BAT RESEARCH NEWS

Volume 36: No. 1 **Spring 1995**

BAT RESEARCH NEWS

Volume 36: Number 1 **Spring 1995**

Original Issue Compiled by Dr. G. Roy Horst, Publisher and Managing Editor of *Bat Research News*, 1995.

Bat Research News is ISSN # 0005-6227.

BAT RESEARCH NEWS

Volume 36 **Spring, 1995** **Number 1**

CONTENTS

Front Cover

The illustration of this handsome bat mysteriously appeared on my desk with no other information (more likely, I lost it). If you can identify the drawing as your own, please send any information you wish and we will include it in the next issue and credit your subscription account for one year's subscription. GRH

BAT RESEARCH NEWS

Publisher and Managing Editor
G. Roy Horst
Department of Biology
State University College at Potsdam
Potsdam, NY 13676
Tel. 315-267-2259
FAX 315-267-3170
E-mail: horstgr@potsdam.edu.

Editor, Recent Literature
Thomas Griffiths
Department of Biology
Illinois Wesleyan University
Bloomington, IL 61702
Tel. 309-556-3230
FAX 309-556-3411
E-mail: tgriff@titan.iwu.edu

Editor for Feature Articles and Letters
Allen Kurta
Department of Biology
Eastern Michigan University
Ypsilanti, MI 48197
Tel. 313-487-1174

Instructions to Contributors and Subscribers:

Bat Research News is published four times each year, each year consisting of one volume of four issues, appearing in Spring, Summer, Fall, and Winter. ***Bat Research News*** publishes short papers, general interest notes, etc., which are edited by at least two reviewers. Manuscripts dealing with original work should be submitted in duplicate following the latest *CBE Style Manual* or following the style used in the *Journal of Mammalogy.* In addition, latest news on bat research, correspondence, book reviews, meeting announcements, reports and an extensive review of recent literature titles are included. Communications concerning recent literature should be addressed to Griffiths, manuscripts to Kurta, all other matters to Horst.

Subscriptions to individuals are $ 15.00 per volume(year). All issues are sent surface mail, postage paid by ***Bat Research News*** to all addresses world-wide. Special arrangements have been made to serve European and Australian subscribers. All copies to Europe are sent bulk via air mail to Dr. Robert Stebbings, in Great Britain, who will then forward them, first class mail to their final destinations. Subscriptions to institutions are $ 25.00 per volume(year).

Please make all checks payable to; ***Bat Research News.*** Subscribers outside the United States can please pay by checks in U.S. dollars, drawn on banks with an affiliated office in the United States, or payment can be made via international money orders, (in U.S. funds). Mail your payment to Dr. G. Roy Horst at the address above.

Bat Research News is : ISSN 0005-6227
United States Internal Revenue Service tax exemption number 16-1356633

Bat Research News is printed and mailed at:
Potsdam College of the State University of New York,
Potsdam, NY, 13676, U.S.A.

BAT RESEARCH NEWS

Volume 36: Number 1 Spring, 1995

Occurrence and Food Habits of Some Bat Species from the Linhares Forest Reserve, Espirito Santo, Brazil

W. A. Pedro and F. C. Passos
Departamento de Zoologia, I.B., Universidade Estadual de Campinas
Present address: PPG/ERN-UFSCar and Departamento de Apoio, Produção e Saúde Animal, Universidade Estadual Paulista, CP 533, 16050-680, Araçatuba, São Paulo, Brazil

Introduction

Food habits of bats from Espirito Santo State, eastern Brazil, have been little studied. Exceptions are the work of Zortéa ('93), Zortéa and Mendes ('93), and Zortéa and Chiarello ('94) on folivory and frugivory in some phyllostomid species. In this note, we provide information about the occurrence and food habits of certain bat species in a remnant fragment of Atlantic forest in the Espirito Santo State.

Methods

On eight nights, between 27 July and 17 August (dry season), we captured eight species of bats in mist nets set in the rain forest, at the Companhia Vale do Rio Doce Forest Reserve, in Linhares, Espirito Santo State, Brazil (19°06'--19°18'S; 39°45'--40°19'W). To obtain feces for analysis of food habits, we placed the captured bats in cloth bags for approximately one hour. Feces were then transferred to paper envelopes, and seeds found in the feces were later compared to those of fruits from local plants.

Results and Discussion

We captured 38 *Carollia perspicillata*, 4 *Platyrrhinus recifinus*, 3 *Artibeus* sp., 3 *Rhinophylla pumilio*, 2 *Desmodus rotundus*, 2 *Phyllostomus discolor*, 2 *P. hastatus*, and 1 *Lonchophylla mordax*. In addition, 88 *Glossophaga soricina*, 12 *Molossus ater*, 4 *Trachops cirrhosus*, and 1 *Myotis nigricans*, were observed inside local houses. Our report confirms the occurrence of *L. mordax* in the Espirito Santo State, as previously reported by Ruschi (1953). There are few other records of this species, but it is also known from the states of Bahia and Pernambuco, in northeast Brazil (Taddei et al., 1983; Willig, 1983).

We found the following data concerning the food habits of these species that were not known until now: Utilization of *Momordica* sp. fruits (Cucurbitaceae, n=1) by *P. hastatus*, *Cecropia* sp. fruits (Cecropiaceae, n=2) by *P. recifinus*, and use of pollen by *Rhinophylla pumilio* (undetermined taxa, n=3; n=frequency of occurrence of the food item in the sample of bats that was captured, in a presence-absence scheme). This last species was considered a fruit-eater by Gardner (1977) and Reis and Peracchi (1987); the latter authors determined that seven kinds of fruits were eaten by *R. pumilio*, at the Manaus area in the state of Amazonas, in northern Brazil. Information obtained for *C. perspicillata* indicated that fruits of the genus *Solanum* (Solanaceae) were the most common item in the diet; fruits of *S. inaequale*, were eaten by 43% (n=13) of the *C. perspicillata*, and 27% (n=8) consumed unidentified *Solanum*. Seeds of *Piper arboreum* (Piperaceae) (n=7; 23%) and insects (n=2; 7%) were less commonly found during the period of study. Marinho-Filho (1991) compared the diets of *C. perspicillata* and *Sturnira lilium*, species that are very similar in size and general food habits; this author found that the first species feeds mainly on *Piper* (64%), whereas the latter fed mainly on *Solanum* (76%) at Serra do Japi, in the state of São Paulo, in southeastern Brazil. He concluded that differential utilization of fruits by *C. perspicillata* and *Sturnira lilium* represented resource partitioning, allowing the coexistence of the two bat

species in periods of low fruit availability. In the Linhares Forest Reserve, *Sturnira lilium* is not abundant (Peracchi and Albuquerque, 1993), and its rarity may permit *C. perspicillata* to become a greater consumer of *Solanum* fruits.

Literature Cited

Gardner, A. 1977. Feeding habits. Pp. 293-350, in Biology of bats of the New World family Phyllostomatidae. Part III. (R. J. Baker, J. K. Jones, Jr., and D. C. Carter, eds.). Special Publications, The Museum, Texas Tech University, Lubbock, 16:1-364.

Marinho-Filho, J. S. 1991. The coexistence of two frugivorous bat species and the phenology of their food plants in Brazil. Journal of Tropical Ecology, 7:59-67.

Peracchi, A. L., and S. Albuquerque. 1993. Quirópteros do município de Linhares, Estado do Espírito Santo, Brasil (Mammalia, Chiroptera). Revista Brasileira de Biologia, 53:575-581.

Reis, N. R., and A. L. Peracchi. 1987. Quirópteras da região de Manaus, Amazonas, Brasil (Mammalia, Chiroptera). Boletim do Museu Paraense Emilio Goeldi, Série Zoologia, 3:161-182.

Ruschi, A. 1953. Morcegos do Estado do Espírito Santo. XVII. Família Phyllostomidae. Descrição das espécies: *Lonchophylla mordax* e *Hemiderma perspicillatum*, com algumas observações biológicas a respeito. Boletim do Museu de Biologia Prof. Mello-Leitão, Santa Tereza, Série Zoologia, 19:1-7.

Taddei, V. A., L. D. Vizotto, and I. Sazima. 1983. Uma nova espécie de *Lonchophylla* do Brasil e chave para a identificação das espécies do gênero (Chiroptera, Phyllostomidae). Ciência e Cultura, 35:625-629.

Willig, M. R. 1983. Composition, microgeographic variation, and sexual dimorphism in caatinga and cerrado bat communities from northeast Brazil. Bulletin of the Carnagie Museum of Natural History, 23:1-131.

Zortéa, M. 1993. Folivory in *Platyrrhinus (Vampyrops) lineatus*. Bat Research News, 34:59-60.

Zortéa, M., and S. L. Mendes. 1993. Folivory in the big fruit-eating bat, *Artibeus lituratus* (Chiroptera: Phyllostomidae), in eastern Brazil. Journal of Tropical Ecology, 9:117-120.

Zortéa, M., and A. G. Chiarello. 1994. Observations on the big fruit-eating bat, *Artibeus lituratus*, in an urban reserve of south-east Brazil. Mammalia, 58:665-670.

Please send us news about what you and/or your students are doing with bats that would be of interest to your colleagues. Or even better, write an article about your work or interest in bats and send it along to us to share with all the rest of us. G.R.Horst

Field Identification of Two Morphologically Similar Horseshoe Bats-- *Rhinolophus malayanus* and *R. stheno*

Mark F. Robinson. 11 Newton Road, Little Shelford, Cambridgeshire CB2 5HL, U.K.

Introduction

Although ultrasonic detectors are commonly used for bat identification (Ahlen, 1993; Jones, 1993), there has been little work on the echolocation calls of bats in southeastern Asia. Heller (1989), Heller et al., (1989), and Surlykke et al. (1993) described the calls of a few species, but several species of bats are difficult to identify in the field--for example, the morphologically similar *Rhinolophus malayanus* and *R. stheno* (McFarlane and Blood, 1986). The present study investigates differences in body size and echolocation calls of these two species to improve our ability to differentiate them in the field.

Methods

Field work was carried out between 18 May and 26 October 1993, in Thung Yai-Huai Kha Khaeng Wildlife Sanctuary, a dry tropical forest in western Thailand. *R. malayanus* and *R. stheno* were caught in mist-nets. Juveniles were distinguished from adult and immature bats by unfused epiphyses of the metacarpo-phalangeal joints. Immature bats were those having grown to their full size, but not sexually mature. The forearm, tail, tibia, and ear length, as well as noseleaf width, of adult and immature bats were measured to the nearest 0.1 mm using dial calipers. Body weight was determined to the nearest 0.5 g with a 100-gram, spring balance (Pesola). Using a bat detector (QMC Mini), calibrated prior to the study, the echolocation frequency with the strongest amplitude, as observed on the detector's dial, was determined for calls from adult bats, both in the hand and in flight.

Results

Rhinolophus malayanus and *R. stheno* were caught in the understory of mixed deciduous and dry dipterocarp forest at heights ranging from 0.5 to 2.0 m. The frequency of the echolocation calls of *R. malayanus* and *R. stheno* were 75 kHz and 85-90 kHz, respectively, and they were detectable over a range of approximately 2-3 m. There was no difference in the observed frequency of calls from hand-held or free-flying bats. There was overlap in all body measurements of *R. malayanus* and *R. stheno*, with the exception of noseleaf width (Table 1).

Discussion

In the past, there has been confusion over the identification of *R. malayanus* and *R. stheno*. Lekagul and McNeely (1977) stated that, although the two species resembled each other externally, it was possible to distinguish between them by size and lancet shape. They described *R. malayanus* and *R. stheno* as having a forearm length of 41-43 mm and 45-48 mm, respectively. However, after examining a series of *R. malayanus* from northern Thailand and Laos and *R. stheno* from Malaya, McFarlane and Blood (1986) found that there were no distinguishable differences in size, lancet shape, or color. Also, Lekagul and McNeely (1977) stated that *R. stheno* was distinguishable from *R. malayanus* by the proportional length of the finger bones, the second phalanx of the third finger being greater than 1.5 times the length of the first phalanx. McFarlane and Blood (1986) argued that this difference was an artifact of variation in wing length. Although McFarlane (pers. comm.) speculated that *R. stheno* and *R. malayanus* were conspecific, Corbet and Hill (1992) clearly distinguished *R. malayanus* from *R. stheno* by differences in the cranial rostrum.

Obviously, field identification of these two species is difficult. The present results support the findings of McFarlane and Blood (1986) in that no differences were found between the forearm, tail, tibia, and ear lengths. However, *R. malayanus* clearly had a wider noseleaf and lower echolocation frequency than did *R. stheno*. Although the frequency dial of a QMC Mini bat detector can be difficult to read accurately, the call frequency of *R. stheno* recorded in the present study is close to the 86 kHz observed by Heller & Helversen (1989). A variation of approximately 3 kHz occurs in the CF portion of calls emitted by adult male

and female *Rhinolophus hipposideros* (Jones et al., 1992). Consequently, the 10-kHz difference observed between species in the present study is unlikely to be a result of intraspecific variation.

Bat detectors can provide a valuable aid to the field identification of certain bats that, in the hand, appear very similar. Ultrasonic identification thus eliminates the need to collect specimens for identification purposes, a practice that may be impractical and/or undesirable.

Acknowledgments

This project was supported by the by The Seub Nakhasathien Foundation in collaboration with The Royal Forest Department, to whom we are very grateful. We would also like to thank The National Research Council of Thailand for permission to conduct research in Thailand. In addition, I would like to thank all the staff of the Thailand Institute of Scientific and Technological Research and Wildlife Fund Thailand for providing help and advice.

Literature Cited

Ahlen, I. 1993. Species identification of bats in flight. Pp. 3-10 in Proceedings of the first European bat detector workshop (K. Kapteyn, ed.). Netherlands Bat Research Foundation, Amsterdam.

Corbet, G. B., and J. E. Hill. 1992. The Mammals of the Indomalayan Region. Nat. Hist. Mus. Publ., Oxford University Press.

Heller, K. G. 1989. Echolocation calls of Malaysian bats. Z. Saugetierkunde, 54:1-8.

Hill, J. E. 1975. Systematic section. Pp. 8-38 in The bats and bat parasites of Thailand (CTNRC staff, Hill, J. E. & J. A. McNeely). Report FE-516-1, U.S. Army Res. Dev. Group, Far East.

Jones, G. 1993. Some techniques for the detection, recording and analysis of echolocation calls from wild bats. Pp. 25-35 in Proceedings of the first European bat detector workshop (K. Kapteyn, ed.). Netherlands Bat Research Foundation, Amsterdam.

Jones, G., T. Gordon, and J. Nightingale. 1992. Sex and age differences in the echolocation calls of the lesser horseshoe bat, *Rhinolophus hipposideros*. Mammalia, 56:189-193.

Lekagul, B., and J. A. McNeely. 1977. Mammals of Thailand. Association for the Conservation of Wildlife, Bangkok.

McFarlane, D. A., and B. R. Blood. 1986. Taxonomic notes on a collection of Rhinolophidae (Chiroptera) from northern Thailand, with a description of a new subspecies of *Rhinolophus robinsoni*. Z. Saugetierkunde, 51:218-223.

Surlykke, A., L. A. Miller, B. Mohl, B. B. Andersen, J. Christensen-Dalsgaard, and M. B. Jorgensen. 1993. Echolocation in two very small bats from Thailand: *Craseonycteris thonglongyai* and *Myotis siligorensis*. Behav. Ecol. Sociobiol., 33:1-12.

Table 1. Weights (g) and linear measurements (mm) of *R. malayanus and R. stheno.*

	R. malayanus				*R. stheno*			
	N	Range	Mean	SD	N	Range	Mean	SD
Forearm length	20	39.8-43.0	41.5	1.1	12	42.8-45.2	44.1	0.7
Tail length	17	19.0-25.5	21.7	1.6	12	15.8-21.2	17.4	1.7
Tibia length	18	15.8-20.8	17.4	1.3	12	20.3-22.0	21.1	0.5
Ear length	18	15.0-20.4	17.9	1.5	12	16.0-19.3	17.4	0.9
Noseleaf width	11	7.9-9.0	8.2	7.0	5	7.2-7.6	7.3	0.2
Weight	18	6.5-9.0	7.0	1.1	12	6.0-8.5	7.3	0.8

Letters to the Editor

Notes on the Mating Behavior of a Captive Colony of *Tadarida brasiliensis*

Rehabilitation activities from 1990 through 1995 in the state of Texas resulted in the accumulation of a captive colony of 27 non-releasable *Tadarida brasiliensis*. No mating activity was observed in the colony until the late fall of 1993. In November of 1993, several of the males were heard singing a faint, bird-like song, unlike any audible sounds heard in the colony for the previous two years. At the same time, several of the males in the colony began exhibiting territorial behavior, rubbing their chests (gular gland area) against fabric roosting pockets provided in the cage, as well as portions of the cage itself. These areas were aggressively defended, both vocally and physically, against intrusion by other males. Only females were allowed to enter and share these roosting pockets. Some of the males also appeared to exhibit possessive behavior towards particular females.

Although no equipment was utilized to record non-audible vocalizations during this time, such vocalizations may have been associated with this behavior, as males appeared to be aware of other males that came within proximity of their female roosting companions when such encounters were artificially manipulated outside of their sight, as evidenced by audible irritation buzzes. There was a significant change in the roosting pattern in the colony at this time, and four of the females began roosting with one particular singing male who had always roosted somewhat separately from the rest of the colony. The male singing, aggression, and territorial behavior continued through the month of February, 1994, and then ceased abruptly, and the colony resumed its former roosting pattern. All four of the females who had been roosting with the lone male became pregnant that season. Aggressive behavior was subsequently exhibited by males in the colony only towards this lone male, who was consistently chased off from any communal roosting area. This behavior repeated itself in the fall of 1994, when once again several males were heard singing. Again male aggression and territorial behavior was observed that continued through February of 1995, and then ceased. Again, several females moved into the roosting pocket used by the lone male while singing was heard, and again these females became pregnant.

This season, pregnant females subsequently moved into a roosting pocket utilized by a second adult male who appeared to guard the area, allowing only pregnant females to enter. Live births resulted in both 1994 and 1995. Infants shared the roosting area that had been utilized by the pregnant females, and also appeared to be guarded by the adult male. Females returned to alternate roosting areas after giving birth, but continued to move into the "guarded" roosting area to nurse infants. One interesting observation regarding the care of the young has been noted in relation to a female who gave birth to a still-born infant. This female was was subsequently seen coaxing the two day old infant of another female to nurse from her. Although the mother of this infant continues to nurse the pup as well, this "surrogate mother" has been observed nursing the infant on a number of occasions for the entire three weeks since its birth.

Information regarding the caging, diet, and behavior of each individual in this captive colony is recorded in "Behavioral Study of a Captive Colony of Non-releasable *Tadarida Brasiliensis*", Amanda Lollar, 1995, and can be obtained from Lollar at 817-325-3404.

Acknowledgments:
My sincerest thanks to Barbara French of Bat Conservation International for helping me to document and summarize observations made over a five year period, and for encouraging me to share these observ-ations with members of the scientific community.

Submitted by Amanda Lollar, 308 S.W. Sixth Street, Mineral Wells, TX

A New Longevity Record for the Bat *Myotis lucifugus*

We have previously reported (Davis and Hitchcock, 1994, Bat Research News, 35:61; Sommers et al., 1993, Bat Research News 34:3) on longevity and survival rates of male little brown bats, *Myotis lucifugus*, and now we report a new record. On his annual check of hibernating bats in an iron mine, at Paradox, New York, on 24 February 1995, Alan Hicks (Endangered Species Unit, Wildlife Resource Center, State of New York) saw two banded bats. The one that he was able to capture carried a band numbered 29-127083. This male *M. lucifugus* was one that we and our students at Middlebury College had banded at the mine on 11 February 1961. At the time of recapture, this bat was more than 34 years old, making it the world's oldest known chiropteran.

Submitted by Wayne H. Davis and Harold B. Hitchcock. 130 Jesselin Dr., Lexington, KY 40503 and 1 Locust Lane, Middlebury, VT 05753

* * * * *

The Brown Creeper (Aves: Certhiidae): a Competitor of Bark-roosting Bats?

Birds and bats are the only extant vertebrates capable of powered flight, and consequently, biologists are intrigued by the potential for ecological and evolutionary interactions between these volant groups. Rydell and Speakman (1995, Biol. J. Linn. Soc., 54:183-191), for example, believed that predation by birds prevented bats from evolving diurnal activity patterns, and Fenton and Fleming (1976, Biotropica, 8:104-110) and Brigham and Fenton (1991, J. Zool., 223:475-489) examined overlap in the foraging niches of nocturnal birds and bats. Potential competition for resting sites has not been addressed, to our knowledge, and herein, we describe the apparent temporary takeover of a bark roost of Indiana bats (*Myotis sodalis*) by the brown creeper (*Certhia americana*).

Since 1991, we have been studying a group of Indiana bats in a small wetland near Vermontville, Eaton Co., Michigan. The area, at one time, was forested pasture, but it had been persistently inundated for years. Consequently most trees were dead or dying, and Indiana bats roosted under the exfoliating bark (Kurta et al., 1993, Amer. Midl. Nat., 129:132-138). On 27 May, at about 1030 hours, we visited the area for the first time in 1995. We readily heard bats in one tree (3F) that Indiana bats had used intermittently in both 1993 and 1994. The presence of bats also was demonstrated by fecal pellets on a collecting screen, placed at the base of this tree during an earlier study.

The most frequently used roost tree (2A) from 1992 to 1994 was located 45 m from 3F. We did not hear any vocalizations at 2A on 27 May, and we saw no fecal pellets on its collector, indicating that Indiana bats had not used this tree in 1995. However, while standing nearby, we noticed a brown creeper fly to the tree and disappear under the bark, precisely where bats had entered in previous years. In the following 30 minutes, a bird flew to the tree about once every three minutes. It was apparent that two birds were involved and that each entered the space under the bark carrying an insect and left a short time later with an empty beak. The birds were obviously nesting there, and we could see nesting material protruding from the space beneath the bark. Five days later, on 1 June, the birds were gone--either the nestlings had fledged or the nesting attempt had failed. During our next visit, on 10 June, we heard bats vocalizing in the tree, and fecal pellets were present on the collector.

The brown creeper typically nests under the loose bark of dead trees (Bent, 1948, U. S. Natl. Mus. Bull. 195), making its nest site, at least superficially, identical to the preferred roosting site of the Indiana bat. Interestingly, Eaton Co., Michigan, is on the southern edge of the breeding range for this bird (McPeek and Adams, 1994, The birds of Michigan, Indiana Univ. Press) but on the northern edge of the summer range for Indiana bats (Kurta, 1995, Mammals of the Great Lakes Region, Univ. Michigan Press). Factors that limit the northward distribution of Indiana bats in summer are unknown but could include distance from suitable hibernacula, temperature, and perhaps competition with the brown creeper. After arriving on their summering grounds, the pregnant bats are presumably in a weakened condition, following an extended hibernation and long migration. Finding a favored roost

site already occupied by birds could be potentially dangerous at this time, especially if alternate roosts are not known or readily available. We realize that this suggestion of interclass competition is only speculation, but we wish to bring our observation to the attention of chiropteran and avian biologists alike and to solicit other observations of interactions between roosting bats and nesting birds.

Submitted by Allen Kurta and Rod Foster, Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197

Announcing a Conference on:

BATS AND FORESTS

to be held 19 to 21 October 1995 in Victoria, BC, Canada

We (Robert Barclay and Mark Brigham) have organized a meeting of interested participants from both the academic and government realms to discuss the various issues concerning bats in forest environments. Victoria is perhaps the only Canadian location at which we can guarantee no snow at this time of year!

The meeting will take place at the Clarion Hotel Grand Pacific, conveniently located in downtown Victoria adjacent to the Royal B.C. Provincial Museum, the Provincial Legislature and literally a stones throw from the Pacific Ocean. Hotel rates are $60 (Can) per night single or double. We would ask that you make your own hotel reservation (1-800-663-7550). The cost of the meeting to all participants, including speakers, will be a registration fee of $30 (Canadian). This will cover the costs of the meeting room, coffee breaks, program and abstracts and a copy of the symposium volume. We have solicited support in the form of sponsorship from a variety of sources in British Columbia (BC Ministries of Forests and Environment) to help offset the cost of the meeting and the publication of a proceedings volume. We also hope to have a sponsored reception on Thursday evening.

The initial response to the meeting has been very positive (approximately 75 expected participants so far) and we are anticipating an excellent get-together. We are especially keen that the meeting be very informal with lots of time for discussion rather than just simply a one-way presentation of information.

Currently 20 individuals have agreed to come and present papers on their work on bats and forests including: Stuart Perlmeter, Mark Perkins, Al Kurta, David Genter, Dave Saugey, Blake Sasse, Rachel Stevens, Steve Cross, Janet Erickson, Todd Mattson, John Hayes, Michael Lacki, Doreen Baichtel and some of our own students (Scott Grindal, Matina Kalcounis, Maarten Vonhof, Lisa Crampton). All of these individuals are currently working on a variety of issues involving bats in forest ecosystems ranging geographically from Alaska to California, and Ontario to New Hampshire and Louisiana. As well, three individuals (Bruce Marcot - US Forest Service, Brad Stelfox - Alberta Environment Centre, and Brian Nyberg - BC Ministry of Forests) with direct links to Government sponsored Forestry Research will set the scene for us.

Although the speaking program is filled and we cannot accept any additional papers, we strongly encourage you to come and join us in the discussions which will be the major emphasis of the meeting. If you are interested in attending, contact either of us at our addresses below. If you cannot attend, we would be happy to sell for a modest price, a copy of the proceedings when published. Write to either of us and we can provide you with the current details concerning price, publication date, etc.

Robert Barclay, Biological Sciences,
University of Calgary, Calgary, AB,
T2N 1N4 Canada.
tel. 403-220-3561, FAX 403-289-9311.
e-mail "Barclay@acs.ucalgary.ca"

Mark Brigham, Department of Biology,
University of Regina, Regina, SK
S4S 0A2 Canada
tel. 306-585-4255 FAX 306-585-4894.
e-mail "Brigham@max.uregina.ca"

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 by e-mail to tgriff@titan.iwu.edu (including complete name of journal and mailing address). 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.

ANATOMY

Aufdermaur, E., M. Haffner, and V. Ziswiler. 1995. Microscopic-anatomical investigations on the ano-rectal region of pipistrelle bats *Pipistrellus pipistrellus* (Schreber, 1774) (Mammalia, Chiroptera). Revue Suisse de Zoologie, 102: 103-108. [Univ. Zurich, Zool. Museum, Winterthurerstr. 190, CH-8057 Zurich, Switzerland]

BEHAVIOR

Gerell-Lundberg, K., and R. Gerell. 1994. The mating behaviour of the pipistrelle and the Nathusius pipistrelle (Chiroptera): a comparison. Folia Zoologica, 43: 315-324. [Lund Univ., Dept. Ecol., Ecol. Bldg., S-223 62 Lund, Sweden]

Haffner, M. 1995. The possibilities of scent marking in the mouse-eared bat *Myotis myotis* (Borkhausen, 1797) and the noctule bat *Nyctalus noctula* (Schreber, 1774) (Mammalia, Chiroptera). Zeitschrift fur Saugetierkunde, 60: 112-118. [Univ. Zurich, Zool. Museum, Winterthurerstr. 190, CH-8057 Zurich, Switzerland]

Catto, C. M. C., P. A. Racey, and P. J. Stephenson. 1995. Activity patterns of the serotine bat (*Eptesicus serotinus*) at a roost in southern England. Journal of Zoology, 235: 635-644. [Univ. Aberdeen, Dept. Zool., Tillydrone Ave., Aberdeen AB9 2TN, Scotland]

Marimuthu, G., J. Habersetzer, and D. Leippert. 1995. Active acoustic gleaning from the water surface by the Indian false vampire bat, *Megaderma lyra*. Ethology, 99: 61-74. [Forschungsinst. Senckenberg, Senckenberganlage 25, D-60325 Frankfurt, Germany]

Storz, J. F. 1995. Local distribution and foraging behavior of the spotted bat (*Euderma maculatum*) in northwestern Colorado and adjacent Utah. Great Basin Naturalist, 55: 78-83. [Dept. Biol., Boston Univ., Boston, MA 02215]

CONSERVATION/PUBLIC EDUCATION

Elmqvist, T., W. E. Rainey, E. D. Pierson, and P. A. Cox. 1994. Effects of tropical cyclones Ofa and Val on the structure of a Samoan lowland rain forest. Biotropica, 26: 384-391. [Dept. Ecol. Botany, Univ. of Umeå, S-901 87 Umeå, Sweden]

Greenhall, A. M., and S. C. Frantz. 1994. Bats. Pp. D5-D24 in S. E. Hygnstrom, R. M. Timm, and G. E. Larson (Eds.). Prevention and Control of Wildlife Damage. University of Nebraska Cooperative Extension, Lincoln, NB. [Dept. Mammalogy, Amer. Mus. Nat. Hist., Central Park West at 79th St., New York, NY 10024]

Robinson, M. F. 1994. Observation on the wildlife trade at the dailey market in Chiang Khan, Northeast Thailand. Natural History Bulletin, Siam Society, 42: 117-120. [11 Newton Rd., Little Shelford, Cambridgeshire CB2 5HL, Great Britain]

CYTOLOGY

Pow, C. S. T., and L. Martin. 1995. Ovarian and uterine lymphatic drainage in Australian flying-foxes (Genus *Pteropus*, Suborder Megachiroptera). Cell and Tissue Research, 280: 371-381. [Univ. Queensland, Dept. Physiol. & Pharmacol., Brisbane, QLD 4072, Australia]

DEVELOPMENT

Defanis, E., and G. Jones. 1995. Post-natal growth, mother-infant interactions and development of vocalizations in the vespertilionid bat *Plecotus auritus*. Journal of Zoology, 235: 85-97. [Univ. Bristol, Dept. Zool., Woodland Rd., Bristol BS8 1UG, Avon, England]

DISEASE

Almeida, M. F., E. A. C. Aguiar, L. F. A. Martorelli, and M. M. S. Silva. 1994. Laboratory diagnosis of rabies in Chiroptera carried out of a metropolitan area of southeastern Brazil. Revista de Saude Publica, 28: 341-344. [Rua Santa Eulalia 86, BR-02031020 Sao Paulo, Brazil]

DISTRIBUTION/FAUNAL STUDIES

Andersen, K. W. 1994. On the status of bats on Andros and San Salvador Island, Bahamas. Pp. 1-4 in L. B. Kass (Ed.). Proceedings of the Fifth Symposium on the Natural History of the Bahamas. Bahamian Field Station, Ltd., San Salvador, Bahamas. [Biol. Dept., Gannon Univ., Erie, PA 16541]

Arita, H. T., and J. A. Vargas. 1995. Natural history, interspecific association, and incidence of the cave bats of Yucatan, Mexico. Southwestern Naturalist, 40: 29-37. [Centro de Ecologia, UNAM, Apartado Postal 70-275, 04510, Mexico, D.F., Mexico]

Baagøe, H., and D. Bloch. 1994 (1993). Bats (Chiroptera) in the Faroe Islands. Fróoskaparrit 41. bók 1994 (1993): 83-88. [Zool. Mus., Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark]

Chytil, J., and M. Vlasin. 1994. Contribution to the knowledge of bats (Mammalia, Chiroptera) in Albania. Folia Zoologica, 43: 465-467. [Adm. Protected Landscape, Area & Biosphere Reserve Palava, Namesti 32, CR-62901 Mikulov, Czech Republic]

Obuch, J. 1994. Types of the bat assemblages (Chiroptera) recorded in Slovakia. Folia Zoologica, 43: 393-410. [Comenius Univ. Bratislava, Bot. Gardens, Detached Unit, Blatnica 03815, Slovakia]

Kapteyn, K., and P. H. C. Lina. 1994. Eerste vondst van een kraamkolonie van Nathusius' dwergvleermuis *Pipistrellus nathusii* in Nederland. (First record of a nursery roost of Nathusius' pipistrelle *Pipistrellus nathusii* in the Netherlandds). Lutra, 37: 106-109. [Provincial Authorities of Noord-Holland, Physical Planning and Landscape Agency, POB 6090, NL-2001 HB HAARLEM, The Netherlands]

Koopman, K. F., and D. W. Steadman. 1995. Extinction and biogeography of bats on 'Eua, Kingdom of Tonga. American Museum Novitates, 3125: 1-13. [Dept. Mammalogy, Amer. Mus. Nat. Hist., Central Park West at 79th St., New York, NY 10024]

Pacheco, V., H. de Macedo, E. Vivar, C. Ascorra, R. Arana-Cardó, and S. Solari. 1995. Lista anotada de los mamíferos Peruanos. Occasional Papers in Conservation Biology, 2: 1-35. [Dept. Mastozoología, Mus. Hist. Nat., Universidad Nacional Mayor de San Marcos, Apartado 14-0434, Lima 14, Peru]

Rydell, J., K.-B. Strann, and J. R. Speakman. 1994. First record of breeding bats above the Arctic Circle: northern bats at 68-70° N in Norway. Journal of Zoology, London, 233: 335-339. [Skogsrydsvägen 14, S-523 33 Ulricehamn, Sweden]

Spitzenberger, F. 1994. The genus *Eptesicus* (Mammalia, Chiroptera) in southern Anatolia. Folia Zoologica, 43: 437-454. [Nat Hist Museum, Burgring 7, POB 417, A-1014 Vienna, Austria.

ECHOLOCATION

Rydell, J., and R. Arlettaz. 1994. Low-frequency echolocation enables the bat *Tadarida teniotis* to feed on tympanate insects. Proceedings of the Royal Society of London B, 257: 175-178. [Univ. Aberdeen, Dept. Zool., Tillydrone Ave., Aberdeen AB9 2TN, Scotland]

ECOLOGY

Adam, M. D., M. J. Lacki, and L. G. Shoemaker. 1994. Influence of environmental conditions on flight activity of *Plecotus townsendii virginianus* (Chiroptera, Vespertilionidae). Brimleyana, 21: 77-85. [Oregon State Univ., Hatfield Marine Sci. Ctr., 2030 S. Marine Sci. Dr., Newport, OR 97365]

Arita, H. T. 1993. Rarity in Neotropical bats: correlations with taxonomy, diet, and body mass. Ecological Applications, 3: 506-517. [Centro de Ecologia, UNAM, Apartado Postal 70-275, 04510, Mexico, D.F., Mexico]

Balasingh, J., S. Suthakar Isaac, and R. Subbaraj. 1993. Tent-roosting by the frugivorous bat *Cynopterus sphinx* (Vahl 1797) in southern India. Current Science, 65:418.[Dept. Zoology,

St. John's College, Triunelveli 627 002, Tamilnadu, India]

Bhat, H. R., and T. H. Kunz. 1995. ALtered flower fruit clusters of the kitul palm used as roosts by the short-nosed fruit bat, *Cynopterus sphinx* (Chiroptera, Pteropodidae). Journal of Zoology, 235: 597-604. [Natl. Inst. Virol., Poona 422011, Maharashtra, India]

Blake, D., A. M. Hutson, P. A. Racey, J. Rydell, and J. R. Speakman. 1994. Use of lamplit roads by foraging bats in southern England. Journal of Zoology, London, 234: 453-462. [Dept. Zool., Univ. Aberdeen, Tillydrone Ave., Aberdeen AB9 2TN, Scotland]

Brooke, A. P. 1994. Diet of the fishing bat, *Noctilio leporinus* (Chiroptera: Noctilionidae). Journal of Mammalogy, 75: 212-218. [Dept. Marine & Wildlife Resources, POB 3730, Pago Pago, American Samoa 96799]

Dejong, J. 1994. Habitat use, home-range and activity pattern of the northern bat, *Eptesicus nilssoni*, in a hemiboreal coniferous forest. Mammalia, 58: 535-548. [Dept. Wildlife Ecol., Box 7002, S-75007 Uppsala, Sweden]

Gopfert, M. C., and L. T. Wasserthal. 1995. Notes on echolocation calls, food and roosting behaviour of the Old World sucker-footed bat *Myzopoda aurita* (Chiroptera, Myzopodidae). Zeitschrift fur Saugetierkunde, 60: 1-8. [Univ. Erlangen Nurnberg, Inst. Zool. 1, Staudtstr. 5, D-91058 Erlangen, Germany]

Hessel, K., and U. Schmidt. 1994. Multimodal orientation in *Carollia perspicilla* (Phyllostomidae). Folia Zoologica, 43: 339-346. [Univ. Bonn, Inst. Zool., Poppelsdorfer Schloss, D-53115 Bonn, Germany]

Jones, G., and J. Rydell. 1994. Foraging strategy and predation risk as factors influencing emergence time in echolocating bats. Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences, 346: 445-455. [Univ. Bristol, Sch. Biol. Sci., Woodland Rd., Bristol BS8 1UG, Avon, England.

Kalcounis, M. C., and R. M. Brigham. 1995. Intraspecific variation in wing loading affects habitat use by little brown bats (*Myotis lucifugus*). Canadian Journal of Zoology, 73: 89-95. [Univ. Regina, Dept. Biol., Regina, SK S4S 0A2, Canada]

Kalko, E. K. V. 1994. Coupling of sound emission and wingbeat in naturally foraging European pipistrelle bats (Microchiroptera, Vespertilionidae). Folia Zoologica, 43: 363-376. [Univ. Tubingen, Morgenstelle 28, D-72076 Tubingen, Germany]

Kunz, T. H., and C. A. Diaz. 1995. Folivory in fruit-eating bats, with new evidence from Artibeus jamaicensis (Chiroptera, Phyllostomidae). Biotropica, 27: 106-120. [Boston Univ., Dept. Biol., 5 Cummington St., Boston, MA 02215]

Lewis, S. E. 1995. Roost fidelity of bats: a review. Journal of Mammalogy, 76: 481-496. [Carroll Coll., Dept. Biol., 100 NE Ave., Waukesha, WI 53186]

Madhavan, A. 1993. Feeding habits of the greater false vampire bat *Megaderma* (*Lyroderma*) *lyra* (Geoffroy, 1810). Observations on the food and feeding habits of Megaderma lyra in laboratory conditions. Trends in Life Sciences (India), 8: 27-31. [Kailath Tharavadu, Paralam P. O. -680 575, Trichur (Via.), Kerala State, India]

Rodríguez-Durán, A. 1995. Metabolic rates and thermal conductance in four species of neotropical bats roosting in hot caves. Comparative Biochemistry and Physiology A, 110: 347-355. [Boston Univ., Dept. Biol., 5 Cummington St., Boston, MA 02215]

Rydell, J., A. Bushby, C. C. Cosgrove, and P. A. Racey. 1994. Habitat use by bats along rivers in north east Scotland. Folia Zoologica, 43: 417-424. [Univ. Aberdeen, Dept. Zool., Tillydrone Ave., Aberdeen AB9 2TN, Scotland]

Suthakar Isaac, S., and G. Marimuthu. 1993. Early outflying and late homeflying in the Indian pygmy bat under natural conditions. Oecologia, 96: 426-430. [Dept. Animal Behaviour & Physiol., Sch. Biol. Sci., Madurai Kamaraj Univ., Madurai-625021, India]

Webb, P. I., J. R. Speakman, and P. A. Racey. 1995. Evaporative water loss in two sympatric species of vespertilionid bat, *Plecotus auritus* and *Myotis daubentoni*: relation to foraging mode and implications for roost site selection. Journal of Zoology, 235: 269-278. [Univ. Pretoria, Mammal Res. Inst., Pretoria 0002, South Africa]

Zortéa, M., and A. G. Chiarello. 1994. Observations on the big fruit-eating bat, *Artibeus lituratus*, in an urban reserve of south-east Brazil. Mammalia, 58: 665-670. [Rua Deck Ruschi 146, Santa Teresa, E. S. 29650-000 Brazil]

EVOLUTION

Legendre, P., F. J. Lapointe, and P. Casgrain. 1994. Modeling brain evolution from behavior: a permutational regression approach. Evolution, 48: 1487-1499. [Univ Montreal, Dept. Sci. Biol., CP 6128, Succ. Ctr. Ville, Montreal, PQ H3C 3J7, Canada]

Rydell, J., and J. R. Speakman. 1995. Evolution of nocturnality in bats: potential competitors and predators during their early history. Biological Journal of the Linnean Society, 54: 183-191. [Univ. Aberdeen, Dept. Zool., Tillydrone Ave., Aberdeen AB9 2TN, Scotland]

PALEONTOLOGY

Benito, C. S. 1994. Paleoclimatical interpretation of the Quaternary small mammals of Spain. Geobios, 27: 753-767. [Museo Nacl. Ciencias Nat., Jose Gutierrez Abascal 2, E-28006 Madrid, Spain]

Reumer, J. W. F. 1994. The insectivorous mammals (Marsupialia, Didelphidae, Insectivora, Nyctitheriidae, Chiroptera) from the early Oligocene of Balm, Switzerland. Eclogae Geologicae Helvetiae, 87: 1029-1035. [Nat Museum Rotterdam, POB 23 452, 3001 KL Rotterdam, Netherlands]

PARASITOLOGY

Bangs, P., and M. J. Bangs. 1995. *Microfilaria sundaicus* sp. n., a chabfilaria-like parasite (Filarioidea, Onchocercidae) from the blood of the horseshoe bat (*Rhinolophus affinis*) in Flores, Indonesia. Journal of the Helminthological Society of Washington, 62: 32-34. [USN, Med. Res. Unit 2, Box 3, APO, AP, 96520]

Klompen, J. S. H., J. E. Keirans, and L. A. Durden. 1995. Three new species of ticks (*Ixodida, Argasidae, Carios*) from fruit bats (Chiroptera, Pteropodidae) in the Australian region, with notes on host associations. Acarologia, 36: 25-40. [Colorado State Univ., Dept. Microbiol., Ft Collins, CO, 80523]

Uchikawa, K., M. Y. Zhang, B. M. O'Connor, and H. Klompen. 1994. Contribution to the taxonomy of the genus *Spinturnix* (Acari, Spinturnicidae), with the erection of a new genus, *Emballonuria*. Folia Parasitologica, 41: 287-304. [Shinshu Univ., Sch. Med., Dept. Parasitol., Matsumoto, Nagano 390, Japan]

PHYSIOLOGY

Kovtun, M. F., and N. F. Zhukova. 1994. Feeding and digestion intensity in Chiropterans of different trophic groups. Folia Zoologica, 43: 377+. [Ukrainian Acad. Sci., Schmalhausen Inst. Zool., B Khmelnitsky Str. 15, Kiev 252601, Ukraine]

Kunz, T. H., J. O. Whitaker, and M. D. Wadanoli. 1995. Dietary energetics of the insectivorous Mexican free-tailed bat (*Tadarida brasiliensis*) during pregnancy and lactation. Oecologia, 101: 407-415. [Boston Univ., Dept. Biol., 5 Cummington St., Boston, MA 02215]

Studier, E. H., and T. H. Kunz. 1995. Accretion of nitrogen and minerals in suckling bats, *Myotis velifer* and *Tadarida brasiliensis*. Journal of Mammalogy, 76: 32-42. [Univ. Michigan, Dept. Biol., Flint, MI 48502]

Tiunov, M. P. 1994. Maximum possible level of energy consumption from food for Chiroptera. Russian Journal of Ecology, 25: 128-131. [Russian Acad. Sci., Far Eastern Branch, Inst. Soil Biol., Moscow 117901, Russia]

REPRODUCTION

Suthakar Isaac, S., G. Marimuthu, and M. K. Chandrashekaran. 1994. Fecundity in the Indian pygmy bat (*Pipistrellus mimus*). Journal of Zoology, 234: 665-668. [Dept. Anim. Behaviour & Physiol., School Biol. Sci., Madurai Kamaraj Univ., Madurai-625 021, India]

SYSTEMATICS

Colgan, D. J., and T. F. Flannery. 1995. A phylogeny of Indo-West Pacific Megachiroptera based on ribosomal DNA. Systematic Biology, 44: 209-220. [The Australian Mus., Sydney 2000, Australia]

Flannery, T. F. 1994. Systematic revision of *Emballonura furax* Thomas, 1911 and E. dianae Hill, 1956 (Chiroptera, Emballonuridae), with description of new species and subspecies. Mammalia, 58: 601-612. [Australian Museum, 6-8 Coll. St., Sydney, NSW 2000, Australia]

Williams, S. L., M. R. Willig, and F. A. Reid. 1995. Review of the *Tonatia bidens* complex (Mammalia, Chiroptera), with descriptions of two new subspecies. Journal of Mammalogy, 76: 612-626. [Texas Tech Univ. Museum, Lubbock, TX 79409]

Zortéa, M., and V. A. Taddei. 1995. Taxonomic status of *Tadarida espiritosantensis* Ruschi, 1951 (Chiroptera: Molossidae). Boletim do Museu de Biologia Mello Leitão, Nova Série, 2: 15-21. [Mus. Biol. Mello Leitão, Santa Teresa, ES 29650-000, Brazil]

Upcoming Bat Research Conferences

It is not too late to plan to attend the

25th North American Symposium on Bat Research

which will be held in conjunction with the

Tenth International Bat Research Conference

in Boston from August 7 to 11, 1995. For last minute details contact Thomas H. Kunz at Boston University. His addresses are: Department of Biology, Boston University, Boston, MA 02215. telephone 617-353-2474, FAX 617-353-6340, E-mail kunz@bio.bu.edu

* * * * * * * * * * * *

A Conference on

Bats and Forests

will be held in Victoria, British Columbia, Canada October 19 to 21, 1995. For details see page 7 of this issue.

* * * * * * * * * * * *

Begin to plan now to attend the

7th European Bat Research Symposium

in Veldhoven, The Netherlands on 12 it 16 August, 1996. For details contact Peter Lina, 7th EBRS, c/o IKC_NBLF, P.O. Box 30, 6700 AA Wageningen, The Netherlands. FAX +3187027561

INFORMATION NEEDED

I am compiling a list of both mega- and microchiropterans for future editions of ***Bats in Captivity***, now being published by Wild Ones, Springville, CA., and a forthcoming publication ***Handbook of Exotic Animals***, Manson Publishing Ltd., London. The following information is needed: Captive longevity data; methods of wing repair and results (radiographs would be a plus); interesting pathological reports (e.g. myopathies, neoplasms, other); blood and serum values especially from megabats and electrolyte content of serum samples. Please send information to: Susan M. Bernard, Department of Herpetology, Zoo Atlanta, 800 Cherokee Ave. SE, Atlanta, GA: FAX 404-627-7514

WANTED: DECEASED BATS

I will buy non-endangered specimens from captive-bred colonies.
Call William Stevens, "Evolution: Natural History in Soho"
120 Spring Street, New York, NY 10012
tel. 212-343-1114, Fax 212-343-1815

Please note: The Publisher of ***Bat Research News*** has spoken with Mr. Stevens (above) and was informed that his organization plans to freeze-dry specimens and market them for educational purposes. ***Bat Research News*** neither endorses nor recommends Mr. Stevens or his organization. This is merely an announcement at his request. G. Roy Horst, Publisher and Managing Editor.

BAT RESEARCH NEWS

Volume 36: Nos. 2 & 3 **Summer and Fall, 1995**

BAT RESEARCH NEWS

Publisher and Managing Editor
G. Roy Horst, Department of Biology, S.U.N.Y. at Potsdam, Potsdam, NY 13676
Tel. 315-267-2259 or -2130 FAX 315-267-3170 E-mail: horstgr@potsdam.edu.

Editor for Feature Articles and Letters
Allen Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197
Tel. 313-487-1174

Editor for Recent Literature
Thomas Griffiths Department of Biology Illinois Wesleyan University, Bloomington, IL 61702
Tel. 309-556-3230 FAX 309-556-3411 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

Instructions to Contributors and Subscribers:

Bat Research News is published four times each year, each year consisting of one volume of four issues, appearing in Spring, Summer, Fall, and Winter. ***Bat Research News*** publishes short papers, general interest notes, etc., which are edited by at least two reviewers. Manuscripts dealing with original work should be submitted in duplicate following the latest *CBE Style Manual* or following the style used in the *Journal of Mammalogy*. In addition, latest news on bat research, correspondence, book reviews, meeting announcements, reports and an extensive review of recent literature titles are included. Communications concerning recent literature should be addressed to Griffiths, manuscripts and letters to Kurta, "news" and all other matters to Horst.

Subscriptions to individuals are $ 15.00 per volume(year). All issues are sent surface mail, postage paid by ***Bat Research News*** to all addresses world-wide. Special arrangements have been made to serve European and Australian subscribers. All copies to Europe are sent bulk via air mail to Dr. Robert Stebbings, in Great Britain, who will then forward them, first class mail to their final destinations. Subscriptions to institutions are $ 25.00 per volume(year).

Please make all checks payable to; ***Bat Research News.*** Subscribers outside the United States can please pay by checks in U.S. dollars, drawn on banks with an affiliated office in the United States, or payment can be made via international money orders, (in U.S. funds). Mail your payment to G. Roy Horst at the address above.

Bat Research News is : ISSN 0005-6227
United States Internal Revenue Service tax exemption number 16-1356633

Bat Research News
is composed, printed and mailed at:
Potsdam College of the State University of New York,
Potsdam, NY, 13676, U.S.A.

BAT RESEARCH NEWS

Volume 36 **Summer and Fall, 1995** **Number 2 and 3**

CONTENTS

Front Cover

Peter Smith, from Wales, U.K., provided the interesting front cover for this issue and sent along the following...."Sheelagh Kerry and I were in Trinidad working on bats from September to December 1992. We found that a disused bunker at Corvine, Chaguaramas was being used by a small number of *Phyllostomus histatus* as a night roost. Remains of their prey (including harlequin beetle elytra) had accumulated on the floor at the back of the bunker. We thought this would make a nice picture for Bat Research News so Sheelagh has done this pen and ink drawing."

BAT RESEARCH NEWS

Volume 36: Numbers 2 & 3 **Summer and Fall 1995**

Original Issue Compiled by Dr. G. Roy Horst, Publisher and Managing Editor of *Bat Research News*, 1994.

Bat Research News is ISSN # 0005-6227.

BAT RESEARCH NEWS

Volume 36: Nos. 2 & 3 Summer and Fall 1995

HAROLD BRADFORD HITCHCOCK, 1903-1995

Thomas A. Griffiths
Department of Biology, Illinois Wesleyan University, Bloomington, IL 61702

Harold B. Hitchcock, one of the early pioneers in this country in the study of bat migration, homing, and longevity, died on September 13, 1995 at his home in Middlebury, Vermont. Hal was born on June 23, 1903 in Hartford, Connecticut, the son of Alfred Marshall Hitchcock and Harriet (Thompson) Hitchcock. He attended the Hartford public schools, Phillips Exeter Academy, and Williams College. After his undergraduate education was completed, he worked for five years at an insurance company in New York City. Deciding that biology interested him more than insurance, Hal attended Harvard University and graduated from there with a Ph. D. in 1938. While at Harvard, Hal met and struck up a friendship with a promising young undergraduate student from Barnstable, Massachusetts who had a strong interest in bats (among many other things): Donald R. Griffin.

Hal taught at the University of Western Ontario from 1939 to 1943, first as an Instructor and later as an Assistant Professor of Zoology. During those years, Hal was active in the Canadian Conservation Association, several ornithological societies, and he served in the Canadian Officers Training Corps. It was also during those years that Hal had the great good sense to court and ultimately marry Martine Cutter, originally of Winchester, Massachusetts. They were married on February 20, 1942, and later had three delightful daughters: Susan, Harriet, and Martha. Martine, all three daughters, and four grandchildren survive Hal.

In 1943, Hal joined the faculty of Middlebury College, where he spent most of his career. He rose rapidly through the academic ranks, eventually becoming Chair of the Biology Department and retiring in 1968 as the Albert Mead Professor of Biology. Formal retirement apparently did not suit Hal, as he immediately accepted visiting professorships at Boston University in the summer of 1968, at Norwich University in the fall of 1968, and at the University of Hawaii in the spring of 1969. In 1969, the President of Bates College in Lewiston, Maine had a problem. He could not find a suitable person to chair the Bates Biology Department. President Thomas Hedley Reynolds had known Hal when both were at Middlebury, and he asked Hal if he would come out of retirement "temporarily" to head the department until a permanent Chair could be found. In 1969, Hal was named Charles Dana Professor of Biology and Chair of the Bates College Biology Department, a position he held until 1972. In the May 1971 Short Term, Hal offered a course on bat banding to six Bates undergraduates, one of them being me. The experience certainly changed my life. We spent six weeks roaming the roads of Vermont, New Hampshire, Maine, and parts of Canada collecting bats from houses, churches, caves and mines. Along the way, we met and worked with a (younger) M. Brock Fenton, who introduced us not only to bats of southeastern Canada, but also to some wonderful Hungarian cuisine, and some lyrically-memorable campfire songs.

Hal studied newts, mice, blackbirds, and crabs at various times in his career, but his two particular interests were the homing behavior of racing pigeons and the migration and homing of bats. He produced a number of important early papers on bat migration, some co-authored with other "giants" of mid-Twentieth Century bat research (see below). In support of his research, Hal received grants from the American Philosophical Society, the National Science Foundation, and the American Academy of Arts and Science. He was named a Fulbright Fellow and traveled to the

Max Planck Institute in Germany in 1954. He held memberships in the American Society of Zoologists, the American Society of Mammalogists, the American Ornithologists Union, the National Speleological Society, the Nature Conservancy, and in our own informal group, the North American bat research society. Following his retirement at Bates College, Hal retained his interest in bats and continued to study them for many more years. He was instrumental in protecting the hibernaculum at Mt. Aeolus in southern Vermont by persuading the Nature Conservancy to buy the land around the cave. He also became very interested in reported sightings of panthers in Vermont and Maine, and he devoted considerable time and energy to collecting evidence proving that native panthers still inhabited the forests of New England.

In 1986, our bat research society awarded Hal its highest honor at the 19th Annual North American Symposium on Bat Research held in Amherst, Massachusetts. Hal joined a roster of distinguished scientists (including his long-time friends Don Griffin) who have been awarded the Gerrit S. Miller Jr. Award. I know that the award meant a great deal to Hal, as it did to two of his former students in attendance: Dorothy C. Dunning and me. Hal touched many people's lives, invariably for the better. We remember him with admiration, appreciation, and affection, and we miss him a great deal.

Publications by Harold B. Hitchcock

Davis, W. H., and H. B. Hitchcock. 1964. Notes on sex ratios of hibernating bats. Journal of Mammalogy, 45: 475-476.

Davis, W. H., and H. B. Hitchcock. 1965. Biology and migration of the bat, *Myotis lucifugus*, in New England. Journal of Mammalogy, 46: 296-313.

Davis, W. H., and H. B. Hitchcock. 1994. A new longevity record for *Myotis lucifugus*. Bat Research News, 35: 61.

Girard, K. F., H. B. Hitchcock, G. Edsall, and R. A. MacCready. 1965. Rabies in bats in southern New England. New England Journal of Medicine, 272: 75-80.

Griffin, D. R., and H. B. Hitchcock. 1965. Probable 24-year longevity records for *Myotis lucifugus*. Journal of Mammalogy, 46: 332.

Hitchcock, H. B. 1939. The behavior of adult amphibian skin cultured in vivo and in vitro. Journal of Experimental Zoology, 81: 299-331.

Hitchcock, H. B. 1939. Notes on the newt, Triturus viridescens. Herpetologica, 1: 149-150.

Hitchcock, H. B. 1940. Keeping track of bats. Canadian Field-Naturalist, 54: 55-56.

Hitchcock, H. B. 1941. *Myotis subulatus leibii* and other bats hibernating in Ontario and Quebec. Canadian Field-Naturalist, 55: 46.

Hitchcock, H. B. 1941. The coloration and color changes of the gulf-weed crab, *Planes minutus*. Biological Bulletin, 80: 26-30.

Hitchcock, H. B. 1941. A device for opening small bird bands. Bird Banding, 12: 73-74.

Hitchcock, H. B. 1943. *Peromyscus maniculatus bairdii* and *Sorex palustris hydrobadistes* in the lower peninsula of Michigan. Journal of Mammalogy, 24: 402-403.

Hitchcock, H. B. 1943. Hoary bat, *Lasiurus cinereus*, at Southampton Island, N.W.T. Canadian Field-Naturalist, 57: 86.

Hitchcock, H. B. 1943. Yellow-headed blackbird and golden eagle in Middlesex County, Ontario. Canadian Field-Naturalist, 57: 88.

Hitchcock, H. B. 1943. Banding as an aid in studying the activities of the little brown bat, *Myotis lucifugus lucifugus*. Michigan Academy of Science, Arts, and Letters, Papers, 29: 277-279.

Hitchcock, H. B. 1945. Recoveries of banded chimney swifts. Canadian Field-Naturalist, 59: 148-149.

Hitchcock, H. B. 1945. *Myotis subulatus leibii* in Ontario. Journal of Mammalogy, 26: 433.

Hitchcock, H. B. 1949. Hibernation of bats in southeastern Ontario and adjacent Quebec. Canadian Field-Naturalist, 63: 47-59.

Hitchcock, H. B. 1949. *Myotis lucifugus lucifugus* mistaken for *Myotis keenii septentrionalis* . Canadian Field-Naturalist, 63: 208.

Hitchcock, H. B. 1949. Caves in eastern Canada. Bulletin of the National Speleological Society, Nov. 1949: 60-63.

Hitchcock, H. B. 1950. Sex ratios in hibernating bats. National Speleological Society, Bulletin No. 12, pp. 26-28.

Hitchcock, H. B. 1950. Aerial observations of homing pigeons. Anatomical Record, 108: 83-84.

Hitchcock, H. B. 1952. Airplane observations of homing pigeons. Proceedings of the American Philosophical Society, 96: 270-289.

Hitchcock, H. B. 1953. How do they find their way home? Animal Kingdom, 56: 9-14.

Hitchcock, H. B. 1954. Felled tree kills beaver (*Castor canadensis*). Journal of Mammalogy, 35: 452.

Hitchcock, H. B. 1955. A summer colony of the least bat, *Myotis subulatus leibii* (Audubon and Bachman). Canadian Field-Naturalist, 69: 31.

Hitchcock, H. B. 1955. Homing flights and orientation of pigeons. The Auk, 72: 355-373.

Hitchcock, H. B. 1957. The use of bird bands on bats. Journal of Mammalogy, 38: 402-405.

Hitchcock, H. B. 1960. Bat-banding in the United States. The Ring, 2: 277-280.

Hitchcock, H. B. 1962. Bat Caves. Vermont Life, 17: 26-33.

Hitchcock, H. B. 1963. An unintended bat trap. Journal of Mammalogy, 44: 577-578.

Hitchcock, H. B. 1965. Twenty-three years of bat banding in Ontario and Quebec. Canadian Field-Naturalist, 79: 4-14.

Hitchcock, H. B. 1967. Hibernation in Vermont. Vermonter, Jan.-Feb., pp. 11-13.

Hitchcock, H. B. 1968. Bats. 5 pp. in R. Duhamel, Ed. Hinterland Who's Who. Queen's Printer, Ottawa.

Hitchcock, H. B. 1974. Reflections of a batman. Massachusetts Wildlife, 25: 8-13.

Hitchcock, H. B. 1986. Panther in Vermont? Vermont Natural History, 1986:

Hitchcock, H. B., and R. Keen. 1980. Possible geographical influence on survival by sex in *Myotis lucifugus*. Pp. 129-133 in D. E. Wilson and A. L. Gardner, eds. Proceedings Fifth International Bat Research Conference, Texas Tech Press, Lubbock, 434 pp.

Hitchcock, H. B., R. Keen, and A. Kurta. 1984. Survival rates of *Myotis leibii* and *Eptesicus fuscus* in southeastern Ontario. Journal of Mammalogy, 65: 126-130.

Hitchcock, H. B., and K. Reynolds. 1940. *Pipistrellus* hibernating in Ontario. Canadian Field-Naturalist, 54: 89.

Hitchcock, H. B., and K. Reynolds. 1942. Homing experiments with the little brown bat, *Myotis lucifugus lucifugus* (LeConte). Journal of Mammalogy, 23: 258-267.

Keen, R., and H. B. Hitchcock. 1980. Survival and longevity of the little brown bat (*Myotis lucifugus*) in southeastern Ontario. Journal of Mammalogy, 61: 1-7.

Sommers, L. A., W. H. Davis, and H. B. Hitchcock. 1993. Longevity records for *Myotis lucifugus*. Bat Research News, 34: 3.

* * * * * *

Short-term Fate of Radiotracked, Juvenile, Grey-headed Flying Foxes *Pteropus poliocephalus* Released at a Colony Site in Sydney, Australia

M. L. Augee, Denise Ford, and Maree Treadwell
University of New South Wales, Sydney 2052 (MLA)
Ku-ring-gai Bat Colony Committee, P.O. Box 607 Gordon NSW 2072, Australia (DF and MT)

Orphaned grey-headed flying foxes (*Pteropus poliocephalus*) raised by animal welfare organizations in Australia are commonly released in March or April, at the age of about four months. This is usually done by placing the banded juvenile bats in a large cage near a natural colony site and, after a period of acclimation, allowing them to leave the cage. Food is commonly supplied at the cage for up to eight weeks thereafter. A successful release is assumed when a bat no longer returns to the release site for feeding. In March 1995, we tested this assumption by placing radio transmitters on juvenile bats released at a colony of grey-headed flying foxes, in Gordon, New South Wales.

Gordon is a middle suburb of Sydney that contains a valley of remnant, degraded forest dominated by Myrtaceae species, especially *Syncarpia glomulifera, Eucalyptus pilularis,* and *E. saligna.* The valley is surrounded by suburban development. Fourteen hectares of this valley has been set aside as the Ku-ring-gai Flying Fox Reserve, and a colony site within the reserve is occupied by *P. poliocephalus* throughout the year. The colony is at its largest from March to May, during the mating period. During this period in 1995, the colony contained about 20,000 bats, occupying 0.57 ha of the valley. Prior to release, 28 juvenile bats were fitted with transmitters (Biotelemetry Tracking Australia, Adelaide) weighing 7g (the bats weighed 372-521g). The transmitters were attached with either Aryldite or contact adhesive, neither of which proved superior. All transmitters fell off or were groomed off within 6 weeks. While the transmitters were attached, the location of bats within the valley during the day was determined by cross bearings from surrounding vantage points. Known feeding areas throughout metropolitan Sydney were checked, but only two bats were located beyond the vicinity of the colony site--one in the suburb of Hornsby, 10 km NW, and one in the suburb of Roseville, about 5 km SW of Gordon.

In addition to these juvenile bats,

which had been hand-reared from an early age, two wild juvenile bats, both female, were released at the same time. These animals had been in captivity either 4 or 6 weeks, while recovering from minor injuries. The signal from one of these bats was lost two days after release, when it presumably left the area. The other disappeared at the same time, reappeared 6 days later, remained 12 days, and then disappeared entirely. During those 12 days, she only roosted three days in the colony site with the resident bats, and on other days, she roosted in the valley, but outside the actual colony.

For released juvenile bats, 90 + 12% (SD) of male and 94 + 7% of female roosting sites, in and around the valley, were outside the colony site (Fig.1). There was no significant difference between males and females in this regard ($p=0.45$ for an unpaired, two-tailed t-test of arc-sine transformed data). Positions fixed within the colony site were simply a subset of a random distribution of the locations used by the released juveniles, along the creek in the valley. Most positions fixed in the colony site were used for one day only, and only four of the juveniles spent 2-4 consecutive days roosting with the resident colony. Six weeks after attachment, 16 of the transmitters that had fallen to the ground were collected from the valley floor. Only one was found within the boundaries of the resident colony.

We concluded that the released juvenile bats did not integrate into the established colony. They did not form any aggregations outside the resident colony, and roosted individually in different trees each day. Their roosting sites were, however, concentrated around the release cage and feeding site (Fig. 1).

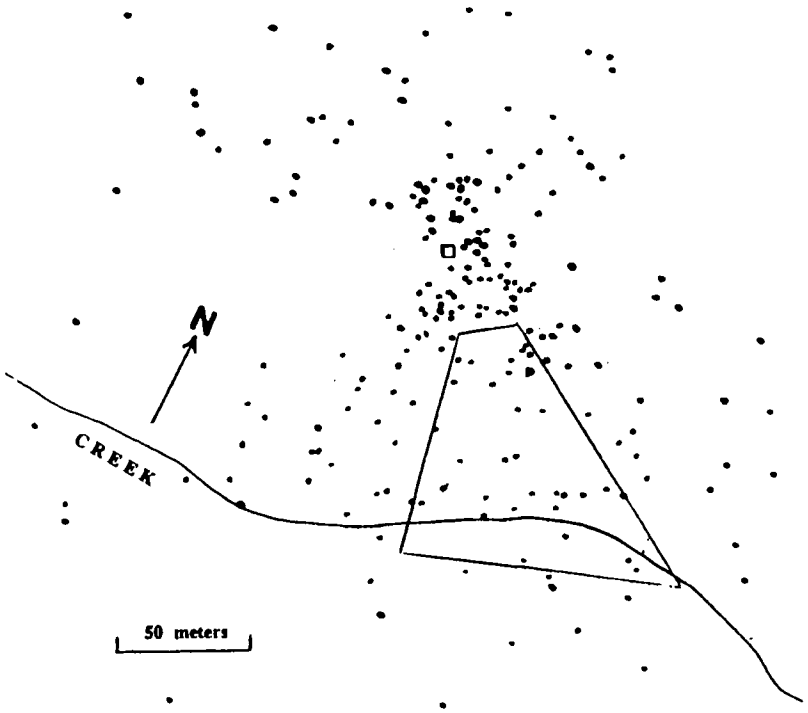

Figure 1. Positions of bats released into the Ku-ring-gai Flying Fox Reserve as determined by radiotracking. The trapezoid-like figure represents the boundaries of the resident colony. The open square indicates the cage from which radio-collared bats were released and where food was provided during the study.

Preliminary Assessment of Radiotransmitter Retention by Fur-clipped and Unclipped Townsend's Big-Eared Bats *Plecotus townsendii* and Pallid Bats *Antrozous pallidus*

David S. Dobkin, Bijaya Kattel, and Ronald D. Gettinger
High Desert Ecological Research Institute, 15 S.W. Colorado Avenue, Suite 300, Bend, OR 97702 (DSD)
Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO 80523 (BK), and
Biology Department, Randolph-Macon Women's College, Lynchburg, VA 24503 (RDG)

Abstract

We used free-ranging Townsend's big-eared bats (*Plecotus townsendii*) and captive pallid bats (*Antrozous pallidus*) to compare duration of transmitter retention by bats with transmitters glued to their fur ("unclipped"), and bats with transmitters glued to their skin after removal of fur ("clipped"). Although sample sizes were small, we found no difference in duration of attachment between species or between treatments. Based on our data, we see no justification for incurring costs associated with the increased handling time and potential physical hazard posed to bats by clipping fur for transmitter attachment. We urge investigators to be cognizant of the potential for error in telemetry studies that may result from inattention to transmitter attachment methodology and to potential differences among species in duration of transmitter retention.

Introduction

The development of inexpensive and increasingly miniaturized radiotelemetry units has generated an unprecedented level of research aimed at understanding the movements and activity patterns of bats (Wilkinson and Bradbury, 1988). The small size (< 30 g) of most North American bats necessitates the use of very small (< 2 g) transmitter/battery units. The need to minimize total mass of the unit carried by an animal strongly constrains both the strength of signal output and battery longevity, which are related directly to the mass of telemetry components. As a result, transmitter units carried by small bats generally produce viable signals for no more than 2-3 weeks. Given this limited period, it is important to maximize the potential time that a transmitter will remain attached to the bat.

Typically, transmitters are attached to the interscapular region or lower back of the bat by gluing the unit to the fur (e.g., Barclay, 1985) or to the skin after clipping the fur (e.g., Brigham and Fenton, 1986), but many studies fail to indicate whether or not fur was clipped prior to transmitter attachment.

Clipping the fur on small bats under field conditions can be time consuming and potentially hazardous to the bat (Brigham and Fenton, 1986). In addition, removal of fur from the back of a small endotherm with a high surface-to-mass ratio creates a potentially significant avenue for heat loss (Calder, 1984) and increased energetic costs.

Actual duration of transmitter retention by bats usually must be inferred in field studies by the number of nights over which signals are received, with typical ranges of one day to less than three weeks. These data provide minimum known durations of transmitter attachment, because units that cease to transmit signals, but remain attached, cannot be distinguished from units that have stopped transmitting and fallen from bats. In addition, bats that move out of receiver range cannot be distinguished from bats with failed transmitters or bats that lost their units in locations that preclude signal reception.

Especially when working with species that are in jeopardy or sensitive to disturbance, the small number of subject animals places a premium on data acquisition and the need to maximize duration of transmitter attachment. Comparisons of transmitter attachment techniques and transmitter retention times have been conducted with small birds (Perry et al., 1981; Sykes et al., 1990; Johnson et al., 1991), but no comparative studies have been conducted with small mammals to evaluate alternative methods of transmitter attachment within species, nor have any studies documented actual duration of transmitter retention on bats under controlled conditions. As part of a field study to examine seasonal movements of Townsend's big-eared bats (*Plecotus townsendii*) (Dobkin et al., 1995), we attempted to evaluate whether removal of fur before transmitter attachment results in longer duration of transmitter retention. To provide comparative data under controlled conditions, we utilized a small captive colony of pallid bats (*Antrozous pallidus*).

