1P3.

Janet Sternburg, Missouri Dept. of Conservation, Wildlife Ecologist, P.O. Box 180, Jefferson City, MO 65102, Sternj@mail.conservation.state.mo.us.

Craig Stihler, WV Div. Natural Resources, Wildlife Biologist, P.O. Box 67, Elkins, WV 26241, cstihler@dnr.state.wv.us.

John Stoddard, Governors State Univ., 6308 Pontiac Dr, Indian Head Park, IL 60525, js-stoddard@govst.edu.

Tim Strickler, Grand Valley State Univ., Professor, Allendale, MI 49401, stricklt@gvsu.edu.

Jason Stumhofer, Albright College, c/o Bio. Dept., Reading, PA 19612-5234.

Monica Svensson, Dept. Zoology, Göteborg University, Ph.D. Student, Box 463, Göteborg, Sweden SE40530, monica.svensson@zool.gu.se.

Phil Tappe, School of Forest Resources, Univ. of Arkansas-Monticello, Assoc. Prof., Box 3468 UAM, Monticello, AR 71656, Tappe@UAMont.edu.

Jason Taylor, Faculty of Environmental Studies, York Univ., Student, 1570 King St. West #10, Toronto, ON, Canada M6K 1J7, jtaylor@yorku.ca.

Jeff Taylor, Michigan State Univ., Grad. Student, Dept. of Zoology, East Lansing, MI 48824, taylo110@pilot.msu.edu.

Adrian Tejedor, Univ. of Miami, Dept. of Biology, Coral Gables, FL 33124.

Kate Thibault, Univ. of Wisconsin-Whitewater, 800 W. Main St., Whitewater, WI 53190-1790, blakbokis@yahoo.com.

Heather Thomas, Clemson Univ., 811 Issaqueena Trail Apt. 204, Central, SC 29630, heathet@clemson.edu.

Bryan Thompson, Albright College, c/o Bio. Dept., Reading, PA 19612-5234.

Marilee Thorsby, Basically Bats Wildlife Conservation Society, Education Director, 1196 Hope Road, Dunwoody, GA 30350-2922, fuscus@juno.com.

Merlin Tuttle, Bat Conservation International, Executive Director, P.O. Box 162603, Austin, TX 78716.

Janet Tyburec, Bat Conservation International, Director of Education Programs, P.O. Box 86493, Tucson, AZ 85754, JTYBUREC@BATCON.ORG.

Ruth C. B. Utzurrum, Dept. of Marine & Wildlife Resources, P. O. Box 3730, Pago Pago, American Samoa 96799, utzurrum@biology.bu.edu.

Tony Valeriano, Albright College, c/o Bio. Dept., Reading, PA 19612-5234.

Ruth van den Driessche, British Columbia Ministry of Environment, Biologist, 2080 Labieux Road, Nanaimo, B. C., Canada V9T 6J9, rvandend@nanaimo.env.gov.bc.ca.

Sunitha Vege, Univ. of Tennessee, Grad. Student, 569 Dabney Hall, Knoxville, TN 37996, svege@utk.edu.

Maarten Vonhof, York Univ., 4700 Keele Street, Toronto, Ontario, Canada M3J 1P3, mvonhof@yorku.ca.

Steve Walker, Bat Conservation International, Assoc. Executive Director, P.O. Box 162603, Austin, TX 78716, swalker@batcon.org.

Demear D. Warner, Texas Wesleyan Univ., 1201 Wesleyan Univ., Ft. Worth, TX 76105, Deeski.com@hotmail.com.

Mike Warner, Speleobooks, Manager, P. O. Box 10, Schoharie, NY 12157, mwarner@albany.net.

Lori Jo Weber, Western New Mexico University, Biology Lab Director, Box 680, Silver City, NM 88062, weberl@silver.wnmu.edu.

Lawana England Whaley, 1001 Fleetwood Dr., Hot Springs, AR 71913.

