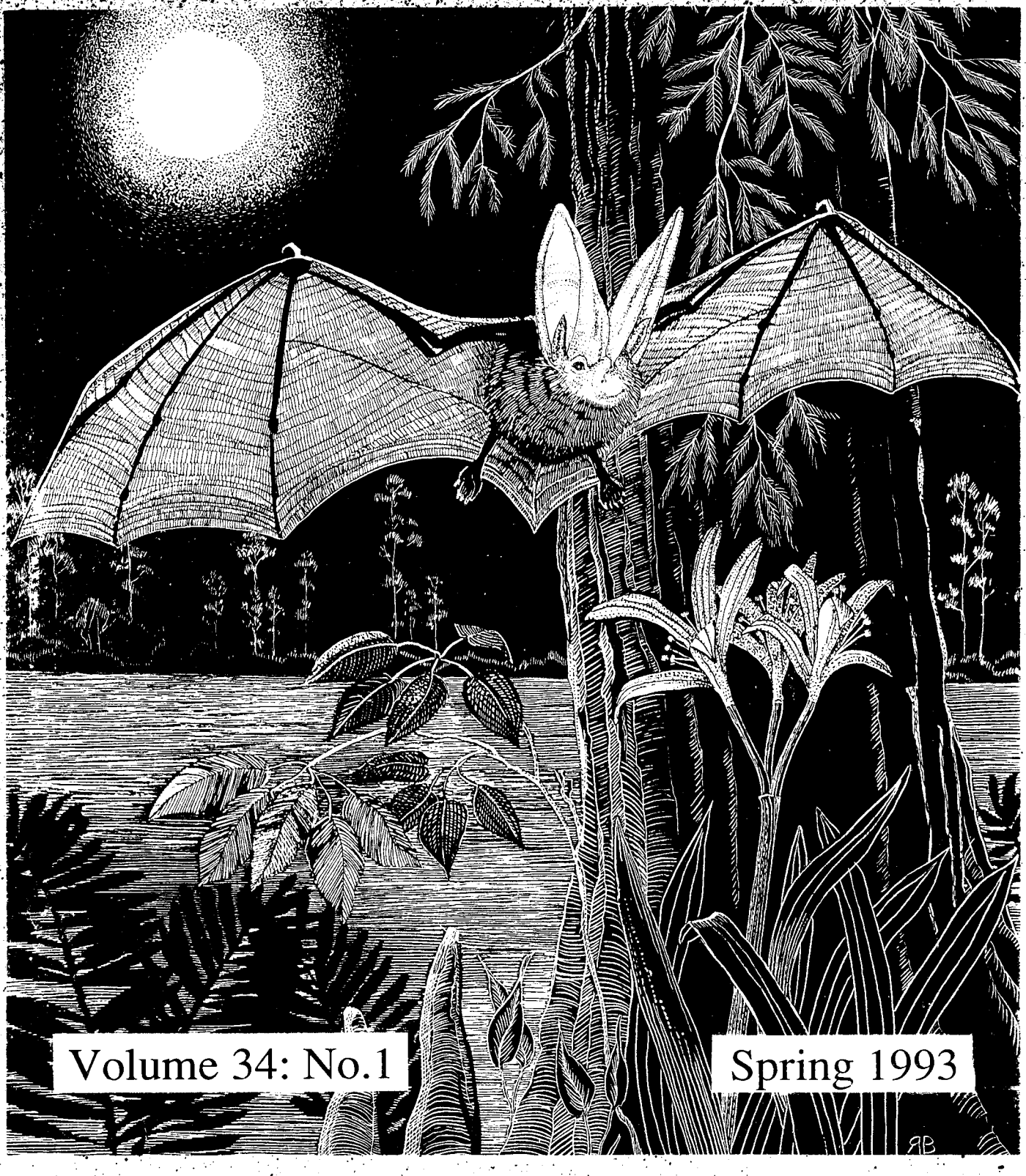
BAT RESEARCH NEWS



Volume 34: No.1

Spring 1993

BAT RESEARCH NEWS

Volume 34: Numbers 1–4 **1993**

Original Issues Compiled by Dr. G. Roy Horst, Publisher and Managing Editor of *Bat Research News*, 1993.

Bat Research News is ISSN # 0005-6227.

BAT RESEARCH NEWS

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BAT RESEARCH NEWS

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Bat Research News is printed and mailed at Potsdam College of S. U. N. Y.
in Potsdam, NY. 13676, U.S.A.

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Front Cover

Our cover illustration of *Plecotus rafinesquii macrotis* was sent to us by Mary Clark of the North Carolina State Museum of Natural Sciences and is the work of free-lance artist Ruth T. Brunstetter who works with Dr.Clark. Ruth is a botanical artist who enjoys switching subjects occassionally. Unfortuantely her original drawing had to be cropped and some of the lovely botanical detail in the foreground was lost, but our attention is captured by the almost ghost-like bat as it flys through a southeastern swamp in the moonlight.

BAT NEWS RESEARCH

Volume 34 Spring 1993 Number 1

Noteworthy Records of Some Bats from Morelos, Mexico

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There have been few reports concerning mammals in the state of Morelos (Davis and Russell, 1952, 1954; Ramirez, 1969a, b; Reddell, 1971). Consequently, we began a survey in the southeastern part of the state (Sánchez and Romero, 1992). Four species of bats that we collected represent new records for the state. Specimens reported herein were deposited in the mammal collection at the Facultad de Ciencias Biologicas, Universidad Autonoma del Estado de Morelos. All somatic and cranial measurements are cited in millimeters, and the weight is in grams.

Sturnira ludovici ludovici Anthony, 1924.

In July 1990, we captured two specimens in Morelos at a site 1 km S, Tres Marías, at 2,780 m. The bats were captured in a mist net together with specimens of *Artibeus aztecus*. The net was set at the edge of a pine-oak forest and an oat field. The bats were nonreproductive female adults. Total lengths were 64 and 68, and both bats weighed 20 g. These specimens represent the first record of the species for Morelos and the site is 220 km southeast of a previously reported capture locality at Mirador in the state of Veracruz (Hall, 1981).

Rhogeessa alleni Thomas, 1892.

We captured seven specimens in Morelos at Ejido Los Sauces, 9 km N El Limón at 1,400 m. This site is 100 km NE of a capture locality reported by LaVal (1973) at 10 km W Actlán, Puebla. We caught the bats in March 1992 in a net set over the bed of a stream. In the same nets, we caught *R. parvula, Pteronotus parnellii, Glossophaga soricina, G. Leachii, Artibeus jamaicensis, Sturnira lilium,* and *Choeronycteris mexicana.* The vegetation at this site is a tropical deciduous forest with cactus. Three of the *R. alleni* that we captured were male, three were female, and the sex of the last bat was not determined. This species, and other members of the genus, are the first to take flight each night. When they begin their activity, they fly between 5 and 10 m over the trees and later within the forest less than 3 m above the ground. External and cranial measurements (mean and range) of three females and three males, respectively are: total length 89.3 (88-90), 88 (88); tail length, 40.3 (39-42), 39 (38-40); hindfoot length 7 (7), 7 (7); ear height 15 (15), 15 (15) weight 4(4), 4.6 (4-6). Cranial measurements of a male are: greatest length of skull, 15.5; condylo-canine length, 13.7; zygomatic breadth, 9.4; braincase breadth, 6.8; postorbital constriction, 3.6; length of maxillary toothrow, 5.5.

Rhogeessa gracilis Miller, 1897.

We captured seven specimens from two different localities in Morelos; five were taken at Canada de los Sabino,3.5 km N El Limón at 1,250 m and two were captured at 3 km N Ejido El Limón, at 1,300 m. These sites are 100 km NW of a previously

recorded locality at Piaxtla, Puebla (LaVal, 1973). In the same nets, we caught *S. lilium, A. toltecus, A. jamaicensis, Eptesicus fuscus, Myotis velifer, R. alleni,* and *R. parvula.* The bats were captured between 1900 and 2030 hours, from February to May 1991, in nets set in tropical deciduous forest containing cactus and over a rocky stream. One male taken in February had inguinal testes measuring 1 x 1 and another had scrotal testes of 6 x 3; a male captured in March had scrotal testes. A female caught in April had an embryo. External measurements of one female and five males were: total length, 84, 83 (75-87); tail length, 42, 39.8 (33-43); hindfood length 6, 6 (5-7); ear height 18, 17.8 (16-20); weight, 4, 3.6 (3-4). Cranial measurements of a female and four males were: greatest length of skull, 13.6, 13.7 (13.5-13.9); condylo-canine length 12.1, 12.2 (12.0-12.4); zygomatic breadth, 8.3, 8.1 (8.0-8.3); braincase breadth, 6.5, 6.3 (6.2-6.3); postorbital constriction, 3.3, 3.3 (3.2-3.5); and length of maxillary toothrow, 4.8, 4.7 (4.7-4.8).

Eumops perotis californicus Merriam, 1890

The skull and mandible of one individual was found in the pellet of a barn owl (Tyto alba) in the entrance to a tunnel containing approximately 150 *Desmodus rotundus* and 40 *Balantiopteryx plicata.* The tunnel was located 3.5 km N, Anenenecuilco, Municipio Villa de Ayala. This tunnel is 100 km southeast of a record previously reported by Sánchez et al. (1989); that locality was: Olympic swimming pool, Colonia Portales, Distrito Federal, at 2,240 m. This new record confirms the wide distribution of the species in central Mexico (Polaco et al., 1992). Other mammals found in the pellets included *Liomys irrotatus, Sigmodon hispidus, Neotoma alleni,* and *Baiomys musculus.* The *Eumops* skull was in good condition, except that the auditory bullae were missing and the dentition was incomplete. Cranial measurements were: greatest length of skull (without incisors), 31.0; condylo-canine length, 29.4; braincase breadth, 18.3; postorbital constriction, 5.2; postorbital breadth, 9.7; length of mandibular tooth row, 23.4. These measurements are similar to those mentioned in Eger (1977).

Acknowledgments

We thank G. Avila García and L. Vargas M. for their advice and support during this study. R. Vargas B., C. J. Alvarez R., and L. Jiménez S., made comments on an early version of the manuscript.

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Longevity Records for *Myotis lucifugus*

Laura A. Sommers, Wayne H. Davis, and Harold B. Hitchcock
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Keen and Hitchcock(1980), in their study of survival of little brown bats in Ontario, reported two male *Myotis lucifugus* that were recaptured 29 and 30 years after being banded. These bats apparently represent the longevity record for Chiroptera(Tuttle and Stevenson, 1982). We now report a new record. On January 17, 1992 a group of people convened by the New York Endangered Species Unit entered an iron mine in Essex County, New York to census the bats. They counted all the bats found hibernating in the mine. Among 23,557 *Myotis lucifugus* there were five males that had been banded at the mine by Davis and Hitchcock and students at Middlebury College February 11, 1961, and two males that they had banded at the mine May 12, 1962. Thus these bats were at least 31 and 30 years old, respectively. Survival rates in *M. lucifugus* favor males(Keen and Hitchcock,1980). During 1961 and 1961 Davis and Hitchcock and their students banded 9,379 *Myotis lucifugus* in this iron mine, 7,842 of which were males. Thus nearly one in a thousand of these are known to have survived and returned to the mine where they were found alive in 1992.

We acknowledge the help of Alan Hicks, Al Breisch, Mike Kallaji, Ed McGowan, Jim Daley, Craig Stihler, Jenny Dickson, and Nancy Davis-Ricci in the census and the search for banded bats.

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Letters to the Editor

Paris Trail (affiliated with the North Carolina State Museum of Natural Sciences) has sent in the following ***Letter to the Editor*** concerning the behavior of *Plecotus rafinesquii* in the presence of a rat snake *Elaphe obsoleta*.

Since 1985 I have been assisting Mary K. Clark with her studies of *Plecotus rafinesquii* by monitoring bat activity at several sites in Chowan County, North Carolina. One of these is located in a large two-story barn that houses livestock, farm equipment and supplies. The *Plecotus* colony usually roosts in the second story, part of which is a loft where loose hay is stored. The bats are accustomed to activity in and around the barn and normally remain in a roosting position while I make observations.

During the fall this colony typically consists of approximately 30 bats, down from a high of about 60 in the summer. When I checked this colony on October 9, 1990, I was surprised to find only eight bats, and they were in continuous flight from one end of the loft to the other. The weather was sunny and warm, it was very quiet in the barn, and I could see no reason for their unusual behavior or low numbers. I scanned the ceiling with my light and discovered a rat snake *Elaphe obsoleta*. with several coils of its body tucked into a space between a rafter and a furring strip, the rest of its body hanging free in a long S - curve. With the light on the snake, I watched the bats fly up and hover momentarily, making small arcs about four feet from the snake. If they had been birds I would describe their behavior as "mobbing". The farm owner, Frederick Inglis, and I captured the snake which was active and alert, slender, and approximately four feet in length. Since it was up in the bats' roost I suspect it was hunting them. Careful examination of the snake did not reveal any lumps which could have been ingested bats. The snake was released several miles away from the colony.

When I checked the site again 5 days later there were 29 bats present and all were roosting normally. Since the behavior and numbers of bats returned to normal after the snake was removed, I am convinced that its presence was the cause for the decrease in numbers observed on two previous visits and for the unusual behavior of those bats that remained in the roost.

Rat snakes have been observed in at least three other roosts of *P. rafinesquii* (M.K. Clark, personal communication). Although predation has not been documented, Clark observed a rat snake (*E. obsoleta*) approaching a solitary male *P. rafinesquii* that was roosting in an abandoned house, but her movements startled the snake. Rat snakes are excellent climbers and have the potential to be significant predators in *P. rafinesquii* roosts. Submitted by Mary K. Clark, Curator of Mammals, N.C. State Museum of Natural Sciences, P.O. Box 27647, Raleigh, NC 27611

* * * * * * * * *

Letters to the Editor is a new feature that we hope will serve as a forum for presenting interesting data that the authors or the editors feel is best presented in this manner. If you have a short communication without references and with limited or anecdotal data, or a response to other items published previously, or even as a sounding board for new ideas, we would be pleased to receive them. Send such letters directly to Horst.

* * * * * * * * *

It is not too late to register for the VI European Bat Research Symposium in Portugal in August. It is probably too late to submit a title for presentation, but if you are eager to present a title contact Jorge Palmeirim or Louisa Rodrigues at the Dept. de Zoologia, Faculdade de Ciênias, Universidade de Lisboa, P-1700 Lisboa, Portugal. FAX# 351-1-7597716.

NEWS

From Malaysia

Charles M. Francis writes, "I am continuing studies of fruit bats in the forest canopy in Malaysia to learn more about their movement patterns and diet, and to look for more lactating male *Dyacopterus*. Anne Brooks from Tennessee hopes to visit for a few months to assist with this project. I am also collaborating with Jorg Haberstezer from Germany to record echolocation calls from horseshoe bats (Hipposideridae and Rhinolophidae) and examine the relationships between call frequency, morphology and ecology. Both of these projects will contribute to my work on a field guide to the mammals of mainland south-east Asia, which I started in 1992 with artist Karen Phillipps. We hope to complete that book over the next two or three years."

From Texas:

What About Radon in Caves?

The November 1992 issue of Environment magazine(p. 22) reports that cavers in Britain are limiting the amount of time they spend below ground because of high radon concentrations. A concentration of 155,000 becquerels per cubic meter was reported in the popular Giant's Hole cave in Derbyshire. This level exposes a caver to the maximaum annual level of ionizing radiation allowed by law for British workers in only 13 hours! A limestone cave in the U.S. was found to contain 54,000 becquerels per cubic meter. Having lived 19 years in Maryland, I know that much of the U. S. from the applacahians east to the Atlantic has radon problems in houses and, presumably, high concentrations in caves.

This information brings up interesting research questions. Can bats smell radon? Do they --by smell or some other way--detect and avoid radon? Is this an important reason why bats do not occur in some caves that appear to be good bat habitat? Or, conversely, are they somehow immune to its effects? And if they are, how do they achieve this immunity(defense against cancer)? Or maybe they cannot detect it and are not immune, and some late winter die-offs in caves are caused by radon? Is the age structure of some cave colonies controlled by radon concentrations? Do some bat populations show genetic effects of radon radiation? Has anyone surveyed bat caves for radon? Are studies going on now? These research questions seem immnetly fundable because of their obvious relationships to human health. Submitted by Donald R. Clark, Jr., College Station, TX

From Costa Rica

Richard LaVal, a long-time subscriber to **BRN**, who has lived in Monteverde, Costa Rica for the past thirteen years, reports that the following activities are keeping him busy. He is co-authoring a book including most of the mammals of Costa Rica, which covers over 90 species of bats in detail(as well as some odd number of miscellaneous non-bat mammals, with color plates. He also gives slide lectures on bats and bat field work to hundreds of college students who come to study in the Monteverde Institute's tropical biology program. Dick also advises serious students in the Institute courses who wish to do field research on bats, and graduate students who come here to do bat research. He also serves as a guide for tour groups who come from Bat Conservation International, as well as presenting an elaborate slide show several times a week to natural history tour groups - with bats hghlighted of course. If anyone is interested in more information on any of these programs feel free to write him at: Dr. Richard LaVal, APDO 10165, San Jose, Costa Rica or E-mail, INTERNET, rlaval@huracan.cr.

From Colorado

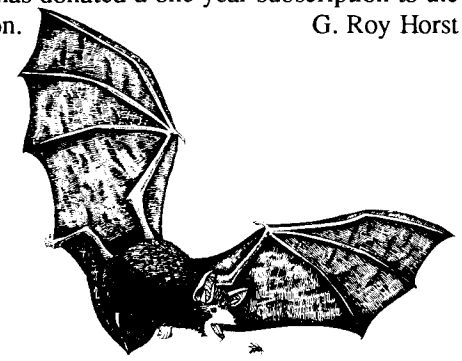
David Worthington recently joined the National Ecology Research Center in Ft. Collins. He completed his M.A. in Zoology at the University of Montana. The focus of his graduate work concerned the bat populations in the Pryor Mountains of south-central Montana. David and Mike Bogan are currently conducting a baseline survey of the bats in National Parks and Monuments of the Colorado Plateau. Their work involves the capture and identifcation of the bats in Mesa Verde, Bryce, Natural Bridges and Capital Reef. They assisted the staff of Jewel Cave National Monument in South Dakota with a wintering colony of about 1200 *Plecotus townsendii pallescens*. Mike and Dave are also conducting a baseline survey of the bats in Badlands National Monument in South Dakota. Jeff Osborne, a graduate student at the University of Northern Colorado, is assisting on this survey, and conducting research on the genetics of the Badlands population of *Plecotus*.

From Northern New York

The Adirondack Nature Conservancy and Adirondack Land Trust, and the New York State Department of Conservation have joined forces with the International Paper Company to sponsor a bat conservation project and at create a new appreciation of bats in the Adirondack region. Based on a continuing survey begun by Al Hicks in 1980, win-

tering bats and bat roosts are being monitored at several old abandoned mine sites scattered through out the region. The Hague Mountain Bat Hibernaculum is the largest known bat hibernaculum in the northeastern United States, providing a hibernation site for six species of bats, *Myotis lucifugus, M. keenii, M. sodalis, M. subulatus, Eptesicus fuscus,* and *Pipistrellus subflavus*. The region is also the seasonal home of *Lasiurus borealis* and *L. cinereus*, which hibernate at more southerly sites. This old mine houses as many as 120,000 individuals during hibernation, and the site is surrounded by a 50 acre "quiet zone" to prevent disturbance of the site during the hibernating season.

The mine is located on a 1,900 acre tract owned by the International Paper Company which has sold a conservation easement to ANC-ALT at a total cost of $180,000. The paper company has deferred payment for a time so that the remaining funds can be raised to pay the company for the for this easement. Generous private individuals have already contributed a substantial part of the funds, and the ANC-ALT is working diligently to raise the rest. Their "campaign" features a program entitled ***"Be a Bat Benefactor"*** and sends out very attractive small cards listing various levels of donations, from $1,000 which awards the donor with a personal tour of the preserve(not during the hibernation season); $100 which is rewarded with ***Bat Benefactor*** stationery; $25.00 earns a ***Bat Benefactor*** Pin; $10.00 earns a ***Bat Benefactor*** sticker, and $1.00 gifts are rewarded by a small ***Bat Benefactor*** certificate. These smaller gifts are aimed at school children, a perfect place to begin raising the public's awareness of bats and their special beauty and importance to the ecology of this lovely region. Those who are interested in learning more about this program, and perhaps how to begin a similar movement in their own area, may call Melissa Mack at 518-576-2082, or write to The Adirondack Nature Conservancy & Adirondack Land Trust, P.O. Box 65, Keene, NY 12943-9988. ***Bat Research News*** applauds this effort and has donated a one year subscription to the organization. G. Roy Horst



art work by Sheri Amsel

RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths, Dept. of Biology, Illinois Wesleyan Univ., Bloomington, IL. 61702-2900, U.S.A.) for inclusion in this section. 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 welcome.

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Don't forget to send in your registration forms for the 23rd Annual North American Symposium on Bat Research !

ANNOUNCING THE 23rd ANNUAL NORTH AMERICAN SYMPOSIUM on BAT RESEARCH

October 13-16, 1993
Host Institutions:
The Lubee Foundation, Inc. and The University of Florida
Location: University of Florida, Gainesville, Florida

Program Director, G. Roy Horst,
Potsdam College of S.U.N.Y., Potsdam, NY 13676
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Co-host: John Seyjegat
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Co-host: Frank Bonaccorso
Department of Zoology
University of Florida
Gainesville, FL 32611
Tel: 904-392-1554

The 23rd Annual North American Symposium on Bat Research will convene on Wednesday, October 13 to Saturday, October 16, 1993 at the University of Florida. Our hosts will be John Seyjegat of the Lubee Foundation and Frank Bonaccorso of the University of Florida.

Our host Hotel is the University Holiday Inn on the corner of University Avenue and 17th Street, diagonally across the square from the campus. Rates are $40.00 per room per night for up to four people per room, i.e., two double beds,$10.00 per person, [a bit more economical than last year]. The Holiday Inn runs a courtesy shuttle service from the airport to the hotel and will meet all scheduled airline flights. Gainesville is served by Delta Airlines and U.S. Air. Many major carriers serve Tampa and/or Orlando, both of which are but a few hours awayif you chose to rent a car. Gainesville is also served by Amtrack and Greyhound Bus line. Gainesville is located on I-75 and easily reached by car.

Please make your own room reservations with the hotel and identify yourself as being affiliated with the Bat Symposium. The reservation number for University Holiday Inn is: 1-800-465-4329 and/or 904-376-1661.

The Lubee Foundation has graciously arranged a welcoming party at the Holiday Inn on Wednesday evening at 7:00 P.M.

Registration for the symposium will be $ 25.00 for students, $30.00 for all others. A picnic-barbecue is being arranged and will cost $15.00 per person.

There will be spaces for approximately 72 oral papers in the regular sessions and a nearly unlimited number of posters. Papers will be awarded place on the program on a first come first served basis. After the 72 slots are filled, all other papers can be presented as posters. There will be a special session, "**Biological Patterns, Processes, and Predictions on the Future of Megachiropterans in the South Pacific**" arranged by Frank Bonaccorso and Brian McNab. These presentations will be included in the 72 scheduled talks. There will also be a special section on "**Bat Conservation and Educational Programs for the Public**" arranged by Brock Fenton and Pat Morton.

This year several friends of the symposium have donated a sufficient amount to award $500.00 to the best presentation and manuscript by a student. Students wishing to be considered for this honor please see the form concerning student honoraria for specific details. There are also sufficient funds available to award honoraria, as in the past, to the best 2 or 3 paper presentations by students, as well as the best poster by a student.

If you have not already received the forms for registration, etc., contact Roy Horst at Tel. 315-267-2259 or FAX at 315-267-3001 These forms are due post-marked no later than Septmber 1, 1993

For questions about the program, contact Roy Horst, for questions about local arrangements contact John Seyjegat

Abstracts of the Ninth International Conference on Bat Research Madurai, India, August 1992

The abstracts of the papers presented at the Ninth International Bat Research Conference held in India in August of 1992 are reprinted below. Abstracts appear as in the original program of the conference. The original program, so kindly provided to me by Dr. Marimuthu, was not of sufficient "copy quality" to guarantee adequate printing. I took the liberty to reset it in new type. The only changes being to correct obvious mispellings, grammatical errors, and what must have been typographical errors. Any other changes are inadvertant typing errors on my part, and in no way represent any effort to edit the abstracts. G. R. Horst

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Reproductive Adaptation in the Male of *Hipposideros speoris* at Different Locations in Maharashtra

N. Badwaik. Institute of Science, Nagpur-440 001 India

The reproductive habits of female *Hipposideros speoris* differ in different locations in peninsular India. At Nandad(19º 09'N, 77º 27' E)in central Maharashtra the females have a sharply defined breeding season and all females conceive during the first two weeks of December. At Chandrapur(19° 57' N, 79° 21' E) in eastern Maharashtra different females conceive on different dates from the middle of December to the middle of March. The males exhibit differences in consonance with the differences in the female sexual cycle in the two regions. In both regions the testis comes to activity in September, reaches a peak state of activity in the middle of December after which it regresses rapidly until it ceases altogether after the middle of January. While at Nanded the changes in the accessory glands closely parallel those in the testis, at Chandrapur the cauda epididymis is distended with spermatozoa, and the accessory glands are in a full state of activity from December to April. Evidently, the spermatozoa stored in the cauda epididymis fertilize the oocytes released during January-March in females at Chandrapur. The endocrine mechanisms involved in the initiation and maintenance of spermiogenesis appear to be different from those which are responsible for maintenance of the activity of the accessory glands in this species at Chandrapur

Night Roosting and Lunar Phobia in the Indian False Vampire *Megaderma lyra*

J. Balasingh. St. John's College, Tirunelveli - 627 002, India

Megaderma lyra night roosted singly and not in groups. An adult female bat continuously occupied the same night roost for more than six months. The night roosts which included cow-sheds and unoccupied buildings were mostly located 50 to 500 m away from the diurnal temple roost. The effects of lunar light on the duration of night roost occupancy and the duration of feeding bouts were observed in tagged males and females. The duration of night roost occupancy and the duration of foraging bouts varied depending on the phases of the moon and the reproductive conditions. In general, activity during the bright moon hours was greatly reduced. In addition this moon light avoidance was significantly higher during the breeding season than during the non-breeding season.

Specialized Skin Glands of Behavioural Relevance in the Microchiropteran Bat, *Megaderma lyra*

K. M. Begum and K. M. Alexander. University of Kerala, Kariavattom-695 581, Kerala, India
and Mahatma Gandhi College, Trivandrum-695 004, India

The microchiropteran bat, *Megaderma lyra* was trapped from its natural habitat, brought to the laboratory, weighed and sexes were identified. Skin samples from specific body regions were carefully excised from anesthetized animals and processed for histomorphological and histophysiological studies. Behavioural responses with specific reference to grooming were also made. It has been observed that hypertrophied skin glands occur at tarsal, facial, cervical, oral angle and preputial regions in both sexes. These specialized skin glands were comprised predominantly of holocrine sebaceous glands. However the facial glands had both sebaceous and sudoriferous glands. Histophysiological studies revealed a predominance of lipoid material in glandular tissues, indicating the lipoid nature of the glandular exudates. No significant sexual dimorphism was discernible in these specialized skin glands.

Behavioural observations indicated that these animals indulged in autogrooming of the olfactorily relevant specialized skin glandular regions facilitating anointing the body with its own scent. Allogrooming responses could also be noted. The behavioural relevance of the data is discussed.

Functional Adaptation of the Hind Limbs for Hanging in Three Species of *Pteropus*

M. B. Bennett. University of Queensland, Brisbane 4072, Australia

Flying foxes spend most of their lives hanging from branches, suspended by their hind limbs. The requirement for isometric muscular activity in opposing the downward force due to gravity would appear to be energetically demanding. Examination of the digits of the hind-limb(and the thumb of the fore-limb) revealed that the major flexor tendons have roughened fibrocartilage surfaces. These interact with ridges of fibrocartilage located on the internal surface of the adjacent flexor tendon sheath, effectively locking the digits in a flexed position. This tendon locking mechanism enables the bats to reduce or eliminate the activity of leg muscles when hanging.

In-flight Bone Stress Measurement in *Pteropus poliocephalus* Forelimbs

M. B. Bennet, University of Queensland, Brisbane, Australia , and
S. M. Swartz and D. R. Carrier. Brown University, Providence, RI, U.S.A.

The bat forelimb has undergone large modifications to facilitate active flight. In particular, the bones have become elongated in order to support the large flight membrane. Our study involved an analysis of how the wing bones behave during flight - in an attempt to better understand how skeletal structure and function are inter-related. We attached small rosette strain-gauges to the dorsal and ventral mid-shaft surfaces of the radius and contralateral humerus of the forelimbs of four grey-headed flying foxes(*Pteropus poliocephalus*, 0.4 to 0.75 kg). Simultaneous bone strain data and flight kinematics were recorded during active, unrestrained flight along a 30 metre flight cage. Analysis of the strain profile for each wingbeat cycle revealed three peaks in the strain magnitude, coinciding with the middle of the downstroke, the bottom of the downstroke and the upstroke-downstroke transition respectively. Calculation of stresses from the strain data showed that bone stresses were quite high, especially the shear stresses, for this slow horizontal flight. These bones have relatively large diameters and this cortices which may be an adaptating primarily to resist torsional stress.

Observations on the Food Regimen and Feeding Behaviour of *Cynopterus sphinx* at Pune

H. R. Bhat. National Institute of Virology, Pune - 411 001, India

Cynopterus sphinx is a ubiquitous frugivorous bat widely distributed in India and some other southeast Asian countries. The species roosts individually or in groups of two to several individuals in the overhanging, cryptic and protected niches on trees and under man-made structures like roofs and ceilings. The species forages upon fruits, flowers and foliages of a number of wild and a few orchard species of trees in varying proportions. The proportion and the seasonal variation in its diet is related to the food predilection and the availability, which is determined by the annual cycles of flowering and fruiting in the study area. The species generally pluck the fruits and carry them away from the original tree to feeding perches where it chews the soft parts of the fruits, sucks the juice and drops the seeds and fibres, resulting in seed dispersal and plant regeneration, thus playing an important role in the ecosystem. The damage caused to the orchard fruits by the species is incidental and often marginal, particularly where there is a large number of wild food species available. In addition, the species also plays some role in the pollination of certain species.

Histochemical Differences in the Intestinal Mucous of *Rhinopoma kinneari*

U.S. Bhati and M. Srivastaga. University of Jodhpur, Jodhpur 342 001, India
and Dungar Autonomous College, Bikaner 334 001, India

Investigation of the intestinal mucous of *Rhinopoma kinneari* r eveals that the Brunner's glands are intensively positive only with P.A.S. test, indicating the presence of neutral mucin. However, goblet cells were intensively positive with all histochemical tests employed indicating the presence of Sialo and strongly acidic (sulphated) mucins.

Synaptic Ribbons in the Chiropteran Pineal Gland: Enigmatic Organelles of Poorly Understood Function

K. P. Bhatnagar. University of Louisville, Louisville, KY 40292 U.S.A.

Synaptic ribbons are presynaptic organelles located only in the sensory receptors of the invertebrate eye, the vertebrate retina and the vestibulo-cochlear organ, the electric receptor organs of teleost fish, and in the pineal glands from lampreys to mammals. Lack of information on the chiropteran pineal synaptic ribbons prompted this investigation. The pineals of *Cynopterus sphinx, Rousettus leschenaulti, Pteropus giganteus, P. poliocephalus, P. lylei, Rhinopoma microphyllum, Megaderma lyra, Macroderma gigas, Hipposideros lankadiva, Desmodus rotundus, Lasionycteris noctivagans* and *Eptesicus fuscus* were examined ultrastructurally. In comparison to synaptic ribbons observed in pineals from other mammals, those in bats appear undeveloped and are relatively fewer in number. Both single and paired synaptic ribbons and the so-called synaptic bodies have been noted. Synaptic ribbon fields have not been observed. The universal occurrence of ribbons in the pineal and the contradictory functions ascribed to them, their numbers, origin and development, life span, morphometry, and involvement in physiological, biochemical and environmental regulatory mechanisms as reported for other species will be presented. The exact function of pineal synaptic ribbons remains to be elucidated.

Light and ultrastructural observations on the pineal gland of the Indian flying fox, *Pteropus giganteus*

K. P. Bhatnagar. University of Louisville, Louisville, KY 40292 U.S.A.
and K. B. Karim. Institute of Science, Nagpur 440 001 India

Pteropus openly roosts under broad daylight exposed to environmental extremes. The possibility of such divergent behavior accompanying changes in pineal structure prompted this investigation. Bats were collected at Nagpur in the morning hours during October and November. Fixation was either immediate or around midnight. Boulin-fixed brains were sectioned serially and stained with trichromes. Ultrathin sections were examined using Philips microscope. The thumb-shaped, solid, compact, type AB pineal measures about 2.3 x 1.8 mm sagittally. It is recessed between the hemispheres. Arteriolar network encapsulates the pineal. Capillaries appear to define the lobular structure of the parenchyma. The great cerebral vein courses dorso-anterior to define the pineal whose ependymal base is attenuated and deficient in part. Pinealocytes do not contact the CSF. Notable ultrastructural features include: round unlobulated nuclei, small mitochondria, multiple Golgi, prominent sER, rER and microtubules, centrioles, rootlet fibers and cilia, desmosomes, degenerating whorls, gap junctions, rate synaptic ribbons and spherules, synapses, lysosomes, nerve bundles, and dense-core vesicles. Clear vesicles and club-shaped pinealocyte processes are generally lacking. The perivascular spaces are unremarkable. Capillaries are unfenestrated. Micropinocytosis is indicated. Neither intrapineal neurons nor melanocytes are seen. Distally, pinealocytes are loosely packed and individually surrounded by glial processes. The structural characteristics of *P. giganteus*, and its recessed and unpigmented condition are suggestive of a correlation with the daylight roosting behavior.

Morphometric and histoarchitectural alteration in the pineal gland of an insectivorous microchiropteran - *Rhinopoma kinneari* exposed to various forms of photic stimulation

S. Bhatnagar and S. B. Lall. M. L. Sukhadia University, Udaipur 313 001 India

Sexually mature adult males of *Rhinopoma kinneari* were subjected to various forms of photic stimulation, e.g., 12 h light (L) and 12 h dark (D); total darkness; red (R); green (G); yellow (Y) and blue (B) light for 2.5 weeks. Significant alterations were observed in the size of the pineal gland; number and distribution patterns of pinealocytes, mast and macrophage cells. The order of effectiveness of various photic stimuli on the length of pineal gland between two habenular commissure was R > B > N > G > D > Y; on the density of pinealocytes it was N > R > D > Y > B > G; and on the mean area of pinealocytes it was: D < G / N < Y < B < R. Bats are nocturnal mammals which use light as one of the principal sensory cues for their emigration from roosting sites. The results of this study indicate that pineal gland morphology and structure are significantly altered by various forms of spectral light as well as by chronic scotophic and photic stimulation. It seems that such changes in this gland are probably mediated via optic pathways, since mammalian pineal gland is basically and endocrine organ and does not have a photosensory role as it does in submammalian vertebrates. Further, these results are at variance with similar studies conducted on placentals and other amniotes.

Ultrastructure of the chorioallantoic placental barrier in the Indian fruit bat, *Rousettus leschenaulti*

D. A. Bhiwgade and S. N. Menon. Institute of ScienceBombay - 400 032 India

The chorioallantoic placental barrier of fruit bat, *Rousettus leschenaulti*, has been studied by electron microscopy. The future cytotrophoblast and syncytiotrophoblast layers can be distinguished shortly after implantation. The chorioallantoic placental barrier is hemochorial throughout the entire functional state of this structure. During the late neural groove and in the early limb-bud stages a few free cells are observed in the maternal blood space but as they do not form capillary structure, the placenta is regarded as hemochorial right from the beginning. Inner to the syncytiotrophoblast, facing the maternal blood, is seen a discontinuous acellular layer called intrasyncytial lamina, through the discontinuities of which syncytium flows and occupies the area of the endothelium. The following elements of the definitive placental labyrinth separate the maternal and fetal circulations: 1) a discontinuous intrasyncytial lamina, 2) syncytial trophoblast, 3) cytotrophoblast intermingled with a few light cells, 4) a thick basal lamina, 5) mesenchyme and 6) fetal endothelium. The definitive chorioallantoic placenta of the bat is hemodichorial since the syncytiotrophoblast and the cytotrophoblast layers persist to term.

Comparative ultrastructural observations on the anterior pituitary in some Indian bats

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The members of the order Chiroptera exhibit interesting variations in the cytoarchitecture of the cells of the anterior pituitary. The present study was aimed at recording these variations, observed at the ultrastructural level in some species of bats. Male and female bats were collected during various phases of sexual cycle like oestrus, pregnancy and lactation. Six cell types viz - STH, LTH, TSH, LH, FSH and ACTH had been identified. The identification and differentiation of six observed cell types and their comparative aspects were based mainly on the morphology of the secretory granules and the cytoplasmic organelles viz - rough endoplasmic reticulum, mitochondria, Golgi apparatus and lysosomes. The cellular features such as shape and location of the nucleus, shape and size of the cells and position of the cells with respect to the blood vessels were also taken into consideration. The probable physiological significance of these cell types has been discussed

The Fine Structure of Term Placenta in Indian Molossid Bat, *Chaerephon plicata*

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In the present study, the fine structure of the discoidal chorioallantoic placenta at term was examined electron microscopically in the Indian molossid bat, *Chaerephon plicata*. This placenta develops from the placental pad during early pregnancy and is hemochorial in nature right from the beginning. The interhemal membrane is made up of an attenuated layer of cytotrophoblast, a discontinuous layer of "homogenous material", a basal lamina common to both the trophoblast and the fetal endothelium and a well developed fetal mesenchyme. Hence, the placenta is designated as hemomonochorial in nature and lacked a continous layer of syncytiotrophoblast. The cytoarchitecture of each layer has been discussed and compared with those of other molossid bats.

Auditory Brainstem Evoked Response (ABR) of the Fruit-Bat, *Rousettus aegyptiacus*

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Jerusalem 91120, Israel, and Technion, Haifa 32000, Israel

The auditory-brainstem-evoked-response (ABR) to click stimuli was recorded in the fruit-bat, *Rousettus aegyptiacus*. The ABR was recorded by earlobe and vertex needle electrodes, while the other ear served as ground. The response was filtered (200-2000 Hz), averaged and recorded by a Microshev C. ERA-100 averaging system. The ABR of the bat consisted of five waves during the first 10 msec. The amplitude of the waves ranged between 1-7 μV. The latencies of the waves (in msec) were: wave I: 1.4 ± 0.3, wave II: 2.7 ± 0.5, wave III: 4.0 ± 0.5, wave IV: 5.4 ± 0.7, and wave V: 7.4 ± 0.8. The patterns of all waves were highly consistent with the human ABR and they were stable in configuration and amplitude, even at rates of 80 clicks per second. The threshold to clicks in the bats was approximately 35 dB SPL, a value similar to the one observed in humans. We suspect therefore, that relationship between the various waves and their neural generators is similar to that found in the nervous system of other mammalian species including human.

Studies on Holocrine Cells in the Epididymis of Some Bats

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The epididymis of five seasonally breeding bats, *Rousettus leschenaulti, Hipposideros fulvus fulvus, H. speoris, Tadarida aegyptiaca* and *Taphozous theobaldi* and one continuous breeding bat, *Pipistrellus mimum mimus* were studied by employing histological and histochemical methods. Only single type of principal cells were observed in the epididymis of *H. speoris, T. theobaldi* and *P. mimus mimus*. On the other hand, two types of cells could be distinguished in the epididymis of *R. leschenaulti, H. fulvus fulvus* and *T. aegyptiaca*. The principal cells were numerically more than the holocrine cells. The holocrine cells were clearly observed during the prebreeding period. These cells exhibited an intense PAS reactivity which was partly reduced by α - amylase digestion. These cells exhibited weak alcianophilia at pH 2.5 but remain unstained at pH 1.0, appeared only blue in AF-AB pH 2.5 sequence and exhibited weak metachromasia with azure A at pH 3.0 and above. Their alcianophilia was reversibly blocked by methylation and methylation followed by saponification and was completely eliminated by acid hydrolysis and neuraminidase digestion. These results indicated the presence of glycogen and sialic acid in the holocrine cells. These observations are discussed at a compartive level and some functions are suggested.

Living Clocks inside a Cave

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There is communication and social synchronization of the circadian rhythm in the flight activity of the microchiropteran cave-dwelling bat *Hipposideros speoris*. Thus, captive bats surrounded by free-flying conspecifics synchronize their activity to the colony activity. The circadian rhythm of a solitary bat in a solitary cave freeruns. Even the rhythm of an 'alien' bat (*Taphozous nudiventris kachhensis*) held captive in the hipposiderid bat cave freeruns. But the rhythms of a closely related species, *Hipposideros fulvus* partially entrain to social cues from *Hipposideros speoris*. Social synchronization of circadian rhythms in bats may be species-specific. This synchronization is abolished when continuous light of 10-20 lux is shone inside the natural cave.

Age estimation of megachiropteran bats by dental cementum lines

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A growing requirement exists to determine the ages of animal species concomitant with increasing management. Teeth often offer the most practical means of age determination in many animal species as changes in the dentition occur with growth and development. Additionally, there may be other morphological changes ascribed to the amount of use of the teeth. A simple, but effective approach is to use characteristics observable in cross-sections of teeth for age analysis. This investigation used mineralized thin (10 μm) and thick (100 μm) mid-root sections of surgically removed canines from three species of fruit bat (*Pteropus alecto, P. poliocephalus* and *P. scapulatus*) in order to try and establish a relationship between the chronological age of fruit bats and changes in the cross-sectional morphology. Annulations in the cementum were clearly visible in sections viewed by Normarski interference microscopy, but their value in age-estimation may prove equivocal.

Comparative studies of H4 - purified lactate dehydrogenase (LDH) from the heart of *Scotophilus heathi* (microchiroptera) and *Cynopterus sphinx* (megachiroptera)

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The enzyme Lactate dehydrogenase (LDH, L-Lactate: NAD^+ - oxidoreductase, EC 1.1.1.27), a regulatory enzyme of the glycolytic pathway is selected for the present study. H_4 - Lactate dehydrogenase was purified using affinity chromatography from the heart of micro (*Scotophilus heathi)* and mega (*Cynopterus sphinx*) chiropteran bats. Michaelis constant (Km) of H_4 - LDH of megachiropteran bats is more than that of the microchiropterans. Inhibitory constant (Ki) with oxalate/oxamate in presence of pyruvate shows differences in the two species of bats. However, enzyme from microchiropteran bat is more thermolabile than megachiropteran. The amino acid analysis of the purified enzyme from both species of bats shows no structural change of the enzyme molecules, thus retaining the mammalian nature.

Histological and histochemical studies of the stomach of six Indian bats

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The stomach of each of the six bats, *Rousettus leschenaulti, Taphozous kachhensis, Megaderma spasma, Rhinolophus luctus beddomei, Hipposideros fulvus fulvus* and *Pipestrellus ceylonicus chrysothrix* was divisible into cardiac, fundic and pyloric regions. The wall of the stomach consisted of mucosa, submucosa, muscularis and serosa. There were numerous foveolae at the bottom of which the glands opened. A single layer of glandular columnar epithelial cells with a clear apical border lined the stomach. Cardiac and pyloric glands contained mucous cells and occasional parietal cells. Mucous neck cells, chief cells and parietal cells were identified in the fundic glands. The histochemical reactivities of mucosubstances in most of the cells of the stomach of bats resembled those exhibited by typical mucosubstances such as neutral mucosubstances, sulfomucins, sialomucins and glycogen. Distribution of the mucosubstances was heterogenous in the six species. Neutral mucosubstances were identified in the mucous neck cells in all the bats. The upper mucous neck cells of *P. ceylonicus chrysothrix* also contained sulfomucins. The chief cells in *R. leschenaulti* contained poor quantities of neutral mucosubstances and atypical sulfomucins. The chief cells in the remaining five species contained only atypical sulfomucins. The parietal cells in *R. leschenaulti* revealed poor to weak quantities of neutral mucosubstances whereas those in the remaining species were devoid of mucosubstances.

Reproduction in some Indian bats

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The limited information that is available on Indian chiropterans reveals not only the existence of certain peculiar features in their reproduction, but also considerable differences in regard to the reproductive cycles and associated phenomena in four species of bats at Varanasi (25° N), viz. *Scotophilus heathi* and *Pipistrellus mimus* (Family Vespertilionidae), *Taphozous longimanus* (Family Emballonuridae) and *Cynopterus sphinx* (Family Pteropidae). *S. heathi* exhibits clear monoestry; copulation in the spring is immediately followed by pregnancy. *P. mimus* breeds twice during the year in quick succession. Although both the species do not undergo prolonged hibernation, they resemble the temperature zone hibernating bats in having a reproductive cycle characterized by slow follicular maturation, unique specialization in the Graafian follicle and prolonged oestrus. Both species also store spermatozoa in the female genital tract for long periods of time (up to 5 weeks in *S. heathi* and 30 to 35 days in *P. mimus*). The length of gestation in *S. heathi* is 116 $\pm$ 10 days and in *P. mimus* about 60 days. *T. longimanus and C. sphinx* exhibit bimodal polyoestry and breed twice in the year in quick succession. Seasonal changes in the testes and male accessory sex glands also indicate the incidence of bimodal polyoestry in these species. However, spermatozoa are stored in the epididymis throughout the year in both species. In *T. longimanus* the first pregnancy, which has a duration of about 105 days, commences in mid-January and terminates in April to mid-May. Within a short period after parturition, the females experience a second pregnancy which has a duration of about 86 days. In *C. sphinx* mating in October is followed by pregnancy again and delivery of the young in late June and July. The first pregnancy has a duration of about 150 days and the second about 120 days. This variation in length of gestation in the two species appears to be due to the differences in the rate of fetal growth in two successive pregnancies. The available information relative to the reproductive cycles of other Indian bats is reviewed. It appears that the breeding patterns of these bats have evolved to take advantage of the available food supply.

Activation of auditory cortical fields by species-specific calls in *Phyllostomus discolor*: A 2-deoxyglucose study

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A common feature among bats of the suborder Microchiroptera is the use of echolocation calls for short distance orientation, obstacle avoidance and, depending upon the species, for catching their prey. Beside these echolocation calls, some species possess a complex repertoire of social calls whose function in detail is less well understood. In *P. discolor* especially those calls recorded in the context of mother-infant communication, were analyzed both physically and behaviorally during previous studies (Esser and Schmidt 1989). In contrast to the short, multiharmonic echolocation calls which always consist of steep downward-directed frequency modulations, the

maternal directive calls are characterized by a sinusoidal frequency modulation pattern showing individually distinct call characteristics. During ontogeny the isolation calls of the young adapt to this vocal signature of their own mother. A corresponding form of acoustic learning, the vocal adaptation to a computer-generated directive call, was also confirmed in subsequent hand-rearing experiments (Esser 1990). In the present neurophysiological study on subadult *P. discolor*, we used both types of signals, the animals' own echolocation calls and computer-generated directive calls, as significant species-specific acoustic stimuli. Serial horizontal brain slices of 2-Fluoro-2-deoxy-D-[U-^{14}C] glucose-treated and acoustically stimulated bats were used to determine spatial extent and subdivisions of auditory cortex in *P. discolor*.

Images of bats

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The use of bats to depict vastly diverse intellectual and emotive images in art and literature is a project being run at the National Museums and Galleries in Merseyside, in Liverpool, UK. It involves much assistance from other bat workers, particularly the members of the London-based Bat Conservation Trust, and it is hoped the project will lead to an authoritative volume on the subject, with chapters written by authors with expertise in a particular area. How to define the main areas for chapters was not immediately obvious, as the subject is so vast and interwoven. However, after discussing ideas with bat workers of several nationalities, a list of topics has naturally evolved as being those of much interest to their authors; thus, likely to be of interest to the eventual reader. These include bats on postage stamps; bats in the movies; bats as photographic images; bats as fairies; bats in German art; bats in field guides; bats in the Romantic era; bats in psychological images; ecclesiastical bats; bats and the Sun-God Cult; bats and ephemera. We have already collected many images concerning these subjects, and the conference paper will involve a resume in preview of some of the most spectacular of these.

Vertical stratification of bats in Malaysian rainforest

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Bat communities in the understory of Malaysian rainforest have exceptionally low members of frugivorous species compared with similar communities in Neotropical forests. This presumably reflects a scarcity of understory fruiting trees, but may also be due to relatively dense vegetation near ground level hindering flight of the visually oriented Megachiroptera. In either case, fruit bats may be much more abundant in the middle story or canopy of the forest if vegetation density and/or fruit abundance differs. Differences in vegetation density or composition of the insect community could also lead to differences in the relative abundance of insectivorous species of bats depending upon their maneuverability and/or preferred diet. To test his, mist nets and harp traps were set at ground level, in the middle storey and in the lower canopy (up to 30 m high) by suspending them from ropes. In my presentation, I shall discuss some of the logistic aspects of setting canopy nets and traps, as well as preliminary results on the relative abundance of bats at different strata within the forest.

Body water and lipid dynamics in the sheath-tailed bat *Taphozous perforatus perforatus*

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The gross body weight, water and lipids in the sheath-tailed bat *Taphozous perforatus perforatus* at Jodhpur (26°18' N Lat., 73°04' E Long.) were estimated in relation to the seasonal changes (i.e., hot-dry, cool-wet, and cold-dry seasons) and the reproductive activity of the animal. The highest body weight was observed in the cold-dry season when both males and females were sexually active, while the water content was at the highest peak during the cool-wet season. The body lipids start depleting during the reproductively active phase. This may be due to utilization and mobilization of lipids to meet the ever increasing physiological demand. It appears that water content of the body and lipid levels are inversely proportional.

Fluctuations in the haematological parameters of *Rhinopoma microphyllum kinneari*

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Fluctuations in the haematological parameters of *Rhinopoma microphyllum kinneari* were observed under laboratory conditions (at 30-35°C and 39-69% relative humidity) when deprived of food and water for ten days and at

their niche when they undergo a semitorpor condition during the cold-dry season and remain almost without food and water. The data were recorded at the intervals of 0, 24, 48, 72, 96, 120, and 240 hours. During this period, the haematocrit, haemoglobin percentage and erythrocytes had increased due to haemoconcentration, while the leucocytes count decreased. This is probably due to the restriction imposed on their muscular activity in captivity. The differential count shows fluctuation.

Effect of Stress on the Tissue Protein of *Rhinopoma microphyllum kinneari*

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Rhinopoma microphyllum kinneari an insectivorous desert bat was kept without food and water in the laboratory (30-35° C and 39 - 69% relative humidity) for different hours, i.e., 24, 72, 144 and 240. During this period, the fluctuation in the tissue proteins (mg/100 g) was estimated in the thigh muscles, liver and the brain. The protein value rises initially between 72-144 hours i.e., 3-6 days in both the sexes. This is perhaps due to the reason that protein is synthesized, stored (like glycogen) and is used as an energy resource to tide over the stress condition. But after 144 hours, the depletion in the protein begins and it is broken down through gluconeogenesis to meet the deficiency of the energy resources.