Study Area and Methods

Fieldwork was conducted from 7 April

to 9 June 1992 in Deschutes County, Oregon, on the Fort Rock Ranger District of the Deschutes National Forest, and on adjacent lands administered by the Bureau of Land Management. The primary study area (44°25' to 43°37' N, 121°15' to 120°48' W) consisted of a basin and surrounding buttes supporting extensive, forested, lava flows, covered by open stands of ponderosa pine (Pinus ponderosa). A more detailed description of the study area is provided by Dobkin et al. (1995).

Six big-eared bats (average mass=10.6 g) were captured by hand between 1100 and 1730 hours, from four different caves, in April and May. Each bat was fitted with a battery-powered (known battery life of 14-21 days), miniature radiotransmitter unit (Model BD-2B, Holohil Systems, Ltd.) weighing 0.6-0.7 g and measuring 10 x 7 x 4 mm, with a 14 cm antenna. Transmitters were affixed to the dorsal, interscapular fur (3 females, 1 male) with eyelash cement (Duo brand), or glued to the skin after fur had been clipped (2 females).

Bats carrying transmitters were tracked with portable receivers (Telonics) equipped with directional antennae. Bats were monitored for nearly 850 observer-hours over the 64-day period. Using the portable receivers, we attempted to locate bats through a combination of daytime ground searches, nighttime triangulation from fixed locations, and nighttime flights by fixed-wing aircraft carrying a receiver and wing-mounted antennas and equipped with a LORAN system. Further details of the monitoring protocol are provided by Dobkin et al. (1995). Minimum duration of transmitter attachment on big-eared bats was inferred from radio contacts with free-flying bats.

Precise durations of transmitter attachment were obtained through the use of a small captive colony of pallid bats maintained at The High Desert Museum. Six female pallid bats (average mass=20.5 g) were housed in a naturalistic exhibit (2 m long x 1 m wide x 1.8 m high) that allowed unhindered flight and provided vertical roost sites on horizontal, wooden, ceiling beams, with embedded radiant-heat cables. The same model of transmitter unit used for big-eared bats was used on pallid bats, and units were attached in exactly the same way--three bats had their fur clipped before transmitter attachment, and two bats had units attached directly to their fur. No more than two bats in the colony carried transmitters concurrently. Pallid bats were checked twice daily for the status of transmitters.

Results

Pallid bats retained transmitters for 1-13 days (median=5) in captivity, and big-eared bats retained transmitters for 3-14 days (median=10) in the field (Fig. 1). There was no significant difference between species in duration of transmitter attachment (p=0.25, Mann-Whitney U-test).

Duration of transmitter attachment on bats with clipped fur ranged from 1-13 days (median=5) and on unclipped bats ranged from 3-14 days (median=10). We tested the hypothesis that bats carrying transmitters glued to their skin would retain units longer than bats with transmitters affixed to their fur, but found no significant difference in duration of attachment (p=0.12, Mann-Whitney U-test).

Discussion

Minimum durations of transmitter attachment in other field studies of small bats are similar to the periods we found for big-eared and pallid bats. One of the largest radiotagging studies of bats (Brigham and Fenton, 1986), for example, reported a range of 1-18 days with a mean of 6.3 days retention by big brown bats (*Eptesicus fuscus*; n=85) carrying one-gram transmitters. Our study provides the first measurements of actual durations for transmitter retention on bats in a captive colony under simulated natural conditions. Although we found no statistically significant differences, either between species or between clipped and unclipped animals, these data must be viewed as preliminary because of the limited sample sizes.

The comparison between species should be viewed with caution as the data for pallid bats are actual durations, whereas data for big-eared bats are inferred durations and thus represent minimum actual periods of transmitter attachment. We do not know if big-eared bats that retained units for one week or less actually lost their transmitters, whether units malfunctioned but remained attached, or whether the bats moved from the study area and could no longer be detected by our receivers (Dobkin et al., 1995). Of the three big-eared bats that retained transmitters for 13 or more days, we know with certainty when a unit was lost only for one animal whose transmitter was recovered one day after the last in-flight radio contact; the other two bats may have retained their units for an unknown number of additional days. Hence, we suggest that big-eared bats actually retained telemetry units longer than pallid bats. Resolution of this question can be achieved only by placing units on bats in a confined area, where individuals can be observed reliably, even if

transmitter output fails, and where units can be recovered if lost from bats.

Pallid bats roosted communally during this study, and telemetry units were subjected to frequent rubbing and possible gnawing and claw abrasion as bats crawled over individuals carrying telemetry units. Antennas often were bowed by other animals positioning themselves dorsally to animals with units, although no antennas actually were broken. We suggest that such activity contributes to shorter retention periods by communally roosting bats and should be examined in future studies. Big-eared bats roosted solitarily during our study (Dobkin et al., 1995), but they do roost communally during some portions of their annual cycle.

The pallid bat that lost its transmitter after one day was clearly bothered by the presence of the attached unit and was observed repeatedly scratching at it in the hours following attachment. We feel confident that the loss of this unit was due largely to the bat's own attempts to remove the transmitter.

The result of clipping fur versus not clipping is less ambiguous than the between-species comparison. The data clearly indicate that gluing small transmitters directly to fur does not preclude extended retention of the units, as three of the four units retained the longest were on unclipped animals. Based on these data, we see no justification for incurring the costs associated with increased handling time and potential physical hazard posed to bats by clipping their fur. We encourage other investigators to report transmitter-retention data and attachment methodologies as routine parts of their manuscripts, and we hope that our study will stimulate studies designed explicitly to examine questions regarding techniques of transmitter attachment and the potential for interspecific variation in transmitter retention times.

Acknowledgments

We thank The High Desert Museum of Bend, Oregon, for permission to work with their pallid bat colony and owe particular thanks to animal care specialists Mary Jo Douglas and Becky Anderson for their maintenance of the pallid bats. We also thank Jamie Haskins for field assistance with the radiotelemetry work. Mike Gerdes and Lew Becker of the Deschutes National Forest and Chris Carey of the Oregon Department of Fish and Wildlife contributed in many ways to the success of this project. Helpful discussions and reviews by Mike Gerdes, Brad Sample, Richard Clawson, and Patricia Brown improved the manuscript.

This project was carried out in part with funding provided by the United States Forest Service under Contract No. 43-04GG-2-69020.

Literature Cited

Barclay, R. M. R. 1985. Foraging behavior of the African insectivorous bat, *Scotophilus leucogaster*. Biotropica, 17:65-70.

Brigham, R. M., and M. B. Fenton. 1986. The influence of roost closure on the roosting and foraging behaviour of *Eptesicus fuscus* (Chiroptera: Vespertilionidae). Canadian Journal of Zoology, 64:1128-1133.

Calder, W. A., III. 1984. Size, function, and life history. Harvard University Press, Cambridge, Massachusetts, 431 pp.

Dobkin, D. S., R. D. Gettinger, and M. Gerdes. 1995. Springtime movements, roost use, and foraging activity of Townsend's big-eared bat (*Plecotus townsendii*) in central Oregon. Great Basin Naturalist, in press.

Johnson, G. D., J. L. Pebworth, and H. O. Krueger. 1991. Retention of transmitters attached to passerines using glue-on technique. Journal of Field Ornithology, 62:486-491.

Perry, M. C., G. H. Haas, and J. W. Carpenter. 1981. Radio transmitters for mourning doves: a comparison of attachment techniques. Journal of Wildlife Management, 45:524-527.

Sykes, P. W., Jr., J. W. Carpenter, S. Holzman, and P. H. Geissler. 1990. Evaluation of three miniature radiotransmitter attachment methods for small passerines. Wildlife Society Bulletin, 18:41-48.

Wilkinson, G. S., and J. W. Bradbury. 1988. Radiotelemetry: techniques and analysis. Pp. 105-124 in Ecological and behavioral methods for the study of bats (T. H. Kunz, ed.). Smithsonian Institution Press, Washington, DC

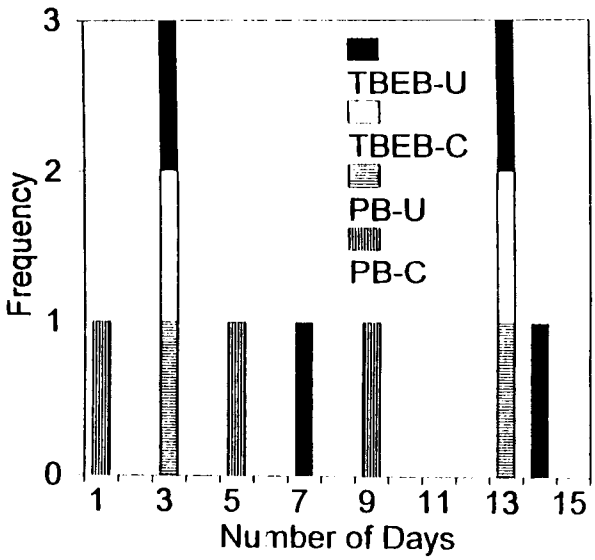

Figure 1. Duration of radiotransmitter retention on Townsend's big-eared bats (TBEB) and pallid bats (PB). Units were attached directly to the bats' interscapular fur (unclipped: TBEB-U and PB-U) or attached to the skin after removal of the interscapular fur (clipped: TBEB-C and PB-C).

Bats and Barbed Wire in Southeastern Brazil

Deborah Maria de Faria and Ivan Sazima. Departmento de Zoologia,
CP 6109, Universidade Estadual de Campinas, 13083-970 Campinas, São Paulo, Brasil

Data on bat mortality are scarce, except for reports on mass mortality due to drastic weather changes or catastrophes (Gillette & Kimbrough, 1970; Tassel, 1995; Tuttle and Stevenson, 1982). As aptly pointed out by Gillette and Kimbrough (1970:279), mortality may be the "least understood aspect of chiropteran natural history." Plant thorns and barbed-wire fences are one cause of bat mortality (Gillette & Kimbrough, 1970). Here we report and comment on seven individuals of four species of insectivorous bats trapped on barbed-wire fences, around the reserve of Santa Genebra, a semideciduous forest fragment in Campinas, São Paulo, southeastern Brazil (22° 49'S, 47° 07'W).

Between 1985 and 1994, we found the vespertilionids *Eptesicus furinalis* (n=1) and *Lasiurus cinereus* (n=3), and the molossids *Molossus molossus* (n=1) and *Tadarida brasiliensis* (n=2) entangled and dead on barbed-wire fences. Three bats (two *Tadarida* and one *Eptesicus*) had one wing entangled, two bats (one *Molossus* and one *Lasiurus*) had both wings hooked, one *Lasiurus* had one wing and the uropatagium entangled, and another *Lasiurus* had only the uropatagium caught by the barbed wire. All bats were young or subadults (unfused phalangeal epiphyses) and were found on fences at the forest edge, close to extensive open areas of cultivated fields that often are used by foraging insectivorous bats. At least one of the mentioned species, *Lasiurus cinereus*, has already been reported as a victim of barbed-wire fences, and it was suggested that the bat does not detect the fence soon enough to avoid hitting it (Gillette & Kimbrough, 1970). Based on the data above and on the number of scars on the patagia of several captured phyllostomid bats (pers. obs.), some of them skilled groundstory foragers, the frequency with which bats hit sharp subjects may be more frequent than generally thought.

Several vespertilionid and molossid bats are skilled, high-speed flyers (Neuweiler, 1989), yet the high speed and deep, free dives when pursuing prey may increase the chances of hitting such obstacles as wire fences, particularly when these lie at the boundary between open areas and vegetation, as at the Santa Genebra forest reserve. We also found doves, tyrants, and thrushes trapped on the same fences (one trapped thrush was evading a hawk). Although bats can successfully avoid a grid of wires ranging from 0.06 to 0.28 mm (Hill and Smith, 1984), such an experimental situation may make the bats more aware of their surroundings, and hence, echoes from the background may be more accurately dealt with than in more natural situations. However, even an alert bat may be subject to involuntary direction changes caused by wind bursts, and this in fact happens (pers. obs.); these bursts are possibly the main cause of trapped bats on wire fences at Santa Genebra. In addition, we recorded several large insects, even skilled flyers such as hawkmoths and dragonflies, hooked on the barbed wire after episodes of strong wind.

It is also worthy of note that all individuals found trapped at Santa Genebra were young or subadults, and at least two species (*L. cinereus* and *T. brasiliensis*) are known to make seasonal migrations in Brazil (Marques, 1991; I.S., pers. obs.). Young individuals, with no previous knowledge of foraging areas, may be more prone to suffer such accidents than older and experienced ones, especially those belonging to migrant species, which must deal with distant and different areas during their lifespan.

Acknowledgments

We thank O. C. Oliveira and M. Sazima for help in the field and the CNPq for financial support.

Literature Cited

Gillette, D. D., and J. D. Kimbrough. 1970. Chiropteran mortality. Pp. 262-283 in About Bats: a chiropteran biology symposium (B. H. Slaughter and D. W. Walton, eds.): Southern Methodist University Press, Dallas, Texas, 339 pp.

Hill, J. E., and J. D. Smith. 1984. Bats: a natural history. University of Texas Press, Austin, Texas, 243 pp.

Marques, R. V. 1991. Ciclo reprodutivo a aspectos do comportamento de *Tadarida brasiliensis* (I. Geoffroy, 1824) - Chiroptera, Molossidae - em ambiente urbano na região de Porto Alegre, RS, Brasil. Unpubl. Thesis, Pontificia Univ. Católica do Rio Grande do Sul, Porto Alegre, 110 pp.

Neuweiler, G. 1989. Foraging ecology and audition in echolocation bats. Trends in Ecology and Evolution 4 (6): 160-166.

Tassel, T. V. 1995. To save the spectacled flying fox. Bats 13: 13-15.

Tuttle, M. D., and D. Stevenson. 1982. Growth and survival of bats. Pp. 105-150 in Ecology of bats (T. H. Kunz, ed.). Plenum Press, New York, 425 pp.

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 should be sent to the Feature Editor.

Attempted Release of Two Hand-raised Big Brown Bats *Eptesicus fuscus*

As more species of bats become threatened and endangered, protection becomes increasingly important. Often pups are found after storms, building renovations, forestry practices, and other natural or man-made catastrophes. It may not be possible to release successfully hand-raised pups into the wild. After observing the behavior of captive and wild big brown bats (*Eptesicus fuscus*), I attempted the reintroduction of hand-raised juvenile big brown bats into a roost site.

On 26 May 1993, I obtained fallen pups from the floor of the attic of Samford Hall, Auburn University, Lee Co., Alabama. This attic has been a roost site for big brown bats and LeConte's free-tailed bats (*Tadarida brasiliensis cynocephala*) for more than 50 years (Durden et al., J. Medical Entomol., in press). I raised the pups on Esbilac (Pet-Ag, Inc., Hampshire, IL) until they were 5 weeks old, when they were weaned onto mealworms.

On 12 July, two juveniles were placed in a 1-m wide by 1-m high by 1.5-m long, screened, flight cage in the attic to begin reintroduction. Feeding consisted of placing mealworms in a small container on the floor of the cages. Before feeding the bats each morning, I carried one in each hand from one end of the attic to the other to familiarize them with the attic and the location of the cage. They were then allowed to fly back to the cage at increasing distances up to approximately 1.5 m. During that time, the male appeared very interested in the surroundings and echolocated continuously. The female displayed little interest, did not echolocate, and often fell asleep.

On 16 July, the cage doors were opened at 2400 hours. At 0300 hours neither bat was in the cage. The female has not been seen since, but the male returned to the cage on 18 July and sporadically thereafter until 1 August. Fecal samples were collected from the male each morning that he was in the cage at feeding time. Samples were collected to determine if he were foraging on his own or if he were eating only the mealworms. Body mass was recorded every 2-3 days. On two occasions, I placed the male in the rafters with a group of free-living big brown bats, rather than returning him to the cage after collecting the fecal sample. Mass dropped continuously from 17.3 g to 13.0 g on 1 August. I was concerned that this was too low, so I brought him home to fatten him up. Examination of fecal samples revealed only mealworms. As of 15 June 1995, the male is still in captivity.

I hope this report may help someone develop a technique that will make the successful release of hand-raised bats possible. A major oversight in this attempt was that the bats were not taught to capture natural food items in flight. This could be accomplished by erecting a screened flight-cage out-of-doors. The doors could be opened and a black light mounted so that insects are attracted to the interior of the cage. The doors could then be shut and the bats released into the enclosure. Previously, I observed untrained, hand-raised bats capture food items in flight. An experienced adult bat also could prove valuable for inclusion in the training process in that the young may attempt to mimic the adult, especially if the adult is familiar to the young bats. Access to a maternity colony also may be a key factor in the successful reintroduction, because evidence suggests that big brown bats forage and roost with their mothers until 36-45 days of age (Brigham and Brigham, 1989, Amer. Midl. Nat., 121:205-207).

submitted by:
Bettie A. Milam
Department of Zoology and Wildlife Science
331 Funchess Hall, Auburn University,
AL 36849-5414

Comments from the Founding Editor of Bat Research News

For 33 years I have lived in a residential section of Lexington, Kentucky--houses, lawns, big trees--ideal habitat for *Lasiurus borealis* and *Eptesicus fuscus*. For the first couple of decades, there was always a pair of red bats that included my property in their foraging territory during the warm months. Big brown bats also occurred in the area and at least one used my garage as a night roost.

Being so intensely interested in bats, I always looked for them whenever outdoors or driving at dusk. For the past decade or so, I have not seen a summer-resident bat in the outlying residential areas of Lexington, although *Eptesicus* still occurs in the central city; I have watched them foraging over Main Street and know of an active colony and a night roost near the courthouse. I have placed a successful bat structure on an urban house, but I have had no success at my home or several other suburban localities.

It used to be that if a door were open on a summer's night at my house, numerous scarabeid beetles (June bugs) and those slim-snouted moths (sod webworms, *Crambus*) would gather on the screen. This has not happened in recent years. On July 28, I turned on the porch light and yard light and watched for insects for 10 minutes. I saw one moth. We even leave the door and screen open at night so that the dogs can come and go into our fenced yard. Only occasionally a June bug or moth will come in.

What has happened? There must be some bugs up there, because we still have chimney swifts in all parts of Lexington, although they seem to be more numerous downtown. Japanese beetles arrived here in the past two decades and became numerous. They are strictly diurnal and perhaps have replaced the nocturnal June bugs. I suspect the main factor, however, has been the tremendous growth of chemical lawn-care services and their effect on white grubs and webworms and other insects. It may be that there is just not enough food to support our moth specialist *Lasiurus* and beetle specialist *Eptesicus*.

Now I wish to bring up another matter. I have retired and have placed my correspondence of the 1960s in the University of Kentucky Library Archives. I threw away the letters that I reprinted in *Bat Research News*, so only letters that were not published were sent to the Archives. Among them are two letters from E. Raymond Hall (then Director of the Museum of Natural History at the University of Kansas) that included the statements that he did not want them published in *Bat Research News*.

One of Hall's letters was stimulated by the paper that Mark Luckens and I published on the sensitivity of bats to DDT (Science, 146:948, 1964). Hall described the correlation between pesticide sprayings and the number of calls to the museum from people who found lasiurine bats in the yard. At that time, pesticides were a highly political issue. The vicious verbal attacks on Rachel Carson by the chemical industries, agriculture interests, and the anti-communists quite readily spread to anyone or any institution that might raise a question about pesticide use. As Director of the Museum, in such an important agricultural state, Dr. Hall could not afford to have his observations made public. I think that now, more than 30 years later, it would not be inappropriate to publish this footnote to history.

submitted by:
Wayne H. Davis
130 Jesselin Drive
Lexington, KY 40503

Editor's Note:
Dr. Davis originated Bat Research News and produced the first ten volumes.

A Symposium on Bats and Forests
Victoria, British Columbia, October 19-21, 1995

About a year ago Robert Barclay of the University of Calgary and Mark Brigham of the University of Regina began planning for a new kind of meeting, bringing together for the first time in an organized fashion, a group of bat biologists and a group of forestry and wildlife management personnel. Students of bat ecology have long been concerned about the effects of logging and other timber management practices and at the same time the professional foresters and wildlife managers have been equally concerned about how bat ecology and forest ecology were interrelated. Mark and Robert determined to bring them together and concentrate solely on these interrelationships. To that effect they convened the "Bat Forest Conference" in Victoria, British Columbia on October 19 to 21, 1995. The conference was attended by over one hundred individuals from several special fields within this broad category. The program included 26 orally presented papers, each of which generated a lively and productive discussion. The program was very focused, but after each presentation the discussions often ranged widely on this very important general topic. The extended discussion time granted to each speaker was one of the high points of the program. This was in very pleasant contrast to the larger, but less precisely focused programs of our regular bat conferences and symposia where there are so many presentations that there is often too little time for thoughtful and creative discussion. Those who attended were unanimous in their judgment that the conference was a success, and at the end, agreed that after perhaps a few years have passed, and the ideas and suggestions, and questions, have been put to the test in the field, the group should meet again, and assess what progress may have been made as the result of this conference.

It was agreed by all that the presentations were excellent, the accommodations at the Clarion Hotel Grand Pacific were luxurious, the food in Victoria is world class, and the hospitality of the people of Victoria is unsurpassed(even though a bit too British, as they all kept reminding us), and the scenery of the surrounding countryside is magnificent. Robert and Mark have set new standards of organization and efficiency in getting it all together and making it run so smoothly and look so effortless. This from one who has organized a conference or two and knows how difficult it is to make it look so easy. G.R. Horst

The abstracts of the papers presented follow in alphabetical order by first author.

Roosting Behaviour of Silver-haired Bats (*Lasionycteris noctivagans*) and Big Brown Bats (*Eptesicus fuscus*) in Northeast Oregon.

B. J. Betts, Eastern Oregon State College, La Grande, OR, USA

I used telemetry to locate maternity roost sites of four *Eptesicus fuscus* and five *Lasionycteris noctivagans* in northeast Oregon, and I measured characteristics of the roost tree, roost site itself, and surrounding habitat. I also recorded the frequency and distance of roost shifts and the size of some maternity colonies. Both species used large live and dead trees with the diameter of the trees used by *E. fuscus* being significantly larger than those used by *L. noctivagans*. Roost sites were high, uncluttered, faced no particular direction and did not differ significantly between the two species. Trees used by *E. fuscus* were in significantly more open forest on flat terrain than those used by *L. noctivagans*. *E. fuscus* tended to have larger maternity colonies than *L. noctivagans*. Bats of both species changed roost trees frequently and *E. fuscus* moved farther between trees than *L. noctivagans*, most of which remained in the same draw. Because of roost tree liability and the need for large trees as maternity roosts, it is important that forest planners retain large trees when laying-out salvage and green timber sales.

* * * * * * *

Old-Growth Forest Structure and the Bat Community: The Physical Nature of Vertical Forest Habitat and its Importance in Shaping Bat Species Assemblages.

P. Bradshaw, University of Regina, Regina, SK

Recent work on forest dwelling bat species has stimulated interest in how the composition of these faunas is derived and maintained. Resource limitation and competition do not appear to be important, but forest structure may be a primary influence in the shaping of bat communities. Old-growth forests differ from younger forests in that they exhibit greater structural heterogeneity and

can be viewed as a volume of habitat with discrete layers, each with its own peculiar structural characteristics. For flying bats, rapid movements into different microhabitats should be possible by vertical shfts between forest layers. From this it is assumed that vertical structural complexity may be an important habitat characteristic for forest dwelling bat species. I quantified forest structure by determining foliage density profiles. Increasing foliage density, represents increasing degrees of physical interference which a flying bat must negotiate. Small interspecific differences in wing and body morphology have important implications for maneuverability and agility. This may be expressed through interspecific differences in microhabitat selection. Hence, predictions, based on wing morphology and foliage density, were made regarding vertical microhabitat selection within old-growth forest. Predictions were tested using ultrasonic detectors and mist nets set at three heights, corresponding to the canopy, understory and shrub layers. The study sites were located within three forest types and two biogeoclimatic zones on Vancouver Island. Preliminary results from this ongoing study will be discussed and future work outlined.

* * * * * * *

Species Composition and Roost Requirements of Bats using Water Sources in Pinyon-Juniper Woodlands of the Middle Rio Grande River Basin

A. Chung-MacCoubrey, Rocky Mountain Forest and Range Experiment Station, Albuquerque, NM.

Bat species composition abd structures used for colony roosts were investigated in pinyon-juniper habitats of the Cibola National Forest. Ten sites with permanent water were mist netted on 4 different nights during September 1995. Number of species and total number of bats captured ranged from 0-11 species at a site and 0-134 bats in a night, respectively. California myotis *(Myotis californicus)*, small-footed myotis *(M. ciliolabrum)*, long-legged myotis *(M. volans)*, fringed myotis *(M. thysanodes)*, big brown bats *(Eptesicus fuscus)*, silver-haired bats *(Lasionycteris noctivagans)*, hoary bats *(Lasiurus cinereus)*, and free-tailed bats *(Tadarida brasiliensis)* were captured at > 5 sites, although not always in high numbers. Species captured at < 5 sites were either locally abundant [e.g. long-eared myotis (M. evotis)] or a rarity [e.g. spotted bat *(Euderma maculatum)*]. Radiotelemetry was used to study maternity roost requirements of 3 federal Category 2 candidate species in the Gallinas Mountains northwest of Magdalena. Three fringed, one long-eared, and two long-legged myotis colony roosts were located. The fringed and long-legged myotis colony roosts with 30 to over 200 bats were found in ponderosa pine snags or live poderosa pine with long, vertical cracks. These snag and live tree roosts were located in stringers of ponderosa pine within pure pinyon-juniper or at the interface of ponderosa pine and pinyon-juniper habitats. Long-eared myotis seemed to use live or dead junipers exclusively for colony and solitary roosts. To manage pinyon-juniper habitats for these 3 federal Catagory 2 species, steps should be taken to ensure that trees that serve or may serve as colony roosts are not disturbed and that potential roost trees remain available for future use.

* * * * * * *

Habitat Selections by Bats in Fragmented and Unfragmented Aspen Mixedwood Stands of Different Ages

L. H. Crampton and R. M. R. Barclay, Dept. of Biological Sciences, University of Calgary, AB

To determine if bats prefer certain ages of aspen mixedwood forest for roosting and foraging, and to predict the impacts of logging on bats, I compared relative abundances and foraging activity of bats in young, mature and old stands in 1993 and 1994, using bat detectors. In 194, I also assessed post-logging bat abundances in two of the mature and two of the old stands. I tracked radio-tagged *Myotis lucifugus* and *Lasionycteris noctivagans* to roost trees, which I measured and compared to a random sample of wildlife trees. Mean total activity of all bats was significantly greater in old than in young or mature stands. It also appeared greater in unfragmented than fragmented stands, but not significantly so. All 27 roost trees were found in old forests. Bats preferred tall (mean: 22.0 m), newly dead Populus sp.. with heart rot and low leaf cover (mean:27%). Tree-roosting colonies were small (4-63 bats) and transient. Bats likely select trees large enough to house colonies and provide suitable temperatures and these trees are only available in old stands. Roost preference in these forests, old stands must be retained, and roost sites preserved by managing the forest at the stand level.

* * * * * * *

Managed Forests in the Pacific Northwest: The Effects of Seral Stage on Bat Habitat Use Patterns.

J. L. Erickson and S. D. West. College of Forest Resources. University of Washington, Seattle, WA 98195

Timber harvest and stand-management practices have restructured the forested landscape of the Pacific Northwest. To investigate the impact of such practices on bats and other wildlife, a research project funded through the Washington State Timber, Fish and Wildlife Cooperative was initiated in 1992. As part of this project, a stand-level survey of bat activity within managed forests was conducted during the summers of 1993 and 1994. To assess patterns of habitat use across a gradient of managed forest conditions, we selected six replicates from each of four distinct seal stages; clearcut (2-3 yrs.), pre-commercially thinned (12-20 yrs.), young unthinned (30-40 yrs.) and mature (50-70 yrs.) stands. Using Anabat II bat detectors, sites were monitored for bat activity on six nights throughout each year. The number of detections recorded were not significantly different between years, but were different among seral stage types within years. Overall, activity levels were low with 46.2% of the nights having no detections. The highest detection rates were recorded in clearcut stands while young unthinned stands had no detections. Members of the genus *Myotis* were detected within all stand types except young unthinned stands but were most often detected in mature stands. Calls of big brown bats, silver-haired bats, and Townsend's big-eared bats were recorded most often in clearcuts. Neither big brown nor silver-haired bats were recorded in mature stands.

* * * * * * *

Habitat Use by Bats in Fragmented Forests

S. D. Grindal, Dept. of Biology, University of Regina, Regina, SK

The habitat disturbance of forest harvesting may have various effects on wildlife. To assess the impact on bats, ultrasonic detectors were used to monitor relative habitat use by bats in forested and riparian areas disturbed by forest harvesting. Sites were sampled for at least 90 minutes after sunset in two forest regions: Columbia (Nelson, BC) and Boreal (Newfoundland). Preliminary results suggest that riparian habitats are important foraging sites for bats, and that the apparent impact of forest harvesting may differ depending on the spacial scale under consideration. Further results of habitat fragmentation at the site, stand, and landscape level will be discussed.

* * * * * * *

The Influence of Logging Riparian Areas on Habitat Utilization by Bats in Western Oregon.

John P. Hayes and Michael D. Adam. Coastal Oregon Productivity Enhancement Program, Department of Forest Science, Oregon State University, Corvallis, Oregon 97331.

We monitored bat activity using Anabat II bat detector systems in three riparian areas that partially had been clear-cut logged in western Oregon. Total bat activity averaged 4.1 to 7.7 times higher in wooded areas than in adjacent logged areas. Activity in wooded areas was almost exclusively *Myotis* species; non-*Myotis* species, especially *Lasionycteris noctivagans*, accounted for a substantial amount of the activity in logged habitats. Lower levels of activity between the habitat types could be the result of differences in insect prey populations in the two habitats. More Lepidopterans, more large bodied insects, and fewer small bodied insects were captured in the wooded habitat than in the logged habitat. Differences in bat community composition in the two habitats could be due to differences in the morphology and echolocation call structure of the bat species. Other hypotheses that might explain differences in activity include differences in risk of predation, competitive interactions, or behavioral or evolutionary constraints. Our findings indicate that forest management activities in riparian areas can influence patterns of habitat utilization by bats.

* * * * * * *

Bat Habitat Use in Giant Sequoia (*Sequoiadendron giganteum*) Forest at Giant Forest Village, Sequoia National Park.

P.A. Heady, III and E.D. Pierson. Mount Hermon, CA; Berkeley, CA U.S.A.

A spectacular element of California's Sierra Nevada mountain flora is scattered, remnant groves of Giant Sequoia (*Sequoiadendron giganteum*), the world's largest tree (in mass and diameter). These trees are highly resistant to decay and fire, but in their several thousand year life span, a substantial fraction develop large, cave-like, basal burn cavities. The remaining groves are now largely held in public reserves and some have been extensively developed for tourism. As a component of habitat restoration, the National Park Service is removing most of the anthropogenic features in Giant Forest Village (1800-2100 m elev.), an extensive older tourist accommodation in a Giant Sequoia grove in Sequoia N.P. During July-Sept 1995, we examined 306 buildings (largely one room cabins) for bat activity, monitored suspended debris traps inside burn cavities of 24 Giant Sequoias (2-5 m diam.) and conducted limited mist netting and acoustic surveys. Approximately 20% of the buildings have some bat use; *Myotis evotis* is the only species identified as occupying building interiors. Twenty-two (92%) of the monitored burn cavities show evidence of bat use. Night roosting by pallid bats (*Antrozous pallidus*) parallels earlier reports of cavity roosting in coast redwood (*Sequoia sempervirens*).

* * * * * * *

Intraspecific Variation in the Tree Roost Site Selection by Male and Female Little Brown Bats (Myotis lucifugus).

M.C. Kalcounis and K.R. Hecker. Dept. of Biology, University of Regina, Regina, SK

In a recent review of roost fidelity in bats, Lewis (1995) suggests that species show intraspecific variability in roost site selection and fidelity can provide insight into questions regarding the costs and benefits of site fidelity. Roost site selection and fidelity are likely affected by sex and reproductive condition, however few data address intraspecific variability in these behaviours. In 1994, as part of a larger study which examined tree roost site selection by big brown bats *(Eptesicus fuscus)* in Cypress Hills, Saskatchewan, we collected data on roost site selection, fidelity and behaviour of 2 males and many female little brown bats *(Myotis lucilugus).* Selection of roost sites varied both between and within sexes. One adult male exclusively roosted in stumps while the other male roosted in snags and cavities in live and dead trembling aspen trees. Females were found roosting in buildings and live aspen trees. Female bats which roosted in buildings showed the highest site fidelity. Of the tree roosting bats, the stump roosting male displayed higher site fidelity than the other male and females roosting in tree cavities. There was variation in the use of torpor. These observations show that there can be considerable intraspecific variation in roosting behaviour and that we should be wary of presenting a simplified picture of the roosting behaviour of a particular species.

* * * * * * *

Habitat Associations of Bat Species in the White Mountain National Forest

R.A. Krusic,C.D Neefus, M. Yamasaki, and P.J. Perkins, University of New Hampshire, NH, USA, and Northeastern Forest Experiment Station, NH, USA.

The study of species communities advances an understanding of their interaction within an ecosystem and provides an insight into the likely consequences of alterations due to environmental change or habitat manipulation. Very little is known about the forest habitat associations of the 9 bat species (*Lasiurus cinereus, L. borealis, Lasionycteris noctivagans, Eptescicus fuscus, Pipistrellus subflavus, Myotis lucifugus, M. septentrionalis, M. leibii, and M. sodalis*) found in the White Mountain National Forest (WMNF). Timber management is the dominant form of habitat manipulation in the WMNF. Anabat II detectors were used to survey the relative flight and feeding activity of the bat species in four age-classes (regeneration, sapling/pole, mature, and commercially overmature) of northern hardwood and spruce/fir forest stands. These vegetative classifications are appropriate to current management structure of the WMNF. Prototype software was used to objectively identify unknown echolocation sequences in a statistically predictable manner. Non-myotids were identified to species, myotid species were identified to genus. Results of this survey indicate a baseline description of bat community structure associated with managed forests in the northeastern United States.

Roosting Behavior of a Peripheral Population of Indian Bats (*Myotis sodalis*)
A. Kurta, Eastern Michigan University, Ypsilanti, MI, U.S.A.

From 1991 to 1993, we monitored the movement of Indian bats (*Myotis sodalis*) in an unshaded wetland in Eaton Co., Michigan. Our goals were to determine patterns of roosting behavior and roost selection and to make management recommendations specific to populations living on the northern edge of the summer range. We radiotracked 23 adult females and juveniles and located the roost tree on 130 days. We discovered 23 roost trees and found that Indian bats selected green ash (*Fraxinus pennsylvanicus*) over silver maple (*Acer saccarinum*) and chose trees of larger and less variable diameter compared to those available. Roost trees and nonroost trees did not differ in the amount of exfoliating bark. Bats carrying a transmitter changed roosts every 2.9 days, and the average distance moved was only 74+/- 8 (SE) m (n=37). While the transmitter remained functional, individual bats used 1-4 trees and changed roosts 0-6 times, whereas the group used as many as 15 trees in a single season. Pregnant bats moved more often than lactating females. Roost switching could not be explained by changing temperature, use of different foraging areas, predator avoidance, or interruption of parasite cycles.

* * * * * * *

The Role of Research in Conserving Bats in Managed Forests.
M.J. Lacki. University of Kentucky, Lexington KY

Awareness of bats as an important component of forest ecosystems has only recently begun to receive attention by both research biologists and forest land managers. Data collection has focused primarily on identifying species composition, roost selection, and frequency of use among habitats, with the latter data sets usually not species specific. Coordinated efforts between research and management are now needed to answer questions related to impacts of intended management programs on bats in forests, particularly application of silvicultural prescriptions. Conserving populations of bats while achieving other forest management goals needs to be a primary focus. I present examples from Kentucky on how research biologists and forest land managers have coordinated efforts to enhance habitat for bats.

* * * * * * *

Surveying Forest-Bat Communities with Anabat Detectors
R. F. Lance, B. Bollich, C. Callahan, and P.L. Leberg
University of Southwestern Louisiana, Lafayette, LA, USA.

Ultrasonic bat detectors may be key to surveying the activity and compositions of bat communities in Southeastern forests. We are currently collecting data on two factors that can influence how bat detectors are used in field research. First, differences between data collected from an Anabat detector hoisted 30+ft. into the canopy and another detector placed directly below it on the ground are being analyzed. Second, we are evaluating the potential use of Anabat detectors in species being identification. To this point the calls of seven different species have been recorded. Duration, maximum frequency, medium frequency, minimum frequency, and slope are being measured for both calls and individual call pulses. These call characteristics are then subjected to statistical analyses for discrimination between species. Preliminary data from this early stage of our research suggest that ground-deployed detectors may survey a larger sampling of bat activity in forested areas than canopy-deployed detectors. Also, large amounts of intraspecific variation and interspecific overlap of call measurements make species identification with Anabat detectors impractical for all but a few species.

* * * * * * *

An Ecosystem Context for Bat Management
B.G. Marcot, USDA Forest Service, Portland Oregon USA

The ecological role and environmental requirements of 15 species of bats were analyzed in an ecosystem assessment of the interior Columbia River Basin in the United States. In this context, the ecological roles of bats are seen to potentially contribute to nutrient cycling, insect population control, transmission of disease, and accumulation of pesticides. Such roles can influence ecological processes in forest canopies, soils, and water bodies, and population levels of other

species, including arthropods and their predators, and other species of bats. Specific studies are needed on rates of effects. The collective environmental requirements of all 15 bat species also provide for a wide range of other species in forest, wetland, riparian, and other settings. Such a systems- and biodiversity-wide approach helps put bat management into an ecosystem context and helps focus needs for further inventory, monitoring, and research.

* * * * * * *

Bats and Forest Ecosystems British Columbia: Recent Management Developments and Research Needs

J.B. Nyberg, Research Branch BC Forest Service, Victoria, BC, Canada

Forest management goals in British Columbia have changed radically in the last ten years, and management programs now incorporate measures to conserve wildlife diversity, habitat diversity, and old-growth forest ecosystems. These measures benefit many of the province's bats, and are critical first steps in maintaining viable populations throughout their native ranges. But poor knowledge of the distribution, habitat needs, and migration behaviour of forest-dwelling bats remain a major obstacle to their conservation. Expanded research is needed on bat ecology; on forestry techniques for maintaining feeding, roosting , and hibernation sites; and on the functional roles of bats, such as insect predation and nitrogen cycling, in forests. New interdisciplinary research programs are being organized to address riparian and stream ecosystems in several areas of the province, providing bat researchers with opportunities to be key co-operators in "systems" studies of what are probably some of the most important forested habitats.

* * * * * * *

Partial Cutting and Bats: A Pilot Study

M. Perdue and J.D. Steventon, Ministry of Forests, Bag 5000, Smithers, B.C. V0J 2N0

Partial cutting systems are often suggested as a means of allowing timber extraction while maintaining habitat for forest-dwelling wildlife. We conducted a preliminary study of bat presence and activity, using ultra-sonic detectors, in two intensities of partial cutting compared to clearcuts and uncut forest. The objectives were to 1) confirm whether bats are present in the 16 treatment units; 2) conduct a preliminary study (and power analysis) of the influence of partial cutting treatments on bat activity; 3) assess potential for future more intensive study. The study was conducted in coast-interior transitional forests (ICHmc) at the Data Creek Silvicultural Systems research site in north-western British Columbia. Presence of bats (*Myotis* spp.) was confirmed, and bat use of partial cut treatments (indexed by number and length of detections) was at least as great for the uncut forest. Bats were also detected in clearcuts, but at a lower rate. We tentatively conclude that the creation of canopy openings in dense favours bat travel and foraging. Roost site requirements is likely the greatest need for further study in relation to partial cutting.

* * * * * * *

Male Bat Distribution Within a Managed Forest

J. Mark Perkins and Joshua R. Perterson
PNW Bat Research Team, 2217 E. Emerson Street, Salt Lake City, Utah 84108.

Non-normality of distribution in forest bat species has been demonstrated (Perkins 1992). Perkins and Peterson (1994) demonstrated that foraging and drinking distribution of some species of reproductive females is independent of some associated species and negatively affected by presence of other selected female bat species. Here we investigate if foraging and drinking areas for 10 species of bat males are independent in relation to the presence of the same species females and other species males.

* * * * * * *

Characteristics, Use and Distribution of Day Roosts Selected by Female *Myotis volans* (long-legged *Myotis*) in Forested Habitat of the Central Oregon Cascades

P.C. Ormsbee. U.S. Forest Service and Oregon State University

I tracked female *Myotis volans* using radio telemetry during July and August of 1993, 1994, and 1995 in two drainages (Quentin Cr. and Lookout Cr.) of the Central Oregon Cascades. Analysis of the data indicates large snags and hollow cedar trees are important day roosts. Individuals radio-marked at the same night roost did not use one common day roost. Individual bats were found roosting in one roost for several days, or using multiple day roosts within distinct areas. The area Quentin Cr. encompassing one night roost and all known day roosts covered 2,841 ha., and the area in Lookout Cr. encompassed 6,391 ha. In taking a landscape level approach to managing day roots for female *Myotis volans* in this study site, consideration for a broad distribution of solitary and patches of snags, specific management of roost areas, management or protection of a 240 m buffer around more permanent roost sites such as hollow trees and rock faces, and monitoring of roost microclimates and use are warranted.

* * * * * * *

Effects of Timber Harvest on Bat Activity in Southeastern Alaska's Temperate Rain Forests

Doreen I. Parker[1,2], Joseph A. Cook[1], and Stephen W. Lewis[1].
[1]University of Alaska Museum, Fairbanks, AK and [2] Tongass National Fores., Ketchikan AK

Five species of bats occur in southeastern Alaska's coniferous rain forests: *Myotis lucifugus, M. californicus, M. volans, M. keenii,* and *Lasionycteris noctivagans.* Over 42% of volume class 6 and 7 timber in southeastern Alaska has been harvested, raising concern about wildlife habitat and conservation. We studied bat activity in old-growth forests, riparian areas, closed-canopy second-growth forests, and clearcuts on Prince of Wales and Revillagigedo Islands using ultrasonic bat detectors. Bats foraged in riparian areas, and activity patterns in this habitat differed during lactation and post-lactation. Bat calls detected in old-growth forests consisted primarily of commuting activity. Bats fed in clearcuts, but activity was low. Bat activity in second-growth was very low. Activity levels and nightly activity patterns make it clear that conservation of old-growth forests and ripparian areas is essential for continued viability of the southeastern Alaska bat community. Diet and reproduction of *M. lucifugus* in these temperate rain forests differed from that reported at lower latitudes. Preliminary diet information for *M. keenii,* and *M. volans* in southeastern Alaska is also presented. Over 300 caves have been surveyed in southeastern Alaska's 1769 km^2 of karst terrain. Evidence of bats occupying these caves is widespread and seasonality of that occupation is just beginning to be assessed. We provide evidence that neither clearcuts, nor second-growth forests provide habitat characteristics essential to most southeastern Alaska bats during the summer. This study also provides strong evidence that old-growth forests and riparian zones provide habitat characteristics needed by bats.

* * * * * * *

Bats and Bridges: Paterns of Night Roost Use by Bats in the Willamette National Forest

S.I. Perlmeter, York University, [Current address: 2311 Alser Street, Eugene, Oregon 97405]

The thermal conditions and social organization of five concrete bridges used as night roosts were studied during 1993 and 1994. Differences in night roosting patterns of *Myotis lucifugus* and *Myotis volans,* and gender differences were investigated. Results support the hypothesis that bat differentially select larger bridges that maintain higher nighttime temperatures compared with smaller bridges. Multiple regression analysis indicates that roost size and daily solar radiation levels significantly influence night roost temperatures. Minutes after sunset, roost size and night roost temperature differentials (roost temperature minus ambient temperature) show a positive relationship to the number of bats observed at night roosts. Significant differences in spatial and temporal patterns of night roost use were found in *M. lucifugus* and *M. volans.* Males of both species showed a strong trend towards roosting alone while clusters were almost exclusively female. Cluster analysis indicated that bats associated with individual clusters show a nonrandom pattern of arrival and departure from these night roost aggregations. Radiotracking data of *M. volans* indicates that while individuals associated with specific night roost clusters did not use the same day

roost sites they did use sites located the same distance and direction from the night roost. Differences in night roosting patterns for *M. lucifugus* and *M. volans* may correlate with the length of gestation and prey taken by these two species. The nonrandom pattern of cluster formation and dispersal may be an indication of group foraging or serve as an anti-predator strategy while traveling back to day roosts.

* * * * * * *

Bat Diversity and Habitar Use in a Forested River Drainage in Northern California.

E.D. Pierson, W.E. Rainey and R. M. Miller
University of California, Berkeley, CA, USA and Mt. Shasta, CA, USA.

Sampling bat diversity in a forested setting presents considerable challenges. In a forested region along the upper Sacramento River in northern California, we have sampled bat diversity using a variety of techniques, including netting over water, acoustic monitoring, and night roost surveys. Surveys of night roosts in anthropogenic features, particularly bridges, proved an efficient method for locating a number of taxa. Some species (e.g.,*Myotis evotis, M. thysanodes, M. volans, Corynorhinus townsendii*) were captured more frequently in night roosts than by mist netting over water, while others (e.g., *Myotis californicus, Lasiurus* species, *Lasionycteris noctivagans, Euderma maculatum*) rarely or never use these sites. Night roost monitoring allowed us to explore seasonal occupancy and site fidelity, as well as providing a springboard for other ecological investigations, e.g., year-to-year reproductive success in a *Myotis yumanensis* population, the association of *Antrozous pallidus* with oaks, and the foraging and roosting patterns of several forest dwelling bat species.

* * * * * * *

Species Compostition and Variation in the Bat Community Over a Northern California Forest River

W.E. Rainey, and E.D. Peirson, Museum of Vertebrate Zoology, University of California Berkeley, CA

Following a major biocide spill into the upper Sacramento River, the bat community was sampled over short intervals in summer or fall 1991-95 at multiple sites. Species diversity of bats netted over water both on the river and an unaffected forested creek was high; 15 of 17 species expected locally were caught at some time during the survey. *Myotis yumanensis* and *Lasionycteris noctivagans* were most abundant. Evidence of local reproduction in most species was observed in July. Limited radiotracking of six species showed that bats captured over the river were drawn from a corridor over ten km wide. Variation, both natural and anthropogenic, in aquatic insect production on a range of spatial and temporal scales likely influence patterns of foraging activity, individual growth and survival, and species population trends for a significant fraction of the bat community within the drainage. In dynamic, free-stone bedded rivers, winter floods may considerably alter local bed topography and cross section. Also, large inter-annual fluctuations in rainfall carry over as variations in water velocity and depth which influence the duration and distribution of algal and, consequently, insect production. This adds another source of site and "treatment" variation to inter-annual and short term weather variation (affecting bat reproductive timing and foraging activity) when trying to extract patterns from intensive short duration, multi-site bat sampling efforts.

* * * * * * *

Summer Roosting Ecology of Cavity-Dwelling Bats in the White Mountain National Forest

D.B. Sasse[1] and P.J. Pekins[2],
[1]U.S. Forest Service, Sisters, OR and [2]University of New Hampshire, Durham, NH

The objective of this project was to study the summer roosting ecology of female cavity-dwelling bats in the White Mountain National Forest of New Hampshire and to examine the relationship of snag and stand characteristics in bat roosting choices. Radiotransmitters were used to track 26 *Mytotis septentrionalis* to 49 roost trees, 66% of which were in snags. Roosts included 14 *Fagus grandifolia*, 13 *Acer saccharum*, 6 *Acer rubrum*, 8 *Betula alleghaniensis*, and 5 other species. Roost snags were larger in diameter (41 cm), taller (14.8 m), had more bark remaining (78%), and were less decayed than a random sample of snags in the surrounding area. Characteristics of the surrounding stand were also related to roost sites; live trees had larger diameters ($p=0.002$) and there was more snag basal area ($3.9 m^2/ha$) in roost plots than the surrounding forest. Potential roost

trees (n=104) were surveyed for bat activity in 1994 using ultrasonic bat detectors; 28 had bat activity and 5 were visually confirmed as roost trees.

* * * * * * *

Roosting Ecology and Roost-Site Preferences of Reprductive Female *Eptesicus fuscus* and *Lasionyteris noctivagans* in the Pend D'Oreille Valley in Southern British Columbia.

M. J. Vonhof, University of Calgary, Calgary, Alberta.

During the summers of 1993-1994 I characterized the trees used by bats as roosts in the West Arm Demonstration Forest in the southern interior of British Columbia. Bats exhibited a strong preference for all tall trees in areas with low percent canopy closure, and short distances to other available trees. The bats also preferred western white pine (*Pinus monticola*) in intermediate stages of decay. During the summer of 1995 I focused on the roost-site preferences of female big brown bats (*Eptesicus fuscus*) and silver-haired bats (*Lasionycteris noctivagans*) in the Pend d'Oreille valley, located just north of the U.S. border in southern British Columbia. Tree roosting sites were located by attaching radio-transmitters to pregnant and lactating female bats and tracking them to their roosts. Once tree roosting sites had been located I measured a range of tree- and site-characteristics. I found approximately 15 roost trees used by each species. With only two exceptions, all roosts were in abandoned woodpecker cavities. The majority of big brown bat roosts were in trembling aspen (*Populus tremuloides*), but silver-haired bats were commonly found in both trembling aspen and Douglas-fir (*Pseudotsuga menziesii*). Bats of both species switched roosts regularly, even while lactating, and subsequent roost trees were generally located within a relatively small area. I made comparisons between the roost trees used by the two bat species, and between roost trees and randomly-selected available trees from both the immediate vicinity of the trees and other areas of the same stand. The results of these analyses will be discussed.

* * * * * * *

Natural Disturbance Regimes as Templates for Boreal Forest Harvest

D. Walker[2], B. Stelfox [1], S. Wasel[1], and D. Hebert[1]
[1]Alberta-Pacific Forest Industries Inc., Box 8000, Boyle, AB, TOA OMO and
[2]Forem Consulting, Box 16, Site 3, RR5, Tofield, AB, TOB 4J0

The importance of natural disturbances (e.g., fire, flooding, insect outbreaks) to forest structure and function is generally accepted by ecologists. Accordingly, forest harvest strategies that reasonably approximate the variability in stand structure created by disturbances may offer a preferred risk management strategy for maintaining forest integrity and biodiversity. A critical task confronting managers who adopt a coarse-filter (e.g., disturbance regime) approach to forest harvest is the identification and measurement of variables that most meaningfully define disturbances. In Alberta, variance in size, age, and structure of stands created by wild fires is presently being considered by the forest sector, academia, and government. Alberta-Pacific Forest Industries Inc., a large FMA holder (~6 million ha) in northeast Alberta, has taken steps to develop a forest harvest strategy based on a natural disturbance model. Specifically, variability in harvest rotation ages, cutblock size, and cutblockk residuals (green trees, snags, downed woody material) would approximate variability in fire return intervals, fire sizes and post-fire residuals, respectively. Justification for this shift in forest harvest planning is the potential for traditional 2-pass, short-rotation, clearcut harvest in boreal mixedwood forests to alter stand and landscape level heterogeneity and thus impair ecological function and homogenize wildlife habitat. To evaluate this contention, a series of stand metrics (size, shape, juxtaposition) were used to compare unharvested landscapes to those created by traditional two-pass harvest and the dispersed harvest regime proposed by Alberta-Pacific Forest Industries. This presentation will focus on the results of this preliminary study.

* * * * * * *

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 as 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.

ANATOMY

Schlossersturm, E., and H. Schliemann. 1995. Morphology and function of the shoulder joint of bats (Mammalia, Chiroptera). Journal of Zoological Systematics and Evolutionary Research, 33: 88-98. [Inst. Zool., Univ. Hamburg, Martin Luther King Pl. 3, D-20146 Hamburg, Germany]

Smith, B. J., S. D. Holladay, and S. A. Smith. 1995. Patella of selected bats - patterns of occurrence or absence and associated modifications of the quadriceps femoris tendon. Anatomical Record, 242: 575-580. [Virginia Polytech Inst. & State Univ., Virginia Maryland Reg. Coll. Vet. Med., Blacksburg, VA 24061]

Thewissen, J. G. M., and S. A. Etnier. 1995. Adhesive devices on the thumb of vespertilionoid bats (Chiroptera). Journal of Mammalogy, 76: 925-936. [Dept. Anat., College of Medicine, NE Ohio Univ., POB 95, Rootstown, OH 44272]

BEHAVIOR

Balasingh, J., J. Koilraj, and T. H. Kunz. 1995. Tent construction by the short-nosed fruit bat *Cynopterus sphinx* (Chiroptera, Pteropodidae) in southern India. Ethology, 100: 210-229. [Boston Univ., Dept. Biol., 5 Cummington St., Boston, MA 02215]

Kunz, T. H., and G. F. McCracken. 1995. Tents and harems: apparent defence of foliage roosts by tent-making bats. Journal of Tropical Ecology, 11: 1 -17. [Dept. Biol., Boston Univ., Boston, MA 02215]

CONSERVATION

Altenbach, J. S. 1995. Entering mines to survey bats effectively and safely. Pp. 57-61 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Altenbach, J. S., and E. D. Pierson. 1995. The importance of mines to bats: an overview. Pp. 7 -18 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Ball, L. 1995. GIS mapping of bat distribution in Nevada. P. 33 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Brown, P. E. 1995. Impacts of renewed mining in historic districts and mitigation for impacts on bat populations. Pp. 138-140 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada

Brown, C., P. E. Brown, and R. D. Berry. Abandoned mines as habitat for bats and other wildlife in the desert. Pp. 19-21 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 77843]

Clark, D. R., Jr., A. Moreno-Valdez, and M. A. Mora. 1995. Organochlorine residues in bat guano from nine Mexican caves, 1991. Ecotoxicology, 4: 258-265. [U.S. National Biological Service, Southern Science Ctr., Brazos Field Station, c/o Dept. Wildlife & Fisheries Sci., Texas A&M Univ., College Station, TX

Dalton, D. C., and V. M. Dalton. 1995. Mine closure methods including a recomended gate design. Pp. 130-135 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Driesner, D. 1995. Nevada abandoned mine lands (AML) program. Pp. 75-104 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Gallegos, D. 1995. Mining company concerns and perspectives on abandoned mines as bat habitat. Pp. 107-109 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Hamlin, R. 1995. Fish and Wildlife Service and listed bat species in Nevada. P. 129 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Henry, C. D. 1995. Abandoned mines in Nevada: their distribution, abundance, and geologic suitability as bat habitat. Pp. 39-47 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Henry, C. D. 1995. Environmental issues in mine closing. Pp. 110-118 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Leshendok, T. V. 1995. Bureau of Land Management abandoned mine lands inventory. Pp. 119-125 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Lumsden, L. F., A. F. Bennett, S. P. Krasna, and J. E. Silins. 1995. The conservation of insectivorous bats in rural landscapes of northern Victoria. Pp. 142-148 in A. Bennett, G. Backhouse, and T. Clark, Eds. People and Nature Conservation - Perspectives on Private Land Use and Endangered Species Recovery. Transactions of the Royal Zoological Society of New South Wales. [Dept. Conserv. & Nat. Resources, Flora & Fauna Branch, 123 Brown St., Heidelberg, Victoria 3084, Australia]

Mark, T. 1995. Forest Service perspective on bat management. Pp. 126-128 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Navo, K. 1995. Guidelines for external surveys of mines for bat roosts. Pp. 49-54 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Navo, K. W., J. Sheppard, and T. Ingersoll. 1995. Colorado's bats/inactive mines project: the use of volunteers in bat conservation. Pp. 55-56 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Rainey, W. E. 1995. Tools for low-disturbence monitoring of bat activity. Pp. 62-73 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Ramsey, M. 1995. Bat diversity and distribution in Nevada. Pp. 22-32 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Taylor, D. 1995. The importance of bats and the role of Bat Conservation International. Pp. 34 -38 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

Threloff, D. 1995. Death Valley National Monument abandoned mine lands project and bat nets. Pp. 136-137 in B. R. Riddle, Ed. Inactive Mines as Bat Habitat: Guidelines for Research, Survey, Monitoring and Mine Management in Nevada. Biological Resources Research Center, University of Nevada, Reno, 148 pp. [entire volume available for $5 from Biological Resources Research Ctr., Dept. of Biology, Univ. Nevada-Reno, Reno, Nevada 89557]

DEVELOPMENT

Hughes, P. M., J. M. V. Rayner, and G. Jones. 1995. Ontogeny of true flight and other aspects of growth in the bat *Pipistrellus pipistrellus*. Journal of Zoology, 236: 291-318. [House of Commons Library, Sci. Environ. Sect., London SW1A 2DG, England]

Kunz, T. H., and S. K. Robson. 1995. Postnatal growth and development in the Mexican free -tailed bat *Tadarida brasiliensis mexicana* : Birth size, growth rates, and age estimation. Journal of Mammalogy, 76: 769-783. [Dept. Biol. Boston Univ., Boston, MA 02215]

DISEASE

Koprowski, H. 1995. Visit to an ancient curse. Scientific American Science and Medicine, May/June, 48-57. [on rabies]

Martorelli, L. F. A., E. A. C. Aguiar, M. F. Almeida, M. M. S. Silva, and E. C. R. Novaes. 1995. Isolation of the rabies virus in a specimen of the insectivorous bat *Myotis nigricans*. Revista de Saude Publica, 29: 140 -141. [Ctr. Controle Zoonoses Prefeitura Municipio Sao P., Rua Santa Eulalia, 86, BR -02031020 Sao Paulo, Brazil]

Perez-Jorda, J. L., C. Ibanez, M. Munoz-Cervera, and A. Tellez. 1995. Lyssavirus in *Eptesicus serotinus* (Chiroptera, Vespertilionidae). Journal of Wildlife Diseases, 31: 372-377. [Dept. Zool., Univ. Aberdeen, Aberdeen AB9 2TN, Scotland]

DISTRIBUTION/FAUNAL STUDIES

Cosson, J. F. 1995. Captures of *Myonycteris torquata* (Chiroptera, Pteropodidae) in forest canopy in South Cameroon. Biotropica, 27: 395-396. [INRA, Faune Sauvage Lab., F-78350 Jouy en Josas, France]

Gaucher, P. 1995. First record of Geoffroy's bat *Myotis emarginatus* Geoffroy, 1806 (Mammalia, Chiroptera, Vespertilionidae) in Saudi Arabia. Mammalia, 59: 149-151. [Natl. Wildlife Res. Ctr., Natl. Commission on Wildlife Conservation & Development, POB 1086, Taif, Saudi Arabia]

Kurta, A., and G. C. Lehr. 1995. *Lasiurus ega*. Mammalian Species, No. 515: 1-7. [Dept. Biol., Eastern Michigan Univ., Ypsilanti, MI 48197]

Yancey, F. D., C. Jones, and R. W. Manning. 1995. The eastern pipistrelle, *Pipistrellus subflavus* (Chiroptera, Vespertilionidae), from the Big Bend region of Texas. Texas Journal of Science, 47: 229-231. [Dept. Biol. Sci., Lubbock, TX 79409]

ECHOLOCATION

Fenton, M. B., D. Audet, M. K. Obrist, and J. Rydell. 1995. Signal strength, timing, and self-deafening - the evolution of echolocation in bats. Paleobiology, 21: 229-242. [Dept. Biol., York Univ., N. York, Ontario M3J 1P3, Canada]

Jones, G., K. Sripathi, D. A. Waters, and G. Marimuthu. 1994. Individual variation in the echolocation calls of three sympatric Indian hipposiderid bats and an experimental attempt to jam bat echolocation. Folia Zoologica 43: 347-362. [School of Biol. Sci., Univ. Bristol, Bristol, United Kingdom]

Pedersen, S. C. 1995. Cephalometric correlates of echolocation in the Chiroptera. 2. Fetal development. Journal of Morphology, 225: 107-123. [Dept. Orthodontics, School of Dentistry, Univ. Washington, SM-46, Seattle, WA 98195]

ECOLOGY

Arlettaz, R., G. Dandliker, E. Kasybekov, J. M. Pillet, S. Rybin, and J. Zima. 1995. Feeding habits of the long-eared desert bat, *Otonycteris hemprichi* (Chiroptera, Vespertilionidae). Journal of Mammalogy, 76: 873-876. [Inst. Zool., & Animal Ecol., Univ. Lausanne, CH-1015 Lausanne, Switzerland]

Dunning, D. C., and M. Krüger. 1995. Aposematic sounds in African moths. Biotropica, 27: 227-231. [Dept. Biol., West Virginia Univ., POB 6057, Morgantown, WV 26506-6057]

Göpfert, M. C., and T. L. Wasserthal. 1995. Notes on echolocation calls, food and roosting behaviour of the Old World sucker-footed bat *Myzopoda aurita* (Chiroptera, Myzopodidae). Zeitschrift für Säugetierkunde, 60: 1-8. [Inst. Zool. I, Univ. Nürnberg, Erlangen, Germany]

Heller, K. G., and M. Volleth. 1995. Community structure and evolution of insectivorous bats in the Paleotropics and Neotropics. Journal of Tropical Ecology, 11: 429-442. [Dept. Zool., Univ. Erlangen Nurnberg, Staudstr. 5, D-91058 Erlangen, Germany]

Kunz, T. H., and C. A. Diaz. 1995. Folivory in fruit-eating bats, with new evidence from *Artibeus jamaicensis* (Chiroptera: Phyllostomidae). Biotropica, 27: 106-120. [Dept. Biol., Boston Univ., Boston, MA 02215]

Lumsden, L. F., and A. F. Bennett. 1995. Bats of a semi-arid environment in southeastern Australia - biogeography, ecology, and conservation. Wildlife Research, 22: 217-240. [Dept. Conserv. & Nat. Resources, Flora & Fauna Branch, 123 Brown St., Heidelberg, Vic 3084, Australia]

Marimuthu, G., J. Habersetzer, and D. Leippert. 1995. Active acoustic gleaning of water surface by the Indian false vampire bat. Ethology, 99: 61-74. [Dept. Anim. Behav., M. K. Univ., Madurai - 625 021, India]

MacKenzie, G. A., and G. S. Oxford. 1995. Prey of the Noctule bat (*Nyctalus noctula*) in east Yorkshire. Journal of Zoology, 236: 322-327. Dept. Biol., Univ. York, York YO1 5DD, N. Yorkshire, England]

Thomas, D. W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy, 76: 940-946. [Groupe de recherche en écologie, nutrition et énergétique, Dépt. Biol., Univ. de Sherbrooke, Sherbrooke, Québec J1K 2R1, Canada]

EVOLUTION

Barton, R. A., A. Purvis, and P. H. Harvey. 1995. Evolutionary radiation of visual and olfactory brain systems in primates, bats, and insectivores. Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences, 348: 381-392. [Dept. Anthropology, Univ. Durham, 43 Old Elvet, Durham DH1 3HN, England]

Gummer, D. L., and R. M. Brigham. 1995. Does fluctuating asymetry reflect the importance of traits in little brown bats (*Myotis lucifugus*).? Canadian Journal of Zoology, 73: 990-992. [Dept. Biol., Univ. Regina, Regina, SK S4S 0A2, Canada]

Kunz, T. H., and K. A. Ingalls. 1994. Folivory in bats: an adaptation derived from frugivory. Functional Ecology, 8: 665-668. [Dept. Biol., Boston Univ., Boston, MA 02215]

FLIGHT

Hassanloo, Z., M. B. Fenton, J. D. De Laurier, and J. L. Eger. 1995. Fur increases the parasite drag for flying bats. Canadian Journal of Zoology, 73: 837-842. [Dept. Biol., York Univ., N. York, Ontario, Canada M3J 1P3]

PHYSIOLOGY

Arends, A., F. J. Bonaccorso, and M. Genoud. 1995. Basal rates of metabolism of nectarivorous bats (Phyllostomidae) from a semiarid thorn forest in Venezuela. Journal of Mammalogy, 76: 947 -956. [Centro de Investigationes en Ecologia y Zonas Aridas, Univ. Nacional Experimental Francisco de Miranda, Apartado 7506, Coro, Falcon, Venezuela]

Kunz, T. H., J. O. Whitaker Jr., and M. D. Wadanoli. 1995. Dietary energetics of the insectivorous Mexican free-tailed bat (*Tadarida brasiliensis*) during pregnancy and lactation. Oecologia, 101: 407-415. [Dept. Biol., Boston Univ., Boston, MA 02215]

Kunz, T. H., O. T. Oftedal, S. K. Robson, M. B. Kretzmann, and C. Kirk. 1995. Changes in milk composition during lactation in three species of insectivorous bats. Journal of Comparative Physiology B, 164: 543-551. [Dept. Biol., Boston Univ., Boston, MA 02215]

Thomas, S. P., D. B. Follette, and G. S. Thomas. 1995. Metabolic and ventilatory adjustments and tolerence of the bat *Pteronotus poliocephalus* to acute hypoxic stress. Comparative Biochemistry and Physiology A, 112: 43-54. [DuQuesne Univ., Dept. Biol. Sci., Pittsburgh, PA 15282]

REPRODUCTION

Bernard, R. T. F., and J. N. Tsita. 1995. Seasonally monoestrous reproduction in the molossid bat, *Tadarida aegyptiaca* from low temperature latitudes (33 degrees S) in South Africa. South Africa Journal of Zoology, 30: 18-22. [Dept. Zool. & Entomol., Rhodes Univ., Grahamstown 6140, South Africa]

Onyango, D. W., J. M. Gachoka, G. E. Otiangaowiti, and A. G. Hendrickx. 1995. Seasonally dependent testicular apoptosis in the tropical long-fingered bat (*Miniopteris inflatus*). Zeitschrift fur Saugetierkunde, 60: 206-214. [Dept. Veterinary Anat., Univ. Nairobi, POB 30197, Nairobi, Kenya]

Suthakar Isaac, S., G. Marimuthu, and M. K. Chandrashekaran. 1994. Fecundity in the Indian pygmy bat *Pipistrellus mimus*. Journal of Zoology, 234: 665-668. [Dept. Anim. Behav., M. K. Univ., Madurai - 625 021, India]

SYSTEMATICS/TAXONOMY

Colgan, D. J., and T. F. Flannery. 1995. A phylogeny of Indo-West Pacific Megachiroptera based on ribosomal DNA. Systematic Biology, 44: 209-220. [The Australian Mus., Sydney 2000, Australia]

Flannery, T. F. 1995. Systematic revision of *Emballonura furax* Thomas, 1911 and E. dinae Hill, 1956 (Chiroptera, Emballonuridae), with description of new species and subspecies (vol. 58, pg. 601, 1994). Mammalia, 59: 1-2.

Kirsch, J. A. W., T. F. Flannery, M. S. Springer, and F. J. LaPointe. 1995. Phylogeny of the Pteropodidae (Mammalia, Chiroptera) based on DNA hybridization, with evidence for bat monophyly. Australian Journal of Zoology, 43: 395-428. [Zool. Mus., Univ. Wisconsin, 250 N. Mills St., Madison, WI 53706]

Morales, J. C., and J. W. Bickham. 1995. Molecular systematics of the genus *Lasiurus* (Chiroptera, Vespertilionidae) based on restriction -site maps of the mitochondrial ribosomal genes. Journal of Mammalogy, 76: 730-749. [Dept. Anthropol., Genetics Lab., Columbia Univ., New York, NY 10027]

ZOOGEOGRAPHY

Schmitt, L. H., D. J. Kitchener, and R. A. How. 1995. A genetic perspective of mammalian variation and evolution in the Indonesian archipelago - biogeographic correlates in the genus *Cynopterus*. Evolution, 49: 399-412. [Dept. Anat. & Human Biol., Univ. Western Australia, Nedlands, WA 6009, Australia]

Research Scholarships Available in Bat Biology

Bat Conservation International announces the availability of Graduate Student Research Scholarships. Four or five grants of $500 to $2000 will be made in 1996. Grants will be awarded for research that best helps document the roosting and feeding habitat requirements of bats, their ecological or economic roles, or their conservation needs. The application deadline for 1996 scholarships is January 15, 1996. For application instructions and forms write to **Bat Conservation International,** Educational Resources Coordinator, P.O. Box 162603, Austin TX 78716-2603, or FAX requests to 512-327-9724.

