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(all errors are mine for a change!)

BAT NEWS RESEARCH

Volume 31 Spring 1990 Number 1

A FLASHING TRANSMITTER FOR BATS

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Nyctimene robinsoni, the tube nosed bat, is a common frugivorous species of pteropodid bat found at Cape Tribulation in north Queensland, Australia (16°.30'S). Its foraging movements were the subject of an initial radio-tracking study by Spencer and Fleming (89), and work is continuing on habitat utilization by this species. *Nyctimene*, which weighs 45-50 gm, appears to be primarily, if not exclusively, a fig eating bat and forages on cauliferous cluster figs (*Ficus variegata*) which are common trees of disturbed areas and regrowth rainforest.

While *Nyctimene* is readily netted under such figs, it is virtually impossible to observe them feeding, their cryptic colouration and hovering flight makes them very difficult to differentiate against a visually cluttered background of fig leaves and fruit covered branches, besides which lights inhibit their activities. In the absence of suitable infrared viewing equipment, we decided to fit the tracking transmitters that we were using with high intensity light emitting diodes (LEDS) with the hope that we would be able to observe the animal's flight underneath the canopy and observe their feeding.

Flashing Transmitter Design.

We were using a 2-stage 'squegging' (self-pulsing) transmitter design powered by a 3v 30 maH lithium button cell, this design was at the time being used for radio-tracking *Pteropus poliocephalus* in NSW (Spencer et al in prep.) The design incorporated a current limiting resistor in the first stage to control current comsumption (Fig 1) and I took advantage of this resistor to provide switching drive for an additional PNP switching resistor which in turn controlled the current through the LED. This results in a 20 mS (normal), 1 mA flash which occurs with each pulse of the transmitter. The increase in total transmitter current consumption is in the order of 20%, which would not be expected to have great significance in a short term study such as this as the transmitters are shed well before the lithium cell is exhausted.

Conventional LED's are quite unsuited for this application because of their very low efficiency. However Hewlett Packard Al-Ga-As high efficiency diodes are capable of outputs of 1 candlepower for a current of 20 mA (but with a 8° beam angle; HLMP 4101). Because of this

high efficiency, a 1 mA current flow produces a quite intense light when viewed in line with the LED axis, being visible with binoculars over 500 M at night. Other LEDs in the series, (eg. TLMP 7005) have beam angles of 30° and comparable efficiencies. In this application we used the narrow beam LED, as it was, at the time, the only type available.

The transmitters were constructed on a 1 cm disk of 1/32nd inch printed circuit board, and constructed using surface mount devices (SMD's). Iron dust toroids (T10-12, Micrometals, 1190 N. Hawk Circle, Anaheim, Ca. 92807) were used for the oscillator and output stages to reduce unwanted harmonic output signals. The completed transmitters were mounted on a simple tuning jig which permitted monitoring current and which provided a standard antenna. The oscillator and output stages were tuned by spreading or compressing the turns of the toroidal windings while observing the output on a spectrum analyser. When satisfied with the result, the windings were locked in place with Q-dope or a drop of molten beeswax.

The finished transmitter with the 200 mm (nom.) guitar-wire antenna attached, was dipped in just-molten beeswax; the battery connected (leaving two wires outside for final turn-on) and potted in a small latex mould which had a hole into which the LED fitted tightly at the appropriate angle. Polyester auto-repair putty thinned with polyester resin monomer was used as the potting compound. It has many advantages over epoxies, in that it gels before setting hard, which permits easy clean up of the moulded item with a scalpel, and, when finally set, is quite water and tooth resistant. The beeswax coating, besides being waterproof, allows the ready recovery of the transmitter by simply cracking the polyester coating off with a pair of diagonal cutters.

The package chosen for the transmitter was a hemispherical one (Fig 2), chosen with the aim of making the package difficult to scratch off; *Nyctimene* having proved itself quite early in the study at being quite adept at removing things from its back using its thumb claws. Total package weight was 5 grams.

With the aim of being able to see the animal as it flew towards the observer (sitting under the fig), the LED was positioned on the package so that it pointed forward, it was anticipated that there would be sufficient light shed onto leaves to enable us to keep track of the animal under the canopy.

Transmitters were attached to the animal using conventional yellow contact adhesive, the adhesive being well rubbed into the fur between the shoulder blades and on the base of the transmitter, the two being pressed together once they had dried to a tacky state. These transmitters stayed on the animals for 5 to 8 days before coming off. Two flashing transmitters out of the total of 6 transmitters were used in this part of the preliminary study.

Results:

Due to the inate cussedness of animate objects; despite the fact that the bats were captured under the fig that we hoped to use as an observation post, not one of the two LED marked bats visited the fig during the periods it was kept under observation. However one bat was observed, very briefly, flying past. The value of the LED transmitters in this study turned out to be that it enabled positive identification of radio-located dead leaves (which cunningly resemble roosting bats) as bats, during the day, even when they were resting high in the canopy.

Discussion:

I am intending to use these transmitters in further studies on *Nyctimene* and the Blossom bats, Syconycter is and Macroglossus, in this area, but using the wide angle versions of the LED's. Despite our limited initial success this I feel that this design has considerable potential for use with nocturnal animals, not only bats. It can be used equally well on transmitters which employ CMOS or other switching systems. There is also no reason why it cannot also be used with single stage transmitters with appropriate curcuit modifications to generate the voltage used to switch the PNP transistor.

Curcuit of 2-state LED flasher - transmitter. T1 has 28 to 32 turns, exact number will depend on the crystal and transistor used. The capacitor marked with the * can be omitted if desired, but serves to prevent current leakage from the antenna to ground.

If used in conjunction with a night vision

scope, such a pulsed light source would make the bat stand out very clearly, especially under the canopy of feeding trees.

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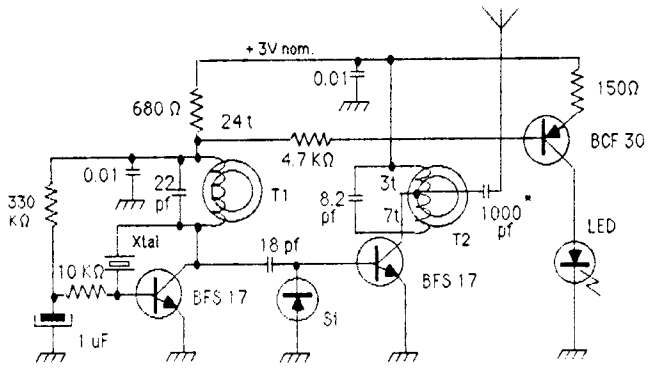

Figure 1

Present Status of Bat Research in Italy

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The first recorded research concerning Chiroptera in Italy was by the great naturalist Lazzaro Spallanzani, who in his work "A letter about the suspicion of a new sense organ in bats" (1794) showed, using the scientific method, that bats lost their ability to fly properly if their ears were closed with an ointment. The nobleman, Prince Giuseppe Luciano Bonaparte, decribed an interesting and in many respects, unknown species of the Mediterranean fauna, *Myotis capaccinii* in 1837. Most of the works that followed until around 1950 dealt primarily with the distribution of species and with various morphological topics. We must recognize the principal scholars of this illustrious period whose works extend over nearly a century. They were Altobelle, Baffoni, Bettoni, Camerano, Carruccio, Cavazza, Cetti, Conci, Corrradetti, Costa, Dal Piaz, De Beaux, De Betta, Doderlein, Doria, Festa, Franciscolo, Galvagni, Ghidini, Ghigi, Giglioli, Gulino, Lessona, Nina Palumbo, Monticelli, Motta, Ninni, Parenzan, Pasa, Patrizi, Pavan, Pavesi, Regalia, Ricci, Ruffo, Sanfilippo, Savi, Senna, Starkoff, Steffanelli, Targioni, Tozzetti, Vignoli, Zangheri, and Zavattari. In 1939 Gulino and Dal Piaz prepared a checklist of all the species collected on the Italian peninsula and the adjacent islands. Twenty years later a monograph by B. Lanza (Fauna of Italy,IV. Calderini, Bologna. 1959) updated our knowledg of the Italian taxa. He recorded 29 species, but in a following contribution (Lanza and Finotello, 1985) this number increased to 30.

This paper represents a brief introduction to the main topics of bat research in Italy during the last forty years.It includes a list of names and addresses of Italian bat biologists and a survey of selected literature. In preparing this survey, I have attempted to limit my efforts to works that are strictly limited to within the Italian political boundaries, or to publications of Italian scholars who have worked on non-Italian species. Hopefully only a few will be unreported.

After Lanza's work, most research was concentrated on various aspects of faunal and

distributional studies, ecology, ethology, cytotaxonomy, anatomy and paleontology. Much attention was devoted to anatomical topics, including ultrastructure, with emphasis on the evaluation of cyclical modifications of cells and tissue during periods of lethargy [4-13; 65-69; 84-89]. Karyological studies on Rhinolophidae, Vespertilionidae, and Miniopteridae emphasized the role of pericentric inversion and centric fusion in the modification of karyotype [21-23; 25-31]. Genome size through the evaluation of DNA content has been ascertained in some species [32; 33; 76]. A taxonomic study deals with the species of *Plecotus* [73]. Paleontological topics were limited to the Neogene (sic) and Quaternary faunas [1; 34; 70-72].Interest in bat ecology was not prominent [20; 36; 44; 47; 50]. Some aspects of general biology and behavior such as migration, homing, and the achievement of sexual maturity, have been investigated through the use of banding methods [51-54; 56-61; 64]. Few papers dealt with social organization [16; 19; 45; 46]. The reasons for the local decrease of two species is the subject of a recent study in Sicily [42]. A great deal of attention was devoted to distributional and faunal studies [3; 15; 16; 35-41; 48; 49; 55; 79; 82; 90; 93-96; 98-100].

The largest collections of recent Italian bats are housed in four institutions: the "G. Doria" Museum of Genoa, the "LaSpecola" Musuem of Florence and the Municipal Natural History Museums of Verona and Milan. A collection of bats from Italy and Eastern Mediterranean countries consisting of nearly 300 alcoholic specimens and skulls representing eighteen species is stored in the head office of the Society of Natural Sciences of Rome.

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An Albino *Myotis sodalis*

Virgil Brack, Jr. and Scott A. Johnson
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and
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In January 1985, 1987, and 1989 an albino Indiana bat, *Myotis sodalis*, has been observed in a cave in Indiana during a bi -annual cencusing of Priority II hibernacula. It has been within a cluster found in approximately the same location each year. The bat has not been banded or disturbed. Mumford and Whitaker (1982) report three *M. sodalis* with white spots on their pelage from Wyandotte Cave in Indiana.

Albinos, although uncommon, have been reported for several species of bats. Smith (1982) reported an albino *Myotis lucifugus* from Alberta, Canada, and Karim (1983) an albino female *Rousettus leschenaulti* from India. Allen (1939) reported albino *Molossus tropidorhyncus, Pipistrellus,* (sp?) *Eptesicus capensis, Chaerephon plicatus* and horseshoe bats.

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NEWS FROM ALL OVER

New York

Karl Koopman of the American Museum of Natural History has recently published three short papers, on *Murina,* on Indo-Malayan bat distribution and on Liberian bats (American Museum Novitates 2934, 2942 and 2946). He has also completed what he hopes will be the final revision of a major work on bat systematics to be published in the "Handbuch der Zoology" series. A paper with Tom Griffiths on the phylogeny of Emballanura and its relatives is also near completion. Karl's major current research efforts are with Guy Musser on the bats of Sulawesi, based primarily on older collections made in the 1930s, together with specimens collected by Guy in the 1970s. Karl participated in the International Bat Conference in Sydney and the North American Symposium in Knoxville. He is also involved with the Species Survival Commission of I.U.C.N., primarily concerning the trade in *Pteropus* in the Pacific region. And we thought that Karl had retired!!

India

K. B. Karim of the Institute of Science in Nagpur sends the following note. "My research student, Nisar Ahmed, is studying some aspects of reproduction in *Hipposideros lankadiva* from two different geographical regions in India, including the role of progesterone in the retarded development of the embryo in this species." Dr. Karim also attended the International Bat Symposium in Sydney where she presented two papers on her work with Rhinopoma hardwickei. She also visited the Western Australian Museum, and the University of Queensland while in Australia. Recent publications include a description of reproduction in *Rhinopoma* (Jour. Reprod. Fertil. Dev. 1:255-264. 1989) She is a member of the organizing committee of the Ninth International Bat Research Conference that will meet in Madurai, India, in August, 1992 and extends to all an early invitation to participate and enjoy India.

The Netherlands

Wim Bergmans sent the following report of his recent activities.....Presently I am working on a review of the taxonomy and geography of African fruit bats. Part I has been published (See Bat Research News 30:2 p. 29). Part II was scheduled for publication in December,1989 and Part III is underway. I am also serving on the Chiroptera Specialist Group of I.U.C.N.'s Species Survival Commission, but my responsibilities as secretary to the Dutch members of I.U.C.N. have prevented me from being very active in the Species Survival group. I have been appointed an Honorary Fellow of the Institute for Taxonomic Zoology of the University of Amsterdam where I formerly worked in the Department of Mammalogy. Dr. P. J. H. van Bree is in charge of Mammalogy at the Institute. He regularly has undergraduates working on bat systematics and has a few small projects underway himself.

As a sideline to my other activities, I have come to the conclusion that the collection of mammals, including bats, is not always carried out in the most effective manner and many animals are destroyed by careless collection methods and have little or no value as scientific research specimens. Sometimes needlessly large numbers are taken from a single locality. Often the proportion of young animals is very large, severely compromising the long term survival of a colony. Many specimens are not well prepared and preserved, and too often are poorly or inadequately labeled. There seems to be little coordination among different scientists when collecting. One group may be making extensive collections for physiological studies, while another group (perhaps even close associates) may be making equally large collections of the same species for taxonomic purposes or for a study of morphology. Could not these groups perhaps work together, the physiologists when their work is completed, turning over their specimens to the latter group, thereby making the total number of animals taken much more

conservative. This cannot always be done, but there seem to be too few efforts in this direction. Very few of us attempt to collect the ectoparasites of the bats that we collect, then the entomologists need to make a second collection of bats for their own needs. Perhaps I may seem to overstate the problem, but I only wish to call attention to this , and certainly do not mean to implicate any individuals. I have worked in the field and know that such coordination can make collecting more difficult, but from a conservationist's point of view, we must make an effort to be less damaging to the animals that we profess to care so much about. Irresponsible collecting can wipe out populations and should be unacceptable in the eyes of conservationists and the public. We should develope a code of ethics for bat collectors and also a system enabling us to put it into practice. I would be pleased to communicate with anyone interested in pursuing this worthwhile goal. My address is:

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Amsterdam, The Netherlands.

The Editors share Dr. Bergman's concerns and are equally willing to participate in a dialogue on this topic. Perhaps at each of our various bat meetings around the world over the next year or so this could be an item placed on the agenda for discussion. GRH and TG

Canada

Matt Saunderes of the University of Calgary in Calgary, Alberta, submitted the following....."I have recently completed my M.Sc. thesis entitled "Resource partitioning between little brown bats *Myotis lucifugus* and long-legged bats, *M. volans,* in southern Alberta". I am working under the supervision of Dr. Robert Barclay at the University of Calgary. In June of 1989 I presented the final results of my thesis at the 69th Annual Meeting of the American Society of Mammalogists in Fairbanks, Alaska.

During the conference I met Brian Lawhead from Alaska Biological Research, Inc. (Fairbanks). He had presented a review of the distribution of Alaska's bats, and gave John Whitaker, Jr. and myself directions to a site where a colony of bats had been located in past years. We visited the site and found a colony of about 100 *Myotis lucifugus* roosting in cracks in the insulation of a quonset-style storage shed. One bat, an adult female, was captured and examined. Surprisingly for that time of year the bat was neither pregnant nor lactating. I photographed the colony and the captured individual and noticed that it seemed larger and darker than *M. lucifugus* from Alberta. No measurements were taken and we did not wish to disturb the other animals in the colony. I learned later that a hibernaculum which may harbour the same bats in winter, was located nearby. The discovery of this relatively large colony brought several interesting questions to mind. Unfortunately my short stay in Alaska did not permit the beginning of an investigatuion. For example, at the time of the conference near the summer soltice there is no "night-time". When do the bats forage? What types of insects do these bats consume? Inspection of a single fecal pellet collected at a nearby location consisted primarily of moth scales. However mosquitoes seemed to be the most common type of insect during our visit. Mosquitoes rarely appear in bat feces, perhaps because they are not "available" to foraging bats. Dr. Whitaker collected fecal pellets at the colony site and may be able to answer this question. Given the relatively short summer season in Alaska, does the timing of the reproductive cycle of these bats differ from more temperate bats? This colony was located at 65 degrees north! Are there any records of bat colonies further north even than this? Where do the bats come from? Do they migrate from points further south or are they year-round residents of the area? There are numerous intriguing questions that could be investigated in an area such as this. Is anyone out there willing to fund me?"

I don't know, Matt, but it can't hurt to ask!

Missouri

Robert D. Owen sends the following news....."I have moved from Texas Tech University to the University of Missouri at Kansas City, where I am teaching mammalogy, comparative vertebrate anatomy, and biometry. Bat research continues with the following projects

currently in progress: Systematics of the genus *Rhinolophus*, with Professor Wieslav Bogdanovich of the Polish Academy of Sciences; Systematics of *Tadarida brasiliensis cynocephela* and the Antillean members of the *T. brasiliensis* group, with Ron Chesser of Savannah River Ecology Lab, and Dilford Carter of Texas Tech University; Systematics of *Dermanura hartii*, with Joaquin Arroyo-Cabrales of Texas Tech; Systematics of *Dermanura concolor*, with J. Knox Jones also of Texas Tech; and a study of the Zoogeography of North African bats, with Mazim Qumsiyeh of the University of Tennessee.

New York

John Hermanson of Cornell University recently returned from a visit to Scott Altenbach's lab at the University of New Mexico. They collected in-flight EMG data for *Tadarida brasiliensis*, a species that had proven difficult to experiment with during the past few years. In collaboration with a research group at Magee Women's Hospital in Pittsburgh, John has recently obtained electrophoretic data on the myosin of *Myotis lucufugus*. The biochemistry has shown a remarkable molecular specialization in the flight muscles. Nina Ingle has returned from the Philippines where she conducted a mark-recapture study on the fruit-eating bat community of Mount Makiling. She presented this work at the Bat Symposium in Knoxville. Deedra McClearn is teaching mammalogy and is taking the class out for weekends of bat-netting and small mammal trapping. It is a great opportunity for the students (graduates and undergraduates) to get a first hand look at bats in their natural environment.

Puerto Rico

Anne Brooke reports that she is continuing her dissertation research work on *Noctilio leporinus* on the island of Culebra. She is primarily interested in cooperative foraging, assortive roosting and reproductive success. The island was ravaged by hurricane Hugo last year but the bats appear to have survived this natural disaster. Anne is currently working under the direction of Gary Mc Cracken at the University of Tennessee in Knoxville,TN.

India

Dr. V. M. Sapkal of the Zoology Department of the Institute of Science in Nagpur sends the following news..... The first research on bats in this department was initiated by Professor A. Gopalakrishna in 1946, and since that time this department has developed into a major center for chiropteran studies. Currently the following projects are underway. Dr. V. M. Sapkal and Dr. Gadegone are working on the embryology of *Taphozous kacchensis* and examining the enzymology and endocrinology of reproductive processes in *Rousettus*, *Megaderma*, *Hipposideros lankadiva* and *Taphozous*. Dr. K. V. B. Roa is planning an investigation of the effects of rare earth-metal complexes on the endocrine functions of several species of bats. Dr. S. A. Bhide is examining the histophysiology of the alimentary tracts in bats. Dr. Nilima Badwaik is studying the utero-blastocyst relationship, placentation, the ovaries and the pituitaries of several species of bats. She is also hoping to secure a post-doctoral fellowship at an advanced studies laboratory in either Australia or in North America. Dr. Gopalakrishna, even though now Scientist Emeritus, is still busy with his studies of the reproduction and embryology of bats. He continues to be a great source of inspiration to all the staff at the Institute. Four of us were able to attend the International Bat Conference in Australia and present our work.

Italy

Bruno Zava of the Associazione Per Lo Studio E La Dei Pipistrelli in Italia, in Palermo, writes that he is busy monitoring bat fauna and their current status in Sicily, in Ambruzzi National Park, in Sardinia, in Basilicata, in Piemonte, and in the Maltese Archipelago. His collaborators on this work are Carlo Violaniof the Dipartmento di Biologia Animale dell' Universita in Pavia, and Mr. John Borg of the Maltese Bat Group in Malta. Professor Zava's students are helping to complete the "Atlas Project" for mapping Italian mammals, including bats. There is also a study being planned of the wealth of preserved bat material in the Italian Museum of Natural History. Much of that

material is from Italy and Africa with some specimenns from Haiti. He also recently traveled to the Cape Verde Islands and Senegal and took part in the section dealing the the protection of bats at the First Conference on Italian Small Mammals held in November 1989 in Milan.

Poland

Dr. Adam Krzanowski of the Polish Academy of Science (Emeritus) writes the following..."Since 1951 I have been working on the world bibliography of bats, from1758 to1987. So far 30,000 titles have been assembled but many of the papers from the nineteenth century and earlier are incomplete owing to the difficulty of visiting libraries outside of this country. Part of this collection [1958-1967] has been published in 1977 in Bonn, Germany. I remain interested in bat conservation and published an article, Water ditches instead of gates in Macroderma 4:63-64. 1988. I served for several years as the official bat conservation expert to the Polish Nuclear Agency and have contributed to the preservation of the famous Nietoperek undergrounds as a bat hibernaculum reservation. I presently have one graduate student who has just begun her work toward the Ph.D. degree on the systematics of Palearctic *Myotis*. She has grant support for three years and after she completes her dissertation will probably find employment here at the institute. I was able to attend the Fourth European Bat Research Symposium in Prague in 1987, and a meeting we held in Poland in 1988."

Missouri

Tom Aley writes that he is serving as President of the American Cave Conservation Association. Their project is the development of the American Cave and Karst Center at Horse Cave, Kentucky. This will include a national-scale museum and educational center with primary emphasis directed toward school children in grades K through 12. They anticipate creating significant displays dealing with bats. If you are interested in more information about this worthwhile project please contact David Foster at the American Cave Conservation Association P.O. Box 409, Horse Cave, KY 42749

Connecticut

Mark Barletta of North Haven, CT is a firefighter and not a professional bat biologist. He has instructed his fellow firemen on the proper techniques for removing bats from houses without harming them instead of killing them. He reports that his fire company removes up to 21 big brown bats each season. He is a member of Bat Conservation International and has built several bat-houses for his fellow firemen and has three himself. He also has a captive-born big brown bat that he takes with him when he lectures on bat conservation in the local schools. Needless to say his friends at the firehouse call him "Batman". We need more enthusiastic lay people like Mark. Keep up the good work.

Indiana

Scott Johnson of the Nongame and Endangered Wildlife Program of the Indiana Department of Natural Resources reports that his current research projects include identification, population monitoring, and protection of the Indiana bat hibernacula in Indiana. This includes the acquisition of sites, and installing signs and gates. Other research involves overwinter weight loss of Indiana bats hibernating in caves that experience different levels of human disturbance. Scott is also preparing educational slides and tape programs on endangered species of bats. He is also serving as an advisor to a graduate student who is doing radiotelemetry of the summer ecology of a maternity colony of evening bats *Nyticeius humeralis* .

Kentucky

Kunwar Bhatnagar of the University of Louisville sent us the following.

"In the past this laboratory has examined chiropteran bacula, main and accessory olfactory systems, and atrioventricular node ultrastructure of *Eptesicus* among other projects. At this time the prinicpal object of study in my laboratory is the comparative anatomy, biochemistry, and physiology of the pineal organ. Besides, bats, pineal organs in other species, such as humans and rodents are also under investigation. Our anatomical

approach utilizes all levels from gross anatomy to light, transmission and scanning electron microscopy. Experimental manipulation of the pineal organ and effects of photoperiod on pineal structure and synthesized products are currently under investigation. In short, there are several pineal related projects which are being studied. For example, work with Drs. Stephan and Frahm on the comparative morphological and volumetric investigation of the pineal organ of 36 megachiropteran species is to appear early next year in the Journal of Anatomy. In this paper we describe the remarkably large pineal organ of the Papua New Guinean nacked-backed bat, *Dobsonia praedatrix.* This *Dobsonia* pineal may not only be the largest pineal desribed for bats but on a relative body weight basis to be the largest so far examined in any vertebrate. In addition to the pineal, our overall objective is to study the other circumventricular organs also including the hypophysis, the subcommissural organ etc. Other more individual projects are concerned with intermediate filaments and skeletal muscle components in bat pineals, enamel content of vampire teeth, and intrabulbar anterior olfactory nucleus in the human olfactory bulb.

Our department is very well equipped for anatomical and biochemical studies leading to PhD/MD and MS degrees in anatomical sciences and neurobiology. At this time there are 20 graduate students,22 faculty members, 6 postdoctoral fellows and several visiting scientists in the department.

John Wible, who is conducting research on bats joined our faculty in July 1989. John's studies on bats have focused on the monophyly/diphyly issue and on the higher-level relationships of Mega- and Microchiroptera. He plans to continue these studies in Louisville through investigations of cranial and postcranial development. Several other colleagues are also cooperating in various aspects of research involving bats.

For interested and competitive students there are various mechanisms for support including University of Louiville fellowships paying up to $10,000 per year for PhD candidates. Enquiries in this regard can be directed to me. The 9th International Bat Research Conference is scheduled for Madurai, India (Aug. 3-7, 1992). As the coordinator for North America, I am looking forward to assisting in making this another highly successful international meeting. In community related service I am a spokesman for the local health department involved in educating people regarding housebat management. Another satisfying service is that of correspondent for *Macroderma,* the Australian journal of bat research. I look forward to hearing from students as well as researchers on subjects of mutual interest to us."

Washington, D.C.

Don Wilson of the Biological Survey and John Engbring from the Honolulu Field Office of the U.S. Fish and Wildlife Service spent the summer censusing fruit bat populations on American Samoa, Western Samoa, and Fiji. The U.S. Office of Scientific Authority has proposed additional CITIES listings for several species of fruit bats in response to a growing demand for importation of these animals to Guam, where they are a traditional delicacy. The service is particularly concerned about the status of *Pteropus samoensis,* the Samoan fruit bat.

A unique subspecies, *Pteropus samoensis nawaiensis,* occurs on Fiji and one objective of the surveys was to determine their status. Gary Graham from Bat Conservation International joined John and Don for surveys on Viti Levu, the major island in the Fiji Group. A rough assessment of the habitat potential suggests that both *pteropus samoensis* and *Pteropus tonganus,* the Pacific flying fox, should continue to do well on Fiji. The team found large numbers of *tonganus* and fewer, but significant numbers of *samoensis.*

The Fish and Wildlife Service has been concerned about the status of these flying foxes in American Samoa since the early 1980's, when botanical researchers suggested that drastic declines had occurred in populations there. A subsequent petition to list *samoensis* as endangered led to a survey of the populations in American and Western Samoa. As a result of that survey, the petition was denied, but

controversy over the status of the species has continued.

In both Western and American Samoa, sites that had been censused in 1986 were revisited and comparable data gathered using the same methodology in order to gain trend data for use in assessing the population status of these two species. Overall results from 49 sites surveyed for *samoensis* showed a total of 242 animals in 1986 and 176 in 1989. The bulk of this decrease is attributable to the island of Upolu in Western Samoa, where the total at 17 sites dropped from 96 in 1986 to 29 in 1989.

Upolu is heavily populated, and the terrain has lent itself to clearing for plantations, which has resulted in considerable habitat loss for the bats. Several important new sites with high densities of this species were found on Savaii, the other island of Western Samoa. The government of Western Samoa has already taken steps to reduce the take from hunting by restricting the season on fruit bats.

The situation in American Samoa is considerably better, with numbers stable or increasing slightly on the main island of Tutuila, and the smaller islands of Ofu, Olesga, and Tau. The latter three were particularly hard hit by a typhoon in 1987, and the bats appear to have recovered from any losses that might have occurred at that time.

In both American and Western Samoa, concern for the fruit bats has been conveyed to the general public quite effectively. Residents of all of the islands visited talked knowledgeably about the plight of the bats, and frequently were aware of steps being taken to insure their continued existence. This process will continue with a meeting in Honolulu in February, 1990 that will bring together representatives from most of the Pacific islands to discuss management concerns for fruit bats. The meeting is being arranged by Bat Conservation International, with logistic support from the Fish and Wildlife Service and considerable input from the academic and conservation communities.

Texas

Michael R. Willig of Texas Tech University writes..."My research primarily focuses on topics in population and community ecology of animals, with strong emphasis on the application and design of quantitative or statistical techniques to answer questions of interest to both the theoretician and field biologist. Increasing emphasis is placed on the consideration of these topics from the perspective of patch dynamics and landscape ecology.

Ongoing research by me and my graduate students involving bats includes work in the following areas; 1)social spacing and foraging dynamics of frugivorous bats via radio telemetry in a tropical rain forest, 2)systematics which consider phenetic patterns as they relate to phylogenetic constraints on sexual dimorphism and multivariate morphometrics, 3)biogeographic patterns of species density and turnover in New World bats, with plans to include comparsions to other taxa in Africa, 4)dietary comparisons of insectivorous and frugivorous bats in Brazil.

I currently have five graduate students, four of whom are working on various aspects of the ecology of the Luquillo Rain Forest of Puerto Rico and are supported by my NSF Long Term Ecological Research grant (1989-1995) or grants through the U.S. Department of Energy. One of my students, Michaea R. Gannon, will have completed his dissertation on foraging patterns and social spacing of the Red Fig-eating bat *Stenoderma rufum* of Puerto Rico by May, 1990. As part of his M.S. program, John F. Cary is examing 3-dimensional space utilization and foraging ecology of *Rattus rattus* in the Luquillo Forest.

Summer research assistantships to work on mammalian ecology are available in addition to teaching assistantships to support graduate students interested in pursuing a career in Mammalogy in my lab. In addition three twelve month research assistantships, each of two years duration are available to students interested in community ecology or population biology."

Twentieth Annual North American Symposium on Bat Research

The University of Nebraska State Museum at Lincoln, Nebraska

October 25-27, 1990

It hardly seems possible but it is already time to begin planning for our next symposium. As some of you may already know, Dr. Patricia Freeman and Dr. Hugh Genoways are serving as our hosts. Trish is chairing the local committee and has been hard at work making arrangements for us. We now need to get some idea about how many people will attend and participate. Our mailing list has grown so large that it is no longer possible to mail all the forms, brochures, hotel information, etc., to all of the nearly one thousand people on the list. If you are interested in recieving more information about the bat symposium, and have not recieved the preliminary mailing by July 1st, 1990, send me a note, or call me at 315-267-2259, and I will send you the packet of hotel descriptions, registration forms, title transmission forms, a description of the honoraria for students, forms for your abstract, forms for just about everything.

A few dates to keep in mind. All titles to appear on the program must be recieved no later that September 1st, 1990. Hotel reservations must be made by September 15th to recieve the much reduced rate at the hotel. Registration before September 15th will be $25.00. After September 15th, registration will be $30.00. Titles transmitted to be included on the program must also include the registration form and fee of the author who will present the paper. Instructions for all these details will be in the packet that you will recieve as soon as I hear from you. If you register and then later find that you cannot attent, we will refund your registration fee and banquet ticket if you notify us before October 15th. After that date there will be a $10.00 refund charge.

I am looking forward to seeing all of you again and I'm sure we will have another great meeting. G. Roy Horst

Ninth International Bat Research Conference

Madurai Kamaraj University, Madurai, India

August 3 - 7, 1992

Dr. G. Marimuthu has asked me to include in this issue and the following several issues of Bat Research News, the announcement of the next international conference. He will be serving as the host. Dr. Kunwar Bhatnagar of the University of Louisville will serve as the coordinator for those of us in the United States who wish to obtain additional information about the conference. Their addresses are below.

G. Roy Horst

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Notes and Comments

It may seem just a little late to call this the "spring" issue, but in northern New York spring comes late. Some years, like this year, it is later than usual, so we are right on schedule. Actually, Tom Griffiths, who invariably does a fine job of editing, has been bothered by a pesky illness all spring and has not had as much time to devote to this issue as usual, so he sent me a huge pile of "things", from which I have attempted to put together an interesting issue. Hopefully, Tom will be back on the job in short order and the next issue will reflect his masterly hand. You will notice that there is no recent literature section in this issue, as Tom has all that on his computer and I have not been able to get that material in time. The summer issue will have a large recent literature section. There is a very long list of literature in the article beginning on page three by Pierangelo Crucitti and I hope that you enjoy browsing through that impressive selection. It might be a good excuse to learn Italian.

Inadvertantly, the typesetter made an error in the running page heading and has the volume and number correct, but listed them as **Winter,1990.** It should have been **Winter,1989**. A good publisher should catch that sort of thing, but that is not one of the areas where I generally look for errors.

The other "good news" is that as soon as I return from the Mammalogy Meetings we will begin to send out renewal notices. We have not raised our subscription fee in over ten years and have managed to make ends meet by using work-study students to cut, paste, proof-read, label, stuff, haul, mail, bill, clean, and take responsibility for all errors. The administration has informed me that beginning January 1st, 1990, these eager beavers will have to be paid by **B.R.N.**, and will no longer be provided free. Tom and I between us put about 100 hours into each issue as it is, so we must have a little extra help. Nearly all our costs have doubled or more since the last time we last adjusted our prices. We are raising the subscription rate to $15.00 per year. We will make a one-time offer of two years for $25.00 or three years for $30.00 (no increase) for all of you who send in your renewal on or before September 30th,1990.

G. Roy Horst, Managing Editor

Long Range Planning

The Tenth International Bat Research Conference will be held in 1995, and invitations for the tenth conference will be considered at the meeting in India. The North American Symposium will meet for its twenty-fifth meeting that same year. We may wish to consider a joint meeting much like the meeting in New Mexico in 1978. It should be at some site in Canada, Mexico, or the United States with good international airline service. Boston, Chicago, Los Angeles, Mexico City, Miami, Montreal, New York, San Francisco, Vancouver, Washington, and perhaps others, are all possible sites, each with local chiroptologists on hand to serve as a local committee. Anyone interested in a lot of work, and a little recognition? Don't wait until July 1992! I will discuss these possibilities with our colleagues in Europe at the European Meeting in Denmark this summer. If you have any suggestions or ideas please contact me as soon as possible. G. Roy Horst

MAMMALOGIST POSITION

The National Fish and Wildlife Forensics Lab anticipates a post-October, 1990, opening for a Mammalogist trained in systematics (morphologically based). The selected individual would be expected to develop a research program in wildlife forensics, and to provide species level identification of mammalian parts and products for the Division of Law Enforcement, U.S. Fish and Wildlife Service.