Temperature Tolerance in Two Insectivorous Desert Bats

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Rhinopoma microphyllum kinneari and *Taphozous perforatus perforatus*, two insectivorous desert bats which live on their biological reserves during the cold-dry seasons when food is not available to them were studied for temperature tolerance in Jodhpur (26°18' N Lat., and 73° 04' E Long.). These bats were weighed and kept in BOD beginning from 27°C. The temperature was raised initially by 2°C each day for 24 hours up to 37°C and then by 1°C till the bats breathed their last. It seems that the temperature and body weight are inversely proportional. While *R. M. kinneari* could withstand temperature up to 41°C; *T. p. perforatus* died at 39-40°C. During this period *R. m. kinneari* and *T. p. perforatus* l ost their body weight approximately by 34 and 18 percent respectively. Thus, it seems that of the two, *R. m. kinneari* is better adapted to xeric conditions.

Seasonal Fluctuations in the Urine Concentration of Certain Desert Bats

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Seasonal fluctuations in the urine concentration (milliOsmols/kg) were observed in three spcecies of bats: *Rhinopoma microphyllum kinneari, Taphozous perforatus perforatus* and *Pteropus giganteus giganteus.* Urine concentration varies seasonally but most concentrated urine is passed in the hot-dry season. The urine concentration depends upon the different level of urea present in the medullary zone of the kidney, and on the feeding habit of the bats. It is also influenced by the relative humidity and availability of drinking water. Small bats can conserve more water and thus are better adapted to a xeric mode of life. Insectivorous bats with protein rich diets excrete urine of higher concentration. *R. M. kinneari* produces the most concentrated urine and is best suited to xeric conditions.

Microscopic Structure and Seasonal Changes in the Kidneys of Certain Desert Bats

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Changes in the microscopic structure of kidneys were observed in two insectivorous bats: *Rhinopoma microphyllum kinneari. Taphozous perforatus perforatus* and a frugivorous bat *Pteropus giganteus giganteus* in Jodhpur (26°19' N Lat., 73°04' E Long.) a town at the eastern fringe of the Great Indian Desert in three different seasons (hot-dry, cool-wet and cold-dry). Nearly all the parameters vary seasonally. The variations in size and glomeruli are genetic. The distribution of glomeruli differs in bats with different feeding habits. Percent Medullary Thickness (PMT) and Relative Cortex Thickness (RCT) are inversely proportional. Higher PMT values suggest more absorption of water by the kidney. *R. m. kinneari* is is most efficiently adapted to the desert mode of life, followed by *T. p. perforatus*, while *P. g. giganteus* is least. The medulla :cortex ratio (M/C) is higher in insectivorous bats.

The Reproductive Cycle of Male *Hipposideros speoris* from Mahalingpur, Karnataka

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Hipposideros speoris widely distributed in Indian sub-continent shows great variations in its breeding season, in different areas. The annual reproductive cycle of male *H. speoris* from Mahalingpur (16° 23'N, 75° 07' E) of Karnataka State consists of 1) sexually quiescent or regressed (April to June), 2) recrudescence (July - August), 3) active (September - November), and 4) regressing (December - March) phases. During regressed period, the seminiferous tubule diameter is small with numerous Sertoli cells which are conspicuously pyknotic with ovoid to oblong nuclei situated towards the luminal side. The basally situated spermatogonia are the only germ cells present in completely regressed testis (May - June). The recrudescence period is characterized by gradual increase in the seminiferous tubule diameter, number of germ cells, especially the primary spermatocytes. During spermatogenetically active periods, there is sudden increase in the population of all germ cells, particularly that of spermatids which are maximum in October. The secondary spermatocytes are first found in August and are last seen in November; they are never numerous because of their apparent brief stage. Though the first sperms are observed in the testis in the month of July, their appearance in the epididymis and vas deferens is noted in September and are found till March. The Leydig cell nuclear diameter shows its peak in the month of November in synchrony with the development of accessory glands. The scrotal pad which grows considerably thick during the active spermatogenic period, a phenomenon not known in any other bats interestingly shows distinct secretory activity. The globular secretory material given out from the free border of epithelium forms homogenous material in the lumen.

The Anatomy of the Female Genitalia and the Arrangement and Structure of the Foetal Membranes in Mormoopidae

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In non-pregnant specimens of *Mormoops megaphylla* and *Pteronotus davyi* the uterus is bicornuate and bilaterally symmetrical. However, all pregnant females carried a single fetus in the right uterine cornu. At full term the amnion was a thin bilaminar membrane. The yolk-sac splanchnopleure occurred as a free, highly folded, vascular structure pushed towards the abembryonic non-vascular omphalopleure which was in close opposition with the uterine endometrium on the mesometrial side. The discoid chorio-allantoic placenta was located on the antimesometrial side and was composed of numerous placental tubules containing maternal blood. The placental tubules occurred in parallel rows in the fetal half of the placental disc, but they had formed a three-dimensional network in the deeper maternal half. Each placental tubule was made up of a maternal blood space surrounded by a single layer of syncytiotrophoblast. There was no remnant of maternal endothelium. Hence the placenta is designated as haemomonochorial. Allantoic mesenchyme and fetal blood capillaries occurred between the placental tubules. The female genital anatomy and the structure and arrangement of fetal membranes of Mormoopidae differ from those of other families included in Phyllostomoidea and bear resemblances to diverse families of Chiroptera.

Roost Preference, Population and Food Habits of the Indian Flying Fox *Pteropus giganteus* at Behra Dun

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We studied Indian flying fox at Behra Dun (30° 24' N; 78° 05' E) from January 1989 to December 1990 in the only roosting site in the town in a walled orchard. There were 113 trees (>20 cm BGH) comprising of *Eucalyptus* spp. (41.5%), *Grevillea robusta* (21.2%), *Sterculia alata* (15.0%), *Magifera indica* (6.1%), *Cinnamomum camphora* (4.4%), *Terminalia arjuna* (3.5%), *Shorea robusta* (2.6%), *Araucaria* spp. (1.7%) and others (3.5%). Sixty to eighty percent of the population roosted on *Eucalyptus* throughout the year while thick crowned *S. alata, T. arjuna* and *S. robusta* were used during summer. Population fluctuated over the year with a bimodal peak in June and September. Maximum population was seen in June, 1989 (ca. 7000 individuals) and in June 1990 (ca. 9000 individuals). The bimodal peak in population coincided with the fruiting season of Lichi (*Nephelium litchi*) in June and peak mating period in September. Population of < 2000 during winter suggested migration from the

orchard. Fruits of *Ficus religiosa*, *F. benzamina*, *F. glomerata*, *Melia azedarach*, Mango, Lichi, Jamun (*Syzygium cumini*) and Guava (*Psidium guajava*) were eaten. Captive feeding trials (n = 5) showed a mean consumption of 24 (range 20-30) Lichi fruits/day by an individual. Fruits with < 11 percent sugar content were not preferred.

Breeding Biology of Indian Flying Fox *Pteropus giganteus* at Dehra Dun, India

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Breeding biology of Indian flying fox (*Pteropus giganteus*) was studied at Dehra Dun (30° 24'n; 78° 05'E) from 1989 to December, 1990. In adult males (n = 95), testis weight was significantly more (P < 0.01) during July-September (mean 2.5 g) than rest of period (mean 1.4 g). Mating occurred during September-October with a peak during September suggesting seasonality in breeding. Presence of developed embryos (< 20 g; n = 7) in December suggested delayed implantation of about one or two months. Most females including pregnant ones migrated to other areas by the end of January. Their return to the nursery roost with young ones of less than a month old in May suggests parturition during April and a gestation of about five months. Both male and female young by about 12 months attained the adult body weight of ca. 650 g and were sexually mature. Only one young was born. Implanted embryos were seen 42% in left and 58% in right sides of uterine cornu (n = 31). Radio tracking of two mothers and their suckling juveniles of about two months old showed that, juveniles foraged independently from their mother near the nursery roost (< 300 m). The mother did not return to nurse the young from its foraging grounds. Juveniles attained half of their adult body weight within the weaning period of three months and thereafter foraged further away from the nursery roost (> 5 km). Deposition and utilization of sub-cutaneous fat was correlated with fruit availability and reproductive conditions.

Morpho-histological Study of the Intestine in Four Indian Bats

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Morphological and histological study of the intestine in two megachiropterans and two microchiropterans - *Cynopterus sphinx*, *Rousettus leschenaulti*, *Scotophilus heathi* and *Rhinopoma kinneari* - of different feeding habits have been made. The intestine differs in the length as compared to the total body length; blood supply; thickness of various muscle layers of muscularis externa; the thickness submucosa; shape, abundance, arrangement and height of villi of mucous membrane; abundance of Goblet cells, crypts of Lieberkuhn and Brunner's glands; plicae and crypts of mucosa. These variations have been correlated with their frugivorous, frugivorous-cum-nectarivorous, insectivorous-cum-frugivorous and insectivorous feeding habits and also from the point of view of phylogeny.

Cochlea Size in Extant Bat Communities and Middle Eocene Microchiropterans from Messel

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For the two microchiroptera *Icaronycteris index* early Eocene of Wyoming, the *Palaeochiropteryx tupaiodon*, early middle Eocene of Germany, it was reported that the size of the cochlea is as large as in extant microbats, and it was concluded that the echolocation system of these Eocine species was already very sophisticated. Recently, the size of the cochlea of six fossil species from Messel was related to the inner ear size of 298 extant chiropterans of all major higher taxa. In this study, high resolution radiographic measuring procedures disclose clear cut correlations between the diameter of the cochlea and the width of the skull. These correlations are markedly different for various taxonomic groups and also reflect different stages of acoustical specialization in extant chiroptera. The fossil microbats from Messel represent a rather isolated group of insect-feeding bats, compared to extant typical insect feeding bats the latter of which are characterized by larger size of the cochlea. This does not agree with previous studies. We suppose that the echolocation performance of Messel bats was less advanced and that this was one of the possible reasons for the extinction of these microchiropteran families ("Eochiroptera") during the Eocene and their replacement by modern families. The latter supposedly had evolved on southern continents and immigrated to Europe successively . The results presented also diminish one argument for the diphyletic origin of bats. The size of the cochlea does not separate micro- from megachiroptera. Rather it connects both groups, especially by the extinct microbats studied. The five stages of acoustical specialization derived from the size of the inner ears further suggests a polarity from echolocation with short multiharmonic sounds to echolocation with long

CF/FM sounds. This agrees with basic features in earlier concepts for the evolution of echolocation. The working hypothesis derived from extant microbats is discussed on the basis of outgroup data and comparison with local bat fauna of which echolocation and foraging behavior are known. The bat society of the Madurai region is one of these reference groups.

Pineal Control of Reproductive Cycles of the Indian Short Nosed Fruit Bat *Cynopterus sphinx*

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A study on the reproductive physiology of the Indian short nosed fruit bat, *Cynopterus sphinx* was made to determine the role of the pineal gland in the regulation of reproduction. We made a preliminary attempt to correlate the annual pineal-gonadal relationship and the effect of melatonin and long photoperiod on the reproductive activity of this animal. The annual pineal gland weight cycle exhibited an inverse relationship with the gonadal weight cycles. During the testicular/ovarian progressive phase (December-January) evening injection of melatonin (aMT) [15 µg/day/animal/S.C./30 days] retarded the recruducing gonads to an inactive state irrespective of the sex. It could be that endogenous melatonin along with exogenously administered melatonin reflected the gonadal inhibition. Hence, it may be suggested that the pineal and its hormone melatonin relays the regulatory messages perceived from the environment which controls seasonal reproduction of this bat. While exposing the animals to a long photoperiod (LP) of 16L:8D during active reproductive phase (February-March), we found an acceleration of the gonadal regression. As noted in the annual gonadal cycle, pineal gland weight of this bat under both the experimental conditions presented an inverse relationship with the gonadal weights. These experiments strongly support the hypothesis that the pineal gland of this bat is also a neuroendocrine transducer of photic information.

Histology of the Flight Membranes of Flying Foxes

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Samples were taken from a variety of locations on the wings of *Pteropus poliocephalus*. Tissue was mounted on frames to prevent curling and processed for light and electron microscopy via modified standard routines. The flight membrane had a dorsal and ventral epidermis with a common dermis in between. There was no hypodermis and all layers were greatly reduced in comparison to other mammalian skin. The epidermis consisted of three layers of active keratinocytes, covered by seven to ten layers of cornified cells. Melanocytes were generally confined to the basal layer and were more numerous in the dorsal epidermis. Prominent droplets of a lipid-like substance were found in the epidermal keratinocytes and these coalesced towards the superficial layers. It is postulated that these droplets contain a waterproofing agent. The dermis consisted of collagen bundles with a network of elastin bands. An array of mechanoreceptors was found on the wing surface. These receptors consisted of a dome-like structure with a protruding hair and are thought to provide information on airflow patterns over the wing.

Kinesthetic Orientation in the Lesser Spearnosed Bat, *Phyllostomus discolor*

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The neotropical bat *Phyllostomus discolor* lives in its day-roosts--mostly hollow trees--in colonies containing up to 400 individuals. Within these groups there are two different social substructures: 1) harems (1 male and up to 15 females); 2) bachelor-groups of subadult and adult males. Single adult males and females may also occur. The position of the harems and bachelor-groups inside the day-roost is very stable over time. This spatial stability may be of great importance for the social structure, as a bat returning from outside to its roost, has no need to search for its group members, but can directly proceed to the roosting-site of its group. Even to find the roosting-site, however, may be problematic owing to the darkness inside the day-roost, the simultaneous echolocation calls of many conspecifics, and a complex odour mixture of all the individual bats. In order to study the orientation mechanisms used in this situation, an artificial roost was constructed, consisting of an octagonal cylinder with four identical roosting sites in the upper part. The bats had to enter this apparatus through a start-box in the center of the bottom using a small ladder. Inside the cylinder the bats had to fly up to reach one of the four roosting-grids. After some days of habituation, most of the bats tested showed a significant preference for one grid. Rotating the whole cylinder inside the experimental room did not change this choice. By rotating the start-box with

the small ladder, it was shown that *P. discolor* finds its individual roosting-site without visual or acoustical cues from the environment: in these rotation-experiments all bats landed on the site that had the same relative position to the ladder as in the standard-experiments. A dim light as a visual marker of the preferred grid was ignored. The bats did not change their orientation mode in rotation-experiments of the start box, and also failed to compensate. Video-analysis of all approaches on the roosting-site demonstrated that *P. discolor* does not exactly reiterate the motor pattern of its approaches. As not only the rhythm of the wingbeats but even the flight-path itself could change, the term "idiothetic" best characterizes this mode of orientation.

Intermittent Breeding During the Annual Cycle of the Indian Pygmy Bat, *Pipistrellus mimus*

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Reproduction in the Indian pygmy bat *Pipistrellus mimus* was studied from May 1990 to May 1991 by tagging and observing the individuals throughout the year. *P. mimum* is a polyoestrus species, and mostly gives birth to twins. There are four distinct breeding seasons during a year. It was confirmed from the tagged individuals that the same females underwent parturition during at least three successive seasons. Each breeding season starts only after the young born in the previous breeding season become volant. The infants were never carried by the mothers to the foraging areas but were left inside the roost during the night. Females give birth at a minimal age of about 103 days. The interparturition interval of individual bats was 102.6 ± 12 days ($n = 12$).

Histochemical Studies on Corpora Lutea of Bats

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The corpora lutea of successive breeding and continuous breeding bats were studied. The corpus luteum was found in ovaries of pregnant females. Even rudimentary corpus luteum was found in nonfunctional ovary of the same female bat. It was found that corpora lutea of all chiroptera were larger than any other mammalian species. Two types of cells were found in corpus luteum viz theca lutein cells and the granulosa lutein cells. Histological, histochemical and biochemical aspects of corpora lutea were studied. PAS staining was moderate in corpus luteum, sudan black and oil red 'o' staining were intense in the cells of corpora lutea. GERL hypothesis in connection with secretary activities of corpus luteum was discussed. Its greater size and undo presence in non-functional ovary of pregnant females were also considered.

Seasonal Variations in the Cells of Pars Distalis in Male Bats, *Hipposideros speoris*

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Cell types in the pars distalis of male bats, *Hipposideros speoris* were studied by employing several staining methods. These cells were studied throughout the sex-cycle of this species. Six cell types were distinguished in the pars distalis. The somatotrophic cells (STH-cells) had affinity towards orange G and Luxal fast blue. The luteotrophic cells (LTH-cells) were stained red with Caroisin L (CL) in CL-orange G sequence, wherein STH-cells were stained orange. Corticotrophic cells (ACTH-cells) appeared blue-black with lead-haematoxylin staining method, in the various sequential staining methods, the thyrotrophic cells (TSH-cells) exhibited staining with periodic acid-Schiff (PAS), Alcian blue (AB) Aniline blue, Aldehyde fuchsin (AF) and Aldehyde (AT). Folliculotrophs (FSH-cells) were stained with PAS, AB, aniline blue and methyl blue. Luteotrophs (LH or ICSH-cells) could be distinguished from FSH and TSH cells in AB/PAS/Orange G Mallory's triple stain, Cleveland and Wolfe's trichrome and Masson's trichrome staining procedures. During the sexual quiescence, numerically more STH and TSH cells were observed as compared to the ACTH and LTH-cells. FSH and ICSH-cells could not be distinguished. FSH cells and few ICSH cells started appearing from the prebreeding period, significant changes were not observed in other cell types. During the active breeding period, prominent changes were observed in the ICSH cells which increased in their number and size. On the other hand FSH cells decreased in their size. With cessation of the breeding activities, few ICSH cells could be distinguished but no FSH cells during the post-breeding period. Significant changes were not seen in the other cell types.

Chemosignal Eliciting Specialised Skin Glands of Behavioural Relevance of the Megachiropteran Bat, *Pteropus giganteus*

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Animals of both sexes of *Pteropus giganteus* were trapped from Trivandrum Zoological Gardens, brought to the laboratory, wieghed and sexes. The animals were killed with over etherisation. Skin samples were carefully excised from various regions of behavioural relevance such as tarsal, oral angle, muzzle, cervical, sternal and perineal. They were processed for histophysiological observations. Autogrooming and allogrooming responses were also recorded.Data on histomorphological features revealed the presence of hypertrophied cutaneous glands at the tarsal, oral angle, muzzle, and perineal zones, Behavioural observations indicate that these specialised skin glandular secretions are deployed by these animals during their social interactions such as auto and allogrooming. Further conspecifics exhibit specific behavioural response involving olfactory investigations of specialised glandular zones very frequently. During male-female interactions, perineal chemosignals of female elicit courtship and sexual response in male culminating in copulation. Mother-infant interactions also involve considerable allogrooming of young one by the mother at certain specific body regions of olfactory relevance involving scent sharing and mother-infant bonding.

Correlation Between Sizes of Frontal Gland and Testis in an Insectivorous Bat *Hipposideros speoris*

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A sexual dimorphism is noted in the bat *Hipposideros speoris* where the frontal gland is present only in males and not in females. There is a positive correlation between the testis size and the size of the frontal gland but the correlation between the body weight and the size of the gland is negative. These correlations are confirmed through histological studies by analysing the glandular portion, diameter of the secretory vesicle in the frontal gland and the amount of spermatozoa in the testis. Our observations indicate that the males may mark the females with the secretions of the gland especially during reproductively active period.

Flight Performance, Echolocation and Foraging Behaviour in the Noctule *Nyctalus noctula*

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Noctules are relatively large (ca. 25 g) insectivorous bats with high wing loadings. Their flight is direct and they usually forage in clutter-free habitats. Flight performance was quantified by using stereophotogrammetry. At feeding sites bats flew at 5.8+- 1.8 m/s. , close to their predicted maximum range speed. The echolocation behaviour of noctules is flexible. Long duration, low frequency calls (ca. 20 kHz) with little frequency modulation were emitted while cruising, but at foraging sites the calls became more frequency modulated. Because the noctule is traditionally thought of as using low frequency echolocation allowing poor resolution of small targets, it was predicted that the species would specialize in eating large prey. Many small dipterans were found in the diet, however. The noctule is probably able to detect such small items because it uses calls which include broadband sweeps descending from high frequencies while foraging. Microphones of bat detectors often underestimate the importance of these high frequency components (and higher harmonics), as shown from comparisons with recordings made by a Bruel and Kjaer 1/4" microphone used in the field.

45 Observations on the Chorio-allantoic Placenta of the Indian Flying Fox, *Pteropus giganteus giganteus*

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The interhaemal membrane of the chorio-allantoic placenta varies from endotheliochorial to haemochorial bats. A controversy exists concerning the structure of the placenta membrane (barrier) in the definitive placenta of *P. giganteus* in that the chorio-allantoic placenta was first described as haemochorial but later as endotheliochorial.

The present study was undertaken to resolve this controversy. Bats in advance pregnancy were collected at Nagpur in November. Their placentas were examined by light and electron microscopy. The chorio-allantoic placenta of *P. giganteus* is discoidal, dichorial (both cytotrophoblast and syncytiotrophoblast persists), and mesometrial. Detached endothelial cells were observed in the maternal capillary lumen. The functional zone contains mono-and multinucleate giant cells. Under light microscopy a thick eosinophilic and aniline blue positive homogeneous layer was noticed below the endothelial cells as well as in the regions devoid of these cells. A PAS, reticulate and discontinuous interhaemal membrane of the chorio-allantoic placenta shows a transition from the endotheliochorial to haemochorial condition. A comparison of the *Pteropus* interhaemal membrane is presented contrasting it with the chorio-allantoic placenta in other bats.

Some Observations on *Hipposideros lankadiva*

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The present observations are based on 429 *Hipposideros lankadiva lankadiva* collected from two different geographical locations viz. Chandrapur in Maharashtra and Mandu in Madhya Pradesh since 1985 till to-data. At Chandrapur they were found in association with *H. speoris* whereas at Mandu they were found along with *Rousettus leschenaulti, Taphozous melanopogon, H. fulvus fulvus* and *Rhinolophus lepidus.* At Mandu the bats were found from November to April and were observed in semitorpor from December to March. AT Chandrapur they were found in active state from May to October. This suggests that this species is migratory in habit. During the breeding season males accumulate lots of fat and during August-September fatty outgrowths from the jaws protrude from the mouth. *H. lankadiva lankadiva* shows fur colour variation. Commonly they are fulvous brown followed by reddish brown and golden red. Bright golden red and pale yellow are rare. This species exhibits sexual segregation. Pairs in copulation were noticed at Ancheleshwar gate at Chandrapur during the last week of August until September first week. At Mandu it was observed that after the blastocyst implants the bats get into an extended period of developmental diapause (five months) during which they are in semitorpor. They arose from semitorpor from the end of March and by mid April they were not noticed at this roost. Delivered bats were collected from underground network of channels in a forest near Chandrapur in the last week of May.

Results of Surveys of Bats in Uganda

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Bats were sampled in three major regions of Uganda described here as western, northwestern and southern. The method of sampling employed mist nets deployed in the sampling areas with metre net hours (mnh) of exposure ranging from as low as 144 to 950490 mnh. The surveys were carried out between January 1990 and March 1992. The areas covered by this report represent much below 25% of the country's area. 31 species of bats representing about 57% of the known country record of bats were encountered. Species diversity is highest in the northwestern region where 16 species have been recorded with up to 81% of these insectivorous bats. The southern and western regions of the country have a higher diversity of fruit bats compared to the northwestern region (i.e. 45% and 61% respectively). Two species *Nycticeius schlieffeni* from the northwestern region and *Myonycteris torquate* from the western region are new records for Uganda. The most abundant bats *Micropteropus pusillus* are found in the northwestern and southern region, but not in the western region. *Rousettus aegyptiacus* is the most abundant in the western region. Insect bats are more difficult to capture which makes them appear less abundant.
Capture rate data is also presented for the different sampling areas in the 3 regions.

Passive Acoustic Orientation in the Vampire Bat, *Desmodus rotundus*

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Hearing thresholds in bats are rather low in the frequency range of their echolocation calls, but most species are also very sensitive to lower frequencies. Amazingly sometimes the range of best hearing is below 25 kHz. Many of these bats are "gleaners", picking up their prey from the ground or from leaves and branches. Vampire bats are also very sensitive to low frequency sounds, as shown by electrophysiological investigations in the inferior colliculus inferior. The most sensitive neurons in this acoustic area have best frequencies between 10 and 25 kHz. Optimum hearing is thus in a frequency range not needed for echolocation. Additionally some neurons responded

extremely sensitively, and some even exclusively, to complex noise stimuli like human breathing. In *Desmodus* the low frequency range may be of importance in locating its prey by passive acoustic orientation. Behavioral investigations with *Desmodus rotundus*, have shown that low frequency noise signals may also influence echolocation behavior. Jamming noise (white noise; 50 dB SPL) in the sonar range increased the detection threshold and *Desmodus* raised the intensity of its echolocation calls in this situation. When using jamming noise with frequencies below the echolocation range (10-20 kHz) the echolocation threshold was altered similarly. The hearing ability of *Desmodus* to low frequencies and the perception of prey generated sounds was investigated in a dual-choice apparatus. Five vampire bats were trained to locate specific acoustic stimuli for a food reward. In spite of intensive training, the animals did not respond to constant frequency pulses (15 kHz, 50 ms duration, 200 ms repetition rate) but easily located noise stimuli (filtered noise, 10-24 kHz). The noise threshold lay between 0 and 5 dB SPL. The vampire's perception of artificial and natural breathing sounds was tested.

Taxonomic Characters in the *Hipposideros bicolor*- group of the Indian Subcontinent

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The correct taxonomic identity of horseshoe bats of the *Hipposideros bicolor*- group, i.e. *bicolor* (including *atrox*), *ater*, *fulvus* (incl. *pallidus* and *atratus*), *cineraceus*, *durgadasi*, and *pomona* (incl. *gentillis* and *sinensis*) is of importance for physiological investigations of bat orientation and studies of behaviour to differentiate between variation on one side and species specific or intraspecific data on the other. Many recent descriptions of results obtained from these bats may be doubtful, because reference specimens of taxa studied are not deposited in collections and thus it is impossible to connect these results with a clearly defined taxonomic unit, especially if current taxonomic classifications are revised. Furthermore, species of the *bicolor*-group are involved in the epidemiology of Japan Encephalitis Virus (Banerjee et al. 1988). Recently collected reference material of the *H. bicolor*-group from S-Asia is studied by modern x-ray technics to reveal the taxonomic value of structures which until present were not or scarcely considered as specific characters. Proportions of the nasal chambers in the rostrum, shape of baculum, size and position of cochlea and bulla tympanica will be correlated with classical features (skull dimensions, tooth characters) used in taxonomy. Species specificity of nasal chamber proportions has been demonstrated by Kock (1969) for African sibling species of the genus *H. caffer* versus *ruber*. The significance of the nasal chambers for ultrasonic orientation, studied in one species of the closely related genus *Rhinolophus*, is not fully understood (Suthers et al. 1988). Correlation of cochlea morphology with echolocation in *H. fulvus* was investigated by Kraus (1983), however interspecific comparisons have not been made as yet. The many different forms of the baculum proved to be taxonomically significant, but was often demonstrated by single samples only. Nomenclatorial problems may become obvious, but will not be solved by the current study due to difficulties to trace type material of long established taxa

Systematic Studies on Nine Species of Korean Bats

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Four external and ten cranial characters of Korean bats representing nine species of two families were measured for morphometric analyses. Groupings by multivariate analyses did not seem to correspond well with the current classification above species level, and it is concluded that quantitative as well as qualitative characters have to be used for the classification of bats.

Bat systematics, 1989-1992

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Yoshiyuki has revised the status of several Japanese species and Yoon and Uchida have studied the humerus in relation to pteropodid systematics. Bergmans has continued his revision of African Megachiroptera. Flannery has described a new species of *Pteralopex*. Kitchener and Maharadatunkamsi have described a few species of *Cynopterus* and recognized others. Peterson has revived a species of *Nyctimene*. Griffiths *et al.*., also Griffiths and Smith have revised the generic and subfamily systematics of Emballonuridae. Yoshiyuki has done taxonomic work on *Rhinolophus* and *Hipposideros*. Gardner and Ferrell made nomenclatorial changes in neotropical phyllostomids.

Alvarez and Eastaneda raised a subspecies of *Hylonycteris* to specific rank. Handley and Owen each made taxonomic changes in *Artibeus* and related genera including a new genus. Volleth and Tidemann have discussed relationships of Australasian Vespertilioninae. Bogdanowicz has treated *Myotis daubentoni*. Frost has revised relationships of plecotines and Yoshiyuki has described a new species of *Plecotus*. Palmeirim has revised a species of *Nyctalus*. Koopman and Danforth treated the systematics of *Murina*. Owen et al. dealt with *Tadarida brasiliensis*, while Dolan revised Middle America *Molossus*.

Histological Study of the Male Reproductive Organs of an Indian Horse-Shoe Bat, *Hipposideros speoris* in Breeding and Non-Breeding Seasons

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Hipposideros speoris is a non-hibernating microchiropteran bat found in India. The mature as well as immature males are available throughout the year. Active sperm formation occurs in the mature males during the breeding season i.e. October to December. Thereafter, the process of sperm formation attains the quiescent state. Histologically the caput, the corpus and the caudal regions of the epididymis are distinct and non-breeding season, but the distinction is abolished during the breeding season. A pair of ampullae of Henle, a prostate gland, urethral glands and a pair of Cowper's gland release their secretion into the urethra. The closely placed ampullae of Henle are separated by a fibromuscular septum. Each ampulla receives a deferent duct which opens dorso-laterally. The ampulla is divided into many lobes. Each lobe consists of many diverticula which are lined with simple low columnar epithelium. The short ejaculatory ducts of either side open into the crista urethrae. The girdle of the prostate gland has massive ventro-lateral lobes. The tubules of the gland are lined with simple cuboidal epithelium. The prostatic ducts open into the crista urethrae. The urethral glands are situated all around the part of urethra between the prostate gland and the penial bulb. The glands are covered by a thin layer of circular non-striated muscle layer. This part of urethra has two lateral strips of striated muscles. The urethral glands are typical mucous secreting glands, the ducts of which open at intervals into the urethra. The Cowper's glands are covered and supported by tough and fibrous connective tissue. Its tubules are lined with simple low cuboidal epithelium. The excretory duct of each gland opens separately on the penial bulb. The penis is surrounded by the disc-like scrotum. The scrotal glands are compactly arranged compound tubular glands which open on the scrotal and penial skin. The glands are rough surfaced but devoid of spines or scales. The urethra runs dorsal to the penial musculature and opens terminally into the penial groove. The prepuce is elongated and without any gland. The os-penis is small and conical.

Population Size and Emergence Order of the Fruit-bat *Rousettus aegyptiacus*

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Population size and emergence order of the fruit-bat, *Rousettus aegyptiacus*, were studied in a maternity cave in Haifa, Israel. Monthly counts of emerging bats were conducted from February 1989 through February 1992, and the sequence of nocturnal emergence was determined by mist net capture at the cave entrance. Population trends were similar in all three years, with the lowest number of bats during the winter months from December to early spring (March). Thereafter, the population size increased through mid June. During the summer months and early autumn (July-October), the population size remained relatively stable, followed by a second increase in late autumn (November), and a subsequent drop to minimum levels during the winter months. During the spring, summer, and autumn, reproductive adult females (pregnant and lactating) emerged from the cave before the juveniles or adult males, suggesting that the emergence sequence is effected by social factors and by differences in nutritional demands.

Ultrastructural Studies of Interhemal Membrane in Three Species of Hipposiderid Bats

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The definitive interhemal membrane in three species of hipposiderid bats has been studied by electron microscopy. These species of bats belonging to the family Hipposideridae, illustrate a different kind of interhemal

membrane. The fine structure of the definitive dis coidal chorio-allantoic placental barrier of *Hipposideros lankadiva* is essentially of endotheliodichorial type due to the presence of two layers of trophoblast, viz, syncytiotrophoblast and cytotrophoblast. The syncytiotrophoblast is characterized by numerous Golgi zones and coated vesicles, indicating high secretory activity. In contrast, the cytotrophoblast does not show the well organized cytoplasmic organelles. The maternal endothelium is also well developed. The interstitial membrane is discontinuous. In *H. speoris*, the chorio-allantoic placenta is found to be endotheliomonochorial due to the presence of maternal endothelium and a single layer of syncytiotrophoblast. The syncytiotrophoblast shows higher deposition of cell organelles towards the maternal endothelium than towards the foetal endothelium. The latter part is rather spongy in appearance with a dense network of parallel cisternae of granular endoplasmic reticulum. The interstitial membrane is discontinuous. The placental barrier of *H. fulvus fulvus* is hemodichorial due to the presence of two layers of trophoblast and the absence of maternal endothelium. The syncytiotrophoblast is thick and continuous. It has sparse endoplasmic reticulum, large lipid bodies, dense granules and fine tubular filaments with numerous desmosomes, in addition to the normal cell organelles. The cytotrophoblast is continuous, unicellular and well defined. The intrasyncytial lamina is discontinuous, irregularly thickened and homogenous.

Adaptational Transformations in the Respiratory System of Bats

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Respiratory proper, airway and respiratory-motor organs of bats were included in this complex morpho-physiological study. There were established differences among: dimensions of alveoli, number of lungs lobes, degree of development of nasal cavity respiratory area, the vascularisation of the nasal cavity and the nasopharyngeal duct. Respiratory-motor organs show the greatest difference with reference to: the shape of the thorax and its elements, the mode of joining amongst thorax elements, the mobility of the thorax, degree of development or reduction of thorax muscles and the abdomen wall, prevailing of the costal or the abdominal breathing. Thus, organs of the bat respiratory system, which have a topographical connection with organs of locomotion, have undergone several changes. Our results permit the consideration of the morphological radiation f bats is obliged to using to a certain degree of the quadrupedal locomotion. Active using of the quadrupedal locomotion (by a majority of bats) assumes a presence of morphophysiological ties between organs of the locomotor system and the respiratory system (just as an ancestral bat forms) i.e. preserving the ancestral trait of the structure. Eliminating of the quadrupedal locomotion (Rhinolophidae, Hipposideridae, some Vespertilionidae) leads to a sharp change in the structure of respiratory organs of bats from those of the ancestral bat forms.

Quantitative Aspect of Ovarian Follicular Development in an Indian Vespertilionid Bat, *Scotophilus heathi* with Reference to Delayed Ovulation

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Follicular growth and kinetic studies in the ovaries of *S. heathi* indicate that antral follicles recruited during November survive till ovulation in early March. Thus, like the temperate zone vespertilionid bat, *S. heathi* also exhibits prolonged survival of antral follicles and delayed ovulation. Two waves of follicular growth appear to be initiated: One in October, November, and another in February. The first wave of follicular growth results in the appearance of 2-3 antral follicles in each ovary. These antral follicles grow slowly and survive till ovulation in March. They differ from typical mammalian Graafian follicles in that the cells of their cumulus oophoricus are relatively large, hypertrophied and vesicular. The second wave of follicular growth resulted in a fresh recruitment of antral follicles, which showed normal granulosa cells and one single large antrum. The selection of a dominant follicle occurs probably in late February, which coincides with the enhancement in steroidogenic activity of the ovary. *S. heathi* parturates and wean two young in July-August, when there is abundance of insects which form the food of this species. Thus, it may be reasonable to state that delayed ovulation in *S. heathi* may simply be a strategy to time lactation and weaning to the most appropriate period of the year using a period of reproduction quiescence.

Ultrastructure and Histoenzymology of the Testes and Epididymis after Clomiphene Citrate Treatment in the Bat, *Rousettus leschenaulti*

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The short term effects of oral administration of clomiphene citrate, on the ultrastructure and the histoenzymology of the testes and the epididymis is investigated in adult male bats. Thirty days after the treatment, the morphology of the reproductive organs is found to be altered. The testes and the epididymis show an accumulation of large number of lipid droplets, dense bodies and lysosomes. The Sertoli cells and germinal cells show atrophy and spermatogenesis is arrested at the primary spermatocyte stage. The epididymal epithelium shows a slight reduction in height and cytoplasmic organelles, but the lumen is full of spermatozoa. Following ;the clomiphene citrate treatment, there is a reduction in the LDH and SDH enzyme content and an increase in the Alkapase and Acpase within the testes. The epididymal enzymes also show a varied spectrum of results. The relevance of this differential concentration f the enzyme and the significance of the morphological alteration of the reproductive organs will be discussed.

Reproductive Energetics and Parental Investment in Free-ranging Bats

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Recent research on reproductive energetics of free-ranging bats has extended our knowledge of lactational costs and the ecological cost of transport. Estimates of field metabolic rates and activity budgets, empirical estimates of flight costs, estimates of milk energy output, and the assessment of life-time reproductive success, are several important criteria needed to quantify maternal investment patterns in free-ranging mammals. Bats provide exceptional opportunities for assessing maternal investment and proximal costs of reproduction. They are of special interest energetically, since females of most species suckle their pups until they almost approach adult size. By contrast, young of most other eutherian mammals are weaned and begin to feed independently well before they attain 40% of adult body size. Since milk is the only source of nourishment and exogenous water before most young bats can fly, the energy investment that mothers make in their pups during lactation may account for as much as 60% of a female's daily energy budget. Although milk energy output during lactation represents a major component of maternal investment in bats, recent estimates of daily energy expenditure (DEE) have revealed that transport (foraging) costs also account for a substantial share of a bat's DEE. Although the ecological costs of transport among bats (30-50% of DEE) appear to be comparable to birds which use similar foraging strategies, the ecological cost of transport among terrestrial mammals accounts for less than 5% of DEE. These patterns are discussed in the context of parental investment strategies.

Spermatogenesis in Indian Bats and the Role of Certain Lysosomal Hydrolases in the Process

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Intricate cytological and biochemical changes occur in the spermatogonial cells as they enter the phases of growth, cell division (meiotic and mitotic), differentiation, and maturation that are an inherent component of the spermatogenic process in mammals. Using PAS Weigert's haemotoxylin staining techniques, and taking changes in the nuclear morphology of germ cells, and steps in the differentiation of spermatids as the parameter of evaluation, it was possible to identify a variety of spermatogonia, premeiotic spermatocytes, and differentiating spermatids characteristically associated in the seminiferous tubules of various bat genera. Differences were observed in the a) number of cell associations, b) spermiogenic steps, c) frequency of cell associations, and d) the stage in which the sperm are released into the lumen of the seminiferous tubules. Thus, the number of cell associations and the spermiogenic steps respectively were 12 and 17 in *Pteropus giganteus giganteus* 11 and 17 in *Cynopterus sphinx*, 12 and 17 in *Rhinopoma kinneari*, 12 and 18 in *Hipposideros fulvus fulvus* and 12 and 17 in *Taphozous melanopogon melanopogon*. Histochemical profile of certain lysosomal hydrolases exhibited a) stage - specific and b) species - specific and b) species - specific characteristics.

Ecology of the Bat Fauna of a Semi-Arid Region of Southern Australia

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An ecological survey of bats was undertaken in a semi-arid region of southern Australia. A sampling effort of 595 trap-nights using harp traps and 595 mist net-hours resulted in the capture of 2075 individuals of ten species. Three additional species had been recorded previously, resulting in a total of 13 species from four families known from the region (1 Pteropodidae, 1 Emballonuridae, 2 Molossidae, 9 Vespertilionidae). Capture success during the study varied between species, with five species comprising 93% of all captures. The overall capture rate was much lower than that for temperate forested areas of southern Australia. Habitat use by each species was examined in relation to four broad vegetation types: riverine woodland, dryland woodland, open woodland/grassland and mallee scrub. There were marked variations in the weight and activity patterns of most species, which correspond with seasonal changes in temperature. Reproductive patterns were also seasonal, with births for all species occurring in late spring/early summer. Aspects of the composition and ecological characteristics of semiarid bat assemblages of Australia are discussed and contrasted with those from elsewhere in the world.

Observations on Roosting Behavior, Food Habits, and Reproduction of Some Bats from Kerala

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This report embodies studies on 16 species of bats from Trichur district in Kerala. In some cases, the field and laboratory studies are supplemented by studies on specimens kept in captivity for periods varying from a few days to more than two years. *Cynopterus sphinx sphinx* was also bred in captivity. In most species, the roosting sites and behavior are highly specific. Although most of the species are specific in their food choice, they become more cosmopolitan in captivity. *Megaderma spasma* is cannibalistic in captivity some times. Most species are monotocous and breed in a strictly defined season which differs in different species. *C. sphinx sphinx* breeds twice in a year in quick succession with the lactation period of the first pregnancy cycle overlapping the early gestation of the second cycle which is followed by an anoestrous period for about four months. Monotoky is associated with varying degrees of physiological asymmetry of the female genitalia. Some vespertilionids bring forth two, sometimes three, young during each cycle. *Pipistrellus dormeri* and *P. mimus* breed all year round. It is highly probable that there are many species of bats in Kerala as yet unidentified and undescribed.

The Influence of Age on Breeding Success in Reproductively Mature Female *Rousettus aegyptiacus*

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A comparison of the breeding success of 879 mature female *Rousettus aegyptiacus* showed that there were significant differences related to age. As part of a capture-mark-recapture study, reproductively mature females were palpated for the presence of embryos and milk. A female was judged to be a successful breeder if embryos or milk could be detected. Parous females were identified by elongated nipples whereas non-parous females had minute nipples. Early stages of pregnancy were overlooked until the embryo was large enough to be detected by palpation. Mature females were assigned to one of seven age groups on the basis of occlusal wear on maxillary canines. Analysis of data from each month made it possible to establish the annual breeding cycle. Changes in body mass, incidence of pregnancies, presence of pups, or milk in females, all contributed to our understanding of the annual breeding cycle. *Rousettus aegyptiacus* has two main birth peaks in Israel, one in April and another in late August and September. In June, most of the parous females (67%) were simultaneously pregnant and lactating, indicating a post-partum estrus; most of these females had two pups per year. The breeding success of the oldest and youngest females was 90% and 70% respectively. When females in early stages of pregnancy were omitted from our analysis (November to February), the overall breeding success was higher as expected, but the oldest bats were still significantly more successful than the youngest ones.

Cell Types and Innervation in the Carotid Body of *Scotophilus heathi* the Indian House Bat

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The carotid body in *Scotophilus heathi* is kidney shaped, situated in between the internal carotid and the occipital arteries, 1.5 mm after the origin of the internal carotid artery. The blood supply to the carotid body is from a fine branch arising from the internal carotid artery from a point adjacent to the carotid body. The glossopharyngeal and the vagus nerves supply the carotid body directly through their branches while the sympathetic nerve supply to the carotid body is from the superior cervical ganglion. In *S. heathi* the cells of the carotid body are all solitary without being arranged into groups. The concave side of the carotid body contains more connective tissue which extends to the interior of the body and this part is occupied exclusively by the connective tissue and hardly contains any of the specific cells. Cell type I and type II, have clearly been observed in the carotid body. Rounded cells which are very few in number but are much larger than the specific cell type I, have also been observed. Their cytoplasm is very granular and vacuolated and a large spherical lightly stained nucleus is present in the center. The nuclei of some of the type I cells are located near the cell boundary. A few specific cells of the type I having two nuclei, have also been observed. The cell type II are present in between the type I cells. Myoepitheliod cells are exclusively present in the connective tissue core in the concave part of the carotid body. Arteriovenous anastomoses infiltrate the glomerular tissue to such an extent that every specific glomus cell appears to be in contact with the fine capillaries. The extensive infiltration of the blood capillaries into the glomus cells and the medullated and nonmedullated nerve fibres supplying the specific cells, both support the view that the carotid body should be a chemoreceptor. As reported by De Kock, light and dark cells have been clearly observed.

Studies on the Pituitary Adrenal Axis After Experimental Manipulation in the Bat, *Rousettus leschenaulti*

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The anterior pituitary and adrenal glands were studied in adult male bats, *Rousettus leschenaulti* following the treatment with hydrocortisone acetate, DOCA, cortisone acetate, Dexamethasone and metyrapone for 20 and 30 days. There was a complete degranulation of ACTH cells in anterior pituitary after hydrocortisone and cortisone acetate treatments. The zona reticularis layer particularly was observed to be affected by hydrocortisone and cortisone acetate treatments as it underwent reduction in the width. After deoxycorticosterone acetate and Dexamethasone treatments, the ACTH cells underwent a marked hypertrophy and were significantly larger than those of control. Similar changes were observed in the adrenal gland as in the case of hydrocortisone and cortisone acetate treated bats. After 30 days of metyrapone treatment, conspicuous hypertropy, hyperplasia and degranulation of the ACTH cells were observed. The adrenal cortex showed significant increase in size due to the hyperplasia and hypertrophy of cells in zona fasciculata and zona reticularis. Administration of exogenous, corticosteroids provide further information about the ACTH secreting cells in anterior pituitary.

Functional Significance of the Cells in the Pars Anterior of the Pituitary Gland of the Indian Fruit Bat, *Rousettus leschenaulti*

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The anterior pituitary of normal and experimental male and female bats were examined by light microscopy. On the basis of their tinctorial affinities, six types of cells viz. somatotrophic (STH), lactotrophic (LTH), thyrotrophic (TSH), folloculotrophic (FSH), luteotrophic (LH/ICSH), and corticotrophic (ACTH), were identified. A marked predominance of STH and LTH cells were present in the intact adult male, female and pregnant bats' pituitary glands. The two gonadotrophic cell types were randomly distributed throughout the gland. Hypertrophy of two gonadotrophs was observed in response to the pathophysiological changes in the animals due to gonadectomy, oestrogen testosterone and the male antifertility drugs like cyproterone acetate, depoprovera, gossypol and clomiphene citrate. TSH and ACTH cells were identified after treatment with propyl thiouracil, thyroxine, metapyrone, DOCA, cortisone acetate, hydrocortisone acetate and dexamethasone and subsequent observations of the hypertrophic cells in the anterior pituitary. On the pathological conditions of bats, the possible functional significance of different cell types are discussed.

The Productive Biology of Australian Flying Foxes (Genus *Pteropus*)

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We have studied seasonal reproduction in wild/captive *Pteropus poliocephalus* , *P. alecto*, and *P.scapulatus* . Females deliver one young after six month's gestation. Distributions of *poliocephalus* and *alecto* births [in spring] have steep leading and shallow trailing-edges and do not differ significantly between species, years, or latitude. *Sapulatus* is highly nomadic and gives birth six months out of phase with *poliocephalus* and *alecto*. Males show marked seasonal changes in testes, testosterone and accessory glands. Steroid-binding-globulin is undetectable; high levels of corticosteroid-binding-globulin, cortisol and progesterone are present in males and females [including castrates]. S males are not reproductively photoresponsive; *poliosephalus* males respond slowly to altered photoperiod. Females show no marked vaginal changes or distinct behavioral oestrus. Plasma progesterone and androgens do not change significantly in the breeding season/early pregnancy. Inhibin is a useful marker of ovarian function [high levels secreted by CL]. Ovaries are encapsulated [follicles/CL remain internal, serial sections are required for diagnosis]. Primordial follicles are segregated caudally; cranially, an ovarian venous sinus encloses the coiled artery supplying the uterus. This arrangement [probably common to all megachiroptera] allows preferential transfer of ovarian steroid hormones to ipsilateral uterus for localised endometrial growth. Segregation experiments indicate *poliosephalus* and *alecto* ovulate spontaneously. Regulation of ovarian function remains an enigma.

Autonomic Innervation of the Gut of *Rhinopoma kinneari*

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Since bats rest most of the time in an inverted position, many biological functions seem to be modified. Intestinal peristalsis is one of them. Because of the "against the gravity action" the peristalsis is supposed to be stronger accompanied by several supporting reflexes. In the present study, the sympathetic and parasympathetic innervation of the intestine of *Rhinopoma kinneari* has been studied through dissections as well as through histological preparations. General innervation was studied using methylene blue and silver reduction techniques. The sympathetic and parasympathetic contributions were studied using fluorescence histochemistry and acetylcholinesterase localization. Complex nerve distribution patterns and various plexus have been described. These structures are associated with various types of nerve endings, nerve cells and ganglia forming local reflex areas which accomplish the complex peristaltic action.

Functional Morphology and Histochemistry of the Heart of *Pteropus giganteus*

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Despite many similarities with birds, bats have many peculiarities which correspond to their orientation at rest. In the present study, the cardiovascular structures of *Pteropus giganteus* have been reported. The sinoatrial node is found to be large unlike other mammalian species. Cytometric study of the heart suggests many differences in different regions of the heart. Myocardial extension over the pulmonary vein suggests the possible role in forcing blood into the left atrium. Innervation of the great blood vessels, myocardium and specialized conducting tissue has been reported. Numerous ganglia have been observed in the vicinity of the nodal regions. Various types of nerve endings have been reported along with intramural nerve plexus and nerve cells. Histochemical study of acetylcholinesterase suggests high vagal control over the sinoatrial node and the atrial myocardium. Localization of glycogen has been correlated with the activity of the different regions.

Bat Activity in a Mixed Lowland Woodland in Relationship to Insect Prey Availability

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Little is known about the specific habitat requirements or preferences of woodland bats or of the relative importance of the different habitats found in woodlands to foraging bats. Walsh and Mayle (1991) showed that greatest bat activity occurred over ponds and in woodland rides in a mixed lowland woodland and suggested that this was probably due to an increase in insect species diversity and density at these sites. Bat activity and insect availability were investigated in five habitats of a mixed lowland woodland in southern UK from mid-May to the end

of July 1991. At each site, bat activity was recorded for 3 x 5 minutes through a QMC S200 Bat Detector onto a cassette tape recorder, and sticky traps were placed at 0, 2 and 4 metres to sample nocturnal insects. Bat activity was greatest in pond habitats. Significantly more insects (weight and species) were caught in felled and pond sites; most insects being caught at gound level. Insect biomass increased with increase temperature. Habitat type and the proportion of 5-10 mm insects caught explained 37% of the variation in bat passes. Results support the view of Walsh and Mayle (1991) and suggest that the creation and sensitive management of ponds will improve woodlands for foraging bats.

Fruit Bat Conservation in India: Establishg a Coherent Conservation Policy

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Old world phytophagous bats play an extremely important role as pollen and seed dispersers in tropical ecosystems, and their significance in preserving and regenerating forests has only recently been recognized. By propagating key plant species on which many other forms of life depend, bats help maintain biodiversity and prevent extinctions. Many plants that bats pollinate and disperse are of considerable economic, medicinal and religious importance. While numerous countries have taken steps toward fruit bat conservation, India has disregarded the subject. Unawareness and ignorance of the beneficiality of fruit bats, coupled with misconceptions and unjust persecution as crop pests, have resulted in their categorization as vermin in Schedule V of the Indian Wildlife Protection Act. Ironically, India's only endemic fruit bat species (and genus), and one of the world's rarest bats, *Latidens salimalii* , is probably close to extinction. I present the results of an ongoing study of a fruit bat community in Sikkim, and outline how such ecological research combined with population monitoring, `education programs, and preservation activities can help conserve these immensely important animals and their environment. However, we must first strive to achieve an immediate reclassification of fruit bats in the Wildlife Protection Act so that they may be afforded adequate protection in this country.