Please note the nearness of the deadline for application for the above

Grants for Conservation Biology Research in Minnesota

The Minnesota Natural and Nongame Research Program is soliciting proposals for projects to be conducted during the 1996 and/or 1997 field seasons(or longer). Proposals should be for work contributing to the conservation and management of nongame wildlife(vertebrate or invertebrate), native plants, and plant communities in Minnesota. High priority will b e given to projects focusing on specified topic areas, and on state endangered, threatened, or special concern species and rare natural communities. Awards average $3,000 per year but requests up to $10,000 per year will be considered. The deadline for submitting proposals is January 19, 1996. Decisions will be announced no later than March 1, 1996. For program guidelines, proposal format, list of priority topic areas, E&T species list, and other information please contact: Richard J. Baker, Natural Heritage and Nongame Research Program, Minnesota Department of Natural Resources, Box 7, 500 Lafayette Road, St. Paul, MN 55155-4007;
phone 612-297-3764; fax:612-297-4961; e-mail: richard.baker@dnr.state.mn.us

This program is supported by contributions to the Minnesota Nongame Wildlife Tax Checkoff, Minnesota State Parks Nature Store Sales, and the Minnesota Chapter of the Nature Conservancy.

Please note the nearness of the deadline for application for the above

Four Corners Regional Bat Conference

26-27 January, 1996

Red Lion Inn, Durango, Colorado

The Colorado Bat Society is sponsoring a regional conference on research, education and management of bats in the Four Corners states (Colorado, Utah, Arizona, and New Mexico). We hope to bring researchers, managers, and educators together to share information on current activities and needs.

Room Reservation

Individuals must make their own reservations with the Red Lion Inn in Durango by calling [970-259-6580] and asking for the group rate of $45-55/night for the Colorado Bat Society. Cut-off date for special room rates is January 4, 1996. Please contact Local Arrangements chair: Kirk Navo, Colorado Division of Wildlife at [719-852-4783, ext. 17] for more travel information.

Meeting Registration

All individuals planning to attend the conference should preregister. Registration fees before December 15 are $20.00 for students, CBS members and spouses, $25.00 for all others: after 15 December registration will be $25.00 for students, CBS members, and spouses and $30.00 for all others. We are planning a Friday evening dinner(Durango Roadkill Special) with speaker at $17.50 per person and need your dinner reservations with the registration fee. Checks payable to Colorado Bat Society should be sent to the Registration Chair: Sheri Jones, Denver Museum of Natural History, 2001 Colorado Blvd., Denver, CO 80205-5798 [tel 303-370-6354] .

Abstracts and Presentations

Presentations on any aspect of bat biology, management, or education are welcome. For more information on presentations please contact the Program Chair: Mike Bogan, National Biology Service, Department of Biology, University of New Mexico, Albuquerque, NM 87131 [tel. 505-766-3903; FAX 505-277-0304: e-mail: mbogan@unm.edu].

Please note the nearness of the deadline for application for the above

The 26th Annual North American Symposium on Bat Research

will be held

October 23-27, 1996

at Jumer's Chateau Lodge in Bloomington, Illinois

Host and Symposium Director:

Thomas A. Griffiths
Department of Biology
Illinois Wesleyan University
Bloomington, Illinois 61702
(309) 556-3230
FAX: (309) 556-3411
tgriff@titan.iwu.edu

Detailed information will appear in successive issues of Bat Research News.

Ed. note[see, I really have retired! GRH]

BAT RESEARCH NEWS

BOSTON
1995

Volume 36: No. 4 **Winter 1995**

BAT RESEARCH NEWS

Publisher and Managing Editor
G. Roy Horst, Department of Biology S.U.N.Y. at Potsdam, NY 13676
Tel. 315-267-2259 or -2130 FAX 315-267-3170 E-mail: horstgr@potsdam.edu.

Editor for Feature Articles and Letters
Allen Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197
Tel. 313-487-1174

Editor for Recent Literature
Thomas 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

Instructions to Contributors and Subscribers:

Bat Research News is published four times each year, each year consisting of one volume of four issues, appearing in Spring, Summer, Fall, and Winter. ***Bat Research News*** publishes short papers, general interest notes, etc., which are edited by at least two reviewers. Manuscripts dealing with original work should be submitted in duplicate following the latest *CBE Style Manual* or following the style used in the *Journal of Mammalogy*. In addition, latest news on bat research, correspondence, book reviews, meeting announcements, reports and an extensive review of recent literature titles are included. Communications concerning recent literature should be addressed to Griffiths, manuscripts and letters to Kurta, "news" and all other matters to Horst.

Subscriptions to individuals are $15.00 per volume(year). All issues are sent surface mail, postage paid by ***Bat Research News*** to all addresses world-wide. Special arrangements have been made to serve European and Australian subscribers. All copies to Europe are sent bulk via air mail to Dr. Robert Stebbings, in Great Britain, who will then forward them, first class mail to their final destinations. Subscriptions to institutions are $ 25.00 per volume(year).

Please make all checks payable to; ***Bat Research News***. Subscribers outside the United States can please pay by checks in U.S. dollars, drawn on banks with an affiliated office in the United States, or payment can be made via international money orders, (in U.S. funds). Mail your payment to G. Roy Horst at the address above.

Bat Research News is : ISSN 0005-6227
United States Internal Revenue Service tax exemption number 16-1356633

Bat Research News
is composed, printed and mailed at:
Potsdam College of the State University of New York,
Potsdam, NY, 13676, U.S.A.

BAT RESEARCH NEWS

Volume 36: Number 4 **Winter 1995**

A Letter from the Publisher

April 28, 1996

Dear Subscribers to Bat Research News,

I am pleased to inform you that effective June 1, 1996 I have accepted a very attractive offer of early retirement from my positions as Chancellor's Professor of Biology and Director of Faculty Research and Grants to that long awaited final "promotion" to Professor Emeritus. I have been given the opportunity to continue to teach our course in Ecology as an Adjunct Professor, but the remainder of my time will free for whatever occupation that Mrs. Horst, my two two-year-old grandsons (cousins, not twins), a little research, and ***Bat Research News*** require of me.

Those of you who have also served in academia will appreciate how much I will miss all those committee assignments where you do most of the work and someone else gets all the credit; those faculty meetings which covered everything from recognizing that DNA is somehow important to what color paper the Christmas party announcements should be printed on; that senior who still hasn't declared a major, and has been to class only twice, and who announces to you one day before the final that "I must have a 'C' in the course or I'll not graduate"; and finally that five-page analytical report on next year's five year plan which will be abandoned the year it was supposed to begin, that no one will ever read but was due yesterday. And those of you who have been in administration will also appreciate how much I will miss those faculty members who come in with research proposals, one day before they are due in the sponsoring agency's office, which are written with crayon on wrapping paper in freshman prose, with no references, and no budget... "but Roy, I thought you were going to do that part for me", ...and no exams to grade!

I am continuing to work with my colony of *Phyllostomus discolor* and *Artibeus jamaicensis* trying to determine what they do with all those calories, all that sugar, and all that potassium, with almost no lipids or protein to work with.

I will be able to devote considerably more time and energy to the task of making ***Bat Research News*** both more timely and more content intensive. Please expect a note from me in the not too distant future asking (pleading, begging, or demanding, or whatever works) for news about your involvement with, work with, or interest in bats. It is not too early to send me an article, a note, or a letter, as soon as you finish reading this. We hope to make ***Bat Research News*** more "newsy" and we can only do that with your help. I am looking forward to a rejuvenation of ***Bat Research News*** and to your continued support in this effort, and I am grateful for the assistance of so many of you in the past.

G. Roy Horst

Abstracts of the papers presented at the combined 10th International Bat Research Conference and the 25th North American Symposium on Bat Research Boston University, Boston MA, U.S.A. 6 - 11 August, 1995

Abstracts are arranged in alphabetical order by first author. A great deal of effort has been made to assure that all "after-meeting" changes have been made as directed. We take full responsibility for any errors of transcription or omission. If any abstract has been omitted, or significant changes have been left out, please contact Roy Horst and we will publish a corrected version in the next issue of *Bat Research News*. GRH and THK

ADAMS, R.A.

CRUSING FOR A BRUSING: VOLANT JUVENILES FACE A STEEP LEARNING CURVE.

R.A. Adams[1] and S.C. Pedersen[2].
[1] University of Wisconsin, Whitewater, [2]Wisconsin, and University of Washington, Washington.

The juvenile period is a precarious time for young, rapidly growing bats. Our research has focused on three different aspects of juvenile development - flight, echolocation, and tooth eruption. Multivariate analysis of wing bone lengths, wing membrane dimensions, wing loadings, and aspect ratios of juveniles, suggest that age-specific shifts in ecology are strongly influenced by morphological changes during growth. In addition, heads of juvenile nasal emitters are incapable of resonating at a frequency produced by the larynx until three weeks post partum, coinciding with first flight ability. Changes in skull size during ontogeny results in a fluctuating perceptual systems which affects navigation and foraging ability of juveniles. Data on tooth eruption patterns show that chiropteran milk teeth are shed around the time of parturition (some teeth actually are shed in utero) and adult dentition has fully erupted by first flight. We believe these data provide strong evidence that natural selection works preferentially on juvenile form and secondarily on adult form. Apparently, selective forces are most intense in rapidly developing juveniles when morphological plasticity (variability), and perhaps responsiveness to "new" pressures, is highest.

AIHARTZA, J.R. PRELIMINARY DATA ON BATS IN BISCAY (BASQUE COUNTRY, NORTHERN IBERIAN PENINSULA).

J.R. Aihartza, M. J. Tororika, E. Imaz, G. Raskin, E. Bernedo, and R. Agirrebeña. Euskal Herriko Unibertsitatae, Bilbo, Basque Country (Spain).

Little is known about the bats of Biscay, except for a few papers in the 1960's, based on samples provided by speleologists. Biscay is a 2,384 km^2 region located in the northern Iberian Peninsula. It a hilly land, with altitudes ranging from sea level up to 1,481 m, and narrow valleys. Climate is temperate and humid, with regular rainfall throughout the year. The vegetation has been altered for many years; pine and eucalyptus plantations, pastures, and croplands have replaced beech, deciduous oak and holm oak forests, which remain only in isolated patches. The territory is densely populated (pop. 1,150,00), with extensive urban areas. There are many caves in the limestone massifs, as well as several mines. The area has been studied since 1993 to determine the distribution of bats in western Basque Country. Several methods have been used; sampling in potential roosts, mist nets, harp traps, and ultrasound detectors. Distribution maps of individual species are included on a UTM geographic grid with 10 km x 10 km squares. Each map displays both bibliographic and new data, phenology, frequencies, and abundance.

ANDREWS, P.T.

HOW DETAILED IS THE IMAGE "SEEN" WITH FM ECHOLOCATION? A THEORETICAL INVESTIGATION.

P.T. Andrews. University of Liverpool, Liverpool, England, UK.

In frequency modulated (FM) echolocation, the direction of a source of echoes is found from the variation in the frequency of the echo intensity heard at the two ears and the differences between them. The variation with frequency results from acoustic dispersion in the outer ear and the variation of the response of the ears with angle. The resolution of detail is limited by the size and flare of the ears and the ability of the bat to distinguish small differences in intensity between the sounds heard at the left and right ears, and at each ear at different frequencies. Detailed calculations using realistic ear sizes reveal that the resolution is rather limited unless the intensity discrimination is better than is commonly assumed. Improvements to the image resolution could be made by

increasing the ear size but this would increase aerodynamic drag and reduce the cone within which insects could be detected. Each species has evolved a compromise which is optimized for their particular mode of feeding. The ears of bats that fly slowly within foliage, or in other cluttered environments, are larger than those of bats which fly fast in the open and the pinna opening is usually long compared to the width. In very cluttered conditions, gleaning, using the same method for directional orientation as used in echolocation, has a distinct advantage. In some cluttered environments the constant frequency (CF) echolocation method used by horseshoe bats is probably superior to FM echolocation.

ANTHONY, E.L.P.

CORROSION CASTING STUDIES OF THE PITUITARY PORTAL VASCULATURE IN *Myotis lucifugus*.

E.L.P Anthony[1] and A.W. Gustafson[2].

[1] Rhode Island College, Providence, Rhode Island, [2]Tufts University Schools of Medicine, Boston, Massachusetts.

Studies of hypothalamic-pituitary relationships in the little brown bat *(Myotis lucifugus)* have shown that many of the neuronal systems that secrete hypophysiotropic hormones do not terminate at the median eminence (ME) as they do in many rodents, but instead terminate in the lower infundibular stem (LIS) and in the neural lobe (NL) of the pituitary gland. This suggests that in bats, long portal blood vessels (which originate in the ME) may play a less prominent role in transporting these hormones to target cells in the anterior pituitary than they do in some other groups of mammals. Transport may rely instead on short portal vessels (which originate in the LIS and NL). Because the pituitary vasculature of bats has never been examined in detail, the existence of short portal vessels has not been documented. Therefore the present study was undertaken to examine the architecture of portal vessels in *Myotis lucifugus* using corrosion casting. Three-dimensional replicas ("casts") of the blood vessels within the hypothalamicpituitary complex were produced by perfusing a rapidly hardening methacrylate resin into cerebral vessels. When examined using scanning EM, the replicas reveal an extensive anastomosing capillary network in the LIS and proximal NL. From this network arises a series of vessels that directly enter the anterior pituitary, fulfilling the necessary criteria to be classified as short portal vessels. These in turn give rise to arcing parallel cascades of sinusoids. This study is the first to describe short portal vessels in a bat and supports the hypothesis that they play a significant role in hypophysiotropic hormone transport.

AREVALO, H.F. LOPEZ

CAVE-DWELLING BATS OF RIO CLARO--COCORNA AREA, ANTIOQUIA, COLOMBIA.

H.F. López-Arévalo[1], Y. Muñoz-Saba[2], A. Cadena[3], and D.A.Salas-Dueñas[1]. [1]Fundación Natura, Santafé de Bogotá, Colombia, [2]Universidad Pontificia Javeriana, Santafé de Bogotá, and [3]Santafé de Bogotá, Colombia.

A scientific survey on karst systems in the Rio Claro--Cocorná, Central mountain range of Colombia, provided information about 32 bat species as follows: Phylostomitidae: six subfamilies, 15 genera and 25 species: Emballonuridae and Vespertilionidae: three genera and three species; and Molossidae: one species. Of the 32 bat species recorded in this survey, there was five new records for the department of Antioquia (*Anoura geoffroyi,Artibeus amplus, Chiroderma trininaturm, Mimon crenulatum, and Eptesicus diminutus*). The former is a new record for Colombia. The presence of *Rhynochonycheris naso* and *Noctilio albiventris* suggests a taxonomic displacement rather than a functional one. The trophic categories identified in this community include aerial insectivorous (seven species), foliage insectivorous (four species), nectarivorous-pollenivorous (three species), sedentary frugivorous (five species), nomadic frugivous (eleven species), and hematophagous (one species). The study also revealed a pattern of cave habitat use for 12 species (about 40% of the species registered). The number of species per cave ranged between one and six. In addition, this study helped determine the importance, vulnerability, and threat indexes for each of the karstic formations studied. We conclude that both the forest cover and caves proper to the karst topography account for the maintenance of the bat fauna, and not the caves alone.

ARITA, H.T. THE MIDDLE AMERICAN BAT FAUNA: CONSERVATION IN THE NEOTROPICAL-NEARCTIC BORDER.

H.T. Arita, J. Ortega, and G.Steers. Universidade Nacional Autonoma de México, México.

Middle America, including Mexico and the seven countries of Central America, covers an area of approximately 2.5 million km^2. The bat fauna consists of 172 species, representing the nine New World families. The region is characterized by an intricate topography that creates a complex mosaic of habitats. Additionally, the zone represents the transition of the Nearctic and the Neotropical regions. Some features of the bat fauna are: 1) a diversity gradient with rich Neotropical communities in the south and poor Nearctic ones in the north, 2) most species have restricted ranges, with 30 species being endemic, 3) species turnover (β-diversity) is high and faunal some of these changes are a consequence of particular species showing altitudinal migratory movements. The high similarity between sites is low, 4) s tructure of local communities changes dramatically along altitudinal gradients,

β-diversity makes the conservation of chiropteran species in protected areas alone not feasible. Conservation strategies should be directed also to the protection of bats outside reserves. Specific recommendations include: 1) increase the knowledge on the basic natural history of species (feeding habits, reproductive patterns, roosting preferences), 2) develop techniques to estimate demographic parameters and to assess the viability of bat populations, 3) study migratory movements of bats, especially along altitudinal gradients, 4) analyze the relationship between local and regional patterns of diversity, 5) implement conservation strategies for sites of high endemism, especially the tropical dry forest of the Pacific coast.

ARLETTAZ, R.

DOES NICHE SEPARATION BETWEEN THE TWO SIBLING SPECIES *Myotis myotis* AND *Myotis blythii* RESULT FROM INTERSPECIFIC COMPETITION? A STUDY OF NICHE DISPLACEMENT AND NICHE RELEASE BETWEEN SYMPATRIC AND ALLOPATRIC POPULATIONS.

R. Arlettaz. University of Lausanne, Lausanne, Switzerland.

The two sibling species of mouse-eared bats *(Myotis myotis* and *Myotis blythii)* occur sympatrically over wide areas of the Western Palaearctic region, from Middle East to Iberia, and often coexist intimately within their nursery roosts. Previous radiotracking and dietary studies on sympatric populations (southwest Switzerland) have established that these two bat species select different habitats and, as a consequence, feed on different prey types. *Myotis myotis* preys on ground-dwelling arthropods (mostly flightless carabid beetles) which are gleaned from the ground surface; its typical habitats consist of old deciduous forests, freshly cut meadows and lawns of intensively cultivated orchards. By contrast, *M blythii* gleans most of its prey (mostly bush crickets) from the grass in habitats like steppe, cow pastures or nonmowed meadows. Does this differentiation arise from (currently active) interspecific competition? To answer this question I compared diet composition and trophic niche breadth of sympatric Swiss populations with those of allopatric populations (from North Africa to Central Asia). There were statistical differences neither in diet composition (ground- vs. grass-dwelling prey) nor in diet breadth between allopatric and sympatric populations in each species. This suggests that interspecific competition presently plays no role in the ecological separation observed under sympatric conditions. Micro-habitat specialization has apparently evolved allopatrically during speciation events.

ATKINSON, A.V.

CHARACTERIZATION OF REPRODUCTIVE CYCLES IN THE ISLAND FLYING FOX (*Pteropus hypomelanus*) USING FECAL STEROID ANALYSES.

A.V. Atkinson[1], K.R. Atkinson[2], J. Seyjagat[2] and T.S. Gross[1]
[1]Biotechnologies for the Ecological, Evolutionary, and Conservation Sciences (BEECS), University of Florida, Gainesville, Florida, and [2]The Lubee Foundation, Inc., Gainesville, Florida.

Knowledge of reproductive physiology and associated hormonal cycles in chiropteran species is incomplete. Most studies have required invasive sampling procedures and/or have not followed individuals throughout defined reproductive events. The current study validated and applied fecal steroid monitoring procedures for correlation to specific reproductive events in *Pteropus hypomelanus* (9 females and 4 males). Plasma samples were collected weekly and feces three times weekly for one year. Fecal and plasma samples were analyzed for estradiol, progesterone, corticosterone and testosterone. Results indicate that this species is polyestrous and non-seasonal with a mean estrous cycles length of 31.07 ± 4.14 days. At estrus, mean estradiol concentrations were 1,456 ± 256 pg/ml for plasma and 2,296 ± 757 pg/g for feces. During the luteal phase of the estrus cycle, mean progesterone concentrations were 1343 ± 51 pg/ml for plasma and 2,265+ 765 pg/g for feces. Fecal and plasma progesterone concentrations remained elevated throughout gestation with mean concentrations of 3,213 ± 907 pg/ml for plasma and 4,103 ± 578 pg/g for feces. Sperm was present in vaginal flushes throughout the estrous cycle and pregnancy, suggesting promiscuity in this species. Fecal steroid monitoring procedures were effective for monitoring reproductive cycles. The application of this non-invasive monitoring procedure should aid in the documentation of reproductive cycles in other Chiropteran species.

BAAGØE, H.J.

ANALYSIS AND ATLAS OF DISTRIBUTION AND ABUNDANCE ON A STRONG COMBINATION OF METHODS.

H.J. Baagøe, Zoological Museum, University of Copenhagen, Copenhagen, Denmark.

The occurrence of the 13 Danish bat species was registered with two different methods: Field identification with bat detectors in 10 x 10 km UTM squares all over Denmark (43,000 km^2), and an active search for bats through

all kinds of contact with the public (press, complaints about bats, bat rabies campaign, etc.). Because of inter-specific differences in biology (choice of both winter and summer roosts, intensity of echolocation sounds, etc.) the species are not equally easily found, and this varies greatly also with methods used. The two methods supplement each other, and the results clearly demonstrate the importance of such a goal directed programme for the acquisition of a more true and detailed picture of the composition of a bat fauna, and of the relative abundance of species. Totals of 2,290 bat localities were found with detectors and 2,953 through public contacts etc. The fact that the detector work was done by the same 1-2 persons throughout the country makes it possible to compare the occurrence and relative abundance of the species, and examples of interesting regional differences will be demonstrated. Non-overlaping distributions of ecologically fairly similar species may indicate interference competition. Declines in populations of some species could be demonstrated.

BADWAIK, N.K.

DELAYED DEVELOPMENT IN CAPTIVE SHORT-TAILED FRUIT BATS, *Carollia perspicillata*.

N.K. Badwaik and J.J. Rasweiler, IV. Cornell University Medical College, New York, New York.

Pregnancy in *Carollia perspicillata* has been studied under controlled conditions in captivity. With rare exceptions the animals exhibited only a single period of estrus following the introduction of a stud male, and pregnancies could be timed from the first appearance of sperm in daily vaginal aspirates (= day 1 post-coitum/p.c.). Gestation periods for females which successfully reared their young varied as follows: females breeding their first year in captivity (105-178 days); females bred at a postpartum estrus during their first year in captivity (110-158 days); females bred during their second year in captivity (113-145 days); young females born and bred in captivity (113-141 days). Histological studies established that most of this variation in gestation length was due to delays occurring after the initiation of implantation. The earliest implanting blastocysts were observed on day 14 p.c., and by day 17 p.c. implantation had been initiated in all females examined. It seems likely that stress, rather than age, was responsible for the prolongation of pregnancy in some animals, because this occurred less frequently in younger and older females. There may be stressful situations in the wild (e.g., lack of sufficient food or roosting sites) in which the ability to delay pregnancies would be of considerable adaptive value in *Carollia*. Evidence was also obtained that under some circumstances *Carollia* may be able to extend gestation even further. Many wild-caught females have successfully given birth at 160-229 days after being isolated from breeding males in captivity. This work has been supported by NIH Grant HD 28592 and Cornell's Department of Obstetrics and Gynecology.

BALASINGH, J. TENT CONSTRUCTION BY THE SHORT-NOSED FRUIT BAT, *Cynopterus sphinx*, IN SOUTHERN INDIA.

J. Balasingh[1], J. A. Koilra[1], and T.H. Kunz[2].
[1]St. John's College, Tirunelveli, India, and [2]Boston University, Boston, Massachusetts.

The short-nosed fruit bat, *Cynopterus sphinx*, constructs shelters by severing up to 300 stems of the curtain creeper (*Veronia scandens*) and several stems and leaves of the mast tree (*Polyalthia longifolia*), creating partially enclosed cavities (stem tents) in which to roost. A tent constructed in *V. scandens* is completed in approximately 30 days, whereas one in *P. longifolia* is completed in about 50 days. Stem-tent construction takes place mostly at night and only single males appears to engage in this activity. The number of bats which occupy completed tents during the day is highly variable, ranging from 2 to 19 females (and their pups), and a single adult male. Our observations indicate that single males constructs tents, recruit females to gain reproductive access, and defend the tent (and its female occupants) from intrusions by other males. The high variance in harem-group size indicates that some males are more successful at recruiting females than others.

BANACK, S.A.

FORAGING ECOLOGY OF FLYING FOXES GENUS *Pteropus*): CONSERVATION IMPLICATIONS.

S.A. Banack. University of California, Berkeley, California.

Flying foxes, of the genus *Pteropus*, play important roles as pollinators and seed dispersers in oceanic island forest communities. Relatively little is known about changes in resource use by flying foxes in relation to seasonal variation in available resources. This research identifies the resources utilized by flying foxes on the Samoa islands and quantifies seasonal variation in use of the major fruit resources in terms of a preference index. Flying foxes generally prefer primary forest fruits to those in the secondary forest, although they increased their consumption of fruits from the secondary forest when fruit availability drops in the primary forest. Although flying foxes feed upon a diverse array of plants (55 different species from 32 different families on the island of Tutuila), four plant families provide the major food sources at different times of year. When fruit biomasss drops, the diversity of plant species utilized increases. Flying foxes interacted with 50% of the forest canopy tree species. Because there are no other potential seed dispersers for large-seeded fruit, and pollination guilds are limited, flying foxes are con-

sidered strong interactors in these communities. Thus, flying foxes should be given a high priority in conservation and management decisions, as the survival of numerous other forest species may be critically linked to flying fox survival.

BAPTISTA, T.L.

GROWTH RATES AND AGE ESTIMATION IN FREE-RANGING LITTLE BROWN BATS: A COMPARISON OF METHODS.

T. L.Baptista[1] and T.H. Kunz[2]. [1]
Wheaton College, Norton, Massachusetts, and [2]Boston University, Boston, Massachusetts.

We used data that we collected from free-ranging little brown bats *(Myotis lucifugus)* to test the null hypotheses that: 1) alternative methods of sampling at maternity roosts have no significant affect on estimates of post-natal growth rates and age estimation, and that 2) size at birth or growth rates of pups are independent of collection date in a given year. We compared growth rates and equations for estimating the age of pups based on mark-recapture data, with mean values derived from longitudinal (grab) samples of bats captured sequentially at the same colony in the same year. Comparisons of these data indicate that longitudinal sampling significantly underestimates growth rates for body mass, length of forearm, and length of the total epiphyseal gap. Age-estimation equations derived from length of forearm and length of total epiphyseal gap indicate that the longitudinal sampling method significantly overestimates age of pups as compared to the mark-recapture method. We found no significant differences in size at birth or growth rates when samples from early and late cohorts or sexes were compared. These results indicate that longitudinal sampling for post-natal growth in bats is unreliable and that mark-recapture data from pups should be used to describe growth rates and to derive reliable estimates of age during the post-natal period.

BARBER, D.M. FACTORS AFFECTING NIGHT-ROOSTING BEHAVIOR N THE LITTLE BROWN BAT, *Myotis lucifugus*.

D.M. Barber[1] and T.H. Kunz[2].
[1]University of Illinois, Urbana-Champaign, Illinois, and [2]Boston University, Boston, Massachusetts.

Most species of insectivorous bats partition the night into two or more foraging sessions, interrupted by periods of night roosting. The night-roosting behavior of the little brown bat, *Myotis lucifugus*, was investigated at a maternity roost located in a barn in southern New Hampshire. Night-roosting behavior was recorded using a low-light level, infrared video camera, and roost occupancy was simultaneously monitored using thermister probes positioned inside a roost cavity that was used by bats mostly at night. The loft space of the barn and outdoor ambient temperatures also were recorded simultaneously. Analysis of video-recordings and temperature profiles indicate that the length of the night-roosting period varied seasonally and was highly correlated with the reproductive phenology of the colony. Night roosts separate from the maternity roosts, but located in the same barn, were used most commonly during the post-lactation period. During lactation females usually returned to maternity roosts to suckle their pups between foraging bouts. Nightly variation in night-roost occupancy was highly correlated with ambient temperature, with more bats using separate night roosts on cool nights than on warm nights. These results suggest that dense clustering behavior in a night roost may confer an important thermoregulatory advantage to bats, especially on nights when ambient temperature is low and insect activity is reduced.

BARCLAY, R.M.R.

EFFECTS OF WEATHER AND AGE ON REPRODUCTION AND SURVIVAL OF FEMALE BIG BROWN BATS, *Eptesicus fuscus*.

R.M.R. Barclay. University of Calgary, Calgary, Alberta, Canada.

Since 1990 we have investigated reproduction and survival of individually-banded female pups and adults at two nursery colonies of *Eptesicus fuscus* in south-eastern Alberta. Over all years, survival of pups (young-of-the-year) over their first winter ranged from 21% to 50%. Adult survival was significantly greater and less variable (82% to 85%). Fewer one year old females reproduced (range 0% to 86%) than did older females (range 92% to 100%). Except in particularly late years (1990), there was no evidence that late parturition significantly decreased survival of young over their first winter. Over all-years, birth date influenced sex ratio of pups: a female bias existed early in the season while a male bias occurred later. Older females gave birth earlier, but otherwise age of the mother did not influence aspects of reproduction. There was no evidence that reproduction lowers survival, even for one year olds. Conditions during hibernation may be more important than conditions during the summer in influencing over-winter survival and subsequent reproduction.

BARLOW, K.E.

SONGFLIGHT CALLS OF TWO PHONIC TYPES OF THE VESPERTILIONID BAT *Pipistrellus pipistrellus*, AND A POSSIBLE MECHANISM FOR SPECIATION.

K.E. Barlow. School of Biological Sciences, University of Bristol, Bristol, England, U.K

Pipistrellus pipistrellus occurs as two phonic types in Britain, termed the 45 kHz and 55 kHz phonic types. The echolocation calls fall into two distinct frequency bands. Intense calls of several components that sweep down and up in frequency are produced by adult males in the mating season. Time-expanded recordings were made of calls produced by bats in songflight via a bat detector and digital signal processor. The phonic type of each individual was determined from frequency of maximum energy (kHz) of echolocation calls. Between three and 10 songflight calls were analyzed for each individual. The number of components and total duration (ms) of each songflight call were measured, and two time (ms) and three frequency (kHz) parameters were measured for each component. Songflight calls differed between the two phonic types. For the 55 kHz phonic type, 87% of songflight calls consisted of three components. Only 25% of songflight calls produced by males of the 45 kHz phonic type had three components, and 68% had four components. Songflight calls of the 55 kHz phonic type were of higher frequencies than songflight calls of the 45 kHz phonic type. Across the two phonic types, frequency of maximum energy of echolocation calls were significantly correlated with frequencies of maximum energy of the first three components of songflight calls. A discriminant analysis of songflight calls classified all individuals to the correct phonic type. If mate choice by females is based on songflight characters, and echolocation call frequency and songflight call frequencies are correlated, sexual selection for high or low frequency songflight calls could drive changes in echolocation call frequency resulting in sympatric speciation. A lack of correlation between echolocation call frequency and songflight call frequency within phonic types fails to support this mechanism, however. The differences in songflight calls may allow reproductive isolation between the two phonic types, and this study supports the hypothesis that the two phonic types are cryptic species.

BARNARD, S.M. FROM THE BAT'S POINT OF VIEW: A UNIQUE TEACHING AID.

S.M. Barnard. Zoo Atlanta, Atlanta, Georgia.

For many years the bat detector has been a useful teaching aid to demonstrate the ultrasonic calls of bats. A program can be enhanced by allowing the audience to experience the concepts of echolocation from the bats point of view. With the use of an ultrasonic mobility device for the blind, an audience can be given an opportunity to transmit ultrasonic waves, and to avoid objects by detecting the pattern of waves that return. The particular mobility device currently in use for educational programs has been modified for classroom use. The equipment will be introduced and demonstrated to conference delegates.

BATES, P.J.J.

BATS OF THE INDIAN SUBCONTINENT: SYSTEMATICS, DISTRIBUTION AND ECOLOGY.

P.J.J. Bates[1], D.L. Harrison[1], and M. Muni[2].
[1]Harrison Zoological Museum, Kent, England, UK, and [2]Bombay Natural History Society, Bombay, India.

To date, 113 species of bats have been recorded from the Indian subcontinent. The current project seeks to summarize the external, cranial and dental characters of each species; evaluate their intraspecific variation and spot-map their distributions. There will be a review of their ecology, feeding and breeding biology, and a conservation status report will be given. Endemic species and subspecies will be highlighted. The geographical scope of the study comprises India, Sri Lanka, Nepal, Bhutan, Bangladesh and Pakistan (localities in Afghanistan and upper Burma are mapped but not discussed). The project seeks to promote the conservation of bats within the region. For the majority of species their population status is poorly known, while for others, recent fieldwork suggests that once widespread and abundant taxa may have experienced significant reductions in population size. At least 18 species may be considered potentially vulnerable or vulnerable; data for 24 species are so limited as to make any estimate of conservation status impractical. This work, to be illustrated with drawings, maps and photographs, seeks to stimulate further interest in the region's diverse bat fauna.

BAUD, K.S.

BATS IN A BOX: A TRAVELING TRUNK FOR ELEMENTARY EDUCATORS IN COLORADO.

K.S. Baud[1], T. Chase[2], J.W. Hubbell[3], C.A. Kampert[4], C.A. Meaney[4]. [1]S.M. Stoller Corporation, Boulder, Colorado, [2]University of Colorado Museum, Boulder, Colorado, [3]City of Boulder Open Space Department, Boulder, Colorado, USA, and [4]Denver Museum of Natural History, Denver, Colorado.

Education about bats is needed throughout the world if the conservation of bats and their habitats is to be successful. "Bats in a Box" is a traveling trunk made available to elementary educators throughout Colorado via the

University of Colorado Museum Science From CU program. The trunk contains numerous books, activity guides, a video, and a bat mount and skeleton. The trunk is designed to provide supporting information to the teacher and to perpetuate students' interest, knowledge, and enthusiasm for bats. The need for new materials, activities and curriculum will be evaluated annually through teacher comments. This trunk is meant to continually evolve and is the prototype for two more trunks that will be made available through the Denver Museum of Natural History and the Colorado Bat Society. The impetus for this project was provided by the Colorado Bat Society with the generous support of its members, the Colorado Division of Wildlife and Bat Conservation International. As such, it is a model of agency cooperation for the common cause of public education and the conservation of bats.

BELL, M.B. THE NORTH AMERICAN BAT HOUSE RESEARCH PROJECT.

M.B. Bell. Bat Conservation International, Inc., Austin, Texas.

The "North American Bat House Research Project" is a member-participation project, designed to determine the needs of bats in man-made habitat. The goal of the project is to document bat requirements and behavior in order to build the most effective artificial roost structures. The study includes more than 2,300 volunteer participants in 49 states and six provinces in Canada. Standardized data-collection forms for each bat house are entered into a computerized database in order to compare the effects of location, mounting substrate, construction materials, design height, solar heating, and differing species behavior. Results from this analysis will be presented along with guidelines for experimentation. Findings are reported in the project newsletter *The Bat House Researcher*, this biannual, layperson publication details participant experiences and summarizes findings for each season's reports.

BELWOOD, J.J. CONSERVATION, EDUCATION AND RESEARCH PROGRAM.

J.J. Belwood. Cincinnati Museum of Natural History, Cincinnati, Ohio.

In October 1994, the Cincinnati Museum of Natural History (CMNH) established a formal bat conservation program as a special initiative of its Geier Center for Collections and Research. This program is multi-disciplinary and capitalizes on existing strengths at the Museum--education, exhibits, and research--to help preserve midwestern (USA) bats. It also serves as a model for the growing role museums can play in conservation biology. The CMNH bat program pursues its objectives through on-site and outreach educational lectures, programs and workshops (for children, adults, professional and lay audiences), a bat exhibit and fledgling Bat Education Resource Center, publications, a telephone "Hotline", a small membership of private and corporate individuals "Bat Boosters" who support the program, and a growing number of in- and out-of-state volunteers who help disseminate the program's message and materials. An active research program has recently begun--to monitor, evaluate and summarize the status of bat populations in Ohio--through contacts with the Ohio Department of Natural Resources, the Ohio Biological Survey, university colleagues, the Ohio Department of Public Health, the Ohio Pest Control Association, other government, public and private organizations, and selected individuals. The bat program is also working with the above-mentioned network to monitor, summarize, and influence the many policies and practices in Ohio that affect the long term conservation and management of bats in the state and the resources they need to survive.

BERNARD, R.F.T.

SPERM STORAGE IN THE BANANA BAT (*Pipistrellus nanus*) FROM A TROPICAL LATITUDE IN AFRICA.

R.F.T. Bernard[1], D.C.D. Happold[2], and M. Happold[2]. [1]Rhodes University, Grahamstown, South Africa, and [2]Australian National University, Canberra, Australia.

The banana bat is found in savanna and forest habitats throughout Africa south of the Sahara where it roosts in the furled leaves of banana plants. Previous studies in South Africa, Malawi and Kenya have shown that there is a period of five to six months between the testes becoming scrotal in April/May and the appearance of pregnant females in September/October. The gestation of a 3-g bat is unlikely to be this long and therefore it has been suggested that there is either sperm storage, or delayed development, or that mating occurs at a later date. Reproductive delays are known in bats from temperate latitudes. To determine what reproductive strategy occurs in banana bats in the tropics, samples (n = 82) were collected from southern Malawi (15° S) and male and female reproductive tracts prepared for light microscopy. Mating took place in mid-June after a five month period of spermatogenesis. The spermatozoa was stored in the region of the uterotubal junction until late August when ovulation and fertilization took place. Births occurred in mid-November, about 10 weeks after fertilization and 20 weeks after copulation. During the period of female sperm storage, he males retained large stores of spermatozoa in the cauda epididymides and the accessory glands were active. Furthermore, throughout this period males and females moved freely between roosts so that one male associated with many females and vice versa. The possibility that

sperm storage may be an adaptation to the seasonal climate, or an adaptation that allows sperm competition will be discussed.

BERNARD, R.F.T.
ON THE OCCURRENCE OF A SHORT PERIOD OF DELAYED IMPLANTATION IN SCHREIBERS' LONG-FINGERED BAT FROM A TROPICAL LATITUDE IN ZIMBABWE.
R.T.F. Bernard[1], F.P.D. Cotterill[2], and R.A. Fergusson[2]. [1]Rhodes University, Grahamstown, South Africa, and [2]Biodiversity Foundation for Africa, Famona, Bulawayo, Zimbabwe.

Mating in Schreibers' long-fingered bat (*Miniopterus schreibersi*) from central Zimbabwe (18° S) occurred between mid-April and mid-May. Implantation was delayed until early July and parturition occurred between late October and mid-November, about four months after implantation and six to seven months after fertilization. This one and-a-half to two and-a-half month period of delayed implantation allows mating to occur at the end of one hot wet season and births at the beginning of the following summer rainy season. The positive relationship between rainfall and insect abundance is well documented and it is assumed that parturition is timed to coincide with a period of insect abundance. The duration of delayed implantation in *M. schreibersi* from Africa decreases from four months at 30° S to two to three months in Zimbabwe (18° S) and Zaire (11° S). There can be considerable temporal variation in the timing and length of pregnancy of miniopterine bats but even taking this into account, there is a strong relationship between the length of delayed implantation and latitude in *M. schreibersi* from Africa. The reproductive biology of *M. schreibersi* from Africa and France differs fundamentally from that of the same species from Australia and Japan, and we suggest that studies of the relationship between latitude and the duration of delayed implantation examine a single species at different latitudes on the same continent. Comparison between species and between continents should be avoided.

BERNARD, R.F.T. DOES CALCIUM CONSTRAIN REPRODUCTIVE ACTIVITY IN SCHREIBERS' LONG-FINGERED BAT, *Miniopterus schreibersi*.
R.T.F. Bernard and A. Davison. Rhodes University, Grahamstown, South Africa.

It has been suggested that for insectivorous Microchiroptera, calcium may be an important factor limiting reproduction. Young are generally born large, weighing 25% of adult mass, and they are weaned only when they reach 85% of adult mass. After weaning their bones are required to withstand the stresses of flight. The latter states of pregnancy and lactation therefore require large calcium input from the mother. Insects are poor sources of calcium (1-4 mg/g) and since insect abundance declines during the winter, a calcium shortage may be responsible for the inhibition of reproductive activity at this time. We tested this hypothesis by measuring bone calcium concentration of adult long-fingered bats in March (late summer), May, (time of fertilization), August (late winter, time of implantation) and in December (mid-summer, just prior o births). Calcium was measured by atomic absorption spectrophotometry and calcium concentrations expressed as mg of calcium per g dry bone. Bone calcium concentrations varied from 304 $\pm$ 20 to 355 $\pm$ 2 (m/g) in females and from 322 $\pm$ 27 to 341 $\pm$ 20 (mg/g) in males, and in no sample were the concentrations for males and females significantly different ($P>0.05$). Neither males nor females showed a significant decline in bone calcium concentrations during winter ($P>0.05$) and we conclude that winter at 30° S does not represent a period of calcium shortage. Finally, in December, about ten days before birth, bone calcium concentration of females was not significantly lower than that of females late in the previous summer, and it appears that the calcium demands of late pregnancy can be met by the available insects.

BERRY, R.D. NATURAL HISTORY AND REPRODUCTIVE BEHAVIOR OF THE CALIFORNIA LEAF-NOSED BAT (*Macrotus californicus*).
R.D. Berry and P.E. Brown. Brown-Berry Biological Consulting, Bishop, California.

Wing-flapping and vocalizations by male California leaf-nosed bats *Macrotus californicus* have been observed in most months of the year. In September, these behaviors are performed with increased vigor. Males have preferred display roosts in abandoned mines, with color-banded males returning to the same roost on sequential nights. These mines may be the same as the day roost, or they may be used only at night. The females enter the mine in groups after dark, and after some delíberation, two females might land next to a displaying male or allow a male to land next to her. He then will attempt to wrap his wing around her as the prelude to a successful copulation. Males were observed "boxing" with each other and flying into one another in apparently aggressive displays. This establishment and defense of temporary territories for the purpose of attracting a mate is equivalent to lek behavior reported in the Old World hammer-headed bats. *Macrotus* exhibits delayed development and the babies are not born until May or June. In summer maternity colonies, small clusters of females with their young are usually "guarded"

by a displaying male. Other males entering the area are driven away by the "harem" male. The accompanying videotape will portray these behaviors.

BHATNAGAR, K.P. CALCAREOUS CONCRETIONS IN THE PINEAL GLAND OF THE LONG-TONGUED BAT, *Anoura caudifer*.

K.P. Bhatnagar[1] and R.A. Hoffman[2].
[1]University of Louisville, Louisville, Kentucky, and [2]Colgate University, Hamilton, New York.

The pineal glands of certain birds and mammals often contain calcified inclusions called acervuli, concretions, or corpora arenacea. Acervuli have been found in the pineal glands of heron, goose, man, rhesus monkey, rat, and gerbil. In addition to the pineal, juxtapineal structures such as habenular commissure, choroid plexus, and leptomeninx have also been reported to contain calcified concretions. This paper reports concretions in the pineal gland of the pollen-nectar feeding bat *Anoura caudifer*. Four males weighing 9.7 to 14.4 g were captured in Cali, Colombia and held in captivity for six months (RAH). Brain-pineal preparations were made using standard protocols. Ten micron thick serial sections were variously stained. The concretions were histologically similar to those reported in other animals. At light microscopic levels they were oval to round in profile, varied in size, and consisted of characteristic concentric lamellae. Lined along the edges of the upper two-thirds of the type ABC and 0.9 mm long pineal, the individual concretions appeared encapsulated by the connective tissue. In *Anoura geoffroyi*, a closely related species, such concretions were not observed. This first observation of intrapineal calcification in a bat appears unique since acervuli were not observed in the serially examined pineals from about 130 other species of bats, including the 22 species collected from Colombia during that period. concretions have been reported from the pineal arachnoid of the bat *Myotis blythi oxygnathus* (Vigh et al., Z. Midrosk.-anat. Forsch, 103:36-45, 1989). However, meninges were removed from all of our specimens; therefore, meningeal concretions in other bat species cannot be ruled out.

BHIWGADE,D.A.
ELECTRON MICROSCOPY: RECENT ADVANCES IN CHIROPTERAN PLACENTATION.

D.A. Bhiwgade and S.B. Shomita. Institute of Science, Bombay, India.

The 12 chiropteran families investigated for placentation present a myriad of peculiarities. It is observed that the early developmental trend follows the general mammalian pattern and the later development of the placenta in these families fall along three lines: endotheliochorial, endotheliochorial changing to hemochorial, and hemochorial. Hemochorial condition as seen in *Rousettus leschenaulti* and *Thyroptera bicolor spix*, exists right from the beginning suggesting the loss of material endothelium at the trilaminar blastocyst stage itself, accompanied by the conversion of interstitial membrane into the intrasyncytial lamina, similar to the phenomenon exhibited in species where the endotheliochorial placenta is converted into hemochorial condition. Such intrasyncytial lamina may facilitate immunological isolation from maternal tissues. Placental peculiarities of Chiroptera include: 1) the extensively developed microtubular system observed in Rhinopomatidae, 2) the placentation pattern in *Miniopterus schreibersii fuliginosis* representing a rare combination of three types of specialization viz. primary, secondary and tertiary placentae, 3) the exclusively cytotrophoblastic endotheliomonochorial in *R. hardwickei hardwickei* and the cytotrophoblastic hemochorial layer along with the "homogenous material" in molossid bats during term, and 4) the frequent infolding of trophoblastic basal lamina between the lateral cell borders, indentated by the fetal capillaries which reduces the thickness of the barrier, serving to increase the surface area, facilitating the expansion of the tubules, aiding the transplacental transfer and lowering the diffusional resistance in many species.

BOGDANOWICZ, W.
PHYLOGENY OF THE PLECOTINE BATS:
A REEVALUATION OF MORPHOLOGICAL AND CHROMOSOMAL DATA.

W. Bogdanowicz[1], S. Kasper[2], and R. D. Owen[2]. [1]Mammal Research Institute, Polish Academy of Sciences, Bialowieza, Poland, and [2]Texas Tech University, Lubbock, Texas.

Recent systematics of the tribe Plecotini (Vespertilionidae) has generated two alternative phylogenetic hypotheses: (1) (*Barbastella* (*Corynorhinus* (*Plecotus* (*Idionycteris Euderma*)))); and (2) (*Euderma* [including *Idionycteris*] (*Barbastella* (*Plecotus* (*Corynorhinus*))). To test these hypotheses, we examined the character-states of 50 morphological and 12 karyological characters of 10 plecotine species, including *Otonycteris hemprichii*. Character states for the hypothetical ancestor were inferred by evaluation on selected multiple outgroup taxa (*Rhogeessa tumida*, *Nycticeius humeralis*, *Eptesicus fuscus*, *Myotis lucifugus*, *M. ciliolabrum*, and *Miniopterus schreibersi*). The most parsimonious trees obtained, identical in topology but different in character-state optimization, were entirely congruent with the systematic hierarchy of hypothesis number one, with *Otonycteris* branching off before *Corynorhinus*. These results strongly support that *Corynorhinus* is distinct, species of *Plecotus*

are limited to the Palaearctic, *Otonycteris* is a natural member of the Plecotini, and *Euderma* and *Idionycteris* are close sister taxa.

BOGDANOWICZ, W.

IN THE MINOTAUR'S LABYRINTH: THE ORIGIN OF THE HIPPOSIDERIDAE.

W. Bogdanowicz[1] and R.D. Owen[2].

[1]Polish Academy of Sciences, Bialowieza, Poland, and [2]Texas Tech University, Lubbock, Texas.

Several standard and novel analyses of a morphological data set, supplemented with karyotypic and palaeontological information, were used in search of a robust hypothesis for the phylogeny and the center of origin of the bat family Hipposideridae. The results obtained suggest that phylogenetic affinities among recent species are not expressed accurately by current systematic arrangements, and that the genus *Hipposideros* probably represents a paraphyletic group. Morphological dispersion analyses failed to reveal any significant differences in morphological diversification among hipposiderid faunas from four zoogeographic regions, and no center of origin was inferred based on phenetic results. The other tests of proposals regarding the origin and patterns of dispersal of the family were provided by cladistic and evolutionary hypotheses.

BOUGHMAN, J.W.

BAT SOCIAL GROUP MEMBER RECOGNITION BY VOCAL CUES IN *Phyllostomus hastatus*.

J.W. Boughman, University of Maryland, College Park, Maryland.

Female greater spear-nosed bats form stable social groups of unrelated individuals. Ongoing field work indicates that social group-mates often forage in small groups. Bats give broadband (4-18 kHz) screech calls in foraging groups and when emerging from their roost. Bats are more likely to give screech calls when they are in foraging groups with members of their own social group than when they are alone or with bats from other social groups. I am investigating whether bats use screech-call features to discriminate social group-mates from others. I analyzed calls to determine if they had the acoustic features required to provide information on caller identity. I measured frequency characteristics from average power spectra. I compared social groups, individuals, and ages using nested multivariate analysis of variance and linear discriminant functions. Screech calls show highly significant variation at all three levels. Individuals within a social group sound different, yet bats from the same social group give calls that converge acoustically. Young bats sound different and are more likely to give calls than adults. Individual and group differences potentially provide the basis for individual and group recognition, important in the formation of foraging groups. Group convergence depends not on relatedness, but on social group membership, suggesting bats may learn call features of their new social group and modify their calls to match. Patterns of age specific variation also suggest vocal learning. The amount of variation in pups' calls is in excess of the variation among groups, potentially allowing pups to trim variation to match their calls to those of the group that they join as adults.

BRIGHAM, R.M

PREY SELECTION BY INSECTIVOROUS BATS: ARE ESSENTIAL FATTY ACIDS IMPORTANT?

R.M. Brigham and G.V. Schalk. University of Regina, Regina, Canada.

Essential fatty acids (EFA's) such as linoleic acid, cannot be synthesized by mammals but are required to make other compounds (e.g., hormones). Rodents and marsupials which hibernate or enter torpor require larger quantities, perhaps because EFA's lower the melting point of fat stores, making them metabolically available at low temperatures. We assessed prey selection by different sex and reproductive classes of *Myotis yumanensis*, *M. lucifugus* and *M. californicus*, to determine whether these bats which enter torpor and hibernate, consume insects with higher EFA content. We predicted that males would consume insects with higher EFA content, since they likely enter torpor more often. We ranked insect orders in bats' diets and light suction trap samples based on linoleic acid content and used the ranks to derive diet and trap sample "fat scores". Dietary fat scores of males, non-reproductive, lactating and pregnant females did not differ significantly. However, scores for males and lactating females were significantly higher than corresponding trap scores. Further, fat scores of male *M. yumanensis* and *M. lucifugus* were significantly higher than male *M. californicus*, suggesting a difference in hibernation or use of torpor. Overall, prey selection by all bats was best predicted by insect availability, consistent with the poor prey discrimination abilities afforded by echolocation.

BRITTON, A.R.C.

SYNCHRONOUS ECHOLOCATION AND HIGH-SPEED VIDEO ANALYSIS OF ATTEMPTED PREY CAPTURE IN DAUBENTON'S BAT, *Myotis daubentoni*.

A.R.C. Britton. University of Bristol, School of Biological Sciences, Bristol, England, UK.

Daubenton's bat forages primarily over water, flying at a relatively constant height, searching for insects present on the water surface. Once detected, the bat attempts to scoop prey up with its feet, assisted by the interfemoral membrane. Variation in echolocation call structure during this behavior was analyzed in a controlled, laboratory environment. Wild-caught bats were successfully trained to fly in a 5 m x 2 m x 2 m flight tunnel and take insects from a water surface. Attempted prey capture behavior was filmed with a high-speed video at 200 frames/s. Simultaneously emitted echolocation calls were recorded on an instrumentation tape recorder and synchronized with the video images using a superimposed intensity-time trace. Experiments were conducted during the normal evening foraging period. Prey items used were grouped into species and size classes, and capture success was noted for each bat. Analysis was carried out to examine the effects of prey type and capture success upon echolocation before and after attempted capture. The changing relationship between wingbeat frequency and pulse emission over this period was also studied. It is hoped this investigation will provide answers to questions which have arisen as a result of field studies on the feeding behavior of this and other trawling *Myotis* bats

BROOKE, A.P.

DIURNAL BATS? DAYLIGHT ACTIVITY OF THE SAMOAN FLYING FOX, *Pteropus samoensis*.

A.P. Brooke[1] and S. Thomson[2]. [1]Department of Marine and Wildlife Resources, Pago Pago, American Samoa, and [2]University of Aberdeen, Aberdeen, Scotland, UK.

The Samoan flying fox, *Pteropus samoensis*, can be seen soaring on thermals and flying low over the forest canopy at any time of day. To document diurnal behavior, we counted the number of bats flying at two sites in American Samoa. Bats were counted in three ten-minute periods per hour, from first light until dark, for five days. To assess seasonal variation, counts were done in December, March and June. We recorded temperature, humidity, sunlight intensity, and wind to determine the effect of weather conditions on activity. Although absolute numbers differed between sites, bats were seen flying throughout the day from first light until dark with no peak activity. The greatest number of individuals was seen in December coincident with peak flowering of *Syzygium inophylloides*, a favorite food tree of the bats. High temperature (30° C), 100% humidity, and intense sunlight did not decrease the number of bats observed.

BROSSET, A. BAT COMMUNITIES AND DEFORESTATION IN FRENCH GUIANA

A. Brosset[1], P. Charles-Dominique[2] , J.F. Cosson[2], D. Masson[1] and A. Cockle[1]. [1]CNRS/URA, ECOTROP, Brunoy, France, and [2]Faune Sauvage, INRA, France.

The present study is related to the effects of the deforestation on the composition and dynamics of bat communities in French Guiana. 7,920 bats belonging to 87 species were captured in various sites including primary rain forests, secondary forests, contact zones, large agricultural areas, plantations and villages. Deforestation was found to be highly detrimental to the specific richness of bat communities. In large, ancient patches of deforestation we noticed the absence of more than half of the species captured in the nearby primeval rain forest. The loss of species concerned mainly the mature forest-dwelling Phyllostomidae. Rare bats were eliminated by deforestation. Modified habitats were repopulated by a few frugivorous Phyllostomidae, opportunists or specialists of natural gaps in the rain forest, and by members of the cosmopolitan insectivorous Vespertilionidae and Molossidae. These species showed demographic explosions consecutive, in phyllostomids, to the explosion of pioneering plants of which these bats eat the fruit and disperse their seeds, and in molossids and vespertilionids consecutive to the colonization of human constructions as diurnal roosts. In consequence the numbers of individual bat species is more than two times higher in the anthropic areas than in the rain forest. Contiguity or presence of forest corridors, between the forested and deforested area, positively influences the specific richness of local bat communities.

BROWN-BUESCHER, C.P.

WHAT GOOD ARE BATS?--ADULT EDUCATION WHILE WORKING ON MILITARY BASES.

C.P. Brown-Buescher and P.E. Brown. Brown-Berry Biological Consulting, Bishop, California

"You are doing a survey on WHAT? What good are bats? Why do we need them? If we find bats, can we kill them?" These are just a few of the commonly asked questions while conducting bat surveys on military bases (or most any other location). Even though the main objective for the survey might be basic inventory work, education plays a large role. The Department of Defense has begun to survey their lands to determine wildlife habitat, with particular attention to threatened and endangered species and candidates. Since almost one-half of North

American bat species fall in this category, bat surveys are now being conducted. Often times the best sources for information on bat locations are personnel working on the base. Most of the general military population do not have a formal biological education, and knowledge of bats is often limited to old myths and superstitions. Sometimes the Environmental Management Branch or Natural Resources Office is considered a hindrance to the military training operations being conducted on the base. With education on the importance of bats, and how to properly manage their habitat without impacting the military mission, military personnel are generally cooperative.

BROWN, P.E.

THE EFFECTS ON BATS OF RENEWED MINING IN HISTORIC DISTRICTS: IMPACTS AND MITIGATION.

P.E. Brown, R.D. Berry, and C.P. Brown. Brown-Berry Biological Consulting, Bishop, California.

Many traditional cave-roosting bats in the western United States now live in abandoned mines. Historic mining operations created safe refuges for bats prior to the time when rural cave roosts were disturbed by recreational exploration, commercialization and vandalism. Now the closure of mines for hazard abatement, reclamation or renewed mining can have profound impacts on bats, especially highly colonial species. Contemporary mining operations usually occur in historic mining districts. In open pit mining, the existing adits and shafts are often destroyed. Occasionally underground techniques are employed, but only if a high quality ore is located deep beneath the surface. This method usually enlarges or destroys the original drifts. Even when historic workings on a mine's property are not directly affected by new operations,they are often targeted for closure as part of reclamation plans. In some current underground operations, future roosting habitat for bats can be created. For example, in the Cargo Muchacho Mountains, the American Girl Mining Joint Venture will leave some of the underground areas open when they finish, and gate the entrances. Other historic mines in the vicinity have already been gated to provide undisturbed roosts for the California leaf-nosed bat (*Macrotus californicus*). This is a viable option to closing abandoned mines as part of reclamation activities. Removal and relocation of bats prior to renewed mining, identification and protection of alternate roost sites, monitoring the success of relocation, and basic research to identify habitat, requirements are some ways in which mining companies can and have mitigated for impacts to bats.

BURLAND, T.M. SOCIAL ORGANIZATION AND KINSHIP IN THE BROWN LONG-EARED BAT, *Plecotus auritus*, IN NORTH EAST SCOTLAND.

T.M. Burland[1,2], E.M. Barratt[1], and P.A. Racey[2].
[1]Institute of Zoology, London, England, and [2]University of Aberdeen, Aberdeen, Scotland, UK.

The brown long-eared bat, *Plecotus auritus*, is a vespertilionid which ranges from the British Isles in the West, across northern Europe and Asia, to Japan. In Great Britain it is the second most common bat and is distributed across the entire mainland, including Scotland, where it is close to both the western and northern range limits. During the summer, *P. auritus* congregates in maternity roosts in which, unlike other British bat species, males are present. Previous ringing studies in England and Scotland have indicated high maternity roost-site philopatry of females and males. Furthermore, little movement between known roost sites (even those <0.5 km apart) has been recorded. Three millimeter wing membrane punches have been collected for genetic analysis from the individuals used in the Scottish ringing study. Mitochondrial and nuclear (microsatellite) DNA markers are being used to test the hypothesis that *P. auritus* lives in extended famiLy groups, but mates with unrelated individuals from proximate roosts (within a 5 km region). The micro- geographic population structure is also being investigated.

CESARI, A.

THE INFLUENCE OF MOONLIGHT ON THE VARIATION OF BATS CAPTURED WITH MIST-NETS IN SOUTHEAST BRAZIL.

A. Cesari and V.C. Tavares. Federal University of Minas Gerais, Belo Horizonte, Brazil.

Many species of neotropical bats have their activities reduced or totally inhibited when it is full moon phase or, in other phases, when it is in the sky. This behavior may be a strategy of escaping from predators, but it is not clear if the reduction of bats captured on moonlit nights is due to some internal rhythm which keeps up with lunar cycles or simply to the greater probability of the bats to perceive the mist-nets and to increase their ability to avoid them. In order to analyze the moonlight influence in the bat capture, we have observed the variation of the frequency of captures of bats during 20 months in Peti reserve (43°22'W 19°53'S) and in three parks in Belo Horizonte (43°50'W 19°56'S) in the Minas Gerais state, in southeast Brazil, in several phases of the lunar cycle. The frequency of captures of two species (568 individuals) shows change and it seems to be related to the lunar cycle and to the place where nets have been placed. The diversity of species captured was greater on nights without moon

(H'= 1.747) compared to those where the moon was present (H'= 1.691). The places studied have been divided in eight categories according the vegetation structure. According to the locality, different capture rates have been obtained which indicates that not only that lunar phase but also the habitat influences capture success. Capture success is reduced mainly in open areas exposed to moon light.

CHINCHOLI, S.

MOTH FLIGHT DURING EXPOSURE TO INTENSE ULTRASOUND: TESTING ROEDER'S MODEL OF THE ROLE OF EVITABILITY IN AVOIDING BATS.

S. Chincholi[1], J.H. Fullard[1] and R.M. Roberston[2].
[1]University of Toronto, Mississauga, Ontario, and [2]Queen's University, Kingston, Ontario, Canada.

Roeder hypothesized that moths exposed to intense ultrasound (i.e. close bats) respond with erratic flight manoeuvres designed to evade the attacking bat by denying it the ability to predict the position of the fleeing moth. We observed the responses of stationary and free-flying wild moths to intense ultrasound using either high-speed cinematography or reflected infra-red (non-heat) videotaping. The infra-red technique provides for extremely low incident light levels and permits the observation of flying moths without the interference of bright lights in the moth's visual range. Our observations suggest that certain species of moths, when exposed to ultrasound, first choose randomly to fly up or down but then reduce the erratacism of their flight while simultaneously increasing their speed. We propose that this response increases a moth's chance of escape by maximizing its angle of dispersion as seen by the pursuing bat and that, contrary to Roeder's model, increased erratacism during this stage of a moth's evasive flight would actually reduce its probability of survival.

CHO, Y.M.

MUSCLE CONTRACTILITY IN HIBERNATING BATS: EFFECT OF TEMPERATURE.

Y.M. Cho, I.H. Choi, and Y.K. Oh. Yonsei University, Won-Ju, Kangwon-do, South Korea.

Theories of thermal adaptation postulate that optimal temperature of physiological properties matches a usually experienced body temperature (T) of organisms. Hibernating bats maintain a range of T that is slightly higher than the ambient temperatures (9-12^{o} C) of their wintering sites. To test the hypothesis that muscle function is adjusted to the T range of the hibernating animals, we examined contractility of the *biceps brachii m.* of Korean greater horseshoe bats, *Rhinolophus ferrumequinum korai* (n = 7) at tissue temperatures of 10-35^{o} C. Relative tetanic force (percent of maximum force) was highest at temperatures of 10-15^{o} C, which match well their T's during hibernation. Because non-hibernating mammals with T of about 37^{o} C show the optimal temperature of muscle force between 35 and 40^{o} C, our results strongly suggest that flight muscle of the bats may exhibit thermal adjustment according to their seasonal T's. This work will be extended for comparative studies on winter and summer bats to see how muscle contractile properties are adjusted to their normal field T's.

CLAGUE, C.L.

SURVEY OF BAT FAUNA IN THE WET TROPICS WORLD HERITAGE AREA OF NORTH QUEENSLAND, AUSTRALIA.

C.L. Clague[1], R.B. Coles[2], and H.J Spencer[1].
[1]Cape Tribulation Tropical Research Station, Cape Tribulation, Queensland, Australia, and [2]University of Queensland, Brisbane, Queensland, Australia.

Because of its fascinating biogeographic history over the past 10 million or so years, northern Australia, and in particular, northern Queensland is becoming the focus of efforts to unravel the causes underlying the present distribution of rainforests and their inhabitants. While the fauna of the area has experienced some cursory collecting, the management of the newly proclaimed "Wet Tropics World Heritage Area" felt that there was a need for intensive collecting, particularly of "rare and endemic" species, and in particular, bats. We have recently completed a survey of the bats of the region, as part of the "Project Gondwana", funded by the Wet Tropics Management Authority, particularly focusing on microbats; using traps, nets and most importantly, ultrasound surveys coupled with the use of a sonar analysis package (Ultrabyte UFO) developed by Kriscomp Pty Ltd., Victoria, Australia. S-25 bat detectors (Ultrasound Advice, UK) are used in countdown mode in conjunction with Sony Professional Walkman cassette recorders. These are small, ultrasensitive detectors which retain the envelope characteristic of the signal in countdown mode, greatly increasing the accuracy of the species determination. The ultrasound survey was carried out in over 100 transects walked along roads and trails or at fixed sites, particularly near water. GPS determination of sampling-site position was used to allow the data to be entered into a Wet Tropics-wide GIS. Records of *Murina florium* have been obtained at 800 and 250 m, and *Kerivoula papuensis* has been collected at 1,150 m and sea level,

and we are focusing on the autecology of these animals. Maternity roosts of the ghost bat (*Macroderma gigas*) have also been located and an unknown hipposiderid and a very small unknown emballuronid have been tentatively identified.

CLARK, M.K.

THE DISTRIBUTION AND CONSERVATION OF *Plecotus rafinesquii.*

M.K. Clark. North Carolina State Museum of Natural Sciences, Raleigh, North Carolina, USA.

Plecotus rafinesquii is a candidate for federal listing (C2) and has frequently been called one of the least known of all North American bats. A review of institutional and literature records, and extensive field work conducted between 1984 and 1995, shows that this bat has a narrower geographic and ecological distribution than was previously reported. The subspecies, *P. r. macrotis*, appears to be dependent on several declining ecosystems: old-growth eastern deciduous forest, southern bottom land hardwoods, and bald cypress-tupelo gum forest. This bat uses these forests for both roosting and foraging activities, is non-migratory and individuals and groups are loyal to specific roosts. These factors make *P. rafinesquii* vulnerable to habitat changes and human disturbances. Although these same factors make it possible to employ effective site-by-site management plans for *P. rafinesquii*, long-range conservation strategies for this bat are dependent upon the protection of the declining ecosystems in which it occurs.

COEN, C.E.

DESCRIPTION OF A METABOLIC CHAMBER
AND ITS APPLICATION TO NUTRITIONAL STUDIES IN VAMPIRE BATS.

C.E. Coen, Cornell University, Ithaca, New York.

A metabolic chamber that effectively separates urine and feces from individually housed bats was designed for comparative studies of digestive efficiency and nutrient assimilation in three genera of vampire bats. By separating urine and feces we can calculate apparent glucose and protein assimilation from the food, more accurately determine protein digestibility of the food, and determine negative or positive protein balance in individuals on different diets. Commercially available metabolic chambers designed for rodents and other small mammals are not suitable for vampire bats. Thus, it was necessary to design a chamber appropriate for animals that hang and have semi-solid feces. Other important features of the chambers include that they are light weight, easy to clean with removable parts, can house animals for several days, and that they are easily constructed with readily available materials. These chambers allow for the quantitative measurement of food consumption, urine and feces. They are suitable for field and laboratory studies. The chambers have been successfully utilized in preliminary nutrition trials with *Diaemus youngi* and *Desmodus rotundus*..

COMEAUX, L.B.

GENETIC DIVERSITY AMONG PTEROPODID (CHIROPTERA PTEROPODIDAE) SPECIES
AS REVEALED BY RAPD ANALYSIS.

L.B. Comeaux and G.F. McCracken. University of Tennessee, Knoxville, Tennessee.

Members of the genus *Pteropus* are important pollinators and seed dispersers in Old World tropical ecosystems. However, factors such as habitat loss, hunting, and pest control threaten many *Pteropus* species. One major concern is the loss of genetic diversity in populations which suffer severe reductions in numbers. Random Amplified Polymorphic DNA (RAPD) analyses were used to determine inter- and intraspecific variation and genetic distances between three *Pteropus* species which vary in population number, geographic origin, and conservation status. *Pteropus rodricensis* experienced a severe loss in population such that in 1974 its size was estimated at less than 80 individuals. To a lesser extent, *P. pumilus* has also suffered population declines, leaving it vulnerable to further disturbances. *Pteropus hypomelanus* seems to be somewhat tolerant of disturbance and is not yet considered to be threatened. Allozyme data suggest that P. *rodricensis* has a relatively low level of genetic diversity in comparison to that of *P. hypomelanus*. *Pteropus pumilus* appears to be intermediate. RAPD data support this contention.

CORBEN, C.

SOME COMMENTS ON THE USE OF ECHOLOCATION CALLS TO IDENTIFY BATS.

C. Corben. Olema, California, USA.

While it is quite easy to analyse and display the frequency-time characteristics of microbat echolocation calls, the use of this information to distinguish between different species of bats has proven troublesome. The most serious problems are the inherent variability of calls given by many species, and the difficulties that are encountered in trying to collect adequate samples of calls from known species under a wide enough range of circumstances. Characterizing a species' echolocation calls with a single example of a "typical" call is nowhere near adequate,

because even an individual bat can produce a wide variety of call types in a very short time. But even worse, different bats of the same species are quite likely to give different calls even in the same situation. Geographic variation might also prove to be a complicating factor. The most urgent need at this time is the accumulation of a database of microbat echolocation calls to document the diversity of calls being produced by each species. The full potential of the technique will only be realized when such a database is available to demonstrate where identification problems exist and how they can be overcome. It is also necessary to understand how the technology being used to analyse bat calls affects the results obtained. Using an ANABAT detector, examples are given to demonstrate the inherent variability of microbat echolocation calls, and also to illustrate how a variety of factors can influence the way in which a bat call will be displayed in an ANABAT graph.

COSSON, J.F.

RESOURCE UTILIZATION AND COEXISTENCE AMONG GROUND-STORY FRUGIVOROUS BATS IN FRENCH GUIANA.

J.F. Cosson[1] and P. Charles-Dominique[2].
[1]Faune Sauvage, INRA, France, and [2]CNRS/URA, ECOTROP, Brunoy, France.

Attempts to understand the structure of frugivorous bat communities in neotropical forests regularly comes back to the basic initial query: how do similar species coexist in the same environment? Early and recent studies emphasized the dichotomy between canopy-fruit and ground-story fruit consumers but how the numerous species inside each group may coexist is not well understood. This paper synthesizes information collected over five years in various localities inside the forest block, including different vegetational stages from open second-growth to undisturbed mature rain forest. Simultaneously, the bat community composition, the diet of the different species and the year-round phenology and spatial distribution of fruits were collected. Results show that: 1) the dichotomy between canopy and ground-story fruit bats was confirmed in French Guiana. The study then focused on the five species of the ground-story community belonging to *Sturnira*, *Carollia*, and *Rhinophylla* genera; 2) community richness and relative abundance of each bat was related to the degree of disturbance of the initial forest; 3) fruit specialization, temporal availability and spatial patchiness of fruits are major component of fruit partition between bat species; 4) forestry and others anthropic perturbations greatly modify the abundance and distribution of bat-fruits, enhancing competitive interactions between bats and leading to local extinction of some species; 5) finally, a mechanism relying on spatiotemporal fruit availability which imply different foraging strategies in concordance with actual knowledge on each bat is proposed as the major component allowing bat species coexistence in undisturbed forest.