Appointment will be at the GS-12 ($35,825-$46,571) or GS-13 ($42,601-#55,381) level, depending upon education and experience. Interested individuals should request the official application forms from:

Dr. Stephen D. Busack
Chief, Section of Morphology
National Fish and Wildlife Forensics Lab
1490 East Main Street
Ashland, OR 97520

BAT RESEARCH NEWS

Volume 31 **Spring 1990** **Number 1**

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Front Cover

The illustration on the front cover is taken from a century-old treatise entitled "Animate Creation" by the Reverend Dr. J. G. Wood, revised and adapted to American Zoology by Dr. Joseph B. Holder, M.D. Dr. Holder was a Fellow of the New York Academy of Sciences, a member of the American Ornithologists' Union, and Curator of Vertebrate Zoology, American Museum of Natural History. This work was published by Selmar Hess, New York, October 13, 1898. The caption under the illustration reads " A Group of Water Bats."

BAT RESEARCH NEWS

VOLUME 31 No.2 SUMMER 1990

BAT RESEARCH NEWS

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BAT NEWS RESEARCH

Volume 31 Summer 1990 Number 2

BIOGEOGRAPHY OF BATS IN COLORADO ECOLOGICAL IMPLICATIONS OF SPECIES TOLERANCES

Rick A. Adams

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The geography of Colorado is quite unique. Nowhere else in North America is the Continental Divide located more eastward. This displacement makes for a rapid transition zone from the eastern lowlands to the western highlands. For example, within the Boulder area, it is possible to traverse an elevational gradient of about 2700 vertical meters in as little as 16 kilometers. Within this gradient there is also a dramatic transition of habitat types with grassland habitats in the eastern lowlands and alpine tundra composing areas of highest elevations.

Armstrong (1972) indicated seven habitat types for Colorado. These types are grassland, sagebrush, desert scrub. saxicoline brush, pinon-juniper, coniferous forest, and alpine meadow/ fellfield. These habitat types are somewhat intermingled, but each is also correlated with elevation.

The bat fauna of Colorado is relatively diverse. There are currently 16 species which have distributional ranges including Colorado. Of these, 14 are in the family Vespertilionidae (eight of these are species of Myotis). The remaining two species are in the family Molossidae.

The purpose of the current study is to reevaluate known Coloradian distributional patterns of bats in the family Vespertilionidae from purely the ecological perspective of potentially limiting factors. This will perhaps help to explain the eurytopic distribution of some species and the stenotopic distribution of others.

A map illustrating habitat types in Colorado was overlaid with a county map of the state. Both of these maps were obtained from Armstrong (1972). Past capture localities for each bat species were then positioned on the habitat map and the habitat present at that locality was then recorded. Data were then cast into bar graphs to show habitat utilization for each species. Stacked-bar graphs were then used to show percent species utilization per habitat type. These data were then compared to the percentages of each habitat type in Colorado.

In addition, percent of insect species utilized by each bat species was obtained as well as information concerning habitat utilization by the insect fauna from Freeman (1984). Armstrong distinguishes between two subspecies of *Myotis leibii (M. l. ciliolabrum* and *M. l. melanorinus).* They do not overlap in distribution in Colorado and are quite distinctive in habitat usage and therefore, this

distinction will remain for the purposes of the study.

Assumptions of the study -- This study has been conducted under several assumptions which can be summed by the following: The study of overall pattern in distributions can be carried out at a crude level of analyses. Although crude, these data will provide patterns that can be interpreted with a relatively high level of confidence. For example, the data points indicated on the distribution maps used in this study are approximately five miles in diameter. While placing these dots on the habitat map it was assumed that there was no intermingling of habitat types in that area less than the resolution of interpretation. If a locality dot straddled two habitats, both were entered into the data set. This, however, only occured in two instances.

In addition, it was assumed that current locality data, although potentially biased for some habitat types due to trapping frequency within those types, would not influence the outcome of this study. A study of the distribution of bats in southeastern Colorado (Ellinwood, 1978) in which several habitat types were equally sampled over a two year period provided data which concures nicely with present known distributions of bats. This implies that patterns of distribution taken from current maps should be accurate as to habitat utilization by the bat species in Colorado despite some biases due to high trapping frequencies in some habitats as opposed to others.

Habitat utilization of the Coloradan bat fauna is diverse (Table 1). Furthermore, the pattern of utilization indicates that some species are eurytopic (occurring in 100% of the habitat types) while others were stenotipic (occurring in only one or two habitat types). *Myotis lucifungus* and *Eptesicus fuscus* are the most widespread bat species in Colorado which is consistant with their neartic distribution pattern as a whole. The least widespread species are *Myotis leibii melanorhinus* and *Lasiurus borealis*, both being restricted to only one habitat type. The other species examined fall within these extremes.

Stacked-bar graphs (Fig. 1) indicate that of the seven habitat types studied, pinon-juniper and sagebrush are the most widely used by bat species in Colorado. Pinon-juniper habitat covers approximately seven percent of the state yet is utilized by 86% of the bat fauna. Sagebrush, which is utilized by 73% of the species, is only considered to cover 3.2% of the state. Grasslands, which cover 66% of the state, are utilized by 60% of the species (Table 2).

Percent utilization of insect types varied among bat species, but the array of insect species consumed as food by the bat fauna of Colorado is quite diverse (Freeman, 1984). Furthermore, it was shown that while insect biomass was variable for 16 different sampling periods over two years, two quite different habitat types (forest edge and sagebrush) were relatively equivalent in insect biomass (Fig. 2).

It has long been observed that high levels of habitat diversity in mountainous areas leads to subsequent faunal diversity (Whittaker, 1960, 1977). Does this hold true for the bat fauna of Colorado? The answer to this question appears to be yes, in part, but the scenario may be more complex than just this simple correlation.

In some respects these data do seem to support the before mentioned condition of habitat diversity in equivalence with faunal diversity. Pinon-juniper is the most spacious of the habitats studied in terms of bat diversity. The complexity of this habitat is high in terms of roost site diversity and, in effect, consists of much high quality microhabitats.

The rim-rock cliffs associated with pinon-juniper habitat are excellent roost sites for rock dependent species. The cliffs are vertical enough to provide for predatory defense and crevices and caverns are deep enough to protect individuals from the physiologically stressing conditions that may exist outside preferred roosting areas.

In addition, juniper trees, due to their high limb density (closeness), are excellent protection from environmental conditions and their thin limbs provide very limited predator access. These factors may be the reason that habitat diversity (in this case, roost site diversity) has led to high bat species diversity in pinon-juniper habitats. The important point in terms of potential population numbers, however, may be that pinon-juniper only makes up about 7% of the Coloradan landscape.

Another trend that seems apparent from these data is that bat species which are less roost site-type dependent are more widespread. For example, *Myotis lucifugus* and *Eptesicus fuscus* are the most eurytopic species and are also the only two that tend to utilize occupied human habitat. Other species that are relatively eurytopic will tend to use only abandoned human habitat. These species, however, are more widespread than species that are obligate rock or tree roosters. The trends observed in this study when integrated with data supplied by Freeman (1984) on food resources available to bat species in Colorado, suggests that bats are roost site limited and not food resource limited.

For the bat species of Colorado, food resources are diverse, although variable, and abundances of potential food biomass is comparable throughout different habitat types. In addition, there is high variability between habitat types in availability of suitable roost sites. This would suggest that patterns of distribution of bat species within the seven habitat types in Colorado is dependent on availability and quality of its roost sites.

In terms of management and conservation, these data may prove important. It seems as though the smallest percentages of habitat (pinon-juniper and sagebrush) in Colorado are the most important to bats species and therefore destruction of these habitats may be lethal to some species. Furthermore, in areas where abandoned human habitat plays a role in supplying roost site habitats for bats, the destruction of abandoned outbuildings, coupled with destruction of natural habitat within the same areas, could severely deplete bat species numbers and diversity in Colorado.

Because bats are important components of all ecosystems, loss of diversity and overall numbers of bats could severely affect ecosystems. In terms of the distribution and population numbers of bats in Colorado, the seeming reliance of bat species on certain types of roost sites (as opposed to food resources) as a potential limiting factor sheds a new light on the importance of abiotic factors (rock cliffs and human buildings) interacting with biotic factors to form components of an n-dimensional hypervolume we call niche space.

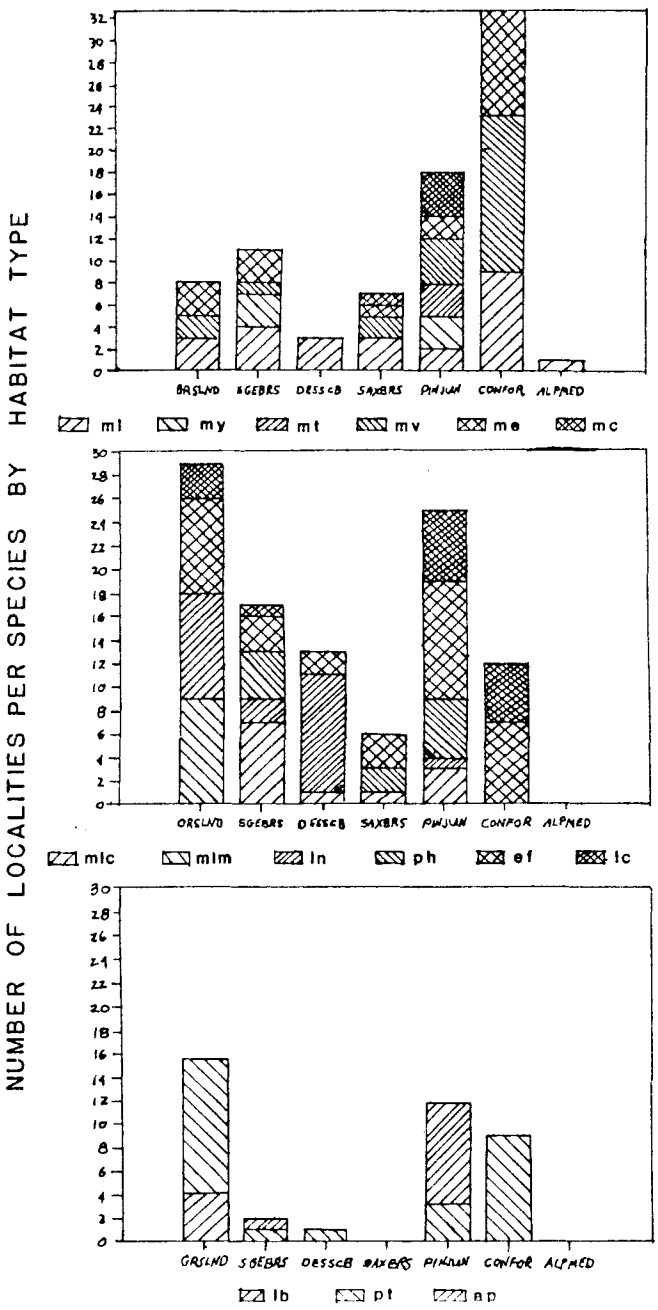

Fig. 1. Stacked-bar graphs showing relative number of localities per species by habitat type. Total number of localities cited per habitat is indicated by the Y-axis. Number of localities per species is, however, independent of the total number of localities per habitat type. [ml=Myotis lucifugus, my=M. yumanensis, mt=M.thysanodes, mv=M.volans, me=M.evotis, mc= M. californicus, mlc=M. leibii ciliolabrum, mlm=M.l.melanorhinus, ln=Lasionycterus nocti- vagans, ph=Pipistrellus hesperus, ef=Eptesicus fuscus, lc=Lasiurus cinereus, lb=L.borealis, pt=Plecotus townsendii, ap= Antrozous pallidus]

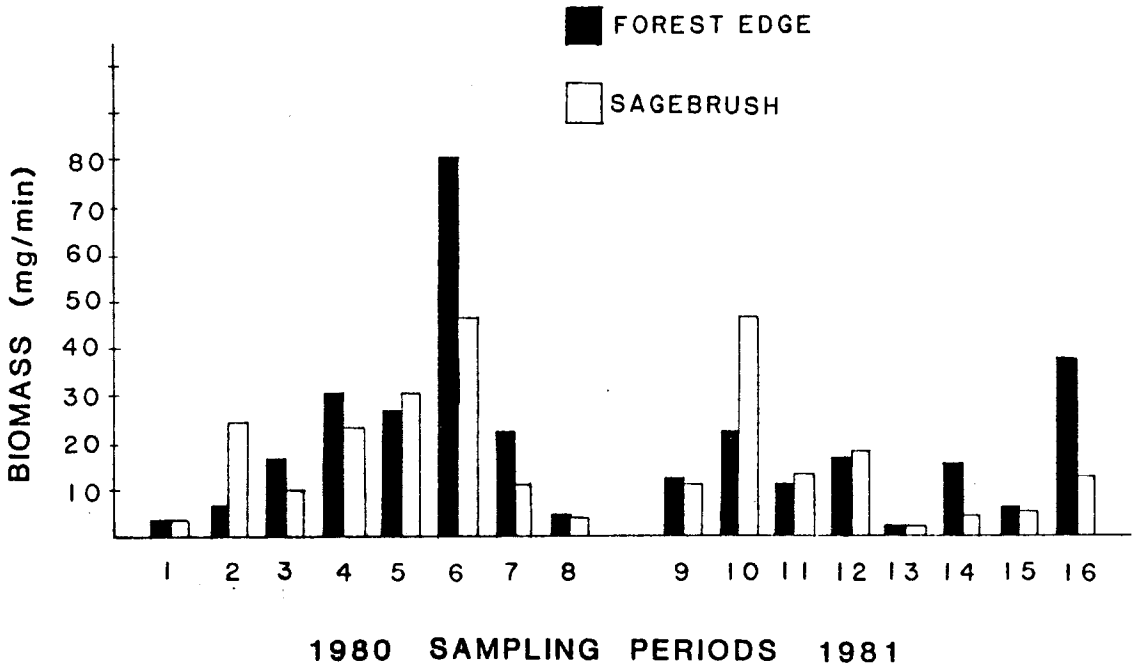

Figure 2. Comparison of biomass (mg/min) between habitats between years

Table 1. Percentages of habitat type utilization by bat species in Colorado

Species	GS	SaB	DS	SxB	PJ	CF	AM
Myotis lucifugus	12%	16	12	12	8	36	4*
M. yumanensis	/	50	/	/	50	/	/
M. thysanodes	/	/	/	/	100	/	/
M. volans	8	6	/	8	17	61	/
M. evotis	16	16	/	5	11	50	/
M. californicus	/	/	/	20	80	/	/
M. leibii ciliolabrum	/	58	8	8	25	/	/
M. l. melanorhinus	100	/	/	/	/	/	/
Lasiurus noctivagans	39	9	43	/	4	/	/
Pipistrellus hesperus	/	36	/	18	45	/	/
Eptesicus fuscus	24	9	6	9	10	21	/
Lasiurus cinereus	20	6	/	/	40	33	/
L. borealis	100	/	/	/	/	/	/
Plecotus townsendii	44	4	4	/	12	36	/
Antrozous pallidus	/	10	/	/	90	/	/

Habitat types: GS=Grassland, SaB=Sagebrush, DS=desert scrub, SxB=saxicoline brush, PJ=pinon-juniper, CF=coniferous forest, AM= alpine meadow. * not an official record

Table 2. The seven major habitat types in Colorado (Armstrong, 1972) vs. percentage of bat species present in relation to percentage of the habitat currently existing in Colorado.

Habitat	Species use ratio		% habitat in Colorado
Pinon -Juniper	13/15	(86%)	7.0%
Sagebrush	11/15	(73%)	3.2%
Grassland	9/15	(60%)	66.0%
Saxicoline Brush	7/15	(46%)	4.0%
Coniferous Forest	6/15	(40%)	16.5%
Desert Scrub	5/15	(33%)	2.3%
Alpine Meadow	1/15	(6%)	1.0%

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PROJECT BARITO ULU
CHIROPTERA SURVEY FEBRUARY — APRIL 1989

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A survey of the bat fauna was carried out in Northern Kalimantan, Tengah, Indonesia, as part of Project Barito Ulu from February 16 to April 15 1989. The base camp for the project is situated on the Busang river at the mouth of the river Rekut in the Barito Ulu (113° 50' - 114° 15E, 0° 05, - 0° 15'S). The camp was situated at an altitude of approximately 500m a.s.l. on the site of an old ladang (an area used for slash-and burn agriculture) which was surrounded by primary forest dominated by dipterocarps.

The main aim was to assess the species and abundance of fruit bats (Magachiroptera) within the study area. Additionally, records were kept of all insectivorous bats (Microchiroptera) encountered during the study.

The bat fauna was sampled in both primary and secondary forest at the base camp and in the surrounding forest. Bats were caught in static mist nets placed at varying heights (0.5 - 7.0m) across small tributaries, natural and man-made pathways in the forest.

In an attempt to locate roosts searches were carried out, for example in hollow logs and trees, rock crevices, earth banks, in tree ferns and foliage. At those sites identified as roosts, bats were caught by static hand or mist nets placed across entrance holes.

The forearm length(fa) was measured to the nearest millimetre(mm) using dial calipers, the weight(wt) taken to the nearest gram(g) with a Salter 100g Super Sampson spring balance and reproductive condition recorded. All bats were individually marked by toe claw clipping.

Fourteen species of bats were found; 6 Megachiroptera and 8 Microchiroptera. Of the

six species of fruit bat only two *Balionycteris maculata* and *Penthetor lucasii* were found in any number. Roosts were located for these two species. Insectivorous bats were found to be more numerous than fruit bats. Roost sites were discovered for all insectivorous species with the exception of *Rhinolophus trifoliatus* and *R. bornieensis.*

Very few bats were seen flying either within the forest or along the rivers and small tributaries, but of those observed, most were insectivorous.

Megachiroptera

The large flying fox, *Pteropus vampyrus* is usually found in lowland coastal areas, occasionally invading the interior at fruiting seasons. Occasionally some were seen at dusk flying over the base camp and the village of Muara Joloi which are situated approximately 400km from the sea.

Cynopterus brachyotis (fa 63mm, wt 35-36g) is regarded as one of the commonest and wide spread megachiropteran in Borneo (Payne et al 1985). However, it was not found to be common in the study site. Only two were caught, once each in primary forest around base camp and in the village of Muara Joloi.

Megaerops ecaudatus (fa 54-57mm, wt 23-29g) and *Chironax melanocephala* fa 48mm, wt 10g) were both caught flying in secondary forest around the camp. Neither have been caught in Central Kalimantan previously with *C. melanocephalus* only being found twice, once each in Brunei and in Sabah (Payne et al, 1985).

A colony of *Penthetor lucasii* (fa 60-67mm, wt 33-50g) containing approximately 50 individuals was located 3km from the base camp, in a roof dome of a large, well lit rock shelter, overhanging the river Rekut. Two bats were caught, a male and a female. The female was carrying a very large juvenile. The colony was only at the site for a few days, after which it moved away. The roost site could only be temporary as it was prone to flooding by the river. *P. lucasii* was caught flying in primary and secondary forest at both the base camp and on the Pakang river.

The small fruit bat, *Balionycteris maculata* (fa 38-42mm, wt 10-18g) was caught in the understorey of primary and secondary forest, with several bats being repeatedly recaptured. A small colony which varied in number from 1 - 6 (n=6) individuals was located in a dome beneath a fallen rotten tree 200m from the base camp in primary forest. The group consisted of juvenile and pregnant females.

Microchiroptera

A small colony of *Emballonura alecto* (fa 45-49mm, wt 6-7g) was located in a large rock shelter 3km from base camp, on the bank of the river Rekut. The group varied in number from 5 - 9 (n=7) individuals of both sexes, with some females being pregnant.

A group of 3 *Nycteris javanica* (fa 47-51mm, wt 13-15g) containing both sexes was found roosting in a hollow log 200m from base camp, in primary forest. A single adult male of the Lesser False Vampire, *Megaderma spasma* (fa 58mm, wt 21g) was located roosting 1km from base camp, under an earth bank also in primary forest.

Rhinolophus trifoliatus (fa 53mm, wt 14g) and *R. borneensis* (fa 42-45mm, wt 8-10g) were both caught flying in the understory of primary and secondary forest. *R. borneensis* was observed using a feeding perch to consume prey during foraging bouts. *R. sedulus* (fa 40-45mm, wt 8-14g) was caught flying in the understory of primary and secondary forest.

Six roosts of *R. sedulus* were located inside hollow logs in primary forest. The roosts contained small groups of bats, ranging from 1 - 3 (n=13) individuals of both sexes. Eight females were caught and all were pregnant.

A single adult male *Coelops robinsoni* (fa 37mm, wt 3g) was located roosting in the buttress cavity of a large tree in primary forest. This represents only the second Bornean record of *C. robinsoni,* the first being a mummified specimen recovered from a cave in Sarawak (Hill 1983).

Myotis muricola (fa 32-35, wt 4-5g) was found roosting in the furled leaves of banana plants in the village of Muara Joloi.

Very few bats were present within the study area. Fruit bats were difficult to locate and of those species caught, and observed flying, most were insectivorous. There was little evidence of any bat-plant interactions and pollinator bats appeared to be absent from the study site. The

lack of fruit and pollinator bats may be seasonal, in which case these bats could be expected at specific flowering and fruiting seasons. Further investigation is needed to ascertain whether the number of bats present at the study area varies seasonally.

I wish to thank Dr. R. E. Stebbings, Dr. D. J. Chivers and Mr. S. R. G. Ridgeway for their help and advice. I am very grateful to Project Barito Ulu, Garuda Indonesian Airlines, English Timbers, Spraysafe Ltd. and Hanwell & Co. Ltd., for their generous financial support, without which the work could not have been completed. Equipment and products were kindly supplied by Clulite Engineering Ltd., and Salter Abbey Weighing Machines Ltd.

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New Locality Record for a Species of the Genus *Periglischrus* (Acarina:Spincternicidae:Mesostigmata) on the Buffy Flower Bat, *Erophylla sezekorni* from the Bahamas

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Kenneth W. Andersen, Gannon University, Erie, PA 16541;
and
Donald T. Gerace, Bahamian Field Station, San Salvadore, Bahamas.

As part of a continuing study of the biology of the buffy flower bat, *Erophylla sezekorni,* 11 species were examined for ectoparasites. One species of spinturnicid mite, *Periglischrus cubanus,* was recovered. The occurrence of *Periglischrus cubanus* on *Erophylla sezekorni* in the Bahamas represents a new locality record for this host-parasite relationship.

Bat Hosts

Erophylla sezekorni is a medium-sized bat that occurs in the Antilles, including many of the Bahama Islands (Baker et al., 1978). It roosts in caves and little information is available concerning its biology. According to Gardner (1977) it prefers to feed on pollen, nectar, insects, and soft fruit.

Mite Parasites

Species of mites belonging to the genus *Periglischrus* are common ectoparasites of bats and have a wide host and geographic range (Webb, 1977; Pence et al., 1977). They have been reported on bats of several genera from throughout the Antilles (Pence et al, 1981; Tamsitt et al., 1970; Webb et al., 1977) and Caribbean, including the Bahamas, Mexico (Dusbabek, 1969; Kingston et al., 1971; Webb and Loomis, 1977; Wolfgang et al., 1985) as well as South America (Dusbabek et al., 1971; Herrin et al., 1975; Machado-Allison, 1965; Machado-Allison et al., 1971, 1970, 1969). Spinturnicid mites most commonly occur on the wing membranes of phyllostomatids. Rare infestations of the eyelashes, anus, legs, and fur of the host may also occur (Webb, 1977). The parasite completes its entire life cycle on the bat host.

On 5 June 1985, eleven specimens of *E. sezekorni* were collected by using mist nets at the main entrance to Lighthouse Cave, situated on the northeast part of the island of San Salvador, Bahamas, near the town of the United Estates.

After capture, living specimens were placed into cloth sample bags and transported to the Bahamian Field Station research laboratory on the island. Just prior to grooming for parasites, specimens were killed by suffocation. Host specimens were individually examined for ectoparasites by careful brushing of the fur, and by examining different parts of the body, particularly the dorsal aspects of the wings, paralleling, but not limited to the wing veins with the aid of a binocular dissecting

microscope. Other areas of the body that were examined were the ears (both externally and internally), the eyelashes, and the anal orifice.

Feeding mites were removed by using probes and forceps; transferred into vials of 70% EtOH for preservation, and identified at a later date.

Mites were cleared and mounted in Hoyer's medium as per established methods (Pritchard et al., 1982), and species identification made by the senior author and confirmed by Drs. Deane Furman, Paul Webb, and Frantisek Dusbabek.

After grooming for ectoparasites the bats were eviscerated and the intestines examined for endoparasites. Bat carcasses were preserved in 10% formaldehyde and later transported to the laboratory at Gannon University. Final deposition of the bat specimens will be in the mammal collection of The Carnegie Museum of Natural History, Pittsburgh, PA.

This study is the first report of the finding of the wing mite *Periglischrus cubanus* (Dusbabek, 1968) on *Erophylla sezekorni* in the Bahamas. These spinturnicid mites were recovered only from the dorsal aspect of the wing veins. Numbers of mites per bat varied from 6 to over 28 per wing, but averaged 15 mites per wing.

When compared with the original description of *P. cubanus* (Dusbabek, 1968), several minor differences were noted. The average size of the females was 907 microns long by 547 microns wide. The males averaged 367 microns long by 318 microns wide. Dusbabek (1968) recorded that females averaged 1,032 microns long by 688 microns wide and males averaged 417 microns long by 368 wide. Thus the specimens we recovered were smaller. These size differences may represent differences between populations. We also observed a difference in the numbers of hairs on the dorsal aspect of Coxa III. In every case, our sepcimens had only one dorsal coxal hair on Coxa III. Dusbabek (1968) reported two hairs on the dorsal aspect of Coxa III.

Other morphological comparisons, for example, of the dorsal plate, the vente, gnathosoma, and legs, etc., were similar to observations made by Dusbabek (1968). Reasons for differences relative to number of hairs on Coxa III between the populations are yet to be studied.

Other mites that have been recovered from *Erophylla sezekorni* in the Bahamas are: *Loomisia desmodus, Microtrombicula boneti, Perates anophthalma,* and *Whartonia querrenensis* (Webb et al, 1977).

No endoparasites were found in the digestive tracts of our specimens and none are known to occur in this species (Ubelaker et al, 1977).

ACKNOWLEDGMENTS

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Drs. Zeakes and Andersen wish to thank Dr. Donald T. Gerace, Executive Director of the Bahamian Field Station on San Salvador, Bahamas, for use of laboratory facilities and for other support.

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RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths) for inclusion in this section. Receipt of reprints 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 welecome.

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NEWS FROM AROUND THE WORLD

Jodhpur, India

B. S. Gaur of the Department of Zoology at the University of Jodhpur sends along the following ...."My three graduate students and I are deeply engaged in the eco-physiological studies of the three most dominant insectivorous and frugivorous bats of the Indian desert; *Rhinopoma microphyllum kinneri*, *Taphozous perforatus* and *Pteropus giganteus giganteus*. Our studies have concentrated on the blood and kidney; total body water and fat content; tissue biochemistry of proteins, cholesterol and glycogen; food habits and the histology of the alimentary canal; and the differential deposition of proteins, fats and carbohydrates in the body. Shri Shahroukh Moghaddas is working on the physiology of blood, Mrs. Renuka Solanki is studying renal physiology, and Shri Umed Singh Bhati is working on the alimentary canal. All three are nearly finished with their dissertations for the Ph.D. degree, and they have arrived at very interesting results and conclusions concerning what changes occur in tissue biochemistry, blood chemistry and renal physiology in different seasons. We have been especially interested in how these bats adjust to the different seasons (hot-dry, cool-wet, cold-dry) and extreme desert conditions where they remain with minimal food and water for the greater part of the year.

I also made a TV film entitled **Desert Bats** (18 minutes in length) under the sponsorship of the Audio Visual Research Centre of the University and the University Grant Commission. This film depicts the ecology and behaviour of desert bats and has been nationally telecast twice in India.

We have recently completed two projects and those are being published. One is entitled **"Ecology and Behavior of Aravali Hills Bats"**, the other is entitled **"Thermoregulation in Desert Bats"**. The University Grants Commission supported both these investigations and is also supporting my present research. I was able to attend the Fifth International Bat Research Conference in Albuquerque, but try as I might I was not able to attend the meetings in Aberdeen or Sydney. (edited by GRH)

Toronto, Ontario

Brock Fenton recently returned from a trip to Zimbabwe where he accomplished three goals. He collected additional data on *Nycteris grandis* for his continuing research on the ecology and behaviour of that species: he avoided being forced to distinguish between recently fed versus foraging lions using the Fenton bioassay technique; and he never did say what his third accomplishment was. He is about to begin his second Bat Conservation International Workshop, and then it's off to Lincoln, Nebraska for the Symposium.

Macau

Emmett R. Easton sends us the following ....."While I was a Fullbright Scholar at the University of Papua New Guinea during 1988, I was able to carry out research on the ectoparasites of bats at a private research institute near Madang.I have enclosed parts of a report that describe the facilities available at the Christiansen Research Institute that you may wish to share with our readers in a future issue of Bat Research News. Readers that wish to do research there should write to the Director, Dr. Matthew Jebb, C. R. I.,. P.O.Box 305, Madang, Papua New Guinea for further information regarding a fellowship. The founder is an American living in California(with Utah Mining and Manufacturing) who formerly gave precedence to scientists from Stanford University and the California Academy of

Sciences but the current director has decided that a limited number of fellowships be open to anyone who is qualified. Biologists can also work there without a fellowship. (but there are charges, ed. note added.) This institute is well endowed with some equipment but biologists working on bats should probably bring with them any specialized equipment or supplies they need to carry out their investigations. For example, I used mist nets to sample populations in mixed coconut forests near sea level, but other types of traps(Tuttle) were not on hand and I had to bring my own anesthesia to quiet the animals while I examined them before release. The bare -backed *Dobsonia moluccensis* and *Rousettus amplexicaudatus* fruit bats as well as *Dobsonia minor*, and tube-nosed varieties, *Macroglossus minimus* and *Syconycteris australis* were common species caught in mist nets set near the institute in mixed coconut forest. There are also insectivorous cave dwellers around Madang. The bat featured on the cover of Paradise Magazine (copy was enclosed) is a Nyctimene that was also found with some regularity. Flying foxes are commonly observed hanging from the tree tops but were not mist-netted. I discovered a chigger new to science from a *Hipposiderus* bat collected in a cave near the Institute of Medical Research and Dr. Lee Goff of the University of Hawaii and I have jointly submitted a manuscript to the International Journal of Acarology in which we described the new species. I will be happy to send you a copy of the paper when it is published for your section on Recent Literature." [Editor's note. A more detailed description of the research station described here will appear in the next issue of **Bat Research News.**]

Aberdeen, Scotland

Adrian Marshall has just today sent me a brief note that he is off to Southeast Asia for an extensive field trip. Hopefully he will send us an account of his trip for a future issue.[GRH]

Nebraska,

An article in **The Lincoln Star** describes the facilities at the University of Nebraska State Museum, our host institution for the upcoming bat research symposium, and the programs that are in progress there. A recent gift of $15,000 from the Mary B. Totten Trust was matched by an additional $45,000 from the University and the Museum, to enhance the programs of the Museum. The article included a very informed description of the nearly four million specimens in the collections and made prominent mention of the large number of bats in the collection. These gifts enabled the Museum to establish a morphometrics program that is equal to the best in the country and places "the University at the cutting edge of morphometrics." The article also included a very winsome photograph of our hostess, Dr. Patricia Freeman, who prefers to be known as Trish to us. It was a very nice preview of what those of us who attend the symposium will see on our visit to Lincoln.

and at home in Potsdam...,

In January I was in Puerto Rico continuing my project on the population dynamics of the mongoose, working at the Cabo Rojo Wildlife Refuge near Boqueron, about 40 kilometers from Mayaguez. While there we took advantage of the opportunity to mist-net some *Noctilio leporinus* and in two evenings we captured four animals, three male and a nongravid female. The animals were taken back to Potsdam where they continue to flourish. These animals became the subjects of an investigation into the relationships between ambient temperature and metabolic rate. Without telling any secrets, it appears that these bats think they are reptiles, and don't seem to have read the literature about lower critical temperatures and increasing metabolic rates to compensate for the increased heat loss. This study will be the topic of a presentation at the Fifth European Bat Research Symposium in Nyborg, Denmark in August. I plan to continue this project and will present a brief progress report at the symposium in Lincoln. It is likely that this fall I will collect additional animals for this study. When the study is complete, I will be receptive of requests for either the surviving bats or samples of tissues. [G.Roy Horst]

Request for Anatomical Materials

I am currently a Ph.D. candidate working with Dr. Patricia W. Freeman, who is Curator of Zoology at the Nebraska State Museum at the University of Nebraska. I am looking at the developmental basis behind the differences in head posture in nasal and oral emitting bats. My preliminary research presented at the 19th North American Symposium on Bat Research in Knoxville in October, 1989, described the development of the skull in an oral emitter, *Eptesicus,* and a nasal emitter, *Artibeus*. I wish to extend this study to taxa that exhibit the morphological extremes found in both oral and nasal emitters. I quantify bone growth and the gross morphogenic movements that occur during skull development with a variety of morphometric techniques, (for example, video capture, radiography, and cleared and differentially stained embryos).I am asking for information concerning prenatal developmental series(and/or preserved adult females with embryos) of the following species or species closely related to these; Rhinolophidae, *Rhinolophus rouxi* and other species?; Mormoopidae, *Pteronotus parnelli;* Vespertilionidae, *Lasiurus cinereus* and *borealis*

I can travel to your institution to pick up the specimens but shipment of pregnant females with embryos intact to my address below would be very much preferred . All materials can be returned at the end of my project, however, trypsin maceration leaves small embryos extremely fragile and subject to considerable damage during shipping. Perhaps a permanent loan of this embryonic material could be arranged. Complete acknowledgement of donors and donor institutions would accompany all subsequent publications concerning this material. Thank you very much for your assistance.

Scott C. Pederson,

my address is:
University of Nebraska State Museum
Division of Zoology
Systematic Research Collections
Lincoln, NE 68588-0514
telephone: 402-472-6606

Ninth International Bat Research Conference

Madurai Kamaraj University, Madurai, India
August 3 - 7, 1992

Dr. G. Marimuthu has asked me to include in this issue and the following several issues of Bat Research News, the announcement of the next international conference. He will be serving as the host. Dr. Kunwar Bhatnagar of the University of Louisville will serve as the coordinator for those of us in the United States who wish to obtain additional information about the conference. Their addresses are below.