Seasonal Changes in Non-specific Esterases in the Testes of the Bat *Cynopterus sphinx sphinx*

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Non-specific esterases were studied in the testes of *C. sphinx* by α-naphthyl acetate and 5 boromoindo acetate as substrates and eserine sulphate (10-4 M) as an enzyme inhibitor. The diffused cytoplasmic staining was eserine sensitive, whereas the granular staining was eserine resistant. Very weak and diffused cytoplasmic staining was observed in the germinal epithelial cells during the sexual quiescence. During the prebreeding, gradually weak to moderate staining was observed in the germinal epithelial cells, spermatogonia, but moderate to intense staining in the spermatids, sertoli cells and leydig cells. Eserine resistant intense staining was also seen in the acrosome of spermatozoa during the late breeding period. Similar results were noted in the aforementioned cells, except that the staining intensities were further increased. The number of spermatozoa was also increased during the active breeding period of the second sex-cycle. The rate of spermatogenesis was slightly reduced during the intervening period. During the post breeding period, an intense enzyme activity was evident mainly in the sperm debris and hypotrophying sertoli cells and leydig cells than the other cells, the staining being eserine resistant.

Studies on Aspartate Aminotransferases and Alanine Aminotransferases from *Cynopterus sphinx* and *Taphozous melanopogon*

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The aminotransferases play an important role in the nitrogen metabolism in mammals. Aspartate aminotransferase - AspAT (EC 2.6.1.2.) and alanine aminotransferase - AlaAT (EC 2.6.1.2.) were extracted from the liver of *Cynopterus sphinx* (a frugivorous bat) and *Taphozous melanopogon* (an insectivorous bat) and kinetic parameters like K_m and V_{max} were established. The two enzymes were exhibited variations in efficiency as indicated by the K_m/V_{max} ratios, in the two species under investigation. The results are discussed in the light of available literature.

Flight Mechanics

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Flight in animals includes *gliding* flight, which costs a minimum of energy, and *flapping* flight, which is very expensive. Some bats can glide, but they seldom do; some small bats sometimes use very short glides, whereas larger Pteropodids have been observed to glide in regions of rising air over a slope (slope lift). Active flight is a very efficient way to transport a unit of mass over a unit of distance, even though it requires extremely high power output (work per unit time). Flying animals can move more quickly than running ones, and flight also permits an animal to reach otherwise inaccessible foraging sites. The obvious advantage of flight makes it easy to understand why flying animals have undergone such dramatic adaptive radiations; the 900+ species of bats make up the second largest group of mammals. Bat flight is complicated, but can be understood by the application of aerodynamic theory. Because powered flight is very expensive, it requires a high degree of morphological adaptations. The connection between wing and body shape and the elicited aerodynamic forces during flight is discussed, as is the relation between wing morphology, flight pattern and foraging behavior in bats.

Seasonal Prolapse in Male Greyheaded flying foxes, *Pteropus poliocephalus*

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Plasma prolactin (PRL) was investigated in Australian greyheaded flying foxes, *Pteropus poliocephalus*, which mate in autumn (March/April). Three groups of four adult males were used: group A, in a breeding colony had been adapted to handling and bleeding procedures; group B (also adapted) and group C (naive) were in a sex-segregated colony. Blood was collected monthly and testicular volume ;(TV) and bodyweight (BW) were recorded. PRL was measured by radioimmunoassay, using anti-human antiserum (McNeilly and Friesen, Endocrinol. 102: 1539-1547, 1978) and ovine PRL for standards and iodination. Homogenates of pituitary diluted in parallel with the standard curve. PRL concentrations were log transformed before analysis of variance. TV and BW were maximum in April (McGuckin and Blackshaw, Aust. J. Biol. Sci. 40: 211-220, 1987). In contrast, plasma PRL was significantly elevated in summer ($P < 0.001$, one-way ANOVA), and in group B ($p < 0.05$). The summer elevation in PRL appeared similar to those in other seasonal breeders, but there was no effect of breeding activity of unfamiliarity with experimental procedures.

Olfactory Discrimination in the Australian Flying-Foxes, *Pteropus poliocephalus* and *P. scapulatus*

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Flying foxes have long been noted for their ability to locate flowers and fruit over considerable distances. It is thought that olfaction plays a major role in this regard despite the paucity of evidence to support such a hypothesis. In this study, using food rewarded preference trails and a Pteropus 'crawl chamber' *P. poliocephalus* showed an ability to select compartments containing fruit-derived odors at a decision distance of 125 mm. A hierarchy of preference between eight fruit odors was found for *P. poliocephalus*, with banana being most preferred and passion fruit the least (based on a visit duration measure), though analysis of the response variables indicates that the hierarchy is not linear. Test odors were analyzed using gas chromatography-mass spectrometry to identify contributory flavor and character impact compounds, however, there appears to be no relationship between volatile composition of the test odors and the position of the odor in the preference hierarchy. Similar methodology was used to compare the discriminatory capacity of the essentially nectar-feeding *P. scapulatus* with that of the fruit and flower-eating *P. poliocephalus*.

Behavioral Factors Determining Potential Gene Flow Among Colonies of *Miniopterus schreibersii*

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Miniopterus schreibersii forms large colonies in caves and mines throughout most of the yearly cycle, during which it uses several different roosts. The migratory movements between all known roosts in Portugal have been closely monitored to study the factors likely to determine the potential gene flow among colonies: juvenile dispersal, colony switching by adults, and mating with individuals of other colonies. Juvenile dispersal to other breeding colonies was found to be rare, for both males (n = 20) and females (n = 31). Only one male appeared during the breeding season in a colony different from the one where it was born. Switching of adults between breeding colonies is also a very rare phenomenon; all adult breeding females returned to the same breeding colony year after year (n = 154). Adult males also showed great site fidelity during the breeding season, never appearing in different colonies during this period (n = 31). Mating with individuals from different colonies is responsible for a great amount of gene flow among some colonies, because bats from several colonies use the same roosts during the mating season. The degree of intermixture of colonies was found to be highly variable; some colonies, or groups of colonies, are almost completely isolated.

Ultrastructural Development of the Interhemal Membrane in Two Species of Rhinopomid Bats

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The present study was planned so as to examine the fine structure of the interhemal membrane in two species of rhinopomid bats, *Rhinopoma microphyllum* and *R. hardwickei hardwickei* by using electron microscopy during the different stages of embryonic development. In *R. microphyllum* the interhemal membrane is typical of endotheliochorial type throughout gestation, and it consists of all the placental elements viz. hypertrophied maternal endothelial cells, discontinuous interstitial membrane, a continuous layers of syncytiotrophoblast and cytotrophoblast, basal lamina and fetal mesenchyme along with fetal capillaries. Thus, the final discoidal chorioallantoic placenta is designated as endotheliodichorial. The cytoarchitecture of each layer has been discussed. In *R. hardwickei hardwickei*, the interhemal membrane is endotheliodichorial up to late limb-bud stage of embryonic development. From mid pregnancy onwards the interhemal membrane shows the presence of well developed maternal endothelium, a discontinuous interstitial membrane, a single layer of well defined cytotrophoblast and fetal mesenchyme along with fetal capillary. Electron microscopic examination of near term placentas confirmed that the interhemal barrier is endotheliomonochorial and lacked a continuous layer of syncytiotrophoblast.

Structure of Rete Testis and Epididymis in the Fruit Bat *Rousettus leschenaulti*

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The rete testis system of the bat, *Rousettus leschenaulti* is composed of transitional zones of seminiferous tubules, tubuli recti, intra and extra testicular parts. At the transitional zones, the seminiferous tubules become progressively depleted of germ cells and finally exhibit only Sertoli cells and spermatogonia. They often show no lumen. The tubuli recti run a short distance to join the intra-testicular rete by a narrow opening. The tubuli recti and the intra testicular rete are lined by cuboidal epithelium. The intra-testicular rete is a simple tubular structure which extends to the exterior through the tunica albugenia as extra-testicular rete. The latter is cylindrical structure lined by loose cuboidal cells and surrounded by muscular layers. The extra testicular rete gives out 2-4 vasa efferentia and the junction between the two is end-to-end with a sudden change in the epithelium from heterochromatic cells to euchromatic cells. The epididymis of *R. leschenaulti* is divisible into seven zones. The first three zones correspond to the caput, zone IV is intermediary between caput and corpus. Zone V corresponds to corpus and the last two zones to the cauda epididymis. Zone I is largely made up of vasa efferentia which are lined by ciliated and nonciliated cells. The vasa efferentia join the epididymis in an end-to-end fashion with a sudden change in the epithelial height. The epithelial height in zone I is the greatest of all zones (55.84 μm) but decreases progressively to minimum (8.1 μm) at the cauda epididymis. The lumen is very narrow and contains few spermatozoa. Its epithelium is composed of principal, basal, apical and narrow cells. The principal cell cytoplasm

in II and III zones possess vacuoles at the sub-nuclear area. The epithelial height of the corpus epididymis increases slightly more compared to that seen in zone IV and VI. Zones VI and VII correspond to the cauda epididymis. They possess a wide lumen engorged with spermatozoa. Their epithelium consists of principal, basal and halo cells. Clear cells found in other mammals were absent in the bat. The apical and narrow cells are present throughout the length of the epididymis. The cauda epididymis and the vas deferens join with their ends. The basal cells are absent in the vas deferens. The principal cells are of varied height and bear cilia at their luminal side. The lumen is undulated. The significance of the above findings in the bat is discussed in comparison with the other mammals studied so far.

Feeding Ecology of the Eastern Horseshoe Bat *Rhinolophus megaphyllus* in Australia

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The feeding ecology of the eastern horseshoe bat *Rhinolophus megaphyllus* (weight 9 to 12 g), is being investigated in eastern Queensland, Australia. Study colonies are located in southeast Queensland, within the Wet Tropics World Heritage Area of north Queensland and at Iron Range on Cape York Peninsula. Colonies are located in caves, unused mines and bunkers in a range of habitats including lowland and mid-altitude rainforest, open-forest and woodland. Analysis of foraging behavior, utilizing light tags and radio transmitters, indicates hunting is confined to wooded areas, with individual foraging up to 2 km from roost sites. *Rhinolophus megaphyllus* catches its prey as it flies within open-forest and woodland and along streams and roads in rainforest. Prey is caught at all levels in the forest from the upper canopy to within 10 to 20 cm of the ground. Dietary information is obtained from analysis of prey remains and faeces. Examination of prey remains frequently allows identification to the level of species or genus. Eight insect orders have been identified as prey. Lepidoptera is the most frequently taken order (16 families), including the noctuid *Speiredonia spectans*, which shares roost sites with *Rhinolophus megaphyllus*. Information will also be presented on the diet of the *Hipposideros* species sympatric with *Rhinolophus megaphyllus*.

A Comparative Study of the Ultrastructure of the Yolk Sac in Some Indian Chiroptera

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A detailed study of the ultrastructure of the yolk-sac in six different species of bats was made in order to gain an insight into the morphology and the functional significance of this vital membrane. The yolk-sac is converted into a richly vascular gland-like structure, with both the mesodermal and the endodermal cells undergoing hypertrophy, during the course of gestation. The mesodermal cells are fusiform, with darkly staining nuclei. Their apical cytoplasm contains absorptive tubules, coated pits and coated vesicles. Mitochondria and ER are few in number. The mesodermal cells are absorptive in function and are involved in collagen and extracellular matrix production. The apical cytoplasm of the endodermal cells contains numerous membrane invaginations, endocytic vesicles, dense tubules and large vacuoles, which appear to form a interrelated absorptive system. Mitochondria and ER are abundant, indicating that the cell is engaged in active protein synthesis. The endocytic activity displayed by both the cell types indicates a role in fluid and metabolite transfer across the epithelium.

Genetic Diversity within a Population of *Myotis myotis* in Southern Germany

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Myotis myotis represents one of the 21 bat species that still exist in Germany and that are all found in the endangered species list of Germany. The knowledge of genetic diversity within a population of the larger mouse-eared bat is therefore not only of evolutionary interest, but also important for future conservation strategies. A 800 bp segment in the noncoding region of the mitochondrial genome of *M. myotis* has been sequenced. This region evolves rapidly and shows high heterogeneity within species. It is therefore, well suited to estimate the genetic diversity of a population. By sequence comparison of that region from individuals of two neighboring colonies and one distant colony of *M. myotis* the number of material lineages in the colonies could be analyzed. In conjunction with studies of highly variable nuclear markers, these data will be used to estimate maternal as well as paternal gene flow between the colonies. This will impact future strategies to ensure the long-term survival of *M. myotis* in Southern Germany.

Preferential transfer of ^{3}H-oestradiol [^{3}H-E2] from Ovary to Ipsilateral Uterus in the Flying-Fox *Pteropus poliocephalus*

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In flying-foxes, both ovaries are functional, but only that uterine horn ipsilateral to the ovulation undergoes preimplementation growth. Blood vessels supplying the uterus are such as would allow preferential countercurrent transfer of steroids from the ipsilateral ovary. Oestrogen receptors (ER) occur throughout both uterine horns. Our experiment was based on rodent studies showing that physiological doses of ^{3}H-E2 injected directly into target-organs, are retained as ER-bound [^{3}H-E2]. To determine if [^{3}H-E2] injected into one ovary appeared preferentially in the ipsilateral uterus, female *P. poliocephalus* were anaesthetised, suspended feet up to maintain as normal a blood flow as possible to the tract and 3H-E2 injected into one ovary, via a body wall incision. After sacrifice 1hour later, the tract was dissected out, separated, extracted with methanol and radioactivity counted. Little radioactivity appeared in the contralateral uterine horn, but significant amounts appeared in the ipsilateral horn. The result support the hypothesis of local passage of steroids from ovary to ipsilateral uterus in flying-foxes, but further experiments are needed to confirm that it involves countercurrent transfer rather than diffusion.

Oestrogen Receptors in the Female Reproductive Tract of the Flying Fox *Pteropus scapulatus*

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Flying-foxes are monovulatory. Both ovaries function, but preimplantation endometrial growth is limited to the uterine horn ipsilateral to the ovulation. This may involve delivery of hormones from ovary to ipsilateral uterus via vascular countercurrent transfer. However, growth may also be limited by the distribution of oestrogen receptors (ER). ER immunocytochemistry was used to explore this possibility. Cryostat sections of uteri were fixed in formalde/methanol/acetone and incubated with antibody H222, which cross-reacts with many mammalian ERs. ER positive MCF7 cells were treated similarly. Negative controls were incubated with normal rat antibody. Diaminobenzidine was the chromogen for peroxidase-antiperoxidase staining. Negative controls did not stain. In preparations incubated with H222, endometrial epithelial nuclei stained intensely throughout each uterine horn. Stromal/myometrial nuclei also stained, as did those of MCF7 cells. Staining intensity of individual nuclei varied, but there was no difference in overall nuclear staining between uteri, and no cytoplasmic staining. The pattern was similar to H222 staining of primate uterus. Since staining occurred throughout each horn, we conclude that endometrial growth is not limited by ER distribution.

Why Do Bats Carry Their Infants?

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The functional significance of the phenomenon of carrying/noncarrying of the young bats by mothers was investigated and the reasoning took the following lines. The bats were classified as carriers and non-carriers of their babies from the information in the vast literature available on both mega and microchiropterans. Twenty eight species belonging to different families recorded as carriers and eight as non-carriers. The following comparisons were made between carriers and non-carriers: i) Flight characteristics of adult; ii) Growth characteristics of the babies. The reasons for carrying and non-carrying of the infants may have more to do with growth characteristics than flight characteristics.

Histoenzymological Study: Effect of CPA on the Reproductive Organs of the Male Bat *Rousettus leschenaulti*

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Cyproterone acetate (CPA) is the only antiandrogen known that has both antiandrogenic and antigonadotrophic effect. Being a steroidal hormone, it is the strongest antiandrogen known. The present study has been undertaken to observe the histoenzymological changes after the administration of CPA. Adult male bats were

administered with 1 mg CPA/100 gm bodyweight (intramuscularly) for 60 days. At the end of treatment, the animals were anaesthetised. Testis, epididymis, seminal vesicle and prostate were quickly excised and 15 thick cryostat sections were cut at - 20°C. The sections were processed to localize lactate dehydrogenase (LDH), succinic dehydrogenase (SDH), alakaline phosphatase (Alk Pase) and acid phosphatase (Ac Pase) activities. Atrophy was seen in all organs indicating lowered androgen levels. Inhibition of LDH and SDH was observed. Lowered Alk and Ac Pase activities were seen after CPA treatment. The study shows that CPA acts as an competitive inhibitor in bringing about a change in the internal milieu of the organs.

What Key Factors Affect the Long-term Survival of Individual Greater Horseshoe Bats and Their Dispersion During Hibernation?

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A long-term population study of greater horseshoe bats in about 35 hibernacula within a radius of 40 km of Bristol (Ransome 1989) identified the mean birth time in July as an important factor influencing the number of first-year animals reaching hibernacula. Furthermore, the earlier in July a cohort was born, the more successful its long-term survival was. These effects were probably due to growth difficulties which are seriously limiting if birth timing is delayed. This paper looks at the birth-timing and the growth of individual baby bats whose mothers are known, in order to try to assess the relative importance of various factors influencing growth, and also kinship. It is based on the following studies: i) detailed growth studies of body mass and forearm length changes of individual baby bats carried out in each summer at a breeding site since 1983; ii) from 1986, 121 mother/young pairs of ringed bats were captured, and the food consumption and diets of individual bats caught on certain dates since 1989 were also investigated; iii) subsequent captures of bats in the breeding site and in hibernacula, which allowed survival to be ascertained, enabling the influence of various factors to be tentatively answered, or further questions raised.

A National Action Plan for Bat Conservation in Australia: Establishing the Framework

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The development of an action plan for Australian bat conservation in a nation that has devoted few resources to bat biology presented a unique set of problems. Recent taxonomic revisions extended the number of species from 55 to approximately 70, and since other revisions are still to come, the action plan, rather than simply treating known species, also includes other conservation units such as subspecies and undescribed forms, resulting in the treatment of 81 taxa. Geographic information systems technology (GIS) was applied to process information on the distribution of bat species over the Australian continent. This revealed areas of high diversity, key conservation areas, and areas demanding imperative survey. One particular problem in developing an action plan is concerned with the distribution of rare species with known conservation problems. Using GIS technology enables the user to create models predicting the distribution of species using an environmental envelope of habitat preferences. The paper describes the problems of, and methods used, to establish 'BAT-NAP', the national action plan bat database. The paper describes procedures for developing the list of Australian bat species, and methods for identifying areas of high species diversity, rarity, and key conservation areas. Maps showing survey intensity, species distribution, and species diversity are presented.

Identifying Key Conservation Areas for Bats on Cape York Peninsula, Australia

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Cape York Peninsula is one of the most naturally diverse wilderness areas of Australia and comprises an area of about 250,000 Km^2. It consequently presents major problems in determining conservation priorities in terms of its conservation and managements. To determine the primary areas required to enhance the conservation of the 46 bat species there, a relational database was developed and analyzed with a Geographic Information System. Areas of high diversity were pinpointed, as were areas with rare, endemic or specialized species, which then led to

key conservation areas being mapped. Areas without bat data that could also be considered important were predicted with an environmental similarity analysis. Distributions of bats could be predicted with HABITAT, a procedure that defines an environmental envelope (based on rainfall, soils, geology, temperature) for a species and identifies which areas without bat records fall within the envelope. This poster shows the procedures for assembling the database, the types of analyses, GIS mapping, and the areas of Cape York Peninsula that are keystone in conserving high diversity, rare species, specializedspecies, and endemics.

Chemi-luminescent Marking of Daubenton's Bat (Myotis daubentonii) for Behavioral Studies

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Marking bats in order to observe behavior when away from the day-roost has been tried using various techniques such as reflective-tape-and-spotlight, radiotracing, etc. Each method has its drawbacks. Chemi-luminescent marking has some advantages over other methods, however. Using chemi-luminescent capsules on the low-flying Daubenton's bat enabled us to observe the hunting technique and two feeding methods, only one of which was detectable with an ultrasonic bat detector. It also gave us information on the distances that the bats travel to their feeding sites (often in excess of 3 km) and the size of the feeding "beats" (usually 50-150 meters). For the first time, we were able to observe bats resting during the night on favorite trees close to the feeding areas for a few minutes to over an hour. Night activity back at the day-roost was also observed. In addition, we were able to observe aerial chases and other interactions between individuals.

Monitoring Population Trends of Cave Bats

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During the past five years, we have been conducting a monitoring programme of our cave bat populations, in both breeding and wintering roosts. This paper discusses the effectiveness of the various methods that we used and the difficulties encountered during this monitoring effort.Depending on the circumstances, bat numbers in a roost were estimated using 1) direct counts (on site or on photographs), 2) estimating the areas occupied by compact bat clusters (on site or using single or stereo photographs), and 3) emergence counts (with the aid of a combination of an infra-red sensitive video camera and a bat detector). Various factors contribute to make the monitoring process quite difficult in many situations. The most important area: 1) irregularities in the use of the roosts from year to year, 2) roost changes within the breeding and hibernation seasons, 3) changes in the location of the colonies within the same cave system, and 4) low precision of some counts. Furthermore, the most appropriate time to monitor different species that use the same roost is not always the same, which adds to the effort needed to the monitoring program. In most cases trends can only be determined using data sets including many years.

Patterns of Use and Association Among Antillean Cave-Dwelling Bats

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In this study, I examined the patterns of use and association among cave-dwelling bats in Puerto Rico. Located in the Caribbean, Puerto Rico is the easternmost of the Greater Antilles. Ten species belonging to five different families were identified in caves and tunnels from the western and northern parts of the island. The species are: *Mormoops blainvillii, Pteronotus parnellii, P. quadridens* (Marmoopidae), *Eptesicus fuscus* (Vespertilionidae), *Tadarida brasiliensis* (Molossidae), *Noctilio leporinus* (Noctilionidae), *Brachyphylla cavernarium, Erophylla bombifrons, Monophyllus redmani* and *Artibeus jamaicensis* (Phyllostomidae). I examined the records of speleological societies to determine the percentage of caves inhabited by bats. These caves were examined and the species of bats identified. Some caves were examined periodically throughout the year to assess the stability of bat populations and changes in microclimate. Previous studies on the energetics and patterns of activity of several species included in this study, suggested that only particular combinations of species would be able to coexist in caves. The results from this study support this hypothesis, rejecting the hypothesis that bats in caves form random assemblages. Microclimatic requisites do not explain association in all cases, since some species with similar requisites seem to exclude each other. Maternity colonies are identified for some neotropical species and families.

Electron Microscopic Studies on the Chorioallantoic Placenta of the Emballonurid Bat, *Taphozous melanopogon*

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The bat, *Taphozous melanopogon* belongs to the family Emballonuridae, which, is unique among the Microchiroptera, because of the presence of a haematoma in the placenta. The structure of the placental labyrinth during the different stages of gestation has been studied with the electron microscope. The maternal endothelial cells observed throughout the gestation are considerably hypertrophied, with many profiles of membranous organelles resembling cells known to secrete proteins. The interstitial membrane is discontinuous, thick, and intervenes between the trophoblast and the maternal endothelium. Certain ultrastructural features of the relationship between maternal endothelium and the surrounding syncytium indicate transport and absorption of materials between the interstitial membrane and the syncytium. The syncytiotrophoblast has numerous lipid droplets, mitochondria and desmosomes. Fetal capillaries progressively invade the syncytiotrophoblast without penetrating the basal lamina. The fine structure of the interhemal membrane of the definitive placental labyrinth is found to be endotheliomonochorial consisting of maternal endothelium, discontinuous interstitial membrane, syncytiotrophoblast, basal lamina, fetal endothelium and mesenchyme.

Haematological Observations in Two Species of Indian Bats

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Scanty information is available on the haematology of Indian bats, particularly associated with the reproductive state and feeding habits. Formed elements such as erythrocyte count, haemoglobin and haematocrit values have been studied during the breeding period of two bats, *Rousettus leschenaulti* and *Megaderma lyra lyra* showing different breeding patterns and dietary habits. These findings have been correlated with the reproductive state and dietary habits of the animals. In both species, the erythrocyte count showed variation in the adult male and female, gravid and lactating female, and juveniles. Lactating females have lower R. B. C. count than others. A higher erythrocyte count is observed in insectivorous *Megaderma* than in fruit eating *Rousettus*. No seasonal variations are found throughout the year in both species of bats, since tropical Indian bats do not undergo hibernation. The haemoglobin concentration also showed changes concurrent with the changes in the R.B.C. count in each group. However, in both species haemoglobin content increased during later parts of the lactation period. The haematocrit (Hct) percentage is observed to be more in *Megaderma* than in *Rousettus*. A high haematocrit value is observed in the adult *Megaderma*, as compared with other bats so far studied.

Levels of Citric Acid and Fructose in the Male Accessory Reproductive Organs in the Fruit Bat *Rousettus leschenaulti*

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In the males, the breeding cycle of *Rousettus leschenaulti* shows two peak periods of activity in a year. The first peak period occurs during October-November and the second during February-March. Citric acid and fructose were biochemically estimated in the accessory reproductive organs throughout the year. Prostate was found to be the major organ contributing citric acid to the seminal fluid while the seminal vesicles showed large amounts of fructose secretion. The data at hand also indicates that both citric acid as well as fructose show cyclical changes during the breeding cycle. Thus, the secretion of citric acid and fructose were found to be under the influence of testicular activity.

Kinetics of Spermatogenesis in the Megachiropteran Bat, *Rousettus leschenaulti*: Seminiferous epithelial Cycle, Frequency of Stages, Spermatogonial Renewal and Germ Cell Degeneration

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The paper describes in detail the cytomorphology of different types of germ cells, the ten typical cellular associations or stages of the cycle of seminiferous epithelium (SCE), frequency of appearance of these stages, pattern of spermatogonial stem cell renewal and percent degeneration of various germ cells in *Rousettus leschenaulti*. Of the

fourteen steps of spermiogenesis (stained with PAS-haematoxylin) the first ten were associated with the stages I-X, whereas, the remaining were found in association with one of the first six stages. The frequency of appearance of the various stages ranged from 3.84% (stage V) to 19.84% (stage I). These observations indicate that stage V is of the shortest duration and stage I is of the longest duration in the bat. Five types of spermatogonia (A1, A2, A3, In and B) were identified based on their shape, size and nuclear morphology. Type A spermatogonia are oval with a large nucleus containing 1 or 2 nucleoli. The chromatin showed progressive condensation from A1 to A3 so that the latter appeared darkest among all the A type spermatogonia. The In type derived from A3 are smaller but appear darker than A3 due to heterochromatin crusts along the inner border of the nucleus. The B type spermatogonia derived from In are round and possess single nucleolus. The B type spermatogonia divided mitotically before entering meiosis or the actual production of the primary spermatocytes. The various spermatogonia divided mitotically at fixed stages of the cycle giving rise to their next generations. Thus, A type divided in stages II, VII and X, while In and B type spermatogonia divided in stage V and VI respectively. Therefore, in each CSE of the bat there were five peaks of mitosis. The A3 divided differently in stage II to give rise to In and A1 spermatogonia. Hence, A3 spermatogonia form the renewing stem spermatogonial cells in the bat. Based on the spermtogonial mitosis, a model for spermatogonial stem cell renewal in the bat is proposed which differs slightly from that reported for the rat. The percent degeneration of germ cells was estimated in the stages in which mitosis occurred. A type spermatogonia showed degeneration of 36.6%, 14.9% and 34.2% in stages I, III and X respectively. Whereas, 33.7% of In and 16.5% of B type spermatogonia degenerated in stages V and VII respectively. The degeneration of Spermatocytes together with spermatids amounted to 16.5%. During a SCE a total of 63.9% germ cells underwent degeneration. These findings indicate that in the bat, spermatogonial degeneration is greater compared to the degeneration of spermatocytes and spermatids.

Behavioral Characterization of Peripheral Auditory Filters in *Megaderma lyra*

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Megaderma lyra obtains acoustic information about its environment from a broadband sonar system and by passive listening. The quality of the perceived acoustic images is essentially determined by the frequency resolution of the auditory system, which, in psychoacoustics, is characterized by the width and the shape of the peripheral auditory filters. These are defined as the frequency range within which simultaneously present spectral components are analyzed together (critical band, CB) and mast each other. Filter properties at ultrasonic frequencies were assessed in two behavioral experiments using a two-alternative, forced choice procedure by masking pure tone signals with noise of different bandwidth. Filter width increased as a function of test tone frequency from about 1.5 kHz at 25 kHz to about 13.5 kHz at 90 kHz (corresponding to an increase of 6.2 dB/octave). Filter shape was symmetric around the masker center frequency; for frequencies far from the center frequency, the threshold in quiet was reached. The filter slopes (related to the CB scale of *M. lyra*) were between 40-70 dB/CB. The monotonic increase of filter width with rising test tone frequency and the symmetrical filter slopes at the used masker level resemble those of non echolocating mammals and man. Filter slopes, however, are somewhat steeper than the steepest slopes in man of about 27 dB/CB (CB scale of man), which can be regarded as an adaptation to noisy and cluttered environments.

The Use of Various Sensory Modalities During Orientation in Phyllostomid Bats with Different Feeding Habits

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Echolocation by means of ultrasonic calls enables microchiroptera to fly in complete darkness and thus to exploit the nightly airspace, a niche that is occupied by birds during the day. This outstanding active acoustic orientation mechanism has been investigated extensively during the last decade and it led to the impression that various other sensory modalities are of minor importance for bats. Recent studies have demonstrated that, in a number of species, passive hearing, vision, olfaction and even thermoreception may play an important role in particular orientation situations, sometimes overriding echolocation. The use of differentiating food. The morphology of these sensory systems and their physiological efficiency are often highly developed. The neotropical Phyllostomidae constitute a bat family with extreme variation in the mode of nourishment. Three species (*Desmodus rotundus:* sanguivore; *Phyllostomus discolor*: omnivore; *Carollia perspicillata*: *frugivore*) are compared in different test situations. It can be shown that, depending on feeding specialization, the olfactory, visual or passive

acoustic cues are of dissimilar value in these species. The biological significance of the results is discussed and data from the literature are reviewed.

Audio-vocal Interaction in the Horseshoe Bat

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In echolocating bats, the coordination between echolocation call emission and orientation of head and ears are essential for successful echolocation. In order to define structures important for such audio-motor coordination, the brainstem was explored with electrical stimulation and subsequent tracer injections at stimulation sites specific for vocalization. This report concentrates on the pretectal area (AP) at the mid brain/diencephalic junction. In the caudal part of this area, intercalated between the deep layers of the superior colliculus and the medial geniculate body, electrical stimulation specifically yields vocalizations and associated ear movements undistinguishable from natural ones. This region received most important auditory input from 1) the central nucleus of the inferior colliculus which contains neurons sharply tuned to the bat's characteristic frequency and 2) from part of the dorsal field of the auditory cortex, specialized to process combinations of the frequency modulated components from vocalization and echoes. There are a variety of afferent and efferent connections of the AP with vocal and motor control structures. The pretectal area in the horseshoe bat is considered to be important for audio-vocal control and acoustically-guided head and ear movements.

Perception of a Missing Fundamental in the Ultrasonic Range by the False Vampire Bat (*Megaderma lyra*)

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The phenomenon of the "missing fundamental" describes the fact, that multiharmonic (complex) tones produce a pitch sensation at their fundamental, even if this frequency is physically absent. There are two classes of models, which could explain this phenomenon. One works in the spectral, the other in the time domain. The spectral models use the harmonics, which are spectrally resolved by the cochlea to determine the best fitting fundamental. The time models take advantage of the periodic time structure of complex tones, which is preserved by phase locking of auditory nerve fibers. Whether a perception of the missing fundamental exists in the ultrasonic range, was tested for *Megaderma lyra* with a two-choice experiment. In the first experiment, bats were trained to discriminate, whether a pure tone is higher or lower in frequency than a reference frequency of 23 kHz. The experiments disclosed an absolute pitch perception since the bats compared test tone frequencies to that of the memorized reference of 23 kHz. In subsequent experiments, complex tones with and without fundamental were offered as test tones. Now the bats had to decide, whether the fundamental of the complex tone is higher or lower than 23 kHz. In all cases, the bats made the transfer from pure to complex tones immediately. The results demonstrate, that *M. lyra* features a sensation of a missing-fundamental in the ultrasonic range (23 kHz). This fact is in sharp contrast to time models of missing fundamental perception, because phase locking above 9 kHz has never been observed.

Investigation on Performance and Relevance of Different Sensory Systems in the Noctule, *Nyctalus noctula*

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Four noctule bats were trained to walk into one of two arms of a Y-maze towards echo acoustic (E), passive acoustic (P) and visual stimuli (V) to obtain a food reward.

The stimuli used were: E: sheet-metal strips (18 x 30 cm)
P: white noise (0 - 50 kHz)
V: a lit frosted glass pane (5 x 5 cm)

The animals were trained to respond to a combination of all three targets as a standard stimulus (EPV vs. empty arm). In the following experiments, they encountered six comparisons of the three sensory modalities daily (each of the combinations E vs. V, E vs. P, V vs. P, being given twice) mixed into nineteen standard expositions. The reactions of the animals indicated that they had only learned the passive acoutis and visual targets. They did not respond to the echo acoustic target; P was significantly preferred over V (67% : 33%). To evaluate the intensity of stimulus perception, the passive acoustic and visual perception thresholds were determined.

Functional Morphology of the Bucco-pharynx and Oesophagus of *Pteropus giganteus giganteus*

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Pteropus giganteus giganteus is present in the Western UP throughout the year, and lives in aggregates forming flocks of 10-500 individuals. Morphological studies of the tongue, palate, teeth, and oesophagus were performed in distilled water under a binocular microscope. Sections 5-6 μ thick were cut from the oesophagus taken from the dead and/or live specimens, after the usual methods of fixation, dehydration, embedding, sectioning, staining, etc. The horny palate of *P. giganteus* displays plain and serrated rugae having horny projections. The comparatively longer, well musculed tongue bears small and large, horny as well as circumvallate and fungiform papillae. Complex cheek teeth and the rasping tongue, when put together, finely grind the fruit pulp and squeeze every drop of the juice of the fruit which is present in the mouth. The vascular supply of the tongue is enhanced by the presence of an accessory lingual artery. The reduction of incisors, in both the jaws, form pseudo-diastema, through which the solid pellet of the fruit is ejected once all the juice is taken out. The longitudinal folds in the oesophagus help transportation of the liquid food through capillary pressure against the gravitational pull.

Morphohistology of the Caratid Body of *Pteropus giganteus,* the Largest Indian Bat

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This study brings to light facts about the morphology, anatomy and the cellular components of the carotid body in the largest Indian frugivorous bat, *Pteropus giganteus* (Brunnich). Bats being highly evolved mammals phylogenetically, immense significance lies in the study of their chemoreceptor systems including the carotid body. This study hopes to highlight the detailed morphometry, histology, and histological relationships with the haemal, neural and connective tissue components, with a view to finding their homolgues in other mammals and bats. Emphasis has been to establish that the innervation patterns of the glomus cells and the capillary network around them is indicative of the view that the carotid body is nothing but the chemoreceptor organ of the bat, *P. giganteus* as also reported by other morphologists.

HCG and PMSG Treatment Failed to Induce Ovulation in an Indian Vespertilionid Bat, *Scotophilus heathi* During the Period of Delayed Ovulation

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The effect of HCG and PMSG on the responsiveness of ovary during the period of delayed ovulation in female *S. heathi* are described. Both HCG and PMSG treatments given between September and early February failed to induce ovulation, though they produced a high degree of ovarian stimulation. Both HCG and PMSG treatments induced a number of changes in ovary which included ovarian enlargement, intense hyperaemia, marked changes in interstitial cells and development of several antral follicles. Further, these treatments induced various degrees of abnormality in the oocyte of most of the antral follicles. The percentage of abnormal oocytes in the ovary following HCG or PMSG treatment was dose dependent.

Echolocation in the Cave Bat *Hipposideros speoris* is Coupled to the Circadian Clock Regulating Flight Activity

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Tropical and temperate insectivorous bats have been reported to display a circadian organization in their daily activity and rest patterns. These bats echolocate nocturnal insects while in foraging flight and capture them. Their orientation ultrasonics last 0.3 to 200 msec and may have frequencies of 12-200 kHz which are produced in the larynx. It has been claimed for a number of temperate insectivorous bats that they constantly emit localization sounds in flight as well as at rest. In the context of vocalization, bats would appear never to sleep. In order to examine this question, we investigated the tropical insectivorous bat *Hipposideros speoris*. This bat shows clear-cut free running circadian rhythms in its flight activity in laboratory experiments performed in continuous darkness. We

have not recorded both flight activity and emission of ultrasonic pulses (134 kHz) simultaneously in bats held in activity cages in continuous darkness. Our results indicate that *H. speoris* emit echolocatory ultrasonic pulses only during subjective nightly bouts of flight and are "silent" during their rest phase.

Intestinal Anatomy and Histology of Desert Inhabiting Rat-tailed Bat, *Rhinopoma kinneari*

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The intestine of desert inhabiting rat-tailed bat *Rhinopoma kinneari* was studied for its anatomy and histology. Macroscopically, the intestine was short (21 cm) and convoluted tube having similar outer appearance with the presence of caecum at the junction of small and large intestine. Microscopically, numerous varied shaped and sized villi were noticed on the mucosal surface of the small intestine. Villi were small in duodenum (325 μ) as compared in jejunum (550 μ). Crypts of Lieberkuhn were found small with relatively less goblet cells in small intestine and were large with abundant goblet cells in the large intestine (i.e. colon and rectum). Simple tubular Brunner's glands with definite openings at the bases of crypts were extended to about 1.4 mm in the submucosa of duodenum from gastro-intestine junction. Absence of Payer's patches and presence of a thick layered lymphoid tissues in caecum was recorded. The length of the large intestine, which did not possess villi, constituted about 30% of the whole intestine. Therefore, the greater portion of the intestine was considered to be a small intestine (70%). Possession of long small intestine with numerous villi may be one of the aerial adaptation to meet the exceeding demand of metabolities needed for the production of energy.

Annual Cycles of Body Weight in Four Species of Male Tropical Bats

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Body weights of male tropical bats *Rhinopoma hardwickei, Taphozous melanopogon, Hipposideros bicolor fulvus* and *H. speoris* (n = 15-25 in each species) were sampled at 10 day intervals from early September 1985 through late October 1986. The mean body weights and SEM were plotted. Insect abundance was calculated in the study area from the overall mean and total number of insect population. The annual mean value of insects captured was considered as 100%/ The percentage of insect abundancewas calculated as the ratio between the annual mean and real numbers of insects at a given time. All four species of bats show significantly higher body weights during September to November when compared with the minor body weight increases (peaks) during February through May. Similar body weight increase is also apparent during summer months (April to June) except in *R. hardwickei*.. Increased body weights coincided with the breeding cyles in *H. bicolor fulvus* and *T. melanopogon.* The increase in the body weights of four species of bats during September through November can be correlated with periods of high insect abundance.

Two Types of Forearm Length Postnatal Growth

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The forearm length is the most frequent parameter used for studying bat growth. For a full description of forearm growth during all developmental periods the logistic equation is usually employed. At the same time, the linear regression equation may also be used for description of the early growth period. It is possible to use this equation in relation to development and growth rate, independent of feeding peculiarity and surrounding temperature, as a characteristic feature of the bat's growth. Postnatal growth of three bat species found in the Far East region of Russia was studied under natural conditions. Using linear equations for description of forearm growth made it possible to reveal the existence of two types of growth curves: 1] the constant growth rate observed till the young bat begins to flutter, when the forearm length is about 85% of adult size (*Hypsugo savii*); 2] the constant forearm length rate measured till the beginning of active flight, when the bats achieve adult size (*Myotis daubentoni, Vespertilio superans*). Two types of forearm growth are revealed in comparison with growth curves, that are circumscribed by means of the logistic equation as well. The growth curve is steep for species whose forearm length increases at a constant rate until the bats achieve minimal adult size. A review of literature has shown that the first

type of growth curve is characteristic of *Rhinolophus ferrumequinum, Myotis lucifugus, Plecotus townsendii, Nyctalus noctula, N. lasiopterus, Eptesicus fuscus, E. serotinus,* and *Miniopterus schreibersii;* and the second type of growth curve is characteristic of *Myotis emarginatus, Pipistrellus pipistrellus,* and *Nycticeius humeralis.*

Studies on Vaginal Sebaceous Glands in Chiroptera

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Bats were collected from different eco-cells of Sangli district. The sebaceous glands were found to be more prominent in vaginal region of megachiropteran bats. These glands were also prominent in and around the male and female genitalia of microchiropteran bats. The other skin regions showed scanty and discrete localization of the glands. The localized distribution of these glands plays an important role in differential physiological exercise. The other histochemical aspects of skin of different bats were also studied. The lipds and mucins were also studied from these glands. Aging glands were reported to contain low amounts of tyrosine and were found to be hormone dependent glands. Their secretion showed cyclic variations. The aging of the glands were correlated with decreased activities of gonadal functions.

Paradigm of Lactate Dehydrogenase in the Contralateral Ovaries of *Rhinopoma kinneari kinneari* during Nulliparous, Parous and Lactation States

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Rhinopoma kinneari kinneari is a seasonally breeding microchiropteran, characterized by functional equivalence of the ovary and extroverted corpus luteum. Histochemical site and pattern of distribution of mitochondrial dehydrogenase viz., lactate dehydrogenase (LDH) was studied in the contralateral ovaries of *Rhinopoma kinneari* as the bats transit from nulliparous to parous and lactation stages. The functional equivalence of the ovaries, yet annual alternation in ovulation seems to be having molecular basis. Not only were significant contralateral differences in paradigm of lactate dehydrogenase discerned but the differential pattern was also found to be reproductive stage specific. The shifts in pattern of distribution of LDH in various follicle types during aforesaid reproductive stages shall be discussed.

Major Reproductive Trends in Transvaal Microchiroptera

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Three conspicuous reproductive patterns have been identified amongst Transvaal microchiropteran bats:
a) The normal mammalian pattern: This cycle is restricted to eastern Transvaal molossids such as the little free-tailed bat, *Tadarida pumila*, and the Angolan free-tailed bat, *T. condylura*, where no delay phenomena interrupts the breeding cycle. However, these molossids are exceptional in that they are polyoestrus with a potential of up to three singletons per breeding season as a result of a post-partum oestrus which occurs after the birth of their first offspring in November. b) The vespertilionid pattern: Amongst the vespertilionids two types of reproductive delay have been found: a) Delayed implantation - Schreiber's long fingered bat, *Miniopterus schreibersii*, has an eight month gestation period of which the first four months are characterized by the presence of an unimplanted embryo in the uterus. b) Sperm storage - In the rusty bat, *Pipistrellus rusticus*, spermatozoa are stored for prolonged periods by both males and females during the winter hibernating period until the end of August when ovulation and fertilization occur. c) The rhinolophid pattern: In Geoffroy's horseshoe bats, *Rhinolophus clivosus*, prolonged storage spermatozoa appears to be the primary responsibility of males. Spermatozoa are stored in the epididymides from May until August. The absence of vaginal plugs and spermatozoa during various stages of the winter hibernation period, as well as the presence of abundant leukocytes at certain stages, strongly suggest that females cannot, or are losing the ability to store spermatozoa for prolonged periods of time.

Observations on Ectoparasites of a Few Tropical Bats of South India

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A preliminary study was made on ectoparasites over a period of seven months from December 1991 to June 1992 in an area around Tirunelveli (lat. 08o.44'N long. 77o.42' E) on a few tropical bats - Indian false vampire bat (*Megaderma lyra*), a leaf nosed bat (*Hipposideros speoris*) and the short nosed fruit bat (*Cynopterus sphinx*). The most conspicuous ectoparasites are Streblid, Nycterilibid flies and adult and larval forms of Argasid ticks. These parasites apparently suck blood and other body fluid and feed from hair follicles of these bats. Present observations show that *C. sphinx* is infected by Nycleriibid *Basiclia* sp. flies, *H. speoris* by two genus of Streblid flies of which one being *Trichobius* and *M. lyra* is infected by Streblid *Trichobius* sp. flies and Argasid soft ticks and their larvae. The study is being continued on the seasonal variations on the number of parasites on different species of bats.

Studies on Mucopolysaccharides in Prostate Glands of Some Bats

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The prostate of nine seasonally breeding bats were studied histochemically to determine the nature of mucopolysaccharides elaborated by the glandular epithelial cells. The lumen of the prostatic tubules continued secretion during their active breeding period. The results obtained revealed the presence of glycogen and neutral mucopolysaccharides in the secretion and prostatic epithelium in *Hipposideros fulvus fulvus, Taphozous kachhensis* and *Megaderm lyra lyra.* On the other hand, these sites contained glycogen and sialic acid in *H. speoris, H. lankadiva* and *Tadarida aegyptiaca.* Two types of cells were identified in the prostate of two bats. The type - A cells elaborated glycogen, sulfomucins and sialomucins and type - B cells only glycogen and neutral mucosubstance in the prostate of *Rousettus leschenaulti.* Both the type - A cells and type - B cells elaborated glycogen, sulfomucins (more) and sialomucins in the prostate of *Pteropus giganteus giganteus*. These cells were present in the different tubules and they differed in their staining intensities. These results are discussed at a comparative level.

Gonadal Steroids and Their Plasma-binding in Flying-foxes (Genus *Pteropus*)

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Peripheral plasma levels of progesterone in female *P. poliocephalus*, previously measured by radioimmunoassay (RIA) of plasma hexane-extracts, were confirmed by direct RIA of plasma, using a different antibody. This RIA showed that high levels of immunoreactive progesterone were present in plasma from intact male *P. poliocephalus, alecto* and *scapulatus* and castrate male *poliocephalus*. Immunoreactive progesterone in male *alecto* plasma ran with authentic progesterone on HPLC. We assume that the adrenal is the source of this progesterone. Intact male *poliocephalus* and *alecto* showed no seasonal change in plasma progesterone levels. Steady-state polyacrylamide-gel-electrophoresis of male and female *poliocephalus* plasma showed no evidence of high-affinity binding of dihydrotestosterone (DHT) to a steroid-binding-globulin-like molecule, but indicated that progesterone bound to a corticosteroid-binding-globulin-like [CBG-like] molecule. Similar results, using DEAE-cellulose filters, were obtained in all three species: DHT and oestradiol showed no high-affinity plasma binding, whereas testosterone showed limited, and progesterone extensive binding. Competition studies, using DEAE-cellulose filters, demonstrated that progesterone occupies a site which binds cortisol and corticosterone with high affinity, testosterone and DHT respectively, with low and very low affinity and oestradiol not at all. This CBG-like protein is present at higher concentration in male than female. Levels do not alter in pregnant *poliocephalus* , but increase markedly in male *poliocephalus* during breeding season.

The Effect of Bat Echolocation Call Structure on the Auditory Responses of Noctuid Moths

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The audiogram of the noctuid moth *Agrotis segetum* shows general sensitivity into the ultrasound region, being most sensitive at 20-25 kHz with a threshold of 34 dB SPL. The duration response follows that predicted for an energy detector of - 3 dB per half duration, with an approximate integration time of 80 ms. For short duration

signals, it becomes increasingly difficult to generate large numbers of action potentials per stimulus. This limits the maximum number of action potentials able to trigger the defense response, and therefore limits the signal to noise ratio of the auditory system. As stimulus intensity increases, interspike interval decreases and may provide the necessary information to separate the short intense calls from a close bat from the long duration but quiet calls of a distant bat. The above effects are discussed in relation to the auditory responses of *Agrotis segetum* to real bat echolocation calls of varying structure, and are analyzed in conjunction with measurements of the call intensity of the free-flying bats. This provides an estimation of the maximum detection distances able to stimulate each stage of the moths two-stage defense behavior.

Studies on Distribution and Ecological Environment of Pteropodidae in China

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There are nine species of Pteropodidae in China: *Pteropus dasymallus formosus, P. giganteus, P. lylei, Rousettus leschenaulti, R. lanosus, Cynopterus sphinx sphinx, C. brachyotis angulatus, Sphaerias blanfordi motouensis* and *Eonycteris spelaea*. These species belong to the South China Range of the Oriental Realm. There are five types of zoogeographic distribution, including the tropical type of S. E. Asia, tropical type of S. Asia and S. E. Asia, tropical type of E. Africa and S. E. Asia, tropical and subtropical type of S. Asia and S. E. Asia, subtropical type of Ryukyu and Taiwan. They are distributed over 11 provinces from Taiwan to Xizang and from Hainan to Qinghai, whose longitude and latitude are 95° 20' - 121° 30' E and 19° 30' - 36° 20'N. *P. giganteus* is the most northern species of pteropodidae in China and the world. The distribution ranges of *P. giganteus, P. lylei, R. leschenaulti, C. sphinx* and *S. blanfordi* are the most northern limits in the world. *R. lanosus* lives in the eastern Africa, but it was found in Longan, Guizhou province in China. Vertical altitude distribution of Pteropodidae in China is about 50 to 1965 meters. The highest species is *R. leschenaulti*. There are five types of their habitat, which are the tropical broadleaf forest, tropical river valley and farmland, subtropical broadleaf forest, subtropical river valley and farmland, and residential areas. During the day, they rest in the mountain caves or tree caves, and some species rest on the tree branches or houses. The annual mean temperature of Pteropodidae environment in China is 14°-24°C, the annual rainfal is 370 - 2000 mm and the relative humidity is 48.6 - 84%. As concerns the quantity of Chinese Pteropodidae, they belong to rare species except *R. leschenaulti* and *E. spelaea. P. giganteus, P. lylei* and *R. lanosus* were found in China more than 30 years ago. Since then these bats have not been found and must have disappeared in China.

Migration, Mating System and Population Density of *Myotis myotis* in Southern Germany

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During the summer female *Myotis myotis* form nursery colonies, mostly in roofs of churches or other big buildings, where they give birth and rear their young. Living alone during the summer months, male bats are visited by females for mating in autumn. Hibernation takes place in caves and mines. A three year field study on the etho-ecology of *M. myotis* is in its second year now. Topics are:

- Migration of females between colonies.
- Home ranges of solitarily living males.
- Origin and number of females visiting males for mating.
- Condition differences in colonies (weight, reproduction, date of birth).
- Population density in the study area.
- Differences in forest composition (forest is the preferred foraging area) and population density within these areas.

Methods used are banding, controlling of summer roosts and evaluation of aerial photographs for comparison of forest composition. First results show regular exchange of animals between colonies up to a distance of 30 km and considerable differences in population density and reproduction success in the different colonies.