John Wible, Carnegie Museum of Natural History, Assoc. Curator, 5800 Baum Blvd., Pittsburgh, PA 15206, wiblej@clpgh.org.

T. Bentley Wigley, NCASI, Program Manager, P.O. Box 340362, Clemson, SC 29634-0362, wigley@clemson.edu.

J. D. Wilhide, Arkansas State Univ., Instructor, P.O. Box 599, State University, AR 72467, jdwil@osage.astate.edu.

Carole E. Wilkey, Colorado Div. of Wildlife, Biologist, P.O. Box 241, Rollinsville, CO 80474, CAROLE.WILKEY@State.CO.US.

Participants, 28th NASBR continued

Bronwyn Williams, Smith College, Student, Box 8977 Green St., Northampton, MA 01063, bwilliams @mail.smith.edu.

John R. Winkelmann, Gettysburg College, Gettysburg, PA 17325, jwinkelm@gettysburg.edu.

Jan Zinck, Portland State Univ., Grad. Student, Dept. of Biology, P.O. Box 751, Portland, OR 97207-0751, psu06746@odin.cc.pdx.edu.

Video Review: "BATS, THE TRUE STORY"

reviewed by Pat Morton

This 35 minute video produced by the Organization for Bat Conservation (OCB), and funded in part by Wild Birds Unlimited, is a ëmust haveí for your education and outreach library. While there are parts of the video that will be meaningful to all ages, this reviewer believes it will be especially relevant to high school students and adults due to some of the more technical language in the sections on echolocation and rabies. I think it is ideal as a tool to encourage opinion leaders and community activists to get involved in a bat conservation project.

The video begins with an introduction to bats presented by OBC founders Rob Mies and Kim Williams. Right up front they address the common myths and frequently asked questions using some good videography to illustrate the topics. Their obvious enthusiasm for the work they do and pleasant communication styles establish a comfortable tone that continues throughout the video as we travel around the country to visit various sites and meet people involved in conservation, education and research activities.

The video highlights ten stories in six states including: Alan Kurta mist-netting in Michigan; George Marks in Florida explaining bat echolocation ; visits to bat exhibits at the Philadelphia and National Zoos; Rob and Kim conducting programs for children; batwatching excursions to Carlsbad Caverns and the Florida Bat House; flying fox research at the Lubee Foundation; bat rehabilitation with Sue Barnard; and a very informative piece with Chuck Rupprecht from the Centers for Disease Control discussing bats and rabies. This series of features really adds credibility to the important bat-related activities going on across the country and should be an inspiration for similar activities. Many of the stories above are illustrated with good video of common, North American speciesóa nice change from the many bat videos and films that feature the more charismatic Old World flying foxes.

This educational tool fills a need for information that is primarily focused on bats in North America. The videography and narration are well done and Mies and Williams have done a fine job of communicating their messages to the general public in an honest and comfortable style. The video can be obtained from Wild Birds Unlimited retail stores as well as from the non-profit Organization for Bat Conservation (HYPERLINK http://www.batconservation.org) www.batconservation.org). The price from OBC is $25, including shipping.

Obituary: Arthur M. Greenhall, 1911- 1998

William Schutt and G. Roy Horst

Arthur M. Greenhall was born on Aug. 6, 1911 in New York City where he grew up. He graduated from the University of Michigan with a B.A. in 1934 and an M.S. in 1935. Arthur's studies of vampire bats began in Panama in 1932. There he found that Desmodus rotundus was a disease vector that attacked both humans and horses. He collected the first vampire bat ever exhibited publically and recorded the behavior of this animal. Greenhall went to Trinidad in 1934 during an extremely serious outbreak of rabies (89 people died) and worked closely with the Trinidadian Government which invited him to serve on a commission studying paralytic rabies. His master's dissertation was one of the first major studies on vampire bats.