The tenth international conference will be held in 1995, and invitations for the tenth conference will be considered at the meeting in India. The North American Symposium will meet for its twenty-fifth meeting that year. We may wish to consider a joint meeting much like the meeting in New Mexico in 1978. It should be at some site in Canada, Mexico, or the United States with good international airline service. Boston, Chicago, Los Angeles, Mexico City, Miami, Montreal, New York, San Francisco, Vancouver, Washington DC, and perhaps others, are all possible sites, each with local chiroptologists on hand to serve as a local committee. Anyone interested in a lot of work, and a little recognition? Don't wait until July 1992! If you have any suggestions or ideas please contact me as soon as possible.
G. Roy Horst

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Twentieth Annual North American Symposium on Bat Research

The University of Nebraska State Museum at Lincoln, Nebraska

October 25-27, 1990

Dear Friends,

It hardly seems possible but it is already time to begin planning for the symposium this fall. As most of you already know, Dr. Patricia Freeman and Dr. Hugh Genoways are serving as our hosts. Trish is chairing the local committee and has been hard at work making arrangements for us. We now need to get some idea about how many people will attend and participate. Our mailing list has grown so large that it is no longer possible to mail all the forms, brochures, hotel information, etc., to all of the nearly one thousand people on the list. If you are interested in receiving more information about the bat symposium, and did not receive the packet mailed to all North American subscribers to **BRN**, call me or send me a note and I will send you a packet of hotel descriptions, registration forms, title transmission forms, a description of the honoraria for students, forms for your abstract, forms for just about everything.

A few dates to keep in mind. All titles to appear on the program must be received no later that September 15th, 1990. Hotel reservations must also be made by September 15th to receive the much reduced rate at the hotel. Registration before October 1st is $25.00. After October 1st, registration will be $30.00. Titles transmitted to be included on the program must also include the registration of the author who will present the paper.

We will refund your registration fee and banquet ticket in the event that you cannot attend and must cancel your registration; notify me before October 15th., after that date there will be a small refund charge.

The Cornhusker Hotel is giving us very reduced rates, $45.00 for single occupancy, #54.00 for double. Please make your hotel reservations directly with the hotel . Call, toll-free, 1-800-228-2676. All the functions and gatherings associated with the symposium will be held in the hotel facilities, with the exception of the banquet, which will be in Elephant Hall of the Museum.

I am really looking forward to seeing all of you again. I'm sure we will have a very good meeting.

G. Roy Horst
my telephone # is **315-267-2259**

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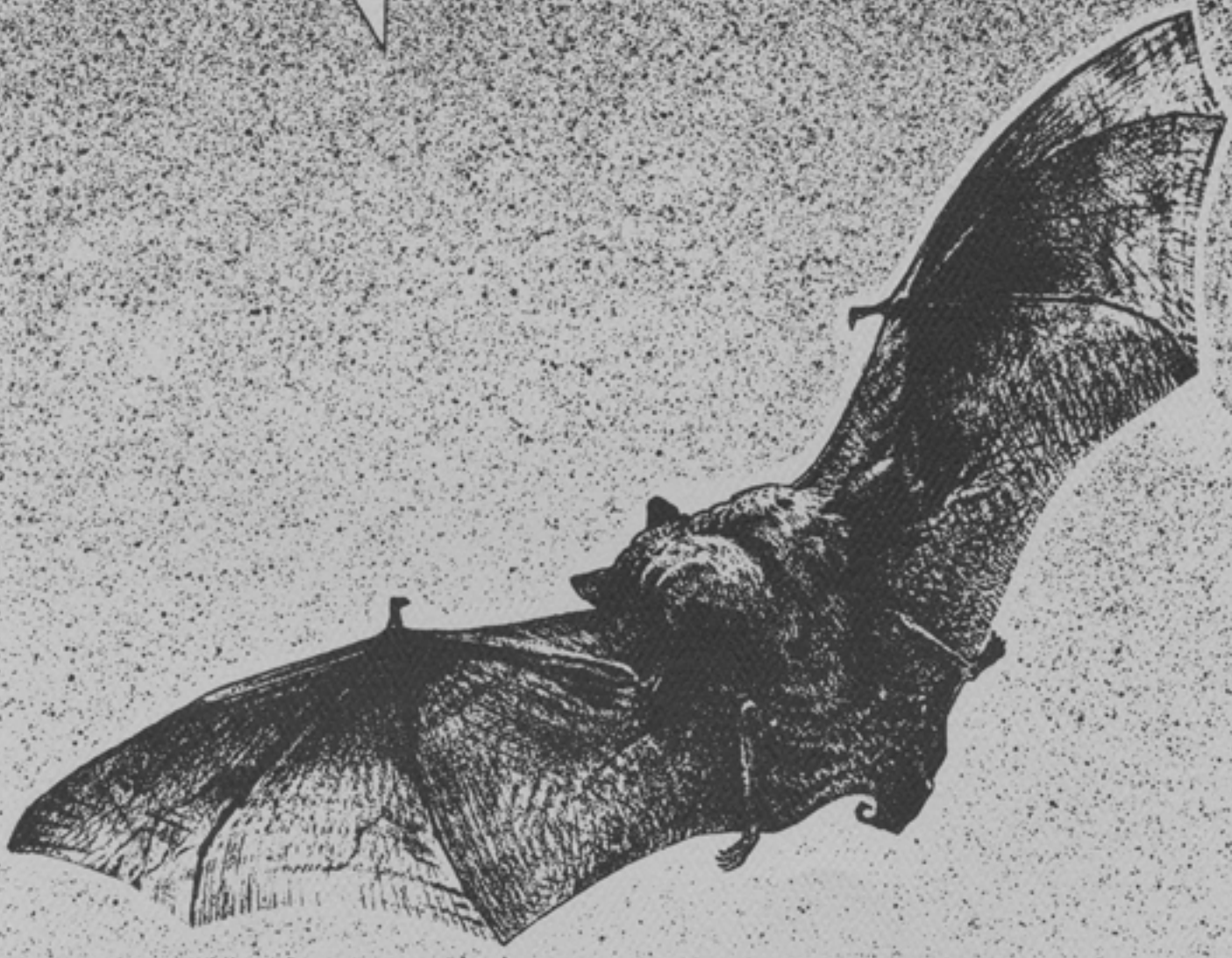
Front Cover

The cover illustration for this issue is the creation of Susan Ellis of Monroeville, New Jersey. Ms. Ellis is very active in bat conservation in New Jersey and is also an accomplished Wild-life artist. She has established an education program about bats and their benefits and makes regular presentations to children in the schools of her area and also gives lectures to adult groups. She is a "graduate" of Brock Fenton's workshop on Bat Biology and Conservation. She is also a very active member of Bat Conservation International, a new participant in our annual symposium, and obviously, a subscriber to Bat Research News. In May, she "baby-sat" (or is it bat-sat) my ***Noctilio leporinus*** colony for two weeks, which gave her the opportunity to create our cover. She has decided that a bat with this much character deserves a better name than merely Noctilio 4; he is now known as "Ahab".

BAT RESEARCH NEWS



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BAT RESEARCH NEWS

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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 these matters should be addressed to Thomas Griffiths.

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. Similar arrangements are being made with Dr. Dedee Woodside in Australia for our Australian and New Zealand subscribers. Subscriptions to institutions are $ 20.00 per volume(year).

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BAT RESEARCH NEWS

Volume 31 Fall 1990 Number 3

The European Bat Research Conference at Nyborg, Denmark

G. Roy Horst

The Fifth European Bat Research Conference was convened in Nyborg, Denmark from August 20 to 24, 1990. The conference was well attended by approximately 140 researchers and conservationists from 23 countries. The list of participants who registered appears in this issue. Many of the registrants also were accompanied by spouses, family, friends or students bringing the total number of individuals to approximately 175. The countries that were represented included Austria, Belgium, Czechoslovakia, Denmark, The Dominican Republic, England, France, both Germanies (now one), Holland, Hungary, India, Israel, Italy, Korea, Luxembourg, Poland, Portugal, Russia, Scotland, Spain, Sweden, Switzerland, and the United States. Not surprisingly, the largest contingent came from Germany. It was especially good to see so many individuals from eastern Europe.

Forty-three papers were scheduled to be delivered from the platform, there were a few cancellations, but there were also some new papers substituted in those spaces on the program. There were an additional forty-seven presentations as posters. The sessions were well attended, with very few "private meetings" in the hallways during presentation times, a distraction often seen at much larger international meetings. Thanks to the excellent organization of the conference, the facilities for meeting were very comfortable, spacious, and well appointed, making the presentations very enjoyable, as well as extremely instructive. The subjects of the papers ran the usual gamut from anatomy to zoogeography and covered many species from *Antrozous* to *Vespertilio*. If there was a central theme that found its way into every paper, it was the unanimous concern that nearly all bats almost everywhere were in grave danger, and that all the species need to be more carefully conserved. No paper purported to answer all the questions it posed, leaving one with rather mixed feelings; first the minor disappointment that the particular question posed had not been settled, but this soon dispelled by the excitement generated by the prospects of new studies. Even those papers that dealt with topics of conservation of endangered species were suffused with a feeling of optimism and hope. There were several cases where the discussion of one author's problem, became another author's solution, or a graduate student's new question. The conference was a very stimulating intellectual experience for all concerned. The language of presentation was English, and all but a few of the participants braved that most difficult task of delivering their papers in what for some was their fourth or fifth language. There were a few papers delivered in "British", but most of us who understand English, can also follow

that language, if it is spoken slowly. The conversations in the dining room, in thelounges, and at the coffee breaks, however, were a wonderful mix of the languages of Europe, making it truly a European Conference. Everyone of us learned at least a few words of Polish, and Hans taught us all how to propose a proper toast in Danish.

At the business meeting there was considerable discussion of the plight of endangered species, with special attention paid to endangered species and endangered sites in Poland. A resolution was drafted and passed urging the government agencies concerned to act in favor of these special cases before it is too late. A copy of that resolution follows this article, and Tom Kunz has agreed to place it before the North American Symposium at that meeting in October in Nebraska. It is hoped that the North Americans can add their voices and strength to this resolution. It was also suggested that the abstracts should be more widely disseminated than to only the registrants. After some discussion of the mechanics of editing, etc., it was decided that the abstracts should appear in Bat Research News. The Editor, after pointing out that the fourth issue of BRN each year was already committed to the abstracts from the North American Symposium, agreed to attempt to have as many ready for this edition as possible. Those of the presented papers follow this article, the abstracts of the poster presentations will appear in the first issue of the new year.

The assembly turned its attention to a site and date for the next meeting of the European group and accepted an invitation from Jorge Palmeirim to meet in the summer of 1993, at the University of Lisboa in Portugal. There was some discussion of the World conference to be held in India in 1993, with an indication of a good turnout for that meeting. Roy Horst, Tom Kunz and Jim Simmons offered an informal invitation to the group to consider meeting for the tenth World Conference in conjunction with the Twenty Fifth Annual North American Symposium in 1995 in Boston; Tom Kunz would be the host and Roy Horst would handle the program arrangements. This invitation was enthusiastically received, but since it was unofficial (like everything the North American group does) it was unofficially accepted. A formal invitation will be made at the India meeting at the appropriate time.

The outing to Egeskov Slot was enjoyed by everyone. It was a step back in time to the world of Hans Christian Andersen. And certainly everyone who traveled via Copenhagen fell in love with the Little Mermaid in the harbour.

Any account of this meeting would be woefully incomplete if we did not recognize the warm hospitality of the Nyborg Strand Hotel. The staff was attentive, sophisticated and courteous. The food was so plenteous, tasteful and exquisite that at least my appetite was ruined for the rest of our European holiday. It would have been nice if we had discovered the discotec a few evenings earlier, if we could have danced with one more of the many lovely young women in attendance, if the Baltic would have been a little warmer, and more of you could have been there.

The highest compliments must be given to the local committee, M. Anderson, V. Hepworth, T. Menne, Lee Miller and Hans Degne, who were everywhere they needed to be every time we needed them, ever gracious and always patient. To them, a very heartfelt thank you. We only hope we can return your many kindnesses when you visit us.

Finally, no other person in the world knows better than this writer, what Hans Baagøe had to accomplish to make this meeting such a huge success. Take it from me, Hans, you did a fantastic job, we can only offer you our congratulations and gratitude.

Abstracts from the papers presented from the platform at the **Fifth European Bat Research Conference,** presented alphabetically by first author. To conserve space, addresses are not included as they are given with the list of symposium participants following these abstracts. The abstracts of the poster presentations will appear in a later issue of **Bat Research News.** GRH

The Role of the Acoustical Properties of the External Ear in Vertical Acoustical Orientation

Peter T. Andrews

In this paper, the acoustical properties of an obliquely truncated finite exponential horn are analysed and the change in the transmission and the directional response with frequency are compared with recently published laboratory measurements made on the outer ears of various bat species. The primary function of the horn shape of the outer ear is to provide optimum transfer of the power of the incoming sound wave to the inner ear, but it is a highly dispersive device at frequencies up to an octave above the cut off frequency and the sound velocity in the horn changes with frequency. The direction of a wave front depends on the variation of the phase velocity from point to point while power transmission and the time delay of pulses depends on the group velocity. The change in phase velocity between free space and the interior of the ear can lead to refraction at the mouth of the pinna. This shows up particularly when the open end of the horn is truncated at an angle to the central axis; the normal situation for bat ears. As the frequency falls, the direction of peak response shifts from being along the horn axis towards a direction perpendicular to the plane of the opening. This occurs sufficiently rapidly compared to the accompanying drop in transmission for it to provide useful information on the vertical direction of FM echoes or other wide bandwidth sound sources in agreement with proposals made by many authors in the past. In the case of echolocation, the sound spectrum may also change as a result of the power reflected from the target falling as the ratio of the target length to the sound wavelength decreases but the bat could correct for this to some extent by using the available information on range to the target and echo intensity. The fact that a wide bandwidth of sound must be used to determine the vertical direction of the sound source would imply that mapping sound directions on the auditory cortex at point frequencies is unlikely to be rewarding. Another consequence of oblique truncation is that the oscillations in the transmission of a short exponential horn will be reduced compared to predictions for horns with openings perpendicular to the horn axis unless the tragus, or some other feature, introduces additional reflections. There is some indication that this may be the case in that measured transmission functions rise more rapidly with frequency, compared to the change in the direction of peak response, than a simple analysis would lead one to expect. It can be shown that mechanisms relying on echoes within the outer ear without dispersion cannot provide the vertical scanning of the direction of peak response which is necessary for determining the direction of sound in three dimensions.

Zoogeography of Moroccan Bats

Stephane Aulagnier

Among Moroccan mammals, bats have been poorly known until recently for lack of investigations in the entire country. In 1932 Cabrera, who gathered information mainly in the north, listed only eight species . After some southern prospections, the list of Heim de Balsac (1948) reached 16 species. In the fifties, J. B. Panouse and A. Brosset initiated the first investigations on Moroccan bats, studying biometrics and reproduction of the 23 species they recorded. After the work of Hill (1964), bat research was suspended for twenty years. Recently, three species were added to the Moroccan fauna, so that now 27 species are listed (Aulagnier and Thevenot 1990), and this is the highest diversity in North Africa. Although data are sparse, the distribution of bats was mapped by Aulagnier and Thevenot (1986), and some zoogeographical features are prominent. Some species, such as *Myotis emarginatus, M. nattereri, Pipistrellus pipistrellus, Nyctalus leisleri* and *Barbastella barbastellus* occur only in the north of the country, or the Middle Atlas Mountains, while some other species live only in pre-Saharan and Saharan areas south of the High Atlas Mountains, namely *Rhinopoma microphyllum, R. hardwickei, Asellia tridens, Pipistrellus rueppelli* and *Otonycteris hemprichi.* In addition, coastal areas provide suitable environments for some Mediterranean *(Myotis capaccinii)* or African (*Nycteris thebaica, Hipposideros caffer*) bats. On the whole, Moroccan bats are mainly palearctic taxa with 11 widely distributed palearctic species and eight "mediterranean"

species (including the African extra-limital *Rhinolophus blasii* and *Pipistrellus kuhli*, and the extensively distributed Asiatic *Tadarida teniotis* and *Myotis blythi*). Saharo-sindian bats are not very numerous in contrast to Rodents (4 species versus 17 species). Paleotropical taxa are also scarce (only 3 bats versus 11 carnivores). The present settlement of Moroccan bats seems recent in spite of the lack of paleontological clues. African taxa such as Megadermatidae (and probably Emballonuridae) moved south of the Sahara during the Pleistocene while European species crossed the Straight of Gibraltar or other parts of the Mediterranean Sea (Siculo-Tunisian way for example). Moreover the Moroccan bat fauna looks more like south-European fauna than northeastern African or sub-Saharian faunas. Maghred, at least in its northern part, belongs to the Mediterranean biozone and bats appear to be good current zoogeographical informers (unfortunately they are often excluded from this kind of study).

Aulagnier S., Thevenot, M. 1986. Catalogue des Mammiferes sauvages du Marox. Trav. Inst. Sci., Rabat, Ser. Zool., 41: 1-164.

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Cabrea, A., 1932. Los mamiferos de Marruecos. Trab. Mus. Nac. Cienc. Nat., Madrid, Ser. Zool., 57:1-361.

Heim de Balsac, H., 1948. Etat actuel des connaissances concernant la faune des Mammiferes du Maroc. Bul. Soc. Sc. Nat. Maroc. Vol. jub.: 289-303.

Hill, J. E., 1964. Notes on a collection of bats from Figuig, Morocco. Mammalia, 28:83-87.

Predation on Bats in the Netherlands

J. P. Bekker and K. Mostert

By early 1989, we documented 511 cases of predation on bats in the Netherlands by searching Dutch literature, archives of the Centraal Diergeneeskundig Instituut and Biografisch Informatie Centrum, and from responses to enquiries in natural history journals. Domestic cats and owls formed the vast majority of the predators. Other predators are several birds of prey, herring gulls, starlings, magpies, dogs, the woodmouse, and beech marten. Predation on bats by the woodmouse, domestic cats and dogs has never been described before in detail. Only a fraction of predation on bats is observed. Most bats are found in owl pellets, which also provides an excellent insight into the diets of these birds. Predation by cats is easily documented because of cats' habit of taking their prey home. Activities of diurnal birds of prey are readily observed and cases of bat hunts have been reported directly. Only a small fraction of all other cases of predation are observed. Series of bats found in samples of owl pellets, or reported in the literature, revealed that owls take bats when bats are leaving or entering nurseries or while they are flying along walls. Predation by diurnal birds of prey was most frequently observed in spring and in late summer and early autumn; mostly in the period between afternoon and sunset. It was further observed that birds of prey and owls take mostly the larger species such as serotines and noctules. Remains of partly eaten bats have been found in a variety of winter quarters. A thorough investigation of these remains and observations of woodmice led to the conclusion that these rodents were the predators in at least nine cases. Due to the outbreak of rabies among bats in Northwestern Europe, many specimens, often taken by cats and dogs, have been forwarded to the Centraal Diergeneeskundig Instituut for further investigation. The spectrum of bat species taken by cats has thus become known. Pipistrelles accounted for 55% and serotines for 24%, forming the largest portion, while the pond bat, Daubenton's bat, and Nathusius' pipistrelle together accounted for 13% of the total. Of the more common species, the noctule was notably absent. As we know the numbers of several owl species and their daily food intake and we know the number of bats in a series of owl pellets, we can estimate the total number of bats taken by owls. Significantly more males than females pipistrelles and Daubenton's bat were caught, suggesting that males are more vulnerable to predation due to the social calls they produce, which are within the auditory spectrum of cats. Microclimate in winter quarters has been claimed as the determining factor in the hanging positions of bats; with disturbance by man as a substitute for predation the choice of the more hidden hanging positions by bats could also be explained.

Phenetic Relationships Among Bats of the Family Rhinolophidae

Weislaw Bogdanowick

Sixty-two species of rhinolophid bats were analyzed phenetically under the 'common-part-removed'

transformation of Wood (1983). Two ordinate methods, one clustering technique, and a minimum spanning tree were employed to assess patterns of overall similarity among species. One grouping was generally formed by Oriental and Australian species, while the second by Ethiopian and Palaearctic species. Phenetic relationships between and within these groupings were discussed.

Notes on the Systematics of the Rhinopomatidae Dobson, 1878.

Victor Van Cakenberghe

The Afro-Asiatic family of the Rhinopomatidae of Mouse-or Rat-tailed bats only contains one genus: *Rhinopoma* Geoffroy, 1813, which can be divided into four species: *R. microphyllum* (Brunnich, 1782), *R. hardwickei* Gray, 1831, *R. muscatellum* Thomas, 1903, and *R. macinnesi* Hayman, 1937. This conclusion is based on the study of 15 skull and 14 external measurements and 6 morphological characters of approximately 1150 specimens.

The metrical data were examined using uni-and multivariate statistical techniques. The multivariate analyses substantiate that *R. macinnesi,* which up until now was considered to be a subspecies of *R. hardwickei,* is much smaller than any other representative of *R. hardwickei* and should be retained as a separate species. The univariate analyses of external measurements show that *R. muscatellum* and *R. macinnesi* can only be separated with great difficulty. This might be an explanation for literature citations of *R. muscatellum* in Africa. Based on the size of the narial inflations and the dimensions, all these African specimens are considered to belong to *R. macinnesi.* The specimens from Genji represent the first material of *R. muscatellum* from India. *R. muscatellum* is divided into two subspecies: *R. m. muscatellum* and *R. m. seianum.* Three of the currently recognized subspecies of *R. hardwickei* are retained: *R. h. hardwickei, R. h. cystops* and *R. h. arabium. R. hardwickei* has also been examined from the Sundae archipelago. The large geographical separation between these specimens and their nearest neighbors, *R. h. hardwickei,* in India might lead to the recognition of another subspecies. Four subspecies are recognized in *R. microphyllum: R. m. microphyllum, R. m. sumatrae, R. m. kinneari* and *R. m. asirensis.* Almost no metrical differences were found between the specimens from Indian and these from Sumatra. However, based on the large geographical separation, the animals from both regions are considered to belong to different subspecies: *R. m. sumatrae* in Indonesia and *R. m. kinneari* in India. Finally, the holotype of *R. m. asirensis* seems to be quite different and is retained as a separate subspecies for the Arabian peninsula.

Foraging Strategies of Serotine Bats(Eptesicus serotinus): A Radio-tracking Study Conducted in Southern Britain

C.M.C. Catto

Radio-tracking was used to monitor individual foraging flights of female serotine bats from a maternity roost in Brighton, Sussex during the summer of 1989. Individual bats were continuously tracked throughout the night. Their nocturnal activity could be divided into three categories: feeding, resting, and commuting. The relationship between the three categories were investigated. Radio-tagged bats were tracked to specific feeding sites which were then assessed for habitat type. Loyalty to feeding sites and day roosting sites was assessed. The average commuting distance/bat/night was 8.6 km and the average number of feeding sites used was 2/bat/night. The bats would forage under most weather conditions including fog, moderate rain, strong winds, and temperatures down to 8°C. White streetlamps and pasture were commonly used as feeding sites.

Bat Research and Bat Conservation in Czechoslovakia

Jaroslav Cerveny

Research concerning Czechoslovakian bats has been conducted in universities, in several institutes of the Czechoslovakian Academy of Sciences and in local museums, while there have been only a few contributions by the staff of the Natural Conservancy. Field studies have mostly focused on faunal investigations, particularly in Central Bohemia, the Moravian karst region and the Sumava Mountains. Recent bat-banding has been limited to a few long-term projects. Regular censusing in hibernacula has been undertaken without disturbing the hibernating bats, except for few selected sites such as Chynovska cave. During the summers, banding studies have been performed in a few regions in connection with studies on *Myotis daubentoni, N. noctula,* and *N. leisleri* inhabiting hollow-trees and/or on *E. nilssoni* and *V. murinus* populations inhabiting

remote buildings in the Sumava Mountains. In respect to protection of bats, the most important results are those which concern the long term changes in population numbers. Only *Rhinolophus hipposideros* appears to be in serious, if not fatal, decline, and perhaps then only in certain regions. Decrease in numbers has also been observed in *R. ferrumequinum, R. euryale, P. austriacus* and *M. schreibersii*. On the other hand, numbers of *M. myotis* were found to be increasing , both in hibernacula and in breeding colonies. An apparent population increase also occurs in *M. daubentoni, E. nilssoni,* and *P. auritus* , and it has also been indicated for *M. mystacinus, M. nattereri, M. dasycneme* and probably some other species. Reasons for this phenomenon are not as yet clear . In any event, at least in the case of *M. myotis,* it seems clear that this apparent increase may result from active conservation measures, protection of hibernacula and protection of breeding roosts. The recent changes mentioned above call for a renewing of current Red Data Listing of Czechoslovakian bats as presented by Barus et al., 1988, which subdivided the Czechoslovakian species into the following categories: **Endangered**: *R. ferrumequinum, R. hipposideros, R. euryale, M. dasycneme, M. schreibersi*; **Vulnerable**: *M. mystacinus, M. brandti, M. myotis, M. b. oxygnathus, M. emarginatus, M. nattereri, E. nilssoni, E. serotinus, P. pipistrellus, N. noctula, P. auritus, P. austriacus, B. barbastellus*; **Rare**: *M. bechsteini, V. murinus, P. nathusii, N. leisleri, N. lasiopterus*; **Indeterminate**: M. daubentoni.

The Bats of Higher Altitudes from Sumava Mountains in Czechoslovokia

Jaroslav Cerveny and Petr Burger

In this paper we consider higher altitude habitats (above 800 meters) according to mountain climate. Bats were observed during the reproductive period at three basic landscapes (or biotopes). 1) The open areas of mountain meadows and pastures with solitary mountain buildings or small settlements, 2) Natural open areas without human settlements, with special attention to peat bogs, and 3) Continuous forest areas, mainly spruce or mixed beech-fir forest. The bats were studied during the period 1972 to 1989, using special traps set in front of entrance holes in the wooden building walls, using mist nets in mines or over water, and by inspection of lofts in buildings. Other data were obtained by the random use of bat detectors, etc. We captured 967 specimens representing 14 species as shown on the following table

.

Species	#	sites	altitude in meters
R. hipposideros	1	1	815
M. mystacinus	36	12	1200
M. brandti	22	7	900
M. nattereri	7	3	950
M. myotis	7	3	875
M. daubentoni	182	6	1170
V. murinus	201	15	1110
E. nilssoni	296	26	1315
E. serotinus	6	4	900
N. leisleri	4	4	1020
N. noctula (by bat detector)		1	820
P. pipistrellus	34	4	1020
B. barbastellus	49	5	1100
P. auritus	132	8	980

The most abundant species, *E. nilssoni,* occurs in all types of landscapes, but the least in closed forest areas, and at all altitudes. The second most abundant species, *V. murinus*, appears to prefer open landscapes with human settlements at all altitudes. The summer appearance of M. daubentoni occurs in association with bodies of standing water including the lakes of the high moor bogs. *P. pipistrellus* and *P. auritus* use different shelters in mountain buildings at altitudes to 1000 meters. *B. barbestellus* very often occurs alone in closed forests. Other species from the piedmont reach higher altitudes irregularly and then only in the summer and only in warmer areas.

The Echo SPL is an important cue for Range Determinaiton in the FM-Bat Eptesicus Fuscus

Annette Denzinger-Bechmann
& Hans-Ulrich Schnitzler

In the auditory cortex of the fm-bat *Myotis lucifugus* Berkowitz an Suga (in press) found neurons that show a paradoxical latency shift and delay dependent facilitation. They simulated a ranging experiment by offering a pulse-echo-pair consistent of a loud first stimulus and a weak second stimulus. The results revealed tht the best delay of these neurons for facilitaiton is highly correlated with the magnitude of latency shift. They postulated the hypothesis, that those neurons are used for ranging. Therefore, ranging performance should become worse, when the echo SPL relative to the SPL of the echolocation signal is modified. In order to test this

hypothesis four individuals of the FM-bat *Eptesicus fuscus* were trained in a two-alernative forced choice procedure to discriminate between two phantom targets that differed in range. The SPL of the returning echo was 28 dB below the SPL of the emitted signal. The experimental setup was similar to that of Simmons (1973). The positive stimulus(S+) was stationary at a distance of 52.5 cm, the negative stimulus (S-) was further away. In the first experiment range discrimination threshold at 75% correct reponses was determined. Threshold was achieved at a delay difference of 80 µs between S+ and S-, corresponding to a range difference of 13.8 mm. In the second experiment the relative echo SPL was modified at a constant delay difference of 150 µs. The bats performed above threshold at relative echo SPLs of -28 ± 5 dB. An increase of the echo SPL to -18 and -8 dB relative to the emitted signal reduced the ability to discrimiate the two ranges. An attenuation of the relative echo SPL to -38 and -48 dB resulted also in a ranging performance below threshold. Analysis of the emitted echolocation signals revealed, that the bats kept the absolute SPL of the emitted signals approximately constant at all offered echo SPLs. Our results support Berkowitz' and Suga's hypothesis that paradoxical latency shift is used for range determination.

Berkowitz, A., and Suga, N. (1989) Neural mechanisms of ranging are different is tow species of bats. Hearing Res.

Simmons, J.A.(1973) The resolution of target range by echolocation bats. J. Acoust. Soc.Am. 54:157-173.

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Audio-Vocal Learning in the Lesser Spear-Nosed Bat *Phyllostomus discolor*, Investigated by Play-Back Experiments with Computer-Generated Calls

Karl-Heinz Esser & Uwe Schmidt

In a previous study of mother-infant communication in *Phyllostomus discolor* (Esser & Schmidt 1989), we showed that the sinusoidally frequency modulated directives (a type of social call) of each mother possess individually distinct call characteristics. During ontogenesis, the isolation calls of the young change gradually, adapting increasingly to this vocal signature of its own mother. In the present study, the hypothesis that audio-vocal learning processes are involved in the ontogenetic changes of infants' isolation calls was investigated by hand-rearing infant *Phyllostomus* under different experimentally controlled acoustic conditions. All infants were isolated from their mothers on day of birth. One group was reared no acoustic contact to conspecifics and without an artificial reference signal. Another group of hand-reared pups had the opportunity to communicate with play-back computer prior to each feeding. Each isolation call of a pup was answered, with an appropriate time delay, by an invariable maternal call, digitally stored in the memory of a D/A converter unit. A comparison of the vocal changes occurring in the isolation calls of both experimental groups with the compuer-stimulus at 50 resp. 100 days of age showed that the animals which could hear the acoustic reference signal strongly adapted the frequency-time structure of their isolation calls to the corresponding characteristics of this play-back signal. As the isolation calls of the controlled group (the animals which never heard the computer-signal) did not show this adaptation, audio-vocal learning must be involved in the change of call structures during ontogeny.

Esser, K. -H. & Schmidt, U. 1989: Mother-infant communication in the lesser spear-nosed bat *Phyllostomus discolor* (Chiroptera, Phyllostomidae) - evidence for acoustic learning. Enthology 82, 156-168.

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The Status of *Rhinolophus hipposideros* in Southern Moravia

Jiri Gaisler

According to Stebbings (1988), the lesser horseshoe bat is locally extinct in some northern areas with populations generally in decline. In the Red Data List of Vertebrates of Czechoslovakia (Barus et al. 1988), *Rhinolophus hipposideros* is considered endangered. In this connection and to supplement the paper by Schofield & Gaisler (this volume) an attempt is made to estimate the relative abundance of the species with respect to other bats. In Southern Moravia, more than 6,000 individual bats were captured or found dead, and more than 13,000 were observed without capture since 1956. Relative abundance of 19 species in the area under study, which is the south-central part of Czechoslovakia bordering on Austria in the south, was evaluated according to three different criteria: (1) occurrence in percent of the area, (2) number of

positive localities, (3) mean number of individuals per one positive check. The mapping grid used consisted of quadrants 10' geographical longitude by 6' geographical latitude or 12 by 11.2 kms. *R. hipposideros* was found to occur in 35.9% of the total area of the region, its nursery colonies in 24.3%, and hibernacula in 19.4% of the area. Combining criterion(1) with criteria (2) and (3), a list based on the ranks of species was compiled. *R. hipposideros* was the third most common after *M. myotis* and *P. pipistrellus*, then came *M. emarginatus, E. serotinus, P. austriacus* and *N. noctula*. This result refers to the entire observational data of more than thirty years but does not tell us anything about the fluctuations in numbers over that time. To study these fluctuations data from cave hibernacula were analysed. In an isolated cave in the south of the region, a decreasing trend was observed both for all species pooled and for *R. hipposideros*. The decline, however, could be correlated with the vandalous interference within the hibernaculum, since after the closing of the cave in 1975, a positive trend was evidenced. In 1983-90, visual censuses of bats were made every year in the same 40 hibernacula in the Moravian Karst in the north of the region. During the eight-year censusing period, the total number of hibernating bats increased considerably which was due mainly to the enormous increase in number of *M. myotis*. Both the general trend and the trend of *M. myotis* were highly significant. On the contrary, no significant trend can be observed in *R. hipposideros*, its numbers have been fairly constant. Conclusion: In Southern Moravia, *R. hipposideros* is still relatively abundant. If there was a decline as in many regions within the species' range, it has stopped some ten years ago. There has been no decline of this species recently.

Barus, V. et al., 1988: Acta Sc. Nat. Brno, 22 (3): 1-33.

Stebbings, R. E., 1988: Conservation of European bats. London.

Bats in Dutch Forests

Wouter Helmer, Herman Limpens, & Wim Bongers

Forest management should reckon with the environmental requirements of bats to promote bat protection. Inventories of bats and bat shelters with bat detectors in a number of forests, representative of the forests in the Netherlands with a total area of 8000 hectares, yielded the following preliminary results: In the Netherlands, forests are among the most important biotopes for bats, especially for a number of the less common species. This concerns their importance as foraging areas as well as for nursery sites and day shelters. The range of biotopes from heath-lands:pine forests:willow forests: timber felling areas: deciduous forests shows a progressively increasing importance as biotopes for bats. In the Netherlands, deciduous forests seem the most important biotope for all species of bats. Within the deciduous forests, the forest borders and open areas in the forests(including timber-felling areas) are the favorite biotopes for *Pipistrellus nathusii, Nyctalus noctula*, and *N. leisleri*. The importance of timber-felling areas decreases with increasing surface of those areas. With increasing age of the forests, the number of foraging areas, day-shelters, and nursery areas to be found increases exponentially. This is true for all species but is most spectacular for *Nyctalus noctula* and *Pipistrellus nathusii*. Day-shelters and nursery colonies are found only in forests older than 50 years. Tree dwelling bats can be divided into two different categories: those having their shelters in holes of woodpeckers (*Nyctalus noctula, Myotis daubentonii* and *Plecotus auritus*), and those having their shelters in cracks and crevices of the bark of trees (*Myotis mustacinus, Pipistrellus nathusii*, and *Nyctalus leisleri*). Bat shelters are more commonly found in deciduous forests (especially oaks, *Quercus rubra*). Relatively more nursery colonies are found in beech trees, *Fagus sylvestica*. The entrances of the tree holes, used by bats, are found in all wind-directions. The height of the entrance of the tree holes is variable and determined by the woodpecker. Though these results are preliminary and more intensive studies are needed with more highly developed research methods, the importance of forests as biotopes for bats is clear.