Hibernation of Bats in Underground Shelters of Central and Eastern Poland

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The study was carried out in 76 underground shelters of bats from 1979 - 1992. We found 11 species hibernating in Central and Eastern Poland: *Myotis myotis, M. bechsteini, M. nattereri, M. mystacinus, M. brandti, M. dasycneme, Eptesicus serotinus, E. nilssoni, Plecotus auritus, P. austriacus, Barbastella barbastellus.* There were four sites with more than 100 individuals recorded on at least one occasion and five sites with more than 50 individuals. *B. barbastellus* predominated in forts (ca 70%), *P. auritus* in small cellars (over 60%), *M. myotis* in caves (ca 40%) and *M. nattereri* in big town underground shelters (ca 80%). The changes in numbers during one hibernation period differed in different underground shelters. Two types of sites were distinguished: (1) caves, where the total community numbers attained the maximum at the end of winter (2) forts, where two peaks were note: in October due to the maximum number of *M. daubentoni* and *M. myotis*, and in the middle of winter due to numerous individuals of remaining species, especially *B. barbastellus*. A slight increasing tendency was noted during the study period in some large hibernation sites, mainly for *M. nattereri, M. daubentoni* and *B. barbastellus*. The observed shorter fluctuations could be explained by the influence of various weather conditions during different years. Warm winters reduced the number of individuals using underground shelters for hibernation, up to even 50% of the maximum number.

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We thank you in advance for your contributions.

Roy Horst, Tom Griffiths, and Al Kurta

BAT RESEARCH NEWS

Volume 34 : Nos. 2 & 3 **Summer & Fall 1993**

BAT RESEARCH NEWS

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

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

BAT NEWS RESEARCH

Volume 34 Summer & Fall 1993 Nos. 2 & 3

Clustering in the Emergence Behavior of Bats : Some Pitfalls in Analysis and How to Overcome Them

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Abstract

Statistically analyzing the temporal pattern in bat emergences from roosts might appear simple. However it is frought with problems. In this article I outline what these problems are and how to solve them.

Introduction

Many people who have observed bats emerging from a roost have formed the impression that the bats are not leaving in a steady stream, but rather emerging in groups or clusters. I used the term "formed the impression" because simply by watching the emergence it is not possible to tell whether bats are in groups or not. Bats emerging at random are bound to vary in the interval between each other; sometimes the intervals will be short and at other times long. If you just watch a colony emerging, you start to interpret the longer intervals as gaps, and bats that are separated by short intervals as a group. If emergence were random, these assignations may describe what appears to be going on, but the terms "gap," and in particular "group," would have no functional significance. Each bat would be behaving independently, and our use of the term "group" would describe nothing more than the fact that two or more bats coincidentally emerged at similar times.

If bats did emerge in true groups this might reflect some important biological process. For example, the bats might be emerging in a group that subsequently remains together throughout the foraging period. Bats foraging in groups may derive advantages in terms of their ability to exploit food resources, and grouped emergence could reflect this behavior. Alternatively bats might emerge in true groups for more selfish reasons. Perhaps bats are able to identify other bats which have been successful when foraging the previous night. They might follow successful bats as they leave the day roost in hope of also finding rich rewards whilst out feeding. Another possibility is that by emerging in groups individuals may be acting in a selfish way to dilute the probability of their own predation.

Even if we could demonstrate that bats actually emerged as true groups, there is still the possibility that the phenomenon is a trivial consequence of a large number of animals attempting to move through a narrow space in a short period of time -- the so-called bottleneck effect. In fact, such a bottleneck alone would tend to produce a regular stream rather than groups; however, if we postulate that each bat varies in the time it waits at the exit before emerging, then groups would build up and then emerge behind those bats that had particularly long waiting times. These intriguing potentialities can only be evaluated once we discount the possibility that the groups which we observe are merely coincidental amalgamations of bats, each acting randomly and independently of other individuals. In this article, I explain some pitfalls that have recently been identified in performing such analyses and how they may be overcome.

Problems and Solutions

Clustered, Regular, or Random?

To quantify emergence many researchers have adopted the strategy of counting the number of

bats that emerge in a given interval (e.g., 15 sec or 30 sec). The resultant distribution, it is argued, reflects the "clumpiness" of the emergence. Hence if you always counted 10 bats in every 15-second interval this would be less clustered than if the range was from 0 to 20 bats.

This type of data collection runs up against two problems, one of which is easily solved, and the other which is not. There is definitely a third problem that I will raise later and probably others about which I am unaware. The first (solvable) problem is exactly how much of a distribution would you expect to get in a random emergence, and therefore how can you test whether the emergence is statistically more clustered than expected if it were random?

Fortunately, this is a very old problem in probability theory that was solved by mathematicians about 150 years ago. The actual distribution of values one expects is described by the Poisson distribution. The probability of getting x bats emerging in the defined interval (in this case 15 sec) is calculated from the equation:

$$p(x) = (e^{-m}) \cdot m^x)/x! \qquad (1).$$

All we need to calculate the probability of getting a value x is its value, the quantity m and e, which is the universal constant, 2.71828. The value m is the "intensity of the process." It makes sense that if the rate at which bats are emerging is very high this affects the probability of getting any particular number within a given interval. It is also obvious that the number within a given interval also depends on the size of that interval. To calculate m, one takes the total number of emerging bats divided by the total number of intervals observed in which these bats emerged. For example if the interval was 15 sec and we observed 158 bats emerge in one hour (3600 sec) that would be 158 emergences/240 intervals or m equals 0.7.

We then plug our estimate of m into Eq. 1 to evaluate the probability of getting any particular number of bats in a given interval. I calculated these probabilities for this example and presented them in Table 1. Since we observed a total of 240 intervals, we can generate an expected distribution of values, if the emergence was random, by multiplying each probability by 240 (Table 1). The next step is to use a categorical statistic like the Chi-squared or G test to compare this random prediction with the observed distribution.

Deviations from random occur in two basic ways, only one of which reflects clustering. The other type of deviation is if bats emerged in a regular fashion. To separate these alternatives, it is necessary to examine the form of the deviation from the random expectation. If the emergence was clustered, one would expect the deviation to involve over-representation of the frequency of low numbers in each interval (the gaps) and of high numbers (the groups). Alternatively if the emergence was regular, there would be over-representation of some intermediate number per interval.

Time Scale

The second problem with collecting data in this manner is that the result depends on the interval that one chooses. Consider how an interval of 15 sec would cope with a situation where groups of 20 bats emerge over three-second intervals separated by gaps of 12 sec. This pattern would be very clustered, yet using a 15-second interval would result in a count of 20 in almost every interval; so the analysis would reveal either a random pattern or worse, a regular pattern. By selecting a different interval and watching exactly the same emergence, a second observer might come to a completely different conclusion about the structure of the emergence. Patterns may exist in the data at different time scales, and choosing only one time scale to divide up the data misses the possibility that the emergence is structured at a different scale.

To overcome this problem one must collect the data in a different manner. Instead of counting the emerging bats in each pre-set interval one records the exact emergence time of each bat. In the past this was difficult, but there are now behavior-logging programs that run on laptop computers, allowing a single observer to key in observations. At worst, without a laptop computer, an observer can dictate events into a portable tape recorder and later translate the tape using a desktop computer or stopwatch. There are also systems based on infra-red beam breaks, passive sensors, or transponders that automatically log emergences.

Once one has collected the exact time of each emergence, one could divide the whole pattern into different intervals, for example 5, 10, 15, 20 sec., etc., and examine the frequency distribution at each interval. However this type of analysis would be tedious. An alternative is to calculate the inter-event intervals. By calculating these intervals we can then frame the question: what would the expected probability distribution of these intervals be if emergence was random? The beauty of this approach is that it is independent of the scale of the pattern. If there is a pattern at any scale then it will manifest itself in the distribution of the inter-event intervals.

The question remains, however, as to what the expected distribution of these inter-event intervals actually is. The expected random distribution is

closely related to the Poisson distribution, and it is called the negative exponential distribution. This distribution is described by the equation:

$$p(x > a \text{ and } x < b) = e^{-a\lambda} - e^{-b\lambda} \quad (2).$$

In this equation, a is the lower time limit of any particular class of inter-event intervals, and b is the upper time limit of the class. The symbol is the intensity of the process generating the events. However, in this equation the intensity is not the number of events divided by the number of intervals (as in the definition of m in Eq. 1), but rather the number of events divided by the total time (expressed in the same units as those used to time the inter-event intervals). This is equal to the reciprocal of the mean inter-event interval.

An immediate problem is how to select the values for the terms a and b (the class limits) to generate predictions. This problem is not as easy as it may appear. If one selects classes that are too small, standard categorical tests will not work. Chi-squared, for example, is prone to errors when expected numbers in each class fall much below 10. However, if one selects classes that are too wide, then one loses power in the test. This occurs for three distinct reasons. First some categorical tests (e.g., Chi-squared) are prone to error when the expectations in each case vary widely. This is because deviations from small expectations are over-weighted in the Chi-squared calculation relative to their true probabilities of occurring. (The G test is robust to this problem). Second one wastes power in the test because classes with large expectations could be subdivided to yield greater degrees of freedom, and third because the classes are too wide to pick up small-scale clustering. A solution to this problem is to make the size of the classes variable so that the predicted number in each interval is constant. This constant should be at the margin that satisfies the requirements for sufficiency in the categorical test (n approximately equal to 10). By using these criteria, the potential inter-event timings are subdivided into the maximum number of possible classes, which maximizes the degrees of freedom, overcomes the problem of weightings with different expectations, and allows maximum resolution of the scale of clustering.

An alternative way of using the negative exponential distribution is not to select a time class (from a to b) but rather to calculate the probability of an inter-event interval exceeding a critical value.

This probability calculation is simply half of Eq.(2):

$$p(x \geq a) = e^{-a\lambda} \quad (3).$$

If one selects sequentially increasing values for the constant a and plots the probability (multiplied by the total number of observations) against the interval size, one gets a cumulative probability function. The shape of this function is an exponentially declining curve (hence the name: negative exponential distribution), approaching an expectation of zero as the critical value increases. This is an exponential curve and if one plots it on a semi-log scale the result is a straight line (Fig. 1). This line is frequently called a log survivorship curve in the biological literature because of its traditional use by population ecologists.

The form of this line reflects two aspects of the original distribution. First, the y-intercept (i.e., where a=0) is equal to the log of the total number of events. This is the case because the probability of an inter-event interval being greater than or equal to 0 must be 1.0 (i.e., all intervals have a zero or positive time no matter how short). Second, the gradient of the decline is equal to the intensity of the process (Fig. 1). High-intensity processes (fast emergences) decline faster than low-intensity processes (slow emergences).

To test the deviation from this random expectation, plot the cumulative data and compare it to the log survivorship function. To start with, we already know for a = 0 the value for the y axis must be the log of the total number of inter-event intervals. To calculate the remaining values one must sort through the data and count the number of values exceeding (or equal to) the variable on the x -axis (a), for every value of the x variable.

Two potential deviations from random appear as changes in the shape of the curve. If events are clustered, then one gets a concave curve or two lines that look like a broken stick, with the points lying mostly below the random function at low values of a and mostly above at high values of a. For a regular distribution, the result is a convex curve with most of the points at low values of a lying above the line and most points at high values of a lying below it (Fig 2).

A basic problem with the log-survivorship approach is how one determines whether the line is really curved or not, and for a long time this was done simply by inspection. If the line "appeared" concave or as a broken stick, then it was decided that the original process was clustered. This approach was clearly inadequate.

To overcome this problem, Sibley et al. (1991) devised an alternative approach based on a regression technique. They suggested that to compare the two lines one must generate an alternative expectation based on clustering and then ask which

model fits the data better. Sibley et al. (1991) suggest way to do this is to generate the expectation assuming that two processes are occurring, each acting at random - one inside the groups and one outside the groups. Given this model one can generate a clustering expectation. One proceeds by fitting a regression model to the data to see how closely the data fit theoretical expectations. Attractive as it appears, this approach has the fundamental weakness of non-independence. In a normal regression, all points are free to exist anywhere in the two-dimensional space defined by the two variables. Indeed the regression technique explicitly assumes that each point in the data set has no influence over other data. However, in a log survivorship curve each point is severely constrained by the preceding points. The line can never go upwards. It is probably invalid therefore to employ regression on these types of data.

In analyzing inter-event intervals, the best technique is to generate truly independent expectations using variable-sized classes (using Eq. 2) that equalize expectations in each class and maximize the degrees of freedom. This expectation can then be tested against the observed distribution using a standard categorical statistic. This approach overcomes all the pitfalls identified so far. The result gives an unambiguous, objective, statistical evaluation of whether clustering occurs or not and is independent of time scale.

Process Intensity

However, there is at least one other problem. This problem is that the expectations of the Poisson and negative exponential distributions are both generated under the assumption that the intensity of the process (m or r depending on equation) is constant. For a roost emergence however that is clearly not the case. A typical emergence is illustrated in Fig. 3. From this plot it is clear that the underlying intensity generating the events rises to a peak and then falls off. Why can we not just use the average intensity across the entire distribution to generate the expectations? The problem with using the mean intensity is that low emergence rates in the tails of the emergence generate longer than expected intervals that simulate gaps, and high rates in the center of the distribution generate shorter than expected intervals that simulate groups; hence, the result is a distribution that appears clustered but is, in fact, the result of random emergence modified only by a change in the underlying intensity of emergence.

In a recent paper, I examined this problem by generating a series of emergences and hence inter-event intervals using a computer simulation program (Speakman et al. 1992). These emergences were actually random and not drawn from an underlying constant intensity but from an intensity that varied as a normal distribution, somewhat similar to real bat emergences (e.g., Fig. 3). When these were analyzed, using either the log survivorship curve or the optimized class comparison, described above, an illusion of clustering occurred and became more pronounced as the total number of emerging bats increased. For emergences above 250 bats, the likelihood was almost 100% that you would infer the emergence was clustered when it was completely random.

To solve this problem I tried several approaches. First I reasoned that there should be an analytical solution. I am not aware of a solution to the problem of the expected probability of a given inter-event interval from the negative exponential when intensity is itself a normally distributed variable. I worked on this analytical solution for some time but it always became messy and intractable. In the end I gave up because whatever the solution was it would in any case be specific to normally distributed emergences and very few bat emergences actually conform closely to this pattern. Although typically unimodal they are, for example, also frequently skewed.

The next solution I tried was to split the emergence into sections, calculate an empirical intensity for each section, and generate expectations for each section using this intensity. These expectations could then be combined to produce an overall distribution of expectations. This approach had one major drawback and that was how to select the size of the sections. Indeed this problem is analogous to the problem of selecting the intervals for dividing the emergence to calculate expectations from the Poisson distribution, and the consequences are the same --the answer one gets is critically dependent on the way the distribution is divided.

The final solution worked well (see Speakman et al. 1992 for more details). I reasoned that the major problem with the variable intensity was that it was just too variable, and one might control the problem by reducing the amount of variability in the intensity. The simplest way to do this would be to trim the ends of the distributions so that one is left with the central portion in which the underlying intensity is relatively stable. The problem is how much do you need to trim before the variability in intensity does not produce a spurious illusion of clustering.

I addressed this problem empirically using the computer-generated random emergences that I had used previously to show that a spurious illusion of clustering becomes increasingly probable as the

emergence size increases. I trimmed the end pairs of data (first and last) repeatedly until the distributions were not significantly different from random and repeated this for 10 simulations at each emergence size between 50 and 1000 bats. This allowed me to generate an empirical function that describes the number of data points that you need to chop off the ends of an emergence before proceeding with clustering analysis. Not surprisingly, the larger the emergence the more data you must discard to make it conform to the constant intensity assumption. The "trimming function" to make a test at the p=0.01 level is:

Log e (n pairs to be trimmed) = 0.1593 - 0.0054 (Emergence size : n bats) (4).

This empirical function has the benefit of appearing to work on skewed distributions, as well as normal distributions, and so can be applied to a variety of natural emergences independent of their form, as long as they are roughly unimodal. To use it, one calculates the number of pairs (nearest whole number) to be rejected, trims that number off each end, and proceeds with the optimized chi-squared or G test as described above.

A potential problem with the trimming approach is that although it can detect the absence of clustering when it is not there we do not know how well it performs when a known amount of clustering is present. Does it provide a good quantitative assessment of clustering, or does it vastly inflate or underestimate the amount, whilst still suggesting it is statistically significant? These questions are important if we are to quantify clustering using the values of G or Chi-squared test derived from tests on the trimmed distributions.

A student of mine recently devised an elegant assessment of the trimming approach (Kerslake, 1992). He selected three actual emergences of pipistrelles that conformed closely to a normal distribution (only 3 of 11 observed emergences conformed to this pattern). He calculated a mean emergence time and standard deviation for each of these emergences and then, using a computer, generated 1000 simulated emergences of the same size that were randomly drawn from normal distributions with the same mean and standard deviation. For each simulated emergence, he calculated the inter-event intervals and pooled all intervals across the simulations to get a random expectation.

By comparing simulation expectations for random and observed emergences using the optimized Chi-squared test, he could define the level of clustering and compare this with the level defined for the same emergence by the trimming approach. The results were encouraging, despite the small sample size, because there was a qualitative agreement between the two measurements. When the 1000 simulations revealed low clustering, so did the trimming, and when clustering was high the trimming approach also indicated a high value. However, for all three emergences the trimming approach produced a Chi-squared value greater than that using the 1000 simulations by, on average, about 37%. This may suggest trimming is slightly liberal in its quantification of clustering.

Conclusions

The data trimming and optimized categorical testing outlined above can statistically identify when clustering is and is not present in an emergence. The approach is robust to the assumption of normality in the emergence structure and provides a quantitative assessment of the extent of clustering. By using this approach to quantify the responses of bats to natural variations in environmental factors and experimental manipulations, we should be able to readily identify why this potentially important bat behavior exists.

Software Available

To help perform this type of analysis, I have written a computer program called CLUSTAN. The program is written in GW-Basic and will run on any PC which has VGA. The program allows you to enter data directly from the keyboard or it accepts ASCII data exported from a word processor, spreadsheet, statistics package, or data-logging software. The program presents a histogram of the data to assess visually whether the underlying intensity is variable or not and then performs optimized categorical comparison tests (Chi-squared and G test) on either trimmed or untrimmed data. Finally, it presents a plot of the pattern of deviation from expectation to assess the form of any significant deviation.

If you would like a free copy of the program, please send me a blank unformatted disk (preferably in a static-protection wallet), and I will provide you with a copy and full instructions. PLEASE DO NOT send formatted discs.

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x(n in interval)	Probability	n 15-second intervals
0	0.4966	119
1	0.3476	83
2	0.1217	29
3	0.0284	7
4	0.0050	1.2
5	0.0007	0.2

Table 1. Probabilities associated with the Poisson process and the expected number of 15 -second intervals containing x emergence events if the total number of 15-second intervals is240 and the intensity (m) is 0.7.

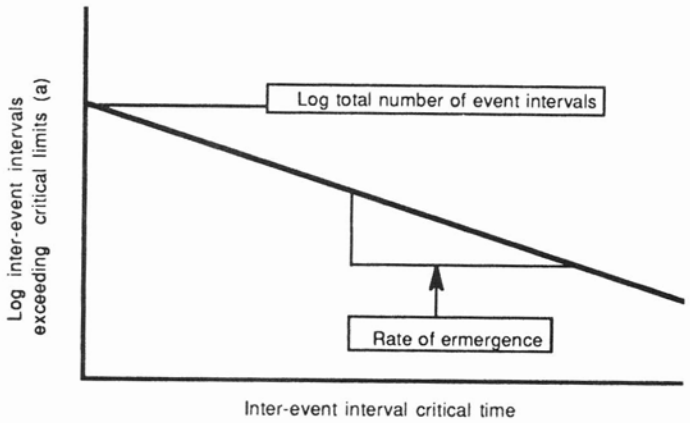

Figure 1. Log survivorship curve. The line represents the logarithm of the random expectations of the number of events greater than or equal to a time "a" plotted against "a". The y-intercept is equal to the log total number of events, and the gradient is the intensity of the process generating the events, which for a bat emergence is the mean rate at which bats emerge.

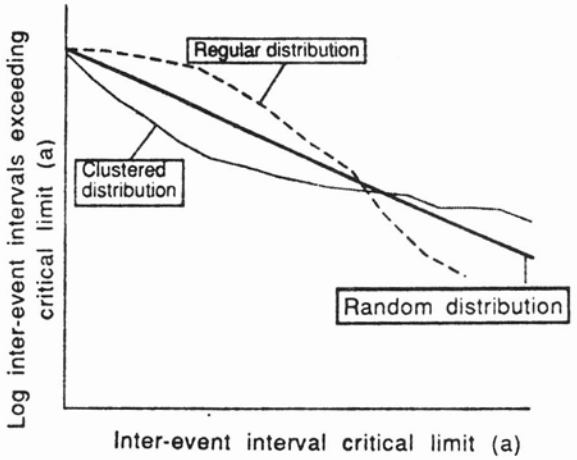

Figure 2. Deviations from a linear log survivorship curve reflecting a random emergence which occur when the emergence is clustered or regular.

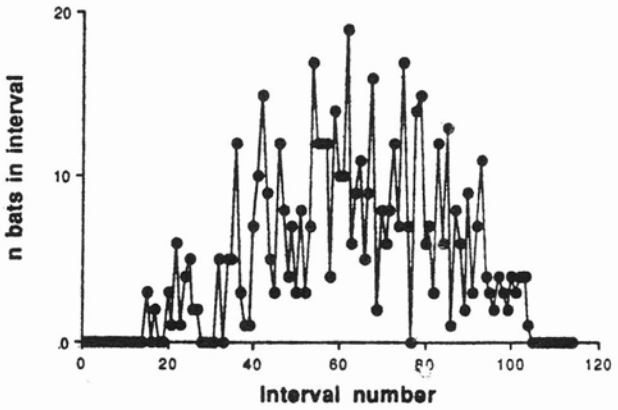

Figure 3. Time course of emergence for a typical bat roost. The emergence is of 535 pipistrelle bats (Pipistrellus pipistrellus) emerging from a maternity roost in northeast Scotland in May 1984. The intervals are 30 sec apart and start at 2115h (GMT).

Observations of Skeletal Pathology in a Little Red Flying Fox *Pteropus scapulatus* from Geelong, Victoria, Australia

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A partly mummified carcass of a Little Red Flying-fox *Pteropus scapulatus* was found under electricity transmission lines in Belmont (38° 10"S, 144° 20" E), a southern suburb of Geelong in Victoria southeastern Australia, on March 4, 1987. The animal was one of an irruption of this normally inland and northern species into the Geelong district during February 1987(Baverstock, unpubl. obs.). The larger congener Grey-headed Flying-fox *P. poliocephalus* is a localized resident in southeastern Australia.

Examination of the carcass revealed that the viscera and external genitalia had decomposed. The absence of a baculum suggested that the specimen was a female. It was noted that the probable cause of death was crushing of the parietal and occipital regions on the cranium consistent with a collision with transmission lines - a common cause of mortality in Pteropus species(Conole and Baverstock. unpubl. obs.) All the phalanges of the left pes had been broken off in the mid-shaft region some time after desiccation.

The skeleton was prepared in a dermestid beetle colony and bleached in sodium perborate solution at the victoria Archaeologist Survey and given the registration number VAS-203. The following observations were made on the cleaned skeleton.

Post Mortem Damage

All phalanges of the left pes severed at mid-shaft.

Pre Mortem Pathology

Innominates and sacrum asymmetrical, twisted in anticlockwise direction. Proximal left ilium and adjacent sacrum show erosion consistent with infection, left ilium detached from sacrum. Partly healed fractures in left pubis and ischium.

Trauma Probably Resulting in Death

Cranium crushed across rear of zygomatic arches resulting in detachment of parietal, occipital, periotic and septum bones. Mandibular rami detached. Left clavicle fractured and left humerus dislocated.

Age of Individual

All major epiphyses and sutures unfused. *P. scapulatus* are normally born in April-May (Richards 1983) so probably 10-11 months old.

Radius Length

Left radius: 123.6 mm, right radius:123.5 mm. Richards(1983) gives the range as 120 -140 mm (mean 132 mm).

Discussion

The anticlockwise twisting of the innominates has probably resulted from the normal movements of the animal during the time that the fractures of the left pubis and ischium were healing. The healing process may have been inhibited by an infection subsequent to or contemporaneous with the injury resulting in the fractures. The head trauma was severe indicating the probable cause of death, but occurred much later than the pelvic injuries. This head trauma gives an insight into the frequent fatalities caused by overhead wires. Richards(1983) describes the typical movements within the population of the nectarivorous and frugivorous *P. scapulatus*. Large camps of up to 100,000 individuals are formed in November or 'December, at which time mating takes place. After mating, the females disperse to have their young in either April or may. When camps reform in November, the juveniles congregate in groups separate from the adults. *P. scapulatus* becomes sexually mature at about 18 months.

The irruption of *P. scapulatus* into the Geelong area in February of 1987 was probably a group of dispersing females or juveniles following the flowering of the riverine Red River Gum *Eucalyptus cameldulensis*. All live specimens examined in the hand were females(T. Prescott & G. McCarthy pers. comm.), and at least two specimens photographed by Prescott in Whittington(38° 11' S, 144° 24'E) were female. We are aware of no data to suggest when *P. scapulatus* becomes skeletally mature, and so cannot be sure whether the animals were females dispersing for parturition, or nomadic first year animals. No skeletal evidence of a foetus was found in the *post mortem* subject.

The evidence is inconclusive, but raises the possibility of sexual segregation in nomadic juveniles. All specimens that were sexed were female but the *post mortem* subject was clearly juvenile and not pregnant. No regular campsite was reported during the irruption, which tends to indicate that a maternity camp was not established, and that these

animals were more likely highly nomadic juveniles.

The specimen of *P. scapulatus* is held in the faunal reference collection of the Victoria Archaeological Survey, Department of Aboriginal Affairs, and was collected under the auspices of Wildlife Act (1975) permit #87-26 issued by the Wildlife Permits Unit, Department of Conservation and Environment.

Acknowledgements

We extend our appreciation to Greg Richards, Trevor Prescott and Gordon McCarthy for information that they supplied during the preparation of this paper.

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Figure 1. Skull of *Pteropus scapulatus* showing fracture of cranium resulting in death.

Bat Activity in Managed Forests of the Western Cascade Range

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Bats in Douglas-fir forests of the Pacific Northwest have been found to roost significantly more often in old than in young forests (Thomas and West, 1991). Because of the widespread loss and fragmentation of old-growth due to timber harvest, it has become increasingly important to determine how bats will respond to changing forest conditions. To investigate the impact of land use practices on bats and other wildlife a research project funded through the Washington State Timber, Fish and Wildlife cooperative entitled Wildlife use of managed forests - a landscape perspective was begun in 1991. As part of this project, a stand-level survey of bat communities occurring in intensively managed forests in the western Cascade range was conducted during August 1992.

Patterns of habitat use were investigated in three structural classes of managed forests; clear-cut (3-7 yrs.), sapling-pole (12-20 yrs.), and mature (50-60 yrs.). Five sites in each of the three structural classes were monitored using ultrasonic detection. This sampling effort resulted in 1029 detections of commuting or foraging bats which will be analyzed using a zero-crossing period meter, and signal processing software.

Preliminary analysis based on the sum of all detections indicates that calls are not distributed equally among sites nor among structural types. Mean detection rates, indexed as the mean number of detections per hour, were found to be twice as high in clear-cut and mature stands than in sapling-pole stands. Further analyses based on species or species group will follow to determine if shifts in species composition exist across habitat types.

Results of this survey will provide baseline descriptions of the bats associated with managed forests. As more information is gained concerning patterns of habitat use and critical habitat elements, forest managers should be able to create management guidelines which encourage bat presence within intensively managed forests.

Acknowledgments

This work was funded by a grant from the Washington State Timber, Fish, and Wildlife Cooperative.

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Infant's Calls Attract Mother *Pipistrellus mimus*

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Most chiropteran species are altricial at birth (Kurta and Kunz, 1987), and mother bats exhibit meticulous care for their young (Gould, 1971). Some species of bats carry their young during foraging flight, whereas others leave their young inside the roost, especially those that live in well-protected areas. Generally, mothers are able to identify their own young, as demonstrated in *Tadarida brasiliensis* (Balcombe, 1990), Eptesicus fuscus (Davis et al., 1968), *Hipposideros speoris* (Marimuthu, 1988) and *Pipistrellus pipstrellus* (Hughes et al., 1989). During the early growth stages of infants, it is the mother that identifies them, whereas in the later stages reciprocal identification occurs (Nelson, 1965; Thompson, 1980).

A maternity colony of the Indian pygmy bat *Pipistrellus mimus* roosts in an unused tunnel that is part of the building housing the Department of Animal Behavior and Physiology, Madurai Kamaraj University, and colony members routinely forage close to the department building. Pipistrellus mimus is polyestrous, giving birth to twins thrice each year. Mothers never carry their young while foraging and leave them behind in the day roost. Newly born infants are naked, weigh 0.58 g, and have a forearm length of 7.9 mm. Infants frequently produce vocalizations in the absence of their mothers.

We have made a serendipitous observation on mother - young recognition in *P. mimus*. In the course of post-natal growth studies, a one-day-old infant was separated from its mother, who was tagged and released, and the infant was brought to a room about 75 m from the roost. While measurements were made on this isolated infant, it emitted vocalizations continuously. The frequency of the emitted sound ranged from 30 to 80 kHz and was measured using a Mini-2 bat detector (Ultra Sound Advice). About 15 minutes later, an adult bat entered the room through the window and flew over the infant that had been placed on a table. We captured the adult bat with a hand-net and identified it as the mother. Presumably, the mother was nearby and was attracted by the infant's vocalizations. Next, we released the mother bat inside the tunnel and placed the infant at the tunnel entrance to see whether the mother would retrieve the infant. About 10 minutes later, the mother flew back, settled over the infant for about 2 minutes, and then flew into the tunnel carrying her infant. Previous studies have suggested that acoustic and olfactory components play a role in mother-young recognition (Kleiman, 1969; Marimuthu, 1988; McCracken and Gustin, 1991), and the *P. mimus* mother that tracked down her missing infant presumably did so on hearing the latter vocalize.

Acknowledgements

We thank Prof. M. K. Chandrashekaran for providing helpful criticisms on an earlier draft of the manuscript. This work was supported by a grant from DOEN research project, Government of India.

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Accidental Death by Web Entanglement in the Western Pipistrelle, *Pipistrellus hesperus*

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Numerous accidental deaths of bats have been reported. Impalement has been recorded on barbed wire (Johnson, 1933; Hibbard, 1963; Long, 1964; Brousset, 1966; Fenton, 1983; Hill and Smith, 1984); on burdocks (*Arctium spp.*; Little, 1924; Lyon, 1925; Johnson, 1933; Fenton, 1983; Hill and Smith, 1984); and on desert plants (Brousset, 1966; Barbour and Davis, 1969; Fenton, 1983; Hill and Smith, 1984). Deaths have also been reported due to entanglement in Spanish moss (*Tillandsia usneosoides*; Dunaway, 1960); in a sandpaper plant (*Eucnide urens*; Hardy, 1949); and in foxtail (*Setaria viridis*; Fors, 1984). One record of accidental mortality apparently caused by spider web entanglement was recorded in China by Cantor (1842). He reported that "common small pipistrelles; frequently tangled themselves in webs of large spiders, but were not eaten by the spiders." This note describes a possibly similar event, but in the western hemisphere.

The result of the entanglement was observed during a 1991 herpetological survey of the U.S. Army Yuma Proving Ground (USAYPG), approximately 35 km northeast of Yuma, Arizona. The study area, covering over 840,000 acres, is composed mainly of lower Sonoran desert-scrub and receives an average annual rainfall of 7 cm. On 12 August 1991, in an unnamed range of the Trigo Mts., best known as the site of Mohave Tanks (AZ: La Paz Co., T1S, R21W, Sec 8, NW 1/4, SE 1/4), I found a partially-filled tinaja (natural water catchment) in a small canyon. The tinaja was surrounded on three sides by > 5 m sheer rock walls. On one side, approximately 5 m above the water, a single cholla cactus, *Opuntia sp.*, was growing on a ledge, 70 cm from a back wall. A disorganized spider web ran from the cholla to the back wall (average width = 50 cm). Entangled in the middle of the web was a mummified adult *Pipistrellus hesperus* (University of Arizona specimen #25510). The bat was fully ensnared in the strands, suspended upside down, but was not encased in silk. Any consumption of the bat by the spider, of unknown species, could not be determined because of the desiccated condition of the specimen.

Pipistrellus hesperus is common around desert water holes (O'Farrell and Bradley, 1970) and their small size, < 3 gm, probably makes them vulnerable to entanglement. Some accidents and mortality occur when young bats are learning to fly (Kunz, 1974; Fenton, 1983), but in this case the bat was an adult. *Pipistrellus hesperus* has been recorded eating spiders (Fries, 1981), but it is thought that those consumed were dispersing ballooning spiders.

Griffin (1958) theorized that bats, once accustomed to a familiar territory, may fly by memory and give little notice to echo information about their surroundings. A bat flying by memory around a frequented watering hole would indeed be susceptible to a newly constructed spider web.

Acknowledgments

I thank the U.S. Army Yuma Proving Ground for their serendipitous funding of this discovery, V. Morrill for her logistical support, Dr. R. Davis for citation suggestions, and P. Collins, D. Doell and Dr. Y. Petryszyn for comments and suggestions on drafts of this note.

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Folivory in *Platyrrhinus(Vampyrops)lineatus*

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Phyllostomid bats eat a wide variety of different foods, which may include fruit, pollen, nectar, leaves, insects, small vertebrates and blood (Gardner, 1977). Many species are predominantly frugivorous, though they may eat other items to complement their diet. Although it is known that leaves may form part of the diet of frugivorous bats, references to this in the literature are few. Marshall (1985) and Zortéa and Mendes (1993) reviewed the occurrence of leaves in the diet of paleotropical and neotropical phytophagous bats, respectively. In this study I focus on the use of leaves by *Platyrrhinus lineatus* a widespread fruit bat which is known to include fruit, insects, pollen, and nectar in its diet (Ruschi, 1953; Sazima and Sazima, 1975; Taddei, 1973; Willig, 1983).

The feeding habits of *P. lineatus* were investigated during a four month period (May to August 1989) in the Museu de Biologia Mello Leitão, Espírito Santo State, eastern Brazil (19o 50'S, 40o 22'W). The methodology consisted of fortnightly collection of food remains (dry oral pellets, seeds, feces and partly eaten foods), using nylon nets arranged over two of the P. lineatus resting sites, located in palm trees (*Livistona chinensis*).

Besides fruits, *P. lineatus* included leaves and insects in its diet (Table 1). The two species of leaves of *Solanum* confirmed in the diet of *P. lineatus* were also used by *Artibeus lituratus* in the same study area. Also similar is the behaviour involved in ingesting leaves and fruits (Zortéa and Mendes, 1993). I observed that *P. lineatus* ate fruits of *Solanum swartzianum* in the same place where leaves of this species were eaten by *A. lituratus* (Zortéa and Mendes, 1993).

Maintenance of protein balance has been used to explain the use of leaves by Old World bats (Fleming, 1982) and perhaps this argument could also be used to justify the occurrence of folivory in neotropical bats, although no study has confirmed this suggestion. The lack of information concerning folivory in neotropical bats may be attributed to the fact that studies of the feeding habits of bats are based principally on the analysis of stomach contents and feces. This type of analysis is inefficient at detecting leaves, because the majority of fibres are discarded in the form of dry oral pellets. Gardner (1977) discussed the problem of analyzing dropped or discarded parts of foods because of the difficulty of identifying whether or not the resting site was used by one or more than one species. However, in this study the two sites were monitored frequently and only *P. lineatus* was observed, during the day as well as at night. Zortéa and Mendes (1993) made similar observations on resting sites of *A. lituratus* , and simultaneous use of shelters by the two species was not observed.

	1989			
Plant part/species	M	J	J	A
Leaves				
Solanum sp. 1	X	X		
Solanum sp. 2	X	X		X
Fruits				
Cecropia glazioui	X	X	X	X
Eriobotrya japonica			X	X
Hovenia dulcis	X	X	X	
Livistona chinensis		X	X	X
Minimum # of species	4	5	4	4

Table 1. Foods eaten by *Platyrrhinus lineatus* in the area of the Museu de Biologia Mello Leitão, Espírito Santo State, eastern Brazil. [Unidentified insects and fruits of *Solanum swartzianum* were also utilized during these months but not sampled on collection days.]

Acknowledgments

I thank S. L. Mendes, E. Price, H. M. Piedade and A. G. Chiarello for helpful comments.

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The 2-Minute Harp Trap for Bats

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INTRODUCTION

Harp traps are devices to catch flying bats, consisting of one or more frames that support banks of vertical strings. The bats hit the strings and fall into a holding bag placed underneath the frames. The efficiency of these traps can be very high, both at the entrance of roosts (Kunz and Anthony, 1977) and across flyways (LaVal and Fitch, 1977; Tidemann and Woodside, 1978).

Harp traps have several advantages over mist nets, also widely used to catch flying bats (1) Francis (1989), LaVal and Fitch (1977), and Tidemann and Woodside (1978) showed that traps have, in some circumstances, much higher catching rates than nets. (2) Extracting bats caught in mist nets can be a very time consuming and potentially harmful task because they often get seriously tangled. In contrast, it is very easy to extract bats from traps; it is therefore possible to use them at the entrance of roosts housing large colonies, where the number of bats caught in a short period of time would make the use of mist nets impossible. (3) Mist nets have to be frequently monitored because many bat species chew them and may escape in just a few minutes, whereas traps can be left unattended for longer periods (although care is needed when there are risks of predation or overcrowding in the holding bag). The biggest disadvantages of the traps is that they are bulkier and heavier than nets, and have a smaller catching surface.

The first model of a harp trap was developed by Constantine (1958). This trap was later modified by several authors (Tidemann and Woodside, 1978; Tuttle, 1974a), who changed the original design to increase the effectiveness of the trap, and to make it lighter and easier to assemble.

In this note, we describe further improvements to the design of harp traps, which make them easier to build, cheaper, lighter, and much quicker to assemble in the field. This model can be built without specialized tools and welding for about US $50.00. It weighs about 4.5 Kg (with legs and holding bag) and can be assembled by one person in less than two minutes.

MATERIALS NEEDED

Trap:

4 aluminum bars	120 x 2 x 0.4 cm
4 aluminum bars	100 x 3 x 0.4 cm
2 aluminum bars	37 x 2 x 0.4 cm
2 aluminum bars	110 x 2 x 0.4 cm
10 threaded rods	10 x 0.6 cm
	(or bolts of similar length)
4 bolts	2 x 0.6 cm
42 regular nuts	0.6 cm
10 wing nuts	0.6 cm
16 washers	0.7cm(0.1cm thick)
2 metal angles	see (8)
100 meters of monofilament fishing line	(6 or 8 pounds)

Holding bag:

1x nylon cloth	100 x 180 cm
2x nylon cloth	35 x 50 cm
	(of the type used in tents)
1x rough cloth	80 x 100 cm

Optional legs:

4x aluminum bar 90 x 2 x 0.4 cm
(or stronger angled aluminum bar, if you are planning to use the legs often)

6x bolts	2 x 0.6 cm
8x regular nuts	0.6 cm
2x wing nuts	0.6 cm
2x metals angle	see (8)

TOOLS NEEDED

Electric drill
Drill bits (0.3 cm and 0.65 cm)
Saw for metal
File or sand paper for metal
Wrench (for the nuts)
Sowing machine

MOUNTING INSTRUCTIONS

(1) Using the 0.65 cm drill bits make eight holes in each of the 120 cm bars (side bars), at 2 cm, 4 cm, 6 cm, 8 cm, 40 cm, 80 cm, 104 cm, and 119 cm. Using the same drill make three holes in each of the 100 cm bars (top and bottom bars), at 1 cm, 50 cm, and 99 cm. Make a similar hole in the middle of the 37 cm bars (bag holding bars) (Fig. 1).

(2) Using the 0.3 cm drill bits, make 38 holes along one of the edges of the four 100 cm bars. The holes should be 2.5 cm from each other and about 0.4 cm from the edge of the bar (Fig. 1a).

(3) Sew four vertical slots along one of the edges of the 37 cm bars. The slots, at 2 cm, 5 cm, 32 cm, and 35 cm, should be 0.5 cm wide and 1 cm deep (Fig. 1a).

(4) Using the file or sand paper, eliminate all the sharp edges where the aluminum was cut or drilled. The edges of the 0.3 cm holes should be smoothed; rough edges may cut the fishing line. This can be done using a small round file and/or sand paper.

(5) Link the side bars in pairs inserting the threaded rods in the holes at 40 and 80 cm. Tighten well using the regular nuts. The bars should stay about 7 cm apart.

(6) Link the bottom and top bars in pairs inserting the threaded rods in the holes in the middle of the bars. Tighten well using the regular nuts. The bars should stay about 8 cm apart.

(7) Using threaded rods, nuts, and wing nuts mount the frame of the trap by attaching the corners of the four pairs of bars prepared about (Fig. 2a). The side bars should stay on the inner side, and be separated from the top and bottom bars by two washers. Attach the top pair of bars to the holes at 8 cm from the end of the side bars.

(8) The holes in the metal angles should be at about 3 cm from the corner on one side and 1.5 cm on the other. If the angles do not have holes in these places make them with the 0.65 cm drill bits.

(9) On each side of the trap, attach one metal angle to one of the bars, using the hole at 104 cm. To each of these angles, attach one of the 37 cm bars (bag holding bars), with the vertical slots facing up (Figs. 2c and 2d).

(10). Cut 140 cm pieces of nylon line and tie them individually to the top and bottom bars using the small holes along their edges. Strands should be pulled until barely tight. They should latter be stretched by moving the top bars to the upper attachment holes on the side bars (at 2, 4, and 6 cm).

The catching surface of this trap is about 95 x 100 cm. Larger traps can be built, but it is important to increase the number of the threaded rods that link the frames to keep the rigidity of the

structure. Using longer rods, it is also possible to install more than two banks of lines, which may increase the efficiency of the trap (Francis, 1989; Masing, 1989).

HOLDING BAG

(1) Center the rough cloth on the 100 x 180 cm nylon cloth and sew them together.

(2) Fold the ends of the nylon cloth at 35 cm from the edges, towards the side with the rough cloth. Sew these folds at 5 cm from the new edge, leaving a 30 cm flap (Fig. 1b). The bats will climb the rough cloth and hide under the flap. They cannot climb the nylon material because it is too slippery.

(3) Round one of the ends of the 35 x 50 cm pieces of material, and sew them to the sides of the piece prepared before (Fig. 1b).

(4) To keep they nylon material from shredding along the edges, burn them with the flame of a candle or lighter (or many matches...). Make a few small holes in the bottom of the bag to drain rainwater.

OPTIONAL LEGS

If the trap is to be used in places where it can simple be hanged, then the trouble of making the legs can be avoided. But the legs are often very helpful. If you plan to use them frequently, you may want to replace the 90 cm bars with angled aluminum bars, which are considerably stronger.

(1) Using the 0.65 cm drill bits, make one hole at 1 cm from one of end of the four 90 cm bars (Fig. 1a).

(2) Using the 0.65 cm drill bits, make two holes on each of the bag holding bars, 7.5 cm from each end (Fig. 1). In each of these holes, place a bolt fixed with two nuts so that the head of the bolt is on the outer side of the trap and there is a space of at least 0.5 cm between the head and the bar (Fig. 2b).

(3) Attach the metal angles to the threaded rods at 80 cm on the side bars, as shown on Fig. 2c and 2e.

(4) Attach the legs to these angles with a bolt and a wing nut. The bolts described in (2) serve to keep the legs in place, but the legs should also be attached to the bolts or to the bars with a string, rubber band, wire or band of velcro.

ASSEMBLING INSTRUCTIONS

To prepare the frame of the trap to be transported, it is simply necessary to loosen slightly the eight wing nuts placed at the corners, and fold it by forcing two opposite corners together. The bag holding bars and legs are placed along the main structure. If the trap will be stored for a long period, it is advisable to reduce the tension of the lines by moving the top horizontal bars to the lower attachment holes on the side bars.

To open the trap in the field, pull the opposite corners and tighten the wing nuts. Place the bag holding bars horizontally. Position the legs or suspend the trap. Slide the 110 cm bars through the pockets along the edges of the bag, and place them in the notches on the bag holding bars (Fig. 1b).

If folded as described above, the trap is 220 cm long. However, if you need to make it more compact (120 cm long), remove the corner wing nuts to separate the side, bottom, and top bars. To keep the lines from getting tangled, roll them onto the top or bottom bars together with a large piece of cloth.

Like other harp traps, the spacing between the frames, the tension of the lines, and the position of the 110 cm bars that hold the bag can be varied. Kunz and Kurta (1988) and Tuttle (1974b) discuss these adjustments. The distance between the vertical lines on each frame may also influence the capture rate (Masing, 1989). The ideal settings vary with the species and the placement of the trap, but regrettably, there is very little data to determine the best adjustments to use for each situation.

ACKNOWLEDGMENT

We are thankful to Pedro Raposo for preparing the illustrations.

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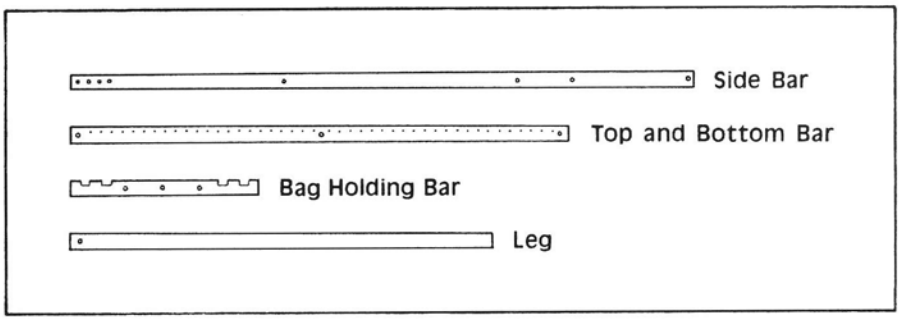

Fig. 1a. Aluminum bars used in the construction of the trap.

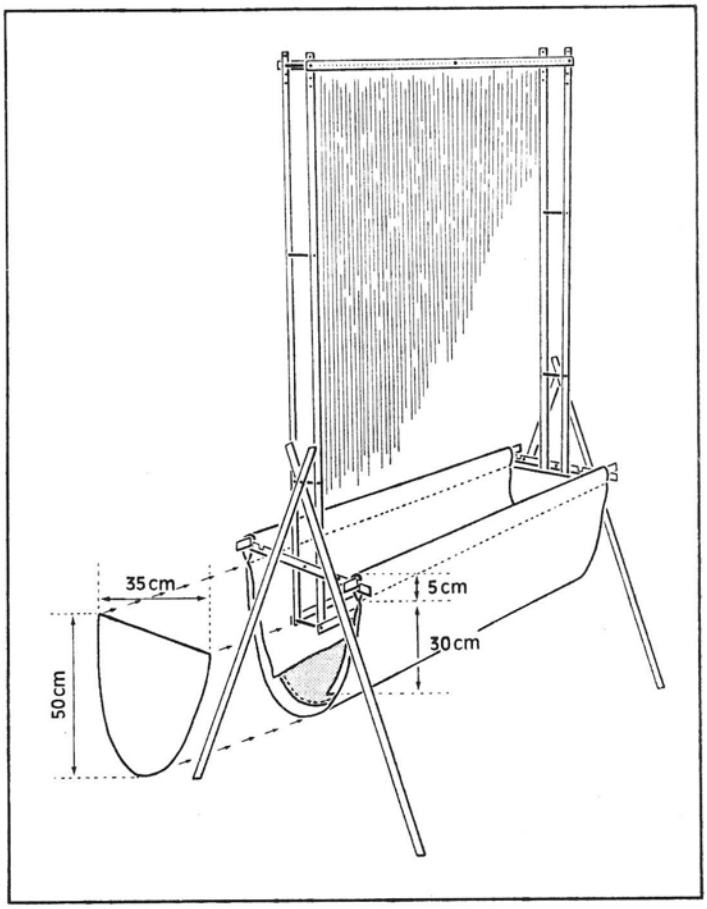

Fig. 1b. General view of the trap and details of the construction of the holding bag.

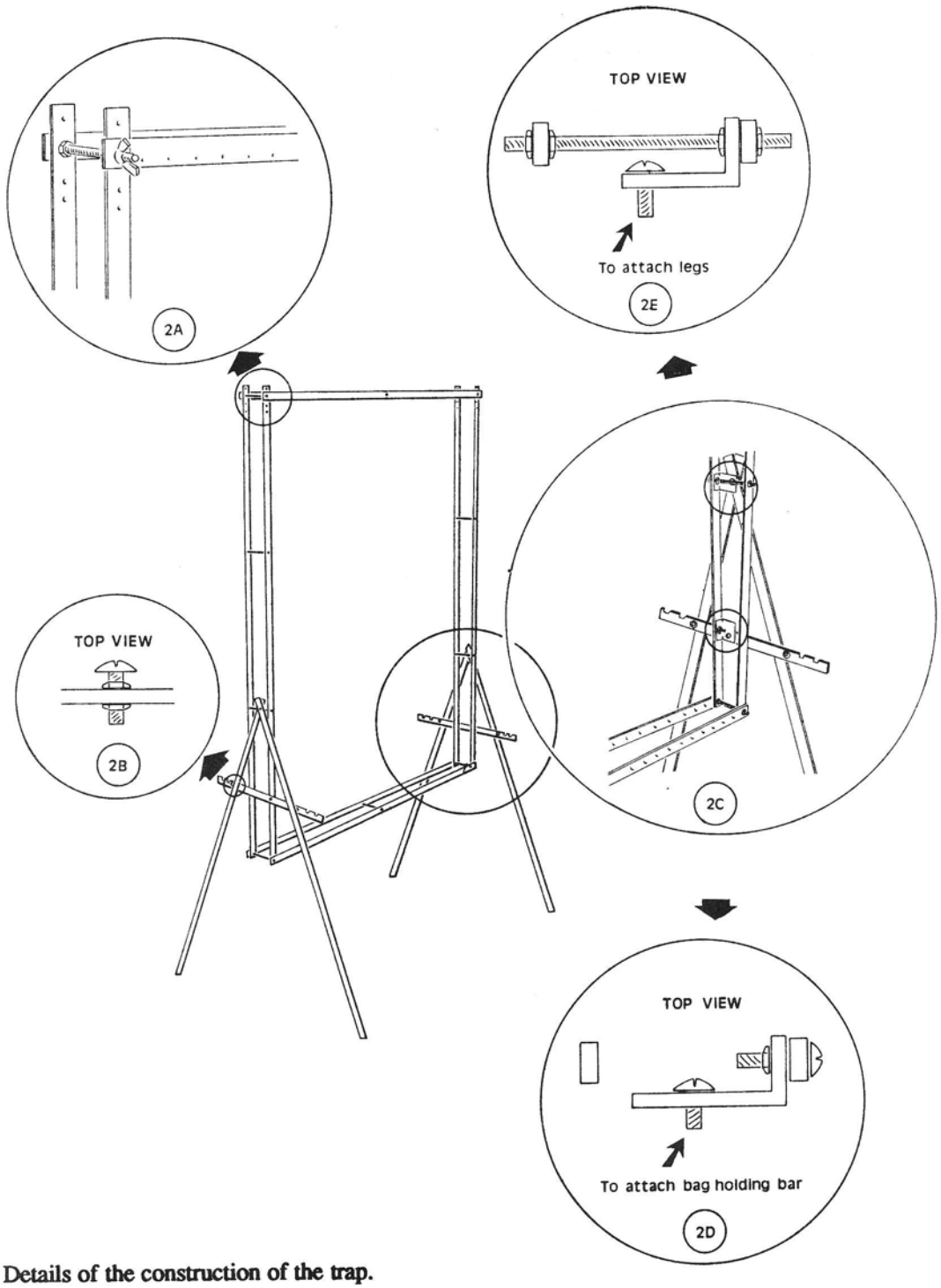

Fig. 2. Details of the construction of the trap.