Graduate studies at Columbia University and New York University toward his Ph.D. were interrupted by World War II. Greenhall became the Director of the Portland Zoo in 1942. In 1947 he became the General Curator of the Detroit Zoo and Aquarium. In 1953 he returned to Trinidad to become the Curator of the Royal Institute Museum, Director of the Emperor Valley Zoo, and Consultant to the Trinidad Regional Virus Laboratory of the Rockefeller Foundation. In 1954, after another rabies outbreak, the Trinidadian

Greenhall, continued:

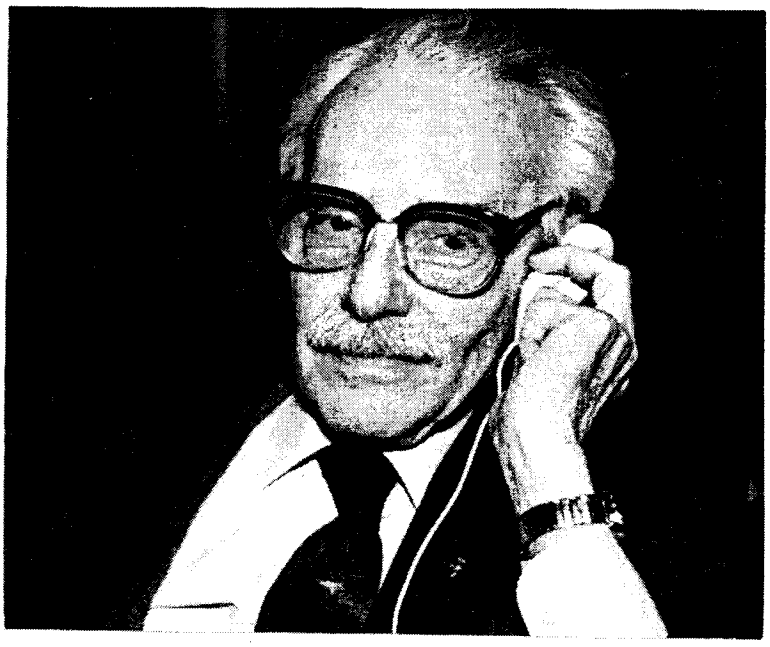
Government appointed Greenhall to become the Zoologist in charge of the country's Anti-Rabies Programme. In 1963, Greenhall returned to the United States, taking a position with the U.S. Fish and Wildlife Service. That year he also became Chief, Mammal Section, Bird and Mammal Laboratories, at the National Museum of Natural History, in Washington, D.C. In 1968 he was seconded to the United Nations to become Animal Health Officer (Bat Ecologist). This led Greenhall to Mexico where he worked with the Food and Agriculture Orginization (FAO) on a paralytic rabies project. In 1972 he returned to Washington, D.C. as a Zoologist in the National Fish and Wildlife Laboratory at the Smithsonian Institution). In 1977, Greenhall became Staff Zoologist, Office of Scientific Authority for the U.S. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

During his long career Arthur Greenhall received a number of awards and honors including a Special Achievement Award from the U.S. Fish and Wildlife Service. Greenhall was also an active member of many orginizations including the American Museum of Natural History (Research Associate); National Museum of natural History (Research Associate); Linnean Society of London (F.L.S.); Phi Sigma, Chi Gamma Phi, Beta Beta Beta (Honorary Member); International Union for the Conservarion of Nature and Natural Resouces (IUCN)/Survival Service Commission (Honorary Consultant); SSC Chiroptera Specialist Group (Member); The American Society of Mammalogists and bat Conservation International.

Greenhall published over 200 papers and articles, both technical and popular. The most significant include "Review of the Bats of Trinidad and Tobago," "Bats and Bat banding," "House Bat Management," "Key to the Bats of Argentina," and "Effects of Vampire bats and Paralytic rabies on Livestock Production." Greenhall (with Dr. Uwe Schmidt)served as editor on what has become an important source of information on vampire bat biology, "Natural History of Vampire Bats." He was cited in "Ripley's Believe it or Not" for discovering thatsnakes have a pelvic girdle.