Feeding Preferences of Myotis mystacinus and Plecotus auritus Related to Call Design, Habitat and Foraging Tactics

Angela M. Hollyfield

Insects were sampled by using suction and light traps, and droppings were collected every lunar month during the summer from roosts of two bat species: *Myotis mystacinus* (whiskered bat) and *Plecotus auritus* (brown long-eared bat). For both species, comparisons were made between prey availability and prey eaten to examine if the bats were exhibiting any obvious preferences. Results indicated that bats were not purely feeding opportunistically (eating the most abundant prey), but were also selecting other

relatively scarce prey items. Prey choices were then related to echolocation call design, to observed foraging habitat and tactics employed in prey capture.

The Enigma of Otonycteris: Relationships, Phylogeny and Ecology

Ivan Horacek

This paper is intended to discuss what the genus *Otonycteris* represents in the framework of the Palearctic bat fauna and what is its position among the Vespertilionidae. Field experiences with *Otonycteris hemprichi* are reported here along with the results of morphometric studies of available museum materials and fossils related to this genus. The recent genus is apparently monotypic. The geographic differences found do not justify subspecific status of the forms named within the species(i.e., *jin*, *petersi*, *cinereus*, etc.). Close relationship between *Otonycteris* and MN12 *Samonycteris majori has* been confirmed. A resemblance among both the taxable and the fossil forms referred to *Scotland*(Stein, Anvils, Dizzying Zee) and/or to the *Epstein serous* group (Sans, Suchlike 3) indicates a possible relationship. Appearance of *Samonycteris*, undoubtedly an ancestor of *Otonycteris*, in the W. Paleolithic is synchronous with the extensive spread of eremite biology associated with the Messing (Cezanne's. also the author's unpublished record of Rhinoceros in MN11 locality Elias 2, N-Greece). Otonycteris is an inhabitant of the temperate zone rocky deserts. Its ecology exhibits a number of respective adaptations including those responding to the food supply in such habitats. Feeding on vertebrate prey (suggested by Norberg and Fenton,1988) has not been observed, but it cannot be excluded. Field observations as well as dental adaptations of *Otonycteris* indicate a carnivorous-like foraging pattern (cf. slow narrow flight, close to the ground, low frequency echolocation with slow repetition rate, well pronounced sensitivity to external acoustic stimuli, etc.). *Otonycteris* closely resembles *Antrozous* not only in these respects, but also in a number of morphological characters. The similarity can either be considered a product of parallel adaptation strategies or as an indication of a phyletic proximity. A similar type of relation also occurs with *Nyctophilus*, *Nycticeius* and /or *Plecotini s. str* (sic). This results in a very intricate taxonomical situation which does not allow a parsimonial solution without substantial changes in vespertilionid classification in general.

Metabolic Rate as a Function of Ambient Temperature in the Fishing Bat, *Noctilio leporinus*

G. Roy Horst

The fishing bat, *Noctilio leporinus* is found throughout the neotropics and on many islands of the Caribbean. Adult males may weigh in excess of 100 grams, females are slightly smaller. In nature these bats are rarely if ever exposed to ambient temperatures below 20 °C. They tend to roost in small clusters or individually, and being large, tend not to lose heat as rapidly as smaller bats. The hypotheses being tested are: As ambient temperature decreases, *N. leporinus* raises its metabolic rate to compensate for the increase in heat loss, or conversely, *N. leporinus* enters into a state of mild hypothermia, like many other tropical bats in similar circumstances. Resting metabolic rate was determined as measured by oxygen consumption on a round-the-clock basis until a total of over two thousand data points were accumulated. Lower critical temperature for this species in captivity was also established. Analysis of metabolic rate was determined both in individual animals and in a small cluster of four bats. Our metabolic chamber was designed so that the bats chose to roost in it and spent all of their time there except when feeding and drinking. All data were collected remotely and the bats were not disturbed in any way either before or during each analysis. *Noctilio leporinus* does attempt to raise its metabolic rate when ambient temperatures fall below approximately 27 °C., if ambient temperature drops slowly. Rapid drops in ambient temperature (greater than three degrees per hour) also result in a drop in body temperature and a lower metabolic rate. At ambient temperatures below 26° C. thermoregulation appears to be poor in this species, and on several occasions all attempts at thermoregulation appeared to be feeble at best. In these cases metabolic rate declines linearly with ambient temperature, and the bats appear to be in a state of mild torpor. We did not take these animals below 18° C. for fear of losing them, as they are part of another investigation. The author would like to thank three students, Amy Krist, Joanne Dayter and Woodward Jackson, who collected nearly all of the data and did most of the statistical work.

Field Studies of the Foraging Behaviour of Greater Horseshoe Bats.

Gareth Jones

Greater horseshoe bats *Rhinolophus ferrumequinum* have been studied near Bristol since 1986. The echolocation and foraging tactics used by free-living bats are described (Jones and Rayner,1989). The dietary ecology of *R. ferrumequinum* was also investigated: the bats show marked seasonal shifts in diet, but specialize in eating Lepidoptera and Coleoptera. Prey abundance was sampled concurrently, and the question of whether the bats forage selectively or opportunistically is addressed (Jones,1990). Recent work on habitat use (studied by radio-tracking) is introduced.,

Jones, G. and J.M.V. Rayner(1989). Foraging behaviour and echolocation of wild horseshoe bats *Rhinolophus ferrumequinum* and *R. hipposideros*(Chiroptera, Rhinolophidae). *Behav. Ecol. Sociobiol.* **25**: 183-191.

Jones, G. (1990). Prey selection by the greater horseshoe bat *Rhinilophus ferrumequinum*): optimal foraging by echolocation? *J. Anim. Ecol.* **59**: 585-600.

Flight Mechanics and Echolocation in Trawling Insectivorous Bats

Gareth Jones and Jeremy M.V. Rayner

Myotid bats of the subgenus *Leuconoe* posses specialized adaptations for capturing insect prey from the water surface (by trawling). The flight morphology and echolocation of *Leuconoe* bats are reviewed, and the relation of these features to the specialized niche occupied by these bats is discussed. The bats generally forage within 30 cm of the water surface, and often capture prey with their large hind feet. Trawling bats possess many preadaptations for piscivory, and the evolution of fish eating in bats is also discussed.The trawling insectivorous lifestyle is illustrated by case studies on two species, *Myotis daubentoni* of Europe and *M. adversus* of Australasia, which have been studied by multiple flash stereo-photogrammetry (Jones & Rayner 1988; in prep.). Although these bats share many similarities in their behavioural ecology, some differences are also apparent, and an attempt is made to relate these differences to variation in flight morphology between the two species. The echolocation behaviour of the two species is also compared.

Jones, G. & Rayner, J. M. V. (1988). Flight performance, foraging tactics and echolocation in free-living Daubenton's bats *Myotis daubentoni* (Chiroptera: Vespertilionidae). *J. Zool., Lond.* **215**: 113-132.

Jones, G. & Rayner, J. M. V. (in prep) performance, foraging tactics and echolocation in the trawling bat *Myotis adversus* (Chiroptera: Vespertilionidae).

Field Studies on the Echolocation and Hunting Behavior of the Long-fingered Bat, *Myotis capaccinii*

Elisabeth Kalko

Using a battery-operated multi-flash unit with synchronous sound recordings, the echolocation and hunting behavior of the long-fingered bat had been documented in the field (northern part of Greece). This method allows to correlate both behaviors. Bats were captured and marked to allow clear identification of the species and to judge individual variations. *Myotis capaccinii* is specialized in hunting insects just above or from the water surface. Capture technique and echolocation behavior are nearly similar to other myotid species of the subgenus Leuconoe (e.g., *Myotis daubentoni*).The echolocation signals of *Myotis cappaccinii* are frequency-modulated. The echolocation behavior can be subdivided into Search Phase (SP), Approach Phase (AP) and Terminal Phase (TP), which is composed of two distinct parts (BI & BII). The hunting behavior is characterized by the stages Search Flight, Approach Flight, Tai Down and Head Down. Sp correlates with Search Flight , where the bat mainly flies above water surfaces with flight height of 17.5 ± 4.6 cm (N=245). After the detection of a target or an obstacle the bat switches to Approach Flight (AP) head and ears are pointing towards the target, flight height is reduce continiously. This stage correlates with AP. At approximately 50 cm before Myotis capaccinii reaches the potential prey the first part of TP starts (BI). Within a distance of 15-20 ms to the target BII starts and the bat lowers its tail membrane (Tail Down). Just before the bat reaches the potential prey BII stops. With the aid of the tail membrane used as a pouch and the large feet the bat catches the prey just above or from the water surface. *Mytois capaccinii* often touches the water surface. This is mainly due to the long tail membrane and to the large feet which help to retrieve insects from the water surface. During the stage Head down no echolocation signals can be recorded. After the catch *Myotis capaccinii* is gaining flight height again and bends its head into the

pouch to seize and to eat the prey during flight (Head down). The first echolocation signals can be recorded as soon as the longfingered bat retruns to Search Flight again. *Myotis capaccinii* is also able to catch insects if free air. After the detection of a target one major feature in echolocation behavior is the continious reduction of pulse duration. No overlap occurs between outgoing sound and the returning echo even in close proximity to the target. Given the assumption that *Myotis capaccinii* always avoids an overlap between outgoing sound and returning echo a minimium deteciton distance of appr. 105 cm can be derived from the sound duration during SP.

Hibernation of Two Age Classes of *Myotis daubentoni* and Effects of Microclimate on Cluster Formation

Tomasz Kokurewicz

Myotis daubentoni hibernating in the Nietoperek Nature Reserve in western Poland have been divided into two age classes based upon the black chin spot. The two classes consist of individuals in the first year of life(age **0**) and adult individuals (age **1+**). In order to minimize the disturbance of hibernating bats, a minimum sample size was determined. Mean weight of bats at the beginning of hibernation was: males, (age) **0**, x=9.56 (grams in all cases), S.D. = 0.32; females **0**, x = 10.31, S.D. = 0.81; males **1+**, x =10.08, S. D. =0.82; females **1+**, x = 11.41, S. D. = 1.1. the differences between classes in each sex are statistically significant (P< 0.01). An attempt was made to distinguish a **2+** class within the adult males but the differences were statistically insignificant. In March the mean weight of hibernating bats was: males **0**, x = 7.16, S.D. = 0.51; females **0**, x = 8.31, S. D. = 0.68; males **1+**, x = 7.58, S.D. =0.4; females **1+**, x = 8.84, S.D. = 0.81. The mean decrease in weight from November to March was 2.4 (25.1%) for **O** males; 2.0 (19.4%) for **0** females; 2.5 (24.8%) for **1+** males; and 2.6 (22.7%) for **1+** females. No significant differences have been found between young and adult individuals in the decrease in weight during hibernation. This may be one of the reasons for the increase in abundance of this species observed in recent years. A study of the dependence between cluster formation and microclimate conditions (temperature, relative humidity, air flow, wall temperature) has been started. Preliminary results suggest that the bats hibernating at low ranges of relative humidity show the strongest tendency to form clusters. Clustered individuals dominate at relative humidity up to 88% and air temperature up to 7.3 C. An increased air flow appears to induce cluster formation in this species.

The Effect of Water Restriction on Heat and Water Balance of the Fruit Bat *Rousettus a. aegyptiacus*

Carmi Korine and Zeev Arad

The thermoregulatory responses [oxygen consumption (VO_2), evaporative water loss (EWL) and body temperature (Tb)] of *Rousettus aegyptiacus aegyptiacus*, the only fruit-bat of 32 bat species in Israel, were measured over a wide range of ambient temperatures (Ta) during normal hydration and during water restriction. The thermoneutral zone of six normally hydrated bats ranged between 32-36°C. The VO_2 in this range averaged 0.96 ± 0.15 ml VO_2/g/h SD. Body temperature averaged 35.85 ± 1.13°C, at ambient temperatures between 25-35°C. At 36°C, Tb increased to 38.03 ± 1.26° C. During water restriction body mass decreased by 16.81% ± 3.56%, and only a slight hyperthermia was observed between 30-34° C Ta. The VO_2 increased and EWL decreased significantly ($p < 0.05$), except at 36° C Ta where, Tb and EWL were not significantly different from normal hydration. Dry thermal conductance increased significantly ($p < 0.05$). In conclusion, the Israeli population of *R. a. aegyptiacus* has a relatively wide thermoneutral zone. It regulates a stable body temperature over a wide range of Ta and regulates its water and heat balance during water restriction by a significantly reduced EWL, and a significant increase in thermal conductance. The present data suggest that the Israeli *R. a. aegyptiacus* is adapted to the hot climate and has a suite of effective thermoregulatory capacities adaptive for regulation of homeostasis in conditions of water restriction.

Maternal Investment and the Energetics of Lactation in the Mexican Free-tailed Bat *Tadarida brasiliensis*

Thomas H. Kunz

The energy and material transfer between Mexican free-tailed bat mothers and their pups, during the six week lactation period, was measured using data from mass change, water flux, and field metabolic rates

(FMR). Age-estimation equations were derived from growth analyses and used to assign ages of pups and stages of lactation to females (when mother-pup pairs were captured) in experiments on milk composition analysis, FMR, water flux, and body composition analysis. FMR and water flux was determined from the turnover of doubly labeled water (tritium and oxygen-18). As an index of maternal investment, data on daily water intake of pups and the proximate composition of milk from females were used to quantify milk energy output of lactating females. Daily energy budgets of lactating females were estimated from FMR, milk energy export, and radiotelemetry. One-hundred and sixteen milk samples were collected and subsequently pooled into 31 samples for analysis representing six stages (weeks) of lactation. Average fat content increased from 18% during the first week of lactation to an average of 29% by the sixth week. This level of milk fat is approximately two times greater than has been reported for other bat species and approaches levels reported for some marine mammals. Protein content was highest (8.5%) during mid-lactation and lowest (7.5%) during early and late lactation. Lactose content decreased from 3.8% in early lactation to 3.2% in late lactation. Estimates of FMR and total daily energy intake in lactating females (n = 14) revealed that *T. brasiliensis* has one of the highest daily energy budgets reported for free-ranging insectivorous bats. These results are consistent with radiotelemetry data which indicate that lactating females (n = 16) may spend an average of 8 h in flight each night. Radiotelemetry data also revealed that there are two nightly foraging periods during lactation, the first averaging 5 h 20 min and the second averaging 2 h 30 min. These two foraging periods are separated by a night-roosting (suckling) period averaging 3 h. FMR's determined for 37 pups, ranging in age from birth to 43 days, increased from 200 mL CO2 day-1 at birth to 600 mL CO2 day-1 at weaning. By contrast the FMR of an average lactating female was 1293 mL CO2 day-1, approximately twice the value reported for a young bat of adult size before it begins to fly (forage). When milk energy output (=production) is added to assimilated energy (=maintenance), the daily energy budget of a lactating *T. brasiliensis* ranged from 43.7 kJ day-1 during early lactation to 111.7 kJ day-1 during peak lactation.

Bats, Their Behavior and Linear Landscape Elements

H. J. G. A. Limpens & C. Kapteyn

Bats orient by means of sonar. The echoes of the emitted ultrasonic sounds provide the bat with information on its position within the landscape, and enable the bat to locate its prey. Smaller bat species generally use higher frequencies, giving a better perception of smaller insects but also a relatively short sonar range. They tend to fly and hunt close to the vegetation surface. Most larger bats use relatively low frequencies giving a larger sonar range, but a less detailed perception of small prey. They tend to hunt for larger insects in relatively open areas. Thus the bat's sonar is an important factor in its foraging strategy. Most bat species tend to commute between roost and hunting sites along regularly used routes or flight paths. In relatively open Dutch landscape, linear landscape elements, such as lanes, hedges, hedgerows, canals, etc., are preferred as flight paths, which facilitate commuting between roosts and hunting sites. And indeed, in areas with well-developed linear landscape elements, a dense network of bat flight paths can be observed. Ranging from smaller to larger species, the following types of relation to linear landscape elements can be distinguished: (1) utilization as a flight path only; (2) utilization as a flight path as well as feeding area; (3) a similar utilization enroute to preferred feeding areas; (4) no direct utilization of linear landscape elements. The preference of commuting along linear landscape elements might be explained by (and is partly depending on): the sonar, determining the range at which landmarks can be used for orientation; availability of insects; linear landscape elements and vegetation borders are habitats relatively rich with insects; shelter for wind and predation, which is dependent upon the structure and height of the landscape elements. Although a preference of commuting along linear landscape elements can be observed, bats are able to cross open areas. In these situations, however, relatively low sonar frequencies and a relatively high flight speed are characteristic. These phenomena are still to be studied in detail. Bats are known to be traditional with respect to roosts and hibernation sites. The same holds true regarding flight paths. It is not yet known in what way the loss of linear landscape elements in regularly used flight paths does affect bat populations. As a consequence of the bats' traditional habits, it may be assumed that populations, especially of small species, will decrease when (re)allocation of the landscape continues to lead to more open landscapes.

Annual Weight Cycles in the Fruit Bat *Rousettus aegyptiacus*

David Makin

In the process of a capture-mark-recapture investigation conducted in Israel on the local fruit bat, *Rousettus eagyptiacus*, 6000 bats were marked during the period from 1982 to 1990. Adults were subjectively sorted into relative age groups according to the abrasion of their canine teeth. The absolute age of the groups were estimated on the basis of the recaptures of known age individuals. The recapture of adults provided information on age determination by providing data on the rate of canine tooth abrasion. The relationships between body weight, month of capture, time of capture, and age were investigated. The results show that body weight in adults exhibits a circannual cycle, a daily cycle and is influenced by age.

IUCN/SSC Action Plan for Old-World Fruit Bats (Family Pteropidae)

Simon Mickleburgh

The Family Pteropodidae comprises over 150 species many of which are confined to islands or island groups in the Indian and Pacific Oceans. The survival of a considerable number of these species is threatened by a number of factors. In the Pacific, the most important factor has been trade in bats for human consumption. This has been centered on the island of Guam and has led to the protection of two genera (*Pteropus* and *Acerodon*) under the CITES (Convention on International Trade in Endangered Species) regulations. In many areas, deforestatio has led to declines in many fruit bat species. Other fruit bats are almost exclusively cave-dwelling and disturbance of these sites through tourist or industrial pressures has precipitated declines. Finally, fruit bats have often been blamed for extensive damage to commercial fruit orchards and control measures have needlessly killed bats which are vital as pollinators and seed-dispersers for many tropical plants.The Chiroptera Specialist Group of the IUCN's Species Survival Commission has initiated the production of an Action Plan for the Family Pteropodidae. The Plan highlights the threats facing these species and suggests projects to assist in their conservation. It is being distributed to all those concerned with the conservation of fruit bats.

Recording Bat Roosts in Britain 1982-1990

A. J. Mitchell-Jones

New legislation in Britain in 1982 required anyone wishing to damage or destroy a bat roost to consult the Nature Conservancy Council and allow time for conservation advice to be given. This, together with a great increase in interest by amateurs and the formation of local bat groups, resulted in a rapid improvement in our knowledge of the distribution of bats as data about over 11,000 roosts have been gathered since 1982. Almost all these records, which mostly originate as inquiries by householders, refer to roosts in buildings, with the most commonly recorded species being the Pipistrelle *Pipistrellus pipistrellus* and the Brown long-eared bat *Plecotus auritus*. In addition, the NCC has gathered detailed information about underground bat sites and other sites of particular conservation significance. On this database, we have records of over 400 caves and 550 mines used by bats. In underground sites, the most commonly recorded species is the Lesser horseshoe bat *Rhinolophus hipposideros* (700 sites), followed by the Greater horseshoe bat *Rhinolophus ferrumequinum* (350 sites). Most underground sites are small, with less than 20 sites containing more than 100 bats. Taken together, these two databases form a major source of information about the distribution of bat roosts in Britain and can be used as the basis for up-to-date distribution maps which can distinguish between hibernation and breeding sites and go some way towards giving a quantitative estimate of the importance of particular areas of bats.

Remarks on the Problem of Optimal Ambient Temperatures in Hibernating Bats

Nagel, A. and R. Nagel

The main reason of hibernation in bats is to endure the time of the year in which no food is available. The energy saving effect on hibernation depends on body temperature of the bats which corresponds approximately to ambient temperature in the hibernacula. The lower the body temperature is, the greater is the metabolism reducing effect of hibernation. Because of this it can be supposed that bats prefer hibernacula with lower ambient temperatures. One possibility to obtain cooler hibernacula is to migrate into regions with higher altitudes where the mean annual temperature, which

determines the temperature in great hibernacula, is lower. In order to get more information about optimal hibernacula temperatures, the ambient temperatures of hibernating bats were investigated in caves of South-West Germany at different altitudes.

Species	Mean amb. temp.	n	range
Myotis myotis	5.5	283	-2.5 - +9.0°C
Myotis nattereri	4.9	82	-0.5 - +8.5°C
Myotis mystacinus	4.6	128	-2.5 - +8.5°C
Plecotus auritus	4.0	97	-2.0 - +8.5°C
Pipistrellus pipistrellus	1.5	20	- 2.0 - +7.0°C

Table 1. Mean ambient temperature, number of measured individuals and range of measured ambient temperatures of hibernating bats.

Mean ambient temperature of the five most abundant species (table 1) is highest for *Myotis myotis* and lowest for *Pipistrellus pipistrellus*. All other species were very rare and no statistics could be made. All mean hibernation temperatures lie below the mean annual temperature. That leads to the conclusion that a great part of the bats hibernate in the more ventialated parts of the caves which normall are near the entrance. Mean hibernation temperatures in relation to the altitude are very constant. At 450 m above sea level mean hibernation temperature is 5.3°C and it decreases only to 4.6°C at 350 m above sea level. In the same range of altitudes mean annual temperature decreases from 8.3oC to 4.8oC. At higher altitudes the preferred hibernation temperatures are equal to the mean annual temperature, that is the temperature of the inner, not ventilated parts of the hibernacula, and therefore bats are able to hibernate there at very constant ambient temperatures. At lower altitudes, bats must hibernate in more ventilated parts of caves, near the entrance, which often involves significant changes in ambient temperatures. As changing ambient temperatures are not favorable for hibernation, bats should prefer to migrate to hibernacula at higher altitudes. In fact, Nagel et al. (1983/84) showed already that most hibernating bats are found in altitudes between 700 and 800 m above sea level. That means, bats really make use of the advantage to hibernate under condition of constant low temperature in hibernacula at higher altitudes.

Nagel, A., Frank, H. & H. Weigold (1983/84): Distribution of hibernating bats in Wurttemberg (South Germany). Proceedings of the 2nd European Symposium on Bat Research. Myotis 21/22, 116.

Flight Behavior and Wing Design of Bats of Different Families

Ulla M. Norberg

High-speed films (80-200 frames/sec) taken in the field on 12 species of bats of different families (Pteropodidae, Emballonuridae, Megadermatidae, Rhinolophidae, Vespertilionidae and Molossidae) in free flight show their flight modes and provide flight kinematic data. Wing design and flight performance can best be described by the bat's wing loading (weight/wing area) and aspect ratio (wing span^2/wing area). High aspect ratio combined with a low wing loading (obtained by long narrow wings) gives the best flight economy, and bats with this combination have slow flight, often in open areas, and they can afford to fly for long periods (*Taphozous australis, Miniopterus australis, Otomops martiensseni*). Bats with narrow, but shorter, wings (*Tadarida brasiliensis, T. pumila*) have high aspect ratio and high wing loading and fly fast continuously in open areas. *Rhinolophus megaphyllus* and *Nyctophilus robinsoni* have low loading, short wings and average aspect ratio, which are adaptations for slow and maneuvrable flight among vegatation.The three megachiropteran bats filmed (*Saccopteryx australis, Eidolon helvum, Nyctimene robinsoni*) are about average in both aspect ratio and wing loading. Their wing strokes are somewhat different from those of microchiropteran species; in the upstroke the wings are arched in a characteristic way while in the microchiropteran bats the hand wings are kept almost straight. This is one of the characteristics that may support Pettigrew's[et al.] idea about a diphyletic evolution in bats (Phil. Trans. R. Soc. Lond. 325:489-559, 1989).

Migratory Patterns and Deme Structure of *Miniopterus schreibersii* in Portugal

Jorge M. Palmerin and Luisa Rodrigues

We describe the seasonal migratory patterns of *Miniopterus schreibersii* based on the results of nearly 2000 recaptures of ringed individuals of this species. We also discuss the consequences of the various degrees of isolation found between local populations. The patterns of movement vary considerably from year to year between colonies. Some caves have suitable conditions for the species the year round, and have resident populations. But in general, most bats of this species leave their breeding caves in August, two months after parturition in early June and exhibit a period of frequent movements of both sexes.During

November and December all bats settle in the wintering caves with breeding females usually arriving before males and immature females. Average distance between winter and summer caves is 46 km for females and 20 km for males. The cave selected for hibernation are not always that which is closest to the breeding cave. There are very few movements between mid December and the end of February. Although bats usually return to the same hibernation cave year after year, in regions where different caves are available, individuals often use different caves in different years. Many movements of both males and females were recorded between the end of hibernation in March and the beginning of parturition in June. Females often move between caves until just prior to giving birth, at which time they settle into the breeding colony, whereas male continue moving around during the breeding season. The reported patterns may have been affected, however slightly, by movements caused by our ringing activity. Although the breeding colonies seem to be stable entities the movement patterns are such that bats from different colonies get thoroughly mixed during Autumn and Winter, when copulations take place. This assures a high degree of genetic interchange between colonies. However, the lack of natural caves seems to create gaps in the movements that result in a very high degree of isolation between some groups of breeding colonies. The Portugese populations appear to be divided into three such groups. Man-made cavities have been colonized by these groups, but not necessarily by the group that is geographically nearest.

Thermoregulatory Responses of Temperate Zone Microchiroptera to Changes in Food Supply During Reproduction

P. A. Racey and J. R. Speakman

Two fundamentally different strategies are available for coping with the increased energy demands of reproduction. These are firstly, increased food consumption and secondly, reduction of expenditure on some other component of the energy budget--called respiratory compensation. There has been some debate recently about the extent to which torpor may be used as a mechanism of respiratory compensation in reproductive bats. We aimed to discover the extent to which torpor is used by measuring the temperature of a cluster of approximately 500 Pipistrelle bats in the field at 15 minute intervals throughout an entire summer and correlating the temperature of the cluster to changes in insect availability and climatic variables. We located 5 thermistors in the cluster and 3 in the roost adjacent to it and logged temperatures using a remote data logger. We also photographed the cluster at 12 hour intervals using a camera linked to a remote timer. Bats returned to the roost on 14 June. They gave birth between 26 June and 7 July with most births on 4 and 5 July. The logger ran out of file space on 26 August and the bats left on 7 September. During pregnancy (14 June to 4 July: n = 21 days) the cluster remained at high temperature (c 35°C) throughout the day (0700 to 2000h) independent of food supply or climatic variables. In contrast, during lactation the bats exhibited varying degrees of torpor on many days. The extent of torpor increased as insect availability and minimum overnight temperature declined. All other variables were not significant. Together these variables explained 31% of the variation in the extent of torpor. Most large deviations from the predicted relationship reflected exceptional events: for example, on two days in lactation the mother did not return to feed their young at all. Torpor is clearly used extensively as a compensatory mechanism to low food availability but only in lactation. This pattern contrasts with the suggestion of Kurta et al. (1987) that bats become torpid infrequently and that of Studier and O'Farrell (1980) that torpor is common in both late pregnancy and lactation. The pattern supports our own suggestion (Speakman & Racey 1987) that torpor is not used during late pregnancy because it results in an increased probability of foetal mortality.

Assessing Age and Breeding Status of Daubenton's Bats *Myotis daubentoni*

Phil Richardson

Weekly visits to a summer roost site of marked Daubenton's bats in the Midlands of England from 1982-1989 have enabled a detailed record to be kept of changes in appearances of adults and juveniles. Pregnant females had nipples that generally grew in size and became more exposed throughout May and June. Often they blackened in June and July before becoming pink again then progressively smaller from August onwards. By September the nipple was often tiny again and hair-covered so appearing similar to that of juveniles. Hair tufts commonly remained on the nipple all summer, even when the bats were suckling. Adult females that failed to produce young

showed little nipple development and were difficult to distinguish from juveniles in autumn. The cauda epididymidis of males usually began to swell from September on in bats over one year old. This did not always happen and the bats were then hard to tell from juveniles at this time. Juveniles showed all the usual characteristics of young bats in the first two months of life--greyer, frizzy fur, rubbery membranes and translucent, tapered finger joints. By September most of these features had been lost and could not be used reliably to age the bats. The undeveloped nipples of juvenile females was a feature that could sometimes be used to age the bats but confusion with some adults at this time of year is possible. A black spot on the lower lip ("chin spot") was found to be a most useful guide to age in autumn since all juveniles have this mark. They begin to lose it at the end of their first year. Some one-year old bats still have this spot but it becomes less black and less well -defined with time. A bat with no black chin spot is adult.

Ethological Observations of the Large Mouse-Eared Bat, *Myotis myotis,* in a Nursery Colony.

Hubert Roer

A study on the composition of roosting sites of *Myotis myotis* was carried out in the Rhine Valley (FRG). Bats were banded with different color combinations during 1959-66. The results show that females of three neighboring roosting sites of *Myotis myotis* form a reproductive community. No recaptures of females roosting permanently outside the reproduction territory could be recorded during the summer. Fifty-seven out of eighty-one females (70.3%) which had been born in one of the roosting sites during previous years returned to the same roosting site when they were mature. Twelve were found roosting exclusively in a neighboring roosting site and nine were found roosting alternatively either in the roosting site where they had been born or in one of the neighboring roosting sites. To assess population dynamics and numbers of adult and sub-adult females flying in and out, *Myotis myotis* were electronically registered at one of the roosting sites during 1985-1990. Those data are presented here and a comparison is given with the results obtained from banded *Myotis myotis.*

The Northern Bat *Eptesicus nilssoni* Feeding Around Street-Lights

Jen Rydell

Northern bats were monitored from a car along a 27 km line transect in southern Sweden every week during a 14 month period by means of a bat detector. The number of bats observed was highly correlated with air temperature, and no bats were observed unless it exceeded 6°C. Bats were active infrequently in April and May as well as in September and October, and were not observed at all during the hibernation period from November to March. In summer (June-July), the bats were observed in forest and farmland, but in spring and autumn most bats were detected along rows of street-lights. By attracting insects, artificial lights probably provide concentrations of food for some bat species during periods which are critical for their survival andreproduction.

Bat-Species, Recorded to date in the Ostalb-Region of Baden-Wuerttemberg, FRG

Manfred Schaffler

The Ostalb-region is situated in the eastern part of Baden-Wuerttemberg in the south of FRG. The bat-recordings of this region are coordinated by the Hoehlen-Interessengemeinschaft Ostalb, called INGO, a group of speleologists. The area covers about 2500 square-kilometers, about 50% of which are karstic. The INGO controls about 60 caves and abandoned mines and about 30 summer colonies of bats. So far there are 14 known species of bats, two of which are extinct. The recorded species were: *Myotis myotis, M. daubentoni, M. nattereri, M. bechsteini, M. mystacinus, Nyctalus noctula, N. leisleri, Plecotus auritus, P. austriacus, Pipistrellus pipistrellus, Eptesicus serotinus, Vespertilio discolor, Rhinolophus hipposideros, Barbastella barbastellus.* Only three species can be noted as common. These are: M. myotis, M. daubentoni, and Pipistrellus pipistrellus. For each of these three species, populations of over 500 individuals could be found. In the case of the Mouse-eared bat we have one colony, that reaches 1,000 individuals (adult females and their young). The other species are very seldom found. Single maternity colonies are known of *Plecotus auritus, Eptesicus serontinus* and possibly *Myotis mystacinus.* The extinct species are *Rhinolophus hipposideros* and *B. barbastellus.*

Neurophysiological Investigations on the Hearing Ability of the Vampire Bat *Desmodus rotundus*

U. Schmidt, P. Schlegel, and H. Schweizer

The sanguivorous feeding habit of the vampire bats requires special orientation methods to locate and recognize the prey. Echolocation seems unsuitable for prey location, as these animals often are hidden; alfaction and thermoperception work only over a small distance and might be used for identifying the prey and selecting an appropriate feeding site. Former behavioral observations indicate that passive acoustic orientation may play a decisive role for detecting the prey. Up to now nothing is known about the hearing ability of *Desmodus*. In our experiments, multi unit thresholds were determined with glass micropipettes from the inferior colliculus. The data were verified by single unit recordings. The tonotopic organization of the colliculus was reconstructed according to the stereotactic coordinates of the electrode penetrations and histological examinations of HRP markings. Multi unit recordings revealed a best hearing sensitivity with -5 to -11 dB SPL to pure tones in the frequency range 110-25 kHz, in the frequency range of the orientation calls (50-95 kHz) the lowest threshold values reached 0 dB. The hearing range of *Desmodus* extends from below 1 kHz (lowest BF of a single unit 700 Hz, threshold value 68 dB SP:) to slightly above 100 kHz. The tonotopic organization of the inferior colliculus shows a rather unspecialized pattern. Although the frequency range of the ultrasonic orientation pulses take up more than 50% of the collicular volume, frequencies below 40 kHz occupy a rather thick dorsal layer. In the isofrequency range between 10 and 30 kHz, a number of single units were found that responded very sensitive to the sound of human breathing with respiration synchronous spike bursts, and to rustling noise. These units had low band-noise thresholds, whereas the response to pure tones was either very poor of completely missing. Regarding their response characteristic to noise signals three unit types could be differentiated. Type I: response during the stimulation, increasing spike rate at growing intensity; Type II: distinct off-reaction at higher niose intensities; Type III: unit is activated only with low intensity noise, 20-30 dB above threshold either no response or inhibition (in spontaneously active neurons). These collicular neurons are qualified to discern hidden pray by faintest noise made during respiration or slight movements of the animals.

The Foundation of a European Group to Study and Conserve *Rhinolophus hipposideros*

Henry W. Schofield and Giri Gaisler

Rhinolophus hipposideros is the smallest and most widespread of the European horseshoe bats. Its worldwide distribution extends from central Asia, west to Erie and south to Africa. This species originally used caves as both breeding sites and hibernacula; however, in central Europe its summer sites are now often associated with old buildings. The hibernacula of this species are found predominantly in caves and mines. *R. hipposideros* is generally associated with small woods and parks in limestone areas, where it feeds predominantly on Nematocera and Lepidoptera. Although the European distribution maps of this species suggest that it is widespread, populations in many countries are classified as endangered. In recent years dramatic declines have been recorded in the Netherlands, Germany and the United Kingdom. A number of factors have been cited as causing these changes: decline in suitable feeding habitat, climatic changes, reduction in suitable roosting sites and direct human disturbance. The decline of *R. hipposideros* is a pan-European problem and the factors causing this decline are likely to be the same in most countries, although special local conditions may exist. Consequently, there is a need to increase communication between those individuals working on the species, in order to establish and coordinate a strategy for its study and conservation. To achieve these goals we suggest the formation of a European Study Group. The objectives of this group would include: providing a method for the exchange of information on the latest research, establishing a data-base on the key European sites, developing a European Recovery Programme, coordination with the Chiroptera Specialist Group of I.U.C.N. and the production of a regular report on this species. We call on any individuals, amateur or professional, who have an active interest in this species to join this group.