Thomas' Mastiff Bat, *Promops centralis* (Molossidae), in Oaxaca, Mexico.

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Thomas' mastiff bat, *Promops centralis*, has been collected at scattered locations throughout Mesoamerican tropical forests, ranging from Panama (Hall, 1981) to the states of Jalisco and Colima (Alvarez and Avina, 1964; Watkins et al., 1972; Kennedy et al., 1984), Guerrero (Polaco et al., 1992), Puebla (Urbano et al., 1987), and Yucatan (Birney et al., 1974) in Mexico (Hall, 1981). In Oaxaca, this bat is known only from Tehuantepec (Goodwin, 1969) and from six specimens collected 6 km E of Mitla (16° 55' 00" N and 96° 25' 30" W), during the wet season, more than 30 years ago (Los Angeles County Museum 9962 to 9966 and 16768).

On 23 December 1990, at the onset of the dry season, and on 11 May 1992, at the end of the dry season, we visited Santa Maria del Tule at 10 km E of Oaxaca City (17° 04' 05" N and 96° 38' 05" W, elevation 1,549 m), and Oaxaca City (17° 02' 50" N and 96° 43' 30" W, elevation 1,580 m), respectively. Both sites were characterized by secondary vegetation dominated by *Stenocereus, Mimosa, Acacia, Bursera,* and *Rhus*. Noteworthy records of Thomas' mastiff bat were obtained at both sites.

We captured a nonreproductive adult male at Santa Maria del Tule, and a pregnant adult female at Oaxaca City, respectively. External and cranial measurements (in mm) were as follows: total length, 134, 135; length of tail, 56, 66; length of hindfoot 8, 13; length of ear, 17, 19; length of forearm, 56, 56; greatest length of skull, 22, 22; breadth of braincase, 12.9, 13.1; length of maxillary tooth row, 9, 9; weight 20.1, 34.5 g, respectively. The total length (crown-rump) of the female's fetus was 30 mm. Both specimens were deposited at the Centro Interdisciplinario de Investigaciones para el Desarrollo Integral Regional-Oaxaca City mammal collection (catalog numbers 538 and 620).

Despite several mammalian surveys conducted in Oaxaca in the last decade, no other specimens of mastiff bats from this state have been reported recently. In an ongoing mammalian inventory involving more than 400 net-nights, we have not been able to collect this rare bat in adjacent regions of Oaxaca, including the Sierra Mazateca, Mixteca, and Madre del Sur.

We thank the personnel at the Los Angeles County Museum and R. Aguilar for their help, and two anonymous reviewers for commenting on this note. Field work was supported by the MacArthur Foundation (grant to V. Sanchez-Cordero and F. Cervantes) and the National Science Foundation (grant no. 92000863 to A. T. Peterson).

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Consumption of Water Boatmen (Hemiptera: Corixidae) By Little Brown Bats, *Myotis lucifugus*

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Although little brown bats *(Myotis lucifugus)* forage in many habitat types, including areas of high vegetative clutter, members of this species seem to prefer open areas and forest edge (Adams, 1990, 1992). Data gathered on diet of some populations of *M. lucifugus* suggest a preference for trichopterans, dipterans, and lepidopterans (Bellwood and Fenton, 1976). In addition, *M. lucifugus* is known to forage selectively. For example, Buchler (1976) notes that choice of insects by adult *M. lucifugus* is not random and not based upon relative abundance of a particular insect species. Further, Fenton and Morris (1976) state that species of *Myotis* selectively pursue and capture the larger insects flying around a black light. The purpose of the present study is to quantify differences in the diets of juvenile and adult *M. lucifugus* at a maternity site; this analysis is part of a larger study documenting resource partitioning between age groups at the site.

Methods

The study took place at Fort Laramie National Historical Site, Goshen County, Wyoming, in 1990 and 1991. A maternity colony of about 3,000 adult little brown bats (*Myotis lucifugus*) arrived at the site in late April of each year and was present until about the first week in August. Juveniles and adults were captured in mist nets erected in three habitat types: open habitat (little or no obstacles present in potential flight paths), semi -clutter habitat (flyways with some obstacles present; flyway tunnels through vegetation have diameters no less than 2 m and no bigger than 3 m), and heavy clutter (flyways with many obstacles present; flyway tunnels no larger than 2 m in diameter).

After capture, individuals were kept in 0.5-liter containers until they defecated or for a maximum of one hour, after which they were released. Fecal samples were wrapped in aluminum foil that was labeled with collection data. Later, each bolus (a pellet may contain up to several boluses) was separated from others in the pellet and teased apart in warm water. Most pellets contained the remains of either one large or two to three small insects (Coutts et al., 1973). Insect parts were identified using a key (Whitaker, 1988) or by comparing them to insects collected at the site. In addition, sticky traps and suction traps were placed near mist nets in each habitat type to capture free-flying insects.

Results

There was a diversity of insect types eaten by both juvenile and adult Myotis lucifugus. Identifiable parts isolated from fecal samples represented nine insect orders for juveniles, whereas adult samples represented eight insect orders (Table 1). Although many kinds of insects were eaten, most were not equally represented in the diets of juveniles or adults. Analysis of fecal samples obtained from juveniles captured in 1990 (n=12), showed Diptera to be present in highest frequency (32.7%). Trichoptera was second highest in frequency (25.1%). Ephemeroptera was third (11.5%), and Hemiptera (7.7%), in the form of water boatmen (Corixidae), ranked fourth (Table 1). For adults in 1990 (n=8), Diptera was present in highest frequency (38.8%). Hemiptera (water boatmen) made up 8.3% of the adult diet in 1990. In 1991 (Table 1), Hemiptera (water boatmen) was the most common (26.4%) insect order in the diet of juveniles (n=17), and in (34.4%) in the diet of adults (34.4%; n=23).

	1990		1991	
	Juveniles (n=12)	Adults (n=8)	Juveniles (n=17)	Adults (n=23)
Diptera	32.7	38.8	24.5	23.4
Trichoptera	25.1	8.3	5.7	20.3
Ephemeroptera	11.5	2.3	1.9	0
Lepidoptera	9.6	22.2	22.6	7.8
Coleoptera	7.7	11.1	13.2	10.9
Hemiptera	7.7	8.3	26.4	34.4
Hymenoptera	1.9	2.8	4.6	1.6
Homoptera	1.9	5.7	1.1	1.6
Neuroptera	1.9	0	0	0

Table 1. Frequency of occurrence insect orders in the diets of juvenile and adult *Myotis lucifugus* for 1990 and 1991.

There were no other types of Hemiptera, besides water boatmen, identifiable in fecal samples collected from *M. lucifugus* at the site in either year. Water boatmen were easily distinguished from other insects in the diet by their distinctively modeled exoskeleton and heavily haired (paddled) rear appendages. No water boatmen were ever captured by sticky or suction traps in either year.

Discussion

Although dietary analyses have been performed on various populations of *Myotis lucifugus*, none reported ingestion of water boatmen. At Fort Laramie National Historical Site, water boatmen were ingested by both adult and juvenile *M. lucifugus* in both years sampled. In 1991, the second year's sampling, water boatmen constituted the highest frequency of insects in the diet of both age groups. This suggested an increase in the boatmen's population at the site in 1991. Independent sampling of insects did not produce captures of water boatmen in either year, but sampling may have been confounded by clustering of water boatmen away from where insects traps were set. Because water boatmen were eaten by some newly volant bats, which could not fly very far from the roost site (located about 100 m from the nearest water source), it appears that the boatmen were flying some distance from water.

Recent studies (Adams, 1992; Powers et al., 1991) have clearly indicated that newly volant juveniles of *M. lucifugus* do not have the same flight ability as adults. Therefore, equivalent frequencies of certain insects in the diet of both age groups suggested that those insects are more easily preyed upon than others. The fact that juveniles and adults had about the same frequency of water boatmen in their diets within years (1991: juveniles 7.7%, adults 8.3%; 1992: juveniles 26.4%, adults 34.4%), coupled with the fact that newly volant young are inefficient fliers, suggested that hemipterans were captured while in flight as opposed to being gleaned from water surfaces, the latter being a task best undertaken by older, more experienced fliers.

Acknowledgments

This study was funded by grants from the University of Colorado Museum and the Department of Environmental, Population, and Organismic Biology, University of Colorado, Boulder.

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HELP WANTED!!

Plecotus townsendii

I need help in tracking down any historical information on *Plecotus townsendii* in Colorado. Anybody out there that has or knows of information on *Plecotus* records, roost sites, or anecdotal information please contact me. We are trying to evaluate the status of this species in the state, but very few historical data exist to help in this endeavor. Anything I can get will be greatly appreciated.

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Letters to the Editor

Cueva de los Culebrones: a Threatened Ecosystem

Armando Rodrígues-Durán

Cueva de los Culebrones is located on a 110 acre private farm in the limestone karst region of northcentral Puerto Rico in the Caribbean. This cave is unique in the assemblages that it holds. Five species of bats are known from this cave: *Brachyphylla cavernarum, Erophylla bombifrons, Monophyllus redmani, Pteronotus quadridens* and *Mormoops blainvillii*. These five species represent 38% of all the species of bats reported from the island. Moreover, one of these species, *Pteronotus quadridens*, is unique in terms of its particular roosting requirements. *Pternotus* is strongly associated with hot-caves, where air temperature is over 28° C and relative humidity is 100%. Less than 12% of all caves studied in Puerto Rico are hot-caves, Cueva de los Culebrones being one of them.

Another unique feature of Cueva de los Culebrones is the phenomena for which it gets its name. An average of seven boas (the endangered *Epicrates inornatus*) were observed capturing bats from branches or rocks at the cave entrance between August 1981 and August 1982. Further observations revealed up to 21 boas distributed both inside and outside the cave.

For many years Cueva de los Culebrones was owned by a nature conscious person who took great care in protecting this unique system. However, in recent years the land has changed hands several times and severe disturbances by owners and outsiders have occurred. Unless some corrective measures are taken, the future of this system is at best uncertain. Some local organizations are looking into this matter. Our intent is to acquire the property. Any information about organizations who might help to fund the acquisition is welcomed.

Submitted by Armando Rodrígues-Durán, Dept. of Natural Sciences, Inter American University, Bayamón, PR 00959

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Bat Gauno Blows up Building???

Rollin Baker

Rollin send along the following item which is both amusing and distressful and we believe it will be of some interest to all of us as we continue to attempt to educate the public about bats. It was printed in The Houston Post June 29, 1993 on page A-12 as printed here.

ASSOCIATED PRESS, NEWBERRY, Mich.

An explosion that leveled an abandoned ranger headquarters at a state park is being blamed on bat dung.

" I originally thought it was propane gas, but this damage was much greater than a propane explosion" state police Detective Sgt. Wally Helmila said. "Methane is pretty explosive stuff."

The June 12 blast at Tahquamenon Falls State Park hurled cement blocks 50 feet and was heard by campers 14 miles away, Park Manager Wayne Suida said.

"It was a tremendous explosion" he said. The building was vacant and no one was injured.

Suida said the building had been infested with bats for years, and Helmila theorized that dung, which collected in the walls and attic of the building generated methane gas. Heavier than air, the gas sank to the basement. When an electric sump pump activated, its spark ignited the methane, Helmila said. Michigan State University Zoologist Richard Snider confirmed the theory wasn't, well, batty.

"The potential certainly existed for this to occur," Snider said, but acknowledged he'd never heard of such a thing before.

"I was in there before the explosion and the bat smell was stronger than it had ever been- probably because the building was closed up," Suida said. [end]

Rollin Baker adds,

"Vernon Bailey and hundreds of other bat specialists have risked life and limb using carbide lamps to look in dank holes for bats. What tripe! Methane forms, so I am told, in anearobic situations.

"A possible outcome of this news story might be real detrimental to house and cave bats. Unscrupulous animal control specialists might use this news release to make big money by "scaring" housewives into allowing them to rid their houses of bats because of their " explosive" droppings. This unfortunate publicity should be squelched indeed!

Submitted by Rollin Baker, 302 North Strickland St.,Eagle Lake, TX 77434-1841

Record of Northern Yellow Bats and Young on Galveston Island

Patricia Morton and David Schmidly

Following a phone call from a Galveston Island fire department on 14 June 1993 David Schmidly and I traveled to the station to collect bats that had fallen out of a recently felled palm tree on the property. We were presented with a grocery sack containing a dead 30 gram female Northern yellow bat *Lasiurus intermedius intermedius*, her three live infant pups and a pup from another mother that had apparently escaped. The mother died on impact when the tree fell. The live pups belonging to the dead female(two males and one female) weighed less than one gram each. We estimated the age of these three pups, with dried umbilical cords still attached, at one to three days. The fourth pup, a male, was significantly larger at 2 grams and perhaps one week of age. The four pups were cared for following procedures recommended in Sue Bernard's book, *The Maintenance of Bats in Captivity*, but all died within four days. This finding demonstrates that Northern yellow bats are resident on the island and producing young in early June. We hope to organize a follow-up study to determine how many of the island palms are occupied by bats, dimensions of the trees occupied and the length of time these bats are resident in Galveston. Submitted by Patricia Morton and David Schmidly, Texas A&M University at Galveston, Galveston, TX.

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Update on Colorado's Bats: Inactive Mines Project

Kirk Navo

Colorado's rich mining history has resulted in more than 20,000 inactive or abandoned mines scattered throughout much of the state. While Colorado Mined Land Reclamation Division(MLRD) is currently closing these mines to safeguard them for the public, they may provide important roosting habitat for some of Colorado's 17 species of bats. The Colorado Division of Wildlife, in cooperation with MLRD, has initiated a volunteer project in an attempt to survey these mines to identify significant roosting habitat prior to closure. Significant roost sites are recommended for bat gate closures to protect roosting habitat that would otherwise be permanently lost.

Volunteers have been recruited, trained and then assigned to specific mine sites to survey them using bat detectors and visual observations outside the mine entrance. Over 550 people have signed up for the project to date, and 382 of them have completed the required four hour training session required to participate in field work. Many of them are return volunteers from past seasons. Over 195 people have participated in survey efforts over the first two years of the project, and in 1992 compiled 2159 volunteer hours. These volunteer hours have resulted in a savings to the agency of at least $ 17,500. For the 1993 field season, about 150 people have been trained and many are participating in field work. Selected sites are further investigated by wildlife biologists to verify species and determine the type of roost use. The project has completed two seasons of field work, and to date over 100 mines have been surveyed. Based on the first of the two seasons' results, about 60 % of mines surveyed have had bat activity associated with them. Close to 15% of the mines surveyed have been verified as roosting habitat for bats by follow up surveys. Townsend's big-eared bats *Plecotus townsendii* have been found at 13 sites, in mostly small colonies of up to 50 bats. Eight species have been documented using abandoned mines during this project. These are: *Plecotus townsendii, Myotis lucifugus, M. ciliolabrum, M. evotis, M. volans, M. californicus, M. thysanodes,* and *Eptesicus fuscus*. Bat gates have been installed at 13 mine portals and 6 more are pending. Gate sites are resurveyed by volunteers to evaluate acceptance of gate designs. I will provide some information regarding the use of gates by *Plecotus* sometime this coming winter. Submitted by Kirk Navo, Colorado Division of Wildlife, 0772 South Road 1 E, Monte Vista, CO 81144.

News

from Ithaca, New York

This summer John Hermanson is continuing to investigate unique contractile proteins and muscle specializations in the primary wing muscles of the common vampire bat, *Desmodus rotundus*.

Paul Faure is continuing his research on insect neurobiology and sensory physiology and he assures us that moths (better known as bat food) do indeed have ears.

Nina Ingle is currently selecting field sites for her research on Mindanao in the Philipppines on how communities living at the forest-edge can be involved in promoting forest regeneration.

Bill Schutt is continuing his dissertation research on the morphology of the chiropteran hind limb and its role in hanging behavior. Many species of bats possess passive digital locks, mechanisms that allow them to hang efficiently for extended periods. Since the vampire bats(Phyllostomidae) as well as representatives of other chiropteran families lack this mechanism, he is utilizing dissection, SEM, histochemistry and contractile protein biochemistry to investigate alternative mechanisms that enable these bats to hang in an energy efficient manner. Recent Visits to the Department of Mammalogy at the American Museum of Natural History have yielded some interesting results. A return trip to Trinidad this summer will provide additional specimens for this study. Bill is also planning to bring back live specimens of *Desmodus* and *Diaemus* for a study of the biomechanics of locomotion in these genera. Submitted by William Schutt, Department of Anatomy, College of Veterinary Medicine, Cornell University, Ithaca, NY

from Connecticut

Mark R. Barletta is a professional firefighter in New Haven, Connecticut and also a wildlife rehabilator (dealing only with bats) in the state. He sends us the following [in part].

As a professional firefighter part of my job involves responding to calls from homes complaining about the presence of bats. The department receives approximately 25 such calls each year. In the past firefighters usually killed the bats, but I have eliminated this practice. I may not have been able to convince them to love bats, but at least now I have convinced them not to kill the bats they encounter. When bats are encountered they are immobilized with a short "whiff" of carbon dioxide, and placed in a "bat box" that I provided, until they recover. The bats are then taken out doors and released. I have placed one of these bat boxes at each of the engine companies in the department.

Here in Connecticut there is a *Non-Harvested Wildlife* Program which distributes an information packet about bats (native to the state) and also includes plans for building bat houses. There is a bat house registration card which lists how many bat houses a respondent has, their location, and whether or not they are occupied by bats. This card is returned to the Program office and kept on file.

I have two big brown bats that I use in my lectures about bats at local schools, church groups, and science fairs. One of these named "Squeeker" I have raised from a two-day-old infant using the guidelines in Susan Bernard's handbook on keeping bats in captivity. There is a great deal of interest about bats here and increasing concern about their future.

I also would like to express my appreciation of Bat Research News and wish it continued good luck in the future. Submitted by Mark R. Barletta, 43 Marlen Drive, North Haven CT 06473.

Edited by GRH

From Virginia

Peter Miller, an animal keeper at the National Zoo and graduate student at George Mason University, has received a grant to study foraging of the big brown bat, *Eptesicus fuscus*. Peter will study the diet preferences of female *Eptesicus* through the reproductive season. The grant was awarded by the Washington Biologist's Field club and sponsored by Don Wilson. The W. B. F. C. co-owns with the National Park Service an island in the Potomac River called Plummer's Island which will be one of the two study sites. The other site is at Fort Belvior Army Base in Alexandria, Va. The Army is planning on expanding development into some of their vast wetlands habitats and Peter hopes to enlighten the military to the bat activities that could be adversely affected. Steve Schilling with the Environmental Protection Agency and fellow George Mason graduate student, is assisting on the project and formulating his thesis research on censusing using acoustic monitoring. Submitted by Peter Miller, 3862 North River Street, Arlington, VA 22207

from West Virginia

Since 1989 I have been visiting public schools and community groups with a slide show on bats. My presentations vary depending on the group I'm speaking to, but generally revolve around basic natural history and conservation. Elementary school students, in particular, seem to be fascinated by bats,

and really enjoy the opportunity to learn about them and share their own experiences. I even had a fifth grade class give up its gym period to continue our discussion!

I encourage all of you to think about undertaking this type of activity. It's not very time consuming, but is highly rewarding on many levels. Since I began, I've been called by people who want to know what to do with the occasional bat in the house: I've even consulted with a local church about how to bat-proof their building without harming the bats. Which leads me to a plea for help! If anyone has information on how to undertake bat removal, I'd really appreciate learning about it. Thanks in advance! Submitted by Kerry Kilburn Department of Biology, West Virginia State College, Institute, WV 28112

from New Hampshire

The New Hampshire Fish and Game Department has begun collecting data on general bat presence across the state. In 1992 they began a yearly bat survey in which volunteers record the number of bats sighted in a two hour period for two nights in either June or July.

The University of New Hampshire's Wildlife Program currently has two graduate students researching bat ecology. Rachel Stevens is completing her second field season studying bat presence and habitat use on the White Mountain National Forest. She is using ultrasound detectors to survey bat use across different elevations, vegetation types and age classes. Blake Sasse began studies at the University in January, and is studying summer roosting ecology of big brown bats, little brown bats and northern long-eared bats on the White Mountain National Forest using radiotelemetry.

Submitted by D. Blake Sasse Department of Natural Resources, University of New Hampshire, Durham, NH 03842

from Gainesville, Florida

The ***Bats of New Guinea*** by Frank Bonaccorso is scheduled for publication as a field guide/handbook of the Christensen Research Institute in the late spring of 1994. Fiona Reid has accepted the commission of illustrating this volume that will include 16 color plates and additional line drawings. The book will include an illustrated field key to the 88 species of bats in Papua New Guinea and a full set of range maps. Section headings for each species account will include conservation status, distribution in Papua New Guinea, extralimital distribution, altitudinal distribution, habits (to include roost and feeding habitats, feeding behavior, echolocation, reproduction, predation, thermoregulation, and ectoparasites), identification(key characters of external morphology and dentition), specimens examined, and a table of standard measurements. This book will be published in Papua New Guinea by the Kristen Press as a sturdy paperback. In addition to 13 months of field work, the author has visited the extensive collections of the American Museum of Natural History, the Bishop Museum, the Museum of Vertebrate Zoology, The National Museum of Papua New Guinea, and the University of Papua New Guinea Museum.

Meanwhile, Brian McNab and Frank Bonaccorso have spent June, July and August in Papua New Guinea at the Christensen Research Institute attempting to pass the 2,000 experiment mark for standard measurement of the basal metabolism of volant vertebrates in New Guinea. Their motto: "If it flies, we'll measure it, even if it does have feathers!" The first of a huge series of papers dealing with this topic authored by Brian will appear in ***American Naturalist*** soon. Fiona Reid was in PNG illustrating the above mentioned book in July and August. The PNG team was joined by Roan McNab for a time on his farewell to freedom before undertaking work on a Master's degree under Charles Woods at the University of Florida.

Other news from Florida -- Steve Humphrey has been appointed Dean of the College of Natural Resources and Environment, newly formed at the University of Florida. Steve has accepted the invitation to act as the official representative of the University of Florida to welcome all of you to the 23rd annual North American Symposium on Bat Research next month. Carlos Iudica will complete his Master's Degree this fall under Steve Humphrey's direction, focusing on community ecology of bats in tropical Argentina.

Research and flying fox birthing is booming at the Lubee Foundation in 1993. Among the numerous bat pups appearing this spring and summer are *Pteropus hypomelanus, P. rodricensis,* and for the first time in captivity, *P. vampryrus* and *P. pumilus.* I have been collaborating with Tom Kunz and his students on a time budget analysis of activity in *P. pumilus* and *P. rodricensis. P. pumilus* gives indication that it may be a lekking species with adult males performing ritualized wing flapping and rocking behavior with peak activity just before dawn. Hugo Ochoa, a graduate student at UF, is conducting a study of body temperature in *P. hypomelanus.* Hugo, with assistance from Tom Kunz, Darrel Hurd,

John Seyjaget, and Keith Atkinson has implanted temperature transmitters in the abdominal cavity of 6 individuals, attached transmitters on the skin and takes rectal temperatures to compare body temperature from each of these sites. In phase two of his research at the Lubee Foundation, Hugo will look at behavioral thermoregulation in these animals with the transmitter implants.

Submitted by Frank Bonaccorso
P.K. Yonge Laboratory School, University of Florida, Gainesville, FL 32607

from New Jersey

Due to lack of documentation of *Myotis sodalis* occurring in the state, the New jersey Division of Fish, Game and Wildlife, Endangered species and Nongame species Program removed the Indiana bat, *Myotis sodalis*, from its official endangered species list in June 1991. With the help of four Bat Research New subscribers, the Indiana Bat is now back on New Jersey's endangered species list.

Rick Dutko, Susan Ellis [who is now doing graduate work with Brock Fenton at York University] and Eileen Muller (all ***BRN*** subscribers), along with Brian Reizfeld were conducting a bat count for the endangered And Nongame Species Program (ENSP) in the winter of 1992 when 18 Indiana bats were found amongst 26,000 + little brown bats in an abandoned iron mine in the northwestern portion of the state. The information was provided to ENSP who attempted to confirm the sightings later in the winter, but were unsuccessful in doing so.

This past winter Dutko was able to lead ENSP zoologist Jim Sciascia, U. S. Fish and Wildlife Service biologist Annette Scherer and New York State wildlife biologist, Alan Hicks to the same location where he had observed the bats the previous winter. Hicks(also a ***BRN*** subscriber) officially confirmed that 24 bats were *Myotis sodalis* . The mine is New Jersey's only substantial hibernaculum and is in dire need of a gate. The mine is popular with the local teenagers and is filled with beer cans and graffiti sprayed walls throughout its entirety. During the last several years the owners have sealed all of the mine's vertical shafts and the only remaining entrance was cemented except for a small passage to allow the bats access. ENSP and USFWS are currently negotiating with the owner and a local grotto to have a gate installed to try and protect the hibernaculum from any further disturbance or destruction.

Submitted by Rick Dutko, 73 Smithfield Avenue, Lawrenceville, NJ 08648

from India

Dr. Nilima K. Badwaik, a young bat researcher at the Institute of Science in Nagpur, India, has received a post-doctoral award as a Research Associate with Dr. John J. Rasweiler in the Department of Obstetrics and Gynecology at Cornell University Medical Center in New York. Dr. Badwaik has been working with Dr. A. Gopalakrishna for the past eight years and her main interest has been the reproduction and embryology of Indian bats, concentrating on the activity of the trophoblast. Her work at Cornell Medical Center will investigate the manner of interaction of the trophoblast with uterine tissue in some New World bats employing immunochemistry techniques and electron microscopy. Her financial support is provided by a grant to Dr. Rasweiler from the National Institute of Child Health and Human Developement. Her travel is financed by the United States Education Foundation in India. Her work and incidental training under the guidance of Dr. Rasweiler will considerably augment research on the embryology of bats in India upon her return home.

submitted by A. Gopalokrishna, Institute of Science, Nagpur, India

AAZK Grants Available

The American Association of Zoo Keepers announces the availability of two $750 research grants in the field of zoo biology. Interested applicants should direct their inquiries to Sue Bernard, Chairperson, AAZK Research Grants Committee, Zoo Atlanta, Department of Herpetology, 800 Cherokee Ave., SE, Atlanta GA 30315. The deadline for submissions is March 1, 1994.

programs. Despite a lucrative summer job in the business world, he vows to remain in the ranks of biology.

April Allgaier has completed a summer of fieldwork in Trinidad where she studied maternal investment in *Phyllostomus hastatus*, including milk composition, lactational energetics, time budgets, and post-natal growth rates. Having spent a summer milking bats, she is now trying to find an explanation for doing what she did that will make sense to her non-biologist friends. Future plans include a complementary study on the energetics of pregnancy in *P. hastatus*.

Helen Papadimitriou is embarking on a study of ontogenetic changes in the biomechanical properties of wing bones in *Tadarida brasiliensis*. In collaboration with Sharon Swartz of Brown University, she is looking at structural, mechanical and mineral composition changes during post-natal development of the wing skeleton which lead to the ability of adult bats to resist large torsional stresses brought about by active powered flight.

Tom Kunz, in addition to overseeing each of the above projects, is also trying to complete the manuscript for his forthcoming best seller, A Guide to the Bats of North America. He conducted a week-long course in New Hampshire on field techniques used to study bats. Tom presented papers on some of his work at the Association for Tropical Biology in Puerto Rico in June, at the ITC in Australia in July, the European Bat Conference in Portugal in August, and at the North American Symposium in Florida in October. Additional projects include several manuscripts on tent-making bats, the energetics of reproduction and post-natal growth in *Tadarida brasiliensis* and *Myotis lucifugus*, and the energetics of lactation and post-natal growth rates in captive Old-World fruit bats at the Lubee Foundation in Florida. Collaborative efforts include studies on flight energetics, the behavior of tent-making bats, and the effects of stress on glucocorticoid levels in both wild and captive bats.

Tom and Roy Horst are also busy planning and getting organized (or planning to get organized) for the "big bat bash" here in Boston in 1995. He also gives the frequent advice to his students and colleagues to "focus on one topic."

submitted by April Allgaier,
Dept. of Biology, Boston University, Boston, MA

Ed. note. No wonder Tom always looks so tired!

WANTED
Live Fleas & Fresh Guano

Dr. Robert E. Elbel, Research Professor, University of Utah, and I are looking for bat flea larvae to describe. We are particularly interested in *Hormopsylla* and *Nyteridopsylla* fleas most often found on *Myotis californicus, Eptesicus fuscus, Plecotus townsendii, Tadarida macrotis* and *Eumops perotis*. The larvae, pupae and sometimes adults of these fleas may live in the guano that accumulates below roosts of bats, if the guano is moist enough to smell of ammonia. We need an approximately 12" by 8" plastic bag of guano, fresh enough so that the smell of ammonia is noticable. The collector may be able to see adult fleas or larvae in the guano. The guano should be shipped immediately so that we can collect live fleas and their larvae. We are also interested in obtaining live adult bat fleas. A continuous blowing through the bat's fur for a minute or so flushes out fleas. If you can save the adult fleas alive in vials, label with the host -locality-date information, store in 100% humidity, such as in a container with a wet sponge, and send to us within a day or so, we can possibly raise larvae from them. Each adult flea should be in a separate vial with a strip of tape on top which permits air to enter.

Send responses to, or contact: Robert L. Bossard, Research Assistant, Department of Biology, Univeristy of Utah, Salt Lake City, UT 84112 Telephone 801-581-6517.

Books and Journals

The very useful book, ***The Maintenance of Bats in Captivity,*** by Susan M. Bernard, is still available for those who are interested in caring for bats in captivity, rescuing and rehabilitating bats that may have been injured, or rearing orphaned infant or juvenile bats. The most recent issue has been expanded to include not only the captive care of insectivorous bats, but fruit-eating species and vampires. The text details successful methods for hand-rearing infants, aspects of rehabilation, environment and housing, nutrition, transporting, medical and necropsy considerations, and many other topics. Copies may be obtained by writing to Susan M. Bernard, 6146 Fieldcrest Drive, Morrow, GA 30260 U.S.A. The price to the U.S. is $7.95; to Canada and Mexico, $8.75 surface mail, $9.50 airmail; to all other countries $11.00 surface mail or $15.00 airmail. All prices are in U. S. dollars.

The first printing of Kunz's ***Ecology of Bats*** is no longer in stock, but the publisher has agreed to do a second printing. Unfortunately, with the new printing the price has increased to $85(U.S. and Canada) and $102(elsewhere). Copies may be ordered direct from Plenum Publishing Corporation, 233 Spring Street, New York, NY 10013-1578. ICBN 0-306-40950-X. All orders must be prepaid. Major credit cards accepted, but give expiration date. Checks should be made payable to Plenum Publishing Corporation.

The book, ***Bats and Bat Rabies*** , by A. M. Greenhall and L. Vallete is available **free** by writing to the publisher at: Rhone Merieux, 29 Avenue Tony Garnier, BP 7123, 69348 LYON Cedex 07, France

Vida Sylvestre Neotropical resumes publication in 1993

Vida Sylvestre Neotropical is a technical journal for publication of high quality papers on wildlife research and management in the Neotropics. ***Vida Sylvestre Neotropical*** responds to a need for an international journal to publish the new information rapidly being generated in the field of Neotropical wildlife management, and to assure the availability of that information to professionals and students interested in this field. Geographically, the journal includes Mexico, Central America, South America and the Caribbean. The subject areas include wild flora and fauna, and terrestrial, freshwater, and marine habitats. Topics published include sustainable use management of wild flora and fauna, natural forest management, conservation of endangered species and ecosystems, maintenance of biotic diversity, indigenous use of wildlife, biological inventories with broad or unique conservation implications, new research and management techniques, biological basis for the design of protected area systems and control of pest species.

Vida Sylvestre Neotropical will reinititate in 1993 at the Regional Wildlife Management Program for Mesoamerica and the Caribbean (PRMVS), Universidad Nacional (UNA), Costa Rica. This was made possible thanks to a startup grant from a consortium formed by World Wildlife Fund-US, U. S. Fish and Wildlife Service, and Wildlife Conservation International. The format will be similar to that used in its first four issues, with articles published in English, Spanish and Portugese. The review process has been changed and will more closely approximate that used by such journals as Biotropica, with and Associated Editorial board composed of prominent scientists with Neotropical experience. We urge you to submit your manuscripts. For information on publication requirements, follow the general policies outlined in past issues of ***Vida Sylvestre Neotropical***, or write for information to: ***Vida Sylvestre Neotropical*** /PRMVS/ Apartado 1350 Heredia, Costa Rica. FAX 506-377036.

The coeditors of ***Vida Sylvestre Neotropical*** are Christopher Vaughan and Michael McCoy.

To receive Volume 3, 1993 (two issues in June and December) the price is:

Students from Latin America: $8.00; other students: $15.00
Professionals from Latin America: $12.00; other professionals: $24.00
Institutions from Latin America: $15.00; other institutions: $30.00

All prices are in U.S. dollars. Send a check in U.S. dollars drawn on a United States bank, or international money order to ***Vida Sylvestre Neotropical,*** **PRMVS,** Department No. 278, P. O. Box 025216, Miami, Florida 33102. Costa Rican subscribers may also send payment by checks drawn on a Costa Rican bank, by certified mail.

RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths, Dept. of Biology, Illinois Wesleyan Univ., Bloomington, IL. 61702-2900, U.S.A.) for inclusion in this section. 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 welcome.

ANATOMY

Glezer, I. I., P. R. Hof, C. Leranth, and P. J. Morgane. 1993. Calcium-binding protein-containing neuronal populations in mammalian visual cortex - a comparative study in whales, insectivores, bats, rodents, and primates. Cerebral Cortex, 3: 249-???. [Dept. Cell. Biol. & Anat. Sci., School Med., CUNY, 138 St. & Convent Ave., Sci. Bldg. Room J-903, New York, NY 10031]

Kumamoto, K., S. Ebara, T. Matsuura, and M. Kawata. 1992. Distribution of oxytocin and vasopressin neurons in the diencephalon of the Japanese horseshoe bat, *Rhinolophus ferrumequinum* - an immunohistochemical study. Acta Anatomica, 144: 80-??. [Dept. Anat., Meiji College of Oriental Medicine, Hiyoshi Cho, Kyoto 62903, Japan]

Quinn, T. H., and J. J. Baumel. 1993. Chiropteran tendon locking mechanism. Journal of Morphology, 216: 197-208. [Dept. Anat., Sch. Med., Creighton Univ., Omaha, NE 68178]

Strait, S. G. 1993. Molar morphology and food texture among small-bodied insectivorous mammals. 1993. Journal of Mammalogy, 74: 391-402. [Dept. Biological Anthropology & Anatomy, Duke Univ. Med. Ctr., Durham, NC 27710]

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Fenton, M. B. 1992. Bats. Facts on File, Inc., New York, 207 pp. [ISBN 0-8160-2679-3]

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Clark, B. S., D. M. Leslie, Jr., and T. S. Carter. 1993. Foraging activity of adult female Ozark big-eared bats *Plecotus townsendii ingens* in summer. Journal of Mammalogy, 74: 422-427. [Dept. Biol. Sci., Southeastern Oklahoma State Univ., Durant, OK 74701]

Kozhurina, E. I. 1993. Social organization of a maternity group in the noctule bat, *Nyctalus noctula* (Chiroptera, Vespertilionidae). Ethology, 93: 89-104. [Inst. Evolutionary Morphology and Animal Ecology, Russian Academy of Sciences, Leninsky Prospekt 33, Moscow 117071, Russia]

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Nieuwenhuijs, J., J. Haagsma, and P. Lina. 1992. Epidemiology and control of rabies in bats in the Netherlands. Rev. sci. tech. Off. int. Epiz., 11: 1155-1161. [Veterinary Public Health Inspectorate, Ministry of Welfare, Public Health and Cultural Affairs, PO Box 5406, NL-2280 HK Rijswijk, the Netherlands]

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Kossl, M. 1992. High frequency distortion products from the ears of two bat species, *Megaderma lyra* and *Carollia perspicillata*. Hearing Research, 60: 156-164. [Zool. Inst., Luisenstr. 14, W-8000 Munich 2, Germany]

Kuwabara, N., and N. Suga. 1993. Delay lines and amplitude selectivity are created in subthalamic auditory nuclei - the brachium of the inferior colliculus of the mustached bat. Journal of Neurophysiology, 69: 1713-1724. [Suga: Dept. Biol., Washington Univ., St. Louis, MO 63130]

Moss, C. F., and J. A. Simmons. 1993. Acoustic image representation of a point target in the bat *Eptesicus fuscus* - evidence for sensitivity to echo phase in bat sonar. Journal of the Acoustical Society of America, 93: 1553-1562. [Dept. Psychol., Harvard Univ., 33 Kirkland St., Cambridge, MA 02138]

Pollak, G. D. 1993. Some comments on the proposed perception of phase and nanosecond time disparities by echolocating bats. Journal of Comparative Physiology A, 172: 523-532. [Dept. Zool., Univ. Texas, Austin, TX 78712]

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Widmaier, E. P., and T. H. Kunz. 1993. Basal, diurnal, and stress-induced levels of glucose and glucocorticoids in captive bats. Journal of Experimental Zoology, 265: 533-540. [Dept. Biol., Boston Univ., Boston, MA 02215]

REPRODUCTION

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SYSTEMATICS

Audet, D., M. D. Engstrom, and M. B. Fenton. 1993. Morphology, karyology, and echolocation calls of *Rhogeesa* (Chiroptera: Vespertilionidae) from the Yucatán Peninsula. Journal of Mammalogy, 74: 498-502. [Dept. Biol., York Univ., North York, Ontario M3J 1P3, Canada]

Qumsiyeh, M. B., and J. W. Bickham. 1993. Chromosomes and relationships of long-eared bats of the genera *Plecotus* and *Otonycteris*. Journal of Mammalogy, 74: 376-382. [Dept. Pediatrics, Univ. Tennessee and T. C. Thompson Children's Hospital, 910 Blackford St., Chattanooga, TN 37403]

Tumlison, R. 1993. Geographic variation in the lappet-eared bat, *Idionycteris phyllotis*, with descriptions of subspecies. Journal of Mammalogy, 74: 412-421. [Dept. Biol., Henderson State Univ., Arkadelphia, AR 71923]

TECHNIQUES FOR BAT STUDY

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ANNOUNCEMENT

The Mexican Association of Mammalogy
and
The University of Guadalajara

are pleased to announce the celebration of the

II International Congress of Mammalogy

This event will coincide with the tenth anniversary of
the Mexican Association of Mammalogy(AAMC),
and will be in **Guadalajara, Jalisco, México March 16-19, 1994**

To obtain more information, write to one of the following addresses:

II CONGRESSO NACIONAL
Asociación de Mastozoología
Apartado Postal 70-419
04510 México, D. F.

or

Dr. Héctor T. Arita
Centro de Ecología, UNAM
Apartado Postal 70-275
04510 México, D.F.

Tel. (5) 622-90-04
FAX (5) 548-52-59

10th IRBC and 25th NASBR

7-12 August 1995

Boston University
Boston, Massachusetts 02215, USA

August 1993

Conference Director
G. Roy Horst

Conference Host
Thomas H. Kunz

Conference Co-hosts
Edythe Anthony
Peter August
Brock Fenton
Mike Gannon
Cynthia Moss
Armando-Rodriguez-Duran
Sharon Swartz
James Simmons
Janey Winchell

Dear Colleage:

Preliminary plans are being made for the joint meeting of the 10th International Bat Research Conference and the 25th North American Symposium on Bat Research. The First Announcement for this conference is enclosed for your information and reply. To date, we have planned three symposia for the conference, including echolocation, functional morphology, and conservation biology. Although we expect a large number of participants, we hope to avoid having concurrent sessions. Thus, we encourage as many of you as possible to present poster papers. We plan to provide ample opportunity for each contributor to display his/her poster in designated sessions. We are exploring several possiblities for publishing abstracts and contributed papers, and we are planning to publish the invited symposium papers in a special volume.

In addition to the week-long meeting in Boston, we are also making plans to host several post-conference workshops and excursions. These are tentatively scheduled to be held in the Boston area, New Hampshire, Rhode Island, and Puerto Rico (see enclosures). Others may be announced in the official announcment.

We hope that you will complete the attached form and return it to us at your earliest convenience, but before May 1, 1994.

Sincerely yours,

Thomas H. Kunz

G. Roy Horst

G. Roy Horst, Department of Biology, State University of New York, Potsdam, New York 13676, USA
Phone: 315 267-2259; Fax: 315 267-3001.

Thomas H. Kunz, Department of Biology, Boston University, Boston, Massachusetts 02215, USA
Phone: 617-353-2474 or 2432; Fax: 617-353-6340; E-mail (internet): kunz@bu-bio.bu.edu

10th International Bat Research Conference and 25th North American Symposium on Bat Research

Post-Conference Workshops and Excursions (13-19 August 1995)

Several post-conference workshops are being planned for the week of 13-19 August. Some will be held in the New England (several sites) and others will be held in Puerto Rico (about 3-h flight from Boston).

Tentative Workshops

1. *Field methods for the study of bats* (New Hampshire) (one 3-day session)

This workshop will be based at Boston University's Field Station in Peterborough, New Hampshire (about 70 miles northwest of Boston). The focus of this 3-day workshop will be on field methods for the study of common New England (insectivorous) bats. It will include trapping, netting, radiotelemetry, marking, and observational methods, including use of night vision devices and bat detectors. [Workshop leaders: Brock Fenton and Tom Kunz].

2. *Ecological methods for the study of neotropical bats* (Puerto Rico) (two 3-day sessions)

This workshop will be based in Puerto Rico (about a 3-h flight from Boston). The focus of this 6-day workshop will be on identification and ecological methods for studying neotropical bats occurring in the Lugillo Experimental Forest. Several species will be examined (including nectarivores, frugivores, and insectivores), some of which are endemic to the Caribbean. Techniques will include radiotelemetry, marking and banding techniques, population estimation, and experimental studies on captive animals. [Workshop leader: Mike Gannon].

3. *Echolocation* (Brown University and Harvard University) (two 1-day sessions)

Workshops on echolocation will be held both at Harvard (Boston area) and Brown (Providence, Rhode Island) Universities. These separate one-day workshops will acquaint researchers interested in echolocation with recording and analytical techniques. [Workshop leaders: Cindy Moss--Harvard; James Simmons--Brown].

4. *Functional morphology* (Brown University) (two 1-day sessions)

This workshop on functional morphology will be held at Brown University (Providence, Rhode Island). Brown University is located about 40 miles south of Boston (access by bus, rail, or auto). This workshop will focus on methods of biomechanical analysis of flight, including demonstrations of a wind-tunnel and X-ray cinematography. [Workshop leader: Sharon Swartz].

Tentative Excursions

1. *Ecology of bats in hot caves* (Puerto Rico) (2 days)

Participants on this excursion will visit several caves to observe emergence patterns of bats and their opportunistic predators. Up to seven species of bats may occupy a single cave. [Excursion leader: Armando Rodriguez-Duran].

2. *Forest associations in Puerto Rico* (2 days)

Six life zones (based on the Holdridge classification) are recognized in Puerto Rico, ranging from tropical rain forest to tropical dry forest. This 2-day excursion will guide participants through most of these forests, ending in a bioluminescent bay in the mangrove forest of the southwest. [Excursion leader: Sandra Molina].

3. *Caves and canyons of the Tanama River, Puerto Rico* (2 days)

For the more adventurous and physically fit, this excursion provides hikes through the forest and limestone caves and canyons in northern Puerto Rico. You will body-raft through river-carved canyons lined with jungle vegetation. You can enjoy sheer cliffs as you plunge into sinkholes or clamber through portions of one of the world's largest cave systems. In these caves you will encounter petroglyphs and large colonies of bats. [Excursion leader: Armando Rodriguez-Duran].

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Front Cover

Rummaging through my assortment of photographs, sketches, drawings and other art for a suitable cover illustration that had not been already used (or under copyright) yielded this unidentified illustration. If you can identify these bats, or if you sent it to me in the first place, drop me a short note and I'll see to it that you are properly acknowledged. G. Roy Horst

BAT RESEARCH NEWS

Volume 34: No. 4 Winter 1993

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 recent literature should be addressed to Griffiths, manuscripts to Kurta, conservation, all other matters to Horst.

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

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

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

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

BAT RESEARCH NEWS

Volume 34 : No. 4 **Winter 1993**

A Message From the Publisher

Dear Subscriber to ***BRN*** :

You must have noticed that the quality of editing and the printing of ***Bat Research News*** has slipped just a little over the past year. One explanation is that I am teaching an overload class this year which contains 225 students in several sections plus my regular Ecology course. In order to get everything done I have relied on student assistants but they are not very good proof readers since they know very little about bats. Unfortuantely I have not had time enough to check all the copy as thoroughly as I would have liked. In the last issue (BRN 34:2-3) there were a few errors, the most glaring of which was that a large portion of the wonderful news sent us by April Allgier about the goings on in Tom Kunz's lab at Boston University was left out. This entire article is presented again in this issue. My apologies to April and all the folks in Tom's group.

The second problem is a lot more serious. Our campus print-shop has been very good about printing ***Bat Research News*** for us and has done so at a very reasonable price. But Potsdam College is a state univeristy and like elsewhere, budgets are very tight. Staff is constantly being reduced and this is true in our printshop. They too have used a great deal of student help, and while enthusiastic(in some cases), they are no substitute for professionals when it comes to turning out a quality product. The print-shop has been told that official publications of the college come first, and all other odd jobs must be fitted(rushed) in when time is available(Bat Research News is about as odd as a job can get so you know where I stand with them). One result is that on occasion it may take as long as six weeks to get ***BRN*** printed after they receive it. The second consequence is that sometimes the product is not up to the standards we would like to see. Several subscribers have informed me that they received defective copies of the last issue. If your copy of **BRN 34:2-3** was defective, please send me a postcard, call me, or send me E-mail, and I will send you a replacement copy at no cost.

I think these printing problems have been solved, as we have for the first time, gone to a commercial printer. I am not yet certain how this will affect the budget, but I believe you will agree that the quality of this issue compared to the last one might perhaps justify a small increase in the subscription rate in the not too distant future.

In closing I would like to inform all of you that I am now on E-mail and my address is **horstgr@potsdam.edu** My FAX # is **315-267-3170**, phone is **315-267-2259.** With all these methods of communication, you have no excuse for not keeping in touch and sending us your latest news.

I again thank all of you for the patience you have shown as I continue to struggle with getting ***BRN*** out to you. I could not do so at all without the great assistance that Tom Griffiths provides by giving me the recent literaure section "ready to print", and Al Kurta who does the same with feature articles after they have been reviewed. Their constant cheerful assistance and your continuing encouragement have inspired me to keep trying and maybe someday we will get it all right in the same issue, and on time to boot!

G. Roy Horst

Modern Equivalents of Genera in Dobson's 1878 "Catalogue of the Chiroptera of the British Museum"

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In 1878, George Edward Dobson published his catalog including all the bat genera and species that were known to him. In 1880, he published a supplement to his catalog with additions and corrections. It should be pointed out that during much of the 19th and into the early 20th century the British Museum catalogs were major vehicles for publication of systematic research in zoology. Far more than mere lists of specimens, particularly the later ones were taxonomic revisions with diagnoses and keys of taxa whether represented by British Museum specimens or not. Dobson's 1878 catalog was such a work, giving, for each species, synonymy, diagnosis, distribution, and list of British Museum specimens, if so represented. This work was the standard source for almost 30 years until partially superseded by Miller's "Families and Genera of Bats." During this period, much was written on various aspects of bat biology, using the systematics of Dobson's catalog. Changes in systematics (particularly nomenclature) since Dobson, however, have made much of this literature difficult to use. At the original suggestion of Dr. William E. Rainey, I decided to compile a list of nomenclatural changes at the generic level since 1878, using my contribution to Wilson and Reeder's 1993 "Mammal Species of the World" as the present standard. I therefore list the genera as Dobson gave them with the present treatments of their contents. This, however, is based on Dobson's synonymies and does not guarantee that the British Museum specimens that he lists necessarily are referable to these species.

Epomophorus : Seven species were recognized in the catalog with an eighth in the supplement. *E. monstrosus* is now in *Hypsignathus; macrocephalus, gambianus, labiatus,* and *minor* are retained in *Epomophorus; franqueti* and *comptus* in *Epomops; pusillus* in *Micropteropus.*

Pteropus : 41 species were recognized in the catalog, one more in the supplement. Of these *wallacei* is now in *Styloctenium, macklotii* and *jubatus* in *Acerodon,* the remainder in *Pteropus*

Cynonycteris : Nine species were recognized in the catalog, of which *amplexicaudata, minor,brachyotis, aegyptiaca* and *collaris* are now in *Rousettus; torquata* in *Myonycteris; straminea* and *dupreana* in *Eidolon; grandidieri* in *Cynopterus.*

Boneia : (added in supplement) One species. Unchanged.

Cynopterus : Seven species were recognized in the catalog and another species was described by Dobson in 1880 (Ann. Mag. Nat. Hist., ser. 5, 6: 117), evidently after the supplement appeared. Of these, *marginatus, scherzeri,* and *brachysoma* are retained in *Cynopterus; melanocephalus* is now in *Chironax; latidens* in *Thoopterus; jagorii* in *Ptenochirus; lucasi* in *Penthetor; ecaudatus* in *Megaerops.*

Harpyia : Two species were recognized in the catalog, both now in *Nyctimene.*

Cephalotes : One species was recognized in the catalog, another in the supplement. Both are now included in *Dobsonia.*

Notopteris : One species in the catalog. Unchanged.

Eonycteris : One species in the catalog. Unchanged.

Macroglossus : One species in the catalog. Unchanged.

Melonycteris : One species in the catalog. Unchanged.

Rhinolophus : Twenty-four species were recognized in the catalog and three others in the supplement. Unchanged.

Triaenops : Two species in the catalog. Unchanged.

Rhinonycteris : One species in the catalog. Now spelled *Rhinonicteris.*

Phyllorhina: Twenty-two species were recognized in the catalog, of which *tridens* is now in *Asellia; tricuspidata* and *stoliczkana* in *Aselliscus;* the remainder in *Hipposideros.*

Coelops: One species in the catalog. Unchanged.