After his retirement, Greenhall's research and consultantships included management and control of vampire bats and paralytic rabies, control of house bats, neotropical mammals, conservation of endangered animals, and the establishment of national parks and wildlife sanctuaries. He was instrumental in stimulating interest in vampire bats especially among students. He was a long time supporter of the North American Symposia on Bat Research and attended 21 these meetings. Arthur was also a charter subscriber to Bat Research News to which he contributed several articles and notes. He left his substantial library of books and scientific papers to The University of the West Indies (St. Augustine Campus, Trinidad).

Arthur Greenhall passed away April 8, 1998, in Manhattan after a tenaceous struggle against pneumonia and the combnations brought on by septic shock. Arthur is survived by his wife Elizabeth (they were married in 1942) their son Paul and daughter Alice, and their grandson. Michael Arthur.



Arthur M. Greenhall 1911 - 1998

This past Summer in at the Internatiuonal Conference on Bat Research held in Brazil, several of Arthur's friends and coworkers announced the establishment of:

The Arthur M. Greenhall Memorial Award.

This award will be presented to students whose presentation of their work at the Annual North American Symposim on Bat Research demonstrates that they have achieved excellence in the field of vampire bat research. Anyone interested in honoring Arthur's memory by contributing to this award should contact G. Roy Horst at Bat Research News, P.O. Box 5068, Potsdam, NY 13676-5068. e-mail horstgr@potsdam.edu tel. 315-267-2259

News from Thailand:

As a Voluntary Service Overseas volunteer from England I have had the good fortune to work on bats with the Wildlife Research Division of the Royal Forest Department in Thailand for the last two years. I have spent a lot of time at a *Tadarida plicata* site with about 2.5 million bats, looking at activity patterns, predation and anything else that could help increase knowledge about bats in Thailand which is still sparse. This site is a good example of nature conservation, sustainable use and tourism being compatible. It is a protected area where the bat-guano is still collected for use as fertilizer as it has for many decades, and it has also now become a major tourist attraction with several hundred people watching the bats emerge every evening, However, no on-site information is present at least partly as nobody knew anything about the bats here, hopefully this can now be rectified.

The other main project I have been involved with was a survey in western Thailand which was interesting because it included the area where Kitti's hog-nosed bat *Craseonycteris thonglongyai* lives. The news for *C. thonglongyai* seems to be reasonably good as its known range is gradually being increased as more surveys are carried out, and it appears to be fairly common where it is found. It also does not appear dependant on forest, having been seen foraging over agricultural land and a golf-course. However, this is no reason for complacency as the range is still very small and we cannot be sure of the effect of changing land -use. Probably one of the most important factors for this species is the presence of a good number of relatively undisturbed caves. *C. thonglongyai* can be found in caves which are used as retreats for monks or for tourism, but in some cases there is clearly some disturbance, and with increasing tourism in the area this is a major concern. There is still some hope that this, the smallest mammal in the world will be found in other areas as there is still a lot of relatively unsurveyed limestone in western Thailand.

This project also produced evidence that several species of bat (mainly the larger hipposiderids) undergo seasonal migrations. This and other evidence suggests a southwards movement in the cool season (November to March) of bats in the west and north of the country, but as yet there is no indication as to how far or exactly where they go.

Yours, Adrian Hillman. **e-mail** ahillman@hotbot.com http://www.hotbot.com

From Australia,

A great deal has been happening down in this neck of the woods. There has been a lurch to the right in Australian politics and all things conservational have suffered Plus we had a second lady die from Lyssavirus late last year and this has caused a definite anti flying-fox backlash.(Although it is generally accepted that the first case was caused by a bite from the Yellow-bellied Sheath-tailed Bat and it is also possible that a member of this species was implicated in the second case). So overall anti-bat media hype has caused a shift in community attitudes reminiscent of the bad old days when flying-foxes were considered vermin. And our politicans have been quick to respond.