Energetics of Flight in Small Microchiroptera Using a Combination of Doubly Labelled Water and Respirometry

J. R. Speakman and P. A. Racey

Flight is the most costly activity in which any flying mammal engages and is therefore an important component of bat energy budgets. Unfortunately, measuring the energy cost of flight is particularly difficult. There are two alternative techniques: measuring respiratory gas exchange in bats trained to wear masks and fly in wind tunnels or measuring the total energy expenditure using doubly labelled water (DLW) across a range of bats which vary in the percent time spent in flight. The former technique involves considerable training of bats and has been successfully applied to less than ten individual bats over the last 15 years. The latter technique; however, provides only an average cost across several individuals, which may have wide confidence limits dependent on the other activities during the non-flight period. We aimed to combine these techniques by measuring energy expenditure of individuals engaged in free flight and rest using DLW and the costs of their rest by respirometry. Flight costs could then be inferred by subtracting the measured resting costs from the combined rest and flight costs. Using this technique, we measured the flight costs of 17 individual Microchiroptera (n = 14 *Pipistrellus pipistrellus* and n = 3 *Plecotus auritus)* which varied between 5.7 and 8.4 grams. Across all individuals the mean flight cost averaged 1.396 Watts (s = 0.506), which was equal to 19.093 x BMR (Kleiber), (s = 7.00, se = 1.7). The flight cost of *Pipistrellus pipistrellus* averaged 19.5 x BMR and for *Plecotus auritus* 16.9 x BMR. These cost estimates were not significantly different from our own previous estimate of flight cost in *P. auritus* using DLW alone (21 x BMR). The very wide variation in individual flight cost estimates is a consequence of error in the DLW technique and a high gearing of this error to error in the final flight cost estimate (36.2%) matches closely that predicted using data on the precision of DLW estimates from our own previous validation study (Speakman and Racey 1988) and the times spent in flight and rest (33.5%). Using the techniques together does not overcome the problems of using DLW alone. Using the data from the validation study on the accuracy of the DLW technique, in comparison to indirect calorimetry to correct the flight cost gives a revised average cost of 14.6 BMR (14.9 for *Pipistrellus pipistrellus* and 13.0 for *Plecotus auritus)*. This is very similar to previous evaluations using masks and respirometry alone. These data indicate there is no extra cost of echolocation to add to that of flight.

Scaling of Wing's Moment of Inertia in Some Bats

Mikael Thollesson & Ulla M. Norberg

One component of the power required for an animal to fly is the intertial power, originating from the moment of inertia of the oscillating wing. The body and wing moments of inertia around the roll axis will probably affect the maximum roll acceleration of a flying animal. This paper describes the allometric equations for the wing moment of inertia (around the shoulder joint, calculated using strip analysis) versus body mass, wing span, and wing area for eight different species of bats from three different familites as well as an estimate of the moment of inertia around the roll axis for different species. The regression coefficients for the allometric equations for the wing moment of inertia do not deviate significantly from the coefficients expected under assumption of geometric similarity.

Ventilation Frequency and Metabolism in Plecotus auritus: Non-invasive Determination Using Doppler Rader and Open Flow Respirometry

P.I. Webb and G. C. Hays

Doppler radar was used to monitor ventilatory movements in the common pipistrelle bat (*Pipistrellus pipistrellus*) and the brown long-eared bat (*Plecotus auritus*). The validity of this technique for measuring ventilation frequency has been demonstrated through use in conjunction with hot wire anemometry. The inter-relationships between ventilation frequency, oxygen consumption, ambient temperature, relative humidity, sex, and body condition (body weight/forarm length) in the brown long-eared bat are discussed.

Hays, G. C., P. I. Webb, J. French, and J.R. Speakman. 1990. Doppler radar: A non-invasive technique for measuring ventilation rate in resting bats. J. EXP. BIOL. In press.

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RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths) for inclusion in this section. Receipt of reprints 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 welecome.

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Stebbings, R.E. *Conservation of European Bats.*

Christopher Helm Publishers Ltd. (Distributed by David & Charles, Inc. North Pomfret, Vermont 05053), 246 pp., 1988. Price (paper), $22.95.

Conservation of European Bats is the first book of its kind to review bat conservation problems and policies of a specific geographic region. It is particularly timely because bat conservation needs in Europe and most of the rest of the world have reached the point that region-wide efforts are required for populations to recover. The author, Dr. R. E. Stebbings, has been conducting research on European bats and their conservation for more than 30 years and is uniquely qualified for this important work.

This book forms an action plan of the Chiroptera Specialist Group of the International Union for the Conservation of Nature and Natural Heritage. It describes the problems and offers solutions to secure the future conservation needs of European bats. The book is divided into three parts. The first part provides natural history and conservation information that is valuable for bat biologists and wildlife planners. Part two discusses bat conservation problems and policies of 34 European countries. Part three provides brief accounts and range maps for each of the 30 species of bats in Europe.

The natural history section briefly reviews basic aspects of bat biology so that even an inexperienced reader can develop an appreciation of bat conservation needs. This chapter covers a broad range of topics including colonies and populations, social organization and metabolism, annual changes in reproduction and hibernation, roosting behavior, movements and migrations, longevity, and habitats and food. Stebbings correctly points out that our knowledge of bat ecology is poor, especially with respect to the habitat requirements of most species. He also discusses the pressing need to locate roosts, estimate population sizes and monitor bat populations over a long period. Such statements challenge research biologists interested in conservation to apply their skills to projects that will contribute directly to bat conservation.

The chapter on conservation problems and achievements is one of the most valuable sections of the book. A disturbingly large number of specific examples of prehistoric and recent population declines are presented. These examples are scattered throughout Europe and include common as well as rare species. Stebbings notes that colonies of over 1000 bats were not unusual 30 years ago but only a few of that size or larger are known today.

Disturbances to roosting and foraging habitats are the most significant general causes of population declines. The author states that most of the population reductions are with species that breed or hibernate in caves. Deforestation as well as destruction of marshlands and riparian habitats are also conservation problems for European bats. He also presents information on pesticide and pollution problems that affect bat populations. Stebbings notes that collecting and field activities by biologists and naturalists were major causes of local bat declines and extinctions. Disturbance of hibernation or nursery colonies and the use of rings (bands) were the biggest problems. The problem has been reduced in recent years through education and exchanges of information.

The section on buildings is particularly useful because they are now one of the most important roosting resources in Europe; all 30 species have been found in them. Stebbings states that most of the problems for bats in buildings are due to renovation or demolition work. Numerous examples of bat deaths from remedial timber treatments in buildings are documented.

It is becoming increasingly evident that bats are crucial components of healthy ecosystems and must be given high priority in conservation and land management planning. Stebbings states that bats need unified conservation campaigns across Europe if they are to survive. He discusses the merits and problems with two international conventions that address this need. The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) became effective in 1982 and 1983 respectively. Although national legislation has been passed in almost all European

countries, much of it is inadequate. These laws usually protect only the animals and not their roosts and feeding habitats. Additionally, the laws are rarely enforced. There are, however, benefits from national legislation such as the emergence of more than 40 bat groups in England. The author concludes this chapter with a table summarizing the status of European bats.

The chapter on conservation needs reiterates and expands materials presented earlier. Stebbings correctly argues that education plays a key role in any conservation effort and should be a part of bat legislation. The sections on education materials and their dissemination should prove helpful to people initiating bat conservation projects. Professional bat biologists and amateurs should value the sections on research and the creation of new roosts. A great deal more research is needed on the distribution, status and ecology of bats in Europe and the rest of the world. The author discusses the different kinds of surveys that should be devised and soundly argues the need for additional long-term (five years or more) ecological studies. Stebbings provides a table summarizing the conservation needs of bats in Annex (Appendix) I. An insightful discussion of how a conservation strategy for endangered bats can be developed is given in Annex II. The author uses *Rhinolophus ferrumequinum* as a case study to illustrate his approach.

Part two of this book is a series of brief reports on bat conservation in each of 33 European countries. Most country accounts include information on feeding habits and habitats, roosts, threats, key sites, protected sites, legislation, education, research, and a brief bibliography. Discussions of artificial roosts and the conservation needs of specific species are provided in some accounts. Each account also includes a checklist of the bats of the country, their frequency of occurrence, and status.

Part three contains brief accounts for each of the 30 species of bats in Europe. These offer a quick reference on the size, distribution, habitats used, and status of the bats. Maps facilitate an appreciation of the general distribution of each species.

Conservation of European Bats is well written and there are only a few typographical errors. This very practical book should appeal to general conservationists as well as bat biologists. At $22.95, the book is affordable for professionals and students. I recommend this volume to anyone working on bat conservation issues in the temperate zone. Gary L. Graham, *Bat Conservation International, P.O. Box 162603, Austin, Texas 78716*

Conference-Workshop on Wildlife Management, JULY 1991

Wildlife 2001: Populations is an international conference intended for research workers and agency personnel whose interest is the science , conservation, and management of vertebrate populations(exclusive of fish and primates). Papers will assess the state of the art and set the agenda for applied wildlife population work on the verge of the 21st century. It is a followup of the highly successful wildlife 2000, which emphasized habitat modeling, and a companion publication will be produced.

The conference will be held July 29 through 31, 1991, at the Oakland Hilton Airport Hotel in Oakland, California. This hotel is a low-rise hotel with outside courtyards and gardens, and is away from the downtown area, within a mile of the Oakland Airport. Free parking and free shuttle buses to the airport and rapid transit (BART) give easy access to the greater San Francisco Bay Area.

Morning general session topics will be: Methods, Modeling, and Threatened Species. Afternoon sessions include Small Mammals, Marine Mammals, Water-fowl, Over-abundant Populations, Herps, Large Herbivores, Game Birds, Seabirds, Passerine Birds, Large Carnivores, Raptors, and Furbearers.

For further information contact the conference organizers: Dale McCullough at 415-642-8462, or Reg Barrett at 415-642-5438. Both are at the Department of Forestry and Resource Management, 145 Mulford Hall, University of California, Berkeley, CA 94720 [FAX 415-643-5438] GRH

NEWS FROM AROUND THE WORLD

France

Bernard Sige provided the following account of the activities at his institution.

"Our pluridisciplinary institute, the Institut des Sciences de l'Evolution, in Montpellier University is devoted to the study of the principal aspects of the evolutionary process. The Laboratory of Paleontology within the Institute has as one of its major research topics the study of fossil bats. Bat remains dating from the Lower Eocene are well-represented in our collections and the subject of study in comparison with other reference material. Some of our work has been concerned with recent representatives of the families Molossidae and Vespertilionidae.These broadly based studies include the techniques and approaches of comparative dental and skeletal morphology, biometry, systematics, phylogenetic relationships, evolution, and paleobiogeography. The fossil bat material is housed in the paleontology collections of the University and the published material is also available for reference and consultation.

Two members of the laboratory, Bernard Sige and Serge Legendre, and an associate, Henri Menu, are involved in bat studies, although they also have other research interests as well. Since 1966 they have published papers on bats, including species from the families Pteropidae, Emballonuridae, Rhinolophidae, and Vespertilionidae, as well as "Eochiropteran (in the meaning of archaic generalized bats)." Among work currently in progress is a study of the bat fauna of middle Oligocene age from Southwestern France. The major focus of this study is a description of the evidence for the stem group of the genus *Rhinolophus*, a widespread group and the most diversified of old world bats. This work is part of a larger study (and monograph) of the entire vertebrate fauna from this region and era. A second study concerns the oldest bat representatives from Africa, assumed to be of Lower Eocene age. This work documents the early emergence of the Rhinilophids and Vespertilionids in Africa, prior to their first appearance in Europe in the Late Eocene.

There are currently no students working on bats at the institute, but the possibility does exist for future students to participate. A complete list of the publications of the institute that concern bats, either as the main topic or as a secondary subject, is in preparation and will soon be available from Dr. Bernard Sige, Institut des Sciences de l'Evolution, U.S.T.L., Place Eugene Bataillon, 34095, Montpellier Cedex 2, France.

Italy

For the past twenty years my students (five) and I have been involved with a field research study of the community structure of cave bats in the Latium region of central Italy. We are also interested in distributional studies of the bat faunas of Greece and Turkey. The laboratories, library resources and museum collections here at the institute give us strong support for this sort of research. Pierangelo Crucitti, Society of Natural Sciences of Rome, SRSN, via Fratelli Maristi, 43, I-00137, Rome, Italy

Editors' Note: Some editorial corrections were made to Dr. Sige's and Dr. Crucitti's notes. Every attempt has been made to convey the original meaning, and any shortcomings or errors in that direction are unintentional and attended by our apologies.

Canada

Mark Brigham has completed his post-doctoral work with Robert Barclay at the University of Calgary and has been appointed to the faculty at the University of Regina in Regina, Saskatchewan. He assumed his new position in August of this year.

AND ON THE LIGHTER SIDE.....

Kunwar Bhatnagar has sent along the following important information. Molds or small pans in the shape of a bat are available for those of you who must have the latest in bat-fads. These molds can cut, crimp, seal and bake pastries, turnovers, fried pies, omelets or cookies. They cost $6.95 each and can be ordered from the *Chef's Catalogue,* 3215 Commercial Avenue, Northbrook, IL 60062-1900, telephone 1-800-338-3232. (One would presume that one could also fry or bake a bat in it. Yuck!)

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FRONT COVER

The illustration on the front cover was generously provided by Charles Alexander Rubadou, a professional artist who describes his art and his interests in bats as "unique". He is interested in communicating with "real bat people" to discuss bats and his work, and the prospects of providing professional art work for publications or other use. He can be contacted at 610 South Almound Street, Fall River, MA 02740, or by telephone at 508-679-0356.

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BAT RESEARCH NEWS

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OBSERVATIONS OF ALLOGROOMING BEHAVIOR IN A BACHELOR COLONY OF LITTLE BROWN BATS *MYOTIS LUCIFUGUS*.

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During the summer of1987, while conducting a behavioral study of day -roosting little brown bats *Myotis lucifugus*, I observed two separate bouts of allogrooming. The study site was a bachelor colony of little brown bats which day-roosted in the attic of the Hope Chapel Methodist Church, Colp, Williamson County, Illinois.

The attic was bi-level, with the rear upper chamber measuring 9.1 m long by 4.6 m wide by 1.5 m high and the lower chamber measuring 6.1 m long by 6.1 m wide by 3.7 m high. The ceilings and floors of both sections were exposed and there was a rough, unfinished ridge pole running longitudinally along each of their lengths. Extending from the ridge pole to the floor, on each side, were a series of 2 x 4 rafters which formed the peaks of the ceilings. The majority of bats were observed roosting along the ridge pole and rafters of the lower attic portion.

Colony size was estimated at 95+ individuals on May 5, by observing nightly emergence from sunset until no other individuals could be seen exiting the roost. The only roost entrance and exit used by bats during the study was located at the junction of the rear and lower attics' roof-tops. Periodically, roosting individuals were extracted from their resting areas and sex was determined; females and young were never observed roosting within the colony.

Observations were obtained using focal animal sampling (Altmann, 1974) and were facilitated by the use of a U.S. Army night vision scope. Because of the scope's effectiveness at amplifying ambient light, supplemental illumination was not necessary. However, a 15-watt red light bulb, covered by an aluminum foil shield, was used to illuminate data sheets. Observer to bat distance was maintained at 2-3 m, a distance that allowed clear observations without disturbing roosting bats (Burnett and August, 1981).

The first instance of allogrooming behavior was observed on June 11 at 06:34 h during the morning observation period (06:00 h-11:00 h) and involved two bats roosting side by side. During this bout, bidirectional allogrooming was observed between the focal animal and a neighboring conspecific. The focal animal, who was being groomed, licked and chewed the back left flank and dorsal surface of the chiropatagium of the conspecific, while the latter was licking the undersurface of the focal animal's right wing.

This bout lasted 96 seconds, after which both individuals resumed resting and maintained body contact.

The second allogrooming bout occurred on August 1 at 12:00 h, during the afternoon observation period (11:59 h-18:00 h) and involved a conspecific crawling 2 m from a higher roosting position down a rafter to a resting focal animal. Upon receiving body contact, the focal animal shifted its posture and then the conspecific began to lick the face and ventrum of the focal animal. This episode continued for 133 seconds and as with the previous bout, once completed, both individuals resumed resting in direct body contact.

It is possible that allogrooming helps in reducing external parasite and debris loads which are otherwise missed during autogrooming and thus increases the health and condition of the individuals involved. Wilkinson (1986) suggested social grooming in some bats may entail a sufficient cost so as to preclude selection for its practice unless kinship or reciprocation is involved.

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A METHOD FOR ESTIMATING THE SIZE OF A *MINIOPTERUS SCHREIBERSI* WINTER POPULATION IN LATIUM, CENTRAL ITALY

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European bat populations are generally of small size, consisting of no more than a few hundred individuals (some *Rhinolophus* and "large" *Myotis*). The Bent-winged Bat *Miniopterus schreibersi*, a cave species of tropical origin whose range now covers a large part of the Old World and Australasia with a European distribution restricted to Mediterranean countries, is an exception to this rule (Brosset, 1966). In temperate regions, hibernating populations of thousands of bats are sometimes observed in natural and man-made underground caves where they are commonly found in closely packed clusters.

Owing to their size, colonies of the Bent-winged Bat are difficult to estimate. If colonies are small (N<100), and the roost sites are easily accessible, it is possible to capture and count the animals. This obviously may represent a severe and unacceptable stress for bats. A photographic estimation of *Tadarida brasiliensis* population, based on a sequence of pictures of its evening flight near the cave entrance, was developed by Humphrey (1971). This approach was made possible by the peculiar site of that particular cave, and it might be difficult to use in other situations. This work (Humphrey's) represents a useful bibliographical source about methods for estimating the size of bat nursery populations.

Our method is primarily based on the analysis of photographs of *M. schreibersi* hibernating clusters. A drawing of each of the clusters were subsequently made in the laboratory and from these the size, area, and number of animals were easily estimated.

A large population of the Bent-winged Bat was discovered in an artificial cave near Blera, in Latium, in Central Italy. This population usually contained four to seven clusters, commonly found in the main

chamber of the cave, continually from November to April. During January and February the average temperature of the shelters was no more than 5°C, lethargy was deep and the bats remained torpid for a long time, even when disturbed by humans.

Our methods are summarized as follows.

1. In February, 1990, pictures of all seven *M. schreibersi* clusters were taken on 35 mm slide film. A folding meterstick was included in each frame as a reference.
2. Slides were projected onto paper, and a contour line was drawn around each cluster. Drawings were always made on the same scale of 1:4.
3. Paper with 5mm x 5mm grids(graph paper) was laid over each drawing and both were placed on an enlightener (or viewbox) allowing visualization of both the squared paper and the cluster contour lines at the same time. We then traced each cluster's contour line onto the 5x5 mm grid of the squared paper. Squares were chosen and counted if their area was occupied by more than 50% of one contour line on the drawing.
4. The surface area (cm2) of the seven drawings, in scale, was determined by direct counting of the squares, dividing the result by 4 (number of 5 mm squares required to obtain 1 cm2).[sic]
5. To determine the number of bats in a surface unit, we increased the image four fold up to the real size (1:1) Afterwards, we constructed a paper frame with a square "window" 10 cm on each side and placed it over some portion of the projected picture :we nearly always found 16 animals/dm2, and we used this estimate for the number of bats present in one dm2.
6. By the above calculations each square centimeter on the graph paper is equal to one square decimeter. The number of bats in each cluster was determined by multiplying the number of square centimeters covered by the cluster by 16. Results are shown in Table 1below.

We compared our data with those of Van der Merwe's study of *Miniopterus schreibersi natalensis* of Transvaal, South Africa, as shown in Table 2 below.

Clusters	S	N+
1A	2.42	39
1B	6.17	99
1C	6.83	109
1D	63.10	1010
2A	43.60	698
3A	1.47	24
3B	34.97	559
Total	158.56	2538

Table 1. Area, S (dm2) and number, N+ (N+ = S x 16) of seven *M. schreibersi* clusters N+: rough estimates according to the first decimal number

Taxon	N	S	N/S+
M.s. natalensis	49500	28	1768
M.s. schreibersi	2538	1.58	1606

N/S+: rough estimates etc. (see Table 1)

Table 2. A comparison between N and S (m2) in two M. schreibersi subspecies.

The difference between N/S values is within 10% and is partially due to different body sizes of these two taxa: agreement between our data and that of Van der Merwe appears to be acceptably close.

With this method we were obtained the following results: A) To appraise the morphology, or shape, of *M. schreibersi* clusters and correlating this with such factors as type and morphology of substratum, ambient temperature, etc.); B) To establish the surface area of each cluster and the total for all the clusters; C) To determine the number of bats in each cluster and in all the clusters.

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FEEDING BEHAVIOR OF THE LINNEAUS' FALSE VAMPIRE BAT VAMPYRUM SPECTRUM IN CAPTIVITY

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The Linneaeus' False Vampire Bat, *Vampyrum spectrum,* ranges from Veracruz, Mexico, southward to central Brazil and Peru and east to the Island of Trinidad. It is the largest of the New World microchirpterans, weighing up to 190 grams and with a wing span of 900 millimeters. Of the 434 institutions participating in ISIS (International Species Information System), none report holding Vampyrum spectrum (ISIS, 1989).

Analysis of stomach contents of this carnivorous bat, has revealed that its diet consists largely of birds, arboreal rodents, and bats (Casebeer, et al., 1963; Peterson and Kirmse, 1969). However, Navarro (1979) found plums and a fragment of an unidentified red seedless fruit in the stomach of one specimen. Other than studies by Vehrencamp et al. (1977), who examined feeding preferences by identification of feathers found in bat roosts (which indicated a preference for non-passerine birds) and foraging behavior by radio tracking, little is known of the natural history of *Vampyrum* in the wild.

Greenhall (1968) reported that in captivity, the bat thrived on raw meat, mice and small chickens. He maintained a captive pair at Trinidad's Regional Virus Laboratory for five and one half years. This pair produced one offspring.

An adult male and an adult female *Vampyrum* were captured in Trinidad in February, 1990 during a collecting trip for vampire bats undertaken for the Cincinnati Zoo and the New York Zoological Society. While housed together prior to importation into the United States, the bats began fighting during a feeding. The male escaped when efforts to separate them were attempted. The female survived air transport and has been maintained successfully in a private collection since February 15, 1990. This bat is currently housed in an enclosure which restricts its flight (42" x 24" x 36" with 1" x 1" square mesh) on a natural light cycle. It prefers to roost in the middle or front of the cage. Two vocalizations most often emitted are a soft purring (a greeting response?) and a rapid clicking accompanied by body vibrations, in response to a perceived threat or annoyance. It also appears to sneeze in an effort to clear her nose of blood after eating.

Captive diet consists of mice (18-28 grams), chicks (50-58 grams), week old mice, strips of chicken, and beef on occasion, fed at 7 a.m., 6 p.m. and 10 p.m. Fruit (grapes, bananas, mangos) was offered but not taken. Fresh water is always available.

During the first three weeks, mice and chicks were offered killed, but after this time were given live. Observations of *Vampyrum's* feeding behavior showed that the bat would hang by both feet and reach out with thumb claws pulling the food item toward its mouth, then it would quickly seize the food animal by the head, crushing the skull causing almost instant death with the bite. If the prey were kicking, the bat would pull its thumb claws away to avoid injury until the prey was motionless. If the animal were seized about its torso or limbs, the bat would manipulate the prey with its thumb claw until the skull was in position for the crushing bite. The animal is progressively consumed from head to tail. The bat consistently removed the small and large intestines of both mammalian and avian prey. It eats the prey until reaching the mid-section, and then loosens the intestines with its tongue, while using the thumb claw to rotate the animal. Then it removes the intestines with its teeth and drops these to the floor of the enclosure, and continues feeding. Tails are sometimes eaten, but chick wings and feet are always discarded. Average time to consume prey is fifteen minutes. Feeding is following by grooming and cleaning.

This method of eating by manipulating prey with the thumb claw is not consistent with that of the Ghost Bat, *Macroderma gigas,* of Australia, another carnivorous bat. *M. gigas* primarily holds prey by mouth, only occasionally

manipulating it with the thumb claw (Guppy and Coles, 1983).

I thank Jeanine LaBanco for help in maintaining the bat, Joyce M. Shaw for bibliographic and editorial assistance, and Steven D. Thompson for reviewing the manuscript.

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Note:

The above author is seeking one male *Vampyrum spectrum* as a breeding loan or for purchase. Please contact this author at (312-549-5881 after 6 p.m.).

BOOK REVIEW

The Short-tailed Fruit Bat: A Study in Plant-Animal Interactions.

T. H. Fleming, University of Chicago Press. xvi + 365 pp., illus., 1988. Price (hardbound), $49.95.

This is a monograph, in 11 chapters, focusing on the long-term field research (1974-1984) of Ted Fleming and his colleagues on the ecology and behavior of the frugivorous bat *Carollia perspicillata*. The first three chapters are introductory. Chapter 1 presents an up-to-date overview of the ecology and evolution of the very important neotropical bat family Phyllostomidae of which *C. perspicillata* is a member. Chapter 2 reviews theoretical considerations and empirically-based generalizations on bat-plant mutalistic interactions. Chapter 3 gives a detailed description of Santa Rosa National Park in Costa Rica, where most of the study was conducted, and reviews information on the phenology of the dry tropical forest plants which are important to many phyllostomid bats and other frugivores. Chapters 4-10 deal with various aspects of *C. perspicillata's* biology and Fleming's research. The titles of these chapter, in order, indicate their basic contents: (4) "Demography," (5) "Social Organization," (6) "Diet and Food Choice," (7) "Foraging Behavior," (8) "Energetics," (9) "Ecological Relationships with Other Animals," and (10) "Botanical Consequences of *Carollia's* Foraging Behavior." Chapter 11 concludes the book with reviews of information on the behavior ecology of other phyllostomid bats and the comparative roles of frugivorous bats, primates, and birds in the ecology of New- and Old-World tropical ecosystems. Each chapter ends with a summary of its major topics and conclusions. The book has copious data tables and illustrations, an extensive bibliography, and both author and subject indices.

Chapters 1, 2, and 11 provide excellent reviews which should benefit any student of tropical forest ecology. I found the latter part of Chapter 11, comparing the ecology of diverse tropical frugivores to be especially

integrative and informative; it clearly reflects Fleming's background and his substantial contributions to studies on the ecology of tropical communities. Chapter 3 should be read by anyone involved in or contemplating research in Costa Rica or on plant-animal interactions in the tropics. Chapter 4-10 summarize information from what I believe to be the longest continuous research effort on the behavioral ecology of any single bat species. As such, they should be required reading for anyone involved in similar research or with interest in such pursuits. The book has additional, inherent interest because *C. perspicillata* is one of the most ubiquitous and common bats in Central America and northern South America. Any ecologist with experience in these regions has almost certainly had first-hand encounters with this species.

As the titles of Chapter 4-10 suggest, the work of Fleming and his colleagues has involved an incredible diversity of research approaches. These include: extensive mist-netting, banding, and mark-recapture analyses, radio telemetry, dietary, seed dispersal and germination studies, genetics, food plant demographics, use of doubly-labeled water, and good old-fashioned observations. The book provides a wealth of information on research techniques, analyses, and data integration. The attempts to integrate this diverse information range from very solid (e.g. *C. perspicillata's* role in seed dispersal) to evidently contrived (e.g. the calculations of daily energy budgets).

My major criticism is that I think the author frequently attempts to do more than he should with what he has. This makes the book tedious in places and can serve to obscure the large amount of information that is presented. For example, substantial space is given to reviewing various aspects of foraging theory. However, gaps in information preclude cogent testing of this theory, and we are led through a discussion based on anecdote and weak inference. I have a similar problem with the treatment of aspects of life history theory (e.g. male reproductive strategies), the calculation of daily energy budgets, and elsewhere. However, on the other edge of the same sword, I'm also disappointed at the apparent unwillingness to speculate more on the evolutionary or ecological causes of some significant major patterns. As cases in point, the fluidity in membership of *C. perspicillata* female groups and the highly skewed adult sex ratio toward males are both very intriguing and warrant more discussion than they receive. The figures and tables often present previously unpublished data and are generally a great asset to the text. Unfortunately, I found many figures difficult to interpret because of inadequate descriptive legends.

On balance, the book has substantial merit. As Ted Fleming points out, despite their ecological significance, their abundance, and the magnificent diversity of behaviors and life history patterns which bats display, the behavioral ecology of very few species as been studied in detail. This book is the most complete and thorough monograph to date on the behavioral ecology of any bat. It thoroughly documents the importance of *Carollia perspicillata* in tropical ecosystems, it clearly illustrates that bats, in general, and *C. perspicillata* as one example, provide excellent systems for the study of evolutionary processes. It assembles an exceptionally detailed data base on the biology of this important species, and it should clearly encourage and point the way for other researchers to take advantage of the diversity of research opportunities which bats provide.

Gary F. McCracken, Department of Zoology and Graduate Programs in Ecology and Ethology, University of Tennessee, Knoxville, TN 37996-0810.

The 20th Annual North American Symposium on Bat Research met in Lincoln Nebraska at the University of Nebraska State Museum and the Cornhusker Hotel. Our Hosts were Dr. Hugh Genoways, Director of the Nebraska State Museum of Natural History and Dr. Patricia W. Freeman, Curator of Mammals at the Museum. The Symposium was attended by 168 registered participants and several guests, local students, and "friends of the family". This is the third largest gathering in our twenty years of meeting, exceeded only by the meeting at the University of New Mexico in Albuquerque in 1978, which also included the International Group, and the meeting at Cornell University in Ithaca, N.Y. in 1982. A total of 68 papers were presented, 57 of these from the podium and 11 as posters. Each year the number of presentations increases, but time to present them is limited. At this meeting we were forced to take the very unpopular measure of having a morning of joint sessions. As a result of this, and in anticipation of an equally large turnout at the next meeting in October in Austin, we resolved to devote three days to paper presentation. As in the past, the presentations were professional, well organized and interesting. As in previous years the presentations by the students were especially well done. Four prizes were awarded for outstanding presentations. First place was awarded to Catherine Sahley of the University of Miami. Three second place awards were also given to Annette Denzinger -Bachman of the University of Tubingen, Alita Acharya of the University of Toronto, and Rick Adams of the University of Colorado. The committee for student honoraria was ably chaired by Gary Kwiecinski.

Dr. Bernardo Villa-Ramirez of the Universidad Nacional Autonoma de Mexico was our guest of honor at our banquet and received the **Gerrit R. Miller, Jr. Award** which reads..." *In recognition of outstanding service and contribution to the field of chiropteran biology, this award is presented to Bernardo Villa-R. by his colleagues of the North American Symposium on Bat Research at its twentieth annual meeting convened at The University of Nebraska on October 26, 1990*"....

The presentation was preceded by a short summary of only a few of Dr. Villa's achievements and his kind service to so many of those in attendance. Dr. Villa, who is an eloquent speaker, responded with a magnificent smile, and a simple, moving, and emotion filled, "much gracious y thank you so very much." Following the presentation his granddaughter, Patricia Villa, honored her grandfather with presentation about the role of bats in pre-Columbian Mexican mythology. Dr. Villa's son Bernardo Jr., a physician practicing internal medicine in Mexico City , his daughter Beatrice, a veterinarian on the Faculty of Veterinary Medicine at U.N.A.M., and his son-in-law, William Lopez-Forment, an Assistant Professor of Zoology at U.N.A.M. all were present to share in the occasion. The previous recipients of this award are unanimous in their feeling that Dr. Villa gives it new stature and dignity, and perhaps no other chiroptologist is as widely known, respected and loved.

The meeting would not have gone off so smoothly if it were not for the many individuals who pitched in and helped. Hugh took care of the grand scheme of things, and was designated the "Grand Poohbah of the Symposium", while Trish worried about the multitude of large and small details. They were ably assisted by the graduate students, Scott Pedersen, Mike Rodell, Kirk Nordike, and Steve Rodiguez. We must not forget Norma Wagner and Gayle Litrell, the charming ladies who sweet-talked you out of your registration fees(more than once in some cases) and saw to it that the registration books balanced. The staff at the Cornhusker Hotel was wonderfully hospitable to all of us. Betsy Apking whose official title is Sales Manager was much more than that. She offered us countless suggestions and good advice all through the planning stages. Jim Meyer, the Convention Services Manager, was everywhere at once, and solved all our problems and saw to our every need from the opening moments until the last of us departed. To all these good people, a heartfelt thank you from everyone in attendance. And to you, Trish, a special thanks from all of us, we couldn't have done it without you. GRH

The following article was presented in honor of and dedicated to Bernardo Villa by Patricia Villa, his grand-daughter, on the occasion of his reception of the **Gerritt R. Miller Jr. Award.** Patricia is seventeen years old, and a high school student, and the youngest person to ever present a paper or to address our group in its tweny year history. Patricia is moderately fluent in English but she has asked me to help in her written translation. We were all impressed with her poise and confidence during her presentation. Bernardo was deeply moved by her tribute, and must be very proud of this young member of his fine family. GRH

The Sentinels of Eternity

Patricia Villa
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As one travels from Oaxaca City along the Panamerican highway in the direction of Tehuantepec, one passes very near the ruins of Dainzu. In the Zapotec dialect this means Organ Hill, apparently named after the great stands of magnificent organ pipe cacti, some still in evidence, which covered the hill in ancient times. There are several pyramids, each with its own courtyard, some large and assuming, others less imposing. In the foreground of the largest pyramid lie the remains of what must have been a large an splendid hall or temple. It has an expansive courtyard which extends away toward the west and the setting sun, surrounded by beautiful walls of stone, some still in excellent preservation. The walls are surmounted by stairs at many places suggesting the entrances to buildings that once rested in splendor upon these foundations. From here the view is directed toward a stele, or column of stone, depicting several characters, and guarding the entrance to a tomb. On the lintel above the door is the face of a jaguar, the jambs of the door representing the jaguar's limbs, as he guards the entrance. To one side of the tomb is a partially restored ball court, the "juego de pelota", that has been accurately dated to the tenth century. There is another figure guarding the tomb, and it too has the body of a jaguar, but its forelimbs are transformed into enormous wings, and its face is the face of a vampire bat.

Close examination of the bat's face reveals a remarkable wealth of detail, the soft rounded ears, not sharp and pointed like the common vampire bat, but like the bird vampire, *Diphylla ecaudata*. It has the large round eyes of *Diphylla* and not the smaller squinting eyes of Desmodus, and the incisure in the lower lip is present but small, again suggesting *Diphylla*. This now almost vanished species was probably much more common a thousand years ago than it is today, perhaps because many large birds like the wild turkey, were also more abundant at that time.