Megaderma: Four species were recognized in the catalog and an additional species in the supplement. *M. lyra* and *M. spasma* are retained in *Megaderma, gigas* is in *Macroderma, cor* in *Cardioderma,* and *frons* in *Lavia.*

Nycteris: Seven species were recognized in the catalog. Unchanged.

Antrozous: One species in the catalog. Unchanged.

Nyctophilus : One species in the catalog. Unchanged.

Synotus : Two species in the catalog. Both now in *Barbastella.*

Plecotus : Two species were recognized in the catalog. Unchanged.

Otonycteris : One species in the catalog. Unchanged.

Vesperugo : This is by far the most complicated genus that Dobson recognized. Fifty species were included (along with another species listed but with doubtful status) in the catalog and two additional species in the supplement. Of these, *velatus, macrotus, montanus,* and *magellanicus* are now in *Histiotus; serotinus, andersoni, hilarii, minutus, capensis, megalurus, nasutus, tenuipinnis, pumilus, grandidieri, propinquus, borealis, atratus, pachyotis,* and *brunneus* are in *Eptesicus; murinus* and *albigularis* in *Vespertilio; pachypus* in *Tylonycteris; noctula* and *leisleri* in *Nyctalus; stenopterus, imbricatus, maurus, affinis, circumdatus, indicus, pipistrellus, tenuis, abramus, hesperus, kuhlii, maderensis, krefftii, pulcher, temmincki, georgianus, nanus,* and *dormeri* in *Pipistrellus; brachypterus* in *Philetor; annectens* in *Myotis; tylopus* in *Glischropus; noctivagans* in *Lasionycteris; doriae, tickelli,* and *blanfordi* in *Hesperoptenus; schlieffeni* in *Nycticeius; parvula* in *Rhogeesa.* Finally, two species, *platyrhinus* and *vagrans,* seem to have disappeared from recent systematic treatments.

Chalinolobus : Seven species were recognized in the catalog. Unchanged.

Scotophilus : Eight species were recognized in the catalog, of which *temminckii, borbonicus,* and *gigas* are retained in *Scotophilus; emarginatus* and *ornatus* in *Scotomanes; ruppellii* and *greyii* in *Nycticeius; pallidus* in *Scotecus.*

Nycticejus : One species in the catalog. The genus is now spelled *Nycticeius.*

Atalapha : Five species were recognized in the catalog, all now in *Lasiurus.*

Harpiocephalus : Six species were recognized in the catalog and one was added in the supplement. Of these, *suillus, auratus, griseus, cyclotis, leucogaster,* and *hildendorfi* are now in *Murina,* whereas *harpia* is retained in *Harpiocephalus.*

Vespertilio : Forty-three species were recognized in the catalog, all now in *Myotis.* This is the most confusing change since the generic name *Vespertilio* is now used for species included by Dobson in *Vesperugo* (see above). The change was made by Miller in 1897 (North American Fauna, 13: 18-19).

Kerivoula : Ten species were recognized in the catalog, two more in the supplement. Unchanged.

Natalus : Two species in the catalog, another in the supplement. Unchanged.

Thyroptera : One species recognized in the catalog. Unchanged.

Myxopoda (added in supplement): One species. Genus is now spelled *Myzopoda.*

Miniopterus: Four species were recognized in the catalog. Unchanged.

Furia : One species in the catalog. The genus is now called *Furipterus.*

Amorphochilus : One species in the catalog. Unchanged.

Emballonura : Four species were recognized in the catalog, one additional in the supplement. Of these, *semicaudata, monticola, atrata,* and *raffrayana* are retained in *Emballonura; nigrescens* is now in *Mosia.*

Coleura : Two species in the catalog. Unchanged.

Rhynchonycteris : One species in the catalog. Unchanged.

Saccopteryx : Six species were recognized in the catalog. Of these, *leptura* and *bilineata* are retained in *Saccopteryx; canina* and *leucoptera* are now in *Peropteryx; plicata* in *Balantiopteryx; calcarata* in *Centronycteris.* In addition, *Cormura brevirostris* (now considered a valid genus and species) is listed, but not definitely placed.

Taphozous : Eleven species were recognized in the catalog, of which *melanopogon, theobaldi, australis, perforatus, longimanus, mauritianus,* and *nudiventris* are retained in *Taphozous; flaviventris, saccolaimus, affinis,* and *peli* are now in *Saccolaimus.*

Diclidurus : Two species in the catalog. Unchanged.

Noctilio : Two species in the catalog. Unchanged.

Rhinopoma : A single species was recognized in the catalog. Unchanged.

Cheiromeles : A single species in the catalog. Unchanged.

Molossus : Nine species were recognized in the catalog, of which *temmincki, planirostris,* and *abrasus* are now in *Molossops; rufus* is retained in *Molossus; nasutus* in *Promops; abrasus, perotis, glaucinus* and *bonariensis* in *Eumops.*

Nyctinomus : Twenty-one species were recognized in the catalog with another in the supplement. Of these, *africanus. cestonii, aegyptiacus, tragatus, australis,* and *brasiliensis* are now in *Tadarida; plicatus, bivittatus, pumilus, limbatus,* and *johorensis* in *Chaerephon; brachypterus, angolensis, miarensis,* and *mops* in *Mops; megalotis, macrotis,* and *gracilis* in *Nyctinomops; norfolcensis, albiventer, acetabulosus,* and *setifer* in *Mormopterus.*

Mystacina : A single species in the catalog. Unchanged.

Chilonycteris : Six species were recognized in the catalog, all now in *Pteronotus.*

Mormops : Two species in the catalog. The genus is now spelled *Mormoops.*

Lonchorhina : One species in the catalog. Unchanged.

Macrotus : Two species were recognized in the catalog. Unchanged.

Macrophyllum : One species in the catalog. Unchanged.

Vampyrus : Two species in the catalog, of which *spectrum* is retained in *Vampyrus,* but *auritus* is now put in *Chrotopterus.*

Lophostoma : Three species in the catalog. The genus is now called *Tonatia.*

Schizostoma : Four species in the catalog and another species was described by Dobson in 1879 (Proc. Zool. Soc. Lond. for 1878), which was somehow omitted from the supplement. The genus is now called *Micronycteris.*

Trachyops : One species in the catalog. The genus is now spelled *Trachops.*

Phylloderma : One species in the catalog. Unchanged.

Phyllostomus : Three species in the catalog. Unchanged.

Tylostoma : Two species were recognized in the catalog, both now included in *Mimon.*

Mimon : One species in the catalog. Unchanged.

Carollia : One species was recognized in the catalog. Unchanged.

Rhinophylla : One species in the catalog. Unchanged.

Glossophaga : One species was recognized in the catalog. Unchanged.

Phyllonycteris : Two species in the catalog, of which *poeyi* is retained in *Phyllonycteris* but *sezekorni* is now in *Erophylla.*

Monophyllus : One species in the catalog. Unchanged.

Ischnoglossa : One species in the catalog. The genus is now called *Leptonycteris.*

Lonchoglossa : Two species were recognized in the catalog, both now included in *Anoura.*

Glossonycteris : One species in the catalog. The genus is now called *Anoura.*

Choeronycteris : Two species in the catalog of which *mexicana* is retained in *Choeronycteris,* while *minor* is now in *Choeroniscus.*

Artibeus : Five species were recognized in the catalog, of which *planirostris, perspicillatus, cinereus,* and *quadrivittatus* are retained in *Artibeus,* whereas *bilobatus* is now in *Uroderma.*

Vampyrops : Three species in the catalog. The genus is now called *Platyrrhinus.*

Stenoderma : Three species were recognized in the catalog, of which *achrodophilum* is now in *Ariteus; rufum* is retained in *Stenoderma,* and *falcatum* is in *Phyllops.*

Ametrida : One species is in the catalog. Unchanged.

Chiroderma : Four species in the catalog, of which *salvini* and *villosum* are retained in *Chiroderma,* whereas *pusillum* and *bidens* are now in *Vampyressa.*

Pygoderma : One species in the catalog. Unchanged.

Sturnira : One species was recognized in the catalog. Unchanged.

Brachyphylla : One species in the catalog. Unchanged.

Centurio : One species in the catalog. Unchanged.

Desmodus : One species in the catalog. Unchanged.

Diphylla : One species in the catalog. Unchanged.

It should be emphasized that I have given only generic reallocations. For species synonymies, the reader is referred to Koopman, 1993, in Wilson and Reeder.

* * * * * * * * * *

Why Are There So Few Species of *Myotis* in Australia?

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As is well known, the genus *Myotis* is by far the most speciose of all bat genera, and Koopman (1993) lists 84 species as belonging to it. Associated with this diversity is an immense geographic distribution, such that *Myotis* probably is "the most naturally widespread mammalian genus" (Hall, 1984). However, the genus "is strikingly less well represented in the Neotropical, Ethiopian, and Australian regions, and on the whole in the southern hemisphere" (Ryberg, 1947). In fact, there are but 12 species of *Myotis* on the mainland of South America and 10 species in Africa (Koopman, 1993). Members of the genus also are ecologically diverse, occupying a range of habitats that includes both mesic and xeric environments (DeBlase, 1980; McNab, 1982; Rybin et al., 1989; Strelkov, 1980).

In view of these facts, the near-absence of the genus *Myotis* in Australia is unexpected. "This is especially evident when the variety of habitats where members of the genus are found on other continents...is considered" (Hall, 1984). Therefore Richards' (1983) explanation that the "potential diversity of the genus in Australia appears to have been limited by the aridity of the continent and the relative lack of areas of permanent fresh water" is not convincing.

Therefore I am investigating this problem by briefly examining the distribution of the genus on islands surrounding Australia, to the north and east, from Sumatra to the New Hebrides. I rely here on the work by Koopman (1993). These islands are inhabited by a total of 10 species of *Myotis*, an unexpectedly low number considering the large geographic size and ecological complexity of the area. I hypothesize that this scarcity of *Myotis* betrays a prevailing inability, or "reluctance," of the genus to cross water barriers. As expected, the islands nearer to the Asian mainland have more species of *Myotis*, and the highest number (10) is found on Borneo. The more outlying islands, in comparison, have fewer species -- Philippines (3); New Guinea, (2); Bismarck Archipelago, Solomon Islands, Mentawai Islands, Riau Archipelago, and New Hebrides (1). Of course, additional factors that may affect species diversity are

each island's area, past history, ecology and -- last but not least -- their degree of exploration.

The largest islands close to northern Australia (Timor and New Guinea) are the most likely source of any *Myotis* migrating to Australia. On Timor, despite its relatively great area, favorable ecology, and thorough exploration, no species of *Myotis* has ever been found (Goodwin, 1979). Therefore, Timor can be excluded as a hopping station from which *Myotis* could have arrived in Australia.

The only other possibility that remains is New Guinea. Forty one bat species live on its mainland, but only two of these are species of *Myotis (M. adversus and M. muricola).* New Guinea was very broadly connected to Australia in the past (Holloway et al., 1968). Therefore, even individuals of "water-shy" bat species could have arrived in Australia "dryshod," as they apparently did. But considering that New Guinea had only two species of *Myotis* to "offer" to Australia, small wonder that Australia has, at most, two species of the genus -- *M. adversus* and the mysterious *M. australis.* It is likely that *M. australis* will prove to be *M. muricola* (Husson, 1970; Hill, 1983; Koopman, 1993). Their taxonomic affinities are here corroborated by geographic considerations. Although *M. adversus* is well established in Australia, *M. muricola* does not appear to be established as yet. It remains an enigma why *M. muricola* did not arrive in Australia in the past, which was so much more favorable in this respect. In short, it seems to be the general "water-shyness" of the genus *Myotis* that explains its near-absence from New Guinea and Australia. This factor appears to be of far greater importance than the sometimes exaggerated aridity of the Australian continent (see vegetation map in Archer et al., 1984).

Out of 10 relevant *Myotis* species, four can be regarded as "water-friendly" judging from their distribution on islands (of course, historical factors play their role). They are in descending order of abundance: *M. adversus* (known virtually from all the islands, from Sumatra to New Hebrides), *M. muricola* (Sumatra to New Guinea), *M. horsfieldii* (Sumatra, Java, Borneo, Bali, Celebes, Philippines, Andamans), and *M. formosus* (Sumatra, Java, Bali, Celebes, and Philippines). As "water-shy" could be viewed: *M. siligorensis* (Borneo), *M. montivagus* (Borneo), *M. stalkeri* (Kai Island), and *M. ridleyi* (Sumatra, and Borneo). The process of colonization of Australia is still under way, which is evident by the apparently recent arrival of *M. australis* (cf. *muricola*).

Acknowledgments

Warm thanks have to be extended to Dr. Allen Kurta for improving my English, to Dr. S. K. Robson for his kindness in providing me important papers and bibliographical information, and to two anonymous reviewers for commenting on the manuscript.

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A New Technique for Marking Bats

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In the past, various methods have been used to mark bats for long-term identification. Metallic wing bands (rings) that attach around the forearm of bats have been the most widely used method for permanent marking (Barclay and Bell, 1988). However, there are a large number of disadvantages associated with this method, including irritation or injury to the subject. In addition, bats may chew bands, often obscuring markings and making numbers unreadable.

Recently, one preferred method for permanent marking has been necklaces threaded through numbered aluminum bands (Barclay and Bell, 1988). If necklaces are fitted properly, they appear to cause little disturbance or irritation to bats and can not be dislodged easily or chewed. Presently the material of choice for necklace construction is bead-clasp ball chain. This material can often be difficult to use, frequently requiring excessive handling of the subject by one or two persons. Closing the bead-catch of the ball-chain necklace usually necessitates the use of two hands, with fingers in close proximity to the mouth of an angry bat. In addition, though ball chain comes in many sizes, smaller lightweight sizes are not manufactured regularly and can be difficult to obtain. In cases where small species (less than 15 gms) are to be marked, weight of the chain and band can be a critical factor. Consequently, this method of marking must be restricted to larger individuals.

Over the past four years, I have been testing a new type of lightweight collar that can be attached in seconds with minimal handling of the subjects. A design similar to this was first used to collar squirrels (Mahan and Yahner, 1994; Wood, 1976) and is constructed from adjustable self-locking plastic cable-ties that can be obtained from a variety of sources (Table 1). A cable-tie is threaded through medical-grade tubing, which minimizes movement of the collar and irritation to the bat. The length of tubing used is determined by the circumference of the neck, and as with ball chain, will vary depending on the species of bat being collared. Silicon spray facilitates threading the tie through the tubing. Lastly, a numbered aluminum band is fitted to the collar (Figure 1). When the finished collar is closed into a loop, it can be dropped easily over the head of the bat and adjusted from the rear within seconds so that it

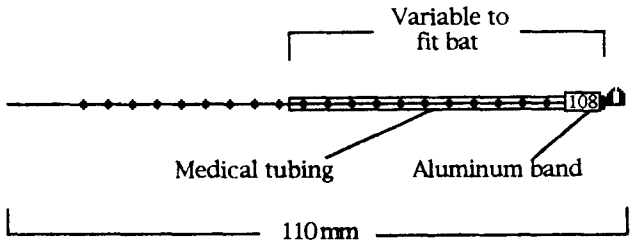

Figure 1 Bat collar and band

fits properly around the neck. After excess plastic is clipped from the collar, the bat is ready for release.

This collar is extremely lightweight and has been successfully field-tested on bats as small as nine grams. Banded *Monophyllus redmani* on Puerto Rico, recaptured several months after being collared, appeared in good health and showed no problems due to the presence of collars. For these individuals, total weight of the collar with aluminum band was 0.18 g. Other bats collared using this method include *Artibeus jamaicensis, Stenoderma rufum, Brachyphylla cavernarum,* and *Erophylla sezekorni.* To date, no adverse effects have been noted for any recaptured individual.

Table 1. Manufacturers of materials tested.

Cable-tie seal
- Secure-a-tie fastener
- Catalog number: 5M
- Size: 5.5 in
- Dennison Manufacturing Co.
- Framington, MA 01701

Medical-grade tubing
- Sylastics tubing
- Catalog number: 602-235
- Size: ID=1.47 mm, OD=1.96 mm
- Dow Corning Co.
- Midland, MI 48686-0994

Aluminum bands
- Catalog number: 374-1
- Size: ID=2.30 mm
- Gey Band and Tag Co.
- Norristown, PA 19404

Gannon continued...

Acknowledgments

Support was provided by the National Science Foundation (BSR-8811902), U. S. Forest Service, The University of Puerto Rico, The Pennsylvania State University Altoona Campus Endowment Fund, The Pennsylvania State University Commonwealth Educational System and Research and Development Grant, and Oak Ridge Association Universities (U. S. Department of Energy).

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Injuries to *Plecotus townsendii* from Lipped Wing Bands

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Abstract

On two occasions, the Pacific western big-eared bat, *Plecotus townsendii townsendii*, has been banded as part of an ecological study in Marin County, California. We found that 3-mm lipped bands, of the design used extensively in Britain and known to be suitable for other North American species, caused significant and potentially fatal injuries to >11% of the recaptured sample. Our data also indicate that bands may cause a decrease in survivorship. We stopped using these bands on P. townsendii and have removed bands from all recaptured animals.

Introduction

Banding has been an important research tool in bat population studies for over 75 years (Hitchcock, 1957) and has been a source of continuing investigator concern. Initially when unlipped, metal, bird-leg bands were the primary option, attention focused on the wing-injury rate of *Tadarida brasiliensis* and several other species (Hitchcock, 1957; Davis, 1960; Herreid et al., 1960). Although there appeared to be fewer wing injuries after introduction of lipped bat bands (Herreid et al. 1960), some populations, particularly in hibernacula, showed significant declines in apparent response to the disturbance caused by banding activities (Davis and Hitchcock, 1965; Stebbings, 1969, 1978; Tuttle, 1979; Barclay and Bell, 1988).

Although many bat researchers still observe the informal ban on disturbing hibernacula, increasing numbers of biologists are banding bats during summer, yet there is little discussion addressing the unresolved consequences of banding per se. Serious difficulties with banding a *P. townsendii* population in California lead us to suggest that there is the need for more dialogue on the effects of banding, particularly comparative assessments of different band materials and shapes (e.g., metal vs. plastic bands) and evaluations of species-specific responses to banding.

Methods and Results

On 9 October 1992, a total of 118 *P. t. townsendii* was captured at a roost site which had been under study for six years. This number represented approximately 95% of the bats present. Each bat was sexed, weighed, measured for forearm length, and evaluated for tooth wear and reproductive condition. Each bat was fitted with a 3-mm, lipped, alloy band issued to the British Mammal Society by Lambournes Ltd. of England. The band was placed over the forearm and manually squeezed shut (without banding pliers) so that it would slide freely along the arm. The band was not loose enough, however, for the metacarpals to slip under the lips and become caught when the wing was folded.

On 21 September 1993, 30 bats were netted in the evening as they exited the roost. One of these had been banded in 1992. As before, each bat was sexed, weighed, measured, and evaluated for tooth wear and reproductive condition. All bats that had not been banded previously were fitted with similar lipped bands (2.8-mm diameter-- the new equivalent to 3-mm bands) obtained directly from Lambournes Ltd. There was no sign of wing injury to the single bat that had been banded the previous year.

On 8 October 1993, 111 bats were captured at the same roost. As in 1992, this represented

approximately 95% of the bats present. Of the bats captured, 51 were recaptures from 1992 and 11 were recaptures from the previous month. All bats were processed as before. We found seven bats that had wing injuries associated with bands. One of these had been banded only 17 days before. This represented an injury rate of 11.8% (6/51) for the 1992 recaptures and 9.1% (1/11) for the 1993 sample.

For the one bat that had been banded 17 days before, the band was lodged at the distal end of the forearm. There was no swelling, but the skin under the band was abraded and had been bleeding. There was a somewhat roughened wing area, proximal to the band, that held the band in place. It appeared that the band would not have come free on its own, and quite likely, the injury would have progressed.

The five injured bats originally banded in 1992 had considerable swelling around the band and adjacent 2-4 mm of forearm. The area was infected, and even modest movement of the band caused puss to be expressed. Each band was carefully removed, revealing an area devoid of skin. In one case, the band had become embedded at the proximal end of the forearm, whereas the others were at the distal end. In three cases, the band had caused a small hole in the wing with the lipped portion penetrating the membrane and allowing the band to completely encircle the forearm. Although penetration of the wing membrane occurs with some frequency in banding studies, such injuries frequently are reported as having healed or callused over (Herreid et al. 1960). This was not the case for any *P. townsendii* that we observed. All animals were carefully inspected for signs of earlier band injury (such as scarring) that had healed or injury from bands that had somehow been removed. No such sign was detected.

Discussion

The most direct way to evaluate impacts from banding is to assess the percentage of a recaptured sample that shows wing injury. In our case, not only did an unacceptably high percentage (11.8%) of our recaptured sample show injury, but all injuries were active and thus judged to be potentially fatal. The fact that no bats had scarring to indicate healed wounds added support to the hypothesis that the bats do not recover from these injuries. Although most animals had been banded for a year, the six wounds we observed were in various stages of infection, suggesting an ongoing problem and an annual mortality rate that is likely much higher than the observed injury rate.

We had reason to believe that band injuries would be minimal. Lambournes' bands were used because they were lighter-weight and smoother-edged than any others available. Also Lambournes' bands had been used with virtually no sign of injury on large numbers of *Myotis yumanensis* (3.0-mm size) and *Antrozous pallidus* (4.0-mm size) (W. E. Rainey and E. D. Pierson, unpubl. data). Though there are suggestions in the literature that some species are more sensitive to banding than others (e.g., Hitchcock, 1957), this matter has been give little attention.

Reports of band injuries with *P. townsendii* are variable. Davis (1960) suggests that *P. townsendii* may be among those species most prone to band injury. This view is supported by the experience, in Oregon, of S. Cross and M. Perkins (pers. comm.), who banded very few individuals but experienced a sufficiently high injury rate with lipped U. S. Fish and Wildlife Service bands that they ceased banding *P. townsendii*. On the other hand, Pearson et al. (1956) had very low injury rates (<2%) using unlipped U. S. Fish and Wildlife Service bands (O. P. Pearson and A. K. Pearson pers. comm.). P. Leitner (pers. comm.), using 4.0 mm (size 2) unlipped USFWS bands, had comparably low injury rates on another *P. townsendii* study in northern California, with 7 out of 391 recaptures (1.8%) having embedded bands. Likewise, Stebbings (1966) had high (>70%) survivorship and almost no sign of wing injury using Lambournes' 3.0-mm lipped bands in England on *Plecotus auritus* -- a crevice-dweller that shows marked behavioral differences from its North American congener.

Why *P. townsendii* may be more prone to band injury than some other species from lipped metal bands is not clear, but we offer several observations that may provide a partial explanation. First, *P. townsendii* does not appear to gnaw on bands as other species do. We found no tooth marks nor other signs of wear on the bands and no differential tooth wear on the bats that could be attributed to band chewing. Chewing behavior, while having potentially negative consequences, such as accelerated tooth wear, may be advantageous in keeping bands from lodging on the forearm. Our observations indicate that *P. townsendii* may not attempt to dislodge bands that are stuck. In one early-stage infection, the band moved with only a slight application of pressure and could almost certainly have been dislodged by the bat with only a modest amount of chewing.

Additionally, *P. townsendii* seems to have especially thin wing membranes. Though we have not quantified this, the wings appear to be more delicate than those of other bats we have handled, including almost all genera present in the western United States. If this is an accurate perception, injuries from

bands that penetrate the wing membrane might be more likely in this species. Also, the wings have a sticky quality we have not observed in other bats. The bands on recaptured animals and the wings of all animals were covered with a sticky orange substance, which when removed with a cotton swab, appeared identical to secretions from the rostral glands. The stickiness of this secretion may play some role in inhibiting free movement of the band.

An injury rate of >11% is clearly too high for any species. It was of special concern for this colony because it represents one of only four known for *P. t. townsendii* along the California coast. This subspecies is a Category 2 Candidate for listing under the Federal Endangered Species Act. Our results lead us to conclude that, unless contrary data are available, other workers should not use this band type on *P. townsendii*. Whether some other banding protocol could work needs to be explored. D. Saugey (pers. comm.) has been using plastic bird-leg bands (A. C. Hughes), individually filed to increase the gap, on *P. rafinesquii*. Preliminary results suggest acceptably low injury rates. He and coworkers, however, observed embedding when unfiled plastic bands were used. This is congruent with observations by one of us (EDP) of an embedded band on an individual that had been banded with a plastic band in southern California. We also note that R. E. Stebbings (pers. comm.) discontinued use of plastic bands over 20 years ago due to high injury rates (partly due to band shrinkage over time) for all species tested. We suggest that before initiating a banding study using plastic bands investigators contact both R. E. Stebbings and D. Saugey.

One of us (EDP) and W. Rainey tried and subsequently rejected the use of bead necklaces (Barclay and Bell 1988) on another population, because the combined weight of the chain and band exceeded the 5% rule. Transponders may offer a viable alternative to banding, though the large size of even the smallest implants needs to be considered.

We are open to the possibility that our banding technique was somehow at fault, although the absence of similar problems for other taxa banded in the same manner argues against investigator error. It is also possible that we should have used a larger size (3.5-mm) band. The 3-mm band is used routinely, however, on comparably sized *Plecotus* in Britain and appeared to fit well on our study animals -- moving freely, with space around the forearm. Since it seemed to be the lip that first became lodged, it is not clear that a larger band, which is more than twice as heavy (105 vs. 43 mg), would have alleviated the problem.

We recommend that until it can be established that a particular band causes no more than minimal injury, banding of *P. townsendii* and other potentially sensitive species be limited to studies in which the impacts of banding can be evaluated directly. Since rates of recapture are generally low for bats netted in foraging areas, studies would probably need to focus on bats at known roost sites. Such research would need to be designed carefully to reduce the possiblity of undue disturbance, especially for *P. townsendii*, which is known to be so sensitive to human disturbance.

Acknowldegments

We thank P. Winters and C. Scott for their assistance in nursing injured animals back to health. J. Fellers and W. Rainey provided helpful comments on the manuscript. Banding was carried out under a permit and Memorandum of Understanding issued to E. D. Pierson by California Department of Fish and Game.

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BOOK REVIEW

La chauve-souris et l'homme.

Denise Tupinier. Paris : L'Harmattan (1989). Pp. 218. Price $38 U.S.

Bats have been the subject of folklore and superstition for centuries. Their nocturnal habits and affinity for eerie places have rendered them a source of mystery, fear, and fascination and have generated an extraordinary number of interactions between humans and these unique flying mammals. In her book La chauve-souris et l'homme, Denise Tupinier traces, in a very singular and idiosyncratic way, various themes surrounding these interactions, and explores the role that bats have played in popular traditions, arts, sciences, and customs, over the centuries and across continents.

The book opens with an account of the first historical documentation of bats and the events leading to the eventual identification of the bat as an organism distinct from birds. Here she notes that bats were first mentioned in the Bible, in which they were considered "impure" and not to be eaten. She also notes that Aristotle gave detailed descriptions of these animals, but it was not until the sixteenth century that zoologists and naturalists became interested in describing and classifying them, although we are reminded that at this point they were considered an intermediate stage between a bird and a mammal. According to Tupinier, it was during the eighteenth century that the puzzling nature of bats was finally elucidated, at which time they became classified in the order Chiroptera, by Blumenbach, in his Handbuch der Naturgeschichte, published in 1779. However, it took until 1850 for the majority of the scientific community to accept this classification scheme.

Equally as interesting as this overview of taxonomic history is Chapter Three, in which she explains the etymology and origins of the word "bat" in different languages. The perception of a "flying mouse" seems to dominate Western European languages and culture, whereas a combination of the terms bird, mouse, and rat is prevalent in Arabic and Asian languages. As she mentions, the association of bats with birds and small rodents (and/or some reference to their nocturnal habits) is present in virtually every language. The chapter also traces the evolution of the scientific nomenclature, from the sixteenth century onward, and the origination of many species' names used today.

In Chapters Four and Five, Tupinier examines the role of bats as technological models (in the design of flying machines) and as therapeutic agents used in ancient medicine and pharmacology. In Chapter Six, she reviews the involvement of bats in historical events throughout Europe and Asia, as well as their exploitation in unconventional military projects, such as "Operation X Ray", which involved unsucessfully training bats to transport and drop incendiary bombs on Japan, during WWII. Chapter Seven is perhaps one of the most interesting parts of the book. It provides an amusing account (accompanied by many fascinating photographs and illustrations) of how bats have been used as symbols in military insignia, coats of arms, and commercial products, ranging from kerosene lamps to the familiar bat logo on bottles of Bacardi rum.

In the chapters that follow, Tupinier explores the role of bats as subjects of folklore, superstition, and popular traditions, as well as their representation in various forms of art, music, and literature. It has been predominantly in Western culture that humans have regarded bats with fear and hatred and have associated them with witchcraft and evil spirits. In China and Japan, bats are considered a symbol of happiness and longevity, whereas in Zaire they inspire respect and admiration.

An interesting sample of poetry and literature, with bats featured as the primary subject, can be found in Chapter Twelve. In addition, this chapter includes a selection of legends, tales, and fables from around the world. This extensive collection is definitely one of the best features of the book. Bats have also been represented in art, ranging from Mayan sculptures to Western European paintings, and have been depicted extensively on tapestries, Chinese porcelain, jewelry, art nouveau objects, and even postage stamps. Many pictures of these objects and works of art can be found scattered throughout the book, as well as in the corresponding chapters. The book concludes with a chapter discussing the important role of bats as keystone species and the mutual benefits that bats and humans can derive from each other.

Overall, Tupinier's book is a compilation of interesting and entertaining facts, written in a simple and comprehensible way, but it also is presented in a rather idiosyncratic manner. The structure of the book is not apparent, and there is no obvious cohesion among the topics covered. Notwithstanding, it is well written and can be appreciated without a particularly strong command of the French language. Its most redeeming quality is the excellent illustrations and photographs, ranging from seventeenth-century drawings and caricatures, to portraits of different species, works of art, and miscellaneous artifacts and objects featuring bats.

Although this is not a scientific publication, the

variety of information presented, which is centered around ethnography and history, should provide interesting material for public lectures. In addition, biologists can derive some valuable insight about the animals that they have chosen to study.

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News from a few places

from Boston

Ed. note. A large segment of this contribution was inadvertently omitted by an error on my part, so we will reprint the entire segment, with my profound apologies to April Allgaier and the rest of the crew at Boston University. G. R. Horst

Ruth Utzurrum spent a year and one half in the Phillipines swatting mosquitoes and avoiding guerillas while conducting a study on the feeding ecology and physiology of Phillipine fruit bats. Ruth presented results of some of her work at the annual meeting of the Association for Conservation Biologists and the American Society of Mammalogists. Now back in Boston, she is being assisted by Rachel Kerner in analysis of the nutritional composition of staple fruits and seasonal changes in body composition. Target species for lab work are *Cynopterus brachyotis* and *Haplonycteris fischeri*. The male *H. fischeri* are militating strongly for the inclusion of some females in the lab.

Jennifer Brunton is studying changes associated with reproductive condition in gut morphology of *Myotis lucifugus*. Aspects of the study include analysis of the digestive tract at the gross, tissue and cellular levels. Having spent a great deal of time hand-feeding neon-colored mealworms to the bats(messy eaters at best), she agrees that facets of the study are indeed gross.

Scott Reynolds has initiated a multi-year study of sex-ratio manipulation by *M. lucifugus*. He is also exploring the use of modular artificial bat roosts for bat management and conservation programs. Despite a lucrative summer job in the business world, he vows to remain in the ranks of biology.

April Allgaier has completed a summer of fieldwork in Trinidad where she studied maternal investment in *Phyllostomus hastatus*, including milk composition, lactational energetics, time budgets, and post-natal growth rates. Having spent a summer milking bats, she is now trying to find an explanation for doing what she did that will make sense to her non-biologist friends. Future plans include a complementary study on the energetics of pregnancy in *P. hastatus*.

Helen Papadimitriou is embarking on a study of ontogenetic changes in the biomechanical properties of wing bones in *Tadarida brasiliensis*. In collaboration with Sharon Swartz of Brown University, she is looking at structural, mechanical and mineral composition changes during post-natal development of the wing skeleton which lead to the ability of adult bats to resist large torsional stresses brought about by active powered flight.

Tom Kunz, in addition to overseeing each of the above projects, is also trying to complete the manuscript for his forthcoming best seller, A Guide to the Bats of North America. He conducted a week-long course in New Hampshire on field techniques used to study bats. Tom presented papers on some of his work at the Association for Tropical Biology in Puerto Rico in June, at the ITC in Australia in July, the European Bat Conference in Portugal in August, and at the North American Symposium in Florida in October. Additional projects include several manuscripts on tent-making bats, the energetics of reproduction and post-natal growth in *Tadarida brasiliensis* and *Myotis lucifugus*, and the energetics of lactation and post-natal growth rates in captive Old-World fruit bats at the Lubee Foundation in Florida. Collaborative efforts include studies on flight energetics, the behavior of tent-making bats, and the effects of stress on glucocorticoid levels in both wild and captive bats.

Tom and Roy Horst are also busy planning and getting organized (or planning to get organized) for the "big bat bash" here in Boston in 1995. Tom also gives the frequent advice to his students and colleagues to "focus on one topic."

submitted by April Allgaier,

Dept. of Biology, Boston University, Boston, MA

Photographs Needed

Students of Eastern Michigan University are currently finishing Mammalian Species accounts for *Lasiurus ega* and *Eptesicus furinalis*. Photographs of each species, however are still needed. If anyone has a publication quality photo that they would like to contribute, please contact Dr. Alan Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, MI. 48197 or call at 313-487-1174.

RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths, Dept. of Biology, Illinois Wesleyan Univ., Bloomington, IL. 61702-2900, U.S.A.) for inclusion in this section. 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 welcome.

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Please Notice

Our last issue(BRN 34:2-3) carried a notice that.. .....The book, Bats and Bat Rabies, by A. M. Greenhall and L.Vallete is available free by writing to the publisher at: Rhone Merieux, 29 Avenue Tony Garnier, BP 7123, 69348 LYON Cedex 07, France.

This announcement was provided by Arthur Greenhall and was printed exactly as received from him. Several readers have written me that when they requested the book, it was sent, along with an invoice for 400 FF. This was also my experience, when I ordered a copy of the book for possible review, only payment was requested before the publisher would even consider shipment. BRN is sorry for the confusion and inconvenience. Interested parties should perhaps contact Arthur Greenhall at:
171 West 12th ST., New York, NY 10011

Abstracts of the papers and posters presented at the Twenty Third Annual North American Symposium on Bat Research Gainesville, Florida, October 13 to 16, 1993

Abstracts are listed alphabetically by first author.

On the danger of being male

Lalita Acharya, York University, North York, ON, Canada

Moths use a pheromone-based system for communication between the sexes. Females release the sex pheromone and are relatively immobile while they are "calling" for males; males search for and follow these female pheromone trails. Because male moths are more mobile than female moths, the risk of predation by aerial feeding bats may be higher for males than it is for females. I tested this hypothesis by examining culled moth wings dropped by *Lasiurus borealis* and *L. cinereus* that were foraging around lights at Pinery Provincial Park, Ontario. In many moth families, the forewings and hindwings are held together during flight by specialized structures arising from wing veins. There is sexual dimorphism in these structures. This dimorphism allowed me to identify the sexes of the moths to which the culled wings once belonged. In 1991, 1992, and 1993 the overall capture of moths by the bats was significantly biased towards males (1991 5:1, n = 107; 1992 6:1, n = 202; 1993 6:1, n = 117). There were differences in the ratios of males to females caught depending upon the time of night and time of season, but these ratios were still significantly biased towards males. Light trap catches in each of these years showed similar biases towards the capture of male moths. Literature values suggest that most moth species have approximately a 1:1 ratio at emergence. Although this sex-biased predation can be explained by intersexual differences in the amount of flight activity, an alternative hypothesis is that males are preferentially attracted to lights. If this latter hypothesis is true, then flying around lights is not only energetically wasteful for males, but also potentially fatal.

* * * * *

Post-natal growth and maternal investment in the greater spear-nosed bat, *Phyllostomus hastatus*

April L. Allgaier, Boston University, Boston, MA

Birth size and post-natal growth rates can be used to measure maternal investment. Changes in body mass, forearm length, total/proximal/ distal epiphyseal gap, and wing area were quantified for a cohort of 35 known-age *P. hastatus* pups. Average forearm of newborn pups was 34.40 ± 2.16, body mass 16.35 ± 1.68, and total gap 4.46 ± 0.21. Age-predictive equations were derived based on forearm length, which increased linearly to the sixth week. Epiphyseal gap measurements extended age-predictive equations to day 64. Total gap increased linearly to 16-18 days of age, when proximal and distal gaps first appeared. Pups initiated flight between six and seven weeks of age. There was no correlation between dimensions at birth and either mortality or dispersal rates. A stable or decreased mass associated with weaning was observed by the end of the seventh week. There was no significant difference at birth between males and females in forearm length or total gap, but males weighed more(16.98 ±1.88 vs. 15.69 ± 1.17, p=0.03, 31 d.f.), gained weight faster, and continued to gain body mass longer. Sex ratio at the onset of the birth season was male-biased, decreasing to a 1:1 ratio just before volancy. There was no correlation between maternal and neonate forearm length, but maternal body mass was positively correlated with neonate body mass(r=0.69). Maternal forearm was significantly larger(p=0.03, 147 d.f.)and body mass greater(p=0.009, 136 d.f.) in females with male pups. The data suggest greater maternal investment in male pups in this polygynous bat.

* * * * *

Conservation biology of the cave bats of Yucatan, Mexico

Héctor Arita, Centro de Ecologia, Universidad Nacional Autónoma de México, D.F., México

Thirty-one species of bats are found in the state of Yucatán, México. Seventeen of these (55%) use caves as

main or occasional day roosts. Current plans of the state government to develop several Yucatán caves as tourist sites prompted a study to evaluate the possible impact on the populations of bats. A one-year study of 36 caves in the southern portion of the state revealed the presence of 14 species of cave bats. Most caves (30, or 83%) contained few (<6) species, whereas only six caves (17%) harbored populations of seven or more species. Caves with high species richness were also those with the highest concentrations of individuals (high multi-species population sizes). There was a significant positive association among species in terms of cave use, so most species were integrationist, occupying caves where species richness is high. Thus, a few caves harbored large populations of many species, whereas many caves contained small populations of few species. This pattern suggests that the protection of these key caves would guarantee the conservation of the cave bat fauna of Yucatán. Unfortunately, these key caves are also those that have been targeted as possible tourist sites, complicating the development of an adequate conservation strategy.

* * * * *

Maneuverability and load carrying in *Myotis lucifugus* : A test of the 5% rule specifically among bats of different age and reproductive classes

Matthew S. Austin, Albright College, Reading, PA

The study of foraging behavior in bats often necessitates the use of radio transmitters. There has long been some discrepancy over the mass of such equipment that a bat can handle without significantly altering foraging behavior. Despite evidence that increased wing-loading detrimentally affects maneuverability, many researchers routinely attach transmitters which may alter a bat's natural flight patterns. This project was designed to investigate differences in maneuverability through the use of a flight tunnel with interchangeable grids of vertically arrayed parallel lines, spaced at intervals of 30 cm, 22 cm, 15 cm, and 11 cm. Thirty five control Myotis lucifugus were tested, including 8 nulliparous females, 5 pregnant females, 10 lactating/post partum females and 12 juveniles(4 males and 8 females). The maneuverability of these control bats in flying through the grids was compared to individuals for the same age and reproductive classes whose body mass was increased by increments of 5 % or 10 %.

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BATLINE: an electronic information exchange network

Michael C. Balistreri, University of New Mexico, Albuquerque, NM

An international information exchange service for bat researchers has been initiated. The purpose of this network is to promote timely exchange of research ideas, questions, and information. This e-mail discussion group can be accessed from any CMS, UNIX, or VMS environment using either BITNET or Internet. Anyone with an e-mail address can subscribe to this free service. Subscription can be accomplished by sending the e-mail message, *"SUB BATLINE yourfirstname yourlastname"* from your address to:

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Constraints on reproduction by bats: energy or calcium?

Robert M. R. Barclay, University of Calgary, Calgary , AB, Canada

Bats are unusual mammals in being small but having long lives and small litters. Bats raise young to near adult size by weaning and I hypothesize that this constrains litter size. Large size at independence appears to be a constraint associated with flight in vertebrates since young birds also do not fly until fully grown. The unique forces placed on wing bones during flight may require nearly fully developed bones at fledging. This means that each young is very costly, restricting the number than can be raised. Although energetic demands may be one proximate constraint, I argue that calcium is more important. For bats, calcium demand on reproductive females is high and calcium availability in diets (insects, fruit, pollen) is low. Birds overcome this by supplementing their diet with calcium-rich inanimate objects. These are unavailable to bats because they cannot forage on the ground and cannot detect such items using echolocation. This may help explain the larger reproductive output of birds compared to bats. If the hypothesis is correct, bat foraging strategies may be based on the calcium content of prey in addition to energy content, and bat pollinated and seed dispersed plants may attract bats by offering high calcium rewards. In addition, however, it would mean that flight could only have evolved in bats in association with long lifespans thereby constraining the possible life histories available to these mammals.

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Zoogeography and conservation of bats in Papua New Guinea

Frank J. Bonaccorso, University of Florida, Gainesville, FL

Nearly 9% of the world bat fauna (88 species) occur in Papua New Guinea (PNG). The Pteropodidae, 33 species, is the most rich of six bat families found in PNG. Lowlands below 500 m elevation include 83% of the total bat fauna, whereas only 7% of the fauna occurs above 2,500 m. There are 18 species endemic to PNG. Species shared with Indonesia, Solomon Islands, and Australia respectively number 46, 30, and 28. These preceding countries provide immigration routes into and through PNG. Though many species in PNG have ubiquitous distributions, others have limited distributions and include some of the rarest or least collected bats in the world, notably *Aproteles bulmerae, Pharotis imogene, Pteropus gilliardi, Pteralopex anceps, Syconycteris hobbit* and *Tardarida kuboriensis*. Conservation recommendations include: 1) expansion of wildlife refuges (local supervision) and national parks (national supervision) to include important maternity roosts; 2) research on endemic and vulnerable species; 3) public education informing citizens of beneficial qualities of bats; 4) support for PNG nationals in advanced education in mammalogy and conservation biology; 5) local, national, and international conservation agency funding directed to conservation in PNG; 6) support from businesses impacted by bats (agriculture, timber, and ecotourism) for research and conservation; 7) development of sustained yield ethics among peoples hunting bats for meat.

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Function of screech calls in *Phyllostomus hastatus* : do calls signal individual or colony identity?

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Female *Phyllostomus hastatus* may cooperate when foraging in groups on rich, ephemeral food sources. To determine whether this apparent cooperation is restricted to a specific subset of individuals, we need to know if individuals can distinguish one bat from another. Acoustic cues are likely to provide the basis for such discrimination, if it occurs. Greater spear-nosed bats give loud screech calls while foraging together and when emerging from the roost cave. We designed a playback experiment to determine whether these screech calls provide information on the identity of the caller. Results verify previous experiments, showing that screech calls elicit approach and calling. Results also indicate that calls vary according to colony, and that bats discriminate between familiar and unfamiliar bats, as evidenced by the different number of screech calls and passes to playbacks from Caura and Guanapo caves. Bats responded in similar ways to tapes containing a single bat's calls and to tapes with four bats' calls, suggesting that they did not discriminate among the individual calls on the tapes.

Doubly labeled water measurement of feathered bat energetics: results and impact of the protocol

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and Donald W. Thomas, Université de Sherbrooke, Sherbrooke, PQ, Canada

The purpose of our study was to evaluate the daily energy requirements of Common Poorwills (*Phalaenoptilus nuttallii*) using doubly labeled water. For any technique to measure attributes of a normally behaving animal, however, it is also necessary to assess the effects of the protocol. We used radio-telemetry to determine if injection, blood sampling, and recapturing birds, altered foraging activity. This, to our knowledge, is the first field test of the impact of this procedure on behavior. We found that the protocol had no significant effect on foraging activity. The daily energy requirements were extremely variable between individuals indicating that poorwills are flexible in the energy requirements, possibly due to the variable use of torpor. On average, breeding poorwills used only 50% of the daily energy predicted by Nagy's equation for non-passerine birds (1.2 kj/g/day). This is extremely low and concords with animals who are 1) desert adapted, 2) use an inexpensive foraging mode and 3) use torpor. In comparison, Kurta et. al. found that pregnant *E. fuscus* and *M. lucifugus* require two and three times the mass specific daily energy intake respectively.

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Scent marking and the use of odorous secretions by the fishing bat, *Noctilio leporinus*

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The distinctively sweet odor of the fishg bat, *Noctilio leporinus* is produced by oily secretions found beneath the bats' wings in the sub-axial region. Dominant males produce the greatest volume of secretions and have the most pungent smell while subordinate males and females have less secretions and a milder odor. Juvenile males and females produce no secretions and lack the sweet smell. Females roost together in small "harem" groups with a single male. I observed females on 48 occasions transferring secretions from other females within their harem to themselves by pressing their heads beneath the other bats' wings and rotating their heads from side to side. On 109 occasions, I observed secretions passed between females by head to head rubbing. Females often moved for short periods to different groups within the roost. When such a "visitor" first approached another gorup, her wings and head were smelled by the resident females. On two occasions, the resident male apparently singled out the visiting female and evicted her from the group. Secretions were collected from 12 bats and analyzed by gas chromatography-mass spectrometry. Four hundred forty four different compounds were identified as glycolipids, nonpolar lipids and phospholipids. Males and females shared 243 compounds, 114 compounds were present only in males, and 87 compounds were found only in females. The relative quantity and number of compounds from each bat was unique. We compared the similarity of compounds and volume among sexes and individuals by an unweighted paired group cluster analysis. Then, using a similarity matrix, we generated a phenogram s howing the closeness of association among the samples. In the nonpolar lipid fraction, females grouped together separately from males. In the glycolipid fraction, the two pairs of males from the same roost were more similar to each other than to other bats. Sub-axillary secretions are apparently used by males and females. The distinct combination and concentration of compounds in each bat suggests that an individuals' smell provides information on age and sex. The strong smell in males apparently advertises dominant status and is likely to be used in sexual selection. Females allomark group members with secretions presumably to develop a group specific odor.

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Abandoned mines as habitat for bats and other wildlife

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In response to increased disturbance in caves from recreational spelunkers and vandals, many cave-roosting bats have taken up residence in abandoned mines during the last century. Bats often congregate in

large numbers, and are especially vulnerable to disturbance during their maternity and hibernation seasons. In the United States, most of the bat species that are Federally-listed as threatened, endangered, or candidates for such status roost in mines or caves. Different species have various environmental requirements for roost temperature, humidity, access and dimensions, that vary with season and reproductive status. Old mines are now being closed at an alarming rate due to a concern for public safety, reclamation, and the resurgence of mining in historic districts. Current mining techniques destroy old mines and create open pits rather than underground workings. When mine destruction is unavoidable, bats and other wildlife should be removed or encouraged to leave. The mines can then be temporarily sealed, but this should not be done in the winter when inactive hibernating bats could be trapped, or in the late spring and early summer if maternity colonies are present. As mitigation for the loss of roosting habitat, other non-impacted mines in the same area with suitable environmental parameters can be gated to provide secure habitat for the displaced bats and other wildlife. Although bats are the most affected species, mines also provide shelter for other wildlife, such as desert tortoises, barn owls, bighorn sheep, ringtail cats and woodrats. Gating or fencing of old mines to protect the public and the bats is a practical solution, and must be tailored to specific animal requirements. Bat and other wildlife use of mines may increase once gates are installed and disturbance is reduced.

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Foraging behavior of the California leaf-nosed bat *Macrotus californicus* as determined by radio-telemetry

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The California leaf-nosed bat *Macrotus californicus*)is a U.S. Fish and Wildlife Service category 2 candidate for threatened or endangered status, with the principal threat being the closure of old mines for hazard abatement or renewed mining. Due to their inability to enter torpor, *Macrotus* congregate in warm deep mines (>80 F) to conserve energy. In California, less than 20 winter roost sites are known. During the summer maternity season, they roost closer to the surface, sometimes in the same mine used by the winter colony. A recent radio-tracking study in the Cargo Muchacho mountains revealed that the bats foraged for large moths and katydids among desert wash vegetation. Males tagged in June 1992 traveled at least three miles from their roost to forage, and were detectable most of the evening since they rested in shallow roosts between foraging bouts. In contrast, the 1992 winter survey showed that the bats stayed on the surface only brief periods before returning to their warm deep mines. Foraging areas in the winter were located within a half mile from the roost. Abundant rains fell in early 1993, with a resulting increase in vegetation lushness and insect abundance. The June 1993 survey, using both males and lactating females, revealed that although they were sexually segregated in their roosts, they foraged in the same area, generally within a mile of the roost. Individual bats had distinct foraging areas. The preliminary conclusion from this study is that foraging areas adjacent to the roost are more important for winter than for summer populations. Knowledge of both roosting and foraging habitats is necessary in order to predict when renewed mining activities will impact *Macrotus* populations. Mitigation measures can include the protection or revegetation of the desert wash vegetation, as well as, the gating of abandoned mines to provide secure roosting habitat.

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The ecology and behavior of the serotine bat *Eptesicus serotinus*

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The aim of this study was to investigate the ecology and behavior of the serotine bat, a widely distributed and poorly known European species, and the main rabies vector in the recent European epizootic. The composition and social structure of maternity colonies were determined during three breeding seasons. Of all females caught, 66% (n = 209) were reproductively active and 34% inactive and only one female reproduced in all three years. There was a significant difference in both size between juvenile males and females and also in the body size of juveniles caught at different roosts at the same time of year. Activity

patterns at a maternity roost were investigated by a remote monitoring system and were unimodal during early pregnancy, bimodal during mid and late pregnancy and multimodal during lactation. The duration of the first flight decreased significantly during pregnancy as the parturition date approached and increased significantly as lactation progressed. Inclement weather inhibited or shortened flights. At weaning, mothers sometimes used different day-roosts and reproductively inactive females sometimes changed roosts, moving up to 5 km. There was no movement of individuals between maternity colonies. Foraging serotines exploited temporary concentrations of insects and used three distinct foraging styles: hawking, flycatching, and feeding on the ground. They often foraged around white street lamps and close to accumulations of cattle during the late summer. *Aphodius* beetles were the commonest item found in the faecal pellets. There was a significant difference in the insect prey consumed for each month of the study with June being associated with the highest diversity of insect prey. The ability of the serotine to exploit man-made buildings as roosts, street lamps as feeding sites and insects associated with cattle has allowed it to adjust to an environment undergoing anthropogenic change.

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Bat abundance and activity in stands of different seral stages in Alberta mixed-wood forest

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As part of a larger study by the Alberta government to determine the impact of logging on the mixed-wood forest, I assessed the abundance and diversity of bats in stands of different age (6 sites in each of 4 stands of 3 age classes). We also observed foraging and roosting activity of bats in these stands. I searched for potential roost trees, monitored echolocation calls and used mist nets in each stand. I identified *Myotis lucifugus, Myotis, spp., Lasionycteris noctivagans, Eptesicus fuscus,* and *Lasiurus cinereus. Myotis spp.* activity predominated in early stands. Preliminary results suggest that the greatest bat activity occurs in old stands. I analyzed the results with respect to vegetation structure and composition of different ages. The study next year will examine the impacts of this winter's logging in half the mature and old stands.