Flying-foxes have been protected in NSW since 1986. This has meant that they can only be harmed under license from the NSW National Parks and Wildlife Service. Until now the NPWS has steadfastly refused to issue a license to harm flying-foxes in their colony sites. A policy which has caused a degree of annoyance in some communities where humans have built in close proximity to flying-fox colonies.

There are problems with noise, smell and so on. In general the townspeople would like the flying--

foxes gone however flying-fox colonies are extremely persistent. Most have histories which suggest that their location pre-dates European settlement and while there is a history of attempts to move these colonies, it is generally accepted that unless the site is cleared of trees, the flying-foxes come back no matter what horrendous method of disturbance (saturation shooting, high explosive, cyanide gas, flamethowers) is used. The NPWS policy was, not only that it was detrimental to the species to move their reproductively important colonies, but that such action would not succeed.

The present crisis was precipitated when confidential papers were leaked to show that a license had been issued and disturbance was planned which would harm flying-foxes at the Maclean site in northern NSW. There are historical records to show that this colony has been in the same location since at least 1880s when it covered 16 acres. Now it has been squashed into less than 2 acres and its trees are touching the recently erected buildings where the children learn cooking. It is not a good location for the school and there have been problems with the flying-foxes since the 1960s when the school was built. However various governments have failed to act on the problem and in the present anti-bat climate, the townspeople's attitude has become rather ugly. Maclean is in a marginal electorate and there is an election in March 99. A "quick fix" was needed. Political pressure was applied and suddenly a plan was approved to disturb a colony of about 20,000 Black Flying-foxes and Grey-headed Flying-foxes on Thursday morning (Jan. 21) at 3 am using extreme, machine generated noise to form a "sound barrier" so that the flying-foxes could not return to the site. A large number of casualties were expected (the 1500 non-flying young in the colony site for starters!) and all casualties and abandoned animals of "non-threatened" protected species (i.e. the Greys) were going to be euthanized. Attempts were going to be made not to hurt the "threatened" protected species (i.e. the Blacks) however it was difficult to see how this latter aim could be accomplished when the two species occupy the same area and the Reserve is so small.

The entire situation was unbelievable. However only hours before the proposed disturbance an interlocutory injunction was granted. It was found that there was a serious question to be tried with the legality of the License to harm the flying-foxes. This will, at least, delay any action for some weeks until it is tried in Court. The Environment Defender's Office brought the case on behalf of the North Coast Environment Council, a small conservation group that managed to find $1500 to fund a day in Court and are now working with various conservation groups to raise the $25,000 for the cost of the trial. It is a David and Goliath struggle. But this fight should not have to happen.

There is no real sense in the NSW Government's position. Disturbance will not solve the problems in the long term solution at the Maclean High School. The only long term solution is to move the school. However the short term damage caused by the Governments reliance on the mirage of "flying-fox colony relocation" is enormous. Not only in potential casualties at the Maclean site but at all the other sites where human have been permitted to build close to flying-fox colonies. The Maclean disturbance, if it proceeds will be used as a precedent to permit disturbance at colony sites throughout the range of the flying-fox in NSW. This would be a huge problem for these species as the Black Flying-fox is already considered "Threatened" under State legislation and the Grey-headed Flying-fox is considered "Threatened" under Commonwealth legislation and has been nominated for "Threatened" status in NSW.

However at least there has been a stay of execution....and perhaps by the time the case is tried, the Premier of NSW, the Minister for the Environment and the Minister for Education will have realized where their advisors have led them astray!

Kerryn Parry-Jones

EVEN IF YOU ARE NOT FROM AUSTRALIA, YOU CAN HELP PREVENT THIS DISASTER.
IF YOU ARE CONCERNED MAKE YOUR FEELINGS KNOWN TO:

Dr. Kerryn Parry-Jones, Biology, University of Sydney, NSW.
TEL. 043-653232 e-mail wambina@ozemail.com.au

NEW or CORRECTED e-mail addresses.