Bats are a constant feature of the pantheon of the ancient peoples of Mesoamerica, recurring in the Artifacts of many cultures, often associated with death. These ancient ceremonial Artifacts can be found in museums around the world from the famous Bat-god of the Berlin Museum to the magnificent jade bat mask in the Museo Nacional de Antropologia in Mexico City. This jade mask, intricately made of many pieces, is one of the "jewels of Oaxaca" and is believed to represent some species of Phyllostomid bat. I have seen in the Museum at Mitla, at the Universidad de los Americas a beautifully preserved mud figure of a bat which is clearly *Trachops cirrhosis*.

All these representations are in harmony with the traditions celebrated at the great Olmec temple complex at Monte Alban. Professor Jose Maria Bradomin has documented that the Olmec religion was inspired by the animals that they both feared and venerated. Chiefs and priests alike associated themselves with the animals of force and power, of which the jaguar was the ultimate expression. These cultures also associated strongly with "rites of blood", hence the many depictions of vampires or vampire-like bats upon ancient tombs and monuments. The jaguar watched by day, and the bat guarded against the evil creatures of the night. For over a thousand years the jaguar and the vampire have been silent sentinels, protecting the spirits of the dead and guarding the lost secrets of the ages for all eternity.

Abstracts of Presentations at the 21st Annual North American Symposium on Bat Research, University of Nebraska, Lincoln, NE., October 22 and 23, 1990. [abstracts appear alphabetically by first author]

* Monitoring the Attack Success of Foraging Bats

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I observed the echolocation and hunting behavior of *Lasiurus cinereus* and *L. borealis* in the field to asses what information about feeding behavior an observer could obtain by monitoring the calls of foraging bats. In Pinery Provincial Park in Ontario, both species forage around street lights where the outcomes of attacks on prey by the bats are clearly visible. At this site, *L. cinereus* and *L. borealis* feed almost exclusively on moths. *L. cinereus* feeds on significantly larger moths (n = 120) than *L. borealis* (n = 50). Moth size was determined by measuring culled moth forewings (a good predictor of moth body length and mass). I tested the hypothesis that the silent period following the last call in a feeding buzz reflects prey handling time. The mean lengths of silent periods after successful attacks (*L. cinereus*, n = 76; *L. borealis* n = 99) were significantly longer than those following unsuccessful attacks (*L. cinereus* n = 42; *L. borealis* n = 61), but there was no threshold value for the duration of the silent period clearly separating successful from unsuccessful attacks. Feeding buzz and silent period length can be influenced by the type of moth being attacked. *Hypoprepia fucosa* is an arctiid moth which possesses sound producing microtymbals ("noisemakers"). Attacks on this moth by *L. borealis* (n = 25) were accompanied by significantly shorter feeding buzzes and followed by significantly shorter silent periods than attacks on other moths (n = 150). The bats often aborted attacks on *H. fucosa* during the tracking stage of a hunt. Bats which did catch these moths always dropped them whole directly after capture, and two captive *L. borealis* would not feed on *H. fucosa*, suggesting that the moths maybe bad tasting.

*** This paper won co-second place for student presentations.**

* Resource Partitioning Between Age Partitioned Little Brown Bats *Myotis lucifungus* in a Mosaic Habitat Setting.

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Although interspecific resource partitioning has been documented between *Myotis* species, understanding of the dynamics between juvenile and adult intraspecific resource partitioning is lacking. Buchler (1980) reported on the ontogeny of flight and echolocation in juvenile *Myotis lucifugus* and showed that there was a temporal pattern to activity between age groups. He reported that juveniles would become active only after the adults had vacated the area. At Fort Laramie National Historical Site in Wyoming, individuals of a maternity colony of *M. lucifugus* can choose between foraging in open, semi-cluttered, or heavily cluttered areas. The purpose of the present study is to determine which habitats adults prefer to forage within and if this preference changes after the young of the year begin flying. I divided each habitat type in clutter indices (CI) based upon density of vegetation as well as what is known concerning the ontogeny of echolocation in *M. lucifugus*. Clutter indices are defined as follows: CI = 0, open areas, flight paths higher than 3 m above ground; CI = 1, open areas, flight paths lower than 3 m above ground; CI = 2, semi-clutter, no canopy, flight paths over tops of bushes within 3 m; CI = 3, semi-clutter, canopy present, side growth present or not, no undergrowth, flight paths greater than 3 m, CI = 4, heavy clutter, canopy present, side growth present, undergrowth present, flight paths greater than 1 m, less than 3 m; CI = 5; heavy clutter, canopy present, side growth present, undergrowth present, flight paths less than 1 m. All individuals are captured in Japanese mist nets, banded with a color coded, numbered arm band which indicates area captured, weighed, measured, and released. There is sufficient difference between habitat utilization between juveniles and adults

throughout June and July. The trend for adults is to use all habitats more or less equally before juveniles are volant. Once the juveniles become volant, adults tend to not use open areas and instead forage in areas of higher clutter. For the first few weeks of flying, juveniles are restricted to the open areas but begin using areas of higher clutter after about 3-4 weeks after first flight. There was no temporal partitioning noted in the present study between juvenile and adult activity patterns. Outflights of all age groups occurred more or less simultaneously.

*** This paper won co-second place for student presentations.**

Vocal Recognition in Mexican Free-Tailed Bats: Do Pups Recognize Mothers?

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Recent studies of reunion behavior in Mexican free-tailed bats have documented both olfactory and acoustic recognition of pups by their mothers. For several reasons, it should also be adaptive for pups to recognize their own mothers, and in-cave reunion videos recorded by Gary McCracken in 1987 show pups moving towards their presumptive mothers. However, experiments on pup recognition of mothers have been equivocal. In this paper, I report findings which support the hypothesis that Mexican free-tailed bat pups recognize their mothers using vocal cues.

To document a call ('directive' call) used by mothers which might function in recognition by pups, I recorded mothers searching for their pups inside James River Cave, Texas, a maternity colony of about six million Mexican free-tailed bats. Simultaneous video monitoring of the recorded area ensured that recorded calls were being uttered by searching mother bats. One hundred directive calls (two each from fifty different bats) were analyzed with a MacSpeech Lab II sound analysis computer. These calls contain features which make them well suited for detectability, locatability, and discriminability. Each call comprises a very intense, rapid burst of 3 to 18 pulses (mean = 5.6) with mean call duration 350 ms. Frequency modulation is usually pronounced, and fundamental frequencies range typically from 11 to 39 kHz. Principal Components and Discriminant Function analyses show directive calls to be highly stereotyped within, and variable among individual bats.

To test the hypothesis that pups can perceive and are attracted to mother directive calls, I ran playbacks using in-cave recordings of pup creches with and without directive calls. The 20 pups tested showed a highly significant preference for the directive call stimulus.

The Digestive Efficiency of Insectivorous Bats.

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In order to analyze the foraging strategies of energy budgets of animals, a knowledge of their digestive efficiency is essential. No such data exists for insectivorous bats feeding on natural prey. We fed moths of various sizes to bats of three species, *Myotis lucifugus, M. evotis,* and *M. volans* and calculated digestive efficiencies using a micro-bomb calorimeter. All three species had mean digestive efficiencies between 75 and 78%, significantly lower than that of individuals fed mealworm larvae in this and previous studies. There was a significant positive correlation between moth size and digestive efficiency, with small moths (20 mg) often being digested at under 70% efficiency. Since most natural prey are even smaller than that, are typically consumed whole (including legs and wings), and at least some are likely less digestible than moths, we predict that actual digestive efficiencies realized by bats in the field will be under 70%. Variation in digestive efficiency may have significant implications for prey selection by bats. In addition, our results suggest that to meet energy demands, bats must consume greater quantities of prey than previously estimated and likely consume more than their own body weight per night during times of high energy demand, such as during lactation.

The University of Florida Bat Relocation Project: An Experiment with Important Management Implications.

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At least 11 buildings on the University of Florida campus house large bat colonies. Recently, colonies in two buildings have grown to more than 3000 individuals. These animals produce large quantities of fecal material daily whose strong odor is a serious problem, particularly in hot summer months. As a result, the bats causing this problem will be evicted from their respective roosts in the Fall of 1990. The former roosts will be sealed and the evicted bats will then be moved to a large, specially-built, "bat house" on campus.

This project is important because it is the first attempt, worldwide, to deliberately relocate a large bat colony to a roost that will not disturb, or be disturbed by people. It offers a unique opportunity to study the feasibility of relocation as a management tool for "building bat" populations (particularly of the Mexican free-tailed bat, *Tadarida brasiliensis)* in Florida, the southeastern U.S.A., and elsewhere.

If successful, this project will protect one of the largest known remaining colonies of *T. brasiliensis* in central Florida. It will also provide easy access to the bats for future study. Like most bats in Florida, little is known about the biology of this species.

The Lobed Mandibular Incisors of the Hairy-Legged Vampire, *Diphylla ecaudata,* with Notes on Lobed Incisor Crowns in Some Other Mammals.

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The hairy-legged vampire, *Diphylla ecaudata* is unique among bats for its fan-shaped, seven-lobed mandibular lateral incisors. During our continuing scanning electron microscopic investigation of vampire enamel it was observed that in the prepared specimen the left lateral mandibular incisor was clearly six-lobed instead of the reported seven. The counterpart on the right side was a seven-lobed tooth. This observation led to examination of 44 more mandibles of *D. ecaudata* of both sexes obtained on loan from the American Museum of Natural History, New York, and the Field Museum of Natural History, Chicago. Additionally, several wet specimens as well as mandibulae of *D. ecaudata, Desmodus rotundus, Diaemus youngi, Macrotus waterhousii, M. californicus, Cynocephalus volans, Rhynchocyon cirnei,* and *Petrodromus tetradactylus* were also examined and compared with *Diphylla.* Of the 85 lateral incisors in *Diphylla,* only 27% had seven lobes. The great majority, 67%, showed six distinct lobes. A single specimen had eight lobes on the right and left incisors and three other incisors had five lobes each on the right side. Ten mandibles showed variability of one lobe between right and left sides. Numerous mammals possess digitate lower incisors. The lobed incisors of *Diphylla* resemble the outermost (third) mandibular comb-toothed incisors of *Cynocephalus volans.* This study has shown that contrary to the reported seven-lobed lateral mandibular incisors in *Diphylla ecaudata,* the number of lobes on this tooth is highly variable.

Additional Records of Wyoming Bats

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Although Clark and Stromberg (1987) recently summarized information on mammals in Wyoming, much remains to be learned of the status and distribution of bats in that state. I recently completed an examination of bats submitted to the Wyoming State Veterinary Laboratory (WSVL) for rabies testing. Although I discarded most specimens after identification, over 300 specimens, including vouchers and species difficult to identify or representing important distributional records, were saved and are deposited in the Biological Survey Collection in Fort Collins (BS/FC). The bats

examined provide a new and comprehensive picture of bat distribution in Wyoming. Long (1965) recorded 11 species of bats based on 188 specimens: Clark and Stromberg (1987) recorded 16 species with no information on number of specimens examined. I tabulate perhaps 16 species based on over 1300 specimens examined. On average, the number of known localities for each species was typically doubled by the WSVL specimens. Species found in the samples were *Myotis californicus, M. ciliolabrum, M. evotis, M. lucifugus, M. thysanodes, M. volans, M. cf. yumanensis, Lasionycteris noctivagans, Lasiurus cinereus, Eptesicus fuscus, Plecotus townsendii, Antrozous pallidus,* and *septentrionalis, L. borealis,* and *Euderma maculatum.* The species of most frequent occurrence in the WSVL sample were *M. lucifugus, E. fuscus,* and *L. noctivagans.* The most widespread species based on localities represented, were *M. lucifugus, E. fuscus, M. volans,* and *L. noctivagans.* Most bats were submitted for examination from May through October but there were records for *Lasionycteris* and *Eptesicus* from January; the months with greatest numbers of bats were July, August, and September. Between 1981 and 1989, 1746 bats were tested for rabies by the fluorescent antibody (FA) test; 113 (6.5%) tested positive. Of 45 FA-positive bats of nine species examined by me, there were 27 *Eptesicus,* 5 *Lasionycteris,* 4 *L. cinereus,* 3 *M. ciliolabrum,* 2 *M. lucifugus,* and 4 from other species. The counties with the richest known bat faunas were Bighorn and Sweetwater, each with 11 species; the modal number of species per county was 8. Several counties deserve further examination as they surely harbor additional species. A new locality for *Euderma* in Wyoming was discovered during field work in August 1990. Additional specimens of some species are needed to determine their subspecific allocation.

Feeding Behavior of *Artibeus toltecus* in Costa Rica: Flight Cage Experiments with Native Fruits.

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Artibeus toltecus (Phyllostomidae), a 15 gram obligate frugivore, was observed feeding in large flight cages. Individual bats were presented, ad lib, with fruits from plant species known to be important in the diet of free-roaming bats from cloud forest at Monteverde, Costa Rica. In whole-night feeding experiments, *A. toltecus* spend 58% to 79% of their nightly time budget handling food items. Fruit was ingested at the average rate of 0.15 g/hr. The ingestion rate did not vary with fruit type. Fruit handling times were directly proportional to fruit mass. Total wet-mass fruit consumption per night equalled 2.5 to 4.2 times body mass of the bat. *A. toltecus* handled food items slowly in comparison to phyllostomids of other genera. Individual bats differed in fruit preference when given pairwise choices of food species.

Activity Periods and Use of Torpor by Two Goatsuckers, the Poorwill, *Phalaenoptilus nuttallii,* and the Common Nighthawk, *Chordeiles minor.*

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Nocturnal aerial foraging should impose a number of constraints on organisms regardless of their taxonomic status. Two of these constraints include coping with unfavorable conditions when insect abundance is low and the detecting of small insect prey under conditions of low light. Although it is widely known that many temperate insectivorous bats use torpor and echolocation to solve these problems, it is poorly understood how visually orienting goatsuckers (Aves: Caprimulgidae) have solved the same problems. The purpose of this study was to use temperature sensitive radio-transmitters to determine if poorwills and nighthawks in the Okanagan Valley of British Columbia (1) use torpor during periods of poor weather and (2) extend activity periods by foraging during periods of the night when the moon is up. Poorwills (40 g) forage from a perch or the ground (fly catcher style) and readily enter torpor during periods of inclement weather, but only outside of the breeding season (April, May, September). The T_B of both sexes was measured to drop below 5°C and periods of

torpor sometimes extended for more than 24 hours. Poorwills were significantly influenced by moonlight, extending their active periods when the moon was up. Nighthawks (80 g) who forage from continuous flight, never entered torpor, nor were they found to extend foraging bouts into periods of the night when the moon was up. Nighthawks foraged crepuscularly, although during the spring of 1990 when the weather was consistently poor, the birds appeared to forage diurnally. Our results suggest that body size and foraging strategy may influence the ability to use torpor and forage in moonlight conditions respectively. These same factors have been implicated as important influences on similar behaviors.

Social Organization of the Fishing Bat *Noctilio leporinus*.

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The social organization of the fishing bat *Noctilio leporinus* was studied on the island of Culebra and at Camuy, Puerto Rico. Bats from eight hollow trees and two caves were banded with both reflective and numbered tags in 1989 and 1990. The bats that had been banded in 1989 were resighted and recaptured in 1990 at the same roost where they were originally captured. Observations of banded individuals showed that roosts were divided into discrete groups of four to twelve females with a single male. Protection of the group's boundary by the resident male was observed. Female associations appear to be stable and maintained for long periods of time. Groups of males were segregated from female groups in large roosts of 40 or more bats, or comprised entire "bachelor" roosts.

Our initial radio tracking showed that the foraging areas of females within a roost were overlapping. However, when females from the same roosting association were radio-tracked, their foraging areas were found to be broadly overlapping. These associated females exited from the roost, foraged and then returned to the roost as a group. This is suggestive that roosting associations of females may benefit from foraging together.

Status Report on the Two Year Pre-Development Study of *Myotis velifer* in Kartchner Caverns State Park, Arizona.

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Kartchner Caverns, a wild cave in southeastern Arizona, was purchased by the State of Arizona for development as a show cave. The cave bat *Myotis velifer,* currently uses the cave as a summer migratory and maternity roost. To prepare for the public viewing in an environmentally sensitive manner, Arizona State Parks has contracted for a two-year pre-development study of the cave. This baseline study will provide a framework of basic knowledge about the conditions within Kartchner Caverns. Due to their importance to the cave ecosystem, a major facet of the study is to inventory and delineate the bat use at the cave. In the area of the cave utilized by the bats, eleven micrometeorological monitoring stations have been installed to provide an environmental profile of their roost. Bat guano is an important food source for many other cave organisms. An inventory of the invertebrates in Kartchner Caverns has resulted in a surprising diversity for a cave in such a dry desert climate. The pre-development study has one more year until completion, but the data collected to date provides information vital to sound management of the cave park.

Variations in Urine Osmolalities of Hibernating *Myotis velifer*.

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Our research has shown that there is considerable variation in the urine osmolalities of hibernating *Myotis velifer*. These variations in osmolalities have not been examined in relationship to various physiological and environmental factors. This research examines the correlation between urine osmolalities and variations in osmolalities to sex of bat, month of hibernation, ambient temperatures, relative humidity, cluster size, the volume of urine in

the bladder, and the position of the bat in the cluster. No significant differences were detected between the osmolalities of male and female bats. Monthly mean osmolalities were different. Osmolalities were correlated with ambient temperature but not to volume of urine in the bladder. Coefficients of variation of urine osmolalities were negatively correlated with cluster size.

A Preliminary Study of Roost Aggregations in a *Myotis lucifugus* Maternity Colony.

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Bats of many species are known to maintain stable social groups or roosting associations for prolonged periods, often lasting for several years. This type of social interactions has not been studied extensively in populations of temperate bats which form large nursery colonies during the summer months. With this in mind, I conducted a preliminary study of a large maternity colony of *Myotis lucifugus* during the summer of 1990. This colony of approximately 1000 bats inhabited a 62 m long covered bridge spanning Tulpehocken Creek in Gring's Mill Park, north of Reading, PA. Within the bridge, there were often as many as 15 inhabited roosts located in the upper reaches of the bridge.

Bats were captured in mist nets as they flew within the bridge and were banded with unique combinations of colored bands so that recognition of individuals was possible. The roosts were then examined on a daily basis, and the position of banded individuals noted with respect to roost location and other banded roost mates. Although some bats were found in a given roost for several successive days, over longer periods the bats were not roost specific, even before most of the young were volant. The number of bats found within several roosts varied from 0 to over 250 during the course of the summer. In addition to identification of any individual interactions within roosts, future work will attempt to determine the proportion of individuals which use the bridge as a regular roost, relative to bats which were found in bridge roosts only occasionally during the summer.

Enhancing Public Awareness Toward Bats Through the Exemplary Use of Bat Houses in Conservation and Management.

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Twenty-four small and five large "Missouri-style" bat houses were erected at Salamonie Lake, a state-owned reservoir in northeast Indiana as part of a project designed to coordinate public education and interest in bats with habitat improvement. Also, research on the effectiveness of bat houses as summer roosts was initiated. Funding from Ball State University and the Nongame and Endangered Wildlife Program of the Indiana Department of Natural Resources, with additional cooperation from the Interpretive Services of the Upper Wabash Reservoir, Salamonie Lake staff, and the Division of Fish and Wildlife, enabled 30 families to attend a five-hour workshop to hear presentations concerning bats of Indiana and the State's bat recovery programs. Each group received materials to build two small houses, one to take home and one to be erected at Salamonie Lake.

The 24 bat houses left at Salamonie were erected in areas where they were visible to the public. In addition, five large bat houses were built, two erected in very public areas and three in more remote locations. The bottom of the houses range from 2.3 to 4.7 meters above the ground. Compass direction, distance from water, topography and vegetation around each house was recorded. The houses were checked twicea month during the summer. Maximum-minimum thermometers were used to record temperatures in the larger houses.

Three mouse nests, a snail, European earwigs and numerous wasp nests were found in the bat houses, but no bats were. Plans call for continued monitoring of the houses for the next few summers and possibly "seeding" of a few houses next year.

The Use of Infrared Imaging in Making Behavioral Observation of the Big Brown Bat, *Eptesicus fuscus.*

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Infrared imaging, particularly mid-range infrared in 10-12 micron wavelengths, is frequently used to detect remote radiance patterns and to analyze heat anomalies in many industrial and medical applications. In the study of bats, infrared imaging provides these advantages: it is portable; self-contained; non-invasive; and can provide a permanent recording of bat location and behavior which may be used for subsequent laboratory analysis and comparison. It is especially effective where stop and slow motion video permits observation of transient occurrences and allows for data collection.

In the current study, big brown bats were first observed in a laboratory setting to determine their responses to the presence of the Inframetrics 565 Imaging Radiometer (IR). The horizontal scan mirror of the IR imager emitted a 3933 Hz noise which did not visibly disturb the bats. Following the determination of its non-invasive properties, big brown bats were located and observed in natural surroundings. The data obtained showed that infrared imaging has potential application in counting emerging bats; counting or estimating size of nesting colonies or area occupied in situ; location of bats roosting in inaccessible sites; non-invasive behavior investigation such as following movement of individuals in the roost; diagnosis of infection sites in injured bats; and image processing for both graphic presentation and analysis of data. In addition, IR imaging proves useful in working with public and their concerns about bats in their attics. It not only provides building diagnostics (locating holes in attics) but allows people to see bats in and/or emerging from their attics. It has been our experience that as homeowners and their neighbors watch the bats, they become fascinated and learn to appreciate them.

Bat Mortality at Gold Mines in Arizona, California, and Nevada.

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Bats constituted 175 of 519 mammals (33.7%) reported dead at cyanide-extraction gold mines in Arizona, California, and Nevada from 1984 through 1989. Only rodents (34.9%) were more numerous. "Bat" was the most frequently reported of 24 mammal species or mammal species group names. There are an estimated 160 cyanide-extraction gold mines in these three states, and the number is increasing. Ten mammal species listed as endangered, threatened, rare, protected, or species of special concern are known to have cyanide-extraction gold mines within their geographic ranges. Six of these 10 species are bats: lesser long-nosed bat *Leptonycteris Curasoae*, long-tongued bat *Choeronycteris mexicana,* spotted bat *Euderma maculatum*, California leaf-nosed bat *Macrotus californicus*, Townsend's big-eared bat *Plecotus townsendii*, and pocketed free-tailed bat *Nyctinomops femorosaccus*.

Nebraska's Tertiary Bats.

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Tertiary sediments in Nebraska have produced miscellaneous, mostly scarce, fragmentary remains of Microchiroptera from scattered localities. *Chadronycteris rabenae* Ostrander 1983, a presumed Vespertilionid, occurred in the early Oligocene Raben Ranch fauna (Chadronian land mammal age). Several Miocene occurrences follow: In the Valentine Formation. in northeastern Nebraska, two localities have produced bats. Cf. *Antrozous* has been reported at Norden Bridge Quarry (medial Barstovian, 14.5-13 Ma) and cf. *Myotis* plus a new genus and species of Vespertilionidae occurred at Annie's Geese Cross (late Barstovian, 13-12 Ma). In the Valentine Fm in southern Nebraska, two species of Vespertilionidae are represented by abundant skeletal remains

in the Myers Farm fauna (late Barstovian). In the Ash Hollow Fm., a single jaw of *Myotis* has been found at Poison Ivy Quarry (medial Clarendonian, ca. 10 Ma), and a humerus fragment of *Lasiurus ?fossilis* occurred at Pratt Slide (late Clarendonian, ca. 9 Ma; the oldest record of a hairy-tailed bat). *Lasiurus ?fossilis* appears again in the Pliocene in the Long Pine Fm. at Big Springs (late Blancan, ca. 3-2 Ma) where it is represented by one humerus and two jaw fragments.

Based on these scanty records and evidence from elsewhere, vespertilionids dominate temperate North American bat faunas by the mid-Tertiary. In fact, except for one member of each of the families Icaronycteridae, Palaeochiropterygidae, and Molossidae in the Eocene, the Vespertilionidae are the only family of bats currently known in temperate latitudes of North America throughout the Tertiary. This is in strong contrast to the tropical character of the bat fauna of southeastern North America in mid-Tertiary, where four families (Emballonuridae, Mormoopidae, Natalidae, and Vespertilionidae) occurred. It is also surprising in view of the fact that subtropical paleocommunities of plants and animals, characteristic especially of the Eocene, persisted locally in the northern plains into late Tertiary (middle Miocene) time.

Evasive Flight Behavior of Moths

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Various families of Lepidoptera have evolved ears which allow them to detect the echolocation calls of foraging bats and to take evasive flight manoeuvres in response to these calls. Sympatric moths may show a variety of inter- and intra-specific variability in their flight behavior which would increase unpredictability in their flight responses and hence increase their chances of escaping foraging bats. I tested the hypothesis that moths will use a variety of evasive flight manoeuvres to decrease their chances of being caught by foraging bats. The data were collected at Pinery Provincial Park, Ontario between May and August 1990. By firing an artificial red bat call at moths with a "bat gun" (which emits pulses mimicking tracking and terminal phases of the bat's cry) from distances ranging from 25cm to 1m, documenting their responses, and then capturing each moth, I recorded four general type of evasive responses. I found dives and lateral turns occurred more frequently than spirals and vertical drops. Individuals species used a variety of responses which may have depended upon the unique conditions at the time of attack.

Substrate Gleaning Versus Aerial Hawking: The Foraging and Echolocation Behavior of the Long-Eared Bat *Myotis evotis*

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Although the foraging and echolocation behavior of insectivorous bats has been studied extensively under both field and laboratory conditions, very little is known about how bats adapt their echolocation call strategies to different foraging situations. To examine this problem, I studied the foraging and echolocation behavior of the long-eared bat (*Myotis evotis*) during substrate gleaning and aerial hawking forays in the lab at the Kananaskis Centre for Environmental Research (KCER). The echolocation calls used by *M. evotis* are short, high frequency, broadband, and frequency modulated (FM). While gleaning, echolocation was used inconsistently or not at all. In 36 hovers, calls were detected only 58.3% of the time and in 34 attacks echolocation was detected only 64.7% of the time. Bats ceased calling on average (±SD) 179.4 (±181.1) ms before attacking moths on surfaces and feeding buzzes were never recorded. The mean number of calls emitted during a gleaning attack phase were 9.2 (±6.0) calls and the mean pulse repetition rate during the search, hover, and attack phases of gleaning sequences were 20.2 (±6.2), 20.8 (±5.0), and 22.5 (±11.9) calls/s respectively. The

gleaning echolocation calls of *M. evotis* were faint and difficult to detect; the mean peak-to-peak intensity was 77.3 dB SPL (@ 10 cm). In contrast, echolocation was always used during aerial attack sequences and feeding buzzes were always recorded (n=11 attack sequences). The number of calls emitted during the approach and terminal feeding buzz phases were 11.9 (±8.4) and 19.6 (±4.4) calls respectively, with the average number of calls emitted during a feeding buzz being significantly larger than the average number of calls produced during a gleaning attack sequence. Also, the average duration of a feeding buzz (135.8 ± 43.7 ms) was not significantly different from the average duration of the silent period when gleaning bats ceased echolocating before attacking. The pulse repetition rate for bats in the approach and terminal phases of an attack were 33.4 (±8.9) and 143.3 (±24.0) calls/s respectively; rates much higher than for gleaning forays. Aerial echolocation calls were of moderate intensity (88.8 dB SPL) and were significantly more intense than calls emitted while gleaning. It appears that *M. evotis* is very flexible in both its foraging and echolocation behavior as it adjusts its echolocation call strategy to suite the perceptual problem at hand.

The Origin of Blood-Feeding in Bats.

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In this paper I propose that blood-feeding in bats originated when protovampire bats began feeding at wounds on large mammals. The scenario has four components. The first is variation in the diets and feeding behavior of bats. Included here is the variety of food taken, flexibility of foraging behavior and the propensity of some bats to feed in concentrations of prey. The second is the Miocene fauna of South America which included a large variety of large mammals and birds that could have offered feeding opportunities for proto-vampire bats. The third is wounds which attracted insects and, thus, the bats. The wounds could have resulted from mishaps, missed attacks by predators, arthropod bites or intraspecific aggression. Wounds infested by screw worm larvae would have offered important feeding opportunities for bats. The fourth component is the upper incisor teeth of bats which explains why blood-feeding bats originated in the New World. Strong upper incisor teeth would have been essential for feeding at wounds and Old World bats with appropriate behavioral flexibility have minute upper incisors (Nycteridae) or lack them completely (Megadermatidae). Other bats with robust premaxillae are molossids and pteropodids. The former feed on airborne prey while the latter take plant material. This hypothesis explains how blood feeding might have originated in bats and why it is confined to the New World.

Tropical Bat Alpha Diversity: A Product of History, Geography, or Community Processes?

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Bat alpha diversity (single-site diversity) is higher in the forested neotropics than in any other tropical region. Alpha diversity of tropical forest bats is strongly correlated with number of bat species in the region (gamma diversity). Gamma diversity is a function of area of forest in the region, and, somewhat more tenuously, of number of presumed Pleistocene forest refuges. At least 70% of the variation in alpha diversity of tropical bats is a function of history and geography, rather than of community ecological processes such as resource allocation and competition.

***Leptonycteris curasoae* and The Evolution of Sexuality in the Columnar Cactus, *Pachycereus pringlei*.**

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It is well-known that animal

pollinators can influence the quantity of quality of seeds produced by flowering plants. It is less well-known that animal pollinators can influence the sex ratios of plants with non-hermaphroditic breeding systems. In this paper, we describe the breeding system of *Pachycereus pringlei* a Sonoran desert night-blooming cactus pollinated by the bat, *Leptonycteris curasoae*, and speculate on the effect this bat can have on sex ratios in this plant. *P. pringlei* is unusual among cactus species in being cryptically subdioecious. Its population at Bahia Kino, Sonora, Mexico consists of 36% hermaphrodites, 41% females, 21% males, and 2% "neuters." We have documented sex differences in the initiation of flowers (males and females begin flowering earlier in the season than hermaphrodites and neuters), the number of flowers per plant per night (males > females and hermaphrodites), and sucrose concentration of the nectar (female > males and hermaphrodites). Bats are equally likely to visit flowers of pollen-bearing (males and hermaphrodites) and female plants. Hand pollination experiments indicate that fruit set in females, but not in hermaphrodites, is pollinator-limited. Despite low bat visitation rates during the latter half of *P. pringlei's* flowering season, females produce twice as many surviving fruits and seeds per plant as hermaphrodites. These latter results indicate that fitness through seed production is higher in females than hermaphrodites. We predict that the ratio of females to hermaphrodites in populations of *P. pachycereus* will vary geographically and will be correlated with visitation rates of *Leptonycteris* bats. Females should predominate in areas of high bat visitation rates whereas hermaphrodites will predominate in areas of low bat visitation rates.

The Coevolution of Hawaiian Moths and Bats: Conundra in Paradise.

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The ears of two species of endemic noctuid Hawaiian moths, one lightly preyed upon *(Agrotis hephaestaea)* and one heavily preyed upon *(Haliophyle euclidias)* were studied to determine their sensory responses to the echolocation and social calls of the moths' single bat predator, the Hawaiian bat, *Lasiurus cinereus semotus. Agrotis hephaestaea* has significantly greater auditory sensitivity to both of the bat's vocalizations than *H. euclidias* and possesses neural responses that would result in high bat detection distances. The ears of *A. hephaestaea* are tuned to the spectral peak of the combined acoustic output (assemblage) of the bat's two main vocalizations and the intermediate calls between them. I conclude that *A. hephaestaea* represents moths that have successfully coevolved to fly within the foraging airspace of the Hawaiian bat by maintaining sensitive ears tuned to a frequency range representing all of the bat's calls. *Haliophyle euclidias's* poor auditory sensitivity suggests that this moth uses non-auditory defenses to avoid the bat (e.g., maintaining its flight and reproductive behavior to low-lying vegetation) and, as a result, exhibits early stages of auditory degeneration. I further suggest that this species suffers a high level of predation only because it is drawn away from its natural concealed microhabitat (ferns and low-lying vegetation) by the lights used for its collecting. Caution should therefore be taken when comparing insect remains in bat faeces to field-sampled abundances as an estimation of the bat's 'normal' (i.e., evolutionarily adaptive) foraging preferences. Problems with this virtuous edict arise from the difficulty in understanding what is 'normal' for a bat foraging near artificial insect concentrations (e.g., lights) in prey-depauparate environments such as oceanic islands.

Summer Roost Selection by *Myotis sodalis* .

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From May, 1986 through August, 1990, more than 340 *Myotis sodalis* were discovered roosting in 51 different trees in nine Illinois counties. Fourteen species of trees were used as roosts. *Myotis sodalis* typically roosted beneath the exfoliating bark of dead trees but other roost sites were located beneath the bark of living trees and in cavities of dead trees. Roosts were located in upland and floodplain forests; commonly in areas actively grazed by livestock. Roost trees were found in palustrine wetlands, heavily grazed ridgetop pastures containing a few scattered dead trees, a partially wooded swine feedlot, an island in the Mississippi River, and a clearcut encircling a segment of a perennial stream. Bats selected roosts near to intermittent streams and farthest from paved roads. Roost trees were used by *M. sodalis* during successive summers, documenting for the first time the significance of these roost sites as traditional roosts. The natural attrition of roost trees indicated that the availability of some tree species used as roosts may be short. Microclimate studies of roost sites revealed that sites exposed to intense solar radiation during mid-summer may develop temperatures potentially lethal to *M. sodalis*. These same roost sites, however, may be entirely suitable when warmed by the sun more moderately in spring and early summer. This information will be incorporated in the Recovery Plan for *M. sodalis*; hopefully contributing to the conservation of this federally endangered species.

The Geometry of Parasitism in Free-Tail Bat Caves.

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A potential cost of gregarious behavior is an increased rate of ectoparasite and disease transmission. In this paper, I examine the dynamics of ectoparasite infestation of colonial roosting bats. The Mexican free-tail bat *Tadarida brasiliensis* roosts in huge colonies of reproductive females in gypsum caves in northwestern Oklahoma. The guano deposited under these roosts serves as the developmental habitat for ectoparasitic bat-fleas, *Sternopsylla texana*. Bats roosting at the periphery were infested with much higher ectoparasite loads than individuals roosting in the center of the colony.

Cladistic Analysis of Chiropteran Relationships: Why Megachiropterans are not Primates.

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Recent arguments concerning bat origins have centered around two competing hypotheses. Monophyly of Chiroptera has been supported on the basis of morphology of the skeleton and cranial vasculature (Wible and Novacek, 1988). In contrast, morphology of the penis (Smith and Madkour, 1980) and visual neural system (Pettigrew et al., 1989) apparently indicate a diphyletic origin of bats. The latter hypothesis suggests that megachiropterans may be "flying primates" --that is, they may be more closely related to primates than to microchiropteran bats.