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Preliminary study of a new way of estimating the maintenance nitrogen requirements of bats

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One of the major problems with bats (and birds) in estimating their nitrogen requirements for maintenance is that urinary nitrogen becomes mixed with feces. This makes it very difficult to analyze both the nitrogen losses in the feces (Metabolic Fecal Nitrogen, MFN) and urine (Endogenous Urinary Nitrogen, EUN). Separation of fecal material from urine and separate estimates of MFN and EUN in bats were virtually impossible to make up to now. For this reason, the weakness of all nutritional studies of bats is that nitrogen requirements and the digestibility calculations are all based on the supposition that bats lose 2 mg N/Kcal of Basal Metabolism Requirements (BMR) by urinary passages. If this supposition is incorrect, all previous calculations and interpretations may need to be reconsidered. Fundamental interpretations such as dietary choices, foraging strategies, nitrogen or energy as dietary constraints may be questioned. In this preliminary study, an attempt was made to produce partial results of the Maintenance Nitrogen Requirements for *Carollia perspicillata* based on a true measure of urinary nitrogen losses (ammonia, urea, and creatinine). By substracting the urinary nitrogen from the total nitrogen losses, we came up with a true measure of the fecal nitrogen losses, and consequently the digestibility. During the experiment, feeding trials were performed and daily fecal material of *Carollia perspicillata* were collected for the determination of the total fecal and urinary nitrogen excretion, the urinary nitrogen losses and the energy content of the fecal material.

Relationships between clicking behavior and palatability to captive bats among Arctiid moths

Dorothy C. Dunning, West Virginia University, Morgantown, WV

Arctiid moths of ten North American species captured at lights were tested for clicking responses to tactile and acoustic stimulation and placed in small cages with sympatric insectivorous bats trained to catch moths there. Control moths similar in body size to the arctiids but belonging to the families Noctuidae, Geometridae, Sphingidae, Lasiocampidae, Saturniidae, and Lymantriidae also were put in the cages with the bats and the arctiids, in proportions approximating those at the lights. Moths of three of the four arctiid species that never clicked were significantly more likely to be eaten by the bats than those of the six species that did click, at least occasionally. Moths of the fourth nonclicking species were as unpalatable as those that did click. Some individuals belonging to five of the other six species clicked and each was marked to identify its clicking responses before being placed in the cage with the bats. All individuals of the sixth species clicked. There were no significant differences in the palatabilities of clicking and nonclicking individuals within and among the five species polymorphic for clicking, nor was there any significant correlation between palatability and clicking propensity among these five species. The biological significance of these relationships will be discussed.

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Responses of South African bats to insect densities

Susan E. Ellis, York University, North York, ON, Canada

Bat species were sampled in open, mixed and heavily forested habitats in the northern Transvaal area of South Africa during the winter season. Habitats containing the highest levels of bat feeding activity were identified as mixed habitats, especially those near permanent light sources, and to a lessor degree, areas near water. Response times of bats to light-attracted insect densities were more rapid in areas with permanent light sources which are already in use as foraging sites by the bats than in normally unlighted areas where a temporary light source was introduced. Fecal analysis of netted bats showed that different sized bat species with intermediate wing morphologies and echolocation calls shared very similar diets. These diets changed over the course of the season, but were always low in diversity. The composition of these diets closely paralleled the insects that were attracted in swarms to light sources. Although sharing similar habitats with the intermediate bats, bat species with more specialized wing morphology and echolocation calls exhibited a higher degree of dietary diversity and tended toward later activity times.

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The relative importance of birds and bats as seed dispersers of solanaceous plants in a Costa Rican tropical rain forest

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Traditionally, it has been thought that there is little resource overlap between frugivorous birds and bats. In Monteverde, Costa Rica, the fruits of at least fourteen plants in seven families are eaten by both taxa. To help understand the relative roles played in the dispersal of these plants by both birds and bats, I examined three secondary growth plants in the family Solanaceae. *Solanum aphyodendron* and *Solanum umbellatum* are thought to be primarily bat dispersed, while *Acnistus arborescens* is thought to be almost solely bird dispersed. Diurnal vs. nocturnal removal rates were measured by counting fruits on marked plants at sunrise and sunset. Unlike fecal analysis, this technique allows for quantitative assessment of overall bird- and bat-specific fruit removals. In addition, in order to determine the relative viability of seeds after ingestion, gut passage effects on the germination of seeds were germinated to estimate seed viability. *S. aphyodendron* and *S. umbellatum* fruits were, as expected, primarily bat removed (for *S. aphyodendron*, 81.5% bat removed; for *S. umbellatum*, 85% bat removed. However, the fruits of *A. arborescens* showed equal removal by birds and bats (45% bat removed). This indicates that bats may play a much more important role in the dispersal of *A. arborescens* than previously suspected. Germination experiments showed high viability of seeds passed through both birds and bats with little variation between taxa. This suggests that the amount of fruits removed may be an important factor in

dispersal effectiveness. Further work involving seed shadow studies and seedling survival is necessary. However, the significant role of bats in the dispersal of all three plants may have important implications for the evolution of these plants in the Monteverde area.

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Status of big-eared bats, *Plecotus townsendii*, in Marin Co., California

Gary M. Fellers, Point Reyes National Seashore, Point Reyes, CA

Big-eared bats *Plecotus townsendii* are a rare and declining species in the western U.S. This has been because of a loss of roost sites and disturbance to maternity and hibernating colonies. Two large maternity roosts were recently discovered at Point Reyes National Seashore. Monthly counts using night vision equipment indicate that increased protection of these roosts by the National Park Service has allowed one colony to increase substantially. With the exception of one year, an average of 52% of the females raised volant young. The colony has increased by 63% over the last five years. The other, more protected, colony has remained stable over the same time. Several types of data-loggers have been employed to gather data on bats. Thermal characteristics of two maternity roosts have been measured in order to gain a better understanding of roost requirements. An automatic bat counter was developed which logs activity at the roost exit and thus provides data on bats leaving and entering the roost throughout the night. Foraging behavior of bats was studied using light-tags. This allowed for visual tracking of individual bats. At Point Reyes, big-eared bats forage for moths among the foliage of several tree species. Movements between foraging sites are typically low and rapid, perhaps to avoid predation. A program to band big-eared bats will assist in evaluating winter dispersal, roost site fidelity, and the location of new roost sites. County-wide bat surveys have resulted in the discovery of small groups of *Plecotus* which may indicate the presence of other maternity roosts.

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Constraints on bat performance: flight speed data

M. Brock Fenton, York University, North York, ON, Canada

Intrinsic factors such as morphology and physiology can limit or constrain an animal's performance. For insectivorous bats, echolocation call design may affect an individual's ability to detect some targets, while its dentition influences the range of insects it can eat. Prey availability, however, also affects the prey taken by a bat, making diet a poor way to explore constraints imposed by echolocation or dentition. Flight performance appears to offer a better way to examine how constraints affect a bat's behavior. Since morphological features affect flight performance, a frequency plot of flight speeds should be skewed to the right, suggesting an upper limit to flight speed. This should apply in situations where bats are flying quickly, not when they are manoeuvering to avoid obstacles or press home attacks on evading prey. I used a Doppler radar to sample flight speeds in field populations of *Myotis lucifugus* to test these predictions.

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Trioecy in *Pachycereus pringlei*:: the role of *Leptonycteris* bats

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The giant columnar cactus *Pachycereus pringlei* (cardon) has a geographically variable breeding system. In the Sonoran desert of mainland Mexico, its populations are gynodioecious (separate female and hermaphrodite plants) in the southern 1/3 of its range and trioecious (separate males, females, and hermaphrodites) in the northern 2/3s. In Baja California, its populations are trioecious in the southern 2/3s of its range and gynodioecious in the northern 1/3. We tested two hypotheses to explain this pattern: (1) a "limited gene flow" hypothesis, which predicts that substantial genetic differentiation that is concordant with variation in sex ratios occurs among cordon populations; and (2) a "limited nocturnal pollinator" hypothesis, which predicts that this pattern reflects concordant variation in the abundance of

cardon's major pollinator, the bat *Leptonycteris curasoae*. Results of an electrophoretic survey of cardon populations do not support hypothesis (1). Three lines of evidence support hypothesis (2): the geographic distribution of *Leptonycteris* maternity roosts, field observations on time of arrival of bats in different cardon populations, and a theoretical model which shows that pollinator limitation can lead to evolutionarily stable trioecy in this cactus. We conclude that the abundance and distribution of *Leptonycteris* bats are major factors in the evolution of trioecy in *P. pringlei.*

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Roost-site selection by the northern bat *Myotis septentrionalis*

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The northern bat *Myotis septentrionalis* is sympatric with the federally endangered Indiana bat *Myotis sodalis* throughout most of *M. sodalis's* range. Previous research indicates both species roost in dead trees, either under loose bark or in cavities *M. sodalis*. Three years of data for *M. sodalis* in Eaton County, Michigan, indicate roosts are under loose bark of green ash *Fraxinum pennsylvanica* located primarily in open unshaded swamp habitat. In this study, I used radio-tracking to determine roost selection by *M. septentrionalis* and compared these findings with *M. sodalis*'s roosts in order to examine the extent of roost resource partitioning between these two species. Seven female *M. septentrionalis* bats were tagged and radio-tracked over a four-month period. These seven bats yielded a total of 18 roost trees; 12 silver maples *Acer saccharinum*, 1 red maple *Acer rubrum*, and 5 green ash *Fraxinum pennsylvanica* . Roosts were located in cavities and under loose bark in both living and dead trees located in a variety of habitats. One green ash tree was used by both species over the four month period, *M. sodalis* under loose bark, and *M. septentrionalis* in a cavity. The largest *M. septentrionalis* roost count was 60.

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Lactation in male *Dyacopterus spadiceus (Pteropodidae)*

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Rhode Island College, Providence, RI, and Boston University, Boston, MA

Lactation is normally exclusive to female mammals. While male lactation is physiologically possible, it is isolated and rare. Male lactation has been reported in domesticated mammals and in humans, but to our knowledge, it has not been observed in wild, free-ranging species. Here we report on apparent lactation by males in a population of Dyak fruit bats, *Dyacopterus spadiceus* (Chiroptera: Pteropodidae), located in the Krau Game Reserve, Malaysia. Ten mature males had well-developed mammary glands from which milk was manually expressed. Subsequent dissection of three males revealed secretory tissue that was histologically similar to a lactating female, although the mammary glands and nipples were distinctly smaller. Testes of these males appeared normal, and in two cases were actively spermatogenic. These observations indicate that spontaneous male lactation is possible, although the function remains to be determined.

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Nectarivores and feeding mechanisms in bats

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Both phyllostomid and megachiropteran nectarivorous bats are examined for cranial and dental characteristics and compared with microchiropteran frugivores and animalivores (insectivorous and carnivorous bats) from previous work. Besides the well-known long, slender rostrum of many nectarivorous bats, these animals also exhibit relatively small teeth compared to palatal area. Megachiropterans, whether nectarivorous or not, have large premolar and small molariform tooth areas relative to total tooth area. Microchiropteran animalivores and frugivores have large tooth areas relative to the area of the palate; but while frugivores have a small area dedicated to area of ectoloph or stylar shelf, the ectoloph in animalivores is large. Phyllostomid nectarivores have a similar proportion of ectoloph area as animalivores, but their

teeth are smaller. Molariform teeth are emphasized in frugivores and compared with frugivores phyllostomid nectarivores have large canines relative to total area of the teeth. Interestingly, the fused mandibulae and thegosed anterior surfaces on their upper canines are typical of nectarivores and other megachiropterans. These could be adaptations at the anterior end of the rostrum to strengthen the lower jaw and brace upper and lower tooth rows while the tongue is working to bring in nectar. The mandibular condyle is shorter in these animals, and the mandible itself is more gracile.

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The dogbane tiger moth, *Cycnia tenera*, times its clicks to the terminal echolocation phase of the attack sequence of the big brown bat, *Eptesicus fuscus*

James H. Fullard, Erindale College, University of Toronto, Mississauga, ON, Canada

Certain tiger moths emit high frequency clicks to an attacking bat cause it to break off its pursuit. The hypothesized mechanisms of how the sounds act is that they either orient the bat by providing it with information that it uses to make an attack decision (aposematism) or they *disorient* the bat by interrupting the normal flow of echo information required to complete a successful capture (startle, jamming). A critical question in this controversy is at what point during a bat's attack does an arctiid emit its clicks. If the sounds are aposematic, the moth should emit them soon in the attack echolocation sequence in order to allow the bat time to understand their meaning. If, on the other hand, the sounds disorient the bat by disrupting its echo-processing behavior, one would expect them to be emitted later in the attack to maximize their confusion effects by not allowing the bat sufficient time to adjust to them. To test this prediction, I exposed individual dogbane tiger moths (*Cycnia tenera*) to an exceptionally good recording of the echolocation calls emitted by the big brown bat (*Eptesicus fuscus*) attacking a stationary target. This playback presents an acoustically accurate stimulus simulating the entire echolocation sequence of tiger moth would be exposed to during a bat's attack. These experiments demonstrate that *C. tenera* does not respond to search or approach calls but waits until well into the bat's terminal phase before it emits its clicks. This timing is evident whether the moth is stationary or flying and is largely independent of the intensity of the echolocation calls. These results support a disorientation effect (e.g., "phantom echoes") over the aposematic hypothesis and suggest that to experimentally determine the effects of arctiid clicks on bats it is imperative that the bats must be: 1. naive, 2. in flight and, 3. emitting terminal buzzes when exposed to the clicks.

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Seasonal changes in gonadal condition, testosterone levels, and mating activity in male *Eptesicus fuscus*

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The purpose of our research is to determine the pattern of reproduction in a southern population of male *Eptesicus fuscus*. Two wild populations, one in Auburn, Lee Co., AL and the other in Georgiana, Butler Co., AL and one captive colony, in Auburn, have been sampled since September 1992. Blood samples were taken upon capture from ten males monthly to determine circulating levels of testosterone. Surgery was performed on the same males to obtain testis volume and biopsied to determine the stage of spermamtogenesis. In early July there is minimal spermatogenic activity as only spermatogonia are observed. Peak spermatogenic activity occurs in September with full regression by the first of November. These data show at least a one month lag in peak spermatogenesis compared to studies on northern populations.

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Parent-offspring relationships and behavioral development of offspring in captive *Pteropus vampyrus*

Thomas T. Gordon, State University of New York, Stony Brook, NY

Most empirical studies using behavioral surrogates for parental investment in mammals have reported similar patterns of behavior. Most notably, there is a reported decrease in suckling and often a reported

increase in suckling attempts by the young resulting in parent offspring conflict. However, two studies of parent offspring relations in two different Australian Pteropids (*Pteropus conspicillatus* and *P. poliocephalus*) reported that the suckling time remained relatively constant for the duration of the studies. Since primary data collection for both studies was during daylight hours, I suggested that the results were an artifact of the data collection procedures and proposed that the only time the predicted decrease in nipple time could be observed would be during the hours of darkness. Additionally, the parent offspring relationships in the large colonial Pteropids show a unique factor not seen in other mammals; the pups are in nearly constant contact with their mothers for a long period of time (nearly two months in the larger species) before suddenly being left along at the roost during the night while the mother forages. These observations led me to predict that 1) if a decline in nipple time exists in these animals, it will be expressed as decreasing contact time during the night hours and 2) any parent offspring conflict behaviors will appear suddenly at the beginning of this contact decline, when the mothers are first leaving the pups to forage. I pursued these questions during a seven week study using two mother-pup pairs of *Pteropus vampyrus* at the Lubee Foundation in Gainesville, FL. The results indicate a fairly steady decrease in nightly contact time as the pup grows beginning at age 10 weeks and an appearance of conflict behavior corresponding with the onset of decreased contact. Other behaviors associated with independence, such as auto-maintenance, investigation, and locomotion, also showed a steady increase with age.

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Phylogenetic systematics of nycterid Bats (Chiroptera: Nycteridae), based on hyoid and other morphology

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The hyoid musculature and hyoid apparatus of bats of the family Nycteridae are described and compared with the hyoid morphology of other bat families described elsewhere. Four hyoid and four non-hyoid apomorphic character states are described within the family. All nycterids share the apomorphic hollowing of the rostrum into a vertical slit, ornamented with the distinctive nycterid noseleaf. All nycterids also possess a distinctive T-shaped terminal caudal vertebra. All nycterids except *N. arge* share a reeduced ceratohyoid insertion and a reduced hyoglossus origin. All nycterids except *N. tragata* and *N. arge* share an epihyal that is reduced in length, a smaller lower second premolar, and a loss of the posterior tragus constriction. A cladistic analysis of the data suggests that the African *hispida, macrotis,* and *thebaica* species groups form a clade. The Asian bats of the *javanica* group are a sister group to the *hispida-macrotis-thebaica* clade. Bats of the African *arge* group are the most basal lineage within the Nycteridae. This analysis supports separating the more primitive nycterids into an *arge* group and a *javanica* group rather than combining them in a single group.

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Impacts of forest harvesting on activity by bats in the West Arm Demonstration Forest near Nelson, British Columbia

Scott D. Grindal, University of Regina, Regina, SK, Canada

Commuting and foraging activity by bats was measured using ultrasonic detectors placed in cutblocks, on the edge of cutblocks, and in forest adjacent to cutblocks for 90 minutes after sunset. Samples were taken in 3 biogeoclimatic zones (ICHdw, ICHmw, ESSF) and in various age stands (80-250 years). Preliminary analysis of the results suggests that commuting and foraging activity was greatest along edges, with very low overall foraging activity. Commuting activity was greatest 30 minutes after sunset, suggesting that bats emerge from roost sites and travel to other locations to forage. Commuting and foraging activity was greatest in lower elevation biogeoclimatic zones (ICHdw) mature age stands, possibly for roost selection and that these sites are chosen at lower elevations, perhaps closer to possible foraging sites (ie. west arm of Kootenay Lake).

Fluctuating asymmetry in wing and leg morphology of bats

David L. Gummer, University of Regina, Regina, SK, Canada

Fluctuating asymmetry is the occurrence of small deviations from perfect bilateral symmetry of morphological traits. If asymmetry of a particular trait decreases the fitness of an individual, and if the degree of asymmetry is heritable, then natural selection should minimize the amount of asymmetry for that trait in a population. The structure and shape of a flying animal's wing affect flight performance. In the case of bats, this may influence foraging ability, and hence affect an individual's fitness. I hypothesized that symmetry in the forearm length of bats is more important to fitness than symmetry in the length of the tibia, and thus, predicted that there should be less fluctuating asymmetry in the forearms than in the tibia. I measured the forearm and tibia lengths from 222 bats of the species *Myotis lucifugus, M. evotis, M. californicus, M. yumanensis, Lasionycteris noctivagans, Lasiurus cinereus, Eptesicus fuscus.* Measurements were made on individuals caught in the field, as well as, museum specimens collected from May to September 1993 in Saskatchewan, Alberta, and British Columbia. Preliminary analysis indicates that there is less asymmetry in the forearms, supporting the hypothesis that forearm symmetry may be more important to an individual's fitness than that of the tibia.

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Roost fidelity and population turnover in big brown bats, *Eptesicus fuscus*, hibernating in buildings.

Sherry L. Gummer and John O. Whitaker, Jr., Indiana State University, Terre Huate, IN

Sixty- four buildings in Indiana serving as hibernacula for big brown bats were studied for up to six years. All bats were banded with numbered bands. Many bats returned to the same building in different years, but there was much turnover in populations, both within and between years. Also, there was relatively little colony fidelity among these bats. Some bats would be present one year, miss a year (or two), then be back. Few bats returned to the same hibernating places. The number of bats per hibernaculum ranged from 1 to 72 in buildings with maternity colonies in summer ($x = 11.7$), and 1 to 9 in buildings not serving as maternity colonies ($x = 2.9$). Sex ratios in larger hibernacula in buildings were male biased (63%).

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Spatial and temporal variation in bat activity in echolocation monitoring studies

John P. Hayes and Patrick Honihan, Oregon State University, Newport, OR

Recent technological advances have stimulated use of echolocation monitoring systems, or bat detectors, to assess levels of bat activity. This technique shows great potential, but has limitations. To date, there are little or no data concerning temporal and spatial variation in bat activity detected by monitoring echolocation calls. We contend that understanding patterns of variation is essential to designing meaningful scientific studies or echolocation monitoring programs. In studies conducted along streams in the Oregon Coast Range, we found that substantial variation in bat activity occurs at different locations on a single stream. In addition, the number of echolocation calls detected at a given echolocation station on different nights can vary dramatically. These data suggest that echolocation monitoring programs need to involve multiple stations over multiple nights in order to obtain reliable estimates of bat utilization. Preliminary results of the environmental factors correlated with bat activity are presented.

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Allometry of litter mass in bats: Comparisons with respect to maternal size, wing morphology, and phylogeny

V. Hayssen, Smith College, Northampton, MA and T. Kunz, Boston University, Boston, MA

Although many studies have examined mammalian reproductive strategies, few comparative investigations are available of the reproductive life histories of bats. Bats are the second most diverse and

one of the most ecologically, morphologically, and reproductively distinctive groups of mammals. They are the only taxon of small mammals with predominantly singleton litters. In addition, the period from mating to conception in bats regularly includes an assortment of timing delays, e.g. sperm storage, delayed implantation, delayed development, and slowed fetal growth. Here we present allometric and phylogenetic analyses of litter mass as an index of the energetic cost of gestation in bats and other mammals. For mammals, the allometry of reproductive characters is typically examined using adult-female mass or, less commonly, head-body length as estimates of body size. For bats, forearm length is an important morphometric character. Data available for bats allow the integration of several estimates of body size into a single variable (wing loading [body mass/area of airfoil[), which is of critical significance to flying animals. Thus, wing loading may be an especially useful estimate of body size for allometric comparisons among bats because it synthesizes many features of body size into an ecologically and physiologically meaningful parameter. Reproductive (litter size, neonatal mass) and morphometric (head-body length, forearm length, body mass, wing area, aspect ratio) data were compiled from primary data and literature sources for over 400 species representing 16 of the 17 families of bats. Where possible morphometric data for females were used rather than those for adults or males. Not all data were available for each species. Both suborder (megachiropterans vs. microchiropterans) and interfamily (rhinolophids, phylostomatids, vespertilionids, and molossids) comparisons suggest significant phylogenetic differences in the allometry of litter mass. However, our detailed analyses suggest that the way in which one estimates body size and/or energetic investment, as well as, the taxonomic level chosen for analysis can determine the magnitude (and possibly the direction) of allometric relationships.

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Endotracheal anesthesia in five species of flying-fox (*Pteropus pumilus, P. rodricensis, P. hypomelanus, P. poliocephalus,* and *P. vampyrus*)

Darryl J. Heard, University of Florida, Gainesville, FL

Isoflurane inhalation anesthesia is used routinely at the Lubee Foundation for bat restraint during physical examination and blood collection. It has also been used for medical, surgical (e.g. dystocia, cesarian section, laceration, and fracture repair), and experimental procedures (e.g. implantation and removal of abdominal telethermometers, electroretinography). Inhalation anesthesia offers the advantages of rapid induction and return to normal function, prolonged steady state immobilization, and less physiological abnormalities when compared to injectable techniques. Inhalation anesthesia has been used repeatedly in pregnant animals and neonates without apparent adverse effect. Disadvantages include cost of equipment, training, and general lack of portability. Inhalation anesthetics also have several adverse physiological effects, most notably dose-dependent cardiopulmonary depression. Endotracheal intubation provides a secure airway, reduces the chances of aspiration, and allows controlled ventilation. All bats are induced with a mask placed over the face, and attached to a non-rebreathing anesthetic system (Ayre's T-piece). Isoflurane concentration is initially 5%, and oxygen flow rate 2 liters/min. The bats usually relax in 1 to 2 minutes and the concentration is reduced to 2% for maintenance. For intubation, the bat is placed in dorsal recumbency, and the mouth opened using gauze placed around the top and bottom jaws. The tongue is pulled forward using either a Q-tip or gauze square. A laryngoscope with small straight blade is used to visualize the glottis, 0.05 ml 2% lidocaine is placed directly on the glottis, and an uncuffed endotracheal tube (2 - 3 mm ID) is passed through the glottis, larynx and into the trachea and tied in place. The endotracheal tube is premeasured from the tip of the nose to the thoracic inlet to prevent introduction into a single bronchus. The endotracheal tube is connected to the Ayre's T-piece for maintenance anesthesia. To maintain warmth during a procedure, the animal is placed on a water blanket and wrapped. Heart rate and rhythm, and pulse strength is monitored with a Dopper flow probe placed either over an ulnar or tibial artery. An opthalmic ointment is placed in the eyes to prevent drying.

Habitat use for foraging *Myotis lucifugus*: A comparison between bats of different age and reproductive classes

Matthew J. Heller, Albright College, Reading, PA

Bats from a natural maternity colony of *Myotis lucifugus* were studied during the summer of 1993. The colony resides in a covered bridge spanning the Tulpehocken Creek in Reading, PA. By use of light-tagging, the foraging behavior and habitat use of the bats was observed. The study was designed to compare the foraging activity of bats of different age and reproductive classes. A total of 60 bats were tagged, including seven pregnant females, 16 lactating/post partum females, 9-nonreproductive females and 28 juveniles (12 males and 16 females). Although most of the foraging activity of all bats was observed in the edge habitat along the creek, the data were also analyzed to distinguish behavioral differences between bats of different age and reproductive classes.

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A comparison of histochemical and myosin electrophoretic properties in the flight muscles of phyllostomid bats

John W. Hermanson, William A. Schutt, Jr., Matthew A. Cobb, Jacquelyn L. Petrie, and James M. Ryan, Cornell University, Ithaca, NY, and Hobart and Smith Colleges, Geneva, NY

We identified a novel histochemical fiber type that correlated with a specific myosin heavy chain isoform in the pectoralis muscle of *Artibeus lituratus* and *Carollia perspicillata*. This fiber type myosin isoform called type II3, was also described in *Desmodus rotundus* (Hermanson et al., 1993, J. Morphol., in press), a species considered by some to be in a sister group of the phyllostomids. Further assessment of other phyllostomids including *Artibeus jamaicensis, Phyllostomus hastatus, Vampyrops, helleri*, and *Glossophaga soricina* suggested that this character is widespread within the family. Thus, regardless of flight specialization exhibited by a particular species, the IIe character was retained. The absence of this character in flight muscles we examined from species representing other families including Vespertilionidae and Molossidae argues for the value of this character in a phylogenetic analysis of bats. Further, the IIe fiber type/isoform has not been described in other mammalian muscles studies. Morphological and biochemical specializations seen in other muscles are not necessarily useful phylogenetic characters. Although such characters might be of interest in interpreting functional attributes of specific muscles, they likely represent apomorphies. Some examples include muscle-based specialization in some of the forearm muscles used in bats capable of hovering as opposed to species that employ direct, forward flight only.

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Sugar preference by phyllostomid nectarivorous bats and its relation to nectar sugar composition of bat-adapted flowers

L. Gerardo Herrera, University of Miami, Coral Gables, FL

Most of the flowers visited by phyllostomid bats produce nectar dominated by the hexoses glucose and fructose and with low proportions of sucrose. It has been hypothesized that phyllostomids prefer the sugars that predominate in their food plants and that this behavior could be an evolutionary force influencing current patterns in the composition of nectar sugar. Preference for sugars that predominate in the nectar they imbibe has been demonstrated for a handful of insects and birds but not for bats. In this study I examine the question: Do nectarivorous bats prefer glucose, fructose and a mixture of both hexoses over the disaccharide sucrose? I offered individuals of *Anoura geoffroyi* pairwise choices among equicaloric sugar solutions in order to answer this question. My results indicate that the bats do discriminate among the different sugars but not in the way expected. They preferred sucrose over glucose, fructose, and the hexose mixture. This would argue against the role of nectarivorous bats in molding the nectar sugar composition of the flowers they visit. Further experiments with other species of nectarivorous bats are needed to substantiate and interpret these findings.

Habitat use and species distribution of bats in the Mica Wildlife Compensation Area, Columbia River Valley, BC: Preliminary results and future proposals

Susan L Holroyd, University of Calgary, Calgary, AB and
Pandion Ecological Consulting Ltd., Ymir, BC, Canada

Preliminary results from an on-going study of the bats of the Columbia River Valley will be presented. The purpose of the project is to map the distribution and abundance of the bat species of the Columbia River Valley in B.C. Critical habitat for both foraging and roosting is to be identified with the ultimate goal of conserving and maintaining stable populations of the species present in the wildlife area. Activity from sampling with bat-detectors in representative biogeoclimatic zones, as well as, data from netting efforts will be presented. Eight species were either captured or detected with *Myotis lucifugus, M. evotis* and *M. septentrionalis* being the three most common species captured (the latter is considered a red-listed species in the province which designates it as endangered or threatened). Year two will involve a more intensive study of the natural roost habitat and will focus on wildlife trees as potential roosting sites.

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Food habits of yellow-shouldered bats *Sturnira lilium* in Northwestern Argentina

Carlos A. Iudica, University of Florida, Gainesville, FL

Data on food habits of *Sturnira lilium* in South America are scarce and incomplete. Analysis of feces showed yellow-shouldered bat to consume a varied diet over five-month period. A total of 11 items (10 plant species and insect parts) constitute its diverse diet. Solanaceae species accounts for almost 60% of its food. *Solanum riparium* was the most frequent item. Despite the fact that *Sturnira lilium* in northwestern Argentina may function as an opportunistic fruit feeder, its diet items are all second-growth species. This confirms its important role on the first stages of forest regrowth.

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Flexible foraging behavior and slug eating in the pallid bat *Antrozous pallidus*.

David Johnston, York University, Toronto, ON, Canada

The process of changing conditions and the capacity to respond to them recurs throughout evolutionary biology. It is becoming increasingly clear that flexibility is an important aspect of the behavioral phenotype of many animals (Caro and Bateson 1986). Although Bell (1982) described certain foraging flexibility in pallid bats *Antrozous pallidus* in the field, and Gaudet (1982) tested for some aspects of flexible foraging behavior in a flight room for this species, there has been little empirical work on the evolutionary basis for flexible foraging behavior. I tested for the degree of foraging flexibility of individual pallid bats to help determine if populations from areas with predictable prey are less flexible than populations from areas with less predictable prey. My preliminary work suggests that there are differences in individual's foraging flexibility as well as dietary preferences in individuals in the field from the same population. This data suggests that there may be an advantage to a population to have indiv iduals with various degrees of flexibility. One captive individual preferred slugs to meal worms. There may be a method to quantify flexible foraging behavior in bats and other vertebrates.

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Bimodal echolocation and speciation in bats

Gareth Jones, University of Bristol, Bristol, UK

Britain's most common bat, the pipistrelle *P. pipistrellus*, exists as two phonic types. One type echolocates with a peak frequency close to 46 kHz, the other close to 55 kHz. Maternity roosts consist of bats which use only one type of echolocation, and the two types occur in sympatry over much of Britain. Significant differences occur in the flight morphology of the two types, but these differences appear to be small compared with the large differences in echolocation (Jones & Parijs 1993). Are the two types cryptic

species, and if so, how did they evolve? Bimodal echolocation is found in other species, and differences in echolocation may translate into differences in prey size selection by competing species. Recent work on differences in social calls (used in mate attraction by males) of the two phonic types of pipistrelles will be introduced, together with some molecular techniques being used by E. M. Barratt, P. A. Racey, and G. Jones to elucidate the cryptic species problem. The evolution of differences in bat echolocation will be contrasted with the evolution of song differences in sibling species of birds, where runaway sexual selection is probably more important.

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Factors influencing the temporal clustering of individuals during the emergence of little brown bats *Myotis lucifugus*

Matina C. Kalcounis, University of Regina, Regina, SK, Canada

When bats emerge from their roosts in the evening to forage and drink, it appears as though the rate at which they leave is not regular, but involves rapid outbursts of bats interspersed with periods during which few bats emerge. It has been suggested that the temporal clustering of individuals may have an anti-predator function or may be the result of large numbers of individuals trying to pass through a small exit hole. Thirty four observations of emergences were made from May to August, 1992 and 1993, in Cypress Hills, Saskatchewan, Canada. To test the two main hypotheses on clustering behaviour, a model predator was placed outside a maternity colony of little brown bats (*Myotis lucifugus*). A plastic Great Horned Owl (*Bubo virginianus*) was used as the model predator and mounted close to roost exits. Recorded calls of the Great Horned Owl were played back toward the roost. Placing the model predator outside the colony did not affect the number of bats that emerged, the median time that the bats emerged, or the degree of clustering in the emergence. There was a significant positive relationship between the extent of clustering and the number of bats that emerged. Generally, emergences of greater than 25 bats were clustered. Thus, clustering is likely the result of many individuals trying to pass through a narrow space, in a short period of time, rather than an anti-predator strategy.

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Bat-plant interactions: how frugivorous leaf-nosed bats find their food

Elisabeth K. V. Kalko and Martha Condon
National Museum of Natural History, Washington, D.C. and University of Maryland, Baltimore, MD

Leaf-nosed bats (Microchiroptera: Phyllostomidae) form the largest group of bats in the Neotropics. They are unparalleled in their choices of foods, ranging from insects, and small vertebrates to fruit, nectar, and pollen. Although all phyllostomids are able to echolocate, for most species the relative roles played by echolocation and other sensory cues such as olfaction, vision, and passive hearing during foraging is not well understood. I compare feeding and echolocation behavior in *Artibeus jamaicensis* feeding on fig fruits (Moraceae) and *Phyllostomus hastatus* feeding on Gurania fruits (Cucurbitaceae). In behavioral experiments, I tested which cues are used by the bats to detect the fruits. The results reveal striking differences between the two species. *Artibeus jamaicensis* depends on olfactory cues whereas *Phyllostomus hastatus* relies mainly on form-recognition mediated by echolocation. The differences in detection mode reflect morphological and physiological characteristics of the plants involved. In my talk I discuss possible evolutionary consequences of these adaptations for interactions between the bats and their food.

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Tent Construction by the Short-nosed Fruit Bat *Cynopterus sphinx.*

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Boston University, Boston, MA and St. John's College, Tirunlveli, India

The short-nosed fruit bat *Cynopterus sphinx* constructs shelters by chewing the stems of vines and the branches of trees, creating inverted enclosures(stem tents) in which to roost. Our observations indicate that tent construction and roost maintenance in *C. sphinx* is an exclusive male behavior. Stem tents are

functionally similar to, but differ from, leaf tents in that they are constructed when a bat severs and drops small stems to create an inverted enclosure. During the day we observed individuals and small groups of *C. sphinx* roosting in shelters constructed in the vine-like shrub *Veronia scandens* and in the ornamental tree *Polyalthia longifolia*. Each tent was either occupied by one male, or by one male and from 2 to 19 females and their young: at night tents were occupied exclusively by males. Tents in *V. scandens* are formed when up to 300 small to moderate-size stems are severed. Tents in *Polyalthia* are formed when up to three medium-sized branches, and several small branches and leaf petioles are severed forming a roost cavity and an opening through which bats can readily enter and depart from the enclosure. Tents constructed in *V. scandens* are completed in about 30 days, whereas those in *A. longifolia* are completed in approximately 50 days. Most tent construction takes place at night although some stem chewing was observed in late afternoon. Night-time activities associated with tent construction are sometimes difficult to separate from feeding activities since males typically forage near the harem roost and return to consume the fruit. At other times during the night tent construction occurs intermittently with periods of rest. On some nights males do not engage in tent construction, but instead they appear to spend considerable amounts of time salivating on branches within their tent perhaps as a form of scent marking behavior.

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An enzyme linked immunosorbant assay for detection of rabies specific IgG in bats

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The aim of this project is to develop an assay for the detection of blood-borne indicators of rabies infection and to obtain some basic information on the course of the bat immune response. We have developed an enzyme linked immunosorbant assay (ELISA) for the detection of rabies-specific G class antibodies. We vaccinated individual *Artebius jamaicensis, Eptesicus fuscus* and *Mus sp*. for comparative studies. We inoculated all animals (IM) with liquid inactivated rabies virus (PM strain) suspension diluted to a minimal NIH potency value. Primary and secondary vaccinations were accomplished with varying schedules for the different animal groups. Blood samples were collected at regular intervals and analyzed by ELISA and denaturing SDS-PAGE. In summary, results indicate that bat primary immune response to rabies vaccination includes the appearance of IgM before IgG. A secondary antigenic challenge in a typical immune response appears more quickly, persists longer, attains a higher titer and consists primarily of IgG. *Eptesicus* developed a measurable immune IgG response following primary antigenic challenge within 26 days while the only measurable response in *Artebius* occurred 82 days post vaccination. Some *Eptesicus* had measurable IgG before vaccination and IgM levels were nondetectable during the primary response. This work was supported in part by a grant from the Howard Hughes Medical Institute.

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Foraging patterns of *Myotis grisescens* in Jessamine Creek Gorge, Kentucky

Michael J. Lacki and Laura G. Shoemaker, University of Kentucky, Lexington, KY

As part of a monitoring program to assess responses to the eventual construction and operation of a sludge treatment facility in the Jessamine Creek watershed, baseline data on foraging patterns of gray bats (*Myotis grisescens*) were obtained by setting mist nets in May, June, July, and August, 1993, along Jessamine Creek, Kentucky, Nets were set at four locations on the creek, both upstream and downstream from two caves historically used as maternity sites by gray bats. Emergence counts indicated that only one cave was used as a maternity site in 1993; however, the other cave was occupied by gray bats in August. Gray bats were the most frequently captured species at all net sites in all months and were the only species of *Myotis* captured. The age and sex class of gray bats captured shifted among months, with adult females most common in May, volant young in July, and adult males and volant young in August. Capture success was lowest in June and is attributed to reduced flight activity in lactating females. The preponderance of volant young netted in July can be explained by the close proximity of Jessamine Creek to the maternity cave; however, the absence of adults from mist net captures along the creek in July suggests a

shift in foraging area by adult females to reduce competition with newly volant young.

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Saving energy by flying: the economy of echolocation in flight

Winston C. Lancaster, University of North Carolina, Chapel Hill, NC

πEcholocating bats produce the energy that they use to image their environment. The production of intense vocalizations would seem to require a significant expenditure of energy. Speakman and Racey (1991, Nature *350*:421-423), however, could not account for any additional energetic cost in a flying, echolocating bat over non-echolocating bats or birds. I have studied the means by which flying bats power biosonar vocalizations and respiration and present morphological and physiological data that suggest how respiration and locomotion may function synergistically to power intense vocalizations at little or not cost beyond that required for flight alone. Electromyographic activity was recorded from the respiratory and flight muscles of seven *Pteronotus parnellii parnellii* from Jamaica. Signals were telemetered during flight with a small FM transmitter modified to summate the low frequency myopotentials with audio signals from an electret microphone. Vocalizations were used as the parameter by which all muscle activities were correlated. A discrete burst of activity in the lateral abdominal wall muscles accompanied each vocalization. Vocalizations and the abdominal muscle activity that accompanied them coincided with myopotentials of the pectoralis and serratus ventralis muscles. Diaphragmatic myopotentials occurred between groups of calls and did not coincide with activity of the pectoralis or abdominal wall, or with vocalizations. Production of pressure for intense vocalization requires force to stabilize the thorax and compress the abdomen. Coincidence of abdominal wall activity for the generation of individual pulses and pectoralis activity allows for the co-utilization of power for flight and echolocation. To achieve the compression of air necessary for vocalization, resting bats expend energy to resist expansion of the thorax during abdominal compression. The force required to resist paradoxical abdominal expansion may account for the energetic cost of echolocation in stationary bats. USPHS grant DC00114 to O. W. Henson, Jr. support this work.

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Evaporative water loss during arousals from hibernation in *Myotis lucifugus*

Hélene Lauziere and Don Thomas, Université de Sherbrooke, Sherbrook, PQ, Canada

Hibernating bats may be subject to slight but cumulative dehydration through cutaneous and pulmonary evaporative water loss (EWL). However, it is during arousals that bats should theoretically face the most severe water stress. As body temperature (Tb) rises exponentially during arousal, increasing water vapour pressure at the tissue surfaces must generate high rates of EWL. This would be further aggravated by enhanced pulmonary ventilation rates. Measures of EWL during arousals indicates that *M. Lucifugus* lost only about 29 mg water. However, during this same period the combustion of fats liberates about 28 mg water. Thus, bats appear to balance their water budget during arousals. Further studies are underway to determine whether bats can recover metabolic water after arousing and so pay off a hibernation water deficit without drinking.

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Development of individually specific sonar emissions in the big brown bat, *Eptesicus fuscus*

W. Mitch Masters and Kelley Raver, Ohio State University, Columbus, OH

While the sonar signals of big brown bats are generally similar, each bat appears to use a slightly different signal. Development of these "personal" signals is likely influenced by both genetic and environmental factors, but the relative contribution of each is presently unknown. The adventitious birth of a number of bats in our lab prompted us to compare the calls of mothers and offspring. We recorded approximately 60 echolocation calls from each of 26 bats (six adult mother bats and ten pairs of offspring, one pair from each mother plus four additional pairs). From these calls we constructed three distance matrices by pair-wise comparisons among bats. (In such a matrix the larger the value at, say, the inter-

-section of row A and column B, the more dissimilar are the data for bats A and B.) The first matrix measured the distance in multi-dimensional space between the vector for bat A and that for bat B, where vectors were derived from a bat's average emission characteristics (e.g.,, mean starting and ending frequency, mean duration, etc.). The second matrix was the reciprocal (to obtain a distance matrix rather than a similarity matrix) of the average cross-correlation amplitude between six randomly chosen emissions of bat A and six of bat B. The third matrix was the average width, in milliseconds, of the cross-correlations between bats A and B. These three matrices were correlated with matrices coding group membership (adult vs offspring, related vs unrelated, etc.) using Mantel's randomization procedure. An association was found between all distance matrices and adult vs offspring status; therefore, in subsequent comparisons only offspring were randomized in order to remove the effect of age. Related bats (mother-offspring pairs and sibling pairs) were more similar than unrelated bats. In addition both mother-offspring pairs and sibling pairs were more similar within pairs than were random bats. These last findings are all consistent with genetic interpretations, since mother-offspring and siblings share on average 50% of their genes. Surprisingly, however, mother-offspring pairs were more significantly associated ($P \leq 0.01$ using the cross-correlation matrix) than were sibling pairs $P \leq 0.07$)--the reverse of expectations if similarity of early environment promotes similarity of sonar signals. A possible explanation for this finding is that siblings adjust their calls to enhance their distinctiveness, perhaps to facilitate recognition of their own echoes.

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Resource use by terrestrial vertebrates on oceanic islands

Brian K. McNab, University of Florida, Gainesville, FL

Many terrestrial vertebrates are found on oceanic islands, the equilibrial number of species determined by the distance of the island from a source and by the area of the island. Here I describe some of the properties of species that have had a long-term survival on oceanic islands. Long-term survival is enhanced by large population numbers, so a reduction in individual resource use is selected because all species are limited by the resources available on an island. The island species most likely to face a resource limitation are those that high individual requirements, namely those that are large. Individual resource requirements, as measured in terms of energy expenditure, are reduced in various ways, including 1) a reduction in body size (e.g., in rails, ducks, pteropodids, and rodents), 2) the evolution of flightlessness (rails, kiwis, and Galapagos cormorant), 3) a reduction in flight activity (note the close approachability to many island birds), 4) a direct "island effect" (pigeons, pteropodids, and rodents), and 5) a shift form endothermy to ectothermy (replacement of endotherms by tortoises, and iguanid and varanid lizards). Isolated oceanic island faunas, then, are characterized by small, inactive endotherms, large flightless birds, and by large ectotherms.

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Bat community diversity and composition in a Mexican tropical fainforest

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Little has been done to document how bats use disturbed habitatsd. We report our preliminary results studying the diversity and community composition of bats in a variety of successional stages and land use patterns in Chiapas, Mexico. Five habitats are being studied: rainforest, cacao plantation, old (>15 years) old-fields, young (<10 years) old-fields, and active cornfields. The cumulative curve of species richness indicates a total of 32 species represented by 1,094 bats so far (six months into fieldwork). Four species represent 65% of all bats captured. the richest habitat is the rainforest with 23 species. Next is the cacao plantation with 17 species, next the old old-field with 15 species, and the young old-field and milpa both with 14 species. Number of bats is highest in cacao plantations and lowest in the young old-field, whereas it is rather stable in rainforest, old field, and active cornfield. Species exclusively found in the rainforest include carnivores and other large species, as well as a few insectivores/gleaners and frugivores. Diversity seems to co-vary with habitat complexity as indicated by vegetation measures (vegetation layers and tree height diversity), as well as with vascular plant species richness.

Effects of sex steroids on sexual behavior in the big brown bat, *Eptesicus fuscus*: preliminary results

M.T. Mendonca, J.S. Dawson, K.E. Nester, G.L. Gardner, Auburn University, AL

Vespertillionid bats exhibit a dissociated pattern of reproduction. Sexual activity occurs in fall and upon arousal from torpor when, in males, testes are regressed and testosterone levels are basal. Females have mature follicles by fall but estrogen levels are basal until spring. The low levels of sex steroids during mating suggest that sexual behavior is independent of sex steroids and more dependent on direct environmental cues. Male and female big brown were collected in Butler, Co., AL in September, 1992 for a preliminary study to determine if mating activity is truly dissociated from sex steroid levels. They were placed and maintained in a flight cage in Auburn, AL. Most animals were not manipulated (INTACT). A subsample of these animals were gonadectomized (GON-X) shortly after capture. A subsample of the GON-X males were given a silastic capsule filled with testosterone (GON-X+T). Mating activity was observed in January and February, 1993 both within the flight cage and in staged behavior tests in aquaria. For males placed in the staged tests, there was no significant difference in frequency of individuals mating among the INTACT, GON-X and GON-X+T groups. In the flight cage observations, INTACT males mated more frequently than either of the treated male groups. In contrast, the frequency of GON-X females mating was significantly higher than INTACT females in staged tests. Additionally, there was no significant difference in mating frequency between GON-X and INTACT females for the flight cage observations. These preliminary results indicate that sexual behavior appears to be independent of circulating sex steroid levels and that both males and females appear to have a truly dissociated pattern of reproduction.

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Host exploitation by vampire bats and screwworm flies in Guanacaste, Costa Rica

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The common vampire bat *Desmodus rotundus* and the screwworm fly *Cochliomyia hominivorax* are both considered pests by the livestock industry in Latin America. Although evolutionarily distant, both species have evolved a dependence upon warm-blooded vertebrates as prey. I examined relationships between these two species, focusing on the use of vampire bite wounds as oviposition sites by screwworm flies. Screwworm maggots develop in the living flesh of warm-blooded hosts (myiasis). This, and the feeding habits of vampire bats, led me to hypothesize that areas with high incidence of vampire predation would have relatively high rates of screwworm infestations. I surveyed damage to cattle by both species at 19 farms in Guanacaste Province, Costa Rica, between May 1992 and May 1993. At seven of those farms, a weekly inspection of a random sample of animals allowed me to estimate proportions of all wound types present on cattle, and thus available to screwworm flies. The survey yielded 8589 records of vampire bites, 4.18% of which were infested by screwworms. The inspections yielded 1468 records of wounds from 2310 animals inspected; 709 of those wounds(48.3%)were vampire bites, and only 2.31% of vampire bites had screwworms. Despite these low infestation rates, vampire bites were important as oviposition sites for flies. In the survey data, 336 of 869 (38.67%)cases of myiasis occurred in vampire bites, while in the inspection data, 16 of 49 (32.65%)cases of myiasis occurred in vampire bites. Log-linear analyses of multidimensional contigency tables from each of the two data sets, broken down into four climatic regions, indicate that the occurrence of screwworm infestation is generally independent of wound type, as well as of the breed, age and gender of the host animal.

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Is Doppler shift a cue for fluttering target discrimnation in the FM bat *Eptesicus fuscus?*

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In a recent psychophysical laboratory experiment (Sum and Menne, 1988. J. Comp. Physiol., 163:349)FM bats *Pipistrellus stenopterus* showed remarkable ability to discriminate between rotational velocities of rotor blades with acuity comparable to CF bats tested in a similar experiment. Given the differences in echolocation emission structure between CF and FM bats (e.g. duty cycles of 50% versus 3%), it is likely these bats use different processing strategies to discriminate fluttering targets. Two possible cues that were available to the FM bats are (1) spectral notches and peaks due to interaction between echoes from stationary objects and the echo from the moving rotor, and (2) degree of Doppler shift (frequency shift) of the echo from the moving rotor relative to stationary echoes. It is possible that the mechanism by which FM bats detect rotor velocities (and perhaps fluttering prey as well)involves one or a both of these cues. The experiment proposed here will examine the processing strategy of flutter discrimination in the FM bat *Eptesicus fuscus* by uncoupling the above cues. Reference and test signals will be passively presented to the bats in a Yes/No psychophysical paradigm according to a pseudorandom schedule. The bat's task will be to determine whether the signal alternates from presentation to presentation within a trial (answer "Yes")or is constant ("No"). In the first part of the experiment, pure tone stimuli will be used, and the threshold of frequency discrimination at 40kHz (the region of peak energy of the fundamental) will be determined. In the second part, a model echo based on the bat's own emission will be used. The varying signal will consist of the model alternating with a Doppler shifted version of the model. Because the bats will receive only one signal at a time, rather than a signal composed of multiple echoes, the spectral interference cues available in Sum and Menne's experiment will not be available here. Thus, this paradigm allows us to measure a bat's sensitivity to frequency changes uncoupled from cues arising by spectral interference.

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The pollination biology of *Oroxylum indicum* in India

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The coevolution of plants and their pollinators is a central theme in the study of animal-plant interactions. Yet, there are few examples where the coevolution between a plant and its pollinator is so tight as to exclude any other organism from that interaction. One such often cited example of bat-plant interactions is the pollination of *Oroxylum indicum* by the dawn bat, *Eonycteris spelaea*. In Malaysia this bat is the sole pollinator even when other nectarivorous bats are present, and it is thought that the flowers have evolved a shape and flowering schedule to suit *Eonycteris*. This present study examined the pollination biology of *Oroxylum* in western India where the dawn bat is not known to exist. A population of *Oroxylum* trees was observed and bats visiting these trees were caught with mist nets. The pollen from the bat's fur were then collected and identified. All three common fruit bats found in that area, *Pteropus giganteus, Rousettus leschenaulti,* and *Cynopterus sphinx*, had pollen of *Oroxylum* on their fur suggesting that they were effectively pollinating this plant species. Thus, while patterns of tight coevolution may appear to be common in one locality, such as the site in Malaysia, they do not necessarily hold true elsewhere. It is unlikely for a plant species like *Oroxylum*, which has such a vast distribution, to be dependent upon a single bat species for all its pollination throughout its range. Insufficient competition from other bat species or effective exclusion by *Eonycteris* may explain the tight coevolution in Malaysia. Further work in areas in India where *Oroxylum* is sympatric with *Eonycteris* and the common bats, will help explain whether this plant always has multiple pollinators or if *Eonycteris* is capable of excluding other bats from this resource.