A complete E-mail directory will appear in the summer issue Volume 40: No. 2

name	e mail	location
Barnard, Sue	batcons@mindspring.com	USA, Georgia
Bhatti, Brenda	BHAT3@aol.com	USA, New Hampshire
Billington, G.E.	GEBillCumb@aol.com.	United Kingdom
Bonaccorso, Frank	PNGMUSEUM@global.net.pg	Paua New Guinea
Butts, Thomas	tbutts@initco.net	USA, Montana
Castillo V., Guillermo E.	e908@hotmail.com	Mexico
Clem, Phillip D.	pclem@uchaswv.edu	USA, West Virginia
Currie, Robert R.	rrcurrie@ioa.com	USA, North Carolina
Currie, Robert R.	Robert_Currie@fws.gov	USA, North Carolina
Ducummon, Sheryl	sducummon@batcon.org	USA, Texas
Dutko, Rick	rdutko@dep.state.nj.us	USA, New Jersey
Fellers, Gary	Gary_Fellers@usgs.gov	USA, California
Findley, James S.	103322.2511@compuserve.com.	USA, New Mexico
French, Barbara	french@batcon.org	USA, Texas
Geiselman, Cullen	cgeiselman@batcon.org	USA, Texas
Genter, Dave	dgenter@desktop.org	USA, Montana
Genthe, Steffen D.	genthes@river.it.gvsu.edu	USA, Michigan
Gregorin, Renato	gregorin@usp.br	Brazil
Herder, Michael	mherder@az.blm.gov	USA, Utah
Hobbs, Donna	Hobbs@sjc.cc.nm.us	USA, New Mexico
Hood, Craig	chood@loyno.edu	USA, Louisiana
Hovis, Julie	hovisj@gfc.state.fl.us	USA, Florida
Hurt, Mollie	Hurt_Mollie/r5_tahoe@fs.fed.us	USA, California
Kazial, Karry	kazial.1@osu.edu	USA, Oregon
Kearney, T.	kearneyt@biology.und.ac.za	South Africa
Keller, Barry	kellerbarr@isu.edu	USA, Idaho
Kennedy, Jim	jkennedy@batcon.org	USA, Texas
Kiser, Selena	skiser@batcon.org	USA, Texas
Kock, Dieter	dkock@sng.uni-frankfurt.de	Germany
Kowalski, Rachel	rkowalski@batcon.org	USA, Texas
Lancaster, Winston	wlancast@pc.edu	USA, Kentucky
Larson, Paula	Larson_Paula/r5_stanislaus@fs.fed.us	USA, California
Lidicker, William	lidicker@socrates.berkeley.edu	USA, California
Lollar, Amanda	batworld@wf.net	USA, Texas
Lynn Kershnar, Rebecca	rlk207@is8.nyu.edu	USA, New York
McCowat, Tom (home)	tmcowat@clara.net	Wales, UK
McCowat, Tom (work)	tommo@ceredigion.gov.uk	Wales, UK
Pavey, Chris	pavey@zi.biologie.uni-muenchen.de	Germany
Pease, Charles	cpease@mwaz.com	USA, Arizona
Ramsey, Marikay A.	mramsey@zianet.com	USA, New Mexico
Ratnasooriya, W. D.	PVR92.UOC@mail.cmb.ac.lk	Sri Lanka
Rowe, Maureen	rowem@dnr.state.wi.us	USA, Wisconsin
Russell, Amy L.	russella@utkux.utcc.utk.edu	USA, Kentucky
Schmidt, Uwe	uwe.schmidt@uni-bonn.de	Germany
Spears, Fran	FYBSpears@aol.com	USA, California
Tirhi, Michelle	tirhimjt@dfw.wa.gov	USA, Washington St
Tuttle, Merlin	mtuttle@batcon.org	USA, Texas
Tyburec, Janet	jtyburec@batcon.org	USA, Arizona
Vann, Cynthia	cvann@goodnet.com	
Vaughan, Nancy	nancy.vaughan@bristol.ac.uk	United Kingdom
Webster, David	webste@uncwil.edu	USA, North Carolina
Worthington, David	dave_worthington@nps.gov	USA, Utah

Future Bat Meeting Announcements

June 1999

The 2nd Irish Bat Conference
will take place at the Burren College of Art,
Ballyvaughan, Co. Clare on June 4th - 6th.