CRAMPTON, L.H.

HABITAT AND ROOST SELECTION BY BATS IN DIFFERENT AGED ASPEN MIXEDWOOD FORESTS.

L.H. Crampton. University of Calgary, Calgary, Alberta, Canada.

To determine if bats prefer certain ages of aspen mixedwood forest, and to thus predict potential impacts of logging on bats, I assessed relative abundances of bats in young, mature, and old stands in 1993 and 1994 using QMC ultrasonic detectors. I also tracked radio-tagged little brown bats (*Myotis lucifugus*) and silverhaired bats (*Lasionycteris noctivagans*) to roost trees, which I measured and compared to a random sample of wildlife trees. In 1994, I used bat detectors to assess post-logging bat abundances in two of the mature and two of he old stands. Mean activity of all bats was significantly greater in old than in young or mature stands. All 27 roost trees were found in or at the edge of old forests. There was no difference in total activity between fragmented and unfragmented stands. Bats preferred newly dead *Populus* spp. showing evidence of heart rot to other tree species and decay classes. Bats also preferred tall trees (mean: 22.2 m) with low leaf cover (mean: 27%). Tree-roosting colonies were small (4-63 bats) and transient, often disbanding after 1-2 days. Bats likely select trees large enough to house colonies and provide suitable temperatures; such trees are only available in old stands and thus roost preference likely explains observed activity patterns. To sustain bat populations in these forests, old stands must be retained, and roost sites preserved by managing the forest at the stand level rather than for individual roost trees.

CVILIKAS,W.S.

VARIATION IN DIETARY COMPONENTS OF THE GRAY BAT (*Myotis grisescens*) IN NORTHERN ALABAMA.

W.S. Cvilikas, T.D. Haas, L.R.Saidak, B.A. Milam, and T.L. Best. Auburn University, Alabama, USA.

There is a paucity of data on food habits of the gray bat (*Myotis grisescens*). The objective of our research was to use contents of fecal pellets to document variation in dietary components among hours, nights, and sample sessions. Fecal pellets were collected at the entrance of Blowing Wind Cave, Jackson County, Alabama, at 2-h intervals for 1-3 nights, during 10 sample sessions from April to September 1991. Insects of the orders Lepidoptera, Diptera, Coleoptera, Trichoptera, and Homoptera were the primary components of the diet. Few remains of the Ephemeroptera were found. There is significant variation among hours, nights, and sample sessions, indicating that gray bats take a wider variety of insects than previous studies have indicated. There were no consistent temporal patterns in the abundance of any dietary component.

DATE, S.N.

THE STRUCTURE AND FUNCTION OF THE OVARY IN THE INDIAN FRUIT BAT, *Rousettus leschenaulti*.

S.N. Date, M. K. Vaishali, and D.A. Bhiwgade. Institute of Science, Bombay, India.

The reproductive cycle of *Rousettus leschenaulti* is characterized by a post-partum pregnancy, in which there is an overlapping of reproductive phases. A preliminary review of these findings shows growth of ovarian follicles at the end of anestrous, which is followed by the ovulation phase. The subsequent increase in serum estradiol was noticed as the first gestation advanced. Serum FSH and LH declined at the time of lactation of the first gestation, resulting in follicular atresia and a sharp decrease in serum estradiol. However, progesterone concentration was elevated significantly and coincided with the enormous development of the corpus luteum of the second gestation. During this period, few peripheral primordial and atretic follicles were present in the two ovaries. A new wave of follicular growth was observed in the non-pregnant horn during early phases of the second gestation, with a steady increase in serum estradiol which increased significantly at full term of the same gestation. Serum FSH and LH remained comparatively low through the second gestation. It was found that serum FSH and LH levels during late pregnancy (when ovulation in the contra lateral horn occurred) of the first gestation were comparable with those of the ovulation phase of the first cycle, suggesting that this is one of the causative factors for subsequent ovulation for the post partum pregnancy. Elevated levels of serum progesterone during the second pregnancy coincided with changes in histology and morphology of the corpus luteum. It appeared that elevated levels of progesterone during the early phase of the second gestation is essential for the establishment and maintenance of pregnancy.

DAVIDSON, S.M.

NIGHTLY EMERGENCE BEHAVIOR OF THE LITTLE BROWN BAT (*Myotis lucifugus*): VIEWS FROM THE INSIDE AND OUTSIDE OF A ROOST.

S.M Davidson[1] and T.H. Kunz[2].

[1] University of Michigan, Ann Arbor, Michigan and [2]Boston University, Boston, Massachusetts.

Nightly emergence behavior of the little brown bat (*Myotis lucifugus*) was investigated at a maternity roost located in southern New Hampshire. We tested the hypothesis that clumping behavior during emergence was influenced by colony size and the small size of an opening used by bats. We predicted that clumping behavior during emergence would be most pronounced when colony size was large and when emergence rates were high. We simultaneously made flight counts from a small opening as viewed from outside the barn and recorded emergence behavior from this opening from the inside of the barn using a low-light level, infrared video camera. Analysis of external flight counts revealed that overall nightly patterns of emergence were normally distributed but at peak rates, but at peak rates emergence behavior was manifested by periodic bursts of activity. Analysis of pre-emergence and emergence behavior viewed from inside the barn indicate that bats departed in relatively rapid succession and the pattern and timing were highly correlated with external counts, but prior to and during peak emergence some bats were delayed from departing because the opening was filled with bats waiting to emerge. During the early pre-emergence and emergence periods, some bats attempted to enter the exit hole, but they returned to the attic either to depart from another opening or to revisit the same opening when fewer bats were present. Our observations suggest that the small size of an opening used by bats during nightly emergence may create a "bottleneck" and thus contribute to the periodic bursts (clumping) of emergence behavior observed in this and other species. However, the similarities in behavioral patterns observed inside and outside of the roost suggest that pre-emergence behavior also may have some effect on the temporal distribution of emerging bats.

de FARIA, D.M.

FOOD RESOURCE UTILIZATION BY A FRUGIVOROUS-NECATRIVOROUS BAT GUILD IN SOUTHEASTERN BRAZIL

D.M. de Faria and I. Sazima. Unversidad Esadual de Campinal São Paulo, Brasil.

In spite of their great trophic diversity, bats have been the subject of few studies focusing on how a community or a guild utilizes the available food resources, especially in the Neotropics. Here we report on the food resource-utilization by a frugivorous-necatarivorous bat guild in a semideciduous forest fragment in Campinas, São Paulo, Southeastern Brazil. The study was carried out from September 1993 to December 1994. We netted 450 individuals of 11 bat species (frequencies in %): *Artibeus lituratus* (50.6), *Platyrrhinus lineatus* (12.8), *Chiroderma doriae* (2.2), *Anoura caudifer* (2.2), *Phyllostomus hastatus* (0.2) and *Vampyressa pusilla* (0.2). We found 18 fruit and six flower species consumed by bats at the study site. Monitoring the phenology of chiropterochoric and chiropterophilous plant species available at the study site, we found that there is a peak of fruiting species at the onset of the wet season (November-December), flowers being more abundant during the dry season. Fecal pellets from the most abundant bat species, showed the differences of the proportion of plant species consumed. *Artibeus lituratus*, the most abundant bat species, showed the broadest diet, consuming at least 13 fruits, 2 flowers and insects but preferred fig fruits (37%), which were also the main item consumed by *Platyrrhinus lineatus* (54%). *Sturniri caudifer* and *Glossophaga soricina* showed the greatest diet overlap, and can be regarded as mainly nectarivorous, although insects made an important proportion of their diet (30%). *Phyllostomus discolor* also fed on nectar and fruits but the bulk of its diet was composed primarily by insects. Thus, different bat species tend to specialize on different subsets of plant genera and this may be regarded as a mechanism by which they avoid competition for the available food resources.

de FARIA, D.M.

DIET AND REPRODUCTION OF THE BAT *Pygoderma bilabiatum* IN A SEMI-DECIDUOUS FOREST IN SOUTHEASTERN BRAZIL.

D. M. de Faria, Universidade Estadual de Campinas, São Paulo, Brazil.

The phyllostomid bat *Pygoderma bilabiatum* is patchily distributed and found in low densities, and is considered to be rare in some areas. Some basic traits of its natural history still remain unknown, such as diet and reproduction. Here, I report on the diet composition and reproductive phenology of *P. bilabiatum* in a semideciduous forest fragment in Campinas São Paulo, southeastern Brazil. The climate of the area is characterized by two distinctive seasons, one wet and warm (October to March) and another dry and cold (April to September). From January to December of 1994, I netted 22 females and 5 males of *P. bilabiatum*. Based on the frequency of captures in adjacent to trees bearing ripening fruits, I found that almost 73% of the bats were caught in near ripening *Maclura tinctoria*, which may indicate a preference for this food resource which occurs locally at low densities and is patchily distributed. From four fecal samples, two contained pulp of *M. tinctoria*, one contained seeds of *Solartum granulosoleprosum* and one contained pulp of *Ficus enormis*. Almost all individuals caught in November adjacent to *M. tinctoria* were pregnant (n=5) or lactating (n=16) females. It seems that *P. bilabiatum* has a reproductive strategy of seasonal monoestry, with the young being born at the end of the dry season and weaned during the wet season. For the study area, the wet season coincides with an increase of the number of available fruit species.

DEAR, S.P.

COMPUTATIONAL STRATEGIES IN THE AUDITORY CORTEX OF THE BIG BROWN BAT.

S.P. Dear. Brown University, Providence, Rhode Island, USA.

Echolocating bats navigate and hunt in the dark by emitting biosonar vocalizations or pulses and analyzing returning echoes. Neurons specialized for the tasks of echolocation have been found in the brains of every species of echolocating bat thus far studied. Typically, the response properties of these neurons are systematically arrayed on the cortical surface in the form of computational maps. Are computational maps sufficient to explain all echolocation behavior? Single and multi-unit neurophysiological data recorded from the auditory cortex of the big brown bat supply evidence for two computational strategies providing target range information to perception for complex targets without computational maps. The first computational strategy corresponds to a neural implementation of a common representation of images used in computational vision. The second strategy corresponds to a wavelet representation of fine target structure. Together, both computations form a multiresolution representation of target range.

DELORME, M.

NITROGEN REQUIREMENTS OF THE SHORT-TAILED FRUIT BAT *Carollia perspicillata*.

M. Delorme[1] and D.W. Thomas[2].
[1]Biodome de Montréal, Montréal, Québec, and [2]Université de Sherbrooke, Sherbrooke, Québec, Canada.

A new method of estimating the Maintenance Nitrogen Requirements (MNR) of bats was used successfully to improve the accuracy of nitrogen nutrition models. It was possible to analyze both the nitrogen losses in the feces (Metabolic Fecal Nitrogen, MFN) and urine (Endogenous Urinary Nitrogen, EUN). By subtracting the urinary nitrogen from the total nitrogen losses, we came up with a true measure of the fecal nitrogen losses, and consequently the apparent and true digestibility of nitrogen. Experimental feeding trials were performed and daily fecal material of *Carollia perspicillata* were collected for the determination of the total fecal and urinary nitrogen excretion, the urinary nitrogen losses and the energy content of the feces. The Dry Matter Digestibility (DMD) and the MNR on a truly digestible basis were calculated. An attempt was made to estimate in a model minimal dietary protein content necessary to the meet maintenance requirements of *Carollia perspicillata*.

DENZINGER, A.

MOVEMENTS INDUCED BY TONAL FROG CALLS IN THE FROG-EATING BAT *Trachops cirrhosus*.

A. Denzinger, H.-U. Schnitzler, and E.K.V. Kalko. University of Tübingen, Tübingen, Germany, and Smithsonian Tropical Research Institute, Panama.

Trachops cirrhosus catches the tungara frog *Physalaemus pustulosus* by homing in on its advertisement calls. This frog produces a whine, a tonal call with a shallow frequency modulation of the 1st harmonic from about 1 kHz to 0.4 kHz in about 400 ms. Hanging bats react to such calls with a stereotyped sequence of ear movements with a latency of about 80 ms. Each ear is moved about three times back and forth; one ear forward the other ear backward and vice versa. This pattern resembles the stereotyped ear movements found in bats with long CF-FM signals when listening to their echoes. It has been assumed that the ear movements change the binaural SPL ratio of the CF echo component in a way typical for the angular direction of the target. Since the bats control their ear movements, they should be able to decode the angular information contained in the changing binaural SPL ratios. We assume that *T. cirrhosus* uses its ear movements in a similar way to determine the anglular direction of the incident sound waves of tonal signals. Non-tonal frog calls did not evoke such stereotyped ear movements. The main intensity of the frog calls is concentrated on the first 80 ms which corresponds to the reaction time of the bat. This prevents the bat from using the loud part of the frog signal for angle determination.

DENZINGER, A.

RELATIVE ECHO SPL AND TRAINING EXPERENCE INFLUENCE THE RANGING PERFORMANCE OF THE BIG BROWN BAT, *Eptesicus fuscus*.

A. Denzinger and H.-U. Schnitzler. University of Tubingen, Tubingen, Germany.

Neurophysiological investigations on delay-tuned neurons in the cortex of the FM-bat *Myotis lucifugus* showed that paradoxical latency shift might be the underlying mechanism for range determination. Therefore, the sound pressure level (SPL) of the echoes should be critical for ranging. We tested this hypothesis with four *Eptesicus fuscus* by measuring twice the psychometric curves in a two-alternative forced-choice range difference experiment. The SPL of the echoes varied from run to run and was either -10 dB, -20 dB, -30 dB, 40 dB or -50 dB relative to the bats' transmission. The S/N ratio was similar for relative echo SPLs between -10 dB and -40 dB. The discrimination performance depended on the relative echo SPL. In the first measurement it was better between -20 dB and -40 dB than at -10 dB and -50 dB. In the second measurement the performance improved at relative echo SPLs of -50 dB, however, at -10 dB no improvement could be observed. At best relative echo SPLs the 75% threshold was measured at 300 µs. In a second experiment we determined the ranging performance at 300 µs delay difference and variable echo SPLs before and after a training phase with constant relative echo SPL of -30 dB. The additional training increased the ranging performance not only at -30 dB but also between -50 dB and -20 dB. It had no effect on the performance at -10 dB. Our results support the hypothesis that paradoxical latency shift might be a possible mechanism for range determination. They also show that bats learn during the whole training procedure and are able to generalize over a great range of echo SPLs. The analysis of the echolocation calls revealed a much higher variability than reported so far. At least at high echo SPLs the receiver is not linear, since the performance at -10 dB is worse than at other relative echo SPLs although the S/N ratio was similar.

DITCHFIELD, A.D.

PHYLOGEOGRAPHY OF NEOTROPICAL BATS.

A.D. Ditchfield. University of California, Berkeley, California.

Little is known about the distribution of genetic diversity in bats. 402 base pairs of the mitochondrial cytochrome *b* gene were sequenced for 14 species of bats occurring in the Atlantic rain forest of Brazil and some geographic outgroups from the Guianas to Mexico. It was found that bats have surprisingly low within species sequence divergence values. The same haplotypes are picked up across broad geographic distances and there is high local haplotype diversity. There is no evident local geographic structuring for many taxa, with geographic structuring found only at a broad regional scale. Bats in general show marked contrast to other small mammals of the same area. Both rodents and marsupials display high levels of sequence divergence with strong geographic partitioning. The pattern for bats is more similar to that of birds. The exception is *Trachops cirrhosus*, where there is evidence of significantly higher geographic structuring. For most bats there are probably high levels of gene flow connecting broadly distributed localities into continent sized populations. The ability to fly across barriers is probably the key difference between bats and other small mammals. *Trachops* is a forest carnivore and is probably facing ecological and historical constraints to high geneflow across continental distances.

DUMONT, E.R

SALIVARY PH AND BUFFERING CAPACITY IN CAPTIVE *Pteropus hypomelanus*.

E.R. Dumont[1,2] and K. Atkinson[2].

[1]University of Pittsburgh, Pittsburgh, Pennsylvania, and [2]Lubee Foundation, Gainseville, Florida, USA.

Within the oral cavity, dental enamel is eroded when pH values drop below 5.0. Many bats rely on fruits that are relatively acidic. However, these animals do not exhibit excessive tooth damage or loss. This study addresses the potential role of salivary pH and buffering capacity in neutralizing oral acids and providing protection from enamel erosion. Salivary pH was studied in 18 captive *Pteropus hypomelanus* fed a diet of fruits and vegetables with pH values ranging from 3.5 to 7.5. The oral pH of each individual was sampled before feeding, one hour following feeding, and again three hours after removal of food from the enclosure. Results of a repeated measures ANOVA demonstrate that pH does not differ significantly either between sexes or across sampling times (x_{pH} = 6.5). Salivary buffering capacity (SBC) was sampled for one male and one female, and appears to be relatively stable over time and between sexes (x_{SBC} = 4.5). The consistency of pH and buffering capacity values across sampling times illustrates that these bats are able to recover normal pH and SBC values within one hour of feeding. However, these pH and SBC values are invariably lower than those of humans (the only other animal for which these values are known; x_{pH} = 7.3, SBC = 5.0-5.4). Because the oral environment of *P. hypomelanus* is relatively acidic and poorly buffered, it is likely that oral pH values are frequently pushed below 5.0 during feeding bouts. Therefore, salivary pH and SBC do not appear to afford these fruit-feeding bats enhanced protection against enamel erosion. Further comparative studies are planned to assess salivary and food plant chemistry in a variety of free-ranging fruit and nectar-feeding mammals and to address the potential protective value of certain morphological variations in enamel microstructure against enamel erosion.

DUNLOP, J.M.

A PHYLOGENETIC ANALYSIS OF THE FAMILY EMBALLONDURIDAE BASED ON MORPHOLOGICAL, BEHAVIORAL AND ECOLOGICAL CHARACTERISTICS.

J.M. Dunlop. York University, North York, Ontario, Canada.

The link between ethology and fitness has been extensively studied, often focussing on the current environmental attributes which maintain the ecological or behavioral characteristic. The mechanisms which effected the origin of the trait have not been examined at length, owing to the difficulty of assessing the selection pressure on ancestral forms of the organism. Phylogenetic analyses are hypotheses of evolutionary relationships within any given group, however they also serve as a framework from which to investigate the influences of current selection pressure versus historical constraints on organisms within that group. The ecology and behavior of bats have not been addressed in a macroevolutionary context. In order to examine the effects of current selection and common phylogenetic history on the ecology and behavior of Chiroptera, I am examining the behavior and ecology of emballonurid bats and comparing that information to a phylogenetic hypothesis of relationships within the family Emballonuridae based on morphological data. Several phylogenetic analyses of the Emballonuridae, based on different types of data have failed to unambiguously resolve the evolutionary relationships of the group. Preliminary examination of external features and post-cranial skeletal material indicate a level of variation adequate to elucidate a well-defined phylogenetic hypothesis. Observations of emballonurids in day roosts indicate that behaviors and ecological conditions may contain true phylogenetic signals which can then be added to the morphological data, and result in a robust phylogenetic hypothesis.

DUVERGE, P.L.

DOES THE WORMING OF CATTLE INFLUENCE USE OF PASTURES BY BATS?.

P.L. Duverge[1] and G. Jones[2].
[1]The Vincent Wildlife Trust, London, England, UK, and [2]University of Bristol, Bristol, England, UK.

Cattle-grazed pastures are one of the key habitats used by serotines, noctules, leisler's and greater horseshoe bats. These bats eat large quantities of insect inhabiting and/or emerging from the pastures and cow pats, such as coprophagous beetles and dipteran flies. Avermectins, a recently developed broad-spectrum pesticide, are commonly used as wormers. These pesticides give effective protection against nematode worms, and endo- and ecto-parasitic arthropods. However, most of the given dose ultimately gets eliminated in the faeces. About 266 species of insects are known to inhabit cattle dung in the UK Some of these may be severely affected by avermectin residues passed out in the faeces of treated animals. A number of studies world-wide have shown that avermectins may increase larval and adult mortality, affect larval growth, interfere with moulting, inhibit metamorphosis and prevent adult emergence of Diptera and Coleoptera. The aims of this project are to investigate the use of pastures where treated and untreated cattle are kept and to determine whether activity is reduced and/or the bat community different on treated pastures. We are currently using frequency division "countdown" detectors and sonograph analyses. Data presented will take into account factors such as: herd size, stocking density, time elapsed since wormed, worming method, distance to the nearest woodland, and size of the latter, among others.

DZERVERIN, I.

STATES OF CRANIOMETRIC CHARACTERS RELATED WITH LEVELS OF DEVELOPMENTAL STABILITY IN *Myotis blythi*.

I. Dzeverin. Schmalhausen Institute of Zoology, Kiev, Ukraine.

Variation of 43 craniometric characters (including 12 pairs of traits measured separately at right and left sides of skull) was studied in 285 *M. blythi* specimens from nearly 2/3 of specific geographic range. Set of fluctuating asymmetry levels measured for 6 characters (notable with their relatively the smallest measurement errors) was used as a multiple estimate of developmental stability. Canonical correlation analysis was applied to characterize a dependence between this set and a set of empirical characters 6 pairs of canonical functions were obtained, and one of correlation coefficients was significant ($R_{can} = 0.54$, $p = 0.51$). A study of individual variation in values of functions related with this correlation allows to reveal relationships of ontogenetic stability with cranial size and shape. Relatively higher level of stability corresponds to completely developed skull shape, dolichocephaly, widened basicranium, enlarged zygomatic breadth and lessened mandible. Fluctuating asymmetry in males is smaller than in females.

EBY, P.

DISPERSAL OF LARGE- AND SMALL-SEEDED DIET SPECIES BY *Pteropus poliocephalus* IN FRAGMENTED RAINFOREST HABITAT.

P. Eby. University of New England, New South Wales, Australia.

Subtropical rain forests in south-eastern Australia have a highly fragmented distribution due to both paleobiogeographical and anthropogenic influences. The frugivorous vertebrate fauna is restricted to volant forms capable of traversing non-rain forest habitat to maintain access to consistent fruit resources. *Pteropus poliocephalus* is the only mammalian frugivore over much of the range of subtropical rain forests. It consumes 48 fruit species and has been implicated as the sole disperser of various large-seeded fruits. Seed length in the native fruit diet of *P. poliocephalus* ranges from <1 mm to 32 mm (mean $\pm$ S.D.= 6.7 $\pm$ 5.3). Foraging *P. poliocephalus* use all available complex landscape matrices. Individuals commute 0.3 to 6.7 km (mean $\pm$ S.D. = 1.8 $\pm$ 1.29) between fruiting trees commonly located in disjunct rain forest patches or as isolated trees. Thus, *P. poliocephalus* extends its functional population size by consuming fruits whose seeds are transported on commuting flights and potentially enhance the genetic integrity of remnant plant species. The array of dietary species which benefit from foraging mobility may be limited by differential dispersal patterns of small, ingested and large, uningested seeds. In particular, the probability of dispersal between disjunct rain forest patches predictably varies with seed size. Seed dispersal patterns of dietary fruits of variable seed length were examined implicitly in a captive study of seed handling techniques and seed processing times and a radio-telemetry study of foraging movements; and explicitly in a seed capture study. The aims of the work are to influence management policy for *P. poliocephalus* and regeneration practices in fragmented subtropical rain forest vegetation.

EBY, P.

THE SIGNIFICANCE OF ASSOCIATED GROSS- AND FINE-SCALE HABITAT USE BY *Pteropus poliocephalus* FOR CONSERVING FOREST ECOSYSTEM FUNCTION IN EASTERN AUSTRALIA.

P. Eby. University of New England, New South Wales, Australia.

An understanding of habitat use is essential for effective wildlife management. Food is widely recognized as the primary determinant of habitat use by pteropodid bats. *Pteropus poliocephalus* in south-eastern Australia feed primarily on nectar and pollen from sclerophyllous forests and fruit from subtropical rain forests. It provides seed or pollen vagility to 102 diet species, influencing reproductive and evolutionary processes in a range of forest types. Blossom and fruit production within their range is temporally and spatially patchy, making habitat use by *P. poliocephalus* difficult to define. Patterns of roost occupation were used as surrogates for estimates of food production and as descriptors of gross-scale habitat use. A radio-telemetry study related these patterns to distant movements of individuals and additionally defined fine-scale foraging patterns. Individual *P. poliocephalus* can be classified as resident animals which permanently occupy roosts in floristically diverse areas, feed on a restricted range of plant species and provide limited pollen and seed vagility; and nomads which move between distant ephemeral food resources, use all diet species and transport pollen and seeds many kilometers nightly. Management prescriptions for Australian forests implemented on a local scale will preserve *P. poliocephalus* by conserving resident populations. However, broad-scale management prescriptions for nomadic animals reliant on distant, unpredictable resources are difficult to conceive and present ecological and political challenges to forest managers. The costs of not meeting those challenges are progressive contractions of the *P. poliocephalus* range to limited areas of high floral diversity; loss of pollination function for the majority of blossom diet species and for forests located outside this restricted range; and diminution of seed dispersal function.

ELLIOTT, P.

INVESTIGATING ROOST ABUNDANCE USING A QUESTIONNAIRE SURVEY.

P. Elliott, and N. Roche. University of Warwick, Coventry, England, UK.

This investigation sought to establish how many buildings were used as bat roosts in two study areas by use of a questionnaire survey. One questionnaire was delivered by hand to each residence, workplace or institution in the study areas. The respondent was asked to complete the simple questions on the form concerning the presence or absence of bats at the property and a request for permission for a follow up visit. The questionnaire included a short introductory section aimed to educate and reassure the recipients, with respect to the implications of having bats on their property. Return postage was attached to encourage a high response rate. The study areas were chosen because they are rural (9 km^2) and semi-rural (8 km^2) areas containing the types of buildings and habitats likely to be favoured by bats, yet from which very few roosts had been reported. Each alleged roost was investigated by the authors to confirm the claim, and if possible identify the species concerned. The study revealed many previously unrecorded roost sites, mainly of *Plecotus auritus* and *Pipistrellus pipistrellus*. The return rates of 44% and 65% were encouraging. However, it is unlikely that all roosts were revealed and there is a high probability that some respondents were unaware of bats using their property. The survey revealed roost density of approximately 0.8/km^2 and this compares well with other a techniques for estimating roost densities

ELLIOTT, P.

GETTING BATS INTO THE SCHOOL CURRICULUM.

P. Elliott, University of Warwick, Coventry, England, UK.

Since 1989 state schools in England and Wales have been required to deliver a national curriculum to 5-16 year old students. A recent revision of the science curriculum omits any overt reference to mammals other than humans. There are still opportunities for mammals to be used as examples when studying certain topics such as ecology. The problem is that many teachers lack the confidence to find a place in their lessons for any subject area not specifically referred to in the curriculum documents, even if many of those which are mentioned are only intended as examples. It will be shown that there is a strong educational case for teachers to recognize the merits of using bats as examples in the science curriculum and other subject areas. They must also be persuaded that it is legitimate to do so.

ENTWISTLE, A.C.

CONSEQUENCES OF ROOST SELECTION IN *Plecotus auritus*.

A.C. Entwistle. University of Aberdeen, Aberdeen, Scotland, UK.

The brown long-eared bat (*Plecotus auritus*) is the second most common bat species in north-east Scotland (57°N) where it roosts in houses. Since these bats may spent up to 21 hours of their day roosting, the roost environ-

ment may affect their behavior and life history characteristics. A study was therefore carried out to identify any such relationships. Bats did not roost at random with respect to the houses available, but selected those which were older, had attics fully lined with wood and divided into several parts, and were warmer compared to control houses in the same area. In addition, houses which contained roosts were surrounded by more woodland within 0.5 km. Differences between roost sites were compared to variations in the behavior an life history characteristics of the bats occupying them. Roosts with more deciduous woodland within 0.5 km, where the bats predominantly foraged, were occupied by larger colonies, the adult males of which underwent testicular growth earlier in the year. The temperature of roosts was positively correlated with the frequency of bat occupancy, and also with the average forearm length of the bats using these sites.

ESPINOSA, A. RUIZ

ECOLOGICAL RELATIONSHIPS BETWEEN *Glossophaga longirostris* (PHYLLOSTOMIDAE) AND COLUMNAR CACTI IN A TROPICAL DRY FOREST-THORN SHRUBLAND OF COLOMBIA.

A. Ruiz Espinoza[1], M. Santos[1], P. Soriano[2], J. Cavelier[1] , and A. Cadena[3].
[1]Universidad de los Andes, Bogota, Colombia, [2]Universidad de los Andes, Merida, Venezuela, and [3]Universidad , de Colombia, Bogota.

The diet and reproductive pattern of *Glossophaga longirostris* were studied in a dry Andean valley at La Tatacoa, Colombia (750 m). Bats were captured every 30 days between August 1993 and July 1994, using mist nets (1,159 net-hours). Reproductive condition of females of *G. longirostris* was recorded. Seeds and pollen grains were identified in fecal samples. The flower and fruiting phenology of three columnar- (*Stenocereus griseus, Pilosocereus* sp., *Cereus hexagonus*) and one decumbent-cactus species (*Monvillea smithiana*) were also studied by measuring the number of flowering and fruiting cacti (n = 33 per species) each month. Flowering was concentrated during the two dry seasons and fruiting during the two wet seasons. *Glossophaga longirostris* consumed pollen (61% of cacti and 39% of *Helicteris baruensis*), fruits (92% of cacti and 8% of *Muntingia calabura*), and insects. Lactating females were present during the two wet seasons (bimodal polyestrous), coinciding with maximum fruit production of cacti. Lactating females were present during the two wet seasons at La Tatacoa; in contrast, they occurred mostly during the dry season at Lagunillas, a dry area in the Venezuelan Andes. And while at La Tatacoa, the availability of cactus fruit (two species) is concentrated during the wet seasons, at Lagunillas cactus fruit is available throughout the year (three species). Further studies are needed to understand the dependence of *G. longirostris* on cacti and other plant species in a dry forest that is being replaced by a thorn shrubland due to human activities.

FASCIONE, N.

ACTIVITIES OF THE AMERICAN ZOO AND AQUARIUM ASSOCIATION'S BAT TAXON ADVISORY GROUP.

N. Fascione[1], B. Brewer[2], and S. Wing[3]. [1]Defenders of Wildlife, Washington, D.C., USA, [2]Brookfield Zoo, Chicago, Illinois, and [3]Folsom Children's Zoo, Lincoln, Nebraska, USA.

The American Zoo and Aquarium Association's (AZA's) Bat Taxon Advisory Group (Bat TAG) was established in 1991. The committee is composed of interested curators, biologists, and educators, and expert academic advisors. The aim of the advisory group is to help coordinate the management of bat collections in North American zoological institutions and to maximize the contribution of these living collections to conservation and science. The TAG is accomplishing this in many ways, including public education, research, fund raising to support *in situ* conservation, and the development of husbandry techniques. This poster will present the goals of the TAG and give specific examples of the committee's activities.

FAURE. P.A.

BEHAVIOR AND VOCALIZATIONS OF THE WHITE-WINGED VAMPIRE BAT DURING BLOOD-FEEDING.

P.A. Faure[1], K.A. Brockmann[2] W.A. Schutt, Jr.[2], F. Muradali[3] and J.W. Hermanson[2].
[1]Section of Neurobiology and Behavior and [2]Department of Anatomy, Cornell University, Ithaca, New York, [3]National Animal Disease Center, Ministry of Agriculture, Centeno, Arima, Trinidad.

The behavior and vocalizations of individual white-winged vampire bats were recorded in the context of blood feeding. Feeding experiments were conducted with a laboratory colony of wild-caught *Diaemus youngi* using domestic chickens as prey. Bats readily fed on the birds and in darkness (observed with a low-level red light) they exhibited typical stalking behavior for avian prey. Bites on chickens were confined to exposed areas of the skin, mainly the toes, lower legs, near the cloaca, and occasionally on the comb or skin surrounding the eyes. Preliminary observations revealed that vampires produced audible (to humans) vocalizations before, during, or after taking a blood meal, but the function(s) of these signals were unclear. Further experiments revealed that calls were emitted only in the presence of other vampires; acoustically isolated, solitary-feeding individuals never emitted calls,

suggesting a social communication role for the signals. Calls were emitted both in aggressive/dominance interactions, usually by bats defending a wound, but also in non-agonistic encounters such as grooming or feeding. In two cases calls were produced by bats that were simultaneously feeding from the same wound. Most calls were linear or hyperbolic downward FM sweeps containing 2-4 harmonics, usually with maximal energy located in the fundamental, however many other unusual call "types" were observed. In addition to containing audible frequencies, social signals were rich in ultrasound (bandwidth range = 37.4-71.6 kHz). Social calls were extremely variable both in duration (range = 2.7-42.7 ms) and frequency (peak frequency range = 16.0-33.9 kHz; lowest frequency = 7.4-21.1 kHz; highest frequency = 50.6-90.6 kHz). The possibility that social signals from individual vampire bats are acoustically distinct is currently under investigation.

FENTON, M.B.

TEACHING BIOLOGY: THE ROLE OF A FIELD COURSE ABOUT BATS.

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

Field courses are usually intensive offerings that provide faculty and students the opportunity to work together away from campus. This setting gives students an in depth exposure to a topic or range of topics, while providing some sense of what is involved in field work. Bats lend themselves to this kind of teaching because of the diversity of topics they introduce. There is a wealth of opportunities: basic questions about sampling, capture and identification, equipment-related topics exemplified by bat detectors, and broader biological issues ranging from behavior and ecology to reproduction and evolution. Echolocation can introduce the history of science, the interface between physics and biology, and the interactions between bats and their insect prey. Questions of public health and bats in buildings are excellent ways to explore people's attitudes to nature and conservation. By collaborating with a local park or conservation authority, it can be easy to make a public education/information even part of the field course. My courses last 5-10 days and involve four components: 1) some lectures to present background information; 2) a range of basic field work to introduce students to techniques and data collection; 3) student seminar presentations; and 4) a written essay/report that includes analysis and discussion of some data collected in the field.

FENTON, M.B.

THE IMPLICATIONS OF IGNORANCE, HUMANS, AND ELEPHANTS FOR THE CONSERVATION OF BATS IN AFRICAN WOODLANDS.

M.B. Fenton[1] and I.L. Rautenbach[2].
[1]York University, North York, Ontario, Canada, and [2]Transvaal Museum, Pretoria, South Africa.

Savannah woodlands cover most of the land area of subsaharan Africa and harbor many species of bats, mostly insectivores and a few frugivores. The conservation of these bats can be considered from a habitat or a species perspective, including both roosting and foraging as relevant factors. A few of these species commonly exploit artificial roosts (buildings, bridges, mines), but the majority do not. Indeed, we know little or nothing about the roosting habits of most of these species. Both insectivores and frugivores appear to forage in the woodland and in adjacent riverine forest. Some species, such as *Nycteris grandis*, appear to be mainly high forest forms that depend upon special conditions to survive in the drier woodlands. Other species, for example *Tadarida chapini* represent the majority. They are widespread but virtually nothing is known of their biology. Habitat destruction is a prime threat to the survival of most bats of the African woodlands. For species that roost in trees, habitat destruction affects roosting and foraging areas, while for those roosting in cliffs or caves, foraging areas may be more affected. Pressure on the woodlands comes from expanding human populations and their demand for firewood and land for agriculture. In large areas of southern Africa, the combination of African elephants and fire has reduced savannah woodlands to tall grasslands or bushlands, significantly affecting the bat faunas (as well as the insects and birds).

FINN, L.S. BAT HOUSE USE IN CENTRAL FLORIDA WITH EMPHASIS ON *Nycticeius humeralis* AND *Tadarida brasiliensis cynocephala*.

L.S. Finn. University of Central Florida, Orlando, Florida.

Bat houses were placed at ten sites in three central Florida counties from 1992 to 1994. Bat Conservation International designs were used for the majority of houses. Bat houses were placed in varying sites (trees, poles, sides of buildings), and treated with varying colors of paint and insulation types. All houses were placed 15 to 20 ft above ground, oriented either SE/NW or E/W and where they receive four or more hours of direct solar radiation per day. Most houses were placed in pairs, back to back, on poles or trees. A primary concern in central Florida's subtropical climate is that bat houses would get too hot and thus many were painted white and/or insulated to prevent overheating. Temperature in the houses was monitored using a Campbell CR10 datalogger. Three local building roosts were also monitored for temperature. Preliminary analysis indicated that bat houses that were painted

white did not get warm enough and these were later modified. Only bat one house that became occupied allowed a valid comparison between occupied building roosts and an occupied bat house. (Comparisons between occupied building roosts and unoccupied bat houses were seen as not truly valid.) The buildng was painted dark brown and had a metal roof A large colony of bats was evicted from this building which had previously been monitored for temperature. This allowed comparison of roost temperatures with and without bats. Prior to the exclusion of bats from this building one *T. b. cynocephala* was found roosting in an unmodified (white) bat house located near the building. This bat house was left unmodified while others at this site were painted darker and fitted with metal roofs. This project is ongoing and current results will be presented.

FINN, L.S.

ROOSTING AND FORAGING ECOLOGY OF A *Plecotus (Corynorhinus) rafinesquii macrotis* MATERNITY COLONY IN CENTRAL FLORIDA.

L.S. Finn. University of Central Florida, Orlando, Florida.

In September of 1993 a colony of *P. rafinesquii macrotis*, the southeastern big-eared bat, was observed in an abandoned trailer on the Disney Wilderness Preserve (DWP) in Kissimmee Florida. This is the only documented maternity colony of this species in Florida. Research was begun in January of 1995 to determine the seasonal pattern of use of this trailer by bats and to attempt to learn more about the roosting and foraging ecology of this rare species. Temperature is being monitored weekly using hygrothermographs placed in three rooms most frequently occupied by the bats. Guano is being collected on a monthly basis as well as culled insect wings. Colony size averages 30 with a low of 20 and a high of 50 or more individuals. This fluctuation suggests use of alternate roosts in the area. Several large cypress trees have been noted on nearby Reedy Creek, and are being monitored as potential alternate roost sites. Active monitoring of the DWP with mist nets and bat detectors will begin in May 1995 and preliminary results will be presented.

FLEMING, T.H.

BAT-FLOWER INTERACTIONS IN TIME AND SPACE.

T.H. Fleming. University of Miami, Coral Gables, Florida.

Two families of bats, Pteropodidae and Phyllostomidae, contain over 50 species that are morphologically specialized for extracting nectar from flowers. These species pollinate the flowers of hundreds of species of tropical and subtropical plants. Although scientific knowledge about flower-visiting bats dates from the end of the 19th century, little was known about the ecology of bat-flower interactions until recently. I will review current knowledge of this interaction by addressing the following questions: 1) What are the energetics of this system? 2) To what extent do plants manipulate the behavior of bats to maximize their fitness? 3) To what extent does plant dependency on bat pollination vary geographically? and 4) What are the genetic consequences of this interaction to plants? My review will stress current work being done on the nectar-bat/columnar cactus system. This system includes two independently evolved groups of bats and cacti: one in the northern Neotropics and another in the Andes of Peru. Despite different evolutionary histories, many, but not all, aspects of this interaction are similar in the two groups. This suggests that there is strong selection for particular plant and bat phenotypes in arid regions of the New World.

FRANCIS, C.M.

INTRASPECIFIC VARIATION IN ECHOLOCATION CALLS AND MORPHOLOGY OF HORSESHOE BATS (*RHINOLOPHUS* AND *HIPPOSIDEROS*)

C.M. Francis[1] and J. Habersetzer[2]. [1]Long Point Bird Observatory, Port Rowan, Ontario, Canada, and [2]Forschungsinstitut Senckenberg, Frankfurt am Main, Germany.

Comparative studies across species of bats have shown a strong relationship between echolocation frequency, and size and morphology of the cochlea. We tested the hypothesis that similar relationships hold within species, by recording echolocation frequencies and cochlear measurements for the same individuals. Horseshoe bats of the genera *Rhinolophus* and *Hipposideros* were selected for the study because their calls can be characterized by a single measurement (the constant frequency component), which can be reliably measured in the hand. Bats were captured at various locations in Malaysia and Laos, using harp traps and mist nets in the forest, or by hand in caves. Echolocation calls were recorded in the field, using a QMC S-25 bat detector, and digitized with a PUSP prior to storage on cassette for computer analysis. Bats were then collected for later radiographic measurements of cochlear size. Several species, captured from multiple locations, showed geographic variation in echolocation frequencies, and a few had strong sexual dimorphism in echolocation frequencies within populations. We will present comparisons of cochlear size relative to echolocation frequency within these species, and test whether the relationships are similar in magnitude to interspecific relationships among Asian horseshoe bats.

FREEMAN, P.W.

CRANIO-DENTAL ADAPTATIONS IN BATS: FUNCTION AND EVOLUTION.

P.W. Freeman. University of Nebraska State Museum, Lincoln, Nebraska.

Cranial and dental characteristics of micro- and megachiropteran bats of all food habits are compared. Of particular interest is the allocation of area dedicated to different kinds of teeth on the palate. Microchiropterans have a larger area for molars, whereas megachiropterans have a larger area for nonmolars, particularly canines and premolars. Microchiropteran animalivores have relatively large teeth on a small palate, have the largest percent of tooth area allocated to molars, and the largest percent of molariform area allocated to the raised stylar shelf. Microchiropteran frugivores also have large teeth on a small palate, have the largest M1's relative to total tooth area, and the largest upper premolars and smallest stylar shelfs of all microchiropterans. Microchiropteran nectarivores, like megachiropteran frugivores and nectarivores, have relatively small teeth on a large palate, but, compared to other microchiropterans, retain relatively large canines and M3's. Their stylar shelf is greater than in frugivores but smaller than in animalivores. Blood feeding microchiropterans have incisors and canines that occupy over three quarters of total tooth area. Megachiropteran nectarivores have the smallest teeth on the largest palates and are clearly different from megachiropteran frugivores, which have relatively larger teeth; but both have the largest premolars relative to total tooth area of all bats. Megachiropteran nectarivores have the largest canines relative to total tooth area of any bat. Evolution of cranial features of bats involves width of the skull and how far away from the temporo-mandibular joint teeth are located. Evolution in bat teeth involves changes in cusp pattern, enlargement or diminution of teeth, or a combination of size and pattern change. How cranial and dental features might affect the function of teeth for a particular diet is discussed.

FULLARD, J.H.

I BEG YOUR PARDON? AUDITORY DEAFNESS IN MOTHS TO THE ECHOLOCATION CALLS OF THE SPOTTED BAT *Euderma maculatum*.

J.H. Fullard[1], and J.W. Dawson[2].
[1]Erindale College, University of Toronto, Mississauga, and [2]Queens University, Kingston, Ontario, Canada.

Moths around the world possess simple ears turned to the echolocation frequencies of sympatric bats that pose significant predatory pressures. These frequencies are typically 20 to 50 kHz and represent the signals emitted by most insectivorus bats. Some bats, however, emit calls with frequencies significantly higher (e.g., *Cloeotis percivalli*: 212 kHz) or lower (e.g., Euderma maculaltum: 9.8 kHz.) than these typical frequencies, and it has been hypothesized that these bats enjoy increased foraging efficiency on eared moths because of their poor detectability of bat calls. Moths were collected from lights in south-central British Columbia at a site inhabited by *E. maculatum*, and their auditory sensitivities were tested electrophysiologically. Moths are generally insensitive (in most cases functionally deaf) to frequencies ranging from 1 to 15 kHz, suggesting that they cannot hear the echolocation calls of *Euderma maculatum*. To test this hypothesis, we exposed moths to the prerecorded calls of *E. maculalum* and compared their auditory responses to prerecorded calls from another species (*Eptesicus fuscus*) collected in British Columbia. These playback experiments support the prediction that from our auditory analyses and indicate that *E. maculatum* emits calls with typically low frequencies as a counter-maneuver against the auditory deafness of sympatric moths.

GAISLER, J.

BAT DETECTOR CENSUS IN URBAN HABITATS.

J. Gaisler. Masaryk University, Brno, Czech Republic.

Although Hooper monitored the echolocation calls of bats within the London area as early as in 1965, bat detectors have rarely been used in urban versus rural, woodland, riverine and karstic environments. In 1977 flying bats were visually registered in seven types of urban habitats in a central European town. The present paper summarizes results of acoustic recording of bats 15 years later in the same town and habitats and under the same sampling schedule. Four observers, each equipped with a bat detector, walked along selected transects for 30 min. Each observation started 10 min after sunset on nights of new and full moon. In total, 246 min of bat calls were recorded and 343 bats were estimated. In both number of min recorded and number of bats estimated, *P. pipistrellus*, *E. serotinus* and *N. noctula* were most common. The proportion of bats per habitat types differed. *Pipistrellus pipistrellus* was most often recorded in garden cities, *E. serotinus*. in old outskirts and *N. noctula* in riverine habitats. Additional transects were walked, not keeping to the original time schedule, usually later at night, and Myotis sp.were most often recorded. The samples of standard and non-standard acoustic recording were compared with the sample of the earlier visual census. The differences in numbers of bats recorded in urban habitat types and the different timing of bat species activity are discussed.

GANNON, W.L.

ECOMORPHOLOGICAL EVALUATION OF CHARACTER DISPLACEMENT IN THE SOUTHWESTERN MYOTIS (*Myotis auriculus*) AND THE LONG-EARED MYOTIS (*Myotis evotis*).

W.L. Gannon. University of New Mexico, Albuquerque, New Mexico.

An analysis of cranial and mandibular structures was initiated to address patterns of character displacement resulting from differential feeding behavior of two sympatric bats, *Myotis auriculus* and *Myotis evotis*. Measurements of 17 cranial, dentary, and forearm variables were analyzed for 512 museum specimens from 25 sites. Eight variables described by five principal components characterized the morphological variation for the samples measured. Principal Components I - V explained 90% of sample variation. These components were associated with jaw closure and prey capture characters. Classification success based on discriminant function analysis was high (93% and 90%, respectively) for both *M. auriculus* and *M. evotis*. Misclassified specimens (n = 18) tended to be on the edge of each species range. Distance measures suggested that for *M. evotis*, the more idealized, less variant species was at the sympatric edge with *M. auriculus*. Conversely, specimens of *M. auriculus* were less variant and more idealized at the center of its geographic range. Peripheral isolation and the shape of the range are important in explaining this pattern. Morphological patterns support the contention of character displacement for the long-eared myotis, but not for the southwestern myotis. Influences from other bat species may play a role in shaping these patterns.

GODAWA, J.S.

PHENETIC RELATIONSHIPS AMONG THE BAT GENUS *Myotis* (CHIROPTERA: VESPERTILIONIDAE) FROM THE PALAEARCTIC, ORIENTAL AND ETHIOPIAN REGION.

J.S. Godawa. Institute of Systematic Evolution of Animals, Polish Academy of Sciences, Kraków, Poland.

Phenetic relationships based on skull measurement were studied using two ordination and one clustering methods. The common-part-removed transformation removed 92.2 % (*Myotis chinensis)* to 99.7% *(Myotis ridleyi)* of the total variation of each species' character vector. *Lasionycteris noctivagans* was used as an outgroup. Eleven dental characters were used to compare taxa with each other. Based on phenetical procedures and dental characters, no differences were found between the subgenera *Selysius* and *Leuconoe*. *Myotis brandti* was excluded from the *"mystacinus"* group. The taxonomic status of *M. ater, M. hermani, M. formosus* and *M. taiwanensis* were maintained. No statistically significant differences were found between palaearctic and oriental faunas. Paleontological data shows that genus *Myotis* probably originated from the southern part of Europe.

GOPALAKRISHNA, A.

IMPLANTATION, DEVELOPMENT OF THE FETAL MEMBRANES AND PLACENTATION IN THE SLIT-FACED BAT, *Nycteris thebaica* (FAIMILY NYCTERIDAE).

A. Gopalakrishna[1], R.T.F. Bernard[2], J.J. Rasweiler, IV[3], and N.K Badwaik[3].
[1]Chaoni, Nagpur, India, [2]Rhodes University, Grahamstown, Republic of South Africa, and [3]Cornell University Medical College, New York.

Implantation and placentation are examined for the first time in a representative of the family Nycteridae, *Nycteris thebaica*. In this species, the blastocyst implants centrally in an implantation chamber located near the cranial end of the right uterine horn. The embryonic mass is oriented mesometrically and slightly towards the uterotubal junction. The wall of the yolk sac becomes vascularized progressively from the embryonic to the abembryonic side and forms an extensive choriovitelline placenta during early stages of gestation. During more advanced stages, the yolk sac splanchnopleure becomes separated from the chorion and lies freely in the exocoelom as a collapsed bag with enlarged endodermal cells and a multilayered, highly folded mesodermal component. The definitive chorioallantoic placenta is discoidal and positioned mesometrically. At the microscopic level this placenta is labyrinthine (i.e., consisting of a three dimensional network of tubules), and the interhemal barrier is endotheliodichorial (i.e., composed of hypertrophied maternal endothelial cells, an inner layer of syncytiotrophoblast and an outer layer of cytotrophoblast). These tubules are surrounded by allantoic mesenchyme containing fetal blood vessels.

GRIFFIN, D.R.

HIGH ALTITUDE INSECT PURSUIT BY ECHOLOCATION.

D.R. Griffin. Concord Field Station, Harvard University, Bedford, Massachusetts.

Several observations of bats pursuing insects at high altitudes above the ground will be reviewed. The evidence includes nonlinear flight paths and recording of feeding buzzes by means of radio microphones attached to kites or kite balloons. The ecological importance to bats of insects at high altitudes may have been underestimated

because of the great difficulties of observation. Radar sometimes shows not only bats at high altitudes but also concentrations of insects that probably result from patterns of atmospheric convection. It might be advantageous for bats to seek out such concentrations of prey. Although molossids have provided the most abundant evidence of high altitude insect hunting, bats of other families also hunt at several hundred meters under some conditions. Future investigations using radio microphones small enough to be carried by the bats themselves might provide significant new data about this and many other aspects of bat behavior. The altitude of flying bats could be at least roughly determined by radio telemetry of air temperature, because under many conditions when the lapse rate is adiabatic air temperature varies predictably with altitude.

GORDON, L.L.

A SURVEY OF THE SPINTURNICID MITES ON PHYLLOSTOMID BATS FROM MICHOACAN, MEXICO.

L.L. Gordon[1], D. Gettinger[2], and R.D. Owen[1]. [1]Texas Tech University, Lubbock, Texas, USA, and [2]University of Central Arkansas, Conway, Arkansas.

Mammals and their ectoparasites were collected in parts of Michoacan, Mexico between 1993 and 1995. In this region, 27 species of phyllostomid bats are known or are likely to occur. Of these 27 species, bats have been collected belonging to the following genera: *Desmodus, Macrotus, Micronycteris, Leptonycteris, Glossophaga, Anoura, Musonycteris, Sturnira, Chiroderrna, Artibeus, Dermanura,* and *Carollia*. Ectoparasites were collected by brushing the bat with a coarse toothbrush, and storing them in ethyl alcohol. Within the mite family Spinturnicidae, the genus *Periglischrus* was closely associated with the bat family Phyllostomidae. The survey reports the associations of the hosts and parasites.

GORDON, M.

NEURAL, PROCESSING OF FREQUENCY-MODULATED SOUNDS IN THE MONAURAL NUCLEI OF THE LATERAL LEMNISCUS OF *Pteronotus parnelli*.

M. Gordon and W.E. O'Neill. University of Rochester, Rochester, New York, USA.

Frequency modulations are an important acoustic component of the communication vocalizations of many species, including humans and bats. For bats, they are also an important component of the echolocation calls, and most of the neurophysiological research regarding frequency modulated (FM) processing in the bat auditory system has been conducted with the aim of understanding how FM processing contributes to echolocation. How FM processing contributes to the recognition of communication sounds is poorly understood, despite their more general relevance to mammalian hearing. In this study, the selectivity of cells to parameters of FM sounds such as direction (up or down) and slope have been examined in the monaural nuclei of the mustached bat lateral lemniscus. These nuclei are believed to be involved in precise temporal coding of sounds, so they could very well be important for the coding of patterns of complex sounds such a communication vocalizations. Of the 3 8 units recorded to date, 22 prefered upwardly directed FM sweeps. Of these 22 upsweep-preferring unit, ten also showed a preference for rapid modulations (short durations) over slow modulations. Only two units showed preference for downsweeps, one unit showed a preference for rapid sweeps but no preference for direction, one unit did not respond to FM sweeps, and 12 units responded to FM sweeps but did not show a preference for direction or slope.

GÖPFERT, M.C.

MADAGASSCAR MICROCHIROPTERAN BATS: NEW RECORDS INCLUDING NEW SPECIES.

M.C. Göpfert, K.-G, Heller, M. Volleth, and L.T. Wasserthal.
University of Erlangen-Nürnberg, Germany.

Madagascar is characterized by an extremely rich and unique fauna. Nevertheless, the bat fauna is thought to be rather impoverished and poor of endemics compared to the neighbouring African countries. However, the number of species as well as their classification remain uncertain. Our records and studies on the classification of some vespertilionid and molossid taxa indicate that the bat fauna of the island is more diverse than previously suggested: the genus *Pipistrellus* was thought to be represented on Madagascar only by *P. africanus [=nanus]*. We collected specimen of two *Pipistrellus* taxa on the west coast of the island, both being clearly different from *P. africanus*. According to bacular morphology and dentition, one taxon should be included in the *"pipistrellus-group"* of the genus *Pipistrellus*. It has hitherto not been described and its closest relatives are supposed to occur in the oriental region. The other taxon belongs to the *"kuhlii-group"*. Due to similarities in skull morphology and bacular shape, as well as corresponding karyotypes, it is conspecific or at least closely related to the South African *P. "kuhlii"*. These taxa differ from European and North African *P. kuhlii* in chromosome number, and therefore should be regarded as distinct species. Of the molossid taxa, the Madagasscar *Mops leucostigma* is judged to be conspecific with the African *M. condylura*, judging from an analysis of bacula. The analysis of bacula also revealed that two different *Chaerophon*

taxa occur in the western and eastern parts of the island, of which both are related to African *C. pumila*. The systematic relationships among the different taxa are currently being examined using DNA-sequences.

GORE, J.A.

FLOODING OF BAT CAVES: EFFECTS ON *Myotis* COLONIES IN FLORIDA, USA.

J.A. Gore[1] and J.A. Hovis[2]. [1]Florida Game and Fresh Water Fish Commission, Panama City, Florida, and [2]Florida Game and Fresh Water Fish Commission, Ocala, Florida.

Floods can disturb or destroy cave-roosting bats, but cave flooding is often considered a rare and relatively insignificant event. We documented three flooding events in Jackson County, Florida, where several limestone caves support large colonies of *Myotis austroriparius* and smaller colonies of *M. grisescens*. In June 1989, heavy rainfall caused water to rise above the portion of the ceiling of Judge's Cave where a maternity colony roosted. When the water receded, we counted carcasses on sample areas of the cave floor and estimated 6,300 juvenile *Myotis* had died. In late March 1990, the Apalachicola River flooded Sneads Cave as the seasonal maternity colony was forming. Extrapolating from carcass counts in sample areas, we estimated 56,000 bats died. Another flood in Sneads Cave, following a tropical storm in July 1994, apparently killed all the roosting adults and young. Based on a pre-flood survey, >210,000 bats may have perished; only 125 bats were counted in April 1995. These natural catastrophes present challenges to the conservation of cave-roosting bats and reiterate the importance of maximizing the number of available roosts. They also identify important ecological questions about the factors influencing roost selection, suitability, and fidelity, and about how variation in annual survival rates might affect population growth.

GRIFFITHS, T.A.

PHYLOGENETIC SYSTEMATICS OF THE SMALL VESPERTILIONOID BAT FAMILIES, BASED ON HYOID AND OTHER MORPHOLOGY (CHIROPTERA: NATALIDAE, FURIPTERIDAE, THYROPTERIDAE, MYZOPODIDAE, AND MYSTACINIDAE).

T.A. Griffiths. Illinois Wesleyan University, Bloomington, Illinois.

The fifteen microchiropteran bat families have traditionally been placed in four superfamilies contained in two infraorders. The hyoid morphology of most families in three of the four superfamilies has been previously described by Griffiths and associates. However, bats contained in the Infraorder Yangochiroptera, Superfamily Vespertilionoidea have received only superficial attention to date. In particular, the hyoid regions of the five vespertilionoid families listed in the title above have been only incompletely described (Thyropteridae) or not described at all. In this study, the hyoid musculature and hyoid apparatus of bats of the five small vespertilionoid families is described and compared with hyoid anatomy of: 1) selected vespertilionid and molossid bats; 2) representative phyllostomoid bats; and 3) representative yinochiropteran bats. Data are analyzed using cladistical procedures, and a phylogeny for the seven families within the superfamily Vespertilionoidea is presented.

GUSTAFSON, A.W.

REPRODUCTIVE MODULATION OF ANDROGEN ACTION DURING REPRODUCTIVE DEVELOPMENT IN THE MALE LITTLE BROWN BAT *(Myotis lucifugus lucifugus)*.

A.W.Gustafson[1], D.A. Damassa[1], and G.G. Kwiecinski[2].
[1]Tufts University, Boston, Massachusetts, and [2]University of Scranton, Scranton, Pennsylvania.

The thyroid is known to influence many aspects of development but its role in the pubertal activation of the male reproductive tract is poorly understood. Plasma thyroxine concentrations in immature male little brown bats are low early in hibernation, but then increase to reach peak seasonal levels at the time of emergence in the spring. Testicular activation also occurs after arousal; however, sex accessory gland (SAG) weights do not increase until later in the summer. Therefore, studies were conducted to assess the androgen-responsiveness of the SAGs and to examine the role of the thyroid in modulating androgen action. Immature males were collected either in November (early hibernation) and housed under a short photoperiod or in March (late hibernation) and maintained under a long photoperiod. All bats were gonadectomized after arousal and housed at 25° C. Treatment with testosterone (T) for 2-3 weeks produced total and free plasma T concentrations that were at or above the peak seasonal levels observed in adults of this species. Significant increases in SAG weights were seen both in early (Veh: 10.7–0.9; T: 35.4 $\pm$ 8.6 mg) and late (Veh: 8.9 $\pm$ 0.8; T: 23.5 $\pm$ 3.1 mg) hibernation. Further experiments on bats aroused from late hibernation demonstrated dose-dependent increases in plasma total T, free T, and the stimulation of the SAG. Thyroidectomized (Trx) males treated with sub-maximal doses of T showed a greater SAG stimulation than sham-operated controls. This enhanced SAG stimulation was associated with the Trx-induced reduction in circulating sex hormone-binding globulin (SHBG) and increased free T. These findings indicate that the thyroid inhibits SAG responses to androgens in immature bats indirectly by increasing circulating levels of SHBG.

HALL, J.S. BAT POPULATIONS ON SAN SALVADOR ISLAND, BAHAMAS

J.S. Hall[1], C. Stihler[2], and P. Dougherty[1].
[1]Albright College, Reading, Pennsylvania, and [2]Division of Natural Resources, Elkins, West Virginia.

We have been studying the population numbers, distribution, behavior and ecology of *Erophylla sezekorni* and *Natalus tumidifrons* on San Salvador Island, Bahamas. This study was conducted during an eight day period in January 1994, an eight day period in January 1995, and a five day period in March 1995. Since little is known about these two species, both of which are endemic to the West Indies, the limited data that we have obtained should be of interest. An investigation of thirteen caves resulted in a total count of 311 *E. sezekorni* and 878 *N. tumidifrons*. Populations of *E. sezekorni* seemed to be consistent in two caves that were observed on five occasions. Groups of *N. tumidifrons* seemed to be transitory and may move from cave-to-cave in large groups. Social behavior of *E. sezekorni* was observed with a night vision scope. Apparent males compete by face-to-face wing flapping for space on the ceiling of the cave. Data were obtained on the numbers of wing flappers and non-flappers. No reproductive activity in the form of apparent pregnant females or young was noted in January or March. The average body mass of 10 male *E. sezekorni* was 15.6 g and one female was 15.2 g. The average mass of 27 male *N.* tumidifrons was 3.6 g and 10 females was 3.45 g. Bats were mist-netted at two cave entrances at night, resulting in more bats being caught than were roosting in these caves during the daytime. Apparently some caves are used as night roosts only. We plan to continue this work in 1996.

HALL, L.S. THE BATS OF GUA PAYAU (DEER CAVE), SARAWAK, MALAYSIA.

L.S. Hall. University of Queensland, Brisbane, Australia.

Gua Payau, located in the lush rain forest of Gunng Mulu National Park, northern Sarawak, Borneo, is an enormous limestone cave formed by a branch of the Melinau River. The cave consists of a large chamber 1.8 km long and averaging 80 m high and 50 m wide. Gua Payau is considered to be the largest single cave passage in the world. Inside the cave there are a number of side branches, a river, a creek, and several "caves within the cave". A large colony of free-tail bats, *Chaerephon plicata*, inhabits the cave and observing their evening exodus has become a popular tourist activity. Surveys were conducted in 1988, 1992-93, to determine the size of the colony of free-tail bats and to gather information on other species of bats in the cave for management purposes. Twelve species of bats have been recorded in Gua Payau. An additional six species which are known to roost in caves, was recorded nearby in the park and are likely to be found roosting in Gua Payau. Observations on the exodus of free-tail bats showed that the number emerging each night varied from zero to almost two million. The factors influencing this variation were not determined. Local weather conditions had little effect on the numbers of free-tails leaving the cave. A small colony of naked bats, *Cheiromeles torquatus*, a species in severe decline in many locations, also inhabits the cave. The only record for Borneo of the rare lesser tail-less roundleaf bat, *Coelops robinsoni*, was a dead specimen picked up from the floor of Gua Payau.

HAMILTON, I.M.

AGE-RELATED INFLUENCES ON THE DIET AND FORAGING BEHAVIOR OF BIG BROWN BATS *(Eptesicus fuscus)*.

I.M. Hamilton. University of Calgary, Calgary, Alberta, Canada.

Prey choice and foraging behavior of many organisms change with age. These changes may result from changes in experience, as individuals become more proficient at searching for and handling prey. In the summers of 1994 and 1995, I examined foraging behavior of juvenile and adult big brown bats at two maternity colonies in Medicine Hat, Alberta. In 1994, pups were born in late June, and first foraged at a mean age of 21 days. I compared the diets of juveniles and adults through fecal analysis. The diet of newly volant juveniles (age < 35 days) differed significantly from that of adults. Newly volant juveniles ate significantly less Coleoptera and more Hemiptera than did adults. The dietary niche breadth of newly volant juveniles was broader than that of adults. There were no differences in diet between older juveniles and adults. To compare prey detection, capture, and handling abilities between juveniles and adults, I measured wing morphology, echolocation call-structure, and prey-handling efficiency. Results of these comparisons will be presented.

HAND, S.J. AUSTRALIAN FOSSIL BATS: NEW PIECES FOR ANCIENT PUZZLES.

S.J. Hand. University of New South Wales, Sydney, Australia.

A 55 million-year-old bat from Australia urges re-examination of evidence for a Gondwanan (South American) origin for Australian bats, a source area also postulated for the origins of, among others, Australia's marsupials, ratite birds and frogs. Bats are absent from the early Tertiary record of South America, but the Australian

fossil record provides evidence for an early and enduring presence here of a range of archaic, cosmopolitan bat groups, including archaeonycteridids (Early Eocene), some molossids (Oligo-Miocene) and members of a new family (Oligo-Miocene) possibly related to New Zealand's endemic mystacinids. Other Australian Tertiary bats show greater affinities to modern and fossil Eurasian and African groups, including probable Miocene relatives of southeastern Asia's curious naked bat *(Cheiromeles torquatus)*. Hipposiderids are particularly diverse and well represented in the Australian middle Tertiary record. Several new, distinctive genera have been discovered in the Oligo-Miocene bat-rich limestone deposits of Riversleigh, northwestern Queensland. Study of the skulls, based on some 70 cranial and dental characters, of these new hipposiderids and representatives of most other genera and species groups has led to a revision of current phylogenetic understanding of the family as a whole. Paraphyly at various taxonomic levels is apparent and significant nomenclatural revision is clearly required. An area-cladogram for the family reveals no clear biogeographic pattern of radiation. Australia's first Miocene vespertilionid has been identified, but as yet no pre-Pliocene emballonurids, pre-Pleistocene megachiropterans or 'true' rhinolophids have been recovered. The absence of these groups in the older record is intriguing in view of their high modern diversity in southeastern Asia, Australia's northern doorstep.

HAYASHI, M.M.

PHYTOPHAGOUS BATS FROM TWO DISTURBED AREAS (*Eucalyptus* MONOCULTURE AND ORCHARD) OF SOUTHEASTERN BRAZIL

M.M. Hayashi and W. Uieda. Universidade Estadual Paulista, Botucatu, São Paulo, Brazil.

The role of phytophagous phyllostomid bats in pollination and seed dispersal is well investigated in several regions, but little is known of their influence over cultivated areas. In 1993 and 1994, we compared phytophagous bat faunas from two nearby disturbed sites (A and B), in Sao Paulo State, southeastern Brazil. Site A is an eucalyptus monoculture area, with pioneer plants of *Piper*,near a secondary forest. Site B is an orchard with several fruit trees (mango, jabuticaba, avocado, papaya, yellow plum) distributed in several rows. The most common species were *Sturnira lilium* (53%), *Carollia perspicillata* (15%) and *Glossophaga soricina* (13%) at site A, and *S. lilium* (38%), *Artibeus lituratus* (29%) and *Platyrrhinus lineatus* (21%) at site B. Throughout the year, *S. lilium* was the most frequent species at both sites and fed mainly on pioneer *Piper* spp. in site A and on *Solanum* spp. at site B, avoiding cultivated plants. *Carollia perspicillata* fed exclusively on *Piper* spp., the most abundant plant in site A. *Artibeus lituratus* and *Platyrrhinus lineatus* essentially explored plants with high fruit production in short periods, such as wild *Ficus sp.* and *Cecropia sp.*, and cultivated *Eryobotria japonica*, *Myrciaria cauliflora* and *Mangifera indica*. Our data indicate that *S. lilium*, *C perspicillata*, *A. lituratus* and *P. lineatus* are the most common species in disturbed areas and act directly in the regeneration of these areas. However, the last two species also visited cultivated plants, some of commercial importance and some not, and may eventually play some negative role in regional fruit growing.

HELLER, K-G.

ECHOLOCATION AND BODY SIZE IN AERIAL INSECTIVOROUS BATS: A LESSON FROM THE GIANT NAKED BAT *Cheiromeles torquatus* (MOLOSSIDAE).

K-.G. Heller. University of Erlangen-Nürnberg, Erlangen, Germany.

It has been recently hypothesized that the maximum size of aerial insectivorous bats is limited due to properties of their echolocation system. A) Large bats should have to use low call frequencies which have been proposed to be suitable for the detection of large prey only (Barclay and Brigham 1991). B) Large bats should have low wing beat frequencies which make a high call repetition rate, which could be necessary for prey detection, energetically impossible (Jones 1994). Both hypotheses were tested by analyzing the echolocation behavior of *Cheiromeles torquatus*, the largest aerial insectivorous bat (body mass 140-200 g). For echolocation, *Cheiromeles* used alternating calls with lowest frequencies of 20 and 28 kHz (call durations 30 and 24 ms respectively), and had a call repetition rate of 6.3 Hz. These call parameters are distinctly higher than the predictions made by both models. Inclusion of the data of *Cheiromeles* and some other large bats in an allometric version of model A changes the prediction of the model distinctly, indicating that call frequency might be only a weak constraint on body size if at all. Call repetition rate seems to be correlated to call frequency and not directly to body size as assumed in model B. In any case, large bats have lower call repetition rates than wing beat rates and the difference increases with body size. Thus, other factors must be considered to explain the size distribution of aerial insectivorous bats.

HELVERSEN, O.v.

AN ACOUSTIC NECTAR GUIDE IN A BAT POLLINATED FLOWER.

O. v. Helversen and D. v. Helversen. University of Erlangen-Nürnberg, Erlangen, Germany.

As most microbats orientate mainly by echolocation, flowers pollinated by bats may be expected to be 'acoustically conspicuous' to the bats. Vines of the genus *Mucuna* (Papilionaceae) include bat-pollinated species both

in the Old-World tropics and in the Neotropics. These flowers are unique among bat flowers as the visitors have to 'crack' the flower by pushing their snout into a slit between the 'wings' at the base of the flower, thereby releasing an explosion mechanism which catapults more than 90% of the flower's pollen supply into a small area of the bat's fur. During the first visit, the bat can obtain about ten times more nectar than during subsequent visits. Thus, it is crucial for a bat to find newly matured flowers quickly. The flower signals its maturity by opening the 'standard' (the upper petal or vexillum). In *Mucuna holtonii* which was visited and pollinated by Glossophaga *commissarisi* and *Lichonycteris obscura* at the O.T.S. field station 'La Selva' in Costa Rica, we found: 1) when we removed the 'standard' which has the shape of a small concave mirror, or when we only reduced its echo reflection by inserting a small pad of cotton wool, the frequency of bat visits was drastically reduced compared to untreated flowers. 2) when tested with ultrasonic bat-like sounds (110-60 kHz sweeps) the 'standard' proved to be the main echo-reflecting structure of the flower; working similar to an "acoustic triple mirror" the 'standard' sends a high intensity echo back into a broad section of space of at least ± 40 degrees. Therefore we conclude that the 'standard' is an acoustically conspicuous 'nectar guide' for echolocating bat visitors in *Mucuna holtonii* .