It is not unusual for cladistic analyses of data from different organ systems to produce different results. In such cases, any phylogenetic hypothesis that is based on morphology should take into account relevant data from all available organ systems--there can be no priori justification for accepting neural characters as more informative (or less subject to homoplasy) than musculoskeletal characters. In an effort to resolve the issue of bat relationships, a new analysis was conducted using an integrated set of morphological data that includes both neural characters (e.g., features of the optic tract and cerebral cortex) and characters from other systems (e.g., features of the optic tract and cerebral cortex) and characters from other systems (e.g., dentition, skull and postcranial skeleton, vascular system, musculature,

flight membranes, penis, and fetal membranes). Living and fossil members of Monotremata, Marsupialia, and 15 eutherian lineages were considered in an effort to assume adequate outgroup comparisons.

Preliminary results strongly support chiropteran monophyly: Megachiroptera is more closely related to Microchiroptera than to Primates or any other mammalian group. Derived features of the visual neural system shared by Primates and Megachiroptera may indicate a close relationship, but not one excluding Microchiroptera. The absence of such features in microchiropterans is most parsimoniously explained as secondary loss, presumable related to the evolution of echolocation and an associated shift from reliance on visual to auditory senses. It is interesting that secondary loss of derived features of the visual system has previously been proposed for odontocete cetaceans (Sanderson, 1986), the only other mammalian group known to rely extensively upon echolocation.

The Systematic Relationship of *Emballonura nigrescens* to Other Species of *Emballonura* and to *Coleura* (Emballonuridae).

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Dissection of the hyoid musculature and examination of ear, penial, and skull morphology of eight species of *Emballonura* and one species of *Coleura* reveal that, with the exception of *Emballonura nigrescens*, all species share a derived character of the hyoid region. The sternohyoid muscle in all species except *nigrescens* is deflected dorsally and laterally by a prominent post-laryngeal tracheal expansion. Additionally, *E. nigrescens* is clearly derived in having a distinctive penis, in contrast with other species of *Emballonura* as well as *Coleura*. These observations strongly suggest that non-*nigrescens* species of *Emballonura* are more closely related to species of *Coleura* than either is to *Emballonura nigrescens*. We conclude therefore that the available generic name *Mosia* Gray, 1843, should be used for the species currently called *Emballonura nigrescens*. We continue to recognize *Coleura* as a valid third genus.

The Galapagos Bats: What are they Doing?

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Two bat species *Lasiurus brachyotis* and *L. cinereus* are known to inhibit some of the Galapagos Islands, Ecuador. Preliminary surveys of three major Galapagos Islands in July-August 1990 demonstrate the presence of both species on Santa Cruz and San Cristobal. Only *L. cinereus* was found on Isabela. Both species occupy a variety of habitats from coastal, lowland xeric scrub to mid-elevation mesic forest. Visual observations and surveys of bat activity using ultrasonic detectors demonstrate that both species are abundant. Levels of bat activity are comparable to levels obtained using similar survey techniques for *L. cinereus* and *L. borealis* in Ontario. Radio tracking of *L. brachyotis* provides preliminary information on ecology and behavior for these species. Three individuals were radio-tracked on 15 bat nights over a period of 10 days in the xeric/transitional vegetation zone near Charles Darwin Research Station, Santa Cruz. Individuals used small (10 ha or less) overlapping foraging areas, with high nightly fidelity to the same area. During the day, individuals roosted alone in trees and shrubs located within their foraging areas. During our observations, the three radio tracked bats used seven tree/shrub species as day roosts. These studies are preliminary to our future research on the Galapagos chiropteran fauna.

The Effect of Radio Transmitters on the Foraging Success of Hoary Bats

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Radio-telemetry is commonly used to study the foraging behavior of bats that are large enough to carry transmitters (i.e., body mass >15-18 g). Despite the widespread use of this technique there are no data on the influence of radio transmitters on the foraging behaviour of bats. At Pinery Provincial Park, Ontario, hoary bats forage around lights where the outcome of individual attacks can be determined by direct observation. I used this situation to compare the foraging success of hoary bats carrying 0.9g radio transmitters and reflective color bands to unmarked bats. Specifically, I tested the hypothesis that carrying a radio transmitter will reduce a bat's foraging success rate. Bats carrying transmitters did not suffer a significant reduction in foraging success. In fact, their foraging success rates were 9% greater than bats without transmitters (49% for bats without transmitters, n=247 attacks; 58% for bats with transmitters, n=160 attacks).

Foraging and Movement Patterns of a Nectar Feeding Bat: *Leptonycteris curasoae.*

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Nightly movement and foraging patterns of migratory *Leptonycteris curasoae* were studied using radio telemetry, light tags, and night scopes in Sonora, Mexico. Two type of individuals used this desert area during the Spring 1989 and 1990; transient individuals who left the area, and 'residents' who commuted 25 km between an island maternity roost and their foraging areas on the mainland. Minimum flying speed between the island and mainland was 40 km/hr. Tagged bats were familiar with the 220 km^2 mainland study area and often traversed it when flying to various night roosts. As a result, individuals flew at least 75 km each night. Bats left the day roost from 19:30-21:00 and returned 02:00-03:30. Thirteen of 25 tagged bats were located five nights or less. These were either transient bats whose signals faded Northeast, or bats with which we quickly lost contact for unknown reasons. The 12 'resident' bats tended to use the same foraging area each night but were not restricted to it. Occasionally, they did not fly to the mainland but remained on the island for the night. *L. curasoae* night roosted in caves, abandoned mines, and vegetation. Amount of time flying versus night roosting varied considerably, but bats were on the wing more than 60% of time after leaving the day roost. Light tag and night scope observations revealed that individuals foraging alone or in small groups worked several plants at a time in large sweeping patterns rather than exhausting the nectar resources of one plant before moving to another. Flowering cacti densities were high but visitation rates were low. This may suggest that this population is not at carrying capacity and that individuals are not food limited.

Metabolic Rate as a Function of Ambient Temperature in the Fishing Bat, *Noctilio leporinus.*

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The fishing bat, *Noctilio leporinus* is found throughout the neotropics as well as on many islands of the Caribbean. Adult males may weigh in excess of 100 grams, females are slightly smaller. In nature these bats are rarely if ever exposed to ambient temperatures below 20 ºC. They tend to roost in small clusters or individually, and being large, tend not to lose heat as rapidly as smaller bats. The hypotheses being tested are: As ambient temperature decreases, *N. leporinus* raises its metabolic rate to compensate for the increase in heat loss, or conversely, *N. leporinus* enters into a state of mild hypothermia, like many other tropical bats in similar circumstances. Resting metabolic rate was determined as measured by oxygen consumption on a round-the-clock basis

until a total of over two thousand data points were accumulated. Lower critical temperature for this species in captivity was also established. Analysis of metabolic rate was determined both in individual animals and in a small cluster of four bats. Our metabolic chamber was designed so that the bats chose to roost in it and they spent all of their time there except when feeding and drinking. All data were collected remotely and the bats were not disturbed in any way either before or during each analysis. *Noctilio leporinus* does attempt to raise its metabolic rate when ambient temperatures fall below approximately 24 ºC., if ambient temperature drops slowly. Rapid drops in ambient temperature (greater than three degrees per hour) also result in a temporary drop in body temperature and a lower metabolic rate.

A Two Year Study on the Effects of Monthly Rainfall on Weight Gain in the Big Brown Bat *Eptesicus fuscus*.

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Colonies of the Big Brown Bat *Eptesicus fuscus* were located and studied in Blackford, Delaware, Grant, Henry, Jay, Madison, and Randolph Counties, Indiana, from June 12, 1988 through August 25, 1989. During the study, 24 colonies were located. Attempts were made to capture as many bats as possible during visits to the colonies. Colony sites were revisited several times during the two year study. A total of 1,846 bats were captured, banded and examined. During examinations bats were sexed, aged, weighed, and checked for wing damage and ectoparasites. The weights from the captured bats provided data on the differences in bat weights for the summers of 1988 and 1989. The summer of 1988 was characterized by drier than normal precipitation, and the summer of 1989 had wetter than normal precipitation. Several comparisons were carried out on the data. The comparisons showed a correlation between increased rainfall and increased bat weights. In the wet year of 1989, adult bats were significantly heavier than they were in 1988. Juveniles were slightly heavier but not significantly. Further detailed data regarding age and sex ratios and wing and ectoparasite occurrence are discussed briefly.

Reproduction and Growth in Two Species of Philippine Fruit Bats.

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Over 1,000 *Ptenochirus jagori* and 200 *Cynopterus brachyotis* were captured in lowland forest on Mt. Makiling, Luzon Island, Philippines from April to August 1989. Captured bats were identified to species, sexed, aged, weighed, their forearm was measured, and their reproductive condition was assessed. They were marked with a uniquely numbered metal band on a ball-chain necklace before release. Both *P. jagori* and *C. brachyotis* reproduced seasonally on Mt. Makiling. A birth peak for *P. jagori* occurred sometime between the second half of April and the first week of May, and one for *C. brachyotis* occurred with the period from mid-March to mid-May. After these birth peaks, both species appeared to undergo post-parturition estrus, as evidenced by females that were simultaneously lactating and in early stages of pregnancy. Two cohorts of *P. jagori* volant juveniles were netted: cohort A was netted from early March to mid-June and cohort B was netted from late-May to mid-August. For each cohort, mean weight of juveniles netted in a trapping period was positively correlated with trapping date, as was mean forearm length. Mean weight was more consistently correlated with trapping date than was mean forearm length, probably because of greater measurement error in forearm measurements. *C. brachyotis* volant juveniles caught from late May through July represented one cohort. For *C. brachyotis*, both mean forearm length and mean weight were strongly correlated with trapping date. Mean weights of the two *P. jagori* cohorts increased by an average of 0.12 g/day (SE = 0.01) for cohort A and 0.26 g/day (SE = 0.02) for cohort B; the mean weight of the *C. brachyotis* cohort increased by an average of 0.11 g/day (SE = 0.01). If these are taken as growth rates, they represent very low growth rates relative to most mammals, but are within the ranges of growth rates

reported for other pteropodids. Adult--juvenile ratios and sex ratios of both *P. jagori* and *C. brachyotis* fluctuated over the 4.5-month period sampled. The variation in adult-juvenile ratios were not due to increases in numbers of volant juveniles as a result of birth and subsequent volancy, and therefore appeared to result from seasonal changes in relative catchability. For *P. jagori*, adult sex ratios were strongly female-biased from May through June, the period when most adult females were lactating. Catchability of adults may therefore vary with their reproductive condition.

The Status and Conservation of British Bats: Past, Present and Future.

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Since the first records were kept, there has been a drastic decline in the populations of all fifteen species of British bats. Even after their plight was noticed, ignorance and bad management meant numbers continued to fall until some species had their populations reduced by over 99 percent. Not until 1981 were all species of bats in the United Kingdom legally protected under the Wildlife and Countryside Act. Not even this could prevent more colonies from being destroyed or depopulated. The formation of voluntary bat groups, supported by the Nature Conservancy Council began to climb the hill towards educating the public on matters of bat conservation. These groups brought about a revolution in mammal conservation in the United Kingdom in less than a decade. Although numbers of many species continue to decline, public awareness has been heightened to such a high level that in 1989 the whole country celibrated its first "National Bat Week". These first footsteps into the area of public education have moved slowly but now appear to be paying off, with many colonies being saved where in the past they would simply have been destroyed.

Nutrition in Pregnant *Eptesicus fuscus* Feeding on June Beetles.

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Based on culled insect parts found in day and night roosts, big brown bats in our study area consume June beetles, *Phyllophaga rugosa,* throughout the month of May. For whole and culled June beetles, we have determined fresh and dry weights, water content, caloric content (culled only), and nitrogen, sodium, potassium, magnesium, calcium, and iron levels. Published data indicate that the metabolic rate for pregnant (21 g) big brown bats is 48.9 Kj/day. Assuming a caloric assimiliation efficiency of 95% and a secondary productivity of 5%, a bat needs to consume 35.9 culled June beetles (0.363 Kcal/individual, 2.89 g dry wt/day, n = 11) to supply 13.0 Kcal/day. Since culled June beetles are 71.63% water, ingestion of 35.9 June beetles will provide 7.2 g of preformed water, along with a minimum of 1.7 grams of metabolic water, excluding drinking water, for a total of 8.9 g water. Elemental composition of dry, whole June beetles (in parts per thousand, n = 15) is iron, 0.168; calcium, 0.433; magnesium,1.90; sodium, 0.787; potassium, 11.51; and nitrogen, 131.6. Elemental composition of dry, culled June beetles (in parts per thousand, n = 13) is iron,0.207; calcium, 0.457; magnesium, 2.64; sodium,1.35; potassium,15.06; and nitrogen, 142.7. Levels of magnesium, sodium, and potassium are significantly higher ($P < 0.001$, t tests) in culled vs. whole June beetles. Ingestion of 2.89 g dry wt/day of culled June beetles yields (in mg/day) iron, 0.598; calcium,1.321; magnesium, 7.621; sodium,3.896; potassium, 43.53; and nitrogen, 412.5. Estimated elemental requirements for maintenance and growth in small mammals (in mg/day) are iron, 0.072-0.405; calcium, 11.56-23.12; magnesium, 1.156-2.89; sodium,1.445-4.335; potassium, 5.78-20.81; and nitrogen, 55.49-83.23. Elemental composition of feces (in ppt) is iron, 1.39; calcium, 0.602; magnesium, 5.95; sodium, 1.402; potassium,13.74 ; and nitrogen,157.1. Assuming 95% assimilation, 0.145 g dry wt. feces is

egested, with fecal mineral concentrations (in mg/day) of iron,0.201; calcium, 0.087; magnesium, 0.863; sodium,0.203; potassium,1.992; and nitrogen, 22.77. Based on the assumptions mineral assimilation efficiencies (in %) are 66.41 for iron, 93.39 for calcium, 88.68 for magnesium, 94.78 for sodium, 95.42 for potassium, and 94.48 for nitrogen. Overall the intake of magnesium, potassium, and nitrogen were sufficient to meet dietary needs, sodium and iron levels were marginally adequate, and calcium concentrations were only one-tenth of requirements.

Demography of Two Coexisting Species of Bats, *Eptesicus fuscus* and *Tadarida brasiliensis*, in Alabama.

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Two bat species, *Eptesicus fuscus* and *Tadarida brasiliensis*, coexist in the attic of Auburn University's administration building. Both species are present in large numbers year-round. While individuals may roost in small, single-species clusters, large mixed groups are common. Samples of adults of both species have been taken monthly since February 1990; we here report preliminary data on demography and reproduction.

The sex ratio in *E. fuscus* was close to 1:1 until June, when females began to outnumber males. In contrast, *T. brasiliensis* males outnumbered females until March, declined in proportion to females through July, and increased again in August. Testes enlargement was evident in *T. brasiliensis* taken in February and March, and in *E. fuscus* in July. Reproduction appeared to be less synchronized in *E. fuscus* than in *T. brasiliensis*, as pregnant *E. fuscus* taken in May had greater variation in embryo length than did *T. brasiliensis* taken at the same time. Each pregnant *E. fuscus* had one embryo in each uterine horn, while each had a single embryo in the right horn.

Foraging Behavior and Echolocation in the Pallid Bat, *Antrozous pallidus*.

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Antrozous pallidus is known as a gleaning bat foraging over open ground and relying on prey-generated sound to detect food. However, radio-tagged individuals (n=21) foraged also in areas of dense ground cover and two bats with light-tags were observed taking prey from branches and catching insects in mid-air. To investigate the flexibility of foraging strategies and use of echolocation, captive adult pallid bats were challenged to respond to acoustic cues from the ground, a vertical wall, and in air. Bats responded most often to cues from the ground (89.5%, n = 316 trials) and landed on the wall to 69.5% (n = 380 trials) and approached the cue in air to 62.6% (n = 358 trials). Preliminary sound analyses show that in light conditions the bats emitted low intensity and short echolocation calls until contact with the target. When approaching prey on the ground or at the wall bats emitted 244-48 calls per second before landing compared to 8-16 calls/sec in search flight. However, when responding to prey in air bats produced echolocation patterns consisting of search-and approach-calls/sec and in average 122.8 $\pm$ 68.0 ms (n = 35) in length.

Comparative Energetics of Postnatal Growth in Two Bat Species Living in the Same Cave.

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Our research integrates postnatal changes in field metabolic rates (FMR's), water and milk-energy intake, growth rates, body compostion, and the age at onset of foraging in two species of insectivorous bats (*Tadarida brasiliensis* and *Myotis velifer*) which occupy the same cave in south-central Texas. FMR's, milk-energy intake, and amounts of fate deposited are higher, postnatal growth is slower, and the onset of foraging is later in *T. brasiliensis*, as compared to *M. velifer*. Roost sites

generally are comparable for both species; however, since birthing in *T. brasiliensis* occurs approximately one month later than in *M. velifer*, the maternity roost environment is significantly warmer for young *T. brasiliensis*. One would predict that high milk-energy intake by suckling *T. brasiliensis*, which roost in a warm (almost thermoneutral) environment, should promote rapid postnatal growth. However, it appears that high fat deposition during the suckling period occurs at the expense of rapid somatic growth. We believe that these extraordinary fat reserves are mobilized by young *T. brasiliensis* during their formative and relatively long foraging flights, and serve as a supplement to their mother's milk before they become proficient at capturing insects. By contrast, suckling *M. velifer* are exposed to a cooler cave environment, consume relatively low energy-rich milk, deposit less fat, grow faster, are weaned sooner, and forage locally during their formative, as well as subsequent, foraging bouts. These alternative growth strategies may have evolved in response to the contrasting roosting and foraging behavior of these two species. For example, *T. brasiliensis* typically forms large maternity colonies (in the thousands and millions) which promote longer individual commuting distances and foraging times, whereas *M. velifer* forms smaller colonies (in the hundreds and thousands), requiring shorter individual commuting distances and foraging times.

Bat Community Structure Along an Urban Riparian Corridor.

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In summer 1990, we mist-netted bats on 35 net-nights, for 4 hours each night, along tributaries of the Rouge River in suburban Detroit. The Rouge River is a classic flood-plain river with most of the adjacent land along its upper reaches preserved as parkland. Our intent was to compare elements of bat community structure in urbanized park areas to that of rural areas. For the rural data set, we used mist-netting data obtained previously on 53 net-nights in southern Michigan using a similar protocol. Overall bat activity was lower over the urban rivers than over rural ones as evidenced by differences in the mean number of bats captured per night (1.34 vs. 4.55) and modal number of bats captured/night (0 vs. 2). Species diversity (Simpson Index) was lower in the city (0.53 vs. 0.28) as was species evenness (0.66 vs. 0.36). The big brown bat, *Eptesicus fuscus*, made up 65% of the catch in rural areas but 83% in the city. The red bat, *Lasiurus borealis*, represented 18% of all bats in rural areas and 13% in the city. The proportion of sites where the big brown bat was captured was significantly lower in the city (51% vs. 74%). The proportion of sites that yielded red bats also declined, from 52% along rural rivers to only 14% in the city. Sex ratio of adult big brown bats did not differ between urban (43% male) and rural (32% male) sites. The ratio of juvenile big brown bats to adult females was significantly lower in the city (1:21 vs. 30:77).

Radiotelemetry of Biosonar Signals from Flying Bats

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Echolocation in bats has traditionally been studied by recording biosonar signals from remote, stationary microphones. Under these conditions the bat's position relative to the microphone constantly changes, the frequency is Doppler-shifted due to the animal's velocity and the pulse-echo timing cannot be accurately determined. To overcome these limitations and obtain detailed information about velocity, pulse-echo parameters and target distance, we fabricated a radiotelemetry system to monitor biosonar signals. Using a design similar to that of Skutt et al. (1967, Electroenceph. Clin. Neurophys. 22:275-277), we coupled a small electret microphone (Knowles Model 1759) to a small tunable FM transmitter. A commercial FM tuner equipped with two folded-dipole antennas oriented perpendicular to one another detected the carrier frequency tuned between 88-108 MHz. The transmitter weighed 1.2 grams and was carried on the

head of an 11 gram Pteronotus parnellii parnellii for a long as one hour while the animal was engaged in specific echolocative tasks (obstacle avoidance, landing and flying through openings).

In preliminary experiments, flights were made in a floor-to-ceiling mesh enclosure (80 x 245 x 245 cm). A piece of poster board at one end with a variable-position escape port provided an echoic target. A stationary 6.25 mm B&K microphone at the escape port recorded emissions from the approaching bat. Signals were recorded on a Racal instrumentation tape recorder. The frequency difference between transmitted pulses and signals recorded on the stationary microphone was used to calculate instantaneous velocity and Doppler-shift compensation. Frequency, pulse timing, distance from target and pulse-echo overlap was measured on a Rapid System R350 FFT Spectrum Analyzer/Digital Oscilloscope. Data obtained during free flight was compared with that collected during simulated flight on a pendulum (Henson et al., 1982, Hearing Res. 7:127-147). Data showed that flight velocity in the enclosure ranged from a maximum of 2.6 m/s and fell to less than 0.5 m/s before the animal passed through the escape port. As they approached the target, they clearly shifted from search phase to approach phase calls. Doppler-shifted echoes were maintained within a narrow frequency band during most of the approach, but accurate Doppler-shift compensation was not maintained when the bats were close to the target. This behavior was seen both in free flight and in pendulum swings. Our preliminary results indicate that bats which accurately Doppler-shift compensate during active flight usually cease compensating during the final approach to a stationary target. These experiments demonstrate the utility and practicality of radiotelemetry to study biosonar behavior in bats. This work is supported by USPHS grant no. DC 00114.

Preliminary Observations of Pallid Bat Maternity Roosts.

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Pallid bats appear to possess stronger social bonds between roost-mates than other North American bats. Studies of captive bats and unmarked bats in the wild have demonstrated that social learning, vocal and olfactory communication, and cooperative behavior all seem to be important in pallid bat social structure. This research is part of an on-going project examining the social structure of marked individuals in pallid bat maternity roosts. Groups of roosting pallid bats were located in the John Day River Valley of central Oregon from mid-April to mid-July, 1990. At least four separate day roosts in rock crevices and several night roosts in buildings and under cement bridges were located. Day roosts contained 25 to 90 adult bats. Forty-one bats (39 female, 2 male) were captured in mist nets and banded. Most females captured before 17 June were pregnant and most captured after that date were lactating. Radio-transmitters were affixed to nine females to locate day roosts and follow movement patterns. Bats captured at the same night roost did not necessarily roost together during the day. Bats were found at day roosts up to 9 km from the night roosts where they were marked. When a radio-tracked bat changed day roosts, it appeared that all other bats in the group moved as well. Some groups of bats changed day roosting locations frequently while others did so rarely. On only one occasion was an abandoned day roost observed occupied later in the study. The composition of day versus night roosting groups and the frequency of movement between day roosts lead to questions regarding the definition of pallid bat social groups.

An Evolutionary Analysis of Non-offspring Nursing

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Non-offspring nursing (NON), also known as communal nursing or milk stealing, is often cited as evidence of either

cooperative or aberrant behavior. Lacking measures of how prevalent NON is among mammals and under what conditions it occurs, it is difficult to judge its relative importance. In this study, we document the occurrence of NON in 102 species of mammals using information from a questionnaire survey and a review of available literature. We are interested in understanding the life-history correlates of NON and how they have affected the evolution of the behavior. To avoid treating single evolutionary events as independent, we use an Evolutionary Covariance Regression analysis that treats related taxa that do not vary for the trait in question as single units. Among the 102 species surveyed NON occurs "commonly" (defined as involving 10 percent of all nursing time) in 23 species and rarely or never in 79 species. Factors that are correlated with the occurrence of NON include whether the study was conducted in captivity, the average litter size of the species, and the number of females in social groups.

The Barn-Owl *Tyto alba* as a Major Predator of Bats in Southern Yunnan, China.

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It is known that the barn-owl, among other birds, preys on bats in addition to many different species of rodents. Of a collection of owl-pellets taken by the authors at the entrance to a large limestone cave, east of the town of Rubber Plantation No. 10, on July 14, 1990, 86.7% of all recognized mammal remains are bats. Dominating the Chiroptera are skeletal remains of *Tadarida plicata* (n=134), with a few *Taphozous melanopogon* (n=2), and *Hipposideros armiger* (n=2). This limestone cave harbors a large (ca. 20,000) colony of *T. plicata* and two small groups (ca. 200 ea.) of *T. melanopogon* and *H. armiger*. The composition of bat species in the owl pellets represents the composition of the bats within the cave, and would thus indicate that the owl preys upon these bats as they emerge from the cave, or in its immediate vicinity. The small percentage of rodents (3.8%) and insectivores (8.8%) obtained from the owl-pellets is indicative of the low numbers of these mammals in the area, information which will be reported in a subsequent paper.

Factors Influencing Female-Pup Scent Recognition in Mexican Free-Tailed Bats.

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Previous work showed that lactating females preferred to odor of their putative pup to that of a different pup in a two-choice Y-maze test. Pups tested mid-way in ontogeny, however, did not discriminate between their putative mother's odor and that of another female. We extended these findings by asking a) whether the source of odors for female recognition of pups was derived from the female or the pup, and b) whether pups tested at other stages of ontogeny are also incapable of distinguishing their putative mother's scent from that of other females. Using the same testing procedure as in previous work, we found 1) pups washed to rid them of all odors produced a recognizable scent after 12 h in isolation, 2) females were unable to distinguish between their own pup's odor and that of a foreign pup that had been washed and then confined with the female for a day, 3) pups in the earliest stages of ontogeny did discriminate their putative mother's odor from that of another female but pups tested mid-way in ontogeny did not. Older, almost volant pups showed a nearly significant tendency to prefer the mother's scent. Taken in sum, these experiments allow us to conclude that both odor production by pups and scent-marking by females seem important in female olfactory recognition of pups. In addition, pups appear capable during at least some stages of ontogeny of recognizing their putative mother's scent. The lack of consistent recognition across all stages of ontogeny may be more the result of the index used rather

than a real effect. These results corroborate the impression from field observations that female-pup reunions involve mutual olfactory recognition by female and pup.

Signal Processing Implications of the Sonar Sounds Used by Big Brown Bats, *Eptesicus fuscus.*

W. Mitch Masters, Susan C. Jacobs, and James Simmons
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The sonar emissions produced by big brown bats, (*Eptesicus fuscus*) when detecting and range discriminating targets were analyzed. Individual bats produce distinctive "personal" emissions, which may help prevent jamming by other echolocationg bats. Contrary to expectations based on earlier analyses of frequency sweep shape, linear period modulation (the optimally Doppler-tolerant sweep shape) was not used; rather the sweep shape was more linear in log time. However, both kinds of sweep are resistant to Doppler effects and therefore more effective when used to echolocate moving targets. We speculate that the use of log time modulation may be related to simplification of neural hardware for signal processing. When approaching a target, the echo perceived by a bat is distorted by the gain control action of its middle ear muscles. This distortion depends only on target distance (which the bat presumably knows) and so could be removed by neural filtering. However, a different filter would be needed for each distance. The gain control is linear in log time, so by using a sweep shape that is similarly linear in log time, combined with a signal duration that occupies a constant portion of the log-time axis, the distance relation is removed and a single filter suffices to remove the distortion. A further potential simplification of neural processing arises from the multi-harmonic nature of the bat's sonar emmisions. The harmonics cause the shape of the Doppler ambiguity surface of a typical *Eptesicus* signal to form a narrow ridge (representing good target resolution by a matched filter receiver) that repeats itself for each change of approximately 1 m/s in the target's velocity relative to the bat. Provided a bat could determine relative velocity to better than 0.5 m/s, which it theoretically could do by measuring target distance on two successive emissions, only two matched-filter templates would be needed to achieve high range accuracy, despite range-velocity abiguity.

Aggressive Behaviors of an Old World Leaf-Nosed Bat, *Hipposideros turpis.*

Sumiko Matsumura
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Hipposideros turpis is the only hipposiderid bat in Japan and it is a relic species in Yaeyama Islands (Ishigaki Island, Iriomote Island, etc.). Male roosts and nursing roosts in Iriomote Island were studied in summer. In the roosts, bats appeared equidistant in distribution. This uniform spacing pattern is maintained by typical territorial behavior including threatening calls and graded aggressive behavior. The same behavior was also recorded using a thermographic video, which showed clearly areas of high surface temperature on the fighting individuals. Another type of aggressive behavior was found among nursing females. Mother bats who have new born infants flew against a person approaching or holding the infants. This particularly aggressive behavior is limited to the first few days after parturition and disappeared thereafter.

The Galapagos Bats: What are They?

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Two bat species have been reported from the Galapagos Islands, Ecuador. A single specimen of a putative endemic species, *Lasiurus brachyotis,* was collected in 1892 from the island of San Cristobal. Between 1892 and our study in 1990, no other live specimens of this species were reported; however, holocene "red bat" -like

fossils have been recovered from owl pellets on two other islands (Santa Cruz and Floreana). *L. brachyotis* is similar to *L. borealis* (the red bat), and the validity of the former taxon is suspect. The other bat species in the Galapagos is identified as *Lasiurus cinereus*, the hoary bat. Galapagos hoary bats are known from only 6 specimens, all from the island of Santa Cruz. There are no reports of hoary bat fossils. In July-August 1990, we examined the distributions and abundances of bats on three islands in the Galapagos (Santa Cruz, San Cristobal, and Isabela). Acoustic and visual surveys indicate that both "red bats" (putative *L. brachyotis*) and hoary bats are abundant and widely distributed on the islands of Santa Cruz and San Cristobal. Hoary bats are abundant and widely distributed on Isabela, but we found no evidence for the presence of *L. brachyotis* on that island. Two specimens of *L. brachyotis* were collected from Santa Cruz and blood samples were obtained from additional individuals. Examination of the captured individuals confirms the similarity of *L. brachyotis* to *L. borealis*. The specimens collected will be compared morphologically and genetically with mainland *L. borealis* to assess the taxonomic status of these endemic "red bats." Future research on the Galapagos bats will involve examination of inter-island and island-mainland differentiation of both *L. brachyotis* and *L. cinereus*.

Relative Capture Rates of Tympanate and Atympanate Moths by *Lasiurus cinereus* and *Lasiurus borealis*.

Cathy Merriman
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Certain moths, particularly of the family Noctuidae, Geometridae and Arctiidae, are known to possess tympana. These sensory organs allow them to hear the approach of echolocating insectivorous bats, and to subsequently take action to avoid being captured. In order to examine the effectiveness of such defense strategies. I observed the foraging activity of *Lasiurus cinereus* and *Lasiurus borealis* at Pinery Provincial Park near Grand Bend, Ontario. The bats prey mainly on moths at well-lit feeding sites. From June to August 1989, I collected moth wings culled by bats, as well as moths that bats attacked unsuccessfully. A light trap sampled all moths available on each night. Comparison of proportions of tympanate and atympanate moths in the two sets of data showed that the noctuids, notodontids and geometrids did not seem to benefit from any possible defensive strategies, whereas arctiid moths made up a low proportion of the bats' diets, as expected. The deaf lasiocampid moths showed a pattern of heavy predation as expected, while the atympanate saturniids and sphingids may be protected by other defenses not linked to auditory cues. Red and hoary bats were found to have slightly different diets in terms of proportions of moth families captured.

Bats of the Hoosier National Forest, Indiana.

Peter S. Miller.
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During the summer of 1990, I conducted a survey of the bats in Hoosier National Forest. The Hoosier Forest covers 76,037 hectares in south-central Indiana. Distribution maps generally indicate that 14 species of bats occur within this range. However, no previous systematic attempt has been made to determine the species composition within the Hoosier Forest. I assessed bat distribution by mist-netting in both upland and riparian forests. A total of 148 bats from eight species were captured during 50 net nights, including *Pipistrellus subflavus*; *Lasiurus borealis; Eptesicus fuscus; Myotis lucifungus; M. keenii; M. sodalis; L. cinereus;* and *Lasionycteris noctivigans*. Most individuals were captured over streams; 15 bats (five species) were captured in upland forests. Environmental variables including characteristics of the vegetation and physiographic features at net sites were recorded to allow association of a wide variety of habitat characteristics with species and numbers of bats encountered. I also collected fecal samples from all species captured in order to compare the diets of foraging bats with insect availability as

determined by placing sticky traps in the habitats netted. This study was undertaken to assist the U.S. Forest Service and the Indiana Department of Natural Resources with development of a management plan for bats in the Hoosier National Forest.

Observations on the Spotted Bat, *Euderma maculatum*, in Northwest Colorado.

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Florida Game & Freshwater Commission,
Panama City, FL ; C.D.O.W., Durango, CO.

In July of 1990, the Colorado Division of Wildlife initiated a census of the spotted bat, *Euderma maculatum*, in Dinosaur National Monument in the Northwest corner of Colorado. The only documented records of this species are from the Monument and nearby Brown's Park. No other localities are documented in Colorado. The purpose of this project was to address several key questions that would assist in future studies and census work for the species in the state. These goals were to: 1) obtain additional data on the distribution and status of *Euderma* in Dinosaur National Monument; 2) test and verify positive identification of *Euderma* by echolocation calls; 3) test the utility of listening devices as an aid in census work; 4) determine if *Euderma* utilizes the canyon river bottoms in addition to the upland sites for foraging.

This study indicated that *Euderma* could be recognized by echolocation calls, and verified by use of a bat detector, as suggested by research in Canada and elsewhere by Fenton, et al. 1987. We found *Euderma* to be locally common, though not abundant, within the Monument. This bat was found in all six sites sampled, ranging from desert shrub and pinyon-juniper, to canyon riparian habitat types. *Euderma* appeared early in the evening, and was detected at various times throughout the night. As reported elsewhere, *Euderma* foraged high above the ground. Electronic listening devices provided no apparent advantage over listening with the unaided ear. However, bat detectors did provide a means of verification of the calls. The range at which we could detect *Euderma* seemed significantly shorter than that reported by Fenton et al. 1987. Atmospheric attenuation and background noise from the Green River are likely factors involved in these apparent differences.

Population Ecology of *Myotis lucifugus*.

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Mark and recapture of over 6000 *Myotis lucifugus* from a population of approximately 12,000, has shown that these animals are faithful to the same nursery roosts nightly and yearly, and that roost availability is a factor which can control their population size. Animals detained in alternative roosts for a 24 hour period, returned to their original roosts after release from their detainment. Bats which were prevented from entering their roosts did not join colonies in other roosts, nor did they move to empty roosts sites nearby.

I tested the hypothesis that bats live in large colonies to decrease the risk of predation. I measured the time between departing bats to see how dispersed they were in time. From May to August, the animals were clumped together in time as they left their roosts nightly. The amount of clumping did not change throughout the summer, after the young were volent, or after the animals had experienced a fake predator (bat trap). After a trap was used, fewer bats used the same exit area. After numerous encounters with the trap throughout the summer, most of the bats had switched to using a different exit from where the trap had been.