Brochures and booking forms will be available in March.
For further information, please contact either
Kate McAney, Tel:+353-93-35360; email: mcaney@iol.ie,
or
Congella McGuire, Tel:+353-65-40266. email:mcguirec.ennis@tinet.ie

* *

August 1999

VIIIth European Bat Research Symposium
Kracow, Poland in August 23 - 27, 1999.

Address all communications to:
Professor Bronislaw W. Woloszyn, Chiropterological Information Centre,
Institute of Animal Systematics and Evolution, Polish Academy of Sciences,
ul. Slawkowska 17, 30-016 Krakow Poland
e-mail address: woloszbr@ isez.pan.krakow.pl or: VIIIEBRS@isez.pan.krakow.pl
TEL. + 4812/422-64-10 or +4812/422-19-01 FAX + 4812/422-42-94

* *

October 1999

The 29th Annual North American Symposium on Bat Research

October 27 - 30, 1999

University of Wisconsin, Madison, Wisconsin
Convened by Thomas Griffiths and hosted by John Kirsch
All enquires should be directed to:
Dr. Thomas H. Griffiths
Department of Biology, Illinois Wesleyan University
Bloomongton, IL 61702
Tel. 309-556-3230 FAX 309-556-3411
e-mail: tgriff@titan.iwu.edu
Bat Research News will publish any new announcements as they arrive.
All subscribers to Bat Research News are on Dr. Griffith's mailing list.

* *

April 2000

Australasian Bat Society Conference
25th-28th April 2000

at Tocal College, Paterson New South Wales, Australia.
for further information please contact:
Kerryn Parry-Jones. e-mail wambina@ozemail.com.au
Bat Research News will publish any new announcements as they arrive.

Future Bat Meetings, continued

October 2000

The 30th Annual North American Symposium on Bat Research

October 28 - 31, 2000

University of Miami, Miami, Florida
Convened by Thomas Griffiths and hosted by Ted Fleming
Bat Research News will publish any new announcements as they arrive.

* *

August 2001

The 12th International Bat Research Conference will convene 5 - 9 August, 2001, in Bangi, Malaysia

The Conference will be convened by Dr. Zubaid Akbar
All enquires should be directed to:
Dr. Zubaid Akbar,
Department of Zoology, University Kebangsaan Malaysia
43600 UKM BANGI MALAYSIA.
Tel/Fax: [60] 603-8293827
e-mail: zubaid@ukm.my or zubaid@pop.jaring.my
Website: www.fsh.ukm.my/fsh/dept/bz/zubaid.htm
Bat Research News will publish any new announcements as they arrive.
All subscribers to Bat Research News are on Dr. Akbar's mailing list.

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October 2001

The 31st Annual North American Symposium on Bat Research

October (exact dates not yet determined), 2000

University of Victoria, Victoria, British Columbia
Convened by Thomas Griffiths and hosted by Mark Brigham
Bat Research News will publish any new announcements as they arrive.

Anyone having any information about future bat meetings, conferences, or workshops please forward the particulars to G. Roy Horst at Bat Research News for inclusion in the coming issues. horstgr@potsdam.edu

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Front Cover

The illustration of the painted bat, *Kerivoula argentata* on the front cover of this issue was generously provided by Conor Kelleher of "Northants", Spring Lane, Carrigagulla, Ballingree, Macroom, County Cork, Éire.