HERMANSON, J.W.

CHIROPTERAN MUSCLE BIOLOGY: A PERSPECTIVE FROM MOLECULES TO FUNCTION.

J.W. Hermanson. Cornell University, Ithaca, New York.

Contemporary thought about bat muscle function stems in large part from T.A. Vaughan's classic study on bat morphology in 1959. Subsequent students of chiropteran morphology have built upon the careful descriptive analysis which that study provided to develop hypotheses of muscle activity-cycles during the wing beat, as well as analyses at the biochemical level to identify specialization of muscle function. Other muscle characters have proven valuable in elucidating probable phylogenetic relationships among bats and other mammals. In short, the muscular system provides valuable insight into the natural history and evolution of bats. Our lab has focused on the evolution of form-function specializations in the flight muscles of bats. Based on simple (monophasic) and complex (biphasic) electromyographic patterns in the flight muscles of *Tadarida brasiliensis* and *Artibeus jamaicensis*, respectively, a high degree of correlation was observed with like patterns of muscle fiber-type diversity in the same muscles. This correlation has been taken further by identifying key muscle proteins that dictate the speed of shortening of muscle fibers. How do these muscle characteristics contribute to or constrain flight performance? Data is presented to show a preliminary correlation of flight muscle proteins with the two-dimensional projections of wing loading and aspect ratio published by Norberg and Rayner (1987, Philos. Trans. R. Soc. Lond., B316). These data, in concert with observations of distal forelimb muscles responsible for wing camber illustrate the complexity of muscle design underlying the maneuverability and endurance properties of bats.

HOLMES, M.R.

A SURVEY OF FRUIT BATS IN THE MALDIVE ARCHIPELAGO, INDIAN OCEAN.

M. R. Holmes. Bat Conservation Trust, London, England, UK.

The IUCN-World Conservation Union publication "Old World Fruit Bats---An Action Plan for Their Conservation" (Mickleburgh, Hutson & Racey, 1992) included twenty high priority projects, one of which was a survey of fruit bats in the maldive Islands. A culling operation had been initiated there in response to suggestions made at the 13th Vertebrae pest Conference held at Monterey, California (Dolbeer, Fiedler & Rasheed, 1988). The advised rate of culling far outstripped the bat's rate of reproduction. There are two sub-species of bats endemic to the Maldives, *Pteropus giganteus ariel* and *Pteropus hypomelanus maris* . The UK Bat Conservation Trust organized a survey team, led by Tony Hutson, the BCT Conservation Officer, which arrived in the Maldives in November 1993. The aims were: 1. to assess fruit bat population, 2. to assess damage due to fruit bats, 3. to discuss survey results with appropriate Maldive authorities, 4. to make management and educational proposals which might be acceptable to these authorities. A boat was hired in which the team lived and traveled. Extremely bad weather was encountered which curtailed both the work and area covered. However, twenty-eight islands were surveyed, with bats found on twenty-two of them. Their feeding habits were noted. Seven were caught in mist nets and examined. Contact was made with the inhabitants and a meeting held with government representatives. It is planned to return and continue the survey in 1996.

HORNER, M.A.

STATUS OF TWO RARE BATS, *Myotis austroriparius* AND *Plecotus rafinesquii*, IN EAST TEXAS.

M.A. Horner. Texas Parks and Wildlife Department, Austin, Texas.

The southeastern myotis, *M.austroriparius*, and eastern big-eared bat, *P. rafinesquii*, are both federally listed as Candidate Species, and *P. rafinesquii* is also listed as Threatened by Texas Parks and Wildlife. Both species are known from east and southeast Texas near the southwestern edge of their range. Although these species typically

roost in caves, east Texas is devoid of such potential roost sites. It is assumed that their natural roost sites are in large hollow trees such as those found in bottomland hardwoods. Due to recent timbering activities, biologists are concerned about the long term population stability of these bat species. Thus, a survey was initiated in 1994 and continued in 1995 to locate populations, characterize roosting and foraging habitats, determine threats, and monitor population trends. In 1994, seven counties were surveyed from May-September and 41 southeastern myotis and two eastern big-eared bats were captured at four state parks. The most common habitat type of captured bats was in the beech-magnolia community, and most captures occurred when nets were placed across narrow trails rather than across water. Females of southeastern myotis were significantly larger than males. This species has two color phases, and sixty percent of all individuals were of the orange color phase, which was significantly more associated with females than males. The survey is still in progress, but it appears that the eastern big-eared bat is difficult to locate and monitor in east Texas, but the southeastern myotis may be fairly common.

HOUCK, B.A. HANDEDNESS IN *Eidolon helvum*.
B.A. Houck, S. Martzall, and L. Rowe. University of Portland, Portland, Oregon.

Behavioral lateralization in hand use has been demonstrated in primates, but few studies have examined handedness in non-primate mammals. In this study, hand preference was observed in a captive colony of *Eidolon helvum*, the straw-colored fruit bat, at the Metro Washington Park Zoo, Portland, Oregon. A continuous all-occurrence focal sampling method was used to identify left hand or right hand preference during feeding and agonistic behaviors. *Eidolon helvum* show a statistically significant preference for left-handedness in selected behaviors.

HUBBELL, J.W.
BATS IN AN URBAN/WILDLAND INTERFACE;
PUBLIC EDUCATION, CONSERVATION AND MANAGEMENT IN BOULDER COUNTY, COLORADO.
J.W. Hubbell and C.K. Miller. City of Boulder Open Space Department, Boulder, Colorado.

Very little is known about the bat species in Boulder County, Colorado. Baseline information on species composition and distribution is necessary for adequate protection of the bat resource. The objectives of this study are: 1) to establish species composition and distribution of bats in Boulder County; 2) to determine conservation priorities and protect appropriate habitat to ensure the conservation of bats; and finally; 3) to provide a unique education opportunity for the community. The program utilizes citizen volunteers and trained scientists in a unique blend designed to educate the public and meet resource conservation objectives. We present a community based education program that combines field experience with classroom education and the integration of bat conservation into resource management decisions.

HUTCHEON, J.
THE BAT CAVES OF THE ANKARANA RESERVE, MADAGASCAR: ESTABLISHMENT OF A MONITORING AND CONSERVATION PROGRAM.
J. Hutcheon. University of Wisconsin Zoological Museum, Madison, Wisconsin.

The reserve Speciale d'Ankarana in Northern Madagascar covers an area of approximately 18,225 hectares and represents the western extension of a limestone massif. This reserve contains a large number of caves which constitute important roosting habitats and hibernacula for a number of endemic bat species including *Triaenops furculus, Emballonura atrata*, and *Eidolon dupraenum*. In answer to concerns about disturbance of bats by tourists, a general census was carried out utilizing exit counts at the mouths of caves and cluster counts inside the caves. Park employees were trained to continue these counts on a monthly basis and the results were recorded in a database.

HUTCHEON, J.
INTER-FAMILIAL RELATIONSHIPS WITHIN THE MICROCHIROPTERA: A PRELIMINARY STUDY USING DNA HYBRIDIZATION.
J. Hutcheon and J.A.W. Kirsch. University of Wisconsin Zoological Museum, Madison, Wisconsin.

Taxa representing twelve genera from nine families of microbats were compared in a 19 x 19 matrix that also included two Old-World fruitbats and five other outgroups. Our results yielded two major complexes of microchiropteran families, the first including vespertilionids, molossids, and noctilionoids; comprising rhinolophoids. Within the first group, DNA hybridization favors placement of *Noctilio* close to phyllostomids; within the second, *Macroderma* is sister to *Rhinolophus* and *Hipposideros*. Emballonuridae fell outside these two clades and was the most basal of the bat families. Regarding outgroups, a striking result was placement of the megabats as sister to the rhinolophoids, a finding that may result from the high AT-bias of these bats remarked by John Pettigrew. Primates,

the flying lemur, and a tree shrew clustered apart from all bats on the tree, which was rooted with an opossum. Thus, our experiments are consistent with bat monophyly and current understanding of microbat superfamilial relationships, but raise the possibility that microchiropterans might be paraphyletic.

ISAAC, S.S.

PARTURITION POST-NATAL GROWTH AND AGE ESTIMATION IN THE INDIAN PYGMY BAT.

S.S. Isaac and G. Marimuthu. School of Biological Sciences, Madurai Kamaraj University, Madurai, India.

The Indian pygmy bat *Pipistrellus mimus* exhibits four distinct bouts of parturition each year. Observations from tagged females indicate that the same individuals can give birth a maximum of three times successively in a year. Parturition with twin babies is relatively common. Empirical growth curves were derived by measuring forearm length, body mass, and length of the total epiphyseal gap (total gap) of the fourth metacarpal-phalangeal joint. Age estimation was made with values of forearm and length of total gap during the preflight (first 20 days) and post-flight stages, respectively. Initiation of flight and foraging occurred at the age of 21 and 33 days, respectively. Females attain sexual maturity within two months after birth and experience parturition for the first time at the age of 112 days.

JONES, G.

BAT SONAR AND MOTH HEARING: AN EVOLUTIONARY ARMS RACE?

G. Jones[1], D.A. Waters[1], and J. Rydell[2].
[1]University of Bristol, Bristol, England, UK, and [2]University of Göteborg, Göteborg, Sweden.

Studies on the audition of tympanate moths predict that bats can reduce their appearancy to moths by calling at frequencies outside the range of best hearing in moths, and by using short duration calls. These predictions were tested in playback experiments of manipulated calls to tympanic preparations of *Noctua pronuba*. *Rhinolophus hipposideros* emits long duration (ca. 50 ms) calls dominated by a constant frequency (CF) component at about 115 kHz. *Pipistrellus pipistrellus* calls are < 5 ms frequency modulated (FM) sweeps terminating in a CF component at about 45 kHz. *Myotis nattereri* calls were < 5 ms FM sweeps from 150-20 kHz. From moth audiograms, we predicted and confirmed a ranking of apparency *Pipistrellus >Myotis > Rhinolophus*. Doubling duration increased apparency by 2-3.5 dB peSPL for all species, as predicted from integration time curves. Halving peak frequency had no effect on apparency for *Pipistrellus*, increased apparency by 2 dB in *Myotis*, by 22 dB in *Rhinolophus*. We conclude that large changes in frequency have relatively small effects on apparency for short-duration calls, but large effects for long-duration signals. Use of the second harmonic may reduce the apparency of rhinolophid calls, and species that emit higher frequencies eat more moths. In Europe, tympanate moths seem to be most sensitive to frequencies emitted by large, fast flying bat species. Moths should evolve responses to bat echolocation faster than bats can evolve countermeasures, and moths should have effective defenses against those bat species that were important predators during the evolution of moth hearing. Whether bats have evolved countermeasures to moth hearing is more difficult to address, and whether the predator-prey scenario is a coevolutionary process is therefore unclear.

JONES, K.E.

DISTRIBUTION AND POPULATION DENSITIES OF SEVEN SPECIES OF BAT IN NORTHERN ENGLAND,UK.

K.E. Jones[1] and J.D.Altringham[2] .
[1] University of Leeds, Leeds, Enngland, UK, and the [2]Harrogate Bat Group.

Distribution and minimum population densities for seven U.K. bat species known to be resident in Northern England were calculated in an area covering 2,500 km^2. The species present were pipistrelle *(Pipistrellus pipistrellus)*, brown long-eared *(Plecotus auritus)*, Daubenton's *(Myotis daubentoni)*, whiskered *(Myotis mystacinus)*, Natterer's*(Myotis nattereri)*, noctule *(Nyctalus noctula)* and Brandt's *(Myotis brandti)*. Data were collected primarily from counts at summer roosts over the period 1983 to 1990. A total of 310 bat roosts were discovered within the study area. Of the 256 roosts at which the species present was identified, the majority, 127 (49.6%) were pipistrelle bats with a minimum population density of 10.8 bats km^{-2} and a mean roost size of 58.7 bats. The relative population levels of pipistrelle bats closely reflect the best estimate for the country as a whole of 50% of identified roosts and mean roost size of 53 bats. The minimum population density estimate was higher than previous studies in Northern England but substantially lower than those reported in Scotland (18.2 bats km^{-2}). The combined density of whiskered, Brandt's and pipistrelle bats, whic h have similar foraging styles (13.5 bats km^{-2}) is still lower than Scottish pipistrelle densities. The density of Daubenton's bats was also lower than in Scotland although the brown

long-eared density was comparable. Urbanization had a major influence on roost distribution. Pipistrelle bats showed high roosting frequencies in built up areas while brown long-eared bats showed the opposite trend. The majority of summer roosts for all species were found in buildings, except noctule and Daubenton's bats which used bridges/tunnels or trees respectively.

JUSTE- B., J.

PHYLOGENETIC RELATIONSHIPS WITHIN THE AFRICAN ROUSETTINAE GROUP.

J. Juste-B.[1], C. Ibáñez[2] and A. Machordom[3].
[1]Texas Tech University, Lubbock, Texas, USA, and [1,2]Estación Biológica de Doñana (CSIC) Sevilla, Spain, and [3]Museo Nacional de Ciencias Naturales, Madrid, Spain.

Evolutionary relationships among fruit bats are in general poorly known. They are especially obscure among the species of the African section of the Rousettinae group defined by Andersen. Particularly, the official inclusion of *Lissonycteris angolensis* within this group has been contested from different sets of data. Genetic relationships among the species *Rousettus egyptiacus, R. angolensis, Myonycteris torquata, M. brachycephala,* and *Eidolon helvum* were investigated using protein electrophoresis, with *Megaloglossus woermanni* as an outgroup. Three different subspecies of *R. egyptiacus* were used to establish values of genetic distances at this taxonomic level. The study was based on a starch gel electrophoretic analysis of the variability at 31 presumptive loci encoding 22 enzymatic systems. Nei and Rogers genetic distances were used to derive phenograms. Locus-by locus analyses and the Wagner procedure were used to construct phylogenetic trees. Bootstrapping was used to assess consistency of dichotomies and a strict consensus tree was produced. Evolutionary and taxonomic relationships among the species will be discussed.

KALKO, E.K.V.

HOW ECHOLOCATING BATS APPROACH AND ASSESS FOOD

Elisabeth K. V. Kalko, Animal Physiology, University of Tuebingen, Germany, and Smithsonian Tropical Research Institute, Panama.

Based on three-dimensional reconstructions of photographic sequences of foraging bats in the field synchronized with sound recordings, behavioral experiments in a flight cage and literature i will give an overview of how echolocating bats approach and assess food. I will describe the perceptual tasks that have to be solved by bats living under different ecological conditions while approaching and assessing food. For instance, depending on their feeding mode (aerial or gleaning) and diet (mobile or immobile) bats are challenged with echolocation tasks of varying difficulty. Bats that close in on prey in mid-air have to continuously monitor the prey's position to successfully track and catch it. The echolocation task for gleaning bats is less difficult since they usually take food that is stationary. These bats use other sensory cues to detect, classify, and localize their prey. Here, echolocation serves primarily to determine the bat's position in relation to clutter targets and to control the approach to the surface where the food is located. I will discuss in detail pursuit strategies (predictive, non-predictive) and capture techniques (e.g., use of tail membrane and/or wing) of bats catching insects in the air. Further, I will compare approach behavior of several frugivorous and insect-gleaning leaf-nosed bats (Phyllostomidae) and link characteristic behavioral stages with differential use of various sensory cues.

KANDULA, S.

TONOTOPIC ORGANIZATION AND PURE TONE RESPONSE CHARACTERISTICS OF SINGLE UNITS IN THE INFERIOR COLLICULUS OF THE FREE-TAILED BAT, *Rhinopoma hardwickei*.

S. Kandula. Madurai Kamaraj University, Madurai, India.

The tonotopic organization of the inferior colliculus (IC) in the bat *Rhinopoma hardwickei* was studied by making multiunit recordings. The frequencies below the range of echolocation signals (up to 30 kHz) are represented in the uppermost region of the IC. The isofrequency contours are oriented horizontally in the mediolateral IC and fall off progressively in the caudal direction. The frequencies of echolocation signals (35-55 kHz) are represented in the central IC. The high frequencies are compressed in the ventral region of the IC. Even though this species has a long pure tone call, the audiogram does not show an auditory fovea as seen in rhinolophid and hipposiderid bats. Neurons in the IC are narrowly tuned both in the frequency range of 35 kHz and also the frequency range of the FM end of the call (18 kHz), *Rhinopoma hardwickei* may be a species which is in the transient stage of evolving clutter resistance through narrow filtering.

KARIM, K.B.

GROWTH RELATED EMBRYO MORPHOLOGY IN *Rousettus leschenaulti*

K.B. Karim and M.S. Sastry. Institute of Science, Nagpur, India, and Department of Zoology, Nagpur University Campus, Nagpur, India.

Growth related embryo morphology in *Rousettus leschenaulti* is based on 12 stages (greatest length 5 mm to a suckling young CH 93 mm) collected from Kandri Mines, Nagpur, Aurangabad (Maharashtra) and Mandu in Madhya Pradesh. The youngest embryo (5 mm) is fairly straight with a distinct cardiac prominence. Embryos with a CRL 5.5 mm have cervical flexture, fore- and hind-limb buds, a distinct tail bud, and three branchial arches. The CRL 10.5 mm embryo has a characteristic paddle stage with a fleshy uropatagium between the hind legs and tail, head distinct almost of the same size as body, mouth bounded by upper and lower jaws, snout with button -shaped hair follicles, nostrils, eyes with eyelids and lens, and ear pit with triangular ear pinna. Embryos at CRL 12 mm have all four patagia with hind limbs tucked midventrally, and snout covered with chiropatagium of forelimbs. At 18 mm CRL, handwings are placed on either side of face covering the eyes, and a minute claw on the index finger is visible. The head is reduced in size at CRL 26 mm, and the patagia are held completely over the face. At a CRL of 31.5 mm, the head is smaller than the body, both limbs are folded and wrapped on one side of the body. Three different postures are observed at CH 72, 75 and 78 mm. None of the embryos have fur but they have parallel wrinkles on the back and circular rings around the neck. At a CH of 30 mm, blackish fur appears on the dorsal side, large leaf-like pinna, lower jaw with deciduous recurved teeth, and patagia are well-formed. A pair of axillary nipples are seen. The suckling young at CH 93 mm resembles the adult. A comparison of *Rousettus* embryos with that of other mammalian embryos have been made.

KEEGAN, D.J.

COMPARATIVE STUDY OF THE ABSORPTION OF 3-O-METHYLGLUCOSE BY THE ENTROCYTE IN THE FRUIT BAT *Rousettus aegyptiacus* AND RAT.

D.J. Keegan, University of Witwatersrand, Johannesburg, South Africa.

The fruit bat, *Rousettus aegyptiacus*, can consume the equivalent of its own body mass of bananas during the night. In addition, there is a very rapid transit time of 40 minutes with little loss of monosacchrides in the feces. *In vivo* methods have shown that Rousettus assimilates glucose and fructose three and four times more rapidly, respectively, than the laboratory rat, which is twice its size. All *in vitro* methods that have been used to study the active transport of glucose from the intestine have failed to demonstrate such a process in the bat. This is readily shown in the rat. In this comparative study, the ring method of Alvarado and Mahmood Akhtarr was used to study the absorption of 3-0-methylglucose by the enterocyte in the rat and the bat , *Rousettus aegyptiacus*. The results show that in the case of the rat, the concentration of 3-0-methylglucose in the intracellular volume increased rapidly and by 11 minutes exceeded the extracellular concentration, confirming an active transport systems for glucose. In the bat, the concentration 3-0-methylglucose in the intracellular volume increased very slowly and was less than 20% of the extracellular fluid after 11 minutes. These results confirm the other *in vitro* experiments and support the hypothesis that *Rousettus aegyptiacus* does not have an active transport system for glucose.

KEELEY, B.K.

ROOST SELECTION BY MEXICAN FREE-TAILED BATS (*Tadarida brasiliensis*) IN TEXAS BRIDGES.

B.K. Keeley. Bat Conservation International, Inc., Austin, Texas, USA.

Over 800 highway bridges in Texas were examined for bat use. Characteristics of 80 bridges located in central Texas were compared in occupied versus unoccupied bridges, and observations of roost preferences within occupied bridges were recorded, including bridge structural characteristics, microclimate of the bridge, roost substrate descriptions, surrounding land use patterns, water availability, and distance from urban areas. Characteristics of bridges utilized by *Tadarida brasiliensis* were matched with the nearest unused bridge of similar design for a paired comparison study. Multiple regression analysis was used to screen 80 characteristics for significance. Ninety-four percent of central Texas bridge crevices that are 30 centimeters or deeper and between 1.9 and 2.5 centimeters wide with closed tops are occupied by *T. brasiliensis*. A state-wide evaluation of bridges used as bat habitat continues through July 1996. Designs for retro-fitting bridges to create roosting habitat for bats are also being evaluated.

KHABILOV, T.K.

STATUS OF BATS IN TAJIKISTAN.

T.K. Khabilov. Khujand State University, Khujand, Tajikistan.

On the basis of long-term studies (18 years), an analysis of the chiropteran fauna comprising 19 species in Tajikistan is presented. Three species of the family Rhinolophidae, 15 Vespertilionidae (1 species - *Miniopterus*

schreibersii - is reported for the first time) and 1 Molossidae. The status of *Myotis frater*, *Miniopterus schreibersi*, and *Eptesicus nilssoni* is not known, but they are mostly likely to be rare, since no specimens have been found for many years. *Rhinolophus bocharicus*, *Vespertilio murinus*, *Otonycteris hemprichi* are uncommon or localized, and *Nyctalus noctula* is very rare. *Tadarida teniotis* is probably more common than the small number of known records in Tajikistan suggests. *Pipistrellus pipistrellus*, *Eptesicus serotinus*, *E. bottae*, *Plecotus austriacus*, and *Barbastella leucomelas* are the most abundant species. *Rhinolophus hipposideros*, *Myotis mystacinus* and *Pipistrellus savii* are common species. There are still many good populations of *Rhinolophus ferrumequinum*, *Myotis emarginatus*, and *M. blythi* in some caves and old mines, but they are threatened by human activities. In 1980, eighteen microreserves (caves and abandoned mines) were created the for protection of the rare and vanishing species of bats in northern Tajikistan. We have now started a project to determine measures for preserving bat populations.

KHAN, N.A.

CORPUS LUTEUM IN THE INDIAN LEAF-NOSED BAT, *Hipposideros lankadiva lankadiva.*

N.A. Khan and K.B Karim. Institute of Science, Nagpur, India.

Hipposideros l. lankadiva is a monotocous bat; breeds once a year with a long gestation of 260-270 days, intercepted by semi-torpor of about four months from November to mid-March. Embryonic development is retarted after implantation during semi-torpor. The female genitalia is morphologically bilaterally symmetrical but physiologically the left side is dominant over the right. Conception in ipsilateral cornu is the general rule with rare instances of intra uterine migration. The corpus luteum (CL) is of three different types: introvert, pedunculated and extrovert. The CL is present in pregnant and non-pregnant females. In non-pregnant females it is the result of reproductive failure with entrapment of oocytes in luteinized follicles. This phenomenon in non-pregnant females was observed throughout the cycle. Some non-pregnant bats possess two luteinized follicles having entraped oocytes. Two CL have also been observed in pregnant females, one with an entraped oocyte. Some females show CL in both of the ovaries. Presence of CL in the contralateral ovary in pregnant bats has also been observed. The CL is very well developed at the early implanted bilaminer blastocyst stage which coincides with trophoblastic placenta. The CL regresses with the establishment of a chorioallantoic placenta.

KHAN, N.A.

FAT ACCUMULATION IN INDIAN LEAF-NOSED BAT, *Hipposideros lankadiva lankadiva.*

N.A. Khan. Institute of Science, Nagpur, India.

Hipposideros lankadiva lankadiva is an insectivorous bat which was noticed in active state at Chandrapur during March to October and in semi-torpor at Mandu during November to mid-March. At arousal no fat was present in the groin and it is during this time of the year body mass ranges from 35 to 50 g. After arousal from torpor individuals begin to feed which results in rapid increase in body mass with a slow and gradual accumulation of fat. Maximum body mass, between 45 to 65-70 g, is achieved in August which coincides with the breeding period. With the commencement of torpor at the end of October additional fat reserves are deposited. The body mass of these bats remains relatively constant until mid torpor (January-February) and begins to decline gradually with the mobilization of bat during arousal. An interesting phenomenon has been observed only in adult males. During August a fatty outgrowth hangs out from their jaws and protrudes from the mouth. During this period copulation takes place. The fatty outgrowth gradually disappears within 30 to 40 days. Fatty outgrowth appears to be composed of long thick white colored fibres when fixed in Alcoholic Bouin's and buffered formalin.

KINGSTON, T.

THE USE OF GIS TO DESCRIBE SPECIES DISTRIBUTION PATTERNS:
BAT SPECIES RICHNESS IN THE NEW WORLD.

T. Kingston, B. Hazam, S. Gopal. Boston University, Boston, Massachusetts, USA.

Patterns of species richness have long been of interest to biologists, but with the current biodiversity crisis identifying and explaining these patterns has become of considerable importance to conservation biology. Previous studies have used quadrats or latitudinal bands to produce maps of species density but such methods are flawed by the effect of quadrat size on density measurements; as quadrat size increases, the concomitant increase in habitat heterogeneity results in greater geographic species turnover. Consequently, the number of species found at any one point in a quadrat will only be a fraction of the quadrat pool of species. We report here an alternative method using the GIS software ARC/INFO. The distributions of 268 species of New World bat were mapped and overlaid to produce species density maps. By directly mapping species distributions, this method avoids the scale problems associated with the use of quadrats. Further overlays of environmental features can be conducted to examine biotic and abiotic distribution correlates, and through the use of the database functionality of GIS the analysis can be extended to incorporate morphological and ecological determinants of species distributions. Species richness of New World bats

declined with increasing latitude, as reported in previous studies. However, the GIS analysis put the peak of species richness at approximately 10° N, whereas quadrat methods had previously placed it at lower, more equatorial latitudes. Overall species richness was highest for northern Colombia, Venezuela, Guayana, and Surinam, and southern Central America, exceeding 100 species. This pattern was mirrored by the Phyllostomidae and Molossidae. The Vespertilionidae species-density was greatest in the southwestern U.S.A. and Mexico, whereas the peak concentration of the Emballonuridae was centered around the Amazon basin, Guyana, Surinam and French Guinea. When species were categorized by diet, it would appear that the overall species distribution pattern is largely driven by insectivorous and omnivorous species. The number of frugivorous species was greatest in eastern Peru and Ecuador.

KIRSCH, J.A.W.

BATS ARE MONOPHYLETIC; MEGABATS ARE MONOPHYLETIC; BUT ARE MICROBATS ALSO?

J.A.W. Kirsch. University of Wisconsin Zoological Museum, Madison,Wisconsin, USA.

Using DNA hybridization, I surveyed about half of the extant megachiropteran genera, affirming their monophyly and finding that only two of the putative macroglossines cluster apart from "typical" pteropodines; the basal dichotomy within Pteropodidae appears to lie between *Nyctimene*, *Paranyctimene*, and the other genera. DNA hybridization strongly supports chiropteran monophyly; but John Pettigrew has pointed out that megachiropterans and many microchiropterans are characterized by unusually high AT/GC ratios, which could produce a false association of the bat suborders. Therefore, Pettigrew and I undertook to examine the effect of AT-bias, performing parallel experiments with whole-genome extracts and fractions that were enriched in either AT or GC content. The results may confirm Pettigrew's suspicion of an AT-bias effect: bats always cluster apart from Primates on our trees, but in addition megachiropterans and the microchiropteran rhinolophoids appear to be specially related, whether whole-genome or fractionated DNA is used. Unless bats do represent a situation in megachiropterans where molecular data can be positively misleading, the phylogenetic implication is that megachiropterans--far from being related to Primates--evolved from *within* Microchiroptera.

KNAUF-KONTIS, B.

COMPARATIVE MORPHOLOGICAL STUDY OF THE KIDNEY IN *Phyllostomus discolor* AND *Desmodus rotundus*.

B. Knauf-Kontis and U. Schmidt. University of Bonn, Bonn, Germany.

The kidneys of *Phyllostomus discolor* and *Desmodus rotundus* were embedded in paraffin using standard histological techniques. Sections were cut at 8 µm, mounted permanently on glass slides and stained with hematoxylin and eosin (H & E). For the comparative study we used light microscopical and morphometrical analysis. There are a number of striking differences in the kidney structure of both species. Although the total volume of the kidney is nearly double in *P. discolor*, in the sanguivorous vampire bat, the medullary region is twice as large as in the omnivorous spear-nosed bat. The kidney pelvis of *Desmodus rotundus* projects deeply into the renal tissue, forming several secondary pouches; in *P. discolor* it is a very simple structure. The total number of the glomeruli is about double in *P. discolor*. On average they are smaller in *Desmodus rotundus*, however, their diameter varies in the different cortical regions.

KOKUREWICZ, T.

ECOLOGY AND ENERGETICS OF HIBERNATING DAUBENTON'S BATS (*Myotis daubentoni*).

T. Kokurewicz. Museum of Natural History Wroclaw University, Wroclaw, Poland.

The observations were carried out in the "Nietoperek" bat reserve in western Poland. The most important factor causing displacements (= spontaneous arousals) of bats was air flow ($r = 0.73$, $P<0.005$). The average relative frequency of arousals (RFD (day^{-1})) of individuals hibernating as singles was twice higher than in hibernating in clusters (0.164 and 0.07 RFD respectively). The RFD was negatively correlated with the size of cluster ($r = - 0.66$, $P<0.001$). Solitary hibernating bats aroused once in every six days, which is twice as high as in other studies. These individuals aroused 20 times during hibernation (about 0.6 g of fat) the energy cost of topor during that period was about 1.6 g. The average loss of mass in individuals in their first year was 2.13 g and in older ones (> 1 year) 2.59 g. In both age groups males had higher decreases in body mass which was probably related with mating (males can obtain sexual maturity in their first year). Individuals in their first year of life, because of smaller fat reserves, hibernated in clusters and in protected positions (crevices) more frequently than individuals > 1 year. In January and February the average mass loss for all classes was 0.25 that was 3 times lower than in the rest of hibernation. This was caused by winter feeding in warm periods of the winter. Observed winter decrease in body mass was not as great as it was 10 years ago (data from literature), and this seems to be related to recently observed climatic changes. The females from Sudety Mts. in southwestern Poland (central Europe) had larger forearms than those from lowlands and from British Isles (western Europe). Differences between sexes were also largest southwestern Poland. These

observations suggest that natural selection is directional, favouring the largest sizes. In colder climates winter feeding, considered as the most important factor influencing the natural selection, is impossible or very limited.

KORINE,C.

THE FRUIT SYNDROMES OF THE EGYPTIAN FRUIT-BAT, *Rousettus aegyptiacus* IN EAST MEDITERRANEAN HABITATS.

C. Korine[1], Z. Arad[1], and I. Izhaki[2].
[1]Technion-Israel Institute of Technology, Haifa, Israel, and [2]University of Haifa at Oranim, Tivon, Israel.

The fruit syndrome of the Egyptian fruit-bat, *Rousettus aegyptiacus* was studied. Twenty-one species of fleshy fruits were fed to the bats and analyzed according to their nutritional and morphological features. Two different sets of bat-fruit syndromes were revealed. One follows the general bat-fruit syndrome, characterized by large and fleshy fruit, low seed mass to pulp mass ratio and a relatively high carbohydrate content. The other represents a special case of bat-fruit syndrome that is only found in East Mediterranean habitats. This syndrome is characterized by dry fruits of a high protein content and a relatively high seed-mass to pulp-mass ratio. Fruit species that belong to this syndrome are available mostly in winter. The dietary overlap between frugivorous birds (based on the literature) and bats was also examined. It was found that fruit characteristics associated with each set of fruit species follow in general the known bat and bird syndromes. However, a limited and asymmetrical dietary overlap was observed between the two taxa, mainly in introduced and cultivated fruit species.

KORINE, C.

FOOD SELECTION OF THE EGYPTIAN FRUIT-BAT *Rousettus aegyptiacus* IN EAST MEDITERRANEAN HABITATS.

C. Korine[1], Z. Arad[1], and I. Izhaki[2]. [1]Technion-Israel Institute of Technology, Haifa , Israel, and [2]University of Haifa at Oranim, Tivon, Israel .

The diet of the Egyptian fruit-bat, *Rousettus aegyptacus*, was monitored in two different daily roost sites in the Carmel National Park, Israel, during 1994-1995. The diet was analyzed through collection of fecal material for microscopic examination and by determination of stomach contents. The bats showed a marked preference for fleshy fruit species, in particular fruits of the genus *Ficus* (five species). Ten of the prefered fruit species were cultivated or introduced plant species, while only two species were wild fruits. There was no evidence for insect or pollen remains. Leaf-eating was also revealed, mainly during winter, when the fruit-bat faces severe shortage in fruit availability and quality.

KOTEJA, P.

ENERGY BALANCE OF HIBERNATING BATS *Myotis myotis*: A STUDY WITH A NEW TOBEC INSTRUMENT

P. Koteja[1] and B.W. Woloszyn[2]. [1]Jagiellonian University, Kraków, Poland, and [2]Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland.

The aim of the study was to evaluate the usefulness of a new instrument (ACAN-2) applying TOBEC (TOtal Body Electrical Conductivity) method for studying the dynamics of fat reserves in hibernating bats. The study was conducted in a semi-natural cave in southern Poland during the 1994/95 winter. Body mass (BM $\pm$ SD), body temperature and ACAN readings were taken on 13 December (N = 40, BM = 28.8 $\pm$ 2.5 g), 21 February (N = 39, BM = 26.2$\pm$ 2.0 g) and 6 April (N = 35, BM = 24.2 $\pm$ 1.7 g). Lean body mass was almost constant during the hibernation; the observed decrease in body mass was mainly due to the depletion of fat. Average energy expenditure calculated from changes in the fat content of individuals was 1.3 $\pm$ 0.5 kJ/d during the first part of hibernation and 1.6 $\pm$ 0.8 kJ/d during the second part. The estimate based on the population average body composition for the first part of hibernation was the same (1.3 kJ/d). In April fat content was lower in individuals measured for the first time than in those observed previously. Consequently, the estimate for the late hibernation (2.1 kJ/d) was higher than that based on data for individuals. This indicates some changes in population composition during the hibernation; calculations based on population samples can be biased. The estimated fat use during the entire hibernation (5 months) was 6 $\pm$ 2 g (230 $\pm$ 80 kJ). The results obtained with ACAN are consistent with the estimates of metabolic rates and fat balance obtained with direct methods. Because the measurement is non-invasive, fast and inexpensive it is possible to follow individual changes of fat reserves and energy expenditures in many individuals. Thus, it appears that the method provides a powerful tool for studying energetics of bat hibernation.

KOVALYOVA, I.M.

BAT FLIGHT AND GAS EXCHANGE.

I.M. Kovalyova, Schmalhausen Institute of Zoology, Ukraine Academy of Sciences, Kiev, Ukraine.

I conducted a comparative morphological study of the chiropteran respiratory system, including an analysis of previously published work. From our analysis, we conclude that the pulmonary characteristics of bats (lung volume, micro-alveolar structure, and permeability) are unable to ensure adequate gas exchange during powered flight. We found that the transcutaneous carbon dioxide exchange in the chiropteran wing is 10 times greater than the transcutaneous gas exchange reported for other mammals. Transcutaneous gas exchange in bats is facilitated by large nasoturbinal surfaces and extensive vascularization of the buccal membranes. In addition to the pulmonary exchange during flight, respiration in bats is enhanced by active transcutaneous respiration. The dual functions of bat-wing membranes (flight and gas exchange) appear to be important preadaptations for the evolution of aerial locomotion.

KOZHURINA, E.I.

EARLY POSTNATAL DEVELOPMENT AND GROWTH IN MICROCHIROPTERAN BATS.

E.I. Kozhurina. Severtsov Institute of Ecology and Evolution, Moscow, Russia.

Observations on age changes in general appearance of pups, their behavior, vocalizations and interactions with mothers and other members of a nursery group in captive *Nyctalus leisleri, N. noctula, N. lasiopterus, Vespertilio murinus*, as well as the data on some other microchiropteran species available in literature, suggest that altricial bats go through four developmental periods from birth to fledging. Each period is characterized by a specific way of interaction of a pup with its environment. By the beginning of each period a pup gains a new fundamental capacity (to withstand a force of gravity, effectively maintain a high body temperature, explore space inside and near the shelter, and, finally, fly). Ear-opening (usually, but not always, parallel to eye-opening), emergence of hiding behavior, and the first display of fright constitute the main phenomena that occur during transition from the first period to the second, from the second to the third, and from the third to the fourth, respectively. Transitional stages also can be distinguished using morphological criteria, largely from the skin and pelage features. The rate of growth is markedly reduced in altricial bats by the end of the second period.

KOZHURINA, E.I.

ONCE MORE ABOUT THE EARLY STAGES OF THE EVOLUTION OF BATS.

E.I. Kozhurina. Severtsov Institute of Ecology and Evolution, Moscow, Russia.

It is proposed that the earliest acquisition of flight in bat ancestors was automation of suspension upside down on a tree trunk. Such a posture enabled proto-bats to hang for along time with little, if any, expenditure of energy and to control the situation underneath. An non-adaptive aspect of that specialization consisted in the weakening of hind-limbs and loss of a pushing function. This inherent contradiction, however, gave an impetus to the development and strengthening of the fore-limbs, thus generating the main forces in upward climbing. Spreading of the manus to increase the area of its adherence to a vertical surface resulted in opposition of the thumb to other fingers and the formation of two functional parts of the hand: the anchoring (the thumb) and dragging (2nd to 5th fingers) digits. The latter was turned aside and secured the hand from sliding downward as the thumb was released or when the animal descended headfirst. In case of need, this part could be folded backwards to the forearm. Development of webbing between fingers and, later, between the 5th finger and elbow provided consolidation of this functional unity and facilitation of the folding. In order to move from tree to tree, the only maneuver that remained for proto-bats was to leap by pushing off by their partially extended webbed hands. Primitive gliding was possible at this stage. The further transformation of a forelimb into a true wing involved lengthening of the hand wing and forearm, knitting of primary membranes with an axillary fold of skin, and expansion of the patagium towards and then along the legs.

KÖSSL, M.

OTOACOUSTIC EMISSIONS AS A TOOL TO COMPARE HEARING SENSITIVITY AMONG BATS.

M. Kössl and M. Faulstich. Universität München, München, Germany.

In the inner ear of mammals the incoming sound is actively amplified by mechanical feedback mechanisms. This nonlinear amplification produces spectral distortions that can be used to assess hearing sensitivity non-invasively. By stimulating the ear with two pure tones (f1, f2) and measuring the acoustic 2f1-f2 distortion with a microphone at the ear drum, we constructed relative audiograms for three FM-bat species *(Carollia perspicillata, Megaderma lyra, Tadarida brasiliensis)* and two CF-FM bats *(Rhinolophus rouxi, Pteronotus parnellii.* The audiograms of the FM bats are sensitive to a broad frequency range between 15-100 kHz. They resemble those of basal mammals like marsupials *(Monodelphis domestica)* but are slightly extended towards higher frequencies. In

contrast, the audiograms of CF-FM bats show pronounced threshold variations. At the dominant CF-frequencies of their echolocation call, hearing sensitivity is poor and there are threshold maxima. A few hundred Hz above the CF frequencies of the call, where the frequencies of the Doppler-shifted CF-echoes are found, sensitivity is low with sharp threshold minima. Supported by the DFG, SFB 204 'Gehör'.

KRUSIC, R.A.

ECHOLOCATION CALLS OF BATS IN THE WHITE MOUNTAIN NATIONAL FOREST: SPECIES IDENTIFICATION USING MULTIVARIATE ANALYSIS.

R.A. Krusic[1], C.D. Neefus[1], M. Yamasaki[2], and P.J. Pekins[1].
[1]University of New Hampshire, New Hamphire, and [2]Northeastern Forest Experiment Station, New Hampshire

Identification of bat species using broadband echolocation recordings has traditionally relied on visual interpretation of individual call patterns rather than on a composite, and objective, interpretation of the entire pass. A pass is the resolution of identification necessary for inventory and monitoring studies appropriate to management and conservation activities. We used Anabat II detectors and our own computer software to record search-phase passes from bats captured and released in a variety of habitats. Six parameters were used to describe echolocation structure: call duration, characteristic frequency (i.e. frequency of minimum slope), maximum frequency, minimum frequency, average frequency, and time between calls. 4,337 calls were analyzed via multivariate discriminant analysis. Individual calls were identified for five of the nine species *(Lasiurus borealis, L. cinereus, Lasionycteris noctivagans, Eptesicus fuscus, and Pipistrellus subflavus)* with accuracies ranging from 89% to 100%. Calls from four myotids were classified to genus with 98% accuracy. Specific identification of *Myotis* ranged from 30% *(M. leibii)* to 70% *(M. septentrionalis)*. Composite analysis of the entire pass correctly classified the five non-myotids with 100% accuracy. Myotid passes were identified to genus with 97% accuracy, pass classification ranging from 42% *(M. leibii)* to 85% *(M. septentrionalis)*. We present a visual key to echolocation signatures of the nine bat species in the northeastern USA and statistically describe their search-phase echolocation passes.

KULKARNI, M.N.

ULTRASTRUCTURE OF THE CORPUS LUTEUM OF *Rousettus leschenaulti* AT THE TIME OF PREGNANCY AND DURING REGRESSION.

M.N. Kulkarni, S.M. Sawant, and D.A. Bhiwgade. Institute of Science, Bombay, India.

Rousettus leschenaulti is of special interest because it exhibits a post-partum pregnancy and an unusual persistence of the corpus luteum throughout the year. This report describes the fine structure of the luteal cells during the pregnancy, lactation and the anoestrous periods. During the full-term pregnancy the luteal cells contain abundant cisternae of smooth endoplasmic reticulum (ER), many mitochondria, and some lipid droplets. During lactation phase the rough ER occurs as small stretches anastomosing with smooth ER, generally dispersed in the cell. A well developed Golgi complex consists of a series of cisternae, a pronounced dilated face and numerous peripherally located vesicles. Numerous large membrane bound granules are present, especially at the margins of the cells. Honeycomb-like smooth ER is abundant in other regions of these cells. Autophagy plays an important role in the regression of the luteal cells in the corpus luteum. Regressing cells also contain increased number of both dense bodies (lysosomes) and lipid droplets. Advanced regression of the luteal cells is characterized by multiple fusion of lipid droplets and decrease in the amount of smooth ER.

KUZMIN, I.V.

BAT RABIES IN THE FORMER SOVIET UNION UNTIL 1994.

I.V. Kuzmin[1] and A.D. Botvinkin[2]. [1]Institute for Natural Foci Infections, Omsk, Russia, and [2]Antiplaque Research Institute, Irkutsk, Russia.

Until 1994 year 2,535 bats exemplars were examined on rabies at the territory of the FSU, 13 strains of rabies and rabies-related viruses were isolated in Siberia (3), Uzbekistan (6), Kyrghyzstan (1) and European part of the country (3). Information reported from Uzbekistan appears to be incorrect due to the inadequate detection methods. Other data are acceptable. Two cases of fatal human diseases following reported bat bites were registered in Ukraine (1977) and European part of Russia (1985). An antigenic structure of six strains from bats and one strain from humans were studied using antinucleocapsid monoclonal antibodies. Strains originating in Vespertilio *murinus* and *Nyctalus noctula* from Ukraine and human strain were identified as rabies-related European Bat Lyssavirus 1 (serotype 4) and Russian point of isolation (near 37°E.) currently is the eastern-most locality. Strains origin of *Vespertilio murinus, Myotis daubentoni* and *Eptesicus nilssoni* from Siberia belong to rabies (serotype 1) and have no differences

with a strains circulating among "terrestrial" animals in Palaearctic. Single strain Aravan isolated from *Myotis blythi* in Kyrghyzstan was interesting. It was quite different from all known lyssaviruses serotypes having a distant similarity with European Bat Lyssaviruses 1 and 2. Thus, in spite of the comparable low percentage of naturally infected bats and an absence of evidence for an epizootic process, we observed a significant diversity of bat lyssaviruses.

LANCASTER, W.C.

WING TEMPERATURE IN FLYING BATS MEASURED BY INFRARED THERMOGRAPHY.

W.C. Lancaster, S.C. Thomson, J.R. Speakman. University of Aberdeen, Aberdeen, Scotland, UK.

Many animals regulate the flow of blood through their extremities to manage heat exchange with the environment. Previous considerations of the thermoregulatory function of bats' wings relied on static measurements on restrained and artificially heat-stressed animals. We collected data on the wing temperature of flying bats to assess the function of wings in thermoregulation. We used a Thermovision 880 infrared imaging system (Agema Infrared Systems), consisting of an infrared sensitive video scanner operated by a dedicated control system. The resolution of the system was 0.1°C. Three *Rousettus aegyptiacus* were trained to fly in a 12 m length of corridor. We captured images as the bat flew past the thermograph. Body temperature was measured before the first fight and immediately following each flight sequence using a thermister probe inserted approximately 1 cm into the rectum. Flight time was measured by the time mark recorded with each image; recording sessions averaged 28 min. Wing temperature was recorded as the temperature of each pixel along a profile from near the elbow to the trailing edge. Temperatures across the wing ranged from an average 34° C near the forearm muscle mass to less than 24° C at the trailing edge (mean ambient temperature 23° C). From the forearm, temperature declined sharply; the majority of the wing was 1-2° C above ambient, and the trailing edge of the wing was seldom more than 0.5° C above ambient. Average membrane temperature was compared between flights and animals by averaging the values along each profile. To eliminate the effect of the warm forearm muscles, we excluded the first 8 % of data points; the last 5 % were dropped because of ambiguities in the position of the trailing edge. We found small, but significant changes in average membrane temperature during flight, ranging from 0.7° to 3.3° C above ambient. Body temperature consistently increased over the first 500 seconds of recording and declined thereafter, but the relationship to wing temperature was ambiguous. More data is needed to clarify the relationship.

LANCASTER, W.C.

THE RESPIRATORY SYSTEM IN BATS: ADAPTATIONS FOR ECHOLOCATION.

W. C. Lancaster. University of Aberdeen, Aberdeen, Scotland, UK.

Many animals use the respiratory pump as an engine for vocalization, but few approach the extremes of sound production seen in echolocating bats. The demands of flight exert adaptive pressure on every component of the respiratory complex. Differences between bat species that use biological sonar, and those that do not, may be attributed to the requirements for echolocation, but the differences may be difficult to distinguish. Functions of the respiratory system for vocalization can be categorized as: 1) air containment, 2) control of volume and pressure, 3) modulation and 4) neuronal integration. Mass specific lung volume in bats exceeds that of birds and non-flying animals; differences between bats and other mammals are greater at smaller body size. Muscles of inspiration and expiration regulate the volume and pressure of air in the lungs and generate the force that powers vocalization. Expiratory muscles of bats generate high subglottic pressures for echolocation and have adaptations to enhance the speed of contraction. Relaxation of the muscle and restoration of pressure appear to limit the rate of vocal repetition. The unique abdominal wall structure may facilitate a rapid recovery. A thick muscular valve in the larynx of echolocating bats assists in the regulation of pulmonary pressure and must bear pressures exceeding 40 cm H_2O The delicate, amuscular vocal membrane, set into tension by the cricothyroid muscles is a major structural control of frequency. Tetany ensues in the cricothyroid at about 200 Hz under continuous stimulation. The speed of contraction of the cricothyroid is not, therefore, considered to be the limiting factor for vocal repetition rate. Upper airway passages modulate the fundamental frequency into the species-specific harmonic call signatures. Coordination of vocalization with wing beat increases the efficiency of the system by coupling sound production to the rhythmic pressurization of the thorax in flight. Constraints of respiratory physiology may limit parameters of echolocation that govern fundamental aspects of life history.

LIM, B.K.

PHYLOGENY OF NEOTROPICAL SHORT-TAILED FRUIT BATS *(Carollia)*: PHYLOGENETIC ANALYSIS OF RESTRICTION SITE VARIATION IN MITOCHONDRIAL DNA.

B.K. Lim[1,2] and M.D. Engstrom[1].
[1]Royal Ontario Museum, Toronto, Ontario, Canada, and [2]York University, North York, Ontario, Canada.

Ecologically and behaviorally, short-tailed fruit bats (*Carollia*) are some of the best known Neotropical bats. However, their systematics are poorly understood, particularly in South America. Previous comparative studies on morphology and chromosomes have not produced an explicit hypotheses on evolutionary relationships. To supplement these studies, we analyzed restriction site variation within 2,400 bp sequence of the ND3, ND4L, and ND4 mitochondrial DNA gene region using a phylogenetic approach to reconstruct the phylogeny of *Carollia* . Species boundaries, previously confused by geographic size variation, were substantiated and indicated that only *Carollia brevicauda* and *Carollia perspicillata* are present in Guyana. Phylogenetically, the widely dispersed geographic samples of all four species were monophyletic under Dollo parsimony. *Carollia perspicillata* and *Carollia subrufa* formed a sister group relationship and *Carollia brevicauda* was the sister taxon to this clade. Within *Carollia brevicauda*, there were two separate lineages corresponding to populations from Western Panamá to Central America, and another from Central Panamá into South America. The relationship of *Carollia castanea* to the other species of *Carollia* and two outgroup taxa (*Rhinophylla* and *Artibeus*) was unresolved, although morphologically and karyologically, *Carollia castanea* shares several derived characteristics with the other species of *Carollia* . The last remaining outgroup taxon (*Glossophaga*) appeared as a basal lineage at the root of the tree.

LIMPENS, H.J.G.A.

A BAT SURVEY IN NIEDERSACHSEN (GERMANY): ORIGINAL CONCEPT AND FIRST RESULTS OF A SYSTEMATIC BAT SURVEY.

H.J.G.A. Limpens, A. Roschen, and M. Nagel. NABU- Niedersachsen, Bremervorde, Germany.

In order to include accurate details of the bat fauna into plans on a regional or national scale which deal with conservation or landscape issues, a detailed survey of bat distribution and status in Niedersachsen (Germany) has been organized. Species distribution is being surveyed on the simple basis of the occurrence of species in defined grid blocks. Because bats are difficult to observe and identify in the field, existing records at present do not effectively represent their true distribution. A systematic survey, on which more reliable distribution maps could be based, requires that each grid block be surveyed with the same *survey intensity*. To cope with different *detection probabilities* for different species, the survey will combine all available survey methods (netting, detectors, bat boxes, visual inspection of potential roost, etc.). Therefore a survey on this scale requires a large number of well-trained, properly coordinated and equipped observers to undertake such a study. To this end, although well aware of the practical problems and limitations of such a survey, we have embarked upon a scheme to organize a nationwide, systematic bat survey in Niedersachsen. The scheme relies upon regional bat groups for the recruitment of observers, and for the general organization and coordination of the survey work within their region. For each survey method, a national working group will oversee the development of training for and implementation of surveys using their particular technique, overseen by a central coordinating body consisting of representatives of all participating groups. The project group of the Naturschutzbund Deutschland (NABU), who initiated the project will oversee the survey work that utilizes bat detectors.

LINA, P.H.C.

THE OCCURRENCE OF BAT RABIES IN THE NETHERLANDS.

P.H.C. Lina. National Reference Centre for Nature Management, Wageningen, The Netherlands.

The first evidence of the presence of bat rabies in The Netherlands was found in 1987. Since then, 2,919 bats collected from 1984 to 1994 and belonging to 11 species have been examined to rabies. Rabies was found in 199 serotines *Eptesicus serotinus* and in five pond bats *Myotis dasycneme*. Approximately 20% of the serotines were diagnosed rabies positive. The majority of the infected animals was found north of the rivers Rhine and Neuse. 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 population of the serotine and scarce or probably absent in other species. The serotine is mainly a building-dwelling species. However, there is no evidence that rabies in this species is a risk for public health.

LONG, E.

SOME ASPECTS OF THE FEEDING AND ROOSTING ECOLOGY OF *Pteropus rufus* IN NORTH EAST MADAGASCAR.

E. Long, M. Wells, and P.A. Racey. University of Aberdeen, Aberdeen, Scotland, UK.

Analysis of feces collected from a diurnal roost site revealed that *P. rufus* was feeding on fruits of *Ficus*, Solanaceae, Piperaceae and Cactaceae as well as numerous cultivated species (such as lychees, tamarinds, papaya and guava). Leaf material from a number of unidentified species and pollen from Sarcolaenaceae, Sapotaceae, Sterculiaceae, Myrtaceae, Gentianaceae and one unidentified species were also ingested. Germination of seeds extracted from faeces indicated that *P. rufus* is an effective seed disperser, although successful germination of ingested seeds is apparently limited by seed size and thickness of seed coat. Ambient light intensity was the most important environmental parameter affecting the distribution of the behaviors studied at the roost and hyperthermia appeared to be an important constraint on the distribution of flight and mating activity, since both occurred at lower temperatures. Techniques of population estimation were compared and gave widely different results.

LONG, J.K. TIME-MINIMIZATION IN COMMON VAMPIRE BATS.

J.K. Long. York University, North York, Ontario, Canada.

The foraging behavior of common vampire bats was examined to test whether or not vampire bats are time minimizers, and to further clarify the role that moonlight plays in constraining foraging behavior. Data on bat activity were collected by tracking radio-tagged individuals. Results show that vampire bats made between zero and three trips away from the roost per night; most bats made only one trip per night. Adult females averaged 112 minutes away from the roost each night. Coefficients of variation suggest that some bats show greater variability in terms of day-to-day activity patterns. The data do not support the hypothesis that vampire bats are strict time-minimizers, but these bats seem to minimize the amount of time they are away from the roost with respect to the amount of time available for foraging. Multiple regression analysis using both periods of darkness and phase of the moon as independent variables shows a trend for bats to spend increased time away from the roost as the period of darkness becomes longer, but time away is never maximized. The possibilities of fine tuning the regression model by adding further constraints and using the regression technique as a predictive tool are addressed.

LOPEZ-AREVALO, H.F.

CAVE-DWELLING BATS OF RIO CLARO--COCORNA AREA, ANTIOQUIA, COLOMBIA.

H.F. López-Arévalo[1], Y. Muñoz-Saba[2], A. Cadena[3], and D.A.Salas-Dueñas[1].
[1]Fundación Natura, Santafé de Bogotá, Colombia,
[2]Universidad Pontificia Javeriana, Santafé de Bogotá, and [3]Santafé de Bogotá, Colombia.

A scientific survey on karst systems in the Rio Claro--Cocorná, Central mountain range of Colombia, provided information about 32 bat species as follows: Phylostomitidae: six subfamilies, 15 genera and 25 species: Emballonuridae and Vespertilionidae: three genera and three species; and Molossidae: one species. Of the 32 bat species recorded in this survey, there was five new records for the department of Antioquia (*Anoura geoffroyi,Artibeus amplus*, *Chiroderma trininaturm*, *Mimon crenulatum*, *and Eptesicus diminutus*). The former is a new record for Colombia. The presence of *Rhynochonycheris naso* and *Noctilio albiventris* suggests a taxonomic displacement rather than a functional one. The trophic categories identified in this community include aerial insectivorous (seven species), foliage insectivorous (four species), nectarivorous-pollenivorous (three species), sedentary frugivorous (five species), nomadic frugivous (eleven species), and hematophagous (one species). The study also revealed a pattern of cave habitat use for 12 species (about 40% of the species registered). The number of species per cave ranged between one and six. In addition, this study helped determine the importance, vulnerability, and threat indexes for each of the karstic formations studied. We conclude that both the forest cover and caves proper to the karst topography account for the maintenance of the bat fauna, and not the caves alone.

LUMSDEN, L.F.

ROOST SITE SELECTION OF TWO SPECIES OF VESPERTILIONIDS IN A FRAGMENTED RURAL LANDSCAPE IN SOUTHERN AUSTRALIA.

L.F. Lumsden and A.F. Bennett. Department of Conservation and Natural Resources, Melbourne, Australia.

Roost sites are a key resource for bats, and the availability of roosts in remnant woodlands may be an important constraint on the ability of species to persist in rural landscapes. As part of a study of the conservation of bats in remnant vegetation, two species of vespertilionids were radio-tracked to determine their roost requirements. The study area was primarily farmland with small areas of remnant native vegetation, adjacent to an extensive floodplain woodland. In total, 45 individuals of the Lesser Long-eared Bat *Nyctophilus geoffroyi* were radio-tracked,

resulting in the location of 139 roosts; and from 27 individuals of the Gould's Wattled Bat *Chalinolobus gouldii*, 91 roosts were located. Selection of roosts occurred at four spatial scales, and both intra- and inter-specific differences were apparent. 1) Type of roost: The two species selected different types of roosts and sizes of roost entrance. *C. gouldii* typically roosted in dead spouts in live trees, while *N. geoffroyi* used sites under bark in addition to fissures, hollows and spouts. Almost all maternity roosts of *N. geoffroyi* were in fissures in dead trees. 2) Tree characteristics: *N. geoffroyi* roosted disproportionately in dead trees, while *C. gouldii* generally roosted in large live trees. Maternity sites of *N. geoffroyi* were in larger trees than those used by males and non-lactating females. 3) Roost area: Both species shifted roosts regularly within a defined area. Roost areas had a higher density of large trees than the surrounding woodland. 4) Position in the landscape: Although all bats were trapped while foraging in remnant vegetation in farmland, all roosts of *C. gouldii* and all *N. geoffroyi* maternity roosts were in the extensive woodland area, a distance of 6-12 km. Most male *N. geoffroyi* roosted in farmland, 1-2 km from their foraging areas. These results show roost site selection is complex. Implications for management of remnant woodlands and the long-term conservation of bats in rural landscapes are discussed.

MACK, I.

BAT POLLINATION OF THE HERB *Irlbachia alata* BY GLOSSOPHAGINE BATS IN COSTA RICA.

I. Mack, F.G. Matt, and O.v. Helversen. University of Erlangen-Nürnberg, Erlangen, Germany.

The neotropical herb *Irlbachia alata* is highly variable in flower design. In Costa Rica two different forms of the corolla can be found: bell-shaped and narrow tube-shaped. The tube-like form seems to be designed for the pollination by insects. Its rate of nectar production and sugar concentration, in contrast to the bell-shaped form, are too low to be attractive for bats. During field studies three species of glossophagine bats were observed carrying pollen of *Irlbachia alata* on their fur. Experiments in a flight cage revealed species-specific differences in the ability to hover in front of the flower and its method of exploitation. *Hylonycteris* is a highly maneuverable flier, which during its short visits only touches the flower with the head. After the visit the flower remains intact. In contrast, *Glossophaga commissarisi* and *Glosssophaga soricina* when confronted with the plant in the flight cage appeared to need more time for exploiting the nectar. They hung on the plant, imbibed the nectar and afterwards climbed up the inflorescence and also licked the nectar from the calyces of the buds. After a few such visits the flower was nearly destroyed by the claws of the bats. These experiments indicate that both *Glossophaga* and *Hylonycteris* are able to pollinate *Irlbachia alata*. However *Hylonycteris is* better adapted to pollinate such fragile plants and should therefore, from the plant's point of view, be the preferred pollinator.

MAHALEY, J.

THE CHORIOALLANTOIC PLACENTAL BARRIER IN THE INDIAN VESPERTILIONIDAE BAT, *Tylonycterus pachypus*.

J. Mahaley, A.P. Manekar, C. Panse, D.A. Bhiwgade. Institute of Science, Bombay, India.

The present investigation of the placenta of the Indian vespertilionid bat, *Tylonycterus pachypus*, at an electron microscopic level through the developmental stages, has revealed that at the early stages of gestation there is the distinct presence of a maternal endothelium along with a compactly packed cytotrophoblastic layer that seems to be the sole contributor to the trophoblastic layers of the interhemal barrier. The cytotrophoblast layer at this stage of gestation bears extensively-vesiculated rough endoplasmic reticulum and well-developed Golgi complexes in fair numbers. However the term placenta of the same reveals the absence of the maternal endothelium and the incorporation of a discontinuous intrasyncytial lamina in the syncytiotrophoblast. The syncytiotrophoblast bears a spongy appearance due to the presence of extensively modified vesiculated endoplasmic reticulum, while the cytotrophoblastic basal lamina displays extensive podocytic specialization, with some possessing desmosomal connections while maintaining a distinct continuity across the limits of both these layers. Glycogen rosettes at the peripheral limits of the two trophoblastic layer are commonly seen. At places the layers are reduced to thin "phalanges" bringing the maternal blood space and fetal capillary closer by reducing the diffusion distance. The definitive chorioallantoic placenta is hemodichorial as both the trophoblastic layers persist to term.

MANN, C.S.

REPRODUCTIVE ACTIVITY OF THE COMMON VAMPIRE IN FRENCH GUIANA.

C.S. Mann[1] and S. Aulagnier [2].
[1]I.R.G.M., Castanet-Tolosan, France, and [2]Université Paul Sabatier, Toulouse, France.

The reproductive activity of the common vampire, *Desmodus rotundus*, was studied in the north of French Guiana in order to determine: 1) if the females, considered to be aseasonally polyestrous, exhibited some synchronized pregnancy, and 2) if the males were sexually active throughout the year, as it was observed in other parts of the species range. Vampire bats have been sampled by mistnetting around several stables for nearly four

years. Pregnancy of the females was evaluated by palpation, then proved by sacrificing some of them. Sexual activity of the males was inferred from the testes size (six classes from "invisible" to "hugely developed"). After dissection testes were weighted, the amount of spermatozoa was gauged from fixed sections. Firstly, our results revealed a strong relation between the observed size of the testes and the presence of spermatozoa; moreover, all the testes heavier than 40 mg contained spermatozoa. Secondly, more than 45% of males were sexually active at any time of year, with a maximum of 80% in August, that is about seven months (average length of the pregnancy) before the highest incidence of the pregnant females (70%). However a significant ratio of pregnant females (20 to 40%) was observed throughout the year. Contrary to previous studies, no evident relation between this reproductive pattern and the seasonal climatic cycle has been found yet.

MANTRI, U.

FINE STRUCTURAL OBSERVATIONS OF ANTERIOR PITUITARY CELLS OF THE FLAT- HEADED BAT *Tylonycteris pachypus*.

U. Mantri[1] , D.A. Bhiwgade[1] and A. Madhavan[2];
[1]Institute of Science, Bombay, India, and [2]Kailath Trichur, Kerala, India.

The present investigation was undertaken to record fine structural changes in the pituitary during the different physiological states in the flat-headed bat, *Tylonycteris pachypus*. Somatotrophs (GH cells) contain large, round electron dense secretory granules (Sg) and few mitochondria. The PRL cells consist of a large round to oval nucleus, two to three lamellar cisternae of RER, round electron-dense Sg of large and small sizes and a few mitochondria. This cell show changes during different stages of pregnancy. The RER shows Nebenkern during late pregnancy and the number of Sg in the PRL cell decreases in lactating females. The FSH gonadotrophs are elongate to irregular in shape with an eccentrically placed irregular nucleus and a moderate number of Sg and mitochondria. A Golgi area consists of small Golgi sacs and empty vesicles. The LH gonadotrophs show slight increases in granulation with forming granules in Golgi vesicles during early pregnancy and swollen mitochondria, short lamellar or vesicular cisternae of RER many mitochondria, and an increased number of lysosomes during late pregnancy. The ACTH cells of active animals display a triangular contour with a somewhat triangular nucleus, and small sized Sg align the cell membrane. The folliculo-stellate cells (FS cells) are devoid of Sg and have an irregular nucleus, very few mitochondria and sometime form a extravascular channel with adjacent cell indicating active transport.

MARINHO-FILHO, J.

SEED DISPERSAL OF STRANGLING FIG TREES BY BATS AT THE PANTANAL REGION, SOUTHWESTERN BRAZIL.

J. Marinho-Filho. Universidade de Brasília, Brasília, Brazil.

Fruigivores have been considered as more opportunistic and generalist than nectarivorous organisms and, consequently, seed dispersal has been regarded as a considerably more relaxed relationship than pollination. I studied the distribution of individuals, fruit consumption and seed dispersal of three species of strangling fig trees, *Ficus brodwayi* Urban, *F. pertusa* L.f. and *F. obhlsifolia* HBK, at eight sites in Poconé and Chapada dos Guimaraes, in the Pantanal region, southwestern Brazil. I censused all individuals of strangling fig trees, recording the species, age or development class, host plant and location of establishment on the host plant. I also made diurnal and nocturnal observations and captures with mist nets in front of fruiting trees to identify the species of frugivores, recording visitation frequency, feeding behavior, number of fruits eaten, the time spent on each visitation and, whenever possible, where they defecated the seeds. As hemiepiphytes, the fig trees never germinated on the ground and they only could be found germinating and growing on palm trees. Fruiting fig trees attracted 26 species of birds and mammals. Birds and bats were the most important visitors but, considering the criteria in the literature, bats of the genus *Artibeus* provided the best quality of seed dispersal services. They are abundant, the bulk of their diets in the region is constituted by figs and, after catching a fig, they systematically flew to a palm tree where, hanging on a leaf axis, they ate the fruit, frequently defecating seeds on the palm trunk, the only place they can germinate and develop. It seems that even fig trees--frugivores systems, that would be considered non-specialized at first glance, could reveal fine adjustments when closer and deeper observations are made on the final density of the seeds.

MARINHO-FILHO, J.

BRAZILIAN BATS AND CONSERVATION BIOLOGY: A CASE FOR SOUTH AMERICA.

J. Marinho-Filho[1] and I. Sazima[2]. [1]Universidade de Brasília, Brasília, Brazil,
and [2]Universidade Estadual de Campinas, Campianas, Brazil.

The diverse and rich Brasilian bat fauna comprises 133 (70%) of the 190 bat species recorded for South America. Bat species in Brazil are distributed over five major biomes, mainly forested areas. Species richness decreases from forested to open formations. Even in the open formations, gallery forests and forest patches seem to

play a crucial role in the maintenance of bat populations. Basic natural hostory is lacking for most if not all species, but most studies in Brazil have concentrated on a few and widespread species of phyllostomids. Studies on plant-bat interactions, reproductive cycles, and activity patterns predominate. Community studies are recent and punctual, but cover the major biomes. Direct threats to bat populations due to roost disturbance or pest-species management is less important in Brazil than habitat disturbance and fragmentation. On the other hand, urbanization may favor certain insectivorous and generalist frugivores. We suspect that the trends we indicate for the Brazilian fauna, and its conservation may extend to most of tropical and subtropical South America.

MARTINO, A.M.

DIET COMPOSITION IN *Leptonycteris curasoae* (PHYLLOSTOMIDAE, GLOSSOPHAGINAE): INFLUENCE OF SEX AND REPRODUCTIVE CONDITION.

A. Martino, A. Arends, and J. Aranguren. Centro de Investigaciones en Ecologia y Zonas Aridas, Universidad Nacional Experimental Francisco de Miranda, Edo. Falcón, Venezuela.

A study of diet composition in *L. curasoae* was made in Northern Venezuela during 1992 at Piedra Honda cave (Paraguaná Peninsula). Pollen from the fur, and feces released into the collecting bag were sampled for each animal. There were not significant differences in the frequency of occurrence between pollen collected from the fur and those observed in the feces. Pollen-diet composition showed highly significant differences along the year between but not between the sexes. Cactaceae was the most frequent pollen registered on the diet, followed by Bombacaceae and Agavaceae. Over the year there was no significant differences between sexes in the frequency of occurrence of seeds and pollen in the feces, but when the analysis is restricted to the period April-June, corresponding to late pregnancy and lactation, there were highly significant differences between sexes and between female-reproductive conditions. These results seem to indicate that breeding females, especially during the lactation period, ingest more fruits to supply their nutritional and energetic requirements. The differences in pollen frequency observed in the diet throughout the year seem related to the flowering pattern of the families involved. This work was partially granted by FUNDACITE Centro-Occidente, F1-07-09-90.

MASTERS, W.M.

EFFECT OF CHANGES IN ECHO PARAMETERS ON THE RANGE RESOLUTION OF *Eptesicus fuscus*.

W.M. Masters and K.A.S. Raver. Ohio State University, Columbus, Ohio, USA.