Fundamental Skull Shape in Bats.

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I utilize radiographic cephalometry to detect patterns of skull growth and skull pattern formation in chiroptera (12 families, 60 species). Cephalometric angles

correspond to divisions between the primary growth centers in the embryonic skull (e.g., brain, paired sensory capsules, basicranium). Early in development, embryos of *Artibeus* (leaf-nosed) cannot be distinguished from those of *Eptesicus* (no leaf) on the basis of these angular relationships. Differential growth between adjacent elements eventually distorts the initial orientation of each component in the rudimentary skull. The two basic patterns of this reorientation coincide with the presence of absence of a nose leaf. Compared to taxa without nose leaves, leaf-nosed adults exhibit a depression of the palate away from the cribiform plate, rotation of the cribiform plate anteriorly, and a posterior rotation of the foramen magnum. Together, these events effect a depression of both the head and rostrum--a characteristic of leaf-nosed bats. The posterior rotation of the lateral semicircular canals is also characteristic of leaf-nosed bats, however, this rotation varies considerably within both groups, and is strongly correlated with head posture rather than with head shape.

Systematic Variation in the Megachiropteran Tube-Nosed Bats *Nyctimene cyclotis* and *N. certans*.

Randolph L. Peterson
Royal Ontario Museum, Toronto, Ontario.

Presented posthumously in honor of and in fond memory of Dr. Peterson, by Judith Eger, Royal Ontario Museum, Toronto, Ontario

This assessment of the sytematic relationships of the tube-nosed bats *Nyctimene cyclotis* and *N. certans*, from New Guinea and New Britain Islands, is based on analyses of skull and wing measurements. Twenty-four adult specimens of *N. cyclotis* Anderson and 36 of *N. certans* Anderson were measured and analyzed using univariate and multivariate statistics. Holotypes, both with incomplete skulls, of *N. cyclotis* and *N. certans* were examined, measured and compared with complete specimens. *Nyctimene cyclotis* and *N. certans* share similar dental, pelage, and ear-shaped characteristists; the two tax occur sympatrically, and are shown to be significantly different from each other as well as distinct from other members of the genus when compared with *N. cephalotes* and *N. papuanus*.

Winter Behavior of Bats at an Abandoned Mine in Vermillion County, Indiana.

Leslie J. Rissler and John O. Whitaker, Jr.,
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An investigation of activity by bats was conducted at the entrance to Copperhead Cave, an abandoned clay mine in Vermillion County, Indiana, between November 21, 1989 and March 17, 1990. A total of 934 bats had been caught in a Tuttle bat trap and banded with numbered plastic bands during the previous fall warming period. The mine is a hibernaculum for about 100 little brown bats and 200 Pipistrelles.

A trap was placed at the entrance to the mine on November 21, and was left in place continuously. It was monitored almost daily until December 1, and sporadically until March 17. Totals of 55 *Myotis lucifugus* (25 males, 30 females), 77 *Myotis septentrionalis* (41 males, 36 females) and 10 *Pipistrellus subflavus* (6 males, 4 females) were taken in this manner during that period. On 11 nights between January 16 and March 17 (3 in January, 4 in February, and 4 in March) the trap was monitored so that bats entering the cave could be distinguished from those leaving it, and the time of activity could be determined. The trap was tended from dusk to 1 AM on each of these nights. A total of 183 bats was taken, 132 of them entering and 51 of them leaving the cave. These numbers included 3 Pipistrelles (1 male, 2 females), 49 little brown bats (32 males, 17 females), and 131 northern *Myotis* (106 males, 25 females). Temperatures on these 11 nights ranged from the -1 to 24 degrees C., with greater numbers of captures at higher temperatures. There was little winter activity by Pipistrelles, but little brown and northern Myotis were flying about during warm nights all winter long. Northern *Myotis* showed greatly increased activity in mid March. Very limited data indicated no feeding was occurring until mid March (6

stomachs examined in January, 4 in early March and 5 in mid-March). The majority of the bats taken in winter had not been previously taken. Recapture rates at the mine entrance were 26 of 104 (25%) for little brown *Myotis,* 18 of 208 (8.7%) for northern *Myotis,* and 11 of 13 (84.6%) for Pipistrelles.

Bat Rabies: New Problems or Rediscovered Phenomena?

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Rabies is an acute encephalomyelitic viral disease with global distribution. All mammals, including bats, are susceptible hosts, but in highly variable degrees. The etiological agents are a group of related RNA viruses within the family Rhabdoviridae, genus *Lyssavirus*. At least three lyssaviral species have been isolated from both Mega- and Microchiroptera: classical Rabies, Duvenhage and Lagos Bat viral serotypes. Each viral serotype may have several antigenic subtypes adapted to different bat species, additionally varying over the host species range. The present distribution of bat rabies may reflect the traditional bias of epidemiological introspection rather than true zoogeographic occurrence, per se, and may be useful for researchers working abroad.

Bat rabies is considered endemic within North America, primarily among *Eptesicus, Myotis, Tadarida* and *Lasiurus sp.*, albeit at a fairly low prevalence. In Latin America, rabies among vampires has received the most attention, especially *Desmodus rotundus*, but a few viral isolations have been made among other non-hematophagous species (e.g., *Artibeus*). In comparisons in the Old World, bat rabies was reported only rarely from Europe since 1954, but recent cases have increased in Denmark, the Netherlands, Germany, and France during the mid-1980s, particularly among *Eptesicus serotinus, Myotis dasycneme* and *M. daubentonii*. European bat viruses are distinct from African viruses (Lagos Bat, Duvenhage) described from Western, Central and Southern Africa; serological surveys from Nigerian fruit bats (*Eidolon sp.*) suggest that other lyssaviruses may circulate in African Chiroptera, much akin to the situation in the New World. From the southern region of the U.S.S.R., at least eight lyssaviruses of bat origin have been recovered from 1967 to date; two of these resulted in human deaths, but other data are scarce. Bat rabies has been reported infrequently from India and Thailand, although systematic surveys from these and other southeast Asian countries are generally lacking. In contrast to other continents, Australia and most Pacific islands (e.g., Hawaii) are rabies free.

As a preventative, bat researchers should receive pre-exposure rabies immunizations, with serological testing or vaccine boosters every two-three years, depending upon the specific level of risk exposure. Consultation with guidelines published for rabies prevention by the U.S. Public Health Service, Centers for Disease Control, or similar federal authorities should greatly alleviate future concerns. Besides obvious public health significance, an understanding of the epizootiology of bat rabies is of greater than academic interest alone, due to oral immunization efforts directed toward rabies control in free-ranging carnivores throughout Europe and North America.

***Power Output During Commuting Flight of a Nectar Feeding Bat, *Leptonycteris curasoae*.**

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Power output during commuting flight of a nectar feeding bat *Leptonycteris curasoae*, was determined using the theory developed by Pennycuick (1989). Morphological measurements including body mass, wingspan, wing area, and body frontal area were taken on twenty-seven free ranging individuals of *L. curasoae*. Individuals included twenty-two females, three juveniles, and two males. The flight speeds predicted by the theory for cruising flight were tested against actual flight speeds obtained in the field using radio telemetry. Flight speeds in the field were calculated for commuting flights only.

Flight speeds observed for bats making commuting flights from the day roost to their foraging areas conformed closely to the predictions made by theory. An adult, non-reproductive, female bat flew twenty-five kilometers from her day roost to her foraging area at a speed of 10 meters per second. The predicted speed for maximum range velocity was 11.4 meters per second. Mechanical power output for flight at 10 meters per second was .227 W, while the total power output was 1.34 W.

The number of visits a bat would need to make to flowers of a commonly visited cactus. *Pachycereus pringlei*, in order to cover the cost of commuting flight, was calculated. A bat taking an average of 0.96 ml of nectar per visit would receive 503 joules per visit. Since the cost of commuting twenty-five kilometers was calculated as 3,244 joules, a bat would have to visit only seven flowers of *P. pringlei* to recoup the energy used in flying from the day roost. Energetic constraints, therefore, may not be the factor limiting distances flown by these bats in a single evening; rather time needed for long flights to foraging areas may be the factor determining how far a bat will fly in one night.

***This presentation was awarded first prize in the competition for the best presentation by a student.**

Postnatal Growth and Longevity in *Natalus stramineus.*

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Studies concerning postnatal growth, maturation and longevity in Neotropical bats are limited. Our objective is to contribute information concerning *Natalus stramineus*. We have been working with a nursery colony located in a colvert 59 km from Barra Navidad on the highway to Puerto Vallarta, since August, 1981. Information on growth and maturation was obtained from 50 newborn bats, each marked with white paint on the forearms. Varying positions and combinations of paint marks corresponded to a unique set of markings for each individual, allowing us to in effect, number each individual. Five to ten male and female bats were recaptured every third day, allowing us to determine the increase of body weight. This routine was continued until the young bats were volant. To obtain information on fertility and longevity, we marked 100 females and 37 males with numbered plastic colored bands in August, 1982. Observations were made every two or three days during the following years. The results show the postnatal growth in newborn bats, until age 18 days, when they became volant. Sexual maturity is reached at six months of age, when some of the marked females became pregnant. Fertility appears to be continuous for the rest of a female's life, the oldest female survived more than six years.

NEWBORN

	males X (min - ma)	females X (min - max)
weight	4.0 (2.9 - 4.7)	4.1 (3.2 - 5.1)
length	63.5 (60.0-68.0)	62.0 (60.0-65.0)
forearm	25.0 (23.0-27.0)	23.5 (22.0-23.0)

AGE 18 DAYS

weight	6.0 (5.0 - 8.9)	5.0 (4.7 - 5.3)
length	82.2 (80.0 - 84.0)	80.0 (78.0-82.0)
forearm	32.3 (31.0 - 34.0)	31.0 (29.0- 33.8)

Habitat Considerations for Bats: Opportunities in Land Management Planning on the Ouachita National Forest.

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Land management planning and the preparation of a Forest Plan is required for each National Forest by the National Forest Management Act and an assessment of its environmental consequences are required by the National Environmental Policy Act. The resulting Forest Land and Resource Management Plan guides all natural resource management activities for achieving established Forest goals and objectives, including wildlife habitat management. This plan may be periodically amended to meet

changing resource needs and will typically be completely reviewed and revised every 10-15 years. Integrating habitat considerations for bats in all resource activities during Plan formulation is an effective way to ensure habitat goals and needs are met. Through land management planning, the Ouachita National Forest has established guidelines for specific levels of attainment, and policies for conducting practices to provide structural habitat components of bat habitat with regard to retention of snags and den trees, protection of extremely rare subterranean habitat in the forms of caves and abandoned mines, riparian habitat, travel corridors, and spatial distribution of seral stage forest conditions including an older growth component. The short and long term goals to be accomplished through these management considerations for bats are to maintain viable populations by enhancing habitat quality on National Forest lands, and providing components important to bats which may not be found on adjacent private lands.

Forearm Curvature Throughout the Summer in *Eptesicus fuscus.*

Steven H. Sevick and Eugene H. Studier
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Pregnant and lactating mammals characteristically exhibit calcium stress as evidenced by bone thinning. The physical, aerodynamic stress on the radius must change drastically with the changes in wing loading which accompany pregnancy and lactation in bats. Beginning 25 April 1990, and at two week intervals through 29 Aug. 1990, big brown bats were collected from an attic maternity roost. Bats were positioned on their back with their left wing extended on a flat surface containing a mm scale and photographed. Bats were then weighed and their sex, age, and reproductive condition was recorded. From the developed, enlarged photographs, the following measurements (to the nearest 0.1 mm) were taken: forearm length, distance from the elbow to the site of maximum radius curvature, displacement of the radius at the site, wing width at digit V and distance from wrist to the end of the wing. Results show that curvature of the radius decreases curvilinearly, i.e., curvature decreases rapidly during pregnancy and more slowly thereafter.

Lunar Philia in Nectar-Feeding Bats in Arizona.

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and Fred Houser.
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The first winter observations of nectar-feeding bats at hummingbird feeders in southeastern Arizona were recorded during 1989 at two residences in Tucson, AZ. *Choeronycteris mexicana* and *Leptonycteris sanborni* were photographed at these feeders in February. Winter residence by these tropical bats is surprising because of physiological constraints in cold climates; it is likely that these species utilize warm roosts in winter like *Macrotus californicus* does, but no such roosts are known. All previous information indicated that these two species are unable to hibernate and must migrate to southern localities to obtain adequate food during cold seasons. Their typical food plants, various columnar cacti and members of the Agave family, flower from April through September in southern Arizona. Additionally intriguing is the question of how these bats could obtain dietary protein normally found in the pollen of food plants. A survey of Tucson Audubon Society members showed that none of those using hummingbird feeders in the area provide protein supplements.

Visual estimates of nocturnal nectar consumption were recorded by Houser from November to February. Beginning in February, masses (to the nearest 0.01 g) of nectar consumption were recorded. During February and March, mass of nectar consumption was compared with minimum and maximum ambient temperatures, days adjusted to reflect proximity to full moon, and progression of calendar days to reflect seasonal change. A stepwise multiple regression of these variables on nectar consumption resulted in R-square values of 0.277 ($P = 0.0024$) for days to full moon and 0.283 ($P=0.0002$) for minimum ambient temperature. The highest consumption of nectar was taken on the day before and day of the full moon. This behavior is strikingly

different from literature reports that bats avoid or decrease foraging during full moon.

Mineral and Nitrogen Nutritional and Roost Utilization Implications from Guano Accumulation and Composition in *Eptesicus fuscus*.

Eugene H. Studier, Dennis P.Viele and Steven H. Sevick,
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In the summer of 1989, all guano defecated in a roost occupied by male big brown bats was collected weekly. Similar collections in a maternity roost began in early July 1989. Guano was dried, weighed, and subsamples analyzed for Na, K, Mg, Fe, Ca, and N levels. Data indicated that male *E. fuscus* utilize the day roost uniformly throughout the summer, show considerable intra-roost variation in roost site selection, and abandon the roost in the fall earlier than did females. Maternity roost study began while bats were lactating when very large amounts of guano accumulated weekly. Marked variation in intra-roost site selection was also evident in the maternity roost. After lactation ceased, weekly guano accumulation varied widely. That variation and direct observations show that during the post-lactation period, the entire colony utilizes alternate day roost locations. Fecal elemental levels probably reflect dietary composition. Dietary inadequacy for a given element is indicated when it is present in constant levels in the feces, especially when those levels fall below expected nutrient requirement for that element. No differences in fecal Fe, Mg, Na, K or N levels exist between the sexes and all those elements, except Fe, are present in variable, high levels in feces. Fecal Fe levels in both sexes progressively decrease and become less variable throughout the summer, implying progressive dietary Fe stress for both sexes. Male fecal Ca levels decrease during the summer but remain variable and at high levels compared to females. Very low, constant Ca levels in guano from females strongly indicate nutritional stress for dietary Ca during lactation and most of post-lactation. Female fecal Ca levels rise just prior to autumnal roost departure. While guano from males was consistent in size, shape and color, distinctly variable pellets were found in guano from females in early July and October. Much female guano in early July consisted of very large, gray pellets which were markedly high in K and N level than typical guano. Guano in October contained numerous small black pellets which were markedly high in Ca and massively higher in Fe level than typical guano. These data imply that females may feed more selectively than males, especially for insects high in Ca and Fe.

Doppler Shift and FM Bat Calls.

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The acuity with which echolocating bats perceive their environment acoustically depends upon the characteristics of the sounds they emit and upon their ability to analyze returning echoes. The ability to distinguish fluttering from non-fluttering targets by detecting, in echoes, Doppler-shifted changes in frequency is usually considered only to be present in bats that use constant frequency (CF) calls. Frequency modulated (FM) signals, however, are also Doppler shifted when they rebound from a moving target. The results of this study demonstrate that bats who use FM signals may be able to distinguish fluttering from non-fluttering targets by detecting Doppler shifted "frequency smears" in echoes reflected from fluttering targets.

Is Evaporative Water Loss the Underlying Cause of Winter Arousals in Bats and Other Hibernating Mammals?

Don Thomas
University of Sherbrooke, Sherbrooke,Que.

All hibernating mammals arouse periodically through the winter. These arousals are energetically very costly and account for 75-85% of winter fat depletion. Thus, the number of arousals rather than hibernation per se is the key element in determining winter fat requirements and survival. Little is known about the causal factors underlying arousals. Two theories

have been proposed. The Biological Clock Hypothesis suggests that the torpor/arousal cycle is merely the normal circadian cycle extended by depressed body temperatures (Tb). The Metabolic Hypothesis says that arousals are provoked by either the depletion of metabolic substrates or the accumulation of wastes to unacceptable levels. One recent study showed that torpor duration was inversely correlated with oxygen uptake (V_{O2}) and Tb and this was taken as strong supporting evidence for the Metabolic Hypothesis. However, evaporative water loss (EWL) has rarely been considered. Both pulmonary and cutaneous water losses are related to V_{O2} and Tb and so could be causal factors. Here, I take our data on EWL measured for hibernating *Myotis lucifugus* and apply them to a study on the ground squirrel, *Spermophilus saturatus* to see whether EWL has a general application. I scaled cutaneous losses by the standard allometric equation relating surface area and mass. I estimated pulmonary losses from the pulmonary minute volume, assuming an O_2 extraction efficiency of 15%. Despite the inherent inaccuracies of scaling, the single variable (total EWL) proved as good a predictor of torpor duration as V_{O2} and Tb together. I suggest that these latter two variables determine EWL and that EWL is the proximate cause of arousals. I suggest that as water reserves decline animals become more prone to arousing and that internal mechanisms optimize the timing of arousals to facilitate feeding or drinking.

Bat Conservation International: A Progress Report.

Merlin D. Tuttle
Bat Conservation International, Austin, TX.

Bat Conservation International spear-headed major conservation progress on behalf of Pacific Island flying foxes, funding status surveys and education initiatives, helping pass C.I.T.E.S. legislation to limit commercial trade, gaining law enforcement personnel in Guam and organizing a Pacific Island Flying Fox Conference that was attended by representatives of 14 island states and nations. As a result, commercial trade in flying foxes has been significantly reduced. A CBS/Survival Anglia documentary on the worldwide importance of bats was completed and will air in over 100 countries following its premiere showing on CBS television early in 1991. A joint Mexican/American conservation project on behalf of migratory bats was begun. Research on the impact of bats as pollinators of Sonoran desert cacti was completed. Workshops for the public and for persons interested in bat management and/or research were conducted, and several major conservation oriented bat exhibits were opened.

We especially thank colleagues Brock Fenton, Ted Fleming, Rodrigo Medellin, Elizabeth Pierson, Bill Rainey and Don Wilson for their invaluable assistance in making this Bat Conservation International's most successful year yet.

Seasonal Swarming Activity at the Entrance to a Historic Hibernaculum.

Terri A. Tyson, John S. Hall
and Karen A. Campbell.
Albright College, Reading, PA 19612-5234.

Swarming activity at the entrance to a cave late in the season has long been considered to be indicative of the bat population found within the cave during the winter months. To test this hypothesis, we have captured and banded bats swarming at the entrance to Durham Mine, in Bucks County, PA on a weekly basis throughout the summer of 1990. This historic hibernaculum was visited extensively by Charles Mohr and Harold Hitchcock in the 1930's and 1940's, and winter bat populations were studied by Hall from 1963 to 1975. In this study a modified harp trap was used at the entrance of the mine, such that we only captured bats entering the hibernaculum.

The number of bats captured each week was relatively low during June and the first half of July, when we captured an average of only 5.1 bats per trap hour (range 4 to 6.4). This number increased steadily from the middle of July, reaching 46.6 bats/trap hour at the beginning of September.Since that time the number of bats captired has declined, reaching a minimum of 2.3 bats per trap hour on October 16, our last

trapping date this time. 82.1% of the bats captured were *Myotis lucifugus,* and most of these were adult males (67.7% of the total number caught). *Myotis septentrionalis* made up an additional 14.3% of the total capture, with the remaining 3.6% consisting of 4 *Eptesicus fuscus,* 17 *Pipistrellus subflavus* and 7 *Myotis leibii.* This capture of *M. leibii* is thought to be the eastern most record in Pennsylvania. We have only 4 of the 768 bats banded to date, suggesting that a large population uses this swarming site throughout the summer and autumn. We hope to enter Durham mine later this year, to determine the composition of the winter population actually using this historic hibernaculum.

Elevational Zonation of Fruit Bats (Pteropodidae) on Mt. Talinis, Negros Island, Philippines.

Ruth C. B. Utzurrum
Boston University, Boston, MA.

Mist-netting conducted in six sampling sites on Mt. Talinis, Negros Island, central Philippines revealed elevational variation in patterns of abundance, species richness, and diversity of the fruit bat fauna. In general, densities of fruit bats decreased with increasing elevation with greatest abundance occurring in low elevation disturbed and agricultural sites. Species richness (S) and diversity (H') were highest in lowland primary forest, moderately high in agricultural areas, but declined significantly in montane and mossy forest at the high elevations. Between-site variation in species composition and the respective relative abundance of species indicate habitat-related and topographic influences on the patterns seen. Geographically widespread species were common in disturbed and cultivated areas, whereas Philippine endemics were associated more with forested habitats.

DNA Fingerprinting of *Myotis lucifugus.*

E. Melanie Watt
University of Toronto, Toronto, Canada.

Myotis lucifugus show high site fidelity to their maternity roosts in Chautauqua, New York even from year to year. If philopatric behavior of females is the cause of this roost stability, the individuals within a roost site should be more closely related than individuals from different sites. In order to test this hypothesis, a method was required to determine genetic relatedness between individual *M. lucifugus.*

DNA fingerprinting has been used on a variety of mammals, including humans, whales, and domestic dogs and cats, but DNA fingerprinting techniques usually require several hundred ul of mammalian blood. Such quantities of blood are not available from smaller mammals such as *M. lucifugus* without sacrificing individuals.

Blood samples were taken from more than 300 *M. lucifugus* before they were banded and released. Rarely could more than 60 ul of blood be drawn per individual, but most bats provided a 40 µl sample. Several individuals were recaptured in good health several days after being bled. Experiments in our laboratory have shown that DNA fingerprints can be obtained from less than 30 µl of mammalian blood. We also have preliminary evidence that DNA fingerprints may be obtained from small samples of wing membrane. DNA fingerprinting will now be used to determine if philopatry is a possible explanation for roost stability of *Myotis lucifugus.*

Length and Sequence Variation in Evening Bat D-Loop mtDNA

Gerald S. Wilkinson & Alyson M. Chapman
University of Maryland, College Park, MD.

In the process of amplifying a region of mtDNA from evening bats *Nycticeius humeralis,* to use for reconstructing matrillines, we have discovered high levels of heteroplasmy, i.e., multiple mitochondrial types within individual. Using the polymerase chain reaction, we have amplified part of the displacement or D-loop which

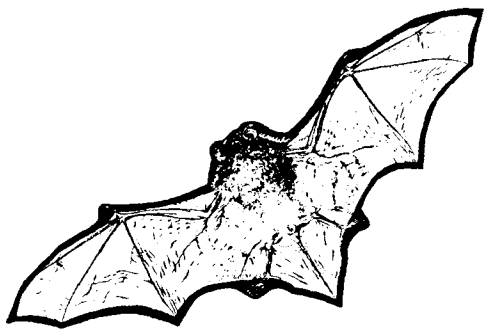
contains between five and eight tandemly repeated copies of an 81 bp fragment. DNA was extracted from muscle biopsies taken from 195 adult female bats at seven nursery colonies either in Missouri or North Carolina. At all colonies the fraction of heteroplasmic bats is 28%. There are no differences in repeat frequencies among colonies or regions; most of the variation in repeat length exists within colonies. Comparison of densitometric estimates of relative fragment abundance for 119 mother-offspring pairs shows that within individual fragment pattern is passed reliably from mother to offspring with the exception of two cases of offspring undergoing apparent length mutations. Sequence analysis of these cases shows that they are due to simultaneous duplication/deletion events presumably caused by replication slippage. To assess the implications of this process for evolution of mtDNA sequence, we analyzed DNA sequences from 52 bats which had six repeats. These analyses show that the repeat nearest the proline tRNA gene plays some functional role, presumably in binding a protein involved in replication, since its sequence is nearly uniform within colonies but shows decreasing similarity with geographic distance and the highest energies associated with secondary structure folding of any repeat. The last repeat shows the greatest dissimilarity and lowest energies indicating that it is accumulating mutations. The internal repeats are markedly similar to each other, presumably due to the duplication/deletion process. We have found similar levels of heteroplasmy in both *Eptesicus fuscus* and *Myotis lucifugus* indicating, in contrast to claims to the contrary, heteroplasmy is common in some mammals. We are in the process of comparing sequences among several species to further understand the mechanism generating heteroplasmy in order to shed light on how mtDNA co-evolves with nuclear replication enzymes.

Editor's Note:

As the reader can see, there are a record number of abstracts in this collection and preparing them for publication was a long and difficult task. There are undoubtedly several or many errors, hopefully all of them trivial, and not confusing to the sophisticated readers of this publication. The editor accepts full responsibility for all errors and extends apologies to those whose abstracts were so abused. Proof-reading them all twice and sending them back to the typesetter yet again, would delay publication even longer than it has been. I am very willing to accept offers of assistance from those who are qualified and willing to serve in this capacity.

As **Bat Research News** becomes more inclusive, the chores of editing and producing it have multiplied considerably. I have been fortunate in that several of my students have been providing many hours of assistance for a very small amount of payment. This has its limits however, as they are not available at all times and as a consequence, the work for some perverse reason seems to fall over their vacations or summer holiday. We (all of us who subscribe and benefit) may soon need to determine whether we need a regular part-time paid assistant to assist us in this rather large task. At present I am spending approximately 100 hours on each issue, and Tom Griffiths and Pete August are also cheerfully contributing more than their fair share. I am eager to receive comments, suggestions and or advice concerning small but reasonable honoraria for their services. I thank you in advance for your responses and assistance. They will be most helpful.

G. Roy Horst



News from Around the World

Kentucky, U.S.A.

Wayne Davis, founding father of ***Bat Research News***, writes.." In 1989 I built a Richard LaVal type bat structure for the state game farm in Frankfort, Kentucky,. Unfortunately it was not yet occupied by this past summer. I have also built several of the smaller bat houses.

Poland

W. Harmata wrote me a very nice personal note in which he described work he is now undertaking studying the effects of temperature on hibernation in some species of bats from Poland. He is planning to attend the Sixth European Bat Research Conference in Lisbon and hopes to meet more of his North American colleagues there. GRH

Saskatchewan, Canada

Mark Brigham sends the following: "Although my research interests are becoming more focussed on goat-suckers(nocturnal insectivorous birds of the family Caprimulgidae), in essence these animals are nothing more than bats with feathers (hopefully no ornithologists will read this). My long term research goal is to compare the behavioural and physiological ecology of these birds with bats to try and determine if similar ecological constraints imposed by a nocturnal foraging strategy have resulted in the evolution of other behavioural and physiological similarities. Presently I am investigating the use of torpor and the energetics of Poorwills, the only avian species thought to be able to truly hibernate. Presently in my lab, I have two honours undergraduate students; Ryan Casada is studying the prey selection by Poorwills relative to prey availability, and Barry Milligan is testing the hypothesis that individual vigilance decreases with the increase in group size in ring-necked pheasants. My new address is: Department of Biology, University of Regina, Regina, Saskatchewan, Canada S4S OA2."

[Someone needs to talk to this boy and lead him back to the cave and belfry. GRH]

Bristol, England

Gareth Jones was kind enough to send along the following list of bat workers at the University of Bristol and their primary research interests.

Dr. Jeremy M.V. Rayner, Royal Society Research Fellow, and as of 1992, University Lecturer. Theoretical models of flight performance. Ecological morphology of flight, physics of echolocation.

Dr. Roger D. Ransome, Honorary Research Fellow. Long-term studies on the population biology of the greater horseshoe bat.

Dr. Patsy M. Hughes, NERC Research Associate. The effects of load on flight performance in bats.

Angela Hollyfield, SERC Research Student(third year). Relationships between echolocation and diet in bats. Directionality of echolocation pulses.

Dean Waters, SERC Research Student(first year). Ecological and behavioural aspects of predator-prey interactions.

P. Laurent Duverge, Research Assistant funded by Vincent Wildlife Trust. Radio-tracking studies of greater horseshoe bats(starts April 1991).

John D. Cotterill is studying part-time for a Ph.D. with the Open University, investigating social communication in foraging Pipistrelles.

Dr. Gareth Jones, Royal Society University Research Fellow. Field studies on flight and echolocation. Recent and current projects include: 1) Radio-tracking studies of habitat use by greater horseshoe bats Rhinolophus ferrumequinum. 2) Causes of individual variation in the echolocation of rhinolophid bats. 3) Behavioural ecology of West African bats. 4) Flight performance and echolocation of trawling insectivorous bats. 5) Using DNA fingerprinting to determine relatedness in bats. 6) Cost of echolocation in greater horseshoe bats(with John R. Speakman of the University of Aberdeen).

Oregon, USA

J. Mark Perkins writes: " I am working as a private consultant, focusing primarily on bats. Most of the work has occurred in the Pacific Northwest and is focused on *Plecotus townsendii*. I am currently constructing a bat data base from field notes, museum records, and Oregon Fish and Wildlife records. I am also working on a project documenting(for publication) migratory patterns of *Lasionycteris noctivagans*. Steve Cross, Dixie Pierson and I are planning to cooperate on a joint paper on the ecology of *P. townsendii*.

I am also involved in securing a listing for the two subspecies of P. townsendii. Other ongoing conservation efforts include educational seminars for public and government workers and raising money to purchase money to purchase a cave site where about 15 % of Oregon's P. townsendii hibernate.

I secured five living Antrozous pallidus for the High Desert Museum. They plan to exhibit the live bats in *North Great Basin* habitat. They are keeping weight, food, and activity records. The bats are all doing well, even though four of the five were recently volant juveniles when captured.

Perhaps my most significant find was discovering that a nursery of P. townsendii, which was believed to number about 20 individuals actually comprised over 400 adult females plus young!

My only significant travel is in the Pacific Northwest, but places like Hell's Canyon and caves in the remote southeast are almost as exciting to a longtime Oregon-Washington resident. Thank you for your efforts in compiling these reports (in Bat Research News).I for one enjoy seeing what other BRN members are involved in and sometimes see great conservation ideas."
[Thank you Mark, both Tom and I appreciate the kind words. GRH]

RECENT LITERATURE

Because of the great number of abstracts contained in this issue there is **no recent literature** section this time. Tom assures me that there is "an enormous pile of stuff" for the next issue. GRH

Request for Information and News

We are very eager to hear from you and about what you are doing in the way of bat research. If you have not sent us anything in the last few years, why not take a few minutes and send us a short note about your activities. Ideally, we would like to hear from every subscriber at least once every couple of years. Your note does not have to be very "fancy". We will type-set it for you and repair any obvious flaws. If you remain silent too long, we may mistakenly write your obituary! In fact if we don't hear from you soon, we may ask other people(some of whom are very creative) to write about your activities. We would like to learn about forthcoming projects in strange or distant places, field trips, short courses, workshops, and anything else that you find interesting. Try to drop us a few lines in the next few days, or even better bring it with you to the bat symposium net week. Mail your notes to either of us. Tom Griffiths & G.Roy Horst

Ninth International Bat Research Conference
Madurai Kamaraj University,
Madurai, India
August 3 - 7, 1992

Dr. G. Marimuthu has asked me to include in this issue and the following several issues of Bat Research News, the announcement of the next international conference. He will be serving as the host. Dr. Kunwar Bhatnagar of the University of Louisville will serve as the coordinator for those of us in the United States who wish to obtain additional information about the conference. Their addresses are below.

Dr. G. Marimuthu
Dept. of Animal Behaviour and Physiology
Madurai Karamuj University
Madurai, 625 021
India Phone, 85216; Fax (0452)-85205

Dr. Kunwar Bhatnagar
Dept. of Anatomy
Univ. of Louisville Health Sciences Center
Louisville, KY, U.S.A., 40292
Tel. 502-588-5174

ANNOUNCEMENT

AND FIRST CALL FOR PAPERS

Twenty-First Annual North American Symposium on Bat Research

The 21st North American Symposium on Bat Research will be held on October 16-19, 1991, in Austin, Texas. Our hosts will be Merlin Tuttle, Patricia Morton, and Jacqueline Belwood of Bat Conservation International. The Crest Hotel on Town Lake is the official hotel for the meetings and all meeting functions, except for a possible field trip, will be held in the Crest Hotel Facilities.

The past several years have shown a rather large increase in both the number of people attending the symposium and in the number of papers submitted for presentation. It has been almost impossible to schedule more that about 40 papers during a two day conference without having concurrent sessions. The assembled participants have invariably voted to have single sessions only, but even so at our last conference in Lincoln we had to resort to a few concurrent sessions in order to include all the titles submitted. We anticipate a similar number of papers and participants this year, and to that end, we have extended the conference to three days of presentations. This will allow a much more leisurely pace of presentation and not require an almost military adherence to an uncomfortably tight schedule. The opening social events will be held on Wednesday evening instead of Thursday as in the past, and papers will begin on Thursday morning instead of on Wednesday morning, and continue through Saturday. There may be time for an afternoon field trip to a cave in the area around Austin. Dr. Tuttle and his staff will arrange that part of the program.

We are still in the process of negotiating hotel rates, banquet dates and prices for the support services provided by the hotel, but it appears that room rates will be almost the same as in Lincoln, that is a single will be approximately $60.00; a double, $65.00; triple or quadruple $75.00. These rates are about one half of the hotel's regular rates.

Registration will probably be about $35.00. This is $5.00 higher than last year, but we will be meeting an extra day, requiring the use of the meeting hall, coffee breaks, etc., for an extra day. There will be a reduced registration rate of $25.00 for students, and a registration fee of $15.00 for any student who submits a paper for consideration in the competition for student honoraria; in effect, a $10.00 prize for merely entering the competition. (There has been some quiet background grumbling in the past that the registration fee is too high. Perhaps we need to be reminded that registration fees for many other scientific meetings are often in excess of $50.00 **per each day,** and do not include any more amenities or services than our fee includes). This year the prize for the best paper by a graduate (or undergraduate) student will be $300.00. There will be two second place awards of $150.00 each. The funds for these awards are provided by ***Bat Research News,*** and by gifts from generous individuals.

Further details and the official call for papers will be included in future issues of ***Bat Research News***. If you need additional information call or write to G. Roy Horst, whose address, telephone and FAX numbers are listed on the inside front cover.

BAT RESEARCH NEWS

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FRONT COVER

The illustration on the front cover was generously provided by Charles Alexander Rubadou, a professional artist who describes his art and his interests in bats as "unique". He is interested in communicating with "real bat people" to discuss bats and his work, and the prospects of providing professional art work for publications or other use. He can be contacted at 610 South Almound Street, Fall River, MA 02740, or by telephone at 508-679-0356.