Individual big brown bats *(Eptesicus fuscus)* appear to produce "personalized" sonar signals, i.e., the values of parameters describing an individual's typical call tend to differ from bat to bat. We determined the average parameters for an individual bat's emissions and used them to make a "model" (a "typical" sonar signal for that bat). A bat can determine the distance (range) to a simulated target created by playing back its model signal as an "echo" in response to the bat's sonar emissions. We have found that a bat's range discrimination ability is better for targets simulated using its own model than for targets simulated using the model of another individual. To determine which signal parameters are most important to a bat for ranging (a sensitivity analysis) we made a small change (usually $\pm$ 3 dB) in a single parameter of a bat's model echo and then tested whether the bat found it more difficult to range-discriminate the altered than the unaltered model. We tested changes in duration, curvature of the frequency sweep, ratio of second to first harmonic amplitude, ratio of third to first harmonic amplitude, phase of the second and third harmonics relative to the first harmonic (180° inversion), signal frequency (up or down shift by about 4%), and Doppler shift (Doppler factor = 1.1). For the two bats tested, the only alteration that produced a significant worsening of the bats' range discrimination was a change in the curvature of the frequency sweep: for a target at 80 cm, threshold changed from about 7 mm to about 25 mm. After extended practice with the altered model, the bats eventually achieved their former threshold (7 mm). These studies suggest that curvature of the signal, that is, its specific time-frequency course, is important to *Eptesicus* in echo processing, and that, given practice, a bat can modify its processing machinery to accommodate a changed signal.

MATT, F.G.

ACOUSTIC TRACKING OF BATS' FLIGHT PATH: A NEW METHOD FOR INVESTIGATING ECHOLOCATION AND FLIGHT BEHAVIOR OF HUNTING BATS IN THE FIELD.

F.G. Matt[1], R. Aubauer[2], O. v. Helversen[1]. [1]University of Erlangen-Nürnberg, Erlangen, Germany, and [2]TU-Darmstadt, Institute of Telecommunication and Electroacoustic, Darmstadt, Germany.

In a joint project of the University of Erlangen and TH-Darmstadt, a new technique was developed for tracking flight paths of bats in the field. The technique is based on calculating the time delay of echolocation calls between eight different microphones. Our new method allows us to correlate flight and echolocation behavior with respect to the proximal and more distant environment. Presently, 75 flightpaths of five bat species at six different field locations have been analyzed. The flight paths of the noctule bat *(Nyctalus noctula)* could be reconstructed up

to a distance of 50 meters from the recording microphones, those of the pipistrelle *(Pipistrellus pipistrellus)* and Savi's pipistrelle *(Hypsugo savii)* up to 20 meters, and those of the smaller *Myotis* species up to 15 meters. Preliminary results show that these sympatrically living species are hunting in different parts of the shared habitat.

MATTERN, M.

THE ONTOGENETIC DEVELOPMENT OF SOCIAL CALLS IN THE COMMON VAMPIRE BAT, *Desmodus rotundus*.

M. Mattern and U. Schmidt. University of Bonn, Bonn, Germany.

The social calls of seven vampire bats (*Desmodus rotundus*) were recorded in weekly intervals from birth to the age of five months. During this period the young ones emitted two types of calls: 1) isolation calls and 2) twitters. The isolation calls are composed of one to seven elements. A detailed analysis of the acoustical parameters showed that they have a clear individual signature in frequency and time structure. The frequency-time-pattern changes very gradually during the ontogenetic development. The twitter consists of up to 13 short, frequency-modulated elements, and was first recorded in the second month of life. There are neither interindividual differences concerning this call, nor developmental changes over the time.

MAYER, F.

MULTIPLE PATERNITY AND SPERM COMPETITION IN THE NOCTULE BAT (*Nyctalus noctula*) REVEALED BY DNA FINGERPRINTING.

F. Mayer. Universiity of Erlangen-Nürnberg, Erlangen, Germany.

Mammalian sperm in general has a short longevity of only a few days after copulation. In contrast, storage of live sperm in the female reproductive tract is common among hibernating bats. This could lead to a long mating period and hence an increased possibility for multiple matings with different males. Therefore, sperm competition is assumed to play a more important role in bats than it does in other mammals. In the noctule bat sperm storage of at least six months was shown. Mating starts in August and ovulation occurs eight months later in March after hibernation. Several different mating strategies were observed and females are expected to mate with more than one male which should result in multiple paternity. In contrast to most hibernating bat species, the noctule gives birth to two offspring each year (instead of one) which allows one to test whether multiple paternity occurs in this species. The relatedness among twins was determined using DNA fingerprinting. During the last few years genetic fingerprinting has been widely used in paternity testing. In most cases it was applied to exclude the paternity of putative fathers. In this study fathers are not known. Multilocus DNA fingerprinting using simple sequence oligonucleotides as well as single locus PCR amplified DNA fingerprinting created highly variable genetic fingerprints which can be used to distinguish between full and half sibs. I report the first evidence of multiple paternity in bats, a phenomenon that appears to be common in the noctule bat. Several cases of full sibs and one case of monozygotic twins showed that the two offspring can also share the same father. Mechanisms of sperm competition in the noctule bat will be discussed.

MAYER, F.

HIGHLY VARIABLE mtDNA CONTROL REGION IN THE FEMALE-PHILOPATRIC BAT *Nyctalus noctula*

F. Mayer. University of Erlangen-Nürnberg, Erlangen, Germany.

In most bat species females form maternity colonies where they give birth to their offspring and raise them without the assistance of males. In the noctule bat *(Nyctalus noctula)* up to 100 females are found within a single maternity roost. The recapture of individually marked bats showed that female noctules return to their natal colony and were never captured in neighboring colonies. Such philopatric behaviour of female noctules should result in social groups of related individuals which consist of one or only a few matrilineages. To test this hypotheses matrilineages were distinguished using mitochondrial DNA (mtDNA) which is maternally inherited. The non-coding control region of the mtDNA is known as the most variable region within the mitochondrial genome. In the noctule bat a segment of the control region close to the Pro-tRNA gene contained a repetitive sequence of 81 base pair (bp) units. A variable copy number (5-9) of repeat units resulted in length variations. Twenty-seven of 128 individuals (21 %) were heteroplasmatic for two or three length variants. Heteroplasmy was inherited from mother to offspring. This suggests the absence of a bottleneck in the germ line. The sequence of the first three repeat units in the 5' end of the L-strand was determined in 70 individuals of six colonies. A total of 36 different types of mtDNA were detected. A pairwise comparison of individuals within a colony resulted in 17 percent identical types of mtDNA whereas individuals from different colonies were identical in 0.5 percent of the cases. In contrast to the hypotheses, high levels of length and sequence variability were found. This suggests at least occasional gene flow between colonies and large sizes of maternity colony assemblages.

McCRACKEN, G.F.

GENETIC DIVERSITY AND GENE POOL CONSERVATION IN SEVERAL SPECIES OF *Pteropus*.

G.F. McCracken. University of Tennessee, Knoxville, Tennessee, USA.

Historical distributional and demographic features can strongly influence the levels of genetic variation carried in populations. A consequence is that genetic concerns for conservation may differ and be more important for some types of species than for others. Thirty-five of the 57 *Pteropus* species listed in the Action Plan for Old World Fruit Bats are island endemics with distributions limited to single islands or small island groups. Many of these species are in danger of extinction, and many may only be conserved through captive propagation. Irrespective of recent population declines, island endemics are expected to carry lower levels of genetic diversity than those of more widely distributed taxa. Information on genetic variation in microsatellite gene loci, random amplified polymorphic DNA, and allozymes are presented for several *Pteropus* species in an attempt to arrive at a mature perspective on the importance of gene pool conservation in this beleaguered taxon.

McLEAN, J.A.

ENERGETICS OF LACTATION IN CAPTIVE, FREE-FLYING BROWN LONG-EARED BATS *Plecotus auritus*.

J.A. McLean and J.R. Speakman, University of Aberdeen, Aberdeen, Scotland, UK.

For female bats, lactation represents a period of increased energy demands. We used doubly labeled water (DLW) measurements of daily energy expenditure (DEE), in combination with measures of food consumption, resting metabolic rate (RMR), and milk production to investigate the partitioning of energy during lactation in captive, free-flying brown long-eared bats (Plecotus auritus). The mean dry food consumption for lactating females (N = 4) was 2.05 g bat^{-1} day^{-1} (49.8 kJ) over day 1 to 40 of lactation, in comparison to 1.52 g bat^{-1} day^{-1} (37.6 kJ for non-reproductive females (N =24). There was an elevation of RMR during lactation. Milk intake of suckling young (N = 4), estimated by tritium dilution, was 2.53 to 2.64 ml day^{-1} (22.3-23.2 kJ) during mid-lactation. This was very similar to milk production in lactating females (N = 8 measures on 4 individuals), estimated by deuterium turnover. There was no significant difference in DLW measures of DEE for reproductive females during early-, mid-, or post-lactation. Total daily energy requirements (including milk export) during early and mid-lactation averaged 44.5 kJ bat^{-1} day^{-1}, compared to 23.6 kJ bat^{-1} day^{-1} for non-reproductive females. In contrast, there was no significant difference in DEE (excluding milk export) of lactating (21.3 kJ day^{-1}, N = 8 measures, individuals) and non-reproductive females (23.6 kJ day^{-1}, N = 15 measured ,4 individuals). For these levels of energy expenditure, we calculated that continuously euthermic , non-reproductive bats would have a flight time of 66 minutes and a capture rate of one moth every 3.4 minutes. To remain in energy balance, lactating females could only achieve a similar flight time by also using torpor.

MESCHEDE, A.

ECHOLOCATION CALLS OF NECTAR-FEEDING BATS (PHYLLOSTOMIDAE: GLOSSOPHAGINAE).

A. Meschede, K.-G. Heller, and O. v. Helversen. University of Erlangen-Nürnberg, Erlangen, Germany.

The echolocation behavior of nectar-feeding bats has been less intensely investigated compared to that of insectivorous bats. Therefore we recorded the echolocation calls of 10 different species of glossophagine bats during free flight and during approach towards a nectar source (all in a large flight cage). The species can be separated into two groups according to call type. Calls of the first group always included the lowest harmonic; this group contains *Glossophaga s. soricina, G. s. antillarum, G. commissarisii, Choeronycteris mexicana, Leptonycteris sanborni, Lichonycteris obscura* and *Hylonycteris underwoodi*. Species from the second group lack the lowest harmonic; this was the case for *Lonchophylla robusta, Monophyllus redmani* and *Anoura caudifer*. Both call types contain a varying number of harmonics, but the 1st and 2nd or 2nd and 3rd, respectively, are most prominent. When bats approach the nectar source the calls decline in duration, but a true final buzz was not observed. Instead, between two and five calls are packed into groups. During approach the highest frequency often exceeding 180 kHz does not change, but intensity decreases.

MICKLEBURGH, S.P.

THE OLD WORLD FRUIT BAT ACTION PLAN: FOLLOW UP PROJECTS.

S.P. Mickleburgh[1], A.M. Hutson[2], and Paul A. Racey[3].
[1]Fauna and Flora Preservation Society, London, UK, [2]The Bat Conservation Trust, London , UK, and [3]University of Aberdeen, Aberdeen, Scotland, UK.

The "Old World Fruit Bats: An Action Plan for their Conservation" was published in 1992 and was the culmination of six years of work involving over 50 of the world's bat experts. Amongst other things, the Plan listed priority projects for the conservation of threatened species. Following the Plan's publication there has been a greatly increased interest in fruit bat conservation, and over half of the 20 highest priority projects have been undertaken or planned. In the Indian Ocean, threatened endemic bats in the Comores (*Pteropus livingstonii*), the Maldives (*Pteropus giganteus ariel* and *P. hypomelanus maris*) and on Pemba (*Pteropus voeltzkowi*) have benefited from survey and educational projects and, in the case of Comores and Pemba species, successful captive-breeding programs. In the Philippines, a captive breeding center has been established to house some of the country's most threatened species. Surveys are planned to look at endangered *Nyctimene* and *Pteralopex* species in the Solomon Islands while in India, a country-wide survey has revealed that almost half of long-term monitored roosts of three species have declined in numbers. A two-year project has been established to look at the endangered *Pteropus mariannus* on Rota in the western Pacific. In the Pacific, an important new reserve has been established that will help further protect endangered *Pteropus mariannus* populations on Guam. Research into the role of bats as "keystone species" is to be undertaken in Sabah, Sumatra, the Philippines, Madagascar and Pemba. Legislation covering bats has been extended or improved: in India plans are being made to remove bats from the "vermin" category and place at least six species in protected schedules; CITES regulations now cover all trade in fruit bats in the Pacific, the last major trade route being closed following the emergence of Palau as an independent nation at the end of 1994; two species of *Acerodon* in the Philippines have been moved from CITES Appendix II to Appendix I.

MILLER, L.A.

HOW INSECTS DETECT AND AVOID BATS: THE TACTICS OF PREY AND PREDATOR.

L.A. Miller and A. Surlykke. Odense University, Odense, Denmark.

Insects conquered all terrestrial habitats at least 200 My before bats appeared in the Eocene, about 50 My years ago. In the period before bats were present, tympanate hearing organs and complex acoustical behaviors evolved independently in at least seven orders of insects. Anti-bat tactics are now known in members of four orders; Lepidoptera (moths), Orthoptera (crickets and locusts), Dictyoptera (praying mantids), and Neuroptera (green lacewings). Echolocation was a prerequisite for success in darkness and even the first bats probably used echolocation. However, bat signals have disadvantages. For one, the echolocating bat forewarns insects that can hear ultrasound and coincidentally exerts considerable selection pressure against those that either cannot hear or do not react. Pre-Eocene tympanate insects (crickets, locusts and mantids) probably evolved evasive behaviors in response to selection pressure by bat predation. The same selection pressure caused new auditory and motor mechanisms to evolve in presumably earless insects (green lacewings and moths). Bats, too, probably developed countermeasures for example by shifting their signals out of the prey's hearing range or by behavioral flexibility. In this review we present some of these adaptations and their refinements.

MILLER, P.S.

FOOD HABITS OF FEMALE BIG BROWN BATS, *Eptesicus fuscus*, DURING PREGNANCY AND LACTATION.

P.S. Miller, George Mason University, Fairfax, Virginia, USA.

Diet composition of the big brown bat, *Eptesicus fuscus*, was characterized using fecal analysis from a maternity colony located in an apartment complex in Fairfax County, Virginia. Guano was collected every few days from May until August. The diet consisted of 10 insect orders, 15 families and one identifiable species: the spotted cucumber beetle, *Diabrotica undecimpunctata*. Major food items were beetles (Coleoptera) and midges (Diptera) comprising 50.7% and 29% of the total volume of food, respectively. The insect families with the greatest average percent volume were Chironomidae (midges) 27.3%, Scarabaeidae (scarab beetles) 20.7% and Elateridae (click beetles) 10.5%. A variety of insects constituted the bat's overall diet, however most were taken opportunistically. The coleopterans and chironomids were taken throughout the study period. Trends indicated a marked decrease in beetle consumption close to parturition, followed by a moderate increase and a leveling off thereafter. Midges were highly erratic but showed a general increase through lactation and post-lactation. Mean percent volume for coleopterans and dipterans were significantly different between months (May to June, June to July, July to May). Contrasting data between months could indicate a selective pressure based on nutritional demands of early pregnancy

and lactation, physical restraints of wing loading during pregnancy, and females leading juveniles habits, to swarming insects during weaning.

MILLS, D.J.

TEMPORAL AND SPATIAL VARIATION IN SURVEYING FOR FOREST-DWELLING, INSECTIVOROUS BATS IN SOUTHEAST AUSTRALIA: IMPLICATIONS FOR SURVEY DESIGN.

D.J. Mills[1], R.B. Cunningham[2], T.W. Norton[1], and H.E. Parnaby[3].
[1]Centre for Resource and Enviromnental Studies, [2]The Australian National University, Canberra, ACT, Australia, and [3]The Australian Museum, Sydney South, Australia.

Microbat surveying was revolutionized in the late '70's with the development of the Tuttle or harp trap. Twenty years later it remains the primary tool for capturing live Microchiroptera. Unfortunately, the variation in capture results often makes it difficult to infer patterns of distribution and habitat use due to the ephemeral nature in which these animals utilize their environment. This study was prompted by a need to obtain reliable, consistent trapping results from which the distribution of a number of forest-dwelling microchiroptera could be characterized. The study was conducted in temperate Eucalypt forest in southeastern Australia. At least 18 species of Microchiroptera are known from the area, the majority of which are dependent upon tree hollows for roosting, hibernacula and maternity sites. The survey had a two-stage spatio-temporal design with confounding effects at the lower spatial scale. Variance components analysis was used to characterize the variation at the different spatial and temporal scales. Statistical dependence between observations usually increases as distance and time decrease, but contrary to what might be expected, there is a suggestion that the largest variation in trap success occurred at smaller scales. The results of this analysis were used to design a more efficient, larger scale survey.

MISTRY, S.

BIOTIC AND ABIOTIC SEED DISPERSAL PATTERNS IN SEASONAL OLD-WORLD FORESTS: ARE BATS REALLY IMPORTANT DISPERSAL AGENTS?

S. Mistry. University of New Mexico, Albuquerque, New Mexico , USA.

Two seasonal forests in India were studied to investigate the relative role of biotic and abiotic dispersal modes in structuring the forest and in aiding in regenerative processes following disturbance. One forest site is a coastal scrub forest that encounters considerable natural disturbances due to wind and water. The second forest site is a dry deciduous forest that has had significant human interference in the form of tree cutting and grazing. Both these sites experience a strong seasonality enforced by the annual monsoon cycle. Within each site vegetation data was collected and species abundances were correlated with dispersal modes. Both forest types showed a significant reliance on abiotic dispersal modes. While the coastal site species utilized such modes for establishment in highly disturbed areas, the deciduous forest had a high number of wind dispersed canopy species. In contrast to disturbance regimes such as neotropical treefall gaps, the dispersal agents responsible for the colonization of recent disturbances at these sites are primarily abiotic. The role of bats in both these sites appeared to be minimal. In the coastal site bats were important in dispersing old growth species but not in disturbed habitats. The deciduous forest site exhibited almost no reliance on bat dispersal. However, this may be more representative of the lack of knowledge about bat dispersal in these forest types than the unimportance of bats as dispersal agents. The type of disturbance pattern as well as the underlying forest structure play an important role in determining dispersal agents for colonization and should be taken into account when planning forest conservation strategies.

MORRIS, D.A.

RECONSTRUCTION OF THE EVOLUTIONARY STAGES LEADING TO CHIROPTERAN FLIGHT.

D.A. Morris. University of New South Wales, Sydney, Australia.

Skeletal and myological studies of the shoulder of a generalized, terrestrial mammal, mammalian gliders, and bats, together with cineradiographic data of the pectoral girdle of a flying bat *(Syconycteris australis)*, provide the basis for reconstructing the transitional stages of forelimb excursion between terrestrial locomotion and powered flight. During downstroke in *S. australis*, scapular rotation of about 70° occurs about the long axis of the scapula; the coracoid border translates laterally and ventrally. The shoulder joint shifts caudally by a distance of one vertebra. The clavicle, adducting around 12° during the downstroke, acts as a radius rod. In the evolution of mammalian powered flight, the scapula has undergone a major repositioning from the lateral to the dorsal aspect of the thorax. The scapula is restructured to accommodate the enlargement of certain muscles (e.g. serratus ventralis) that are recruited for the downstroke, and the clavicle is lengthened. In gliders, the proportions of the vertebral, coracoid and axillary borders of the scapula and the length of the coracoid process are intermediate between those of a generalized, terrestrial mammal and bats. The orientation of the glenoid, which in terrestrial mammals is ventrally directed, becomes increasingly more laterally directed in gliders, and is laterally directed in bats. The clavicle of gliders is

intermediate in orientation between the horizontal position in terrestrial mammals and the vertical position in bats, and is likewise intermediate in length. These features of the shoulder in gliders appear to be related to increasing the range of abduction, which in turn is preadaptive to employing powered adduction of the downstroke.

MORRIS, M.R.

PERCEPTION OF COMPLEX STIMULI IN THE ECHOLOCATING FM BAT, *Eptesicus fuscus*.

M.R. Morris and C.F. Moss. Harvard University, Cambridge, Massachusetts, USA.

Echolocating bats perceive their environment by listening to the echoes produced when their vocalizations reflect off of surrounding targets. Using such a system, bats often experience complex stimuli, such as the echoes reflected from a fluttering insect target, which combine echo-delay cues with spectral and amplitude modulations. As part of a series of experiments designed to explore how the FM bat *Eptesicus fuscus* uses these different cues, bats were presented with two stimuli differing in echo delay patterns. The stimuli were produced using a phantom target simulator; one stimulus presented successive echoes at progressively decreasing delays, while the other presented successive echoes at randomly patterned delays. One stimulus was used per trial; bats were trained to indicate which stimulus was being offered by moving to a platform to their right or left. Stimulus parameters, such as the delay-change step size and the echo-delay pattern, were varied in additional phases of the experiment. We found that *Eptesicus fuscus* can successfully (using 80% correct criteria) discriminate between a patterned and a random sequence of echo delays, indicating that this species can integrate echo delay information over a series of echoes to form a concept of its changing environment over time. Additional experiments aimed at exploring how FM bats perceive complex stimuli will be presented. Supported by a grant from the Whitehall Foundation.

MORTON, P.A.

VOLUNTEERS IN CONSERVATION: SUGGESTIONS TO MAXIMIZE SUCCESS.

P.A. Morton. Texas Parks and Wildlife Department, Austin, Texas, USA.

Building local awareness about conservation issues is vital to the future of wildlife conservation and management, especially for nongame and endangered species. If communities do not understand or care about their local natural resources, the long-term viability of those resources is threatened. Natural resource professionals must work in partnership with landowners and communities in order to promote and maintain healthy ecosystems. This is especially true in states like Texas where the majority of land (95%) is privately owned. Volunteer programs initiated in communities near important wildlife resources can offer a foundation on which to build an extensive network of local management and outreach efforts. This presentation will discuss some of the opportunities that can arise out of volunteer programs including: field assistance for research and management activities; training for resource professionals; education and research opportunities for university students; public interpretive programs at state parks; media coverage of regional wildlife issues in local newspapers; increased appreciation for resources on public and private land; and ecotourism development.

MOSS, C.F.

SENSORIMOTOR INTEGRATION IN BAT SONAR.

C.F. Moss and D.E. Valentine. Harvard University, Cambridge, Massachusetts, USA.

Field and laboratory data show that an echolocating bat continuously modifies its outgoing sonar emissions, relying on incoming echo information to shape the characteristics of its subsequent sonar cries. In bats using frequency modulated sounds for echolocation, there are systematic changes in the repetition rate, duration and bandwidth of signals with closing target distance. This requires a common sensorimotor interface, where acoustic information about the spatial location of a target is used to guide vocal behavior. Here we present new data on biologically relevant specializations in the superior colliculus of the bat for acoustic orientation by sonar. A population of neurons in the bat superior colliculus shows facilitated- and delay-tuned responses to pairs of sounds, simulating sonar emissions and echoes. Echo delay-tuning, believed to be related to the encoding of target range, may play a role guiding the bat's motor responses appropriate for changes in target distance. In addition, microstimulation in the bat superior colliculus elicits sonar vocalizations coupled to head movements, implicating this neural structure in motor commands for the production and reception of echolocation signals. Together these data suggest biologically relevant specializations in the superior colliculus of the bat for acoustic orientation by sonar, a complex interactive system coordinating vocalizations and orienting maneuvers to the reception of echoes. Supported by the Whitehall Foundation, National Science Foundation, and Sackler Programme.

MUNI, M.N.

HAEMOGLOBIN POLYMORPHISM IN SOME INDIAN BATS--SIGNIFICANCE TO CHAEMOTAXONOMICAL STUDIES.

M. N. Muni[1] and A. M. Bhagwat[2]. [1]Bombay Natural History Society, Bombay, India and [2]R J College, Bombay, India.

During the present study a total of 16 species of Indian Chiroptera belonging to 11 genera and 7 families were analyzed to determine the haemoglobin polymorphism using polyacrylamide gel electrophoresis from the chaemotaxonomic perspective. A consolidated profile for species, genus, family, suborder and order-specific haemoglobin patterns were prepared. The order-specific haemoglobin polymorphism exhibited a distinct seven band profile having a distribution from Rm 0.27 to Rm 0.55. The same data was further used to analyze genetic identities for the haemoglobin-loci which were then used to carry out a cluster analysis to obtain species, generic and familywise dendograms.

MUNI, M.N. RESURVEY OF INDIAN CHIROPTERA: SIGNIFICANCE TO BAT CONSERVATION PROGRAM IN INDIA.

M. N. Muni. Bombay Natural History Society, Bombay, India.

India has about 100 species of bats belonging to the suborders Megachiroptera and Microchiroptera distributed throughout the country including Andaman and Nicobar Islands. Besides the reports of 'Mammal Survey of India' conducted by the Bombay Natural History Society during 1911-1923, there have been very few systematic studies on the bats of India. Misconceptions and lack of awareness of the benefits of bats and degradation of habitat have resulted in the decline of some bat populations in India over the past 70 years. A long-felt necessity to resurvey the bats of India materialized in 1991 when the Society independently as well as in collaboration with the Harrison Zoological Museum initiated a project to reassess the recent taxonomic and ecological status of Indian bats. The present paper discusses systematics, ecology, biology, status and conservation priorities of some of the bats in the light of field work conducted during 1991-1994. The distribution maps, discussions on key conservation areas, areas demanding imperative surveys, and a note on rediscovery of the rarest fruit bat in the world, *Latidens salimalii* from the southern India have been incorporated.

MÜLLER, R.

THE PSYCHOPHYSICS OF BAT ECHOLOCATION SEEN FROM THE PERSPECTIVE OF HUMAN LISTENING EXPERIMENTS.

R. Müller and H.-U. Schnitzler, H.-U. University of Tübingen, Tübingen, Germany.

Experimental procedures designed to test the performance of the bats' echolocation receiver were adapted for human subjects by scaling the frequency of the stimuli into the human hearing range. Paradigms for evaluating performance in range difference and range-jitter discrimination as well as experimental designs for characterization of the psychophysical effects associated with dual-wave front stimuli were presented to listeners in a three-alternative, forced-choice task in order to obtain threshold estimates for the discrimination capabilities of a mammalian hearing system not specialized for echolocation tasks. By means of this strategy we hope to determine whether bats could make use of psychophysical qualities, the occurrence of which is a general feature of the mammalian hearing system.

NAVO, K.W. BAT ROOSTS IN ABANDONED MINES IN COLORADO.

K.W. Navo, T. Ingersoll, and J. Sheppard. Colorado Division of Wildlife, Denver, Colorado, USA.

The Colorado Division of Wildlife initiated the Bats/Inactive Mines Project in 1991 to evaluate the use of abandoned mines by bats prior to closure. The project represents a cooperative effort between several state and federal agencies, as well as volunteers from the public. Trained volunteers conduct surveys outside mine entrances using bat detectors, and document bat activity at mine sites. Mines with bat activity are then surveyed to determine species and roost types. Over four years, volunteers have conducted over 550 surveys, compiling over 5,832 hours. The project has evaluated 485 mines to date. Results indicate that 47% of the mines surveyed have bats associated with the site. Of these, 15% provide roosts for bats based on follow up surveys. Over fours years of study, 388 bats representing eight species have been documented roosting in mines. Four species comprise 85% of the total bats captured at mines; *Plecotus townsendii*, *Myotis volans*, *M. evotis*, and *M. ciliolabrum*. Mines surveyed ranged in elevation from 5,520 to 12,400 feet, and averaged 8,457 feet. Bats used mines as roosts at elevations ranging from 5,800 to 10,740 feet. The average elevation of mines used as roosts was 7,802 feet. Maternity roosts were documented at elevations up to 9,100 feet for *M. volans*. Bat gates have been installed at 37 mines, and an additional 34 mines are scheduled for gate installation. Gate monitoring indicated that all species documented using abandoned mines prior to gating continue to utilize the gated mines.

NEEFUS, C.D.

COMPUTER-AIDED IDENTIFICATION OF BAT SPECIES BASED ON BROADBAND DETECTION OF ECHOLOCATION CALLS.

C D. Neefus and R A. Krusic University of New Hampshire, Durham, New Hampshire, USA.

It is possible within some geographic regions to distinguished many of the indigenous bat species on the basis of search-phase echolocation call characteristics. For this reason, broadband ultrasonic bat detectors have been used as research tools in an increasing number of studies on bat ecology and habitat use. While computer software is presently available to display call structure from broadband detectors, identification of calls must be made subjectively by visual comparison to known calls or by comparing call parameters to those of known calls. This can make call identification a prodigious task even for small-scale monitoring studies. To assist in this task, and to make identification more objective and statistically predictable, we have developed computer software that analyzes output from broadband detectors and automatically classifies bat calls based on a multivariate discriminant function derived from characteristics of positively identified calls. The system has been used successfully for laboratory analysis of detector recordings made as part of two studies on bat habitat use and roost selection in the White Mountain National Forest in New Hampshire. Using an Anabat II broadband detector and a laptop computer we are also using the software in the field to display call and pass structure and make "real time" identifications of echolocation calls made by flying bats. Results of field validation of the system call-identifications will be reported.

NOEL, D.C.

AGUA CALIENTE CAVE: PROTECTING THE FUTURE.

D.C. Noel, T. Snow, and S. Castner. Arizona Game and Fish Department, Phoenix, Arizona, USA.

In 1994, the Arizona Game and Fish Department, under a Right of Entry Permit from the State Land Department, placed bat gates on three entrances at Agua Caliente Cave. This cave had been a popular recreation site for at least 25 years. It also contained a maternity roost of about 100 Townsend's big-eared bats (*Plecotus townsendii*) and a winter roost of about 50 California leaf-nosed bats (*Macrotus californicus*). Research results had shown that the maternity colony had experienced a 50% decline culminating in a complete reproductive failure in 1994. This presentation will review the events that lead to this situation, the actions taken; and the hope for the future at this site.

NORBERG, U.M.

MORPHOLOGICAL ADAPTATIONS FOR FLIGHT.

U.M. Norberg. University of Göteborg, Göteborg, Sweden.

Since flight is energetically very expensive, bats have highly advanced morphological adaptations in their wings for efficient flight. Flight mechanics impose significant constraints on behavior, which are responsible for shaping the bat's niche, and the influence of these constraints may be traced in wing adaptation. A brief review is given on myological and osteological arrangements improving rigidity and flight performance (Norberg 1969, 1972). Variation in wing shape can be correlated with different flight modes, kinematics, and speed. Flight speeds and wing beat frequencies were measured from high-speed ciné films (200 frames/s) in 21 morphologically diverse bat species, representing nine families, and ranging in body mass from 8 g to 270 g. Least squares regression shows that wingbeat frequency is proportional to (body mass) $^{-0.27}$, and flight speed to (wing loading) $^{0.48}$. The latter regression includes data from the literature of flight speeds of another 27 species. Maximum and minimum wingbeat frequencies set bounds to the maximum size of animals with aerobic flight (Pennycuick 1975). The observed frequencies indicate that the maximum size for bats would be about 2.3 kg. if the frequency alone should determine the size. The size and shape of the wings can be quantified by three parameters: wing loading, aspect ratio, and wingtip-shape index, and used to predict flight performance, agility, and maneuverability of the different species (Norberg and Rayner 1987, Thollesson adn Norberg 1991). A simplified way of grouping bats according to aspect ratio and a wing-loading index that is independent of body size is demonstrated.

NORONHA, V.C.

CORRELATIVE STUDY OF ULTRASTRUCTURE AND PHYSIOLOGY OF SEASONAL REGRESSION IN THE EPIDIDYMAL EPITHELIUM IN THE INDIAN FRUIT BAT, *Rousettus leschenaulti*.

V.C. Noronha[1] and D.A. Bhiwgade[2]. [1]R.D. National College, Bombay, India, and [2]Institute of Science, Bombay, India.

Seasonal variations in the ultrastructure of the caput and cauda epididymides of *Rousettus leschenaulti* were studied in relation to the reproductive functions. The epithelium of the epididymis consists of four types of cells, the principal, the apical, the basal and the lymphocyte cells. The principal cells like other steroid synthesizing cells,

contain the Golgi apparatus, the smooth and the rough endoplasmic reticulum, the secretory vesicles and lipid granules during the breeding season, but they are practically devoid of these organelles during regression, except for the retarded Golgi and moderate RER. The basic cell, on the other hand, shows lipids and well-developed organelles during regression but poorly developed structure in the sexually active bats. The possible function of these cells is to store lipids during regression which are subsequently used at the beginning of the recrudescence. This study indicates that the ultrastructural changes in the epididymides during regression could be used to evaluate and correlate the changes taken place during infertility.

O'DONNELL, C.F.J.

IDENTIFICATION OF CRYPTIC SUB-GROUPS IN A POPULATION OF A THREATENED BAT *Chalinolobus tuberculatus* IN A NEW ZEALAND RAINFOREST.

C.F.J. O'Donnell. Department of Conservation, Christchurch, New Zealand, and University of Otago, Dunedin, New Zealand.

Only two species of bats remain extant in New Zealand, both are considered threatened. Both have declined significantly since humans arrived in New Zealand. Little is known about the current status, stability, limiting factors and ecology of bat populations. Over the summers of 1993-94 and 1994-95, populations and movements of long-tailed bats *(Chalinolobus tuberculatus* Vespertilionidae) were studied in beech *(Nothofagus)* dominated temperate rain forest in the Eglinton Valley, Fjordland. While radio-tracking indicated that feeding ranges of bats (n = 31) overlapped considerably, the marking of individuals revealed that two apparently distinct groups used the lower Eglinton Valley; they almost always associated with their traditional roosting companions during the day. The 'Bluff Group' with 91 tagged individuals, ranged over a minimum of 48 km^2 whereas the 'Southern Group', comprising >70 individuals ranged over at least 56 km^2. Only 22% of the Bluff Group's feeding range and 14% of the Southern Group's range appeared to be exclusive. Of 189 recaptures of 96 bats harp-trapped at 23 tree roosts, there were only seven cases (4%) of bats switching between groups: four were adult males, two nulliparous females, and only one parous female. Of 35 bats marked in 1993-94 and recaptured in 1994-95, all but two were associated with individuals with whom they were caught during the previous summer. However, only 42% of males were recaptured more than once with the same group of bats, compared with 93% for parous females and 87% for nulliparous females. Numbers of bats in a roost varied considerably each night (mean = 21, SD = 20.6, range = 1-117, n = 174) and the bats moved to a new roost tree almost every day (mean days/roost = 1.6, SD = 1.1, range = 1-9, n = 166). The degree of intermixing between groups in the longer term and whether juveniles disperse, mix with other groups or return to their natal colonies the following year is unknown. Adult males may not always associate with traditional groups but intermix more freely. Results raise questions about how bat populations are defined and have implications for conservation management.

O'SHEA, T.J.

DETERMINING BAT POPULATION STATUS IN THE UNITED STATES: AN UPDATE ON NEW EFFORTS BY THE NATIONAL BIOLOGICAL SERVICE.

T.J. O'Shea[1], M.A. Bogan[2] and L.E. Ellison[1]. [1]National Biological Service, Fort Collins, Colorado, and [2]National Biological Service, University of New Mexico, Albuquerque, New Mexico.

Considerable concern exists about the status and trends of bat populations in the United States, and much discussion has centered on establishment of bat inventory and monitoring programs. The National Biological Service is beginning a four-year effort to compile all existing information on bat populations in the United States and Territories from historical times to the present. We will rely heavily on input from bat researchers and conservationists for original data, in addition to published records and other information in the public domain. Data will be compiled, analyzed for trends, and published in a master report (coding colony locations for protection from vandalism). Based on this information and other possible methodologies, during the final year of the project we will hold an expert workshop to recommend the design of future national-scale bat inventory and monitoring programs. The initial phase of the project is a compilation of data from selected states. We provide a preliminary overview of efforts, seek input for improvements, and seek contacts for information on sizes and status of various bat populations in the U.S. and Territories.

OH, Y.K.

EFFECT OF LOW-TEMPERATURE ON THE ACROSOME REACTION AND METABOLISM OF SPERMATOZOA.

Y.K. Oh and J.H. Chang. Yonsei University, Wonju, Kangwon-do, South Korea.

It is well known that the acrosome reaction of spermatozoa is remarkably influenced by Ca2+ and ATP/ADP ratio and that it assumes an important role in sperm motility. This experimental study was designed to

examine the acrosome reaction and energy metabolism in the spermatozoa of heterothermic and homeothermal mammals. The experiments were carried out using the following methods: 1) sperm preparations, 2) induction of acrosome reaction, 3) evaluation of acrosome reaction, 4) qualitative estimation of ATP and ADP, 5) quantitative measurement of intracellular free Ca2+. Based on our experimental results, we suggest that in a low temperature environment, the acrosome reaction-ratio of spermatozoa was reduced compared with that at room temperatures. ATP levels that were affected by the low-temperature environment barely facilitated the fertilizing capabilities such as sperm motility, capacitation and acrosome reaction.

OH, Y.K.

CALCIUM UPTAKE OF THE SARCOPLASMIC RETICULUM - MICROSOME OF PECTORALS MAJOR MUSCLE IN THE RABBIT AND THE KOREAN GREATER HORSESHOE BAT, *Rhinolophus ferrumequinum korai*.

Y.K. Oh and W.S. Yang. Yonsei University, Wonju, Kangwon-do, South Korea.

This experimental study was designed to examine physiological and morphological characteristics of the microsomes in the sarcoplasmic reticulum and muscular fibers in the hibernating Korean greater horseshoe bat, *Rhinolophus ferrumequinum korai*, and a non-hibernating rabbit.. Our experiments were conducted using: 1) segregation of the sarcoplasmic reticulum-microsomes, 2) analysis of Ca2+ ATPase activities, and 3) fine structural characteristics of the muscle fibers. The rate of uptake of Ca2+ in the microsomes of the sarcoplasmic reticulum changed in accordance with concentrations of caffeine, $MgCl_2$, pH and temperature, and fluctuated markedly with Ca2+ ATPase. From these experimental results, we conclude that there may be *in vivo* difference in physiological characteristics between the non-hibernating rabbit and the hibernating Korean greater horseshoe bat. Marked differences in the thickness of the muscle fibers and the size of the mitochondria were observed in both animals. These morphological differences are judged to be closely related to functional differences such as twitch rate of the pectoralis major muscles in these two species.

OSTROWSKI, S.

UPDATE ON U.S. FOREIGN QUARANTINE REGULATIONS: BATS, IMPORTATION, AND THE CENTERS FOR DISEASE CONTROL AND PREVENTION (CDC).

S. Ostrowski. Centers for Disease Control and Prevention, Atlanta, Georgia.

The Centers for Disease Control and Prevention (CDC), through the Foreign Quarantine Regulations of the Public Health Service Act, has regulatory authority over the importation and subsequent distribution of all vector species into the United States and its territories. Although previously handled as a "miscellaneous" category of permit request, recent events have resulted in the initiation of a specific permit program for bat importation and quarantine. Regulations and zoonotic disease concerns will be reviewed and application packages for permits will be provided. Concepts of occupational safety, animal biosafety levels (ABSLs), and appropriate quarantine facilities and procedures will be explained.

OTTMAN, J.R.

THE BAT CONSERVATION SOCIETY OF OKLAHOMA: A GRASSROOTS BAT CONSERVATION, EDUCATION, AND RESEARCH ORGANIZATION.

J.R. Ottman. Bat Conservation Society of Oklahoma, Oklahoma City, Oklahoma.

The Bat Conservation Society of Oklahoma (BCSO) is a nonprofit, education organization incorporated in June 1994 under the laws of the State of Oklahoma. It is supported by tax deductible contributions used for education and research programs focusing on bats and bat habitats within Oklahoma. BCSO accomplishes its objectives through outreach education programs given by volunteers to the general public, government agencies, civic organizations, schools and other interested groups. Several projects designed to heighten public awareness about Oklahoma bats include a 24-hour telephone "Information Access line", library information database, Oklahoma bat species fact sheets, bat conservation status reports (by county), publications, Oklahoma bat roost registry program, backyard bat census program, bat garden/backyard habitat program and a quarterly conservation-alert newsletter. BCSO also provides financial assistance and volunteer manpower to various state agencies for support of field research in the ecology, life-history and conservation of bats and bat habitats within Oklahoma.

PAPADIMITRIOU, H.M.

ONTOGENETIC AND ANATOMIC VARIATION IN MINERALIZATION OF THE WING SKELETON OF THE MEXICAN FREE-TAILED BAT, *Tadarida brasiliensis*.

H.M. Papadimitriou[1], S.M. Swartz[2], and T.H. Kunz[1].
[1]Boston University, Boston, Massachusetts, and [2]Brown University, Providence, Rhode Island.

We examined patterns of variation in the mineral content of the wing skeleton of the Mexican free-tailed bat, *Tadarida brasiliensis*. We ashed humeri, radii, metacarpals II-V, and phalanges of digit III, and quantified mineralization differences among elements at specific ages, and ontogenetically for each element. The most mineralized elements are the humerus and the radius, followed by the metacarpals, of which the third and fifth are the most mineralized. The proximal and middle phalanges of the third digit exhibit the lowest mineral content, and the distal phalanges have no mineral content according to our ashing protocol. Histological examination shows a thin (<10 microns) shell of unmineralized osteoid surrounding a cartilaginous core in distal phalanges. Mineral content of each bone increases linearly with age during post-natal development, but there are differences in the rate and extent of this increase among the different elements. The mineralization differences we observed parallel substantially different bone loading patterns found in different parts of the wing in other studies. The humerus and radius are subjected to large torsional loads during flight, while the metacarpals and phalanges experience dorsoventral bending. The high mineral content of the humerus and radius and the low mineral content of the metacarpals and phalanges may resist torsion proximally and promote bending distally. Furthermore, the decrease in mineral content along the wing's proximodistal axis decreases bone mass disproportionately at the wing tips, where the energetic cost of accelerating and decelerating mass is greatest.

PARK, K.J.

SOCIAL STRUCTURE IN THREE SPECIES OF TEMPERATE BATS.

K.J. Park and J.D. Altringham, University of Leeds, Leeds, West Yorkshire, UK.

We have examined the social structure of three sympatric bats species occupying woodland in southern England: pipistrelle (*Pipistrellus pipistrellus*), brown long-eared bat (*Plecotus auritus*) and Natterer's bat (*Myotis nattereri*). Two-thousand bats occupying small roost boxes have been banded since 1976. Marked differences were seen between the pipistrelle and the other two species. Pre-parturition, pipistrelle populations were heavily skewed towards solitary males. Post-parturition, females greatly outnumbered males. Recapture rates support the idea of a resident male pipistrelle population invaded by a transient female population during the post-parturition period. The sex-ratios of populations of long-eared and Natterer's bats were very close to unity, both pre-and post-parturition, and recapture rates were similar for both sexes. In the mating season (August-October), solitary male pipistrelles attracted small groups (1-10) of females. By contrast, in both long-eared and Natterer's bats, mixed-sex groups were found during the pre-and post-parturition periods, and mating groups contained up to 20 females and 10 males. Stability of female groups in both long-eared and Natterer's bats was higher than in the pipistrelle: known females were found together more frequently. The size and stability of female groups are believed to be related to the temporal and spatial dispersion of food and the foraging style of the bat, which are related to wing morphology and echolocation-call structure. The structure of female groups is in turn believed to be important in determining the mating strategy adopted by males. Are the observed differences in social organization consistent with this hypothesis, and what testable predictions can we make about the behaviour of these species?

PARKER, A. FUNCTIONAL ARCHITECTURE OF TRABECULAR BONE IN BAT HUMERI AND FEMORA.

A. Parker and S.M. Swartz. Brown University, Providence, Rhode Island, USA.

The distinctive locomotion of bats imposes extremely different forces on the fore- and hind limbs, unlike the similar loads applied to all limbs of terrestrial quadrupeds. Therefore, functional architecture of the skeleton should differ between the fore and hindlimbs, both in overall geometry and in the fine-scale patterning of trabecular bone tissue. Trabecular bone architecture has long been thought to map bone function; specifically, trabeculae are believed to align preferentially along principal stress trajectories. To better understand how trabecular architecture changes with function and body size, we investigated the structure of trabecular bone in bats and terrestrial mammals (22 bat and 13 non-bat species) over a large range of body sizes. We measured trabecular element size from the proximal humerus and proximal femur of each specimen. Trabecular size scaled similarly in bats and terrestrial mammals. The absolute size of trabecular elements in a bat of a given size, however, were absolutely larger than bat taxa of the same size, for both the humerus and the femur. The distinct architecture of bat trabecular bone in relation to that of terrestrial mammal bone may have consequences for the stress experienced by bat bones. To further investigate the effect of trabecular architectural variations on bone mechanics, we developed a simple mechanical model of a bat femur, based on our detailed morphological observations. Despite fourfold variation in trabecular

width and number, and changes in element orientation, our model showed little variation in total bone stress. Thus, variations in the structure of trabeculae had minimal effects on the stress experienced by the bone. These results suggest that trabecular architecture may not relate directly to stresses imposed during normal locomotion in the manner previous studies have proposed.

PARKER, D.I. DISTRIBUTION AND STATUS OF BATS IN ALASKA.

D.I. Parker[1], B.E. Lawhead[2], and J.A. Cook[1].
[1]University of Alaska Fairbanks, Fairbanks, Alaska, [2]ABR, Inc., Fairbanks, Alaska.

The distribution of bat species in North America is relatively well documented, yet little is known about bats in Alaska, the northwestern limit of several species ranges. Alaska's 1.5 million km^2 encompasses an area 20 percent the size of the lower 48 United States, or 15 percent the size of Canada, but there has been no comprehensive study of bat species occurrence and distribution in the state. Although *Myotis lucifugus* occurs in most of the state, bats reach their highest diversity in southeast Alaska, where five vespertilionid species comprise 13 percent of the land mammal diversity. We conducted field studies and investigated museum holdings to provide information about species occurrence and distribution in Alaska. Six bat species have been reported from the state: *Myotis lucifugus*, *M. californicus*, *M. volans*, *M. keenii*, *Lasionycteris noctivagans*, and *Eptesicus fuscus*. Until recently, most species were documented in Alaska from one or two specimens. During this study, we captured additional specimens of *M. keenii*, an apparently rare species which is a candidate for endangered or threatened species status in neighboring British Columbia. Three additional records of *L. noctivagans* were also documented.

PARSONS, S.

A COMPARISON OF THE PERFORMANCE OF FOUR BRANDS OF BAT DETECTORS UNDER FIELD CONDITIONS IN TWO HABITAT TYPES.

S. Parsons. University of Otago, Dunedin, New Zealand.

There are now many different brands of commercial bat detectors available on the market. The decision of which brand to use has been made easier by studies investigating the performance of different brands. However, most of the tests carried out have not evaluated the performance of the detectors under field conditions. Those which have were rarely quantitative in terms of the detectable distance of bat calls and signal strength. Few studies, if any, have compared the performance of different brands of detector in different habitat types. Thus, we set out to compare four brands of detector (3 narrow-band and 1 broad-band) against each other in two different habitat types. The performances of the four brands of ultrasonic bat detector were compared for their ability to detect a 40 kHz sound of variable amplitude along 10-meter transects in open grassland and beech forest--two common habitats used by bats in New Zealand. Results showed that the different brands of detector differed in their ability to detect the source in terms of maximum and minimum detectable distance of the source. The rate of sound degradation as measured by each brand was different. Significant differences were also found in the performance of different brands in open grassland and beech forest. No significant differences were found within any brand of detector. The distances at which the detectors were able to detect the sound source in both habitat types were over twice what would be expected from theoretical and laboratory studies. This result emphasizes the need for more field-based studies of sound transmission characteristics. Though not as sensitive as the narrow-band detectors, the broad-band model has an advantage in its ability to identify species where several species are found together.

PAUZA, D.H.

COMPARATIVE STUDY OF THE SUBEPICARDIAC NERVE PLEXUS OF SIX VESPERTILIONID BATS.

D.H. Pauza, N. Pauziene, and Stropus. Kaunas Medical Academy, Kaunas, Lithuania.

The aim of this research was to describe the anatomical patterns of the subepicardiac nerve plexus (SNP) in *Myotis daubentoni* (n = 4), *M. brandti* (n=2), *Nyctalus noctula* (n = 1), *Barbastella barbastellus* (n=2), *Eptesicus serotinus* (n = 2), *E. nilssoni* (n = 1), and to examine levels of anatomical variability in the SNP of bats. The intracardiac nerve structures were visualized and examined in entire hearts. The study suggested that in all investigated bats, as in primates, carnivores, artiodactyles, lagomorphs, and rodents, the extra cardiac nerves consistently innervate heart at the hilum cordis and in the subepicardiac layers of the atria and ventricles from seven subplexuses. These subepicardiac nerve subplexuses (SNSP) spread to different heart regions by their own pathways and innervate myocardium, endocardium, coronary vessels, etc. In *N. noctula* and *E. serotinus* the SNSP were numerously ganglionic nearly to the heart apex. In *M. daubentoni*, *M. nattereri* and *E. nilssoni* the patterns of SNSP were quite similar and the ganglia were extended a bit farther than the coronary groove. In *M. brandti* the majority of subepicardiac nerve cells were formed only in two relatively large ganglia and the SNSP of *B. barbastellus* were almost lacking in the ganglia. Therefore, the anatomical patterns of SNSP were different within genera but were quite similar between genera. This comparative analysis revealed individual variability in the

structural organization of SNSP of bats and topographical invariability of these subplexuses on the species level. These observations led us to suggest that in some vespertilionid bats the anatomical pattern of SNP may be defined by ecological rather than by phylogenetic factors.

PAUZINE, N.

STATE OF THE HEART INNERVATION OF THE BATS *Myotis daubentoni* and *Eptesicus serotinus* DURING HIBERNATION

N. Pauziene, D.H. Pauza, and R. Stropus. Kaunas Medical Academy, Kaunas, Lithuania.

It is well known that hibernating bats have heart rates fewer than 10 beats/min in the torpid state and greater than 700 beats/min during arousal flights. It is understood that the cardioaccelaration is a function of heart innervation. Thus, the aim of this study was to investigate the structural organization of heart innervation in *M. daubentoni* and *E. serotinus* during natural hibernation and to ascertain the morphological changes of the heart that would cause hibernating bats to adapt quickly (average = 15 min) in heart activity to meet the needs of a euthermic or hypothermic animal. Hearts of seven *M. daubentoni* and two *E. serotinus* were sacrificed for electron microscopic studies. The animals were euthanized in both euthermic and hibernating states. The most interesting and novel findings were as follows: 1) the ultrastructural heart innervation pattern of bats is quite distinguished from other mammals. During bat hibernation period: 2) the intercellular space in the sinoatrial node of *M. daubentoni is* filled with a dense substance that might act as a temporary barrier between conducting cardiomyocytes and nerve fibers. 3) Acetylcholine vesicles were often aggregated in the nerve varices, and vesicle clusters were absent near the presynaptic membranes. Probably, the aggregation of vesicles enables a decrease in cholinergic influence on the bat heart during hibernation. 4) The catecholamine vesicles were almost empty in the intracardiac nerve fibers. Thus, a significant role of catecholamines in cardioacceleration during bat hibernation must be questioned.

PEDRO, W.A.

TAXONOMIC ASSEMBLAGE OF BATS FROM PANGA RESERVE, SOUTHEASTERN BRAZIL: ABUNDANCE PATTERNS AND PHYLLOSTOMIDAE TROPHIC RELATIONSHIPS.

W.A. Pedro[1] and V.A. Taddei[2]. [1] Unicamp Post-graduation Program.
Present address: Aracatuba, Brazil, and [2]Unesp, Sao Jose do Rio Preto, Brazil.

A bat assemblage was studied during one year (June 1990 to May 1991) at the Panga Ecological Reserve, southeastern Brazil, in order to investigate general abundance patterns and trophic relationships in the Phyllostomidae. At a height of 0-3.5 m, two species (*Carollia perspicillata* and *Sturnira lilium*), out of 13, were common during the dry season, and three (*Platyrrhinus lineatus, C. perspicillata,* and *S. lilium*), out of 16, were common during the rainy season. Many species were rare in both seasons. An overall recapture rate of 5.03% was obtained for Phyllostomidae. Small trophic niche breadth values were obtained for the most common species. Frugivorous species showed larger niche breadth in the dry season, which corresponds to the period of low fruit availability. The mean of niche overlap for these species was substantially higher during the dry season, suggesting the possibility of competition.

PEFFLEY, A.L. VERTEBRAL FUSION IN BATS: PHYLOGENETIC INTERPRETATION.

Peffley, A.L. American Museum of Natural History, New York, USA.

Fusion has been noted between vertebral elements in four areas (cervico-thoracic, thoraco-lumbar, lumbar, and sacral) of the chiropteran vertebral column, but reports disagree on the distribution and number of fused vertebrae in bats. Perhaps as a result, the usefulness of these data to phylogenetic reconstruction has not been fully explored. In the present study, I examined representatives of the seventeen microchiropteran families and five of the six megachiropteran tribes for vertebral fusion. All rhinolophids, megadermatids, furipterids, natalids, tomopeatines, molossids, and some nycterids and mormoopids exhibit fusion of the last cervical vertebrae to the first thoracic vertebrae. Regular fusion of the last cervical, first, and second thoracic vertebrae occurs in Thyropteridae and Hipposideridae. Fusions in the lower thoracic and lumbar regions are found in Furipteridae, Natalidae, Mormoopidae, Craseonycteridae, and some Megadermatids. lumbar fusions are found only in some hipposiderids. The presence or absence of fusion between vertebral elements does not appear to be vriable within most species. The main difference seen in individuals of the same species is in the total number of vertebrae fused in a specific region (e.g., a species where individuals have either 5 or 6 fused lumbar vertebrae). Age may influence vertebral fusion in some taxa. The number of vertebrae in the fused sacrum of bats does not appear to exceed seven, and two or three articulate with the ilia. The shape of the sacrum appears to be phylogenetically informative. none of the fusion characters appear perfectly correlated with generalized locomotor mode and hypotheses of the functional role of vertebral fusions remain to be fully investigated. To examine the evolution of vertebral fusions, characters were mapped onto two hypotheses of microchiropteran evolution based on different data sets (immunology and a "total

evidence" approach). Based on the interpretation of the vertebral fusion characters on these trees, it seems clear that vertebral fusions have evolved more than once in Microchiroptera. This study was supported in part by NSF grant BSR-9106868.

PETERSONS, G.

A COMPARISON OF METHODS USED FOR MONITORING BATS DURING AUTUMN MIGRATION.

G. Petersons. Latvian University of Agriculture, Jelgava, Latvia.

At least five species of the vesper bats (*Vespertilionidae*) of the genus *Pipistrellus*, *Nyctalus*, and *Vespertilio* migrate annually from their maternity sites in northwestern Europe to central and western Europe for wintering. During autumn migration bats follow the coast line of the Baltic sea and concentrate in southwestern Latvia in large numbers. Monitoring of bats was carried out from 1986 to 1994 at the Pape Ornithological station (56° 11', N 21° 03' E) during peak migration. Three methods were used: 1) trapping by an enlarged Helgoland trap in combination with Tuttle traps and hand nets, 2) visual counting by means of light beam and 3) censusing with ultrasound detectors. The benefits of the trapping method were accurate species identification and the capture of 14,529 bats of 15 species (90% *Pipistrellus nathusii*), ranging from 341 to 3,975 per season. Visual observations made from one locality three times nightly produced more standardized results, but species identification was not possible. The bat detector census covered a much larger sample area than the previous methods--800 m wide tract from the coast inland. Three times nightly all series of ultrasound pulses were counted. During the nights when bats were flying in groups, the number of individuals was underestimated. This method is selective for bat species with strong ultrasound calls. The minimal number of bats crossing the observation area was calculated as 13,000 in 1993 and 15,000 in 1994. Advantages and disadvantages of each method are discussed in detail. No single method is adequate for monitoring bat migration. A combination of census methods is necessary to monitor long-term fluctuations of migrating bat species.

PFEIL, A.

THE MULTIMODAL CONVERGENCE OF VISION AND ECHOLOCATION IN *Phyllostomus discolor*.

A. Pfeil, P. Höller, and U. Schmidt. University of Bonn, Bonn, Germany.

In order to investigate the multimodal convergence of vision and echolocation in the lesser spear-nosed bat, three *P. discolor* were trained to proceed directly from a defined starting point to a defined goal inside an octagonal test apparatus (providing four identical landing grids to the bats). The trained target was illuminated from behind. Under this standard condition the bats did not establish a stereotyped echolocation pattern, but the number of calls emitted during flight was quite variable in each of the test animals. It is noteworthy that only one bat reduced the total number of calls during the course of the experiments (more than 1,000 trials). In order to estimate the relative importance of vision, the standard target was darkened, while one of the alternative grids was illuminated. This modification did not cause any variations of the animals' flight paths, but all bats increased the repetition rate of echolocation. Neither did the change of the take-off alignment of the bats influence the flight paths. Usually the bats flew on a fixed route; taking off with a changed body alignment, the test animals failed to reach the trained target. In summary, route-based information seems to be most important for the orientation of bats flying within a familiar space. However, visual perception of environmental changes evidently influence the echolocation behaviour.

PIERSON, E.D. TALL TREES, DEEP HOLES, AND SCARRED LANDSCAPES: CONSERVATION BIOLOGY OF BATS OF NORTH AMERICA.

E.D. Pierson. University of California, Berkeley, California.

Bats are at risk of being overlooked and undervalued under the new "ecosystem management" approach being advocated by federal land managers in North America. Bats tend to be linked to geomorphic rather than the botanical landscape features upon which many habitat models are based. Additionally, status assessments based on a comparison of historic and current ranges overlook the tendency for bat populations to undergo local declines, while maintaining overall distribution. By focusing on rare and endangered taxa, we may fail to explore the potentially critical ecological role played by more numerous species. As the only insectivorous animals to undergo such large scale daily movements, bats may serve as nutrient "pepper shakers" in nutrient limited environments. Information on local distribution and specific habitat requirements, critical to conservation strategies, are lacking for most North American bat species. The geographic separation of roosting and foraging habitat requires a dual focus when considering the conservation biology of these animals. Although roosts are likely to be limiting for most temperate zone species, foraging habitat is generally poorly understood, and may be limiting as well. Human disturbance at maternity and hibernating sites, particularly in caves, has been responsible for the current endangered status of several North American species, and continues to be a significant concern. Recently, however, several other factors, linked

to land use and management practices, have emerged as threats to bat populations: widespread, federally-funded closures of historic mine workings for hazard abatement; a resurgence of renewed mining in historic districts; timber practices which favor the removal of those trees that are most likely significant bat roosts (e.g. large diameter trees and snags); water impoundment projects which frequently inundate caves, mines, and cliffs; overgrazing, which has altered the vegetative composition of meadows and destroyed riparian habitat.

PINK, B.
SOCIAL BEHAVIOR IN A CAPTIVE COLONY OF *Glossophaga soricina* (PHYLLOSTOMIDAE).
B. Pink, and O. v. Helverson, Department of Zoology University of Erlangen, Erlangen, Germany.

The general behavioral repertoire of *Glossophaga soricina* was investigated in captivity. Observations were made with a group of individually marked animals, three pregnant females and one adult male, which had been separated from a larger breeding colony (origin Mexico) that has been maintained at the Erlangen University for the past six years. Bats were kept in a tropical greenhouse ($25m^2$) under natural light conditions on an artificial nectar-diet, banana, pollen and insects. Observations were made without disturbing the animals by using a remote-controlled videosystem and infrared light illumination installed at the roost between March 1994 and April 1995. The interactions in three mother-infant-pairs, from the first day until weaning, were observed. One female was pregnant twice within the same year. Two births were observed and videotaped. During parturition the females hung in their usual position, head down. Pups were born head first, were furred and had open eyes. First flight attempts occurred between day 19 and 21 . Females had a post-partum estrus. Copulations could be observed from the day of parturition until about one month later. Females left their young alone in the roost during courtship and copulation, even on the first day of life. During courtship, males displayed a hovering flight in front of the female. Hovering was often followed by copulation attempts and preceded all four copulations observed on the videotape. At an age of eight months one young male started to exhibit this "courtship hovering." Mainly during the period of lactation, "aggressive" interactions between females occurred which might indicate a hierarchical structure in the female group during that period. When a juvenile male was one year old the adult male showed territorial behavior: it forced the young out of the roost repeatedly, followed by "tandem-flights" outside the roost, accompanied by loud ticking calls.

PORTFORS-YEOMANS, C.V.
EXTENDING BATS' RANGES OF PERCEPTION: THE ROLES OF VISION AND ECHOLOCATION.
C.V. Portfors-Yeomans[1], M.B. Fenton[1], and I.L. Rautenbach[2]. [1]York University, North York, Ontario, Canada, and [2]Transvaal Museum, Pretoria, South Africa.

The roles of vision and echolocation in the orientation behavior of 17 species of African microchiropteran bats are explored using field observations of echolocation calls and optokinetic data on visual resolution. The frequency and temporal characteristics of echolocation calls were examined in the context of the impact of spreading loss and atmospheric attenuation. For aerial-feeding vespertilionid and molossid bats we considered predictions about the effective range of echolocation for insect-sized and larger targets. Spreading loss and frequency-dependent atmospheric attenuation severely limit the effective range of echolocation. At frequencies <15 kHz, echolocating bats can extend their range of target detection by separating adjacent echolocation calls in frequency, but above 15 kHz atmospheric attenuation and spreading loss make this strategy ineffective. Alternating the bandwidths of adjacent echolocation calls suggests that the molossid *Tadarida midas* used this approach to extend its operational range of echolocation. Molossids and vespertilionids using higher frequency calls (≥15 kHz) showed high overlap of the bandwidths of adjacent echolocation calls. The visual resolution abilities of the bats we studied were used to estimate the distances at which they would first detect insect-sized and tree-sized targets. For insect-sized targets, echolocation provided a greater effective range than vision, but for larger objects, the reverse was true. The findings have implications for the general orientation of microchiropteran bats.

RACEY, P.A. THE ECOLOGY OF EUROPEAN BATS IN RELATION TO THEIR CONSERVATION.
P.A. Racey, University of Aberdeen, Aberdeen, Scotland, UK.

In the past decade, several initiatives involving research, surveys, and monitoring have been undertaken in Europe. These include: UK, National Bat Habitat Survey, surveys of bat distribution in the Netherlands, surveys of bat occupancy of churches, the use of landscape features by bats, surveys of bats in river valleys, studies on the roosting and foraging ecology of several bat species, the interrelationships between flight morphology, echolocation calls and foraging behavior, the use of mating territories for survey and monitoring, and the stimuli resulting in arousal from hibernation. The implications of this work for conservation and management of European bat populations will be discussed.

RAINEY, W.E.

OCEANIC ISLAND BATS: NATURAL HISTORY PATTERNS AND CONSERVATION.

W.E. Rainey. Museum of Vertebrate Zoology, University of California, Berkeley, California.

Though widespread relative to other terrestrial mammals, bats on remote oceanic islands typically coexist with more diverse assemblages of birds and reptiles. Among these bats, evolutionary divergence at the species level is common, but local radiations are not. Even where long isolation can be reasonable inferred, the morphology of island bats remains generalized. The avian pattern of insular evolutionary novelties (e.g., flightlessness and large body size), replicated across lineages and islands, is apparently absent in bats. A limited island zooarchaeological record, primarily from Polynesia, shows that bat species are much more likely than bird species to persist from human settlement to the present. At low human desitites, cultural perspectives (bats as prey, forage competitors, or traditional icon) interact with the natural history of species to shape local extinction risks. Recent developments influencing island bat survival are the widening availability of firearms and improving local and international transport infrastructure, which aids both wildlife and timber trade. In the absence of commercial export hunting, tree roosting bat populations likely track rates of habitat conversion, but aggregated cave-roosting species are more vulnerable. Where indigenous forests persist or are managed, predator introduction, particularly arboreal snakes with low maintenance costs and a broad prey base, is an extremely serious risk to island biotas from expanding inter-island trade. We can view impending losses of island bats (and allocate effort to forestall them) from the perspective of local or regional biodiversity, ecosystem perturbation or impact on human welfare. At high human densities, particularly in physiographically and floristically simple systems such as atolls, where bats are harvestable competitors for limited agroforest productivity, the prospects for long-term persistence are poor.

RAKHMATULINA, I.K.

THE PROBLEM OF SEX RATIOS IN BAT POPULATIONS.

I.K. Rakhmatulina. Academy of Sciences of Azerbaijan Republic, Batu, Azerbaijan.

Sex ratios of *Chiroptera* are analyzed on the basis of literature and the author's own data, considering the animal's age, ecological, and ethological specificity. Among 23 species of eight genera, more than half of the young bats have equal sex ratios, and about 30% unequal ratios. Females predominate in less than 10% of the species examined, males in 5% of the species. In eight species from the eastern Transcaucasia, there were more males among the yearlings, more females among two- and three-year-old animals, but again more males among 4-year old and older bats. For old individuals in the same population there is often large variability in the sex ratio. Among the 23 species examined, three species of *Myotis* (*M. mystacinus, M. nattereri, M. lucifugus*) males were the most common in all seasons. In two species of *Rhinolophus* (*R. blasii* and *R. mehelyi*) and two species of *Myotis* (*M. grisescens, M. sodalis*) females predominated. 60.8% of species had disproportionate sex ratios (*Barbastella, Eptesicus, Nyctalus, Pipistrellus, Plecotus, Miniopterus*). In temperate regions, the sex ratio is often shifted in favor of males, whereas in the tropics the sex ratio is either equal of in favor of females. The processes that regulate sex composition in populations (genetical, physiological, ethological, anthropogenic, etc.) are complex, and variable, and appear to reflect ecological requirements of a species in different periods of its life history. Further study is need to clarify these factors.

RANSOME, R.D.

DOES SIGNIFICANT MATERNAL CARE CONTINUE BEYOND WEANING IN GREATER HORSESHOE BATS?

R.D. Ransome. University of Bristol, Bristol, England, UK.

Repeated captures of young bats within a breeding site (attic), at short term intervals from birth through growth and weaning and until the onset of hibernation, has made it possible to determine the timing of mortality in early stages of life. Mortality peaks during the 10 days following weaning, which occurs about 45 days after birth. Captures of mother/young pairs over a 5-year period from 1987 to 1991 has shown that young bats born to individually marked mothers have widely differing chances to survive to the age of breeding. The number of young produced by 14 females, which bred each year and survived the 5-year period, was correlated with six variables. Step-Stepwise multiple regression analysis revealed that the number of days a female remains in the maternity roost post birth (NDPB) is the most significant variable ($p<0.001$) influencing productivity. NDPB varied from 53 to 67 days among individuals, and was positively related to productivity. This variable explained 63% of the observed variation. Mean maternal age and mean parturition date over the 5-year period were also significant factors ($p = 0.003$ and $P = 0.030$, respectively). Maternal age affects productivity positively and the parturition date affects productively negatively. Neither the mother's skeletal size, nor her feeding success from pre-dawn foraging were significant variables. When NDPB, and mean parturition date were combined, they explained 77% of the variation in productivity. Older females showed greater productivity of successful young since NDPB is positively related to age

($p = 0.024$). It appears that some form of maternal care continues after weaning. The longer this care lasts the higher the survival of the young to maturity. Mortality rates rise in spring, especially if climate is poor, but survival of young through their second summer appears to depend upon the return of their mothers, indicating maternal care continues into the second year.

RASWEILER, IV, J.J.

REPRODUCTIVE BIOLOGY OF CAPTIVE SHORT-TAILED FRUIT BATS, *Carollia perspicillata*.

J.J. Rasweiler, IV and N.K. Badwaik. Cornell University Medical College, New York, New York.

The reproductive biology of *Carollia perspicillata* has been more closely examined utilizing animals maintained in a captive breeding colony. Most nonpregnant, adult females bred within 30 days of being housed with a stud male. Ovulation was spontaneous and followed by the formation of a functional corpus luteum (CL). The cycle length in most nonpregnant females appeared to be between 20 and 30 days. Luteal regression in such animals was associated with true menstruation, and the latter was usually periovulatory. Many aspects of pregnancy were unusual. The tubal journey of the oocyte/embryo was long (>10 days), and development progressed to the zona pellucida-free blastocyst stage in the oviduct. Implantation was initiated soon after the blastocyst entered the uterus, usually at a predetermined, localized site. The rate of development was then highly variable, because embryos sometimes went into delays that could substantially lengthen pregnancy. *Carollia perspicillata* has an extraordinary invasive trophoblast that rapidly penetrates into the myometrium and uterine mesenteries. During pregnancy the regressing CL of the previous nonpregnant cycle, as well as the CL of pregnancy, appears to be rescued, presumably by a gonadotropin of trophoblastic origin. Females exhibit a postpartum estrus, most frequently at 3-6 days after the birth of either term or non-term fetuses. The ability of *C. perscillata* to menstruate after fertilization failures, or early embryonic losses, or to ovulate again soon after abortions, should promote greater fecundity in the females. This work has been supported by NIH Grant HD28592 and Cornell's Department of Obstetrics and Gynecology.

RATHOD, V.M.

GIANT CELLS IN THE PLACENTA OF *Taphozous kachhensis*.

V.M. Rathod and V.M. Sapkal, Nagpur University Campus, Maharashtra, India.

Giant cells become visible at the utero-placental junction only after the invasion of the cytotrophoblast into the synctiotrophoblastic shell. The number of giant cells increases until mid-pregnancy. In a specimen showing late neural groove stage of the embryo, giant cells were observed between masses of remnant degenerating endometrial cells. These endometrial cells exhibit degenerating changes. Some giant cells are mononucleate, but the majority of them are either binucleate or multinucleate. Most of the maternal blood vessels in this region are surrounded by these giant cells. A close examination of these cells shows a lightly stained protoplasm surrounding maternal vessels in which are embedded darkly stained protoplasm with more than one nucleus. The nucleoli of these giant cells are conspicuous suggesting that they may play a metabolic role.

RAUT, P.D.

PROFILE OF CERTAIN SERUM BIOCHEMICAL AND HORMONAL CHANGES DURING THE REPRODUCTIVE CYCLE OF THE MALE INDIAN FRUIT BAT, *Rousettus leschenaulti*.

P.D. Raut, D. Uthaman, U. Mantri, and D.A. Bhiwgade. Institute of Science, Bombay, India.

The Indian fruit bat, *Rousettus leschenaulti* shows a peculiar breeding cycle. Adult males show double peaks in their testicular weight corresponding to the two pregnancy cycles of the female. The first peak occurs during October-November and the second during February-March. This study examined levels of certain serum biochemical parameters and hormonal levels throughout the entire reproductive cycle. The biochemical parameters such as cholesterol and proteins, increase during November; lipids and sialic acid are high during March, whereas the enzymes acid and alkaline phosphotase show peak values during August. Hormones such as FSH, LH and PRL are high during November, whereas the testosterone levels are at their highest levels in September. The role played by these parameters in relation to the testicular weight will be discussed.

REASON, P.F.

THE CONSERVATION OF *Pteropus livingstonii:* A MULTIDISCIPLINARY APPROACH OF ACTIVE CONSERVATION, RESEARCH AND ENVIRONMENTAL EDUCATION.

P.F. Reason, W.J. Trewhella, and S. Wray.
Action Comores, c/o Bristol Ecological Consultants Ltd., University of Bristol, Bristol, England, UK.

Pteropus livingstonii is an endemic fruit bat of the Comoros Islands, Western Indian Ocean. Two United Kingdom organizations (Action Comores and Jersey Wildlife Preservation Trust, working through the IUCN Species Survival Commission and in close collaboration with the Government of the Comores) are currently involved in a conservation program for this bat. Active conservation measures taken include the capture of individuals for a *ex-situ* breeding colony at Jersey Zoo, the setting up of in-situ population monitoring schemes, recommendations for legislation and the establishment of reserves. Research includes work on the behavior and feeding ecology, and a comparison of niche separation with other frugivores. The environmental education program has provided materials addressed to all sectors of the Comorien population, on the theme of interdependence of fruit bats, forests and the Comorien people. This paper discusses the conservation and education work, with the dominant themes of collaboration and communication.

RICHARDS, G.C.

THE CONSERVATION BIOLOGY OF AUSTRALIAN BATS: ARE RECENT ADVANCES SOLVING OUR PROBLEMS?

G.C. Richards[1] and L.S. Hall[2]. [1]CSIRO, Canberra, Australia, and [2]University of Queensland, Brisbane, Australia.

Major threats to bats in Australia include land clearance and forest logging, culling of flying foxes in orchards, and disturbance or destruction of colonies in underground roosts. Complicating the resolution of many of these threats is a plethora of taxonomic problems and a lack of basic biological information for many species. Recent advances include our ability to model the effects of forest modification on temperate species and communities, having established that levels of foliage nutrients and habitat structure are primary determinants of habitat utilisation. New developments in exclusion methods in orchards may assist in arresting the losses of flying-foxes through culling practices. The destruction of bat colonies in underground roosts will be reduced through the development of interactive software for the mining industry, allowing the identification of roosts of threatened species before detrimental operations take place. Advances in the computerisation of video imagery, the application of GIS software for morphological mapping, and the procurement of holotypic reference material has improved the potential to resolve taxonomic problems. These recent advances in research methods, combined with the development of a national Bat Action Plan engenders some optimism to which we have the ability to respond, and resolve problems as they are identified. Unfortunately, given the modest number of researchers and a low level of funding, utilising our advances to conserve Australia's bat fauna will remain difficult to accomplish.

ROBERTSON, C.

BAT CONSERVATION: THE REALITIES OF EXCLUSION AND BAT HOUSES.

C. Robertson. Toronto, Ontario, Canada.

Many humans object to sharing their accommodation with bats and there is considerable demand for bat control. Since 1989, I have excluded bats from 1,000 buildings, either *Myotis lucifugus* (n = 951) or *Eptesicus fuscus* (n = 49). Most of the *M. lucifugus* colonies (68.5%) were in 20 to 50 year old brick houses, some (31%) in wood houses, including log buildings and cottages, and a few (0.4%) in field stone buildings 100 to 200 years old. The *Eptesicus fuscus* colonies were usually in 20 to 50 year old brick houses (89%), the remainder (11%) in 1 to 10 year old brick houses. By blocking bat access routes with enerfoam backer and filler, I effectively excluded little brown bats 90 to 100% of the time, big brown bats, 66 to 100% of the time. Bats had entered the buildings under wood trim around windows, at the corners of facer boards and soffits, under the brick work near the soffits, usually at the peak, or along the soffit brick or field stone interface. Since 1993 I have installed 16 bat houses in conjunction with exclusion operations. Two of four bat boxes installed at dormers were occupied by three male little brown bats, while triangular bat boxes installed on the house side of the old vent access route were occupied, each by 350-400 little brown bats. Three of five bat boxes installed on the house side of old soffit access points were used by from 100 to 225 little brown bats, while three boxes installed outside adjacent to soffits were each occupied by from 50 to 400 bats. One large bat house installed inside an attic was not occupied, while another that used wood taken from the old bat roost, was used by 500 female little brown bats. My results demonstrate that exclusion is an effective means of controlling bats in buildings, and, when combined with the installation of bat houses, can encourage bats to use alternate housing.

ROCHE, N.

PREY AVAILABILITY AND HABITAT UTILIZATION BY BATS IN ENGLISH DECIDUOUS WOODLANDS.

N. Roche and P. Elliott. University of Warwick, Coventry, England, UK.

Deciduous woodland is important foraging habitat for bats in Europe. However, little work has been carried out to determine utilization of component sub-habitats and the influence of insect abundance. Woodlands of differing size and similar sub-habitats were chosen as sites for this study. Deciduous woodlands are complicated habitats with many variables influencing bat and bat-prey abundance. Four study sites were divided into sub-habitats such as areas of coppice, wetland, rides and glades. Bat abundance in spring and early summer was estimated in these sub-habitats by walking transects of known length and observing bats using ultrasonic bat detectors and a torch light. Prey availability was studied during the night using a suction trap, a light trap and a sweep net. Variations in weather conditions were recorded at each site with a remote data logger. Field work each month was conducted during the same stage of the lunar cycle. The study examined the use of woodlands by bats and determined the sub-habitat preferences during a single season. Preliminary findings suggest that long rides within dense woodland are used more than other, more abundant, sub-habitats such as areas of coppice, by *Myotis* spp. However, this pattern of use may change during the season.

RODRIGUEZ-DURAN, A.

BAT PREDATION BY THE PUERTO RICAN BOA:
FORAGING ECOLOGY, CARRION FEEDING, AND PIRACY.

A. Rodriguez-Duran. Inter American University of Puerto Rico, Bayamon, Puerto Rico.

The Puerto Rican boa, *Epicrates inornatus*, is a large endemic boid listed as an endangered species by the U.S. Fish and Wildlife Service. I examined the behavior of *E. inornatus* feeding on a large assemblage of bats and the importance of such assemblages as a source of food for this snake. The plant-species composition and patterns of vegetation disturbance during this century were assessed. I estimated the number of bats in the cave and observed the level of bat and snakes activity, as well as the capture and handling of bats. The results suggest that bats are a very important item in the diet of adult *E. inornatus* and that the snakes know the distribution of resources in the environment and remember patches that have temporally predictable qualities.

RYDELL, J.

THE TIME OF EVENING EMERGENCE OF ECHOLOCATING BATS.

J. Rydell[1], G. Jones[2], and P.A. Racey[3]. [1]University of Göteborg, Göteborg, Sweden, [2]University of Bristol, Bristol, England, UK., and [3]University of Aberdeen, Aberdeen, Scotland, UK.

The time of evening emergence of bat species from their roosts is correlated with the species- foraging strategy and diet. Aerial-hawking bats that feed primarily on small dipterans tend to leave their roost much earlier than species which feed on other prey types including non-flying arthropods, moths or plants. In northern Europe, dipterans show a peak in flight activity just before sunset, well before the bats start to feed, and a minimum around midnight, whereas moths are most active around midnight. Since most aerial-hawking bats generally emerge to feed after the peak in flight activity of their insect prey, their foraging flights seem to be constrained at high light levels. Among European aerial-hawking bats, large fast flying species, i.e. those with high wing loading, emerge earlier than more slow flying ones. This suggests that the risk of aerial predation from birds may the direct factor responsible.

SANTOS, M.

THE PHENOLOGY OF CACTI AND ITS RELATIONSHIPS WITH THE BAT COMMUNITY IN A TROPICAL DRY FOREST-THORN SHRUBLAND OF COLOMBIA.

M. Santos[1], A. Ruiz[1], J. Cavelier[1] , and P. Soriano[2].
[1]Universidad de los Andes, Bogota, Colombia, [2]Universidad de los Andes, Merida Venezuela.

The flower and fruit phenology of three columnar- (*Stenocereus griseus, Pilosocereus* sp., *Cereus hexagonus*) and one decumbent-cacti species (*Monvillea smithiana*), were studied during one year (August 1993 to July 1994) at La Tatacoa. The bat community was also studied by means of monthly censuses. Seeds and pollen of the plant species consumed by bats were identified in the feces of the individuals captured in mist nets. Although there were cactus flowers and fruits throughout the year, flowering was concentrated during the two dry seasons and fruiting during the two wet seasons. No overlap in the timing of either flowering or fruiting occurred among cactus species. Fruit production was highest for *S. griseus* followed by *M. smithiana, C. hexagonus* and *Pilosocereus* sp. A total of 518 bats were captured belonging to 23 species. The most common species were *G. longirostris, Carollia perspicillata*, and *Desmodus rotundas*. Only three species (*G. longirostis, C. perspicillata* and *Sturnira lilium*) con-

sumed cactus fruits, and at least one (*G. longirostris*) consumed both pollen and fruits. The trophic structure of the bat community showed that it was composed of insectivorous (46.5%), frugivorous (36.1%), nectarivorous (7.8%), and hematophagous (9.6%) bats. The high density of species like *C. perspicillata* and *D. rotundus*, indicates the perturbation of this dry forest and its transformation into a thorn shrubland.

SASTRY, M.S.

SPERMATOGENESIS IN THE INDIAN FLYING FOX *Pteropus giganteus giganteus*

M.S. Sastry and K.B. Karim. Nagpur University Campus, Nagpur, India, and Institute of Science, Nagpur, India.

This report is based on 10 males of *Pteropus giganteus* collected between July 31, 1990 to December 8, 1991 from a colony roosting on a banyan tree, *Ficus religiosa* within Nagpur City. Males were heavier in weight than females and weighed 600-1000 g. The testis is round in shape and dark purplish in color. The testis size was largest in July (length of right testis 1.9 cm, breadth 1.7 cm, and weight 1.9802 g) and smallest in December (length of right testis 10 mm, breadth 0.9 mm and weight 0.3256 g). In adults, body weight has no correlation with the weight and size of the testis. Although the weight of testis declines in December spermatogenesis continues as evidenced by seminiferous histology and presence of sperm in the epididymis and vas deferens. Histogenesis of the testis during December (weight of male 810 gm, size of right testis--length 1.5 cm, breadth 1.2 cm, weight 1.6239 g) shows the germinal epithelium differentiated into spermatogonia type A and B. The type A rest on the lamina propria and are oval in shape, paler in color with recticular chromatin material. Type B shows active mitotic division and are smaller than type A. The spermatocytes are smaller in size than spermatogonia with a dark compact nucleus. The spermatids are with elongated dark nucleus and residual cytoplasm. Bunches of spermatozoa are seen attached to Sertoli cells which are columnar in shape, extending from the basal lamina of the seminiferous tubule (ST) to the lumen. Groups of Leydig cells are observed amidst connective tissue between ST. Not all of the ST show similar histology. Some ST show only divisions of spermagogonial cells and ST towards tunica albuginea show spermatogenesis. This clearly indicates that there is a definite wave of spermatogenetic activity along the ST.

SCHLANGEN, M.

ACOUSTICAL COMMUNICATION IN THE LESSER SPEAR-NOSED BAT, *Phyllostomus discolor*.

M. Schlangen and U. Schmidt. University of Bonn, Bonn, Germany.

The lesser spear-nosed bat *Phyllostomus discolor*, a highly social phyllostomid, has a variety of social calls. In a laboratory colony, calls of *P. discolor* were recorded on a high frequency tape recorder; simultaneously the behaviour of the bats was recorded on video-tape. The different types of calls were analyzed and coordinated with the different kinds of behavior. With regard to the acoustical parameters, three groups of calls were differentiated: 1) linear modulated calls (3 types), 2) ondulating calls (5 types), 3) complex calls (1 type). Four of the call types were unequivocally related to a definite behavior; for the other five types trends could be shown regarding their behavioral significance.

SCHMIDT, C.

DIFFERENTIATION OF NOISE SIGNALS IN THE COMMON VAMPIRE BAT *Desmodus rotundus*

C. Schmidt and U. Schmidt. University of Bonn, Bonn, Germany.

For finding and identifying its prey, the common vampire bat, *Desmodus rotundus*, relies on passive acoustic cues. It's acoustical sensitivity to low frequency noise is extremely well developed. One possible means by which *D. rotundus* differentiates between prey animals are by individual differences in the noise made during respiration. To establish their discrimination abilities, vampire bats were trained in a Y-maze to distinguish between computer-generated noise signals. Bats were able to discern very slight difference in the amplitude modulation of the signals. These finding support the hypothesis that respiration sounds contribute to prey related orientation in these bats.

SCHMIDT, U.

SPATIAL MEMORY IN BATS:
THE INTEGRATION OF VISUAL, ACOUSTIC AND IDIOTHETIC INFORMATION.

U. Schmidt and P Höller. University of Bonn, Bonn, Germany.

Bats are famous for their ability to orientate by means of spatial memory. They seem to ignore both visual and echo acoustical information, when flying within a familiar space. We investigated whether the bats relied solely on their endogenous spatial information or whether they actually used their exteroceptive sensory systems to avoid unsuccessful attempts to land at a modified target. For this purpose three *Phyllostomus discolor* were trained to proceed directly to and land on a rectangular lattice that was illuminated from behind. In the critical tests, we

replaced the lattice by different non-grid-targets [with an absolutely smooth surface]: 1) grid-projection-target [the same visual pattern and outline like the lattice], 2) rectangular-projection-target (same outline, but no pattern), 3) circular-projection-target [circular outline, no pattern], and 4) noprojection-target [not illuminated]. We found that avoidance behavior of the bats was best in the case of the no-projection-target and worst when the grid-projection-target was installed, although the targets were echo-acoustically identical. To estimate whether the bats used path integration for orientation during certain phases of the flight, we analyzed head-trunk-angles, the body alignment in space and the transverse deviation from the individual mean trajectories. In these experiments the bats used endogenous spatial information during early phases of the flight, whereas on the straight ahead flight towards the target they relied on visual and echo acoustic information.

SCHNITZLER, H.-U.

FORAGING AND ECHOLOCATION BEHAVIOR OF THE FROG-EATING BATS *Trachops cirrhosus* WHEN CATCHING FROGS AND INSECTS.

H.-U. Schnitzler, A. Denzinger, and E.K.V. Kalko,
University of Tübingen, Tübingen, Germany, and Smithsonian Tropical Research Institute, Panama.

The foraging and echolocation behavior of *Trachops cirrhosus* was studied during two 4-week periods at the Smithsonian Tropical Research Institute on Barro Colorado Island, Panama. The foraging behavior of bats catching frogs and large insects in a flight room and at a small pond was documented with a night vision video system. Simultaneous recordings of the echolocation signals allow a correlation of foraging and echolocation behavior. Frogs and sitting insects were caught in the gleaning mode. Sometimes bats also captured flying insects in the aerial mode. Our recordings identify the sensory cues which led bats to their prey. The bats only preyed on frogs or insects which revealed their presence by some kind of acoustical cues, and under favorable circumstances by optical cues. Especially attractive were the tonal advertisement calls of tungara frogs, the flight sounds of large insects, and the noise of a large insect crashing into an obstacle. During the search and approach phases, mulitharmonic and frequency-modulated echolocation signals were emitted continuously. Our results indicate that bats catching frogs and insects in the gleaning mode use prey-generated signals for the detection of the prey and the initial localization of the prey site. Subsequently, echolocation is used to control the approach to the prey site. When catching flying insects in the aerial mode prey-generated signals are used for detection, but the approach to the prey is guided by echolocation. In one case we observed a bat which took a well-illuminated frog from a leaf on the water surface without changing its echolocation behavior. We assume that in this case visual cues guided the bat.

SCHNITZLER, H.-U.

THE ECHOLOCATION BEHAVIOR OF THE GREATER MOUSE-EARED BAT *Myotis myotis*.

H.-U. Schnitzler, A. Denzinger, and I. Kaipf. University of Tübingen, Tübingen, Germany.

It has been shown by fecal analysis that *Myotis myotis* is a gleaning bat which predominantly feeds on rather large terrestrial arthropods. Catches of insects in the aerial mode previously have not been observed. In continuous search flights the bats search for prey in forests but also over meadows. In the field echolocation signals of commuting bats and of bats searching for insects over meadows have been recorded. In the laboratory the foraging and echolocation behavior of bats gleaning prey from surfaces and catching flying insects have been studied. In all situations *M. myotis* use unharmonic and frequency-modulated (FM) signals of wide bandwidth. In commuting bats and in bats searching for prey the signal structure depends on the clutter situation: the more clutter, the shorter the signals, the higher the bandwidth. Gleaning *M. myotis* use prey-generated signals for the detection of prey and the initial localization of the prey site. Afterwards echolocation is used to control the approach to the site where the prey is sitting. In this case the approach sequence lacks a distinct terminal phase as it is typical for other gleaning bats. In bats hunting in the aerial mode the approach to flying insects is guided by echolocation. In this situation the approach sequence ends with a distinct terminal phase as it is typical for other vespertilionids which catch flying insects. The laboratory results indicate that the gleaning bat *M. myotis* also has the potential to forage for flying insects in the aerial mode.

SCHNITZLER, H.-U.

HOW ECHOLOCATING BATS SEARCH FOR AND FIND FOOD.

H.-U. Schnitzler. University of Tübingen, Tübingen, Germany.

Echolocating microchiropteran bats exhibit a wide variety of species-specific search signals which differ in frequency, structure, duration, and sound-pressure level. To understand the adaptive value of signal design the basic sensory tasks which have to be solved by foraging bats will be described and the suitability of typical signal elements for such tasks will be discussed. Habitat types will be defined according to the tasks which they impose on bats and the observed variability in signal design will be related to ecological constraints set by habitat type, feeding

mode, and diet. Finally, this approach will be expanded and all bats will be categorized into guilds characterized by habitat type, mode and diet. It is suggested that this is a promising approach for standardized comparisons of species assemblages, which are essential to understand the high diversity in bats.

SCHOFIELD, H.W.

THE USE OF GIS TO PREDICT THE POTENTIAL DISTRIBUTION OF THE LESSER HORSESHOE BAT, *Rhinilophus hipposideros* IN THE UK.

H.W. Schofield. the Vincent Wildlife Trust, London, UK.

Predicting the poitnetial distribution of endangered bat species has an important role in conservation biology. It is necessary for the successful implementation of species recovery programs by predicting areas where such programs are most likely to succeed. In this study, the phyysical and biological features of roost localities of *R. hipposideros* were characterized from known sites. A GIS was then used to project the potential distribition of the species based on this combination of features by identifying all areas where the combination occurs. The land classes preferred by *R. hipposideros* were identified as those where the proportion of each landclass in 1 km^2 containing roosts exceed the proportion in 1 km^2 for England and Wales as a whole. An initial potential distribution was generated based on the presence of these landclasses. This distributuioin was refined using statellite data of habitat cover. Habitat preference was determined by comparing differences in the density of habitat in 1 km^2 surrounding breeding roosts, with 500 randomly selected 1 km^2 from the generated distribution. The areas in the intital potential distribution with higher than median preferred foraging habitat were selected.

SCHUTT, JR., W.A.

VAMPIRE BAT HINDLIMB MORPHOLOGY AND THE EVOLUTION OF BLOOD FEEDING.

W.A. Schutt, Jr. Cornell University, Ithaca, New York, and American Museum of Natural History, New York.

Comparative hindlimb morphology of three vampire bat genera has shown variation related to arboreal vs. terrestrial feeding. *Desmodus rotundus* and *Diaemus.youngi* share derived hindlimb character states related to terrestrial blood-feeding and locomotion. Sturdy hindlimb bones (with increased surface areas for muscle attachment) and the insertion position of the semitendinosus and gracilis muscles (proximal to the knee) appear to be adaptations for rapid and agile terrestrial locomotion. The close phylogenetic relationship of *D. rotundus* and *D. voungi*, coupled with reports of dietary flexibility and terrestrial feeding behavior in *D. youngi*, support the following possibility: competition with *D. rotundus* may have led *D. youngi* to undergo a dietary shift to primarily avian blood. *Diphylla ecaudata*, exhibits hindlimb character states which are primitive for vampire bats. These include incomplete fibulae and hindlimb bones with reduced surface areas (relative to the same bones in *D. rotundus* and *D. youngi*). Additionally, the distal insertion of the gracilis and semitendinosus muscles suggest an important role for these muscles in knee flexion. *Diphylla ecaudata* possesses a uniquely digitiform calcar which is apparently employed as an opposable sixth digit during arboreal feeding and locomotion. Finally, a new theory proposes that blood feeding in bats originated in arboreally feeding, omnivorous phyllostomids. The arboreal omnivore theory is based upon the following: 1) Unlike the parasite and wound-feeding theories, omnivory is a feeding mode exhibited by a number of extant bat species (including several phyllostomids), 2) Behavioral and morphological similarities exist between omnivorous phyllostomids and vampire bats, 3) Arboreal feeding and locomotion appears to be a primitive condition in vampire bats, 4) The ability to exploit larget arboreal species as prey may have provided the selective pressure for protovampires to adopt a blood-feeding lifestyle.

SCOTT, M.G.

THE DETECTION OF ATMOSPHERIC PRESSURE CHANGES BY BATS.

M.G. Scott and G.L. Vaughan. University of Tennessee, Knoxville, Tennessee.

The ability to detect atmospheric pressure changes may be critical for flying animals as a means of obtaining altimetric and meteorological information. However, little is known about how well bats detect atmospheric pressure changes. The inference that bats can detect changes in atmospheric pressure associated with weather patterns has been supported in two studies that correlated flight and/or foraging activity of temperate insectivorous bats with changes in atmospheric pressure. In a preliminary study, we found that three species of temperate insectivorous bats (*Eptesicus fuscus, Myotis velifer* and *Tadarida brasiliensis*) appear to be very sensitive to rapid atmospheric pressure changes. Bats of all three species exhibited spontaneous changes in ventilation rate when exposed to induced atmospheric pressure changes typical of those they might encounter during flight; 0.35 kPa, equivalent to a 35 m change in altitude over 15 sec. The current investigation is utilizing behavioral conditioning procedures with *E. fuscus* to better examine how well this species can detect rapid changes in atmospheric pressure and whether it can discriminate between increases and decreases in pressure.

SEDGELEY, J.

A TECHNIQUE FOR HARP TRAPPING AT BAT ROOSTS IN TALL FOREST CANOPY.

J. Sedgeley and C. O'Donnell. Department of Conservation, Christchurch, New Zealand.

Long-tailed bats *Chalinolobus tuberculatus* roost high in trees (mean = 15.7 m, range = 1.7-32 m, n=62) in temperate rain forest in Fiordland, New Zealand. We describe a harp-trapping technique used directly at these roosts for sampling the composition of bat groups. A preliminary study of roosting showed that 60% of long-tailed bat roosts were only occupied for one night (range = 1-7, n = 22), implying that there was little risk of disturbing them. The harp trap (Austbat Research Equipment, Australia) was originally designed to stand on the ground and to be easily collapsable. Simple modifications, as described, were required to prevent the trap from falling apart when hoisted into trees. To hoist the trap into a tree a line was fired over a branch above the roost hole using a slingshot to dispense a lead weight and light line from a fishing reel. The line was then used to pull over an 11 mm static climbing rope and the rope then attached to a harp trap. Correct positioning in front of the roost hole is important to achieve optimal capture rates. We captured on average 78% of bats in a roost (SD = 20, range = 37-100, n = 14). We consider that harp-trapping directly at the roosts had no adverse effects on the bats. We minimized disturbance of the population by only trapping at a small proportion (10%) of roosts we found. Average occupancy of roosts trapped (mean = 1.6 days, range = 1-5, n = 20) was the same as those not trapped (mean = 1.6, range = 1-9, n = 172) and bats returned to 40% of roosts the day after trapping, compared to 30% for roosts that were not trapped (the difference was not significant). This technique enabled us to record details of group structure and dynamics and breeding which we would otherwise be unable to observe.

SEYJAGAT, J.

BAT CONSERVATION INITIATIVES OF THE LUBEE FOUNDATION, INC.

J. Seyjagat, The Lubee Foundation, Inc., Gainesville, Florida.

The initiatives of the Lubee Foundation, Inc. are three fold: research, education, and captive propagation, with emphasis on the conservation of Old-World fruit bats. In collaboration with researchers at several institutions, the Lubee Foundation supports research on reproduction, ecology, behavior, conservation, nutrition, and clinical veterinary medicine. Research on captive bats has focused on reproduction (including growth and development, lactation, and endocrinology), metabolism (basal metabolism, flight energetics, and thermoregulation), behavior (feeding, social, and communication), dietary and nutritional studies, genetics, and the development of non-invasive techniques for use in field-based conservation research. Field research, conducted mostly on endangered and endemic species in the Philippines, Papau New Guinea, and Malaysia, focus on field surveys, community structure, feeding ecology, reproductive biology, social behavior, and rooting ecology. Education and research programs include the sponsorship of a small grants program for graduate students, a research grant program for scientists, community outreach programs, and the support of national and international workshops and conferences on bats. As a captive breeding facility, the Lubee Foundation maintains the world's largest and most diverse collection of Old-World fruit bats (*Pteropus vampyrus, P. hypomelanus, P. pumilus, P. rodricensis, Cynopterus brachyotis,* and *Eidolon helvum*). The Lubee Foundation also is a partner in international conservation and propagation programs, including those involved with the Rodrigues flying fox (*Pteropus rodricensis*), Pemba island flying fox (*P. voeltzkowi*), the naked back bat (*Acerodon leucopterus*) in Papau New Guinea, and the golden crown flying fox (*Acerodon jubatus*) in the Philippines.

SHEEN, G.C.

EFFECT OF SC LESIONS ON PREY-CAPTURE BEHAVIOR IN THE FM-BAT, *Eptesicus fuscus*.

G.C. Sheen, L.D. Taft, and C.F. Moss. Harvard University, Cambridge, Massachusetts, USA.

Echolocating bats orient in the environment by emitting high-frequency sounds and listening to reflecting echoes from surrounding objects. Features of these echoes allow the bat to estimate target azimuth, elevation, and range. The bat uses these spatial cues to adjust its motor behavior, such as sonar vocalizations and head aim, when tracing and intercepting prey. Previous work has implicated the superior colliculus (SC) in a sensorimotor feedback system coordinating motor control over acoustical cues. To further study the role of the SC in a goal-oriented behavioral task, blinded FM-bats (*Eptesicus fuscus*) were trained to capture tethered and moving insects in the laboratory, with a success rate of >80%. Synchronized high-speed video and audio recordings documented the animal's flight behavior and sonar emissions during pursuit. Following electrolytic and/or chemical lesions, the animals displayed profound deficits, missing or completely neglecting the tethered insect. However, they continued to fly and to produce active sonar emissions. The extent of the deficit appears to vary with the size and laterality of the lesion.

SHOMITA, S.B.

LIGHT AND ELECTRON MICROSCOPE STUDY--RE-EXAMINATION OF THE PLACENTAL BARRIER IN *Rousettus leschenaulti* AND *Cynopterous sphinx gangeticus*.

S.B. Shomita and D.A. Bhiwgade. Institute of Science, Bombay, India.

This study was initiated because the complex relationship between the trophoblast and the maternal blood in the chorio-allantoic placental of pteropodid bats has been variously interpreted by different authors and lacks a definite resolution. Using light and electron microscopy, we examined the chorio-allantoic placental barrier of the fruit bat, *Rousettus leschenaulti*. The future cytotrophoblast and syncytiotrophoblast layers can be distinguished shortly after implantation. Our studies also have shown that the maternal endothelium is absent from as early as the trilaminar blastocyst stage of the gestation and the concomitant placentation is hemodichorial throughout gestation. In both *R. leschenaulti* and *Cynopterus sphinx gangeticus*, inner to the syncytiotrophoblast layers, facing the maternal blood, can be seen a discontinuous acellular layer called intrasyncytial lamina, through its discontinuities, syncytium flows and occupies the area of the maternal endothelium. The definitive chorio-allantoic placentation in both species is hemodichorial since the syncytiotrophoblast and cytotrophoblast persists to term.

SIMMONS, J.A. WHAT BATS "SEE" WITH THEIR SONAR.

J.A. Simmons. Brown University, Providence, Rhode Island.

Do echolocating bats perceive objects as having specific features and being located at specific positions in space, or do they perceive auditory attributes whose correlation with the spatial environment is adequate to account for spatially-oriented behavior? During pursuit of individual flying insects well away from other objects in open areas (so echoes are discrete, isolated sounds), any bat could detect, approach, track, and intercept the target with knowledge of little more than azimuth and elevation from one echo to the next. Perception of distance, size, or shape is not necessary. In fact, however, bats adjust their approach and tracking behavior to accommodate distance, indicating that they also perceive this feature from one echo to the next. Moreover, FM bats can distinguish among simultaneously or sequentially presented targets entirely by shape, and CF bats can detect and even recognize fluttering objects in both open space and clutter. Echolocating bats of all types are capable of using sonar to guide flight through obstacle-strewn surroundings and often to pursue flying insects while doing so. These tasks are vastly more demanding--requiring simultaneous knowledge of the distance and direction of more than one object at a time, including identifying characteristics of the insect referred to its specific location. For FM bats, this implies perception of some sort of 3-D spatial image with a variety of features imbedded in a fundamental dimension of FM echo delay or target range. Analysis of obstacle-avoidance and interception flights reveals a minimum delay acuity of 5-10 s, and, when tested in lower-uncertainty tasks, FM bats exhibit delay accuracy of 0.01 s and resolution of 2 s. Multiple-target situations can only be imaged by segregating each reflected replica of the transmitted sound from the incoming echo stream and assigning it an arrival-time at each ear, which requires the equivalent of at least partial reconstruction of the time-series waveform of echoes in the brain. Astonishingly, physiological mechanisms for reconstructing features of echo delay and phase have now been identified in the auditory midbrain and cortex of bats.

SIMMONS, N.B.

HIGHER-LEVEL RELATIONSHIPS OF MICROCHIROPTERAN BATS

N.B. Simmons. American Museum of Natural History, New York.

Hypotheses of relationship provide an important framework for comparative biological studies. While most bat species can be easily assigned to one of several monophyletic families, there is little agreement concerning interfamilial and subfamilial relationships. This is not just a problem of resolution: previous hypotheses are largely incongruent. Lack of a well-substantiated phylogeny has hampered attempts to understand patterns of morphological and molecular change among species, and has made interpretation of biogeographic, ecological, and behavioral data more difficult. To address this problem, I am using a "total evidence" approach to construct a higher-level phylogeny of microchiropteran bats using Megachiroptera and Dermoptera as successive outgroups. Data on craniodental morphology, postcranial osteology and myology, fetal membranes, reproductive tract morphology, secondary sexual characteristics, and rDNA restriction sites have been combined in a single data set for this purpose. Preliminary results of parsimony analyses suggest the following: 1) all currently recognized families appear to be monophyletic with the possible exception of Vespertilionidae; 2) Rhinolophoidea and Phyllostomoidea are each monophyletic; 3) Hipposideridae and Rhinolophidae are sister taxa; 4) Emballonuroidea is paraphyletic (Rhinolophoidea nests within this group); and 5) Yinochiroptera is monophyletic. In the current study, the greatest resolution and stability is found in the yinochiropteran portion of the tree. Monophyly and relationships within Yangochiroptera, Vespertilionoidea, and Vespertilionidae remain unclear. Future work on the project will include filling in gaps in the data set, inclusion of fossil taxa, work on new morphological characters, and inclusion of behavioral traits in the analysis.

SIMMONS, N.B.

A PRELIMINARY ASSESSMENT OF SPECIES LIMITS IN THE SUBGENUS *Micronycteris* (CHIROPTERA: PHYLLOSTOMIDAE).

N.B. Simmons. American Museum of Natural History, New York.

The subgenus *Micronycteris* is a monophyletic group of small to medium-sized Neotropical bats believed to be specialized for gleaning insects. Diagnostic features of the subgenus include presence of a notched band of skin between the ears, bicolored dorsal fur (brown with white bases), and a metacarpal formula (shortest to longest) of 3-4-5. As such, the subgenus *Micronycteris* includes *hirsuta* as well as those species traditionally referred to the subgenus. Discovery of six sympatric species at a locality in French Guiana inspired a study of character differentiation, species limits, and biogeography in the subgenus. Significant preliminary results include the following: 1) *megalotis* and *microtis* are distinct species that can be easily distinguished on the basis of external characters; *megalotis* is apparently restricted to South America, while *microtis* ranges from Brazil to at least Nicaragua; 2) many specimens identified as *megalotis* in museum collections are actually *microtis*, while still others represent an undescribed species (n. sp. A) that ranges from Peru to Brazil and French Guiana; 3) *mexicana*, which ranges from western Costa Rica and Nicaragua to central Mexico, is either a subspecies of *microtis* or a distinct species; it is not a subspecies of *megalotis*; 4) *schmidtorum* ranges from Brazil to southern Mexico, while *minuta* occurs from Bolivia to Nicaragua; several Brazilian specimens previously referred to these taxa actually represent an undescribed species (n. sp. B) closely related to *minuta*.

SINGH, U.P.

SEASONAL CHANGES IN THE PITUITARY CELL TYPES OF THE TROPICAL VESPERTILIONID BAT, *Scotophilus heathi* WITH REFERENCE TO DELAYED OVULATION.

U.P. Singh and A. Krishna. Banaras Hindu University, Varanasi, India.

The anterior pituitary cell type (TSH, LH, FSH, PRL and ACTH) were identified by peroxidase antiperoxidase (PAP); techniques in the pars-distalis (PD) during various reproductive phases in female *Scotophilus heathi*. LH, FSH and PRL cells exhibited significant variation during reproductive cycle of female *S. heathi*. The areas of the PD occupied by LH and FSH cells were significantly ($p<0.05$) higher during winter dormancy and the breeding phase as compared to quiescent phase. The percentage area of PD occupied by LH and FSH cells declined in March following ovulation and remained low during pregnancy and quiescence. The area of PD occupied by PRL cells varied from minimum during winter dormancy to a maximum during pregnancy. Several of the PRL cells exhibited degranulated appearance during delayed period (winter dormancy) suggesting PRL release. The area occupied by TSH and ACTH immunoreactive cells did not show any significant ($p>0.05$) variation during the reproductive cycle. No evidence of involution was observed in the PD cells during period of delayed ovulation.

SMITH, C.L.

PAIR ASSOCIATIONS IN ROOSTING GROUPS OF GREATER SPEAR-NOSED BATS, *Phyllostomus hastatus*.

C.L. Smith. University of Maryland, College Park, Maryland.

The observed behavioral patterns of female greater spear-nosed bats, *Phyllostomus hastatus*, led to the investigation of pair and trio associations in roosting groups. Previous research has shown that females form long-term, highly cohesive roost groups and that group members forage in pairs and trios over several nights. It is also known that pups disperse from their maternal roost group each year and that many groups contain half-siblings. The nature of this species' social structure creates an environment in which pair and trio associations may exist among roost members. If these associations do exist, they may be reflected in the position of a given female within her roost group. The data used in this study was collected from two groups of captive *P. hastatus* which are housed at the National Zoological Park in Washington, D.C. Every day over a one year period the position of each bat within the roost was recorded on a roost diagram. Three days of data per week were analyzed. A digitizing program converted the bats' position to a set of coordinates which were subsequently used to calculate the distance of each bat to every other bat in the roost. From the pair-wise distances, a matrix was constructed for each day and a Mantel test was used to generate a randomized set of matrices to conduct comparisons. These randomized matrices are currently being used to determine the likelihood that these observed distances are due to chance alone. Similar methods will be used to ascertain the duration and frequency of any observed associations.

SPENCER, H.J.

SECRETION OF MARKING FLUID FROM THE PENIS OF THE SPECTACLED FLYING FOX, *Pteropus conspicillatus*.

H.J. Spencer and B.H. Flick.
Cape Tribulation Tropical Research Station, Cape Tribulation, Queensland Australia.

A 10-minute video will be shown of two adult male *Pteropus conspicillatus* anointing their neck ruffs with a cranberry-red secretion produced from their urinogenital tract. A male *Pteropus scapulatus* exhibited the same behavior but the secretion was straw colored, and thus not noticeable. This secretion has been analyzed, and contains a high concentration of a long chain fatty acid (molecule size and identity not yet available). The site of secretion is still unknown, and males which have recently died from tick paralysis often have their bladders full of this red solution, which appears mixed with the urine. No obvious glandular structures, other than the prostate, are likely candidates. This secretion and the extracted fatty acid appears to be largely responsible for the characteristic smell of the male bats.

SPENCER, H.J.

MIDWIFE CARE OF BIRTHING IN THE BLACK FLYING FOX, *Pteropus alecto*.

H.J. Spencer and B.H. Flick, Cape Tribulation Tropical Research Station, Cape Tribulation, Queensland Australia.

A one-hour video is presented of a hand-reared black flying fox, Annie, who is assisted during parturition by a co-reared female black flying fox, Alexis (both reared in 1986 by Ted Fleming while on sabbatical at James Cook University in Townsville). Alexis supports Annie during her labor, and becomes actively involved in the cleaning the partly and completely emerged infant. The larger flying foxes, which include the black flying fox, are not noted for mutual grooming behavior, and this behavior between this pair has been consistently observed by us over the last four births of Annie's. Alexis has never been pregnant.

SPENCER, H.J.

HAND-REARING AND RELEASE OF ORPHANED FLYING FOXES (*Pteropus* spp.) IN EASTERN AUSTRALIA--A SIGNIFICANT ACT FOR SPECIES CONSERVATION OR MERELY MISGUIDED EFFORTS?

H.J. Spencer and B.H. Flick. Cape Tribulation Tropical Research Station, Cape Tribulation, Queensland, Australia.

Flying foxes of the genus *Pteropus* are represented by four species in eastern Australia (*P. poliocephalus, P. alecto, P. conspicillatus;* and *P. scapulatus*), many of which are come to grief and to the attention of would-be rescuers. Judging from the 1931 pioneering observations of Radcliff, flying foxes are considered to be in severe decline in Australia. Most of the decline is due to habitat reduction and the shooting of bats as vermin. Flying foxes are currently protected in all states, but the death rate from misadventure can be very high. Chief accidents befalling flying foxes are being caught on barbed wire fences, electrocution on powerlines, occasional severe heatwaves, and locale-specific problems such as tick paralysis. During parturition, September to December for the three largest species, and May-June for *P scapulatus*, the problems are worsened by the fact that the victims are frequently females carrying young, and the young animals often survive their mother's death. With the exception of heatwaves, the other causes of death are all related to the impact of humans on the environment. In most major coastal cities, there are several flying-fox rescue groups, which often attempt to rehabilitate the injured adults, collect the juveniles and distribute them to volunteers for foster care, and retrieve them after five to six months for release into the wild. The degree of expertise and commitment available is very great, and it appears that the success of deliberate reintroduction of the juveniles is high. Death rates from tick paralysis in north Queensland, directly attributable to human impact on the environment, has been estimated as high as 34,000 bats per year. For an animal with a low recruitment rate, we assume this has a major impact on flying fox populations. While the rehabilitation of flying foxes gives them a high profile, and increases calls for their protection, the actual biological impact of rescue efforts must be determined.

STADEN, D.V.

THE ECHOLOCATION AND FORAGING BEHAVIOR OF BECHSTEIN'S BAT (*Myotis bechsteini*).

D.v. Staden and H.-U. Schnitzler. University of Tübingen, Tübingen, Germany.

The foraging and echolocation behavior of Bechstein's bat was studied in the field and laboratory. *Myotis bechsteini* is a small vespertilionid (about 10 g) with rather long ears, and is found throughout Europe. It displays both substrate-gleaning and aerial modes of foraging. When flying to its hunting grounds *Myotis bechsteini* emits uniharmonic frequency-modulated (FM) signals of large bandwidth (38-110 kHz) with an average duration of 1.9 ms and an average pulse interval of 74 ms. To study the substrate gleaning mode we offered mealworms and various

species of other insects sitting on a substrate in the laboratory. Because bats even found noisy, hidden insects we conclude that they use prey-generated acoustic cues to detect and locate the insects. During the approach phase, the bats reduced pulse duration and pulse interval, but they did not produce a terminal phase. We assume that in this situation the bats use echolocation to control their approach flight but not for detection and localization of the prey. To describe the aerial mode we offered either flying insects or insects tethered to a fine string. When approaching their prey, the bats also reduced pulse duration and pulse interval without producing a distinct terminal group at the end of the approach sequence. We assume that in this situation echolocation is used to detect and locate the prey. In most situations the echolocation signals sweep down to a terminal frequency of about 38 kHz. Only in a few pulses at the end of an approach sequence is the terminal frequency raised up by 25 kHz. Since *Myotis bechsteini* never showed a distinct terminal phase we conclude that it primarily hunts in the gleaning mode in highly cluttered situations where it uses acoustic cues to detect and locate the prey, and echolocation to control the approach to the prey site. However, Bechstein's bat is also able to use echolocation to detect, locate and catch insects flying close to vegetation in edge and gap situations.

STEPNIEWSKA, A.

BAT RESEARCH AND CONSERVATION IN THE GDANSK COASTAL AREA (NORTHERN POLAND).

A. Stepniewska, T. Jarzembowski, and A. Przesmycka. University of Gdansk, Gdansk, Poland.

Until recently most data on the bat fauna of the Gdansk coastal area were based on accidental records. In 1992 the Gdansk Chiropterological Group was established by biology students from the University of Gdansk. The main objectives of the group are to encourage faunistic knowledge on bats and to increase public awareness of bat conservation. Training and educational programs--consisting of courses, lectures and workshops--were developed and put into practice. Field studies are focused on the coastal area along the Gulf of Gdansk and the surrounding countryside. Fieldwork includes locating and surveying winter roosts and mapping species distributions based on foraging bats in summer. At some sites bat boxes have been erected in order to study ecological aspects of tree-dwelling species. Since the group's inception a substantial number of new records have been added to the previously scant data. Ten bat species have now been recorded from the area.

STERN, A.A.

THE ENERGETICS OF PUP GROWTH AND LACTATION IN THE GREATER SPEAR-NOSED BAT, *Phyllostomus hastatus* (CHIROPTERA: PHYLLOSTOMIDAE).

A.A. Stern. Boston University, Boston, Massachusetts.

Lactation is potentially the most energetically expensive event of a female mammal's life. Few studies have quantified this cost in free-ranging animals, where foraging, locomotory, and thermoregulatory expenditures may be several times greater than in captive animals. I measured the energetic costs of lactation in *Phyllostomus hastatus*, an 80-g tropical omnivore. Using doubly-labeled water to measure energy expenditure and water flux in free-ranging lactating females and pups, I was able to quantify milk production and energy expenditure throughout lactation. Water flux in pups, which indicates food intake, increased linearly with the exception of a temporary decrease during weaning. Pup energy expenditure showed no decrease during weaning, increasing linearly through day 100 when the study was terminated. These data suggest that weaning is a time of high energy expenditure and variable foraging success, and may explain the phenomena of fat deposition in pups just before weaning. The range of energy expenditure in males over a five-month period was similar to that of females in all stages of lactation, suggesting that the costs of harem maintenance persist beyond the breeding season. Energy expenditure by lactating females significantly exceeded predictions. Energy expenditures for *P. hastatus* during early, mid-, and late lactation were 3.05, 6.81, and 4.24 ml CO_2 g^{-1} h^{-1}, respectively. FMR of females at peak lactation was 7.8 times BMR. This value during peak lactation of a mean FMR in excess of seven times BMR is the highest recorded for a mammal, and may explain why this species bears only single young. The high variability in maternal energy expenditure, which parallels variation in milk composition and foraging time, may contribute to differential reproductive success in females.

STORMARK, T.A.

BAT SONAR SEARCH CALLS FROM SOUTHERN NORWAY.

T.A. Stormark. University of Bergen, Bergen, Norway.

Sonar search calls of *Myotis* spp., *Nyctalus noctula*, *Eptesicus nilssonii* and *Pipistrellus* spp. from southern Norway were analyzed using 10 frequency and temporal parameters. Interrelation and variation of the parameters were analyzed within taxa. Principal components and discriminant analysis were performed to test

subjective species identifications based on behavior. Depending upon the species, most variability was found in initial frequency and prepulse interval, whereas peak and terminal frequency showed least variability. Distinct bimodal distribution in *Pipistrellus* spp. indicated presence of two distinct taxonomic groups not hitherto described in Norway.

STUDIER, E.H.

CONCENTRATIONS OF MINERALS AND NITROGEN IN *Carollia* MILK.

E.H. Studier[1], S.H. Sevick[1] and D.E. Wilson[2]. [1]University of Michigan, Flint, Michigan, and [2]Smithsonian Institution, Washington, D.C.

While concentrations of nitrogen and minerals (magnesium, potassium, sodium, calcium, and total iron) in bodies of bats are quite similar, levels of those elements in the highly diverse foods consumed by bats vary widely. As a part of a broader goal of studying whether dietary composition relates to composition of milk of bats, nitrogen and mineral levels were measured in milk of some *Carollia castanea*, *C. perspicillata*, and *C. brevicauda* as well as in infructescences of one of their common foods, *Piper*. Compared to other mammals, *Carollia* milk is high in potassium, low in calcium, and contains typical levels of magnesium, sodium and total iron. Compared to milk of the insectivorous *Tadarida brasiliensis*, *Carollia* milk is low in nitrogen. High potassium and low nitrogen concentrations in *Carollia* milk are similar to levels of those elements in *Piper*. Low levels of calcium in milk of *Carollia* may reflect slow postnatal growth in those bats compared to *Tadarida*. The more nutrient-dense milk of *Tadarida* may also reflect its greater renal capacity to conserve water, an option not available to *Carollia*.

SWARTZ, S.M.

SKIN AND BONES: THE MECHANICAL PROPERTIES OF BAT WING TISSUES.

S.M. Swartz. Brown University, Providence, Rhode Island.

The flight performance of bats depends not only on patterns of wing movements during the generation of lift and thrust but also on the mechanical properties of the structural support tissues. To better understand the relationship between flight ability and wing morphology, I have examined the function, architecture, and mechanical characteristics of bat wing bones and wing membrane skin, drawing both on in-depth functional analysis of a single species *(Pteropus poliocephalus)*, and on broad comparative analyses. I assessed skeletal loading with *in vivo* bone strain analysis; examined key aspects of structural geometry and allometric patterns in the limb skeleton from high resolution radiographs; measured stiffness and strength of bat wing bones in both torsion and bending; and carried out mechanical tests on skin from several regions of the wing membrane. During flight, the function of the bones of the armwing and the handwing are clearly distinct from one another: proximal elements experience significant torsional loads and distal elements are loaded in extreme dorsoventral bending. This functional differentiation is reflected in cross-sectional geometry; the humerus and radius are circular and exceptionally thin-walled, while the metacarpals and phalanges are compressed and thick-walled or completely solid. Scaling patterns also differ among wing regions. Material properties map onto this proximodistal gradient, with stiffness, strength and density decreasing with distance from the shoulder, in coordination with geometric changes. Wing membrane skin also reflects the functional differences among wing regions. The plagiopatagium is the most extensible and weakest part of the wing, the dactlyopatagium is the least extensible region, and the uropatagium supports the greatest loads at failure. Furthermore, wing membrane skin is unique among mammals in its high degree of anisotropy, and is stiffest and strongest parallel to the wing bones and most extensible perpendicular to the bones, in parallel to the wing's trailing edge. Comparatively, we find greater energy absorption and load at failure in the species with the highest wing loading.

TAVARES, V.C.

ASPECTS OF THE "IPANEMA BAT" BIOLOGY *Pygoderma bilabiatum* (PHYLLOSTOMIDAE), IN A BRAZILIAN RESERVE.

V.C. Tavares. Federal University of Minas Gerais state, Belo Horizonte, Brazil.

Several aspects of the *Pygoderma bilabiatum* biology have been studied by means of captures with mist nets. This work has been conducted from November 1993 to February 1995 in the Estação de Pesquisa Desenvolvimento Ambiental de Peti, a reserve which is in the east of Minas Gerais state, Brazil (43°22'W, 19°53'S). The "Ipanema bat" was captured in a secondary growth forest which was in an antropical influence area. Although not many *P. bilabiatum* have been captured, it is not a rare species. No specimens have been captured during the cold and dry months (June, July and August). This species bites its food laterally, using its molars and pre-molars. It has an agile and slow flight ("speed index" = 18.83 km/hour) and good propulsion ("tip index" = 2.47). Pollen and amorphous plant material have been found in its stomach and digestive tract. *Pygoderma bilabiatum* has a long wingtip (similar to the Glossophaginae) and its fecal, stomach, and intestinal materials analyzed suggest a predom-

inantly frugivorous diet, supplemented with nectar. Sexual dimorphism in this species is not determined by the degree of the facial glands, but by differences in size between males and females (cranial and external measurements). This bat's sexual activity appears to be concentrated in the second half of the year, when pregnant females were captured (September and November) together with a lactating female (November).

TAYLOR, D.A.

THE NORTH AMERICAN BATS AND MINES PROJECT: A COOPERATIVE APPROACH FOR INTEGRATING BAT CONSERVATION AND MIND-RECLAMATION.

D.A. Taylor. Bat Conservation International, Inc., Austin, Texas.

Abandoned underground mines have become essential habitat for North American bats. Tens of thousands of abandoned mines have already been closed across North America without consideration for bats, and thousands more are slated for closure. Available evidence suggests that millions of bats have already been lost. The continued closure of abandoned mines without consideration for bats could endanger even currently abundant species. This threat to bat survival is cause for serious concern. The North American Bats and Mines Project (NABMP) is a partnership effort between BCI and the U.S. Bureau of Land Management created to address this critical conservation issue. The NABMP is providing national coordination and leadership among federal, state, and private agencies and the mining industry to minimize the loss of bats living in mines. This is being accomplished by: 1) educating the public and natural resource managers on the importance of mines for bats; 2) providing training on assessment and closure methods that protect both bats and people; 3) producing the *Bats and Mines* Resource Publication and other information required to assess and protect mines for bats; 4) providing assistance to agencies and industry to protect and enhance existing abandoned mine roosts; 5) ensuring that bat conservation language is incorporated into state and federal mine land reclamation legislation; and 6) developing techniques to create new bat habitat during mine land reclamation.

THIES, W.

THE ROLE OF ODOR AND ECHOLOCATION IN TWO SPECIES OF *Carollia* (PHYLLOSTOMIDAE) FORAGING FOR *Piper*.

W. Thies, E.K.V. Kalko, and H.-U. Schnitzler.
University of Tübingen, Tübingen, Germany and Smithsonian Tropical Research Institute, Panama.

The neotropical leaf-nosed bats (Phyllostomidae) represent the most diverse family of bats worldwide, not only in terms of species numbers but also in the use of food resources. Only in this family one can find insectivorous, omnivorous, carnivorous, frugivorous, nectarivorous and sanguivorous bats. Although these bats use different food sources the habitat they live in is remarkably similar. All members of the family search for food in dense vegetation or along the edge of vegetation. An interesting question is how these bats orient in their habitat and how they find and assess their special food. Laboratory studies indicate that phyllostomid bats use acoustical, olfactory or visual cues to find food. However, there is almost nothing known about the role of echolocation in the foraging behavior of phyllostomid bats. We present the results of a study on the foraging and echolocation behavior of two frugivorous bats (C. *perspicillata* and C. *castanea*). The work was done with untrained animals in a flight cage on Barro Colorado Island, Panama, the tropical field station of the Smithsonian Tropical Research Institute. A branch with a ripe *Piper* fruit was offered and echolocation and foraging behavior were documented simultaneously. Both *Carollia* species show a typical foraging pattern. During foraging both species of *Carollia* always produces echolocation signals. However, experiments with artificial and real fruits showed that both species of *Carollia* use odor as a sensory cue for the initial detection and localization of ripe *Piper* fruits. After detection a bat approaches a branch with the ripe fruit several times and finally tears it off in flight. We conclude that during the approach flights the bats make a transfer from imprecise olfactory localization to the precise localization of the fruit by echolocation. Furthermore we conclude that the final approach is mainly guided by echolocation.

THOMAS, D.W.

HIBERNATING BATS ARE SENSITIVE TO NONTACTILE HUMAN DISTURBANCE.

D.W. Thomas. University de Sherbrooke, Sherbrooke, Quebec, Canada.

Previous laboratory studies of auditory systems and metabolic rates of hibernating bats have indicated that bats are insensitive to nontactile (sound and light) stimuli while in deep torpor. However, anecdotal evidence indicates that bats arouse in response to the presence of humans in the hibernacula, suggesting that in the field they are sensitive to nontactile stimuli. I tested the sensitivity of hibernating bats to human disturbance using infra-red detectors placed in a hibernaculum containing about 1,276 *Myotis lucifugus* and *M. septentrionalis*. During days preceding our visits to the hibernaculum, flight activity was extremely low. However, flight activity began to in-

crease 30 min after a visit, peaked 1-2 h later, and remained significantly above pre-visit levels for 2.5-8.5 h. These data show that a proportion of hibernating bats are sensitive to nontactile disturbance and that visits to hibernacula can have a severe impact on activity and hence fat reserves.

THOMAS, N.

SYSTEMATICS OF THREE SPECIES OF *therhinolophus ferrumequinum* COMPLEX IN ASIA AND AFRICA

N. Thomas. Harrison Zoological Museum, Kent, England, UK.

Systematic studies often use only a single technique (e.g., biochemical analysis) in determining taxonomic relationships. This can mean that the problems addressed by the study are not comprehensively resolved, as only one aspect of the data is examined. The aim of this study is to combine morphological, morphometric and biochemical techniques to address a complex taxonomic problem within the Rhinolophidae. Interpretation of the morphological similarities between Eurasian *Rhinolophus ferrumequinum*, Caucasian *R. bocharicus* and African *R. clivosus* has led to considerable divergence of views as to their taxonomic relationships. There is no doubt that these taxa are closely related, but the nature of this relationship is questionable. These taxa have been treated as distinct species by some authors, while others have either considered *clivosus* and *bocharicus* to be subspecies of *R. ferrumequinum*, or have included *bocharicus* as a subspecies of *R. clivosus*. Morphometric analysis (CVA) carried out to date has recognized *R. bocharicus* as a distinct species, but could not distinguish between *R. clivosus* and *R. ferrumequinum*. It is expected that phenetic and DNA analysis will provide comprehensive results regarding the taxonomic status and relationship of these two taxa.

THOMAS, S.P.

METABOLIC AND VENTILATORY ADJUSTMENTS AND TOLERANCES OF THE BATS *Pteropus poliocephalus* AND *Phyllostomus hastatus* TO ACUTE HYPOXIC STRESS.

S.P. Thomas, D.B. Follette, A.T. Mrozinski, and G.S. Thomas. Duquesne University, Pittsburgh, Pennsylvania,

While birds in general are much more tolerant of acute hypoxia than are non-hibernating (n-h) mammals, little is known about the hypoxic tolerances and adjustments of n-h species of bats. In this study, we have investigated the maximum tolerances and metabolic and ventilatory responses of the n-h bats *Pteropus poliocephalus* (PP, Megachiroptera) and *Phyllostomus hastatus* (PH, Microchiroptera) to acute normobaric hypoxic stress. Different levels of hypoxia were achieved by blending air and N_2 with a digital gas blender. Inspired minute ventilation rate (V_i) was measured with an electronic flow probe simultaneously with O_2 consumption rate (MO_2). PP and PH can safely tolerate inspired oxygen partial pressures (P_iO_2) down to 30 torr; a value which corresponds to an ICAO Standard Altitude of around 10.3 km. These bats are the most hypoxia-tolerant n-h species of mammals of which we are aware, and have values which lie within the range of minimum tolerable P_iO_2's reported for Pekin ducks. Unlike most n-f mammals of its size, PP maintains its normoxic MO_2 even in deep hypoxia. The maximum "Hypoxic Ventilatory Response" [HVR = (hypoxic V_i/ normoxic V_i)] and the maximum air convection requirement (V_i/MO_2) of PP in deep hypoxia are both substantially greater than those of n-f mammals, but are less than those of the most hypoxia-tolerant avian species. In contrast to PP, PH lets its MO_2 drop to around 0.7 times its normoxic value in response to deep hypoxia, and attains maxima HVR and V_i/MO_2 values at a P_iO_2 of 33 torr that are generally similar to those that certain n-h mammals (dogs, sheep) achieve at substantially higher minimum P_iO_2's. Despite their different responses to hypoxia, data from both species are consistent with the hypothesis that at least some of their respiratory adaptations for flight may serve as pre-adaptation for withstanding hypoxic stress.

TIUNOV, M.P.

RELATIVE ABUNDANCE AND DISTRIBUTIONAL RECORDS OF BATS IN THE FAR-EAST OF RUSSIA IN SPRING-SUMMER PERIOD.

M.P. Tiunov. Far East Branch of the Russian Academy of Sciences, Vladivostok, Russia.

The number and features of distribution in bats were studied in the far-East of Russia. During spring-summer period in the south of Primorye up to latitude 44° North, *Vespertilio superans* and *Myotis daubentoni* prevail in total numbers. In more northern regions (from 44° to 49°) *M. daubentoni* is more abundant than V. *superans* . However, according to distributional records in the south of Primorye, *V. superans* is third in relative abundance to the more abundant *Pipistrellus savii* and *M. daubentoni*. High degree of relative abundance and poor distribution of *V. superans* are associated with large size of maternal colonies in this species (up to 1,500 individuals). *Pipistrellus savii* is more widely distributed, but its colonies never reach large numbers. Widely-distributed *M. daubentoni* forms large colonies (about 1,300 individuals) in the very south of region under study. For all other species in the south of Primorye the relative abundance is approximately 7%. Northward from 44° N

the relative abundance's of *M. nattereri* and *M. brandti* are increased (10.4% and 8.7% respectively). In the Kchabarovskyi region, north of 49°, and in the Amurskyi region first place in terms of relative abundance (58.3%) goes to *M. brandti*. On Sakhalin Island, *M. daubentoni* is the most abundant, followed by *M. brandti* . The relative abundance of *Amblyotus nilssoni* also has increased considerably . On Kunashir Island the most widely-distributed (distributional record is 33.3%) and the most numerous (relative abundance is 56.5%) species is *M. macrodactylus*.

TREWHELLA, W.J.

COEXISTANCE OF *PTEROPUS LIVINGSTONII* AND *P. SEYCHELLENSIS* IN THE COMOROS ISLANDS (WESTERN INDIAN OCEAN)

W.J. Trewhella, W.J. Reason, and S. Wray. Action Comores, c/o Bristol Ecological Consultants Ltd., Department of Biological Sciences, University of Bristol, Bristol, U.K.

Pteropus livingstonii and *P. seychellensis* both occur on two of the Comoros Islands. Whereas *P. livingstonii* is rare and endangered, *P. s. comorensis* is common; factors tht might explain this difference are of considerable importance in the conservation management of *P. livingstonii*. The behaviour, roosting requirements, feeding ecology, timing of reproduction and flight dynamics of the two species are compared. *P. livingstonii* prefers montane forest for roosting, prefers native forest flowers and fruits in its diet, and has different flight characteristics (gliding and showing greater use of thermals). *P. s. comroensis* is more at home in secondary forest and takes more non-native food items. Two other frugivores, the fruit bat *Rousettus obliviosus* and the mongoose lemur, *Lemur mongoz*, are also potential frugivore competitors.

TSCHAPKA, M.

SUPPLY VERSUS DEMAND: RELATIONSHIP BETWEEN NECTAR-DENSITY AND RESOURCE USE BY FLOWER VISITING PHYLLOSTOMID BATS.

M. Tschapka, O. v. Helversen. University of Erlangen-Nürnberg, Erlangen, Germany.

We studied the interaction between flower visiting bats (Phyllostomidae: Glossophaginae) and the bromeliad *Vriesea gladioliflora* at a clearing in a Costa Rican lowland rainforest by monitoring both nectar availability and bat activity. The predominant pollinator is the 9 g *Glossophaga commissarisi*, which uses the nectar of the bromeliad during a two-month flowering period as its main food source. Flowers of a*V.riesea gladioliflora* inflorescence are displayed singly, last one night and produce an average of 1,059 µl (SD = 281; n = 99) of nectar (16 % sugar w/w); this is the equivalent of 180 mg of sugar. By using phenological data from part of the plant population, we calculated the nectar-density produced by all the bromeliads (n = 292) on the 2.1 ha clearing during the whole flowering period. Based on this value and on food requirements of the bats, we estimated that the maximum carrying capacity is 14 bats during peak flowering time and correspondingly fewer individuals during the off-peak. Our recapture data support the idea that number of consumers is closely matched to nectar production, with food availability exceeding demand during the peak flowering time. Accordingly, the number of visits per flower, as measured by lightbeams, was highly variable (between 0 and 44), and did not always result in complete consumption of nectar. Flowers were used by more than one bat as indicated by photographs at flowers and by recording individually tagged animals (by transponders). In addition telemetry data also showed overlapping foraging ranges for individual animals.

TUTTLE, M.D.

BAT CONSERVATION INTERNATIONAL GOALS AND ACCOMPLISHMENTS.

Tuttle, M.D. Bat Conservation International, Austin, Texas, USA.

Bat Conservation International initiatives of the past year focused primarily on: 1) protecting bats in the US. and Canadian abandoned mines now threatened with safety closures; 2) building partnerships with federal and state agencies to further broad conservation initiatives; 3) establishment of a binational project to protect migratory bats that move between Mexico and the United States; 4) provision of workshops and distribution of educational materials on vampire bat control in Latin America; 5) research on artificial habitats for bats; 6) public education, highlighted this year by production of an article on the values and conservation needs of North American bats for the August 1995 issue of the *National Geographic*. We also established a special student scholarship fund that currently is distributing $10,000 annually in amounts ranging from $1,000 to $2,500 per student. Awards are based on the assessment of three leading bat specialists who serve as outside reviewers. Contact BCI for application forms, functions, and submittal deadlines.

UIEDA, W.

FEEDING BEHAVIOR OF VAMPIRE BATS, *Diaemus youngi* AND *Desmodus rotundus* (PHYLLOSTOMIDAE) ON CAPRINES AND SWINES, UNDER CAPTIVITY CONDITIONS.

W. Uieda, Universidade Estadual Paulista, São Paulo, Brazil.

Desmodus rotundus is a well known and studied vampire bat species which feeds on mammal blood, mainly on domestic equine and bovine. On the other hand, *Diaemus youngi* is poorly known and specializes on birds. Little is known on the interactions of these two bats and caprines and/or swines. In my study, I have used nine individuals (4 males and 5 females) of *D. youngi* and six (2 males and 4 females) of *D. rotundus*, all captured in southeastern Brazil. These bats were kept alive and observed in two flight cages (3 x 3 x 2.5 m) illuminated by a 15 Watt red lamp. *Desmodus rotundus* flies and alights directly on the body of caprines and swines whereas *D. youngi* walks down across the cage wall and moves over the floor towards the food source. The reactions of the prey, their nocturnal activities, and resting behavior directly influences the feeding tactics of the desmodontines, mainly those of *D. youngi*. The attacks by *D. youngi* are normally made from the floor, whereas *D. rotundus* attacks the body of the prey. *Diaemus youngi* preferentially bites on the lower hind-region of caprines (principally knees and toes) whereas *D. rotundus* bites the upper anteriorportion (shoulders and neck). Both species preferred the upper anterior-region (ears) of pigs. After a meal, *D. rotundus* flies away from the prey, but *D. youngi* moves across the floor and climbs the cage wall moving backwards. It appears that the latter species is unable to take off vertically, which may explain why it feeds mostly on arboreal prey and does not attack terrestrial mammals in nature.

UIEDA, W.

EFFECTS OF PREDATION BY VAMPIRE BATS, *Diaemus youngi*, *Desmodus Rotundus*, AND *Diphylla Ecaudata* (PHYLLOSTOMIDAE) ON BIRDS, UNDER CAPTIVITY CONDITIONS.

W. Uieda and V.S. Uieda, Universidade Estadual Paulista, Botucatu, São Paulo, Brazil.

The effects of predation by the three species of vampire bats on chickens were studied under experimental conditions in captivity. Two types of conditions (A and B) were considered and repeated four times, always with a control group to allow comparisons: A, bird and bat in a 1:1 proportion, B, bird and bat in 2:1 proportion. Bats and birds were kept alive in flight cages (3 x 3 x 2.5m) and were observed for 15 consecutive nights. The birds were weighed in the beginning and by the end of each experiment and whenever they died, they were replaced by others. The symptomatological picture of the birds bled by the three species of vampires was characterized by weight loss, lowering of the posterior part of body including the tail, somewhat shrunken neck, pale face, sad appearance and sleepiness. These symptoms were most frequently observed when the proportion was 1:1. *Desmodus rotundus* and *Diphylla ecaudata* were more harmful to chickens than *Diaemus youngi*. The 2:1 proportion was found to be the minimal condition to assure no harm to birds preyed by the latter species. For the two former ones, a proportion of at least 3:1 seems to be acceptable. When in 1:1, *D. ecaudata* killed 45.8% of the chickens, *D. rotundus* killed 33.3%, and *D. youngi* did not kill any prey. When in 2:1, only three birds were killed (two by *D. rotundus* and one by *D. ecaudata*). Bird death seems to be related to the part of the body which was bitten by *D. ecaudata* (cloacal region). It was not possible to explain how *D. rotundus* comes to kill its preys, while *D. youngi* does not, since they have similar feeding behaviors.

UIEDA, W.

EFFECTS OF PREDATION BY THE THREE SPECIES OF VAMPIRE BATS (PHYLLOSTOMIDAE) ON BIRDS UNDER CAPTIVE CONDITIONS

W. Uieda and V. S. Uieda, Universidade Estadual Paulista, São Paulo, Brasil.

Two types of experimental conditions (A and B) were considered in a study of the predatory effects of vampire bats on chickens: A, bird and bat in a 1:1 proportion; B, bird and bat in a 2:1 proportion. *Desmodus rotundus* and *Diphylla ecaudata* were more harmful to chickens than *Diaemus youngi*. The 2:1 proportion was found to be the minimal condition to assure no harm to birds preyed by the latter species. For the two former species, a proportion of at least 3:1 seems to be acceptable. When in a 1:1 ratio, *D. ecaudata* killed 45.8% of the chickens, *D. rotundus* killed 33.3%, and *D. youngi* did not kill any prey. When in 2:1 ratio, only three birds were killed (two by *D. rotundus* and one by *D. ecaudata*). A relation between bird death and feeding behavior of *D. ecaudata* was established. It was not possible to explain how *D. rotundus* comes to kill its preys, whereas *D. youngi* does not, since they have similar feeding behaviors.

URBANCZYK, Z.

PROGRESS IN BAT CONSERVATION IN POLAND.

Z. Urbanczyk. Polish Society for Bat Protection, Poznan, Poland.

All bat species in Poland were given legal protection by the Species Protection Act 1983. Six species are listed in "Polish Red Data Book": *Rhinolophus hipposideros* (E) *Myotis bechsteini* (V), *M. emarginatus* (E), *Vespertilio murinus* (R), *Eptesicus nilssoni* (R) and *Nyctalus leisleri* (R). Extremely endangered are R *hipposideros* and *M. emarginatus*. Their populations decreased about 100 times during last 40 years. There are over 200 bat hibernacula known in Poland. The most important bat hibernation sites are old military tunnels in western Poland, where about 30,000 bats of 12 species hibernate. A small part of the system is protected by law as bat nature reserve "Nietoperek". A few other hibernacula have been lately taken under protection as places of ecological importance. Several educational actions have been carried out, producing informative materials, organizing meetings and workshops, and publishing articles in newspapers. Bat exhibitions have been established by Lubuski Nature Club in the vicinity of "Nietoperek Reserve", with about 10,000 visitors in 1994. The Polish Society for Bat Protection have been established to promote and coordinate protection, research and education with special emphasis to developing of public awareness of bats and making a bat lobby in the society. Since 1991 Ecological Foundation Nietoperek raises money for nature protection in western Poland, particularly for bat protection.

USMAN, K.

BEHAVIORAL THERMOREGULATION IN THE MOUSE-TAILED BAT *Rhinopoma hardwickei*.

K. Usman. Dr. Zakir Husain College, Ilayangudi, India.

A survey was made on the habitats of a few species of microchiropteran bats such as *Hipposideros speoris*, *H. bicolor*, *Rhinopoma hardwickei*, *Taphozous melanopogon* and *Megaderma lyra*. These bats inhabit caves, caverns, interiors of temple and cellars. The variations in temperature is significant in the proximity of the cave entrance occupied by *Rhinopoma* and *Taphozous*. Under such circumstances, these bats move deep into the cave where a constant temperature prevails, and thus exhibit "in-roost behavioral thermoregulation." This kind of movement and habitat selection is of adaptive significance.

UTZURRUM, R.C.B.

GEOGRAPHICAL PATTERNS, ECOLOGICAL GRADIENTS, AND THE MAINTENANCE OF TROPICAL FRUIT BAT DIVERSITY: THE PHILIPPINE MODEL.

R.C.B. Utzurrum. Boston University, Boston, Massachusetts, and Silliman University, Dumaguete City, Philippines.

Biogeographical analysis of patterns of species richness among Philippine fruit bats show distributions coincident with land masses formed during the Pleistocene lowering of sea levels. Additionally, local gradients strongly indicate the close association between forest habitats and endemic species. Comparisons of species distribution and relative abundance patterns along several elevational transects indicate the potential for loss of endemic species with increasing habitat degradation. In this paper, I review results of various empirical studies from gradient surveys conducted over the past years and evaluate the consequences habitat fragmentation have on the maintenance of Philippine fruit-bat diversity. The examination is centered around the key questions: 1) how is species diversity patterned over unfragmented (i.e., local gradients) and naturally fragmented (i.e., biogeographical) landscapes; 2) what impact will habitat fragmentation have on diversity maintenance; and 3) do macro- and microgeographic patterns of community, associations provide practical insights into diversity conservation?

VAN DEN BUSSCHE, R. A

PHYLOGENETIC ACCURACY, STABILITY, AND CONGRUENCE: RELATIONSHIPS WITHIN AND AMONG THE NEW WORLD BAT GENERA *Artibeus*, *Dermanura*, AND *Koopmania*.

R.A. Van Den Bussche, J.L. Hudgeons, and R.J. Baker. Texas Tech University, Lubbock, Texas.

We examined DNA sequence variation from the mitochondrial cytochrome b gene (1,140 bp) for fig-eating bats of the New World genus *Artibeus* to better understand the systematic relationships within this controversial group and to estimate the level of resolution supporting each clade. Although trees that estimate the phylogenetic relationships of taxa are commonly generated, how to determine which clades are robust and should have the greatest confidence is difficult to resolve. We compare the bootstrap and Bremer Support analyses to examine the extent to which the two methods corroborate the phylogenetic relationships estimated by the other. All clades supported by at least 80% of the bootstrap iterations required greater than 20 steps before they decayed. Bootstrap clades identified by 70-79% collapsed within 2 to 13 additional steps. Results from the relative-rates test are interpreted as indicating that this data set exhibits minimal problems associated with heterogeneity in the rate of

nucleotide substitutions among the various lineages. Taxonomic conclusions from this study are: 1) *Dermanura* and *Artibeus* as recognized by Owen (1987, 1991) form a monophyletic group; 2) both *Artibeus* and *Dermanura* are monophyletic within this larger group; and, 3) these data are interpreted as failing to support recognition of the genus *Koopmania* and we conclude that this taxon should be recognized as *Artibeus concolor*.

VAN DER MERWE, M.

THE REPRODUCTIVE CYCLE OF THE FEMALE ANGOLAN FREE-TAILED BAT *Tadarida condylura* IN KRUGER NATIONAL PARK.

M. Van der Merwe[1], and L. Viviers[2].

[1]University of Pretoria, Gauteng, South Africa, and [2]University of Zululand, Natal, South Africa.

Female Angolan free-tailed bats are seasonal bimodally polyestrous, with the breeding season extending from early spring (September) to late autumn (May). Parturition of the first offspring in early December is followed by a post-partum estrus. During the first reproductive cycle, 90% of the adult females examined conceived during the first three weeks of September, with the peak of parturitions during early December. The second reproductive cycle was initiated in late November, with the peak of conceptions during the first two weeks of December, and the peak of parturitions during the period end of February and beginning of March. During the first cycle, 83% of births occurred between 1-15 December, while during the same period, 70% of the females had conceived for a second time, being lactating as well as pregnant. Gestation and lactation periods were approximately 85 and 50 days, respectively. When the two reproductive cycles are compared, conceptions and births appeared to be more synchronized during the first cycle, with 83% of the females conceiving during a 14 day period compared to 70% for the same period during the second cycle. The reproductive tract displayed dextral dominance typical of molossids. Implantation of the bilaminar blastocyst was mesometrial with the embryonic disc oriented antimesometrially.

VANITHARANI, J.

DEVELOPMENT OF WING MORPHOLOGY, FLIGHT BEHAVIOUR AND ONTOGENY OF FLIGHT IN A FEW TROPICAL SOUTH INDIAN BATS.

J. Vanitharani, Sarah Tucker College, Tirunelveli, India.

Postnatal changes in wing morphology, flight ability and associated behavioral activities were investigated in an area around Tirunelveli (08° 44' N, 77° 42' E) for five species of bats-- a frugivore *Rousettus leschenaulti*, a carnivore *Megaderma lyra* and three insectivores *Taphozous melanpogon*, *Hipposideros speoris* and *H. ater*. The morphological and behavioral studies were conducted at their maternity colonies in the field. Ontogeny of flight was studied through the flight tests using launching apparatus. Observations were made on the development of body mass, wing span, wing area, aspect ration, wing loading, tip length ratio, tip area ratio and tip shape index. Analysis of these changes were used to draw conclusion about the refinement of flight apparatus, ontogeny of flight, in particular concerning their relevance to the time of the first flight. Adaptations for the reduction in the energy requirement in the early flight are recorded. There is no sexual dimorphism in the young bats.

VATER, M.

HOW THE AUDITORY PERIPHERY OF BATS IS ADAPTED FOR ECHOLOCATION.

M. Vater. University of Regensberg, Regensburg, Germany.

Cochlear structure was analyzed by scanning and transmission electron microscopy in four species of echolocating bats. The horseshoe bat (*Rhinolophus rouxi*) and the mustached bat (*Pteronotus parnellii*) have independently evolved Doppler shift compensation behavior. As previously reported, their cochlea is characterized by exceptionally sharp tuning and expanded mapping of the 2nd harmonic CF-component of the long CF-FM echolocation signal (auditory fovea; mapping coefficient 40 mm/octave). The Mexican free-tailed bat (*Tadarida brasiliensis mexicana*) has a flexible repertoire of typically brief CF, CF-FM or FM-echolocation signals. We report that cochlear tuning is slightly enhanced to frequencies around 25 kHz and a frequency range encompassing the lower frequencies of the FM-sweep is slightly expanded (6 mm/octave). The big brown bat (*Eptesicus fuscus*) is classified as a typical FM-bat and previously reported to possess unspecialized peripheral-tuning properties. As a general property, the cochlea of all species is optimized for processing ultrasonic signals as evidenced by the dimensions of the passive hydromechanical system and the small size of receptor cells and stereocilia bundles. The ultrastructure of outer hair cells, generally discussed as active elements in cochlear tuning, is similar in all species and throughout the cochlea. Auditory foveae and enhanced cochlear tuning appear to be created by species-specific gradients in the morphology of the basilar membrane and the tectorial membrane.

VAUGHAN, N.

IDENTIFICATION OF BRITISH BAT SPECIES FROM ECHOLOCATION CALLS.

N. Vaughan, G. Jones, and S. Harris. University of Bristol, Bristol, England, UK.

In ecological studies of bats, species identification from echolocation calls is often attempted, but the success of various methods of identification is rarely quantified. In this study, results of multivariate discriminant analysis on parameters of call structure are used to design an accurate method of bat species identification from echolocation calls. Recordings of echolocation calls of all 14 species of British bat were made either on release from the hand, or on flight paths outside roosts where bats had previously been caught and identified. The high frequency output from a bat detector was time-expanded by a portable ultrasound processor, and the output was recorded on a Sony Walkman. Three to seven calls made by each individual were analyzed on a Kay Sonagraph, and individual means for five frequency and time parameters were calculated. Using these means, a key was developed to classify each of the 14 species in one of six groups: 1) *Myotis* and *Plecotus* species and *Barbastella barbastellus* (8 species), 2) *Nyctalus* species and *Eptesicus serotinus* (3 species), 3) *Rhinolophus ferrumequinum*, 4) *Rhinolophus hipposideros*, 5) *Pipistrellus pipistrellus* (45 kHz phonic type), and 6) *Pipistrellus pipistrellus* (55 kHz phonic type). To allow the identification of bats producing calls placed in groups 1 and 2, multivariate discriminant analysis was carried out on the individual means of the five cell call parameters. For each of these groups, a separate model was created based on recordings of known individuals. Important classifying parameters could be identified, and the percent correct reclassification could be determined for species in both groups. Unknown bat echolocation calls recorded in field studies can be analyzed and subjected to the key. If they are classified to group 1 or 2, frequency and time parameters of call structure are introduced into the discriminant analysis. The degree of certainty of classification is calculated. This method of bat species identification is valuable because it quantifies the certainty of identification, but also because it allows field work to be carried by inexperienced workers. Recordings of individuals of known species identity are needed. These bats must have been identified by means other than from echolocation calls.

VOIGT, C.

THE ENERGETICS OF HOVERING FLIGHT IN NECTAR-FEEDING BATS (PHYLLOSTOMIDAE; GLOSSOPHAGINAE).

C. Voigt, Y. Winter, and O. v. Helversen. University of Erlangen-Nürnberg, Erlangen, Germany

Nectar-feeding glossophagine bats normally hover while feeding from flowers. As aerodynamic theory predicts that hovering is one of the most expensive modes of flight for a bat, it should make up a substantial part of a glossophagine's foraging cost. Due to their natural feeding behavior these bats are well suited for investigating the metabolism of hovering as they can be trained easily to hover in front of an artificial flower while feeding nectar. For this study individuals of *Glossophaga soricina* were trained to hover in front of a feeder for a duration of more than four seconds, which was measured photoelectrically. The feeder was constructed as a flow-through mask. The air drawn through the mask was sampled and O_2-depletion and CO_2-production were calculated. The determination of the RQ indicates which substrate is oxidized and may indicate whether the muscles work under aerobic conditions.

VÖLLETH, M.

KARYOTYPES AND SYSTEMATIC RELATIONSHIPS OF SOME AFRICAN "PIPISTRELLOID" BATS.

M. Völleth[1], G. Bronner[2], M. Göpfert[1] and K.-G. Heller[1].
[1]University of Erlangen-Nürnberg, Erlangen, Germany, and [2]Transvaal Museum, Pretoria, South Africa.

Until recently, pipistrelloid bats were classified with the genera *Pipistrellus* and *Eptesicus* according to the presence or absence of the second upper premolar. Some recent studies, based on morphological and chromosomal characters, however, have shown that this grouping may not reflect natural relationships, and proposed new classifications. Due to the rarity of material, for many species karyological data are still missing which are necessary to group the species with the tribes Pipistrellini, Vespertilionini or Eptesicini, and which give information about the generic classification. Here we present data on four African species of this group: 1) *Pipistrellus "kuhlii"* (Madagascar; 2n = 42, FN = 50), a nyctalodont member of the tribe Pipistrellini, differs from the European members of this species in its chromosomal complement, 2) *"Eptesicus" capensis* (South Africa; 2n = 32, FN = 50), 3) *"Pipistrellus" eisentrauti* (Rwanda, 2n = 42, FN = 58), and 4) *"Pipistrellus" crassulu* (Zaire; 2n = 30, FN = 56) have to be classified according to morphology and karyology as members of the tribe Vespertilionini and, at least as the two last species are concerned, as members of the genus *Hypsugo*. The (sub)genus *Neoromicia*, *E. capensis* was classified by Hill and Harrison, however, it is very difficult to separate morphologically as well as karyologically from *Hypsugo* and may represent a synonym of this genus.

VONHOF, M.J.

MAN IS IT HOT OUT HERE!
THE USE OF STUMPS IN CLEARCUTS AS ROOSTING SITES BY *Myotis evotis*.
M.J. Vonhof. University of Calgary, Calgary, Alberta, Canada.

I report for the first time widespread use of loose bark on stumps in clearcuts as roosting sites by *Myotis evotis*. I first discovered stump-roosting behavior during the summer of 1993 when a radio-tagged female *Myotis evotis* roosted beneath loose bark on four separate stumps. During the summer of 1994 I searched for stump roosts in eleven south-facing clearcuts in the West Arm Demonstration Forest near Nelson, British Columbia. A total of 20 roosts in 18 different stumps were located in three different clearcuts. Males and females each accounted for 10 of the 20 roosts. Within clearcuts, bats selected large diameter stumps, and tended to roost in SW facing cavities. Temperatures of roost cavities were intermediate between, and did not differ significantly from those within randomly selected cavities, or from ambient temperatures. However, temperatures within randomly-selected cavities were significantly warmer than ambient temperature. Cavities on large diameter stumps tended to be relatively cool, and cavities on the south side of stumps were relatively warm. I thus conclude that bats chose to roost in clearcuts to gain significant thermal benefits through increased exposure to sunlight and reflective heat, but within these clearcuts chose stumps which provided relatively cooler temperatures, presumably to avoid heat stress. Bats selected clearcuts with high proportions of uncluttered stumps, and stumps in clearcuts used by bats provided relatively deep cavities that were further away from neighboring shrubs. Bats roosting in clearcuts may be subject to a trade-off between increased energetic savings and increased predation risk.

WALDMANN, B.

COLOR SPECTROGRAM FREQUENCY--ANALYSIS SYSTEM FOR BIOACOUSTIC RESEARCH.
B. Waldmann and H.U. Schnitzler. University of Tübingen, Tübingen, Germany.

Analysis of bioacoustic signals in mammals or birds usually relies on expensive and bulky equipment for color spectrogram display. In field research on echolocating bats, the need arose for a lightweight, PC-compatible tool for viewing and analyzing animal sounds. Using commercially available hardware, we developed software to concurrently acquire data and display color spectrograms in realtime at up to 20 kHz bandwidth. Vocalizations of birds and many mammals can be viewed in realtime; the high frequency echolocation calls of bats have to be slowed down via a time-expansion recording system. Contrary to conventional systems, which are mainly geared towards engineering applications, our system was developed expressly with the bioacoustics researcher in mind. A high-speed digital signal processor offloads computational tasks from the host computer, thereby enabling lowgrade IBM AT-compatible computers to be used as a sophisticated analysis tool without sacrificing performance. The half-size 16 bit PC-slot card features an integrated a/d converter with 16 bits resolution and 20 kHz bandwidth, complete with microphone preamplifier and anti-aliasing filter. Its small outline and low power consumption allows the board to be used even in laptop computers, providing sound analysis directly in the field. Display options include various FFT lengths and offline zoom, control over dynamic range, and cross-hair cursor measurement with data logging to spreadsheet-compatible text files. Data can be stored on harddisk for later retrieval and offline analysis. Hardcopy output is supported for various types of printers, including inkjet color devices. Screen snapshots can be exported to graphics and paint programs. An optional interface connects to a video time code source, permitting integrated analysis of sound and video via a common time frame. The system will be demonstrated at the conference.

WALSH, J.S.

MOLECULAR SYSTEMATICS OF THE *Cynopterus* GROUP.
J.S. Walsh. University of Chicago, Chicago, Illinois, USA.

Since Knud Andersen's authoritative tome on megachiropteran systematics in the second decade of this century, the Megachiroptera have been regarded as being divided into two monophyletic groups, the nectarivous Macroglossinae and the frugivorous Pteropodinae. Recent work in molecular systematics has cast this arrangement into doubt and has indicated that there has been extreme convergence in fruit bat morphology. One putative clade within the Pteropodinae, the *Cynopterus* group, has appeared to remain monophyletic in light of the new molecular data (although the placement of *Nyctimene* has been controversial); however, the *Cynopterus* group has been rather poorly represented in these molecular studies. Several of the genera in the *Cynopterus* group are endemic to the Philippines and, based on chromosomal evidence, it has been suggested that these Philippine taxa are the result of an adaptive radiation in the Philippines. I will investigate the phylogenetic relationships of the genera of the *Cynopterus* group and examine the proposition that the Philippine endemics form a monophlyetic radiation using sequence data from the mitochondrial cytochrome b gene.

WANG, H.

THE STUDY OF CHINESE BATS: A REVIEW

H. Wang[1] and J. Lou[2]. [1]Shanghai Teachers University, Shanghai, P.R. China, and [2]Kongjiang High School, Shanghai, P.R. China.

This review reports the research progress of Chinese bats, existing issues in studies and future work. Its goal is to make people understand the status of Chinese bats, and to promote and strengthen the study and cooperation in this area. In China, there are about 99 species of bats (include 4 spp. endemic to Taiwan) belonging to 6 families, 29 genera, over 10% of the total number of species in the world. Before 1980, little research work had been conducted on the Chinese bat fauna, and no monographs have been published on bats. Recently, more researchers have begun to study bats, and over 43 scientific research papers on Chinese bats have been published in Chinese academic journals in the past fifteen years (an * indicates the number of papers published in each study area). This work can be divided into the following five aspects: 1) faunal study (15*): to cover 10 of 30 provinces and metropolises in China. Most of papers have only reported bat species and distribution at study sites, no information about the numbers and changes in numbers and ranges of bats were included. 2) Ecological study (11*): to deal with obstacle-avoidance test (4*), observations on bat habits (4*), effects of environmental factors on seasonal activity and species distribution (2*) and food preference (1*). 3) Physiological study (7*): mainly to focus on neurophysiology referring to auditory responses to stimuli (4*), morpho-physiological indices during hibernation (2*) and changes in sexual gland with seasons. 4) Karyotype analysis (6*): to refer to 9 species. 5) Others (4*) refer to common knowledge about bats. Finally, the authors concluded with their suggestions for future work of Chinese bats.

WATERS, D.A.

DETECTION AND DISCRIMINATION BY BAT ECHOLOCATION: SIMULATION USING ARTIFICIAL NEURAL NETWORKS .

D.A. Waters[1], G. Jones, D.R. Bull[2], and J.M.V. Rayner[1].
[1]School of Biol. Sciences, [2]Dept. of Electrical and Electronic Engineering, Universlty of Bristol, Bristol, England

Bat echolocation is particularly interesting in operating as a sole sensory modality for the capture of prey. In addition, the total information contained within one sonar echo can be quantified, and is comparatively small compared to visual sensory systems (typically <5,000 bits for a 5 ms call). Since the information from the current echo, and that from previous echoes is all the bat has to make a decision about the target distance and type, there is a real possibility of discovering the global processing algorithms occurring in the bat brain. To generate predictions as to the class of algorithms used, we have adopted an engineering optimization approach. By abstracting the problem to an engineering one, we can vary all the parameters we require to investigate the interaction of signal structure with target type, and signal processing procedure. We have developed a system by which two ultrasonic microphones and an ultrasound speaker are mounted on a trolley which is propelled along a rail at speeds over 5 ms^{-1}. Pre-recorded or synthesised bat echolocation calls are broadcast at a stationary target at the end of the rails. The echo is digitized and processed by decomposition using wavelet techniques. This multi-resolution technique is likely to be analogous to the way information is decomposed in the cochlea. Parameters from the wavelet transform domain are then used as inputs into a multi-layer perceptron artificial neural network and trained using the family of back-propagation learning algorithms. The neural network operates simply as a non-linear discriminant. The ultimate aims are firstly to make predictions as to which call structure is optimal for the detection of certain targets in certain environments. Secondly, to generate hypotheses as to the global processing algorithms occurring in the bat brain, and finally to design unambiguous expeliments to test these hypotheses on real bats.

WATERS, D.A.

CALL APPARENCY OF SEARCH PHASE ECHOLOCATION CALLS TO NOCTUID MOTHS.

D.A. Waters and G. Jones. Bristol University, Bristol, England, UK.

Predictions exist as to the call structures bats should adopt in order to reduce their apparency to the auditory systems of noctuid moths. However, these predictions have never been directly tested using real calls from a variety of species. Also, in order to adequately test the effect of frequency and temporal structure of the call on apparency, it is necessary to control the confounding variable of call intensity. We present new data on frequency and temporal characteristics of the moths' auditory system, generate predictions as to the call design to reduce the apparency, and test these predictions using broadcast search phase calls of six bat species. Two noctuid moths, *A. segetum* and *N. pronuba* have auditory systems with best frequencies at 25 kHz (40 dB SPL) and 15 kHz (36 dB SPL), respectively. *A. segetum* shows reduced auditory sensitivity with reduced stimulus duration with an integrating time constant of 69 ms. Bats using high frequency and short duration calls are thus predicted to be acoustically less apparent to these

moths. Broadcast search phase calls of the FM bats *Pipistrellus pipistrellus, Myotis brandtii, M. nattereri* and *P. auritus* have the same threshold values despite differing temporal and frequency structures. The CF bats *Rhinolphus ferrumquinum and R. hipposideros* are predicted to be acoustically less apparent by way of the high frequency of the call (83 kHz and 113 kHz respectively, both 50 ms long). Only *R. hipposideros* is acoustically less apparent, as the decreased apparency of the call of *R. ferrumequinum* due to the high frequency, is counteracted by the long duration. Although the calls of *P. auritus* are acoustically no less apparent than other FM bats, it is proposed that the lower call intensity of this species at 87-95 dB peSPL at 10 cm allows it to forage successfully on tympanate moths. It is proposed that two mechanisms operate to reduce echolocation call apparency, high frequency in CF bats, and low intensity in FM bats.

WATTS, P.

ESTIMATES AND SENSITIVITY ANALYSIS OF BONE STRESSES
IN A BAT HUMERUS IN FREE FLIGHT.

P. Watts[1], E.J. Mitchell[2], and S.M. Swartz[2].
[1]California Institute of Technology, Pasadena, California, and [2]Brown University, Providence, Rhode Island.

We combined a two-member model (shoulder to wrist and wrist to tip) of wing kinematics fit to video records of a flying fox (*Pteropus poliocephalus*) in free flight with a simple "constant circulation" model of the aerodynamic force in order to estimate the load carried internally by the actual wing structure (skeletal and muscular). We calculated internal reaction forces and moments at the bat shoulder and at evenly spaced, distal locations on the bat humerus. We approximated stresses in the bat humerus at these locations using standard engineering models of stresses in beams. We converted stresses to strains using an orthotropic model of humerus mechanical response and compared the results with previous measurements of humerus strain from flying foxes in free flight. The sensitivity analysis includes perturbations of the bat mass, the location of center of lift along the chord, the flapping frequency, the humerus wall thickness and radius, the bone elastic modulus, the phase of the angle between the two members at the bat wrist, and the humerus orientation in time.

WEGNER, T.

ALTERATIONS OF THE ECHOLOCATION CALLS DURING JAMMING
WITH SMALL BAND NOISE IN *Rhinopoma microphyllum*.

T. Wegner, A. Dybek, and U. Schmidt. University of Bonn, Bonn, Germany.

The echolocation calls in the Egyptian mouse-tailed Bat *Rhinopoma microphyllum* consists of 5 - 6 slightly frequency modulated harmonics. During jamming with conspecific calls or artificial noise the intensity of these calls is raised up to 20 dB. In these studies small band noise of different intensity was applied when *Rhinopoma* was flying in a flight tunnel. The alterations of calls emitted under the influence of different acoustical disturbances were analyzed. The increase of intensity was various in the different harmonics, depending on the frequency range of the interfering noise. The reaction time of the behavioral changes is related to the overall intensity of the noise.

WEINSTEIN, B. S.

TENTS PRODUCED AND MAINTAINED BY *Uroderma bilobatum*
ARE USED BY *Artibeus jamaicensis*.

Weinstein, B.S. University of Michigan, Ann Arbor, Michigan, U.S.A.

A tent-bat system is described from the lowland tropical rainforests of north-eastern Costa Rica. Several groups of *Artibeus jamaicensis* were found diurnally roosting in multi-leaf (conical) tents. These tents were produced by the alteration of all or nearly all of the leaves on individual plants. *Uroderma bilobatum* was also found roosting in conical tents. The pattern of tent use by these two species clearly supports the hypothesis that *U. bilobatum* is the species responsible for construction of these tents and that *A. jamaicensis* simply uses existing tents opportunistically. A review of the literature reveals that all reports of tent use by *A. jamaicensis* are likely to have the same explanation: opportunistic use of tents produced by other bat species. Evidence suggests that individual *U. bilobatum* tents are used and maintained over extended periods of time. Maintenance of tents involves the alteration of new leaves that have grown since the initial modification of the tent-plant. One tent was re-modified after a long period of disuse.

WHITMAN, K.L. BAT TRUNKS:
A TRAVELING EDUCATION PROGRAM FOR COUNTRIES WITH ENDANGERED ENDEMIC BATS.
K.L. Whitman. Zoological Society of Philadelphia, Philadelphia, Pennsylvania,
and Villanova University, Villanova, Pennsylvania

The Bat Taxon Advisory Group (TAG) of the American Association of Zoos and Aquariums (AZA) developed a traveling education kit for use in countries with endangered endemic bats. The kit is packaged in a mailing crate and can be easily shipped overseas. The kit contains background information, lesson plans, activities, teaching props, and supplies and requires no supplemental materials. Three lessons appropriate for 6-8 year olds highlight different aspects of bat biology, ecology, conservation and natural history. Lessons address a range of topics; basic classification of bats as mammals, diversity of bat forms, bat food items and feeding strategies, the role of bats in ecological communities, threats to bats, bats in myths and information specific to bats endemic to the area where the trunk is being used. All lessons are designed to be interactive and utilize a variety of games, activities, photographs, puppets, and crafts. Outcomes of the bat trunks will be evaluated by means of pre- and post program questionnaires. A prototype bat trunk was tested at the Philadelphia Zoo and the Franklin Institute Science Museum of Philadelphia. In the autumn of 1995, while on the island of Rodrigues doing my graduate research, I will further test bat trunks. Once they are thoroughly tested, the trunks will be distributed free to teachers requesting them. In the first year of the program, the TAG intends to place trunks in three different locations; Rodrigues, Malaysia, and Pemba. The TAG has received a grant to fund production and shipment of the trunks.

WIBLE, J.R.
THE VOMERONASAL ORGAN IN BATS: A PHYLOGENETIC PERSPECTIVE.
J.R. Wible and K. P. Bhatnagar. School of Medicine, University of Louisville, Louisville, Kentucky, USA.

A well developed, functional vomeronasal organ (VNO) is widely distributed among eutherians and is considered to be primitive for the group. Within the Chiroptera, the vomeronasal system has a spotty distribution, ranging from well-developed, to rudimentary, to wholly absent. The VNO and associated structures were studied in serially-sectioned representatives of all extant chiropteran families except Craseonycteridae and Myzopodidae. Taxa were scored for the following characters: the degree of formation of 1) VNO epithelial tube and 2) VNO complex (including nerves and accessory olfactory bulbs); 3) VNO cartilage shape; and 4) nasopalatine duct incidence. To assess the phylogenetic significance of the VNO complex, the distributions of these four characters were mapped, using the computer program MacClade, onto four previously published chiropteran phylogenies derived from other data sets (Smith, 1976; Van Valen, 1979; Novacek, 1980; Pierson, 1986; *In* Simmons, 1993. Am. Mus. Novitates 3077:1-37). In all phylogenies, these four characters exhibit a high degree of homoplasy, only part of which is accounted for by the occurrence of several polymorphic taxa. Perhaps the most remarkable result is that the absence of the VNO epithelial tube and VNO complex is identified as primitive for Chiroptera in all four phylogenies, with rudimentary and well-developed structures evolving numerous times. Among mammals, such a scenario is unique to bats..

WIDMANN, P.J.
CONSERVATION OF FRUIT BATS (*Chiroptera, Pteropodidae*) IN SEMINATURAL FOREST SYSTEMS IN LEYTE, PHILIPPINES.
P.J. Widmann[1], P.P. Milan[2], and J. Margraf[2].
[1]University of Hohenheim, Hohenheim, Gemany, [2]ViSCA-gtz Ecology Program, Leyte, Philippines.

Non suitable forms of land use are still the main reasons for deforestation in the Philippines. Therefore, the "Closed Canopy High Diversity Forest Farming System" was developed, which differs from other deforestation systems by the use of more than 100 timber and fruit tree species. We found that at least 25 plant species that occur in this system are pollinated or dispersed by fruit bats. The plants do not only provide timber, fruits or fibres, but also can be used in erosion control and as shade trees for sensitive seedlings. Therefore fruit bats play a major role to accelerate succession in young and maintain stability in mature managed forest systems. Because of its close resemblance to natural forest the "Closed Canopy High Diversity Forest Farming System" could provide habitats for at least ten species of fruit bats in Leyte. We investigated the habitat requirements of the single species in the surrounding agroecosystems and forests to find out the most important conservation measures for seminatural systems. These are: 1) Planting and tolerating of food plants for fruit bats that are available all-year-round, esp. wild figs (*Ficus*) and wild bananas (*Musa*). 2) Protection and management of roost sites. 3) Establishment of a subcanopy, which is preferred by the rare *Harpionycteris whiteheadi* as foraging area. 4) Maintenance of forest tracts with densities of woody plants, that resemble those of primary forests to avoid possible competition between the ubiquitous *Cynopterus brachyotis* and the "primary forest species" *Haplonycteris fischeri* and *Ptenochirus minor*.

WILKINSON, G.S.

EVOLUTION OF INFANT VOCALIZATIONS IN CF AND FM BATS.

G.S. Wilkinson. University of Maryland, College Park, Maryland, USA.

Natural selection should favor behavioral mechanisms for identifying offspring in those bat species which leave their young in communal creches. Here I examine whether creching, colony size or type of echolocation call has influenced the evolution of infant vocal signature complexity among bats. From recordings made in the Transvaal of South Africa, Texas and Missouri, I measured 5 infant isolation calls between three Rhinolophoid bats (*Rhinolophus simulator* , *Hipposideros caffer* , *Cloeotis percivali*) which produce CF calls with three Vespertilionid (*Scotophilus borbonicus* , *Nycticeius humeralis* , *Nycticeinops schlieffenii*) and two Molossid (*Tadarida brasiliensis* and *Chaerophon pumilia*) bats which produce FM calls. Discriminant function analyses on 10 frequency, time and relative amplitude variables adjusted for size indicate that sufficient information is present to classify calls to pup with nearly complete accuracy for all species. The total information contained in each species' calls, as measured by the Shannon-Wiener information statistic, was independent of creching and type of echolocation pulse, but increased significantly with colony size. Among FM bats, the most colonial species contained more information in frequency and duration variables, while among the CF bats, the most colonial spedies increased information in frequency and relative amplitude, but not in duration. Comparison of the most colonial species from the three clades indicates significant similarity between the information profiles across variables. These results suggest that infant call complexity has evolved convergently multiple times.

WINTER, Y.

THE ECOLOGICAL CONSEQUENCES OF FLIGHT ENERGETICS.

Y. Winter. University of Erlangen-Nürnburg, Erlangen, Germany.

Under resource limitations species can only coexist if interspecific competition coefficients are sufficiently low or if abundance-regulating disturbances inhibit the process of competitive exclusion. The high species diversity of tropical communities has been explained to be partly due to such disturbance effects. In view of this hypothesis, the present study investigated for a tropical community of nectar-feeding bats (Glossophagine) with interspecific exploitation competition for nectar if niche differentiation per se is sufficient to explain community composition. Nectar-feeding bats are especially suited for such an analysis as the energetic parameters relevant for interspecific competition (i.e. food energy requirement and feeding efficiency, are relatively easy to quantify. Data were collected for different species on : daily energy expenditure (=food energy requirement), flight cost, flight speed, flight activity, and flight morphology. From these data, the energetic habitat requirements (nectar energy density and distribution) for the different species were determined. The results of this analysis suggest that for species to coexist in equilibrium, larger species should use a different foraging strategy to avoid exploitation competition by smaller species, and that equally-sized species differ with respect to flight energetics. Available data are in agreement with the predictions of the model according to which the co-existence of nectar feeding bats on the Caribbean side of Costa Rica can be understood as a non-disturbed equilibrium community.

WORTHINGTON, D.J.

STATUS AND CONSERVATION OF MARIANA FRUIT BATS, *Pferopus mariannus*, IN THE MARIANA ISLANDS.

D.J. Worthington[1] and G.J. Wiles[2].
[1]Division of Fish and Wildlife, Commonwealth of the Northern Mariana Islands, Rota, USA, and [2]Division of Aquatic and Wildlife Resources, Guam, USA.

The Mariana fruit bat (Pteropididae: *Pteropus mariannus mariannus* and *P. m. paganensis)* occurs throughout the Mariana archipelago (represented politically by the Commonwealth of the Northern Mariana Islands [CNMI] and Guam) in the western Pacific. On the populated islands (Saipan, Rota, Tinian, and Guam), perhaps 1,500 bats are present, although almost all of these occur on Rota, with Guam possessing a few hundred. The population estimate for the largely uninhabited islands north of Saipan is 7,450 bats, but this is based on data collected 11 years ago. As a food item, bats are an important part of the Marianas culture, and illegal hunting, together with habitat loss, has combined to greatly reduce populations over the past 30 years, especially on populated islands. Thousands of bats have been imported annually from Palau for consumption, but Palau gained independence in October 1994; importing Palauan bats into the CNMI and Guam is now prohibited under CITES. It is the challenge for Guam and CNMI biologists to conserve this species in the face of poaching, increasing land development, and a limited understanding of the bat's status, biology and ecology.

WORTHINGTON-WILMER, J.M.

GENETIC EVIDENCE FOR EXTREME POPULATION STRUCTURING *Macroderma gigas*: IMPLICATIONS FOR CONSERVATION.

J.M. Worthington-Wilmer, C.M. Moritz, and L.S. Hall. University of Queensland, Brisbane, Australia.

The ghost bat, *Macroderma gigas*, has undergone a major range contraction and is currently restricted around a few, highly disjunct maternity sites. The amount and distribution of mitochondrial (mtDNA) variation within extant populations has been used to assess levels of current and historical maternal gene flow between those populations. An approximately 330 base pair fragment of mtDNA spanning a hypervariable area of the control region, was amplified and sequenced using 47 individuals from the 11 currently known ghost bat populations. The net nucleotide divergence of 4.6% between populations was ten times higher than the nucleotide diversity within populations (0.46%). There is strong phylogeographic structuring to all mtDNA alleles. Restriction enzyme analysis of amplified products from an additional 210 individuals revealed fixed allelic differences in the distribution of control region genotypes between six of the populations, while frequency distributions of genotypes for the other five were population specific. Levels of male-mediated gene flow were assessed by examining the amount and distribution of nuclear DNA variation. All 257 samples were screened across six variable microsatellite loci. Numbers of alleles at each locus ranged from 11 - 23 with levels of heterozygosity ranging from 0.386 to 0.916. Population structure from the microsatellite data set was found to be concordant with that from the mtDNA data set strongly indicating that each population is an independent entity for management purposes.

YANCEY II, F.D.

INCIDENCE OF RABIES AMONG BATS FROM THE BIG BEND REGION OF TEXAS, U.S.A., SAMPLED UNDER NATURAL CONDITIONS.

F.D. Yancey II[1], C. Jones[1], and P. Raj[2].
[1]Texas Tech University, Lubbock, Texas, and [2]Texas Department of Health, Austin, Texas

In the state of Texas, USA, the frequency of bats infected with rabies has been reported as high as 11 percent. This figure, however, was determined from a biased sample of bats submitted to the Texas Department of Health. These bats were, n most instances, acquired from the ground or other abnormal locations. We examined 166 bats that were taken under natural conditions (i.e., while in flight) from the Big Bend Ranch State Natural Area, Presidio County, Texas. Using an immunoflouorescent antibody procedure, brain tissues from 12 species of bats were tested for the presence of the rabies virus. The incidence of rabies from our sample is compared to Texas Department of Health records, and the results are discussed.

YOGESH, P.

LEARNING BEHAVIOUR TO AVOID DIRECT SUNLIGHT IN COLONY OF *Pteropus giganteus giganteus*.

P. Yogesh. S.N. Government. P.G. Aut. College, Khandwa, India.

Report of twenty-five years of regular observations of the colonies of *Pteropus giganteus giganteus* in Khandwa and Indore with variation in temperature and climate indicate learning behavior in the Khandwa colony. In Indore (M.P. India) the colony of *Pteropus giganteus giganteus* remains on Peepal and adjoining trees throughout the year. In May 1994 mass mortality of bats occurred due to high temperature. (116° F.) Khandwa is very hot as compared to Indore and the temperature reaches up to 118° F. in May and June but such mass mortality never occurred in Khandwa. To avoid direct sunlight the bats take shelter on palm trees from March to June.

ZHUKOVA, N.F.

AN HYPOTHESIS ON PRIMARY EURYPHAGY IN CHIROPTERAN ANCESTORS.

N.F. Zhukova, National Academy of Sciences, Kiev, Ukraine.

The question of chiropteran origins and evolution remains disputable. The resemblance of characteristics of the digestive system from the Chiroptera to Insectivora, and Prosimii (often uncommon mammals in general) makes it possible to suggest the origin of these mammals from common insectivorous ancestors. This suggestion is supported by extraordinary high enzyme activity along the entire digestive tract (including the esophagus and large intestine) in both insectivores and bats. An ancestral (basic) complex designated in the structure of digestive systems in bats may provide the basis for their trophic divergence and yield evidence for primary euryphagy of common or closely related ancestral groups. Furthermore, the appearance in chiropterans of wide trophic specializations was made possible, in our judgement, by the presence in an ancestral digestive tract with a high basic level of activity associated with the transfer of carbohydrate and protein molecules, as is characteristic of other polyphygous animals. This is confirmed by the high phytolytic amylase activity found in insectivourous bats. An

argument in favor of this suggestion is reflected in changes to a non-characteristic food in certain specialized species under natural conditions. Thus, a hypothesis of primary euryphagy in the ancestors of bats has been supported by morphological, biochemical, physiological, and ethological data.

ZUKAL, J.

BAT ACTIVITY IN A TOWN AS REVEALED BY ULTRASOUND DETECTORS

J. Zukal[1], J. Gaisler[2], Z. Rehák[2], M. Homolka[1].
[1]Institute of Landscape Ecology, Brno, and [2]Masaryk University, Brno, the Czech Republic.

Echolocation calls of bats were monitored during the year 1993 within a central European town (230 km^2, 350,000 inhabitants). Four bat detectors were used along walking transects during nights of new and full moon (± one night). Each observation interval started 10 min after sunset and lasted 30 minutes. In total, 55 standard transects were walked and 246 min of bat calls were recorded (henceforth, min rec). The following species, including one group of species, were registered: *Pipistrellus pipistrellus, Eptesicus serotinus, Nyctalus noctula, N. leisleri, Myotis myotis, M. daubentoni* and other small *Myotis* spp. During the year, *P. pipistrellus* and *Myotis* spp. were recorded from March to September, *E. serotinus* from April to September and *N. noctula* from March to October. Peaks in the number of min rec were evident in *N. noctula* (July) and *P. pipistrellus.* (August), possibly reflecting the emergence of fledged young. In all, except for *Myotis* spp., the number of min rec was higher during nights of new, as compared to full, moons. During the observation periods, the number of min rec was high since the first min for *P. pipistrellus.* and since the first min for *E.serotinus* and *N. noctula,* recordings were low at the beginning, increasing until the end for *Myotis* spp. In addition, 41 non-standard transects were walked, not keeping to the time schedule. For *P. pipistrellus* the number of min rec was highest during the first hour, for *N. noctula* and *Myotis* spp. during the second hour and for *E. serotinus* during the third hour after sunset. In addition, *Plecotus* spp. were recorded within 30-90 min after sunset.

ZUKAL, J.

FORAGING ACTIVITY AND ECHOLOCATION OF *Myotis emarginatus.*

J. Zukal[1], J. Gaisler[2] and Z. Rehák[2].
[1]Institute of Landscape Ecology, Brno, the Czech Republic, and [2]Masaryk University, Brno, the Czech Republic.

The bat species *Myotis emarginatus* was studied at a nursery colony in a hunting castle near Lednice (Czech Republic) during the years 1987 to 1993. Pre-emergence activity for this species at around 60 minutes before first emergence and, near the end of this activity period, light sampling behavior was noted in 10 cases. The emergence of the first bat was related to sunset and, on average, occurred 17.3 ± 14.2 min after that time. The departure of the whole colony showed a unimodal pattern of distribution. At approximately one hour before sunrise, the major part of the colony returned to the roost. The bats showed a preference for foraging in the vicinity of tree cover (forest, patches of woodland, alleys and windbreaks) as opposed to open fields and ponds, where foraging activity was never recorded. Bat detector transects confirmed that the bats foraged, in the main, close to the roost, at distance of up to 600 m. The highest intensity of foraging activity was observed between 31 and 60 minutes after sunset (i.e. between 2000 and 2100 hours), with such activity practically stopping after 23.00 hours. Patterns of echolocation signals were seen to vary within differing foraging habitats, two fundamental types of sound being clearly distinguished: one very short (1-2 ms), FM sweeps that started at 80-100 kHz and ended at 40 kHz (Fmax ca. 60 kHz), often with second and third harmonics present, and two long signals (2-4 ms), of the FM-CF type, with narrower bandwidth (11.3 ± 3.2 kHz) and Fmax of 57 kHz.

A Brief History of the Annual North American Sympsosia on Bat Research

G. Roy Horst, Department of Biology, State University of New York at Potsdam, NY

The idea for a symposium dedicated exclusively to the biology of bats originated in a series of conversations with interested bat biologists in late 1969 and early 1970 while I was on the Faculty at the University of Arizona College of Medicine in Tucson, Arizona. The concept was developed further at the North American Society of Mammalogists Annual Meeting in College Station, Texas in June in 1970. Several of us were taking a break in the cocktail lounge from a long afternoon of "mouse papers" when one of us made the irreverent comment that it was too bad we had to sit through all those mouse and rat papers, just to hear one paper on bats." At this point Jim Findley made the casual comment that "somebody" should organize a small, definitely informal, local get-together on some convenient weekend and we would spend a day discussing our various interests and projects concerning bats. After a few more thoughts and opinions were expressed, we reached the conclusion that this in fact would be a pleasant and worthwhile experience. A meeting was subsequently arranged for November 27-28, 1970, the weekend of Thanksgiving Day, when most of us would have a short break from our teaching responsibilities. We decided to invite all those bat biologists in the southwestern United States and that the meeting would be in Tucson, as this was centrally located in the southwest. Invitations went to all those individuals working on bats in Arizona, California, Colorado, New Mexico, Nevada, Texas and Utah. We also extended an invitation to our colleagues in Mexico as well as anyone else who might be interested and could afford the time and journey to Tucson. The University of Arizona and the Arizona Sonora Desert Museum generously agreed to serve as our host institutions, Philip H. Krutzsch served as our host and I assumed the responsibility for putting some sort of program together.

We anticipated that 15 or 20 individuals might attend this minimally organized gathering, but were pleasantly surprised when 42 biologists attended and presented 25 papers. The sessions were very informal and a great deal of very relaxed(most of the time) discussion accompanied each presentation. At the end of the meeting everyone agreed that this was very useful experience and "we should do it again next year." Jim Findley agreed to serve as our host but only if someone else would do the paperwork involved with sending out invitations, assembling the submitted presentations into some sort of program, and handle the correspondence that is inherent in such conferences. All agreed that since "it was your idea in the first place, Roy" and since "you had already done it once", and presumably now an expert at organizing meetings, I should be the "program person". We also decided at that meeting that we would call ourselves the Southwestern Symposium on Bat Research, and agreed that we wold meet the following year on the fourth weekend in November (to coincide again with the Thanksgiving Day holiday weekend. So ended that first Symposium on Bat Research in the Southwest.

The Second Southwestern Symposium on Bat Research was convened on November 26-27, 1971 at the University of New Mexico in Albuquerque, New Mexico where we were graciously hosted by James Findley. Twenty-nine papers were presented and 57 biologists participated. Some noteworthy observations from that meeting. Lendell Cockrum urged "that we address ourselves with renewed zeal to the problems of bat conservation." The program minutes reported that, "Clyde Jones made an excellent and timely report on this topic which did much to re-awaken our concern in this area and we are all resolved to quicken our efforts in bat conservation." This was as far as I can determine, the first organized attempt to address this critical problem of bat conservation, and a special section on conservation was proposed for the next symposium. Clyde Jones agreed to organize this section of the program and did so for the next several years, and there has been a section on conservation at every symposium since that early date. It was also at this meeting that the group decided that since so many attendees were not from the southwest but included individuals from all over the United States, Canada, and Mexico, this meeting would change its title to the Annual North American Symposia on Bat Research.

The Third Annual North American Symposium on Bat Research convened at The University of San Diego and San Diego Zoo, in San Diego, California on November 24 -25, 1972, hosted by Roger E. Carpenter. It was at this meeting that a session was initiated devoted solely to the issues involved in bat conservation. There were 93 participants and 49 presentations on the program.

The Fourth Symposium convened in New Orleans, Louisiana, November 23-24, 1973, hosted by Alfred Gardner. There were 117 participants and 41 presentations on the program.

The Fifth Symposium convened in Lubbock, Texas, November 29-30, 1974, hosted by Dilford Carter at Texas Tech University. There were 89 participants and 36 presentations on the program.

The Sixth Symposium convened in Las Vegas, Nevada, October 10-11, 1975, hosted by Glen Bradley and Michael O'Farrell at the University of Nevada, Las Vegas. There were 76 participants and 29 presentations on the program.

The Seventh Symposium convened in Gainesville, Florida October 15-16, 1976, hosted by Stephen R. Humphrey at the Florida State Museum of the University of Florida There were 109 participants and 46 presentations on the program.

The Eighth Symposium convened in Ottawa, Ontario, Canada, October 14-15, 1977, hosted by M.Brock Fenton at Carleton University. There were 82 participants and 35 presentations on the program. It was at this meeting that the Gerritt S. Miller Award "in recognition of outstanding service and contribution to the field of chiropteran biology" was initiated. The Gerritt S. Miller Award was presented to G. Roy Horst and to Karl F. Koopman.

The Ninth Symposium convened in combination with the Fifth International Bat Research Conference in Albuquerque, New Mexico August 6-11, 1978, hosted by James S. Findley and Don E. Wilson, at the University of New Mexico. There were 217 participants from 24 countries, and 102 presentations on the program.

The Tenth Symposium convened in St. Louis, Missouri, at Washington University, October 11-13, 1979, hosted by James A. Simmons. There were 119 participants and 53 presentations on the program. The Gerritt S. Miller award was presented to Don Griffin.

The Eleventh Symposium convened at the Los Angeles County Museum in Los Angeles, California, November 20-22, 1980, hosted by James D. Smith and Donald R. Patten. There were 89 participants and 32 presentations on the program.

The Twelfth Symposium convened at Cornell University in Ithaca, New York, October 15-17, 1981 hosted by William A.Wimsatt. There were 167 participants and 66 presentations on the program. The Gerritt S. Miller award was presented to William A. Wimsatt.

The Thirteenth Symposium convened at the University of Louisville in Louisville, Kentucky, October 15-16, 1982, hosted by Kunwar Bhatnagar. There were 107 participants and 49 presentations on the program. The Gerritt S. Miller award was presented to M. Brock Fenton. .

The Fourteenth Symposium convened at Colorado State University in Fort Collins, Colorado on October 21-22, 1983, hosted by Michael Bogan. There were 59 participants and 20 presentations on the program.

The Fifthteenth Symposium convened at Rockford College in Rockford, Illinois on October 19-20, 1984, hosted by Lawrence Forman. There were 71 participants and 43 presentations on the program. The Gerritt S. Miller award was presented to Thomas H. Kunz .

In 1985 the North American Symposium did not meet, as this was the year of the Seventh International Bat Research Conference in Aberdeen, Scotland, and many of the members elected to attend that meeting.

The Sixteenth Symposium convened at the University of Massachusetts in Amherst, Massachusetts, on October 16-18, 1986 hosted by David Klingener. There were 94 participants and 36 presentations on

the program. The Gerritt S. Miller Award was presented to Harold Hitchcock and Merlin D.Tuttle.

The Seventeenth Symposium convened at the Royal Ontario Museum in Toronto, Ontario, Canada, on October 15-17, 1987 hosted by Judith Eger of the Royal Ontario Museum, M. Brock Fenton of York University, and James Fullard of Erindale College of the University of Toronto. There were 106 participants and 41 presentations on the program.

The Eighteenth Symposium convened at the University of Calgary in Calgary Alberta, Canada, on October 13-15, 1988, hosted by Robert M.R. Barclay. There were approximately 100 participants and 56 presentations on the program.

The Nineteenth Symposium convened at the University of Tennessee, in Knoxville, Tennessee, October 19-21, 1989, hosted by Gary McCracken. There were 137 participants and 63 presentations on the program.

The Twentieth Symposium convened at the The Nebraska State Museum of the University of Nebraska in Lincoln, Nebraska, on October 24-26, 1990, hosted by Patricia Freeman and Hugh Genoways. There were 159 participants and 67 presentations on the program. The Gerritt S. Miller Award was presented to Bernardo Villa-R.

The Twenty-First Symposium convened in Austin, Texas, October 16-19, 1991, hosted by Merlin D.Tuttle and Bat Conservation International. There were 203 participants and 88 presentations on the program.

The Twenty-Second Symposium convened at the Chateau Frontenac in Québec, Québec, Canada, October 21-24,1992, hosted by Don Thomas of the Universite dé Sherbrooke. There were 193 participants and 77 presentations on the program. The Gerritt S. Miller Award was presented to Don E.Wilson.

The Twenty-Third Symposium convened at the Florida State Museum and the Lubee Foundation in Gainesville, Florida, hosted by John Seyjegat. There were 231 participants and 96 presentations on the program.

The Twenty-Fourth Symposium convened at the Hotel Westin in Ixtapa, Mexico, hosted by Bernardo Villa.R., Hector Arita, and Rodrigo Medellin, all of Universidad Nacional Autonoma de Mexico. There were 174 participants and 87 presentations on the program.

The Twenty-Fifth Symposium met in combination with the Tenth International Bat Research Conference at Boston University, hosted by Thomas H. Kunz and G. Roy Horst. There were 382 participants and 287 presentations on the program. The Gerritt S. Miller award was presented to Paul A. Racey.

Upon review of all those programs it turns out that approximately 1375 presentations have been made at these meetings which were heard by a total of about 3,100 people. Admittedly some of these individuals are counted many times over, but only Tom Kunz and I were at all twenty five of these meetings. Looking over the past registration records it appears that there are about 1,150 different names recorded as paid attendants. It does not seem possible that 1375 abstracts have crossed my desk during that time. Nor does it seem possible that I processed (with a great deal of generous and much appreciated assistance from many other people) over 3,000 registrations and cashed all those cheques! I noticed that dues for that first meeting were $5.00 which went for coffee and pastries, with a few bucks for duplicating the program, and $7.00 for mailing! How much was it in Boston? Happily we always managed to break even or very nearly so, but there were a few harrowing moments. I will not soon forget that sinking feeling when the head waiter at the Auberge du Tresor in Quebec City handed me the checque for the banquet and it was "only" $4,700. What if somewhere I had miscalculated, when I calculated the registrations fee.

The Symposium is now entering its second quarter-century and is planning to hold its twenty-sixth

meeting in Bloomington, Illinois, at Illinois Wesleyan University with Thomas Griffiths as host. Hopefully he will enjoy organizing the symposia as much as I have and will agree to undertake that responsibility for at least the next decade. I also hope that he will be as fortunate as I was and will receive the same generous assistance of so many of you as I have. For the opportunity of being of some use I am deeply grateful: It has been a very rewarding and satisfying experience.

To all of you who continue to meet and talk about bats long into the future, best wishes and godspeed. May your cave always be warm and your belfry dry. As for me, I intend to sit in the second row, center aisle, next to Karl, and listen, and perhaps occasionally terrorize a speaker or two with a question that begins, " It seem's to me....? "

* * * * * * * * * *

International Bat Research Conferences : Historical Glimpses

T. H. Kunz, J. Gaisler, K. F. Koopman, P.A. Racey, J. S. Findley,
G. Marimuthu, M. L. Augee, and G. R. Horst

On the occasion of the 10th International Bat Research Conference, we have prepared this document for all present and future participants to share our collective views of history on the origins and activities at these meetings over the past 28 years. We hope that this document will stimulate future generations of bat biologists to continue the tradition of international collaboration and exchange of ideas and experience.

Origins

The idea to organize an international conference of bat researchers began with discussions between Beatrice Dulic (Yugoslavia) and Jiri Gaisler (Czechoslovakia) in 1965. These discussions were facilitated by exchange visits by Dr. Dulic to Brno and Dr. Gaisler to Zagreb during collaborative field studies. The inspiration for organizing an international bat research conference came from the 1960 Symposium Theriologicum, the first international meeting of mammalogists, convened by Professor J. Kratochvil in Brno. The reason why Czechoslovakia seemed to be a good place for such a meeting was that it provided relatively good opportunities (politically) for participation by both "western" and "eastern" scientists. At this time it was easier for "westerners" to visit a socialist country, than it was for scientists from "socialist countries to visit "western" countries. The relatively good attendance at the 1st International Theriological Congress, by mammalogists from the former Soviet Union and members of other Soviet-block countries, led Gaisler and Dulic to conclude that an international bat research conference would be equally well attended if the meeting was held in Czechoslovakia.

Subsequent meetings between Jiri Gaisler, Vladimar Hanak, and Milan Klima concluded that the 1st International Bat Research Conference should be held somewhere in western Czechoslovakia (Bohemia or Moravia). Hluboká n. Vlavou, a small town in southern Bohemia, with a large castle, was eventually chosen as the site of this inaugural meeting. Preparations were made, including financial backing from Charles University in Prague and the Institute of Vertebrate Zoology in Brno, to convene the meeting in 1967. At the time, this as well as other international meetings required the support of the Czechoslovak Academy of Science who, in addition to having the scientific responsibility, was supervised by the state security office (STB). The Presidium of the Academy refused to allow the international conference to be held because "the meeting had not been sufficiently prepared."

In the following months, Gaisler, Hanak, and Klima persuaded the Academy leaders to allow them to organize the meeting in 1968, with the promise of additional financial support. The political situation in the "Prague Spring" of 1968 seemed to be ideally suited for an international conference on bats. The majority of the Czech and Slovak people supported political changes introduced by Alexander Dubcek and his "progressive" communist regime. The citizens of Czechoslovakia had witnessed a renewed sense of freedom. The most important factor in organizing the conference was that it was much easier for scientists to travel to and from Czechoslovakia. Announcements of the conference were sent to colleagues from both

"western" and "eastern" countries, and the proposed conference was met with great enthusiasm by all. The conference was scheduled for 6-9 September 1968. Two weeks before the scheduled conference, Soviet military troops invaded Szechoslovakia.

First IBRC , Hluboká n. Vltavou, Czechoslovakia (1968)

Conveners: J. Gaisler and V. Hannak

In spite of the ominous situation created by this invasion, the 1st IBRC was held at the art gallery of Hluboká Castle, Hlukoká n. Vltavou, Czechoslovakia, on 6 September 1968. The meeting was convened by Jiri Gaisler (Institute of Vertebrate Zoology, Czechoslovak Academy of Sciences, Brn) and Vladimar Hanak (Department of Zoology, Faculty of Sciences, Charles University, Prague). Fifteen participants attended the conference, seven from Czechoslovakia, three from the Netherlands, three from West Germany, and two from the United Kingdom. Nine oral papers were presented, and the results of bat banding in Czechoslovakia were displayed as a single poster. On the nights of 7-8 September, the conference participants were housed at a field station at Ruda, a wooded area with a large fish pond. Eight of the participants participated in an excursion to Moravia, where they visited caves in the Moravian Karst, and southern Moravia they had an opportunity to see fifteen species of bats. The conference was closed at Castle Park at Lenice, Czechoslovakia.

The proceedings of the 1st IRBC, edited by Jiri Gaisler and Vladimar Hanak, were published in the journal Lynx, volume 10, 1969, and included 14 papers. Some of these papers were submitted by scientists who had planned to attend the meeting, but were discouraged to participate because of the military intervention against Czechoslovakia.

Second IRBC, Amsterdam, The Netherlands (1970)

Conveners: A. Punt, S. Daan, and J. Dorgelo

The 2ndIBRC was held at the University of Amsterdam, organized by A. Punt, S. Daan, and J. Dorgelo (Laboratory of Animal Physiology, University of Amsterdam) from 17-22 March 1970. The conference was held at the lecture hall at the Institute of Systematic Zoology. There were 88 participants from 16 countries. The venue for the conference included 30 oral papers and a round table discussion on bat conservation.

The proceedings of the conference included 26 papers, and were published in Bijdragen tot de Dierkunde, Volume 40 (1970). A conference excursion was taken to the limestone quarries in South Limburg. These quarries had served as study sites by Dutch bat biologists for many years.

Third IBRC, Plitvice, Yugoslavia (1972)

Convener: B. Dulic

The 3rdIBRC was held at the Plitvice National Park, in Croatia, organized and convened by Beatrice Dulic (Department of Zoology, Faculty of Natural Sciences, University of Zagreb) from 5-10 September 1972. The conference was jointly sponsored by the Council for Scientific Research of the Republic of Croatia and the Biological Section for the Croatian Society for Natural Sciences. Conference sessions were held in the Jezero Hotel, and housing for participants was provided in a nearby hotel. The conference was attended by about 90 participants from 20 countries. Approximately 30 oral papers were delivered. The proceedings of this conference, edited by B. Dulic, were published in Periodicum Biologorum, Zagreb, Volume 75 (1973).

A conference excursion was organized to the region of Lipica, famous for its breeding of Lipica horses, and to several local caves (Skocjanske jame, Postojnska jama, and Predjama). Donald Griffin attended the conference and excursion and displayed his bat detector. Plitvice is currently under Serbian control. It is included into the "Republic Serbian Kraina" in the territory of Croatia. This republic's existance has not been organized by any country except the present (smaller) Yugoslavia.

Fourth IBRC , Nairobi, Kenya (1975)
Convener: F. Mutere

The 4thIBRC was held at the Safari Park Hotel, Nairobi, and was organized and hosted by Festro Mutere (Kenyatta University College, Nairobi), from 22 September to 1 October 1975. The conference was attended by approximately 74 participants from 24 countries. Following a welcoming ceremony, 38 oral papers were delivered by participating scientists. Although there were no formal poster sessions, many drawings of East African bats were displayed by Johathan Kingdon. Two films entitled "The Baobob" and "Mzima Spring" by Alan Root were shown. An evening slide show on East African bats also was given by Dieter Kock and an introduction to Kiboko Caves was given by James Simmons.

The proceedings of this conference, edited by R. J. Olembo, J. B. Castelino, and F. A. Mutere were published as the "1978 Proceedings of the Fourth International Bat Research Conference," Kenya National Academy for Advancement of Arts and Sciences.

From 27-30 September, an excursion was organized to caves (Kiboko Caves) in the Chyula Range, to Diani Beach, near Mombasa, Shimoni Caves, Simitani Cave (a marine cave only accessible at low tide), Tsavo West National Park, and Mzima Springs. This excursion ended when some participants (including Paul Racey) were transported back to Nairobi. A subsequent excursion included a visit to a Safari Park which included many large game mammals and birds. The trip involved a long overland trip to the Tsavo West Park through Massai territory to Amboseli National Park where one could see Uhuru Peak of Mt. Kilimanjaro.

Fifth IBRC, Albuquerque, New Mexico (1978)
Conveners: J. S. Findley and D. E. Wilson

The 5th International Bat Research Conference was held on the campus of the University of New Mexico hosted by James Findley and Don Wilson from 6-11 August 1978. The conference was attended by over 200 participants from 24 countries. In addition to three plenary symposia on reproduction, energetics, and evolution, 40 oral papers were delivered and 20 posters were displayed. One-hundred six abstracts were published in Bat Research News. The conference proceedings, which included 29 contributed papers and 12 papers from two of the invited symposia "Energetics" and "Evolution and Energetics" were published as the "Proceedings of the Fifth International Bat Research Conference," edited by D. E. Wilson and A. L. Gardner, Texas Tech University Press, 1980. The proceedings of the symposium on "Bat Reproduction", edited by Al Gustafson, were published as a special issue of the Journal of Reproduction and Fertility, Volume, Vol. 56 (1979).

A highlight of the conference was a western-style barbecue and spontaneous pool-dipping party hosted by James Findley at his ranch in the outskirts of Albuquerque. After the conference, several participants joined an excursion to the Carlsbad Caverns in Carlsbad, New Mexico where thousands of Mexican free-tailed bats could be observed emerging from the cave at dusk.

Sixth IBRC, Ife-Ife, Nigeria (1981)
Conveners: Eyo E. Okon, A. E. Caxton Martins, and V.O. Marquis

The 6thIBRC was convened by Eyo Okon, Caxton Martins, and V. O. Marquis and held on the campus of the University of Ife from 29 August to 3 September 1981. For various reasons, this was one of the smallest of all the international conferences held to date, with less than 20 participants. Only five of the participants came from outside of Nigeria: F. Mutere and Aggundey (Kenya), K. Karim (India), B. Dulic (Yugoslavia), K. Koopman (USA). All of the participants from Nigeria (all but one from the University) spoke on various aspects of the biology or utilization of *Eidolon helvum*. Papers by foreigners: covered bat "ringing", reproduction, karyology, and systematics of various African and Indian bats.

Since there were so few papers given during the week-long session, there was plenty of time for information discussion and tours of the campus. No formal excursions were scheduled, but several participants spent time as "tourists" in the town of Ife-Ife. The major attraction on campus was the large colony of *Eidolon helvum*, which is the source of the biological research material at the University of Ife.

The sights of the large numbers of these bats hanging from tree branches and their evening flight was most spectacular. Some mist-netting was done, but only Epomops franqueti was captured during the conference, although other species were obtained later.

Seventh IBRC, Aberdeen, Scotland (1985)

Conveners: P. A. Racey and A. D. Marshal

A joint meeting of the 7thIBRC and the 3rd European Symposium on Bat Research was convened by Paul A. Racey and Adrian G. Marshall at the University of Aberdeen, Aberdeen, Scotland from 19-24 August 1985. The conference was attended by approximately 220 delegates from 25 countries, including 43 from the USA, 47 from Great Britain, 36 from West Germany, 11 from India, 10 from Canada, and 3 from Japan.

In addition to these three symposia, the meeting included submitted oral papers and poster grouped into session on Conservation, Ecology, Echolocation, Reproduction, Systematics, Physiology, and Ecophysiology together with a workshop on Observation Techniques was convened by J. D. Pye. In all, 66 oral papers and 53 poster papers were presented. Abstracts of these papers were distributed and later published in Bat Research News. The proceedings of the symposia which included 24 papers, and edited by M. B. Fenton, P. Racey and Roer were published in Myotis, Volume 23-24 (1986-1985).

The social program included an evening visit to a distillery, a post-conference excursion to the Lonach Gathering, a Highland Games preceeded by the march of a private army, the Men of Lonach in full highland dress, armed with pikes and claymores, and accompanied by a bag-pipe band--a truly memorable sight! The highlight of the social program, however, was the conference dinner where guests were led to their tables by a piper, who in traditional fashion was presented by a Quaich (a shallow drinking cup) of whiskey by the University President. Less traditional was the President's subsequent idea of having a large silver salver filled with whisky and passed around the entire gathering for each guest to sip. This was followed by a traditional Scottish dinner of phesant and claret.

Eighth IBRC, Sydney, Australia (1989)

Convener: M. L. Augee

The 8thIBRC was held on the campus of the University of New South Wales from 9-15 July 1989. the conference was organized and hosted by Mike Augee and Karen Parry-Jones (Department of Zoology, University of South Wales). The conference was attended by approximately 162 participants from 20 countries. The venue included six special sessions (Acoustic Behavior and Echolocation, Energetics, Functional Morphology, Reproduction, and Systematics with 15 speakers as well as 50 oral papers and 40 posters. Abstracts from the conference were published in Macroderma, Vol. 5 (1989).

The social events, sponsored by the Royal Zoological Society, included a boat excursion in Sydney harbor and a visit to the Taronga (Sydney) Zoo. A field trip to a local Pteropus poliocephalus colony also added interest to the scheduled activities. An organized excursion to Chiligoe, with stops to see large colonies of Pteropus poliocephalus and P. scapulatus, were highlights of the post-conference tours. Several of the conference participants also joined pre- or post-conference workshops convened near Cairns in northeast Queensland organized by John Nelson and Chris Tidemann, focused on the use of field techniques for the study of bats. These workshops provided opportunities for participants to see the Australian subtropics and to use radiotelemetry, bat traps and mist nets and bat detectors.

Ninth IBRC, Madurai, India (1992)

Conveners: C. Chandrishakian and G. Marimuthu

TheIBRC, convened by C. Chandrishakian and G. Marimuthu was held on the campus of the Madurai Kamaraj University, Madurai, India from 3-7 August 1992. About 140 participants from 13 countries attended the meeting. The Vice-Chancellor of Madurai Kamaraj University opened the meeting, which was followed by Paul A. Racey's keynote address with a question, "Are you a paradigm breaker of a paradigm

infiller?" Oral presentations were organized into various sessions, including conservation, behavioral ecology and field ethology, functional morphology, echolocation and neurobiology, biogeography, systematics and evolution, biochemistry and physiology, anatomy and histology, and reproduction and development. Each session was opened by a plenary lecture, delivered by experts in the relevant sessions. Poster sessions were held separately. The total number of papers presented as oral and poster papers numbered 119. Abstracts of these papers were published in Bat Research News, Volume 34(1), 1993.

Field trips were organized to visit the Samanar Hills where a colony of Hipposideros speoris live in a cave, and the KKB Hills where a colony of Rhinopoma hardwickei live in a wide, vertical crevice. The conference delegates also visited the Alagarkoil Hill Complex, a rain forest area occupied by Pteropus giganteus. Most of the conference delegates enjoyed walking and shopping in the crowed city of Madurai, with its famous Meenakshi temple complex which was built by the Pandya king in the 12th and 13th Centuries. Subsequently, this site was developed into a large complex by the Nayak rulers.

Tenth IBRC, Boston, Massachusetts (1995)
Conveners: T. H. Kunz and G. R. Horst

The 10thIBRC, convened and organized by Tom Kunz and Roy Horst was held on the campus of Boston University, Boston, Massachusetts from 6-11 August 1995. The conference was attended by approximately 380 delegates representing 33 countries. The venue included four plenary symposia (Phylogeny and Evolution, Conservation Biology, Functional Morphology, and Echolocation). In addition to the four symposia, over 150 oral papers were delivered and 120 poster papers were displayed. An evening workshop on conservation education, and round-table discussions convened by the IUCN (World Conservation Union) and the American Zoo Association (AZA) to discuss matters related to bat conservation. The proceedings of the conference symposia, entitled "Bats: Phylogeny, Morphology, Echolocation, and Conservation Biology," will be edited by T. H. Kunz and P. A. Racey and published by the Smithsonian Institution Press. Abstracts from the conference will be published in Bat Research News.

The conference opened on Sunday evening with a gala reception hosted by the Lubee Foundation, Inc. On the following evening, a reception was hosted by Bat Conservation International, Inc., following the conference picnic. Poster sessions were held on two evenings. During the mid-week, delegates were free to enjoy the sites and sounds of Boston (taking advantage of historic tours, shopping, whale watches, and visits to museums, the zoo, and aquarium). On the final night, awards were given to students for the best oral, written, and poster papers, and distinguished participants were honored at the conference banquet.

Pre-conference workshops were convened at the Lubee Foundation, Inc. in Florida (John Seyjagat) and Arizona (Merlin Tuttle), and post-conference workshops were held in Puerto Rico (Armando Rodriquez-Duran and Michael Gannon), New Hampshire (Tom Kunz, John Whitaker, Jr., and Chris Neefus), and Rhode Island (James Simmons and Sharon Swartz).

The 26th Annual North American Symposium on Bat Research

will be held

October 23-27, 1996

at Jumer's Chateau Lodge in Bloomington, Illinois

Host and Symposium Director:

Thomas A. Griffiths
Department of Biology
Illinois Wesleyan University
Bloomington, Illinois 61702
(309) 556-3230
FAX: (309) 556-3411
tgriff@titan.iwu.edu

Detailed information will appear in successive issues of Bat Research News.

Ed. note[see, I really have retired! GRH]

BAT RESEARCH NEWS

Volume 36 **Winter 1995** **Number 4**

CONTENTS

Front Cover

This month's front cover is the logo used for the Combined 10th International Bat Research Conference and the 25th North American Symposium on Bat Research .