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Bat conservation education program for Northern Mexico

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In 1991, I completed a study to determine the current status of Mexican free-tailed bat roosts (*Tadarida brasiliensis*)by censusing known important caves in Northern Mexico. This study found that five of ten

caves examined had bat population declines of 90% due to vandalism and deliberate destruction. In response to these findings, an education campaign was designed and implemented in communities surrounding the five most affected caves. The campaign consisted of oral presentations accompanied by Bat Conservation International's audiovisual program, "Los Murcielagos de America Latina." Programs were given to more than 3500 people in 58 educational and government institutions, conservation associations and state and federal agencies related to natural resources and/or the ranching and agricultural industries. Forty B.C.I. audiovisual programs and 1000 vampire bat control brochures ("Murcielagos Latinoamericanos y la Identificacion y Control del Murcielago Vampiro Comun") were donated. Articles about the importance of bats were written and appeared in four important Mexican newspapers. Finally, as a result of the education campaign, La Mula cave and Quintero cave, both in Tamaulipas, are now in the process of being protected by the state government.

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Observations on feeding behavior in the white-winged vampire bat, *Diaemus youngii*

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and WIlliam A. Shutt, Jr., Cornell University, Ithaca, NY

The island of Trinidad is home to two of the three extant vampire bat genera, the common vampire bat, *Desmodus rotundus* , and the white-winged vampire, *Diaemus youngii* . Trinidad has an active rabies control program, part of which involves the reduction of vampire bat populations. Recently, observations have been made by rabies control units and researchers, on both wild and captive specimens of *Diaemus* , which help to broaden our knowledge of these rarely studied bats. Several aspects of feeding behavior in *Diaemus* were examined and are reported here, they include: feeding location, time and duration; the influence of moonlight; prebite positioning and preparation; the bite; and bat/bird interactions. Where possible these observations are contrasted with what is known about similar behavior in *Desmodus*.

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Update on Colorado's bats/inactive mines project

Kirk W. Navo, Judy Sheppard, and Tom Ingersall
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Colorado's rich mining history has resulted in more than 20,000 inactive or abandoned mines scattered throughout much of the state. While the Colorado Division of Minerals and Geology (DMG) is currently closing these mines to safeguard them for the public, they may provide important roosting habitat for some of Colorado's 17 species of bats. The Colorado Division of Wildlife, in cooperation with DMG, had initiated a volunteer-based project in an attempt to survey these mines to identify significant bat roosting habitat prior to closure. Significant roost sites are recommended for bat gate closures to protect roosting habitat that would otherwise be permanently lost. Volunteers have been recruited, trained and then assigned to specific mines sites to survey them using bat detectors and visual observations outside the mine entrance. Over 550 people have signed up for the project to date, and 382 of them have completed the required four-hour training session required to participate in field work. Many of them are return volunteers from past seasons. Over 195 people have participated in survey efforts during the first two years of the project, and in 1992 compiled 2159 volunteer hours. These volunteer hours have resulted in a savings to the agency of at least $17,500.

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Bat gate designs for *Plecotus townsendii* at abandoned mines in Colorado

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As part of an ongoing cooperative project involving the survey and protection of mines for bats, the Colorado Division of Wildlife is gating and monitoring some mines that have been scheduled for closure. As mines are determined to be used by *Plecotus* as roost sites, they are recommended to the Division of Minerals and Geology to receive a bat gate as the preferred closure method. Due to a lack of funding and a

concern for public safety, experimental gate designs have been used at some roosts. These experimental designs, called "windows", were installed and then monitored by return visits and infra-red monitors/counters to determine the acceptance of gate design to Plecotus and other species of bats. To date, nine window gates have been installed, Preliminary results indicate that bats do not abandon mines after installation of a window gate, and return to use the same roost the following year. Eight species have been documented using the window design gate, but current data is inadequate to evaluate any potential changes in populations using these mines. Surveys of one site indicate that a nursery colony of Plecotus did not change the year after gate installation, and may have increased slightly. Monitoring of these sites is continuing to verify the acceptance of the window at various types of roosts, as well as for other species.

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Factors controlling reproduction in female big brown bats, *Eptesicus fuscus*

Kerry E. Nester, Auburn University, Alabama.

It is hypothesized that big brown bats display a dissociated pattern of reproduction. This pattern occurs when gamete maturation, sex steroid production, and gonadal growth are asynchronous from reproductive behavior. It has been documented that in vespertillionid bats, late summer and early autumn are the periods when estrous and mating behavior occur. The bats then enter hibernation, during which bats may experience periodic arousal and copulations. The female reproductive tract stores the sperm until ovulation followed by fertilization and implantation occurs in the spring. This has been conformed for bats in a northern region, but there is, as yet, no information on southern populations, where winter temperatures do not fall as low as those in the north. This study will document the annual cycle of circulating estrogen and progesterone and examine how these levels correlate to annual changes in ovarian and uterine morphology and mating behavior of female big brown bats, *Eptesicus fuscus*. Data has been taken to monitor the gonadal cycle and sex steroid level changes in three populations: two wild populations and a captive colony taken from one of the wild populations. Monthly blood samples have been collected from individuals within each of the three populations, and the blood plasma will then be analyzed for sex steroid levels. The entire captive colony (consisting of both male and female bats) is maintained as naturally as possible, and through the use of video equipment, reproductive behavior is monitored. This paper will include the analysis of ovarian and uterine histology to determine changes the females' estrous and uterine cycle and vaginal swabs for sperm to establish time of mating.

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Monophyletic or diphyletic origin of bats as inferred by DNA-DNA hybridization

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Traditionally, bats have been considered monophyletic based primarily on the contention that flight in bats evolved only once. In recent years, the monophyletic origin of bats has been questioned after finding that megabats have an advanced primate visual pathway from eye to midbrain. The monophyletic -diphyletic origin of bats remains a major controversy in the current literature. The primary objective of this project was to determine the phylogenetic relationships among megabats, microbats, lower primates, insectivores, and edentates by DNA-DNA hybridization. DNA from representatives of these five taxa was extracted, purified, fragmented, single copy DNA separated from repetitive DNA, radiolabeled with I^{125}, and hybridized. Complete thermal elutions were collected from 30 homologous and 163 heterologous hybrids and estimates of genetic divergence among taxa were obtained from the normalized percent of hybridization (NPH) and the difference in median melting temperature (delta T_m) between homologous and heterologous hybrids. Matrices were corrected for nonreciprocity by ten correction cycles (Springer, 1988) before being analyzed. Independent "trimmed" mean values were bootstrapped to generate pseudoreplicate average-distance matrices by resampling the original data with replacement. Phylogenetic relationships were estimated for each pseudoreplicate matrix using the least-squares pair algorithm. Estimating genetic divergence from delta Tm values appeared more sensitive to variations in the complexities of the single-copy genome among the species than estimates from 100-NPH values.Normalized percent of hybridization

estimates are not as sensitive to genome complexities and provided a better method for the analysis of the data in this DNA-DNA hybridization study. A monophyletic origin of bats and the placement of primates as sister taxa to bats are supported by DNA-DNA hybridization. These results imply that the primate visual pathway shared by megabats and primates probably evolved once in the lineage leading to the primates and bats but was subsequently lost in the lineage leading to the microbats as this group evolved echolocation to orient themselves. Flight, with all the anatomical and physiological adaptations, seems to have evolved only once in the lineage leading to the bats after the primates diverged form their ancestor.

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Body Temperature, Rectal Temperature, Skin Temperature and Behavioral Thermoregulatory Response in the *Pteropus hypomelanus*.

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The thermoregulatory ability of the small island flying fox, *Pteropus hypomelanus* was investigated throughout different ambient temperatures (T_a). Five *Pteropus hypomelanus* (two males and three females) were fitted with intraperitoneal and skin temperature transmitters to record body temperature (T_b) and skin temperature (T_s). Rectal temperatures (T_r) were also obtained at selected T_a. Only readings taken after the first half hour were used for analysis. In addition, a total of 100 hours was devoted to perform scan samples of behavior, every 10 min., 12 hours a day. The data obtained indicate that, like other pteropodid bats, *Pteropus hypomelanus* is able to maintain a constant T_b when exposed to T_a ranging between -3.4°C and 37.4°C. However, a significant relationship was found between T_r and T_a ($p<0.01$), and this relation was influenced by body size. Also, T_r was always lower than T_b, and this difference increased when T_a decreased (1.9°C at 37.4°C T_a to 3.8°C at 8.7°C). T_s was strongly related with T_a ($p<0.001$) and not with T_b, suggesting that the animals actively regulated T_s . The behavioral data show that this species regulates heat exchange with the environment by changing the amount of body surface exposed to it. Above 30°C T_a, and when $T_s - T_a$ approaches 0, a dramatic increase in the percentage of wing exposure and wing fanning was observed (from 5% to 40%). Furthermore, when $T_s - T_a < 0$, the animals began licking their wings. The results suggest that the large and naked wing skin surface has a clear adaptive advantage to cope with the high temperatures that these animals face in the wild.

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Faces and tails: external morphology as a guide to relationships among phyllostomid bats

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In recent years numerous attempts have been made to resolve phylogenetic relationships among the 50 extant genera of phyllostomid bats. Data used to address this problem have included immunological distances, protein electrophoresis, G-banded chromosomes, hyoid and lingual morphology, morphology of the female reproductive tract, and rDNA restriction sites. Although several cladistic analyses of discrete character data have been conducted, all were based on limited subsets of data and some have included a *priori* assumptions about monophyly of various groups. As a result, many aspects of phyllostomid phylogeny remain unresolved and monophyly of several subfamilial taxa has yet to be adequately tested. In the present study we describe two new data sets: facial morphology (including noseleaf, lips, and chin papillae) and tail morphology (including caudal vertebrae, uropatagium and calcar). Over 30 characters from these regions appear to be phylogenetically significant. As in previous studies, phylogenetic analyses of face and tail characters provide only limited resolution of phyllostomid relationships. However, we obtained very different results when we combined these data with published character sets (e.g., hyoid and reproductive tract characters, rDNA restriction sites). Analysis of the combined data set provides good resolution of phyllostomid relationships at several levels and permits evaluation of the status of currently recognized subfamilial groupings. Monophyly of many groups is supported, with the exception of Phyllostominae, Phyllostomini, Vampyrinae, and Carollinae, none of

which appears to be monophyletic. Low resolution of stenodermatine interrelationships and the basal branching pattern of phyllostomids remain persistent problems in phyllostomid systematics. This research was support in part by NSF grant BSR-9106868.

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Life under bridges: night roosting patterns of bats in the Willamette National Forest

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Bridges are commonly used as night roosts by several species of bats in the Willamette National Forest in Oregon. Ambient and bridge chamber temperatures along with occupancy rates were monitored at four bridges used as night roost between July 7 and August 22. Initial results indicate that occupancy rates may be influenced by both daytime and nighttime ambient temperatures. These concrete bridges act as "heat sinks" and their occupancy rate appears to increase on those evenings when daytime temperatures are higher and these structures absorb large amounts of solar radiation. Six species including *M. volans, M. lucifugus, M. californicus, M. evotis, Eptesicus fuscus* and *Plecotus tonsendii* were observed using these night roosts with Myotic *volans* being significantly more common than the other five species. Peak occupancy rates occurred around 0300 hr. with a progressive increase in number of individuals per cluster as the night progressed. Preliminary observations indicate that male. *Plecotus townsendii* arrive early at these night roost but leave as other species of bats begin to congregate at the bridges. Initial experiments with different colors of fluorescent powders may prove to be useful as a "passive" marking system for monitoring movements of bats from one night roost to another.

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The role of Pteropodids in oceanic island ecosystems of the Pacific

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Evaluating the ecological and evolutionary role of pteropodids in oceanic island ecosystems is a challenging task because of the extensive and continuing alteration these communities have experienced. The popular preception, present even in the Western scientific community of South Pacific islands are relatively pristine ecosystems with man living in harmony with nature is at odds with mounting evidence of extensive avifaunal extinctions following arrival of the Polynesians. The differential loss of large birds including canopy and forest floor frugivores suggests that where pteropodids persist in these partly defaunated islands, their ecologic role has changed both quantitatively and qualitatively in the last few thousand years. Concurrent with the extinctions were extensive aboriginal introductions of fruiting trees, some of which are now exploited and dispersed by birds and bats. Superimposed on these earlier changes are the effects of post European vertebrate introductions, guns, altered land tenure, agricultural methods and urbanization. We attempt to evaluate the role of pteropodids both past and present by three approaches: 1) direct observations of foraging behavior for two flying fox species in Samoa; 2) comparison of two ecosystems--one with viable populations of flying foxes (Samoa), and one that has effectively lost its flying fox populations through overhunting and commercial exploitation (Guam); and 3) a biogeographical analysis examining the distribution of island flying foxes, other dispersers and selected food plants. Each approach has obvious limits, but offers some basis for inference. We suggest that current rainforest vegetation persistence pivots on a very limited array of generalized pollinators and seed dispersers and that islands in the latitudes with high typhoon frequency and thus heavy natural disturbance regimes will have vegetative communities with are closer to equilibrium with the current pollinator/seed disperser assemblage.

Bats in Riverine forests and woodland: A transect through the Kruger National Park

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Using two 100' x 20' macro-mistnets per locality, the bat diversities at night within riparian forests and in dry woodlands > 3 km from the nearest river, were compared for a period of three nights each along the three main river systems of the Kruger National Park, situated in the easter Transvaal lowveld of the Rupublic of South Africa. Mistnet data were augmented with regular bat detector sweeps of ultrasonic bat calls. Data on bat abundance within respective habitats and between river systems were correlated with insect abundance and related to landscape complexity.

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Dry matter intake and body weight of captive adult male fruit bats *Artibeus jamaicensis* fed isocaloric diets of differing protein content

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The fruit bat *Artibeus jamaicensis* naturally consumes a diet low in protein and relatively high in energy content. The objective of this study was to determine the level of crude protein(CP) necessary to maintain body weight in a group of 39 adult male fruit bats. Five diet treatments, similar in energy content (CV= 3.33%), but varying in CP were fed. The percent CP for each diet was: diet 1 = 1.30%, diet 2 = 3.7% , diet 3 = 4.9%, diet 4 = 6.20%, and diet 5 = 7.20%. Average body weight did not differ among treatment, with respective means of : diet 1 = 37.42 ± 6.63 g, diet 2 = 38.11 ± 6.74 g, diet 3 = 37.62 ± 6.74 g, diet 4 = 38.86 ± 6.96 g, diet 5= 38.76 ± 6.78 g. Average daily energy intake per bat decreased with a higher protein content in the diet with respective means of: diet 1 = 124.33 kJ, diet 2 = 87.43 kJ, diet 3 = 82.42 kJ, diet 4 = 70.52 kJ, and diet 5 = 62.59 kJ. Average daily dry matter intake per bat also decreased with a higher protein content in the diet with respective means of : diet 1 = 8.61 g, diet 2 = 5.63 g, diet 3 = 5.38 g, diet 4 = 4.48 g, and diet 5 = 4.03 g. Average daily protein intake per bat increased with a higher protein content in the diet with respective means of: diet 1 = 0.11 g, diet 2 = 0.14 g, diet 3 = 0.27 g, diet 4 = 0.28 g and diet 5 = 0.29 g. Therefore since body weight did not very throughout the study but dry matter intake and energy intake varied inversely with the protein content of the diet, it appears these bats may have adjusted their food intake in order to meet protein needs.

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The use of modular artificial roosts in the conservation and management of a *Myotis lucifugus* colony in central Massachusetts

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The dismantling of a blacksmith barn in Paxton, Massachusetts in the winter of 1991 eliminated a maternity roost that has been occupied by a colony of *Myotis lucifugus* for up to 130 years. To mitigate the anticipated loss of this roost, a shed was built in the summer of 1990 near the barn site to act as an alternative roost. Roosting surface was increased in the shed by the construction of six modular artificial roosts placed in the roof arch. Data collected during the summer of 1993 suggest that these bats have been utilizing these modular units. Data was also collected to determine population size estimates and the environmental parameters affecting emergence time in this population. This data was subsequently compared to similar data collected before the barn was dismantled to determine whether any population behaviors have predictably changed as a result of the modular roosts. Successful occupancy of the modular artificial roosts suggest their potential in both the conservation of other bat populations whose present roosts are threatened, as well as the management of bat populations in locations where the containment of the bats in pre-determined areas of a large roost could be offered in lieu of their extermination.

Bat rabies and human mortality in the United States

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The recent bat rabies-related death of an 11-year old girl in Sullivan county, New York, with no clear history of animal bite exposure, has prompted an examination of the role of bats in the epidemiology of human rabies mortality. With the recognition in 1953 of insectivorous bats as a rabies reservoir, an average of some 500 cases per year (e.g. 647 reports in 1992) have been diagnosed by public health laboratories throughout the United States. During a surveillance period from 1950 to 1993, bats were implicated in 20 (12%) of the 170 human deaths from rabies. Through the development of molecular typing methods, it is now possible to characterize more carefully 13 of these 20 related cases, for which material is available. Antigenic and genetic analysis of these isolates identified a virus variant associated with silver-haired bats *Lasionycteris noctivagans,* in 11 of the 13 human cases; *Lasiurus borealis* and *Tadarida brasiliensis* were implicated in the other two cases. These findings are presented within the context of generating discussion towards potential explanations for the association of this virus variant and bat species with human rabies. Prior to this study, silver-haired bats were considered unimportant as rabies reservoirs, responsible for < 1 % of reported cases. Regarding prevention and control, bat researchers should emphasize rabies pre-exposure vaccination, with the need for booster doses dependent upon risk assessments of the continuing level of exposure at least every two years: bats should be excluded from human dwelling areas by environmentally-sound methods.

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Rivers as foraging habitats in NE Scotland: effects of treelessness and urbanization

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Thirty 100 m sections of the rivers Dee, Don and Ythan in northeast Scotland were monitored with a bat detector for 15 minutes each during June - August 1993. In addition ten lakes or ponds, 32 woodland plots(each 0.5 ha) and twelve open(farmland) plots(0.5 ha), 100 to 1,000 m away from the rivers were monitored in the same way. The Dee sections(n=14) were located along a relatively well-wooded river valley. The Don sections(n=3) were located in Seaton Park in urban Aberdeen. The Ythan sections(n=13) were located in virtually treeless farmland. *Pipistrellus pipistrellus* and *Myotis daubentonii* were concentrated along the rivers(observed foraging in 100% and 80% of the river sections respectively). In contrast, *Plecotus auritus* was only found among trees in the Dee river valley. There was no difference in frequency of occurrence or abundance of *P. pipistrellus* or *M. daubentonii* between the three rivers or between wooded and treeless sections along the rivers. Hence there is no indication that treelessness or urbanization affects the distribution of these two species along the rivers. *Plecotus auritus,* in contrast, seem to depend on woodlands.

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A technique for the safe removal of bats from abandoned water wells

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A method was devised using an umbrella equipped with two control cords and two hardened edges to successfully and safely remove active and torpid bats from cased wells. Modification to the umbrella included removal of the lock-latch used to maintain the umbrella in the open position, and covering or removing the tips of fabric support struts to prevent snagging the roughened areas of the well casing. The umbrella was lowered in a collapsed position, positioned beneath the bat(s) and partially opened. Opening was accomplished by pulling on a central cord which allowed the umbrella to expand to the inside diameter of the well. The second cord, attached to one of the fabric support struts, allowed for partial rotation of the umbrella until a hardened edge, composed of custom-cut plastic with the outside edge covered with several

layers of duct tape, was positioned beneath the bat(s). The central cord was used to raise and maintain horizontal stability of the umbrella. The hardened edge would slide between the bat(s) and the well-wall, effectively sealing off downward escape possibilities and forcing active bats to fly towards the surface where they were captured using hand nets. Bats in torpor would be lifted away from the wall and fall into the catch basin created by the soft umbrella material and transported to the surface. To date, no bats have been injured as a result of employing this method.

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Roosting and foraging ecology of *Rhinolophus hipposideros*, the lesser horseshoe bat and implications for habitat conservation and management

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Rhinolophus hipposideros, the lesser horseshoe bat, is one of the most endangered members of the European bat fauna. Efforts to conserve it have centered on the protection of its summer and winter roosts. However, it also makes extensive use of night rrosts, but little is known of their role, particularly in relation to its reproductive phenology. In addition, the habitat requirements of this species have not yet been fully evaluated, despite the fact that protection and conservation of foraging areas is an important component of any management strategy. In this study, I investigated the roosting ecology of *R. hipposideros* over a twelve month period, and attempted to relate the patterns of roost use to its reproductive phenology. Linked to this was an investigation of its foraging behavior and habitat use. The main aim of the study was to gather data for the implementation of a program of habitat protection around key colonies. The maternity, night roosts, and hibernacula of one colony in North Wales were monitored regularly over a twelve month period, and the number of bats or signs of bat activity were recorded both day and night. An infra-red television system was used to monitor the activity of the main maternity colony. Using remote bat detectors and a dectector linked to a right-sight, foraging behavior and habitat use of the species was recorded. A theoretical model is suggested to explain the use this species makes of the available habitat. The study has emphasized the importance not only of continuous landscape features between roosts and foraging areas, but also the importance of the structure of those features. Bats forage and commute along continuous landscape features such as outgorwn hedgerows, and riparian trees. These features link together blocks of broadleaf woodland which form the principal foraging area for the species. This study underlines the importance of maintaining not only the principal maternity and hibernation roosts of a colony, but also right roosts and small satellite roosts around the main maternity site. In addition, protection should be given to linear landscape features in the rea surrounding maternity roosts and where necessary active conservation measures should be undertaken to instate new features or to improve the structure of existing ones.

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Aspects of locomotor morphology, performance, and behavior in two vampire bats: *Desmodus rotundus* and *Diaemus youngii*

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Vampire bats exhibit complex terrestrial locomotion. For example, although many bat species are known to take flight from the ground, the common vampire, *Desmodus rotundus*, is the only species reported to initiate flight by jumping vertically. In addition to getting the bat airborne, jumping allows *Desmodus* to avoid being trampled by the large terrestrial mammals upon which it feeds. Locomotor morphology in *Desmodus* was first studied by Altenbach(1979). Jumps are effected by powerful adduction of the brachii, extension of the elbows, and flexion of the elongated thumbs. In this study, a specially designed force platform was constructed to measure the vertical, horizontal, and mediolateral components of the ground reaction forces generated during jumping behavior in *Desmodus*. Signals acquired as the test animals jumped from the platform surface were digitized, displayed and synchronized with high-speed motion picture recordings. The magnitude and distributions of force components generated during flight initiating jumps in *Desmodus* are reported for the first time. The white-winged vampire, *Diaemus youngii*, was also tested. *Diaemus* is arboreal in its feeding behavior, preying primarily upon birds. In our study,

Diaemus was found to be a stealthy and agile climber but when locomoting on the ground did not exhibit the speed and agility observed in *Desmodus*. *Diaemus* did not undertake flight initiating jumps. As a group, vampire bats have evolved specializations for agile terrestrial locomotion and efficient flight. The potential for competition between vampire genera is reduced through specializations related to selection of either mammalian or avian prey. Thus, the differences in limb morphology (e.g. the thumb), locomotor performance(e.g. jumping) and behavior (terrestrial vs. arboreal feeding) between *Desmodus* and *Diaemus*, are related to principal prey selection.

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Proximate, caloric, nitrogen and mineral composition of bodies of some tropical bats

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Proximate(live mass, water, lipid, ash, non-fat organic) caloric, nitrogen, and mineral(sodium, potassium, calcium, magnesium and iron) contents of bodies of 24 species of tropical bats were determined. Although quite variable, fat and total organic content decrease and water content increases (g/100 g live mass) with increasing body size expressed in dry mass(DM). Although body fat levels in tropical bats are routinely lower than in temperate species, a few species, e.g. *Chiroderma villosum*, especially females, show much higher fat concentrations than other tropical species. Except for iron, where no relationship exists, concentrations(mg/g DM) increase with increasing DM for all other measured elements. Comparing total body content as functions of DM in small birds, bats, and other small mammals, sodium levels in large bats are higher than in other mammals, which are higher than in similar-sized birds; magnesium and calcium increase most rapidly in very large bats but are otherwise similar in all three groups; total body potassium is lower in birds than in similar-sized bats and other mammals; and, total body iron content in both birds and bats is higher than in non-bat mammals of similar size. Mineral compositions, therefore do not consistently align bats with other (tetrapodal) mammals or flying endotherms.

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Selection of lepidopteran prey by *Plecotus townsendii virginianus* in the Daniel Boone National Forest of Kentucky

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Black-light traps were used to determine the availability of lepidopteran prey to *P.t.virginianus* in five habitats in Daniel Boone National Forest, Kentucky: above cliff, below cliff, young timber(>30 years of age),older timber(>30 years of age), and clearings. Rock shelters in sandstone cliffs, used as night roosts by *P.t.virginianus*, were surveyed for culled moth wings to assess consumption. Samples were obtained in June, July and August, 1992. A total of 3,707 moths were identified from light trap samples and 222 wings were recovered from rock shelters. Moths of the family Arctiidae were most abundant, representing 37.5% of the total moths available, but no member of this family was consumed. Noctuid moths made up 12.2% of the available prey and comprised 62.6% of the moths consumed. Moth availability changed across seasons: however, consumption patterns remained consistent with members of the families Geometridae, Noctuidae, Notodontidae and Sphingidae representing the majority of moths consumed. There was no significant difference found across habitats for the mean numbers of moth families available($p= 0.40$), mean number of moth species available($p= 0.56$), or the number of available moths($p=0.38$).

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Functional Aspects of patterns in the emergence of pipistrelle bats leaving maternity colonies

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Many species of bats emerge from nursery roost in a manner which is not random. However, quantifying the extent to which the emergence differs from random is complicated by the underlying

variation in the intensity of the emergence. We have recently devised an empirical method which overcomes these analytical difficulties, and confirmed that the emergence behaviour is clumped. Using this approach allows us to examine the functional nature of the clumped pattern of bat emergence. Several different functional hypotheses have been proposed to explain the clumped structure of bat emergence. First, emergences may be afunctional and reflect many animals moving through a restricted space - the so-called bottleneck effect. Second, bats may clump together because they subsequently feed together and synchronising emergence allows them to synchronize their subsequent behaviour. Third, the bats may clump together as a 'selfish' anti-predator mechanism. We monitored the emergence behaviour of bats from two large roosts of pipistrelle bats containing between 450 and 900 bats during the summers of 1991 and 1993, using a laptop computer to log emergence times. Both of these colonies were selected from a wide range of available colonies because they had two primary exit holes, with bats from one hole crossing the face of the second hole. If the clumping in the emergence was a consequence of a bottleneck we might anticipate no interaction between bats from the two holes would be apparent. However, if bats are following each other, or behaving as a selfish herd, we might expect emergence events at the first hole would trigger events at the second hole. Analysis indicated that such influence was indeed occurring at booth roosts indicating the effect is not a bottleneck artifact. If predation was the key driving force behind this phenomenon then we might anticipate a difference between the extent of clumping between the first half and second half of the night, when it is darker and hence there was less risk of predation. Data in this respect were more equivocal.

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Preliminary time budget and observations on behavior of the little golden mantled fruit bat *Pteropus pumilus* in captivity

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Observations made during the summer on a captive group of *Pteropus pumilus* consisting of six males, seven females and three juveniles, gave us a time budget estimate on several behavioral categories. Our observations were made over a 72 hour period during the 12 hours between dusk and dawn. We used marking devices as well as night vision equipment to observe these bats at night. Activities that we looked at were flying fighting feeding autogrooming, allogrooming and crawling. During out time budget observations we noted several other behaviors that are candidates for further study. These behaviors include territorial establishment of males as well as choice of territories by females, night and day roost choices, wing display behavior, and harem formation.

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The presence and habitat use of bats in the White Mountain National Forest

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Little is known of the presence and habitat use of bats in the White Mountain National Forest, NH. Knowledge of their distribution and ecology is necessary to understand how timber management techniques affect bats. Of the nine species of bats found historically in New Hampshire, one is listed as endangered and three as species of concern. Bat detectors (Anabat, Titley Electronics, Australia) were used to survey the relative abundance and feeding activity of bat species at two foliage heights in four age-classes of northern hardwood and spruce/fir forest stands. The effect of elevation on relative species presence, the association of bats with trails and water bodies, and the presence of flying insects in each forest type was also investigated. Mist nets and a harp trap were used to compliment the detector surveys. The calls of captured bats were recorded to develop species-specific echolocation signatures appropriate to the Anabat system. Initial data indicate that bat activity was highest in over-mature hardwood stands (36%) and group cuts in spruce/fir (30%), whilst activity was similar in all other forest types ($x = 12\%$). Within a forest stand activity was uniform, except at trail and water body edges where it was three times greater. Of the five species of bats trapped, 77% of individuals were *Myotis lucifugus.* Only adult males were captured prior to 25 July 1992, the subsequent capture-rate of sexes was equal (37% juvenile).

Endangered bat populations in West Virginia caves Gated or fenced to reduce human disturbance

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During the last 12 years, chain-link fences or round bar or angle-iron gates were constructed at the entrances of 10 West Virginia caves to protect populations of federally endangered bats. These cave are hibernacula for *Myotis sodalis* (2 gated; 4 fenced) and /or *Plecotus townsendii virginianus* (4 fenced). Six caves harbor summer colonies of *P. t. virginianus* (3 gated; 3 fenced). All *M. sodalis* populations increased after the caves were protected; total number of *M. sodalis* increased from 1,615 to 6,297 bats(289.9%). Two caves have exceeded historic (pre-1965) levels; one cave although exhibiting an increase, presently houses only 6% of the historic number. Populations of *P. t. virginianus* in 4 hibernacula increased following fencing, showing an overall increase from 3,455 to 7,491 individuals (116.8%); one cave with "occasional winter use" contained 643 bats 4 years after a fence was constructed. These increases in the numbers of hibernating bats appear to be due to reduced human disturbance, however, other factors may have contributed to the increase at one cave. Summer colonies of *P. t. virginianus* seem to have adapted well to gates and fences, and populations remained stable or increased when the bats were not disturbed. Two case histories demonstrate the impacts of human disturbance. During the 3-year period following fencing, one maternity colony of *P. t. virginianus* increased from 739 to 1,137 bats. The fence was then vandalized and the cave entered illegally; the colony numbered only 286 individuals the following summer. Four years later, the population had increased to only 39.9% of the pre-vandalism total. Another *P. t. virginianus* maternity colony in a gated cave increased 124% over the 8-year period following gating (from 225 to 560 adults). After illegal human entry into the cave in 1993, the population fell to 168 bats, the lowest count for this colony since 1983. Angle-iron gates, because they are probably the most difficult to breach, appear to offer the best protection where such gates are feasible.

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A model of bat hibernation energetics

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For the last three years I have monitored the activity and mass of a colony of free-ranging *Eptesicus fuscus* during hibernation, in an attempt to build an energy budget model. Three categories of behavior were used (torpor, arousal and activity). Activity is defined as the bat exiting the roost. The amount of energy devoted to each of these behaviors was determined using the mass as an indicator of energy. The timing and frequency of activity of individual bats was monitored using transponders. There was no significant difference between the number of activities in males and females in either year ($F = 0.00056$, $p>0.05$, $F = 0.261$, $p>0.05$). Mass was monitored using an electronic balance positioned at the single exit point. This provided mass changes in individual bats both within and between activities as well as over the course of the season. Mass declined over the season but there were small stair-step increases during activities indicating that bats are either feeding or drinking. Two sacrificed bats contained no food in their gastrointestinal tract although they had been gaining mass during activities. This suggests that they are drinking to maintain their water balance. The energy budget thus included a dehydration variable. The energy budgets were done separately for two years. They included the variables of starting mass, cost of torpor, cost of arousal and activity, individual bat variation, and mass loss due to dehydration. All these variables were significant in 1991-92 ($p<0.05$) but only starting mass, cost of torpor, and individual bat variation were significant in the second. They both conclude that torpor is the main energy drain.

A survey of organochlorine pesticide contamination in the bats of Eckerd James River Cave in Texas

Monte Thies, Sam Houston State University, Huntsville, TX

Insectivorous bats play an extremely important role in maintaining a balance in ecological systems by serving as biological controllers of insect populations. However, in recent years, severe declines in the numbers of bats have been observed. Much of this observed decline has been attributed to the destruction of habitat and exposure to agricultural chemicals. The exposure and toxic effects of organochlorine pesticides have been well documented for only a handful of bat species, with most of the research efforts focusing on the population of Mexican free-tailed bats *Tadarida brasiliensis* at Carlsbad Caverns, New Mexico. This population, which demonstrates the highest level of organochlorine pesticide contamination of any species or population examined to date, has suffered a decline in numbers from 8.7 million in the 1930's to about 200,000 in 1974. Very few data are available on the exposure of other bat species to agricultural chemicals. This study begins an extensive survey of current pesticide contamination in the bats of Texas by examining a colony of 4 to 6 million free-tailed bats and 20,000 cave myotis *Myotis velifer* at Eckerd James River Cave in Mason County. Because both species occupy similar ecological niches but differ in that the free-tailed bats are long range migrators wintering in Central America and Mexico whereas cave myotis remain in the southern U.S., this study will provide valuable information about sources of pesticide contamination. Data collected in this study serve as a beginning of a long-term survey of the bats of Texas, the primary objectives being to identify species, populations, and geographic areas which may be at risk to pesticide contamination, and to provide a foundation for maintaining the health and diversity of Texas' bat fauna.

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Cytogenetic aberrancy and organochlorine pesticide accumulation in the Mexican free-tailed bat: a comparison between Oklahoma and New Mexico populations

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The summer population of Mexican free-tailed bats *Tadarida brasiliensis* at Carlsbad Caverns, New Mexico, has declined from 8.7 million in 1936 to 200,000 in 1974. This decline, which has been attributed to organochlorine(OC) pesticide contamination and habitat disturbance, has also been observed in other populations as well as other species of insectivorous bats. This study examines the potential chronic genetic effects of OC pesticide contamination on two populations of free-tailed bats. Pesticide accumulation, frequencies of chromosomal aberrancy, and nuclear DNA content variation were monitored in specimens collected from Carlsbad Caverns and Vickery Cave, a colony in northwestern Oklahoma, during the summers of 1990 and 1991. Pesticide residues in brain and carcass tissues were identified and quantified using electron capture gas chromatography. Chromosomal aberrancy was examined using standard bone marrow chromosomal aberration assay, and nuclear DNA content variation was measured in spleen and testicular tissues using flow cytometry. Relationships among pesticide content, observed chromosomal aberrancy, and nuclear DNA content variation were examined for statistical differences and possible correlations. Both populations demonstrated significant levels of OC contamination; however, the Carlsbad Caverns population showed consistantly higher pesticide loads. Males also demonstrated higher levels as compared to females. No statistical differences in chromosomal aberrancy or nuclear DNA content variation were observed among sexes, sites, or collection periods. No correlations among OC contamination and the genetic assays performed in this study were found

Continuous radio-telemetry of body temperatures of hibernating Myotis lucifugus: initiation, timing and duration of arousals

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Arousals account for over 75% of winter fat depletion in hibernating bats, so understanding their underlying causes and organization is central to any analysis of winter energy balance. To examine the organization of arousals, I placed temperature-sensitive radio tags on 18 hibernating *Myotis lucifugus* and followed surface temperatures(T_s) over a 30 - 43 day period. Bats aroused during all times of the day, with 48% of arousal occurring in the 0h00-12h00 period and 52% occurring between 12h00 and 24h00. The first post-handling torpor bout (5.1 days) was shorter than the subsequent bouts (ca. 13 days). In all cases where torpor bouts lasted less than 7 days, arousal was preceded by a steady drift of T_s from ambient temperature(T_a=4.5°C) to approximately 2.5° C above T_a. Rewarming took a mean of 1.6 h and bats remained active for about 1.8 h. Re-entry into torpor required 1.4 h and was preceded by 0-8 test drops in T_s. On re-entry into torpor, T_s was reset at T_a. Subsequently, T_s either drifted upward, resulting in a short torpor bout, or remained stable at T_a, resulting in an extended torpor bout. These results confirm the absence of a "biological alarm clock" in *M. lucifugus* and raise questions about the control of metabolism and heat production in torpor.

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Bat Conservation International progress report

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

During the past year, Bat Conservation International greatly increased its support of conservation - relevant graduate student research, assisting projects in eight countries. Most funded studies involved bat feeding behavior and habitat needs. Three of North America's most important bat hibernation sites were protected. Significant progress was made in protecting the bats at Bracken Cave, and the lease to establish a national park for flying foxes in American Samoa was signed. BCI also established a vital partnership with the U. S. Bureau of Land management to conserve bats on the 270 million acres of public lands administered by the BLM. Protection for bats living in caves and abandoned mines and special training for BLM wildlife managers already have been mandated. A 5,000 square foot interactive exhibit about bats with BBH Exhibits was completed and will reach millions of people in North America, Asia and Europe. Our special education campaign in Mexico has reached hundreds of thousands of people and has gained nature reserve protection for two important overwintering caves for U. S. free-tailed bats. We recently completed a Spanish-language training film on vampire control which will be used throughout Latin America. A major study of 420 bat house owners in 26 states was completed, and BCI 's North American Bat House Research Project was established. Bat house use averaged 52 % nationwide, and much progress is being made. The greatest threat to American bats is the rapid closure of thousands of abandoned mines without adequate consideration of bats that now often require them as critical habitat.

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Mitigation of impacts to summer habitat of the federally endangered Indiana bat

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In 1991, proposed large scale developments at the Indianapolis International Airport prompted concerns for the federally endangered Indiana bat *Myotis sodalis* at the project site. These concerns were identified in response to mandates of the National Environmental Policy Act of 1969 that ensure legal protection to federally endangered species and their habitat through the Endangered Species Act (1973, as amended). Results of initial studies indicated that the project area provided suitable summer habitat for the species. Later results indicated the presence of a maternity colony of Indiana bats near the impact site. In order for the proposed project to continue lawfully, it was necessary to develop a plan to avoid impacts to individuals and compensate for loss of habitat resulting from project development. To mitigate potential losses resulting from project impacts, provision of resource requirements of the species has been addressed

through the protection and enhancement of existing habitat, and through development, management, and long-term maintenance of newly created habitat. As required by federal regulations, mitigation for impacts to most environmental resources, including federally endangered species, requires that when applicable, compensatory actions prevent net loss of the resource, and be in-kind, on-site, and concurrent with impacts. However, there is little precedence for implementing these requirements for many endangered species; virtually no work of this scope has been undertaken for the Indiana bat. Thus, developments at the Indianapolis Airport have led to investigation of techniques for enhancing, creating, and preserving habitat for this species. A variety of methods are being used to meet project goals; assessment of success through monitoring programs should allow evaluation of the relative value of these techniques.

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Are patterns of diversity and endemism in Pteropids addressed in the design of the nature reserve system in the Philippines?

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and Lawrence R. Heaney, Field Museum of Natural History, Chicago, IL

There are presently 25 species of pteropid fruit bats from the Philippines, 15(60%) of which are endemic to the country. Intensive inventories and elevational transect work in the last decade have tremendously improved current knowledge of their distribution at a biogeographic and local scale. In general, species richness correlates significantly with island area size. Of the 10 non-endemic species, 6(24%) are widespread within the Philippines and in the Indo-Australian region. The other 4, (16%) species are restricted to distribution within the Philippines and are shared with some nearby islands. There are three basic patterns of distribution of the endemic species. Six(24%) are widespread throughout the country, with the exception of Palawan Island. Two(8%) others are restricted to two or more Pleistocene islands, and the remaining seven(20%) are endemic to a single Pleistocene island. These patterns follow a biogeographic distribution defined by Pleistocene sea levels, and coincide with those seen in nonvolant mammals and other vertebrate taxa. As such, provision of an adequately protected park in four of the five major Pleistocene faunal regions, i.e., Greater Luzon, Greater Mindanao, Negros-Panay, and Greater Palawan, would potentially protect 96% of over-all fruit bat diversity, including 93% of the endemic species. An ongoing revamp of the Philippine's park system(i.e., Integrated Protected Areas System Project or IPAS) calls for a strong recognition of both faunal and floral patterns of diversity and endemism in the design and choice of park areas. Unfortunately, the challenges of protecting such a diverse fauna are more complicated. There are clear ecological differences in habitat requirements between endemic and non-endemic species, both in fruit bats and non-volant mammals, that should additionally be considered in the actual design of areas designated for protection. These local patterns of distribution will be described, a brief review of the status of the various species will be presented, and more specific protection needs discussed in light of the IPAS project.

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Why Missouri-style condos have not been used by bats in Minnesota; a qualitive assessment

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Of the 15 known Missouri-style bat house "condos" in Minnesota, only one is utilized by a nursery colony of little brown bats (*Myotis lucifugus*). This condo, located at Detroit Lakes in northwestern Minnesota, was used as a standard against which all other condos were compared to determine which parameters of design, construction or placement might be limiting the attractiveness and suitability of the other condos for use by bats. The design, construction and placement of the unutilized condos were also compared to parameters delineated in BCI's recent publication "The Bat House Builder's Handbook", as important considerations in bat house utilization. In all, 12 parameters were assessed. Incorrect placement of the condos in areas with too much shade or too much vegetation seemed to be the predominant causes for the bats' absence from the condos. This poster illustrates the "proper" and "improper" design components and discusses recommended modification to retrofit the condos and enhance their suitability.

Roosting ecology of bats in the West Arm Demonstration Forest near Nelson, B.C. and the potential effects of forest harvesting practices

Maarten J. Vonhof, University of Calgary, Calgary, AB, Canada

During the summer of 1993, I set out to characterize the trees used by bats as roosts in the West Arm Demonstration Forest, an area of approximately 14.5 thousand hectares in the southern interior of British Columbia. Tree roosting sites were located by either watching trees at dusk for emerging bats or by attaching radio-transmitters and tracking bats to their roosts. Once tree roosting sites had been located, I measured a range of tree and site characteristics. Preliminary results indicate that Silver-haired bats, *Lasionycteris noctivagans*, use both loose bark and old woodpecker cavities as roosting sites, and do not remain in the same roost tree for long periods but rather change roosting sites on a regular basis. Myotis spp. appear to be using loose bark as roosting sites. Preliminary observations indicate that only two species of trees are used as roosts by bats, Western White Pine, *Pinus monticola,* and Western Larch, *Larix occidentalis*, although ten other species of potential roost trees are present. The information collected will be used to develop a set of recommendations regarding the kinds and numbers of trees that should be left untouched during forest harvesting to maintain a healthy population of roost trees.

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The big brown bat, friend of the farmer

John O. Whitaker, Jr., Indiana State University, Terre Haute, IN

Big brown bats are the most common bats in buildings in the midwest. Some of their major foods are cucumber beetles(Chrysomelidae), Junebugs(Scarabaeidae), stinkbugs(Pentatomidae) and leafhoppers (Cicadellidae). The 150 bats of an average midwestern maternity colony readily eat in a season 38,000 cucumber beetles, 16,000 June bugs, 19,000 stinkbugs, and 50,000 leafhoppers. All of these are serious pest species, but cucumber beetles, genus *Diabrotica* , are one of the most serious agricultural insect pests in the United States. The adult beetles attack corn, spinach and various cucurbit vines, but the larvae are the corn rootworms, which annually cost farmers in the United States about one billion dollars annually. Destruction of 38,000 adult cucumber beetles would mean about 18, million rootworms would not have been produced. Adult June bugs defoliate trees, whereas the larvae(grubworms) feed on the roots various plants. Stinkbugs are often pests in orchards and of soybeans. Leafhoppers are pests of many plants. They reduce prouctivity and often serve as vectors of plant diseases. These four items often total nearly 100% of the diet of big brown bats at certain times and places We should protect colonies of big brown bats as natural biological control agents, which are free and safe in contrast to insecticides.

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Hematological and plasma biochemical reference ranges in three species of flying foxes

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Plasma biochemical and hematological reference ranges were determined for three species of flying fox (*Pteropus hypomelanus* , n=65; *P. vampyrus* , n=13 and *P. rodricensis* , n=16).The bats were anesthetized with isoflurane in oxygen. Within 3 minutes blood was collected from the ulnar vein into a heparinized 3 ml syringe with a 25 g needle. After removal of the needle, 0.5 ml of blood was transferred to a lithium heparin microcontainer, placed in crushed ice and submitted for hematological analysis. The remaining 1.0 ml was placed in a 2.0 ml cryotube, and centrifuged at 3,000 rpm for 5 minutes. The plasma was then transferred to a second cryotube, placed in crushed ice and submitted for biochemical analysis. An analysis of variance for nonrepeated measures was used to compare means, and where a significant difference was identified Tukey's post hoc test was used. A P value< 0.05 was considered significant. For each variable the means between species and sexes was compared. Additionally, in *P. hypomelanus* the means for juvenile (> 2yrs) and adults (< 2yrs), and pregnant and non-pregnant adult females were compared. No

significant differences between species were found for the following variables: calcium, aspartate transaminase, hemoglobin, hematocrit, mean cellular hemoglobin, mean cellular hemoglobin concentration, monocytes, eosinophils and basophils. Significant differences between the sexes in *P. hypomelanus* include:carbon dioxide, calcium, cholerserol, globulin, ionized calcium, and mean cellular hemoglobin concentration. In *P. rodricensis* differences due to sex include potassium, creatinine and gamma-glutamyltransferase, while *P. vampyrus* demonstrated differences in glucose, potassium, calcium, albumin, cholesterol and albumin/globulin ratio. In *P. hypomelanus* variables found to be different between adults and juveniles include the following: sodium, potassium , calcium, phosphorus, protein, alkaline phosphatase, bilirubin, globulin, albumin/globulin ratio, ion gap, ionized calcium, white blood cells, red blood cells, hematocrit, mean cellular hemoglobin and mean cellular hemoglobin concentration. Differences between pregnant and non-pregnant adult females were found for the following variables: phosphorus, alkaline phosphatase, alanine transaminase and cholesterol.

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The influence of reproduction on diet and foraging behavior of *Eptesicus fuscus*

Lisa Wilkinson, University of Calgary, Calgary, AB, Canada

To understand the influence of reproductive demands on the diet and foraging behavior of big brown bats(*Eptesicus fuscus*) it is instructive to compare reproductive females to males. For two seasons, in Southeastern Alberta, maternity colonies containing small populations of males have been studied. Both males and females foraged primarily along the river valley, sometimes in excess of 12 km. Male foraging locations were more variable than that of females. One of the most important influences on females may be their high calcium demand, due to the large skeletal size of newly volant pups. Although conventional foraging theory considers energy maximization as the currency for which animals forage, calcium may be an important currency for reproductive female bats. Diets of males and females are being compared by fecal analysis, the preliminary analysis of which indicates that their diets differ. Insects in the diet are being analyzed by atomic absorption spectrophotometry to determine calcium levels. Suction traps are being used to sample available insect fuana in foraging areas, to determine if certain habitats are more profitable for reproductive females. An additional feeding experiment is testing the efficiency with which males and reproductive females digest calcium.

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Roost site selection of the Indiana bat *Myotis sodalis* on the northern edge of its range

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The first Indiana bat(*Myotis sodalis*) maternity colony was discovered in Michigan in 1991. Using radiotracking techniques, we monitored patterns of roost-site selection from 1991 to 1993 with a total of over 150 transmitter-days. During this three-year period, the bats occupied 23 roost trees, all identified as green ash(*Fraxinus pennsylvanica*). Average dbh of the roost trees was 40±1(S.E.) cm. This was significantly greater and significantly less variable than the dbh of non-roost trees. The mean distance from a 1991 to another 1991 roost was 33±10 m. The mean distance from a 1992 roost to another 1992 roost was 45±13 m, and the mean distance from a 1993 roost to another 1993 roost was 37±13 m. Over this three year period, population size varied from 1 to 44 bats.

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House bat maternity colonies in Pennsylvania: bat boxes and management implications

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Myotis lucifugus and *Eptesicus fuscus* rely heavily on buildings as maternity roost sites because of low availability of hollow tree roosts. Maternity colonies that inhabit buildings are threatened by both

extermination and exclusion. Installing suitable alternative roosts, or "bat boxes" near a building roost may limit bat-human conflicts and protect beneficial animals. However, there is no consistent information concerning the efficacy of bat boxes in serving as alternate roosts for displaced colonies. We designed, constructed, and field tested two types of bat boxes. One design was oriented vertically to provide vertical temperature gradients, whereas the other design was oriented horizontally to provide higher more uniform temperatures. Our initial objective in this project was to monitor the thermal characteristics of the bat boxes to determine if either design was superior in providing for the thermoregulatory needs of little brown and big brown bats. Our ultimate objective was to determine the efficacy of bat boxes in housing displaced maternity colonies. We documented differences in the thermal characteristics of the two bat box designs. During the field trials, six maternity colonies were successfully excluded from their attic roosts, and five colonies moved into nearby bat boxes. These findings suggest that bat boxes may be important tools for managing house bat maternity colonies in Pennsylvania.

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Syconycteris australis in Chimbu Province, Papua New Guinea, with notes on other bats of the area

Debra D. Wright, University of Miami, Coral Gables, FL

I looked at bat abundance, movement, and reproduction by mist-netting and banding bats 0 - 8 nights per month from March 1992 to March 1993 in the rainforest surrounding Crater Mountain Biological Research Station in Papua New Guinea. *Syconycteris australis* accounted for 90 % of all captures. Of 129 S australis individuals banded, 37 were recaptured. Five of these recaptures were more than 250 m from their original capture site, the longest being 1 km away. The monthly number of captures per net-hour was positively correlated with rainfall. The study area receives 6-7 m of rain per year and *S. australis* go into torpor when wet and cold. Therefore during rainy months bats may be more active in non-rainy periods (.e.,times I chose to net) thus increasing the probability of capture during these times. Pregnancy, lactation, and juvenile size all indicated aseasonal breeding. Females were never captured carrying nursing young, suggesting they leave them behind at roosts. Juveniles take about two months to grow from newly free-flyng pups to adult size but require another 2-3 months for their epiphyseal plates to close. I netted five other bat species with the modst frequently caotured, *Paranyctimene raptor* accounting for only 6% of total captures. Some range extensions and previously unrecorded months of reproduction were noted.

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Bat use of old-growth redwood hollows: effects of season, tree characteristics and stand location

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Old-growth redwoods, *Sequoia sempervirens,* commonly exhibit basal hollows that may provide roosting habitat for bats. Bat use of hollows was monitored using "guano traps" comprised of semi -permeable membranes suspended inside the hollow. The first phase of the project focused on sampling 26 trees in a narrow, but relatively contiguous, stand of old-growth Bat guano was discovered in each of the 26 hollows (varying from 1.3 g to 10.7 g/month) and guano was found in some hollows during every month of the year. Peak deposition occurred in late May but significant amounts of guano were discovered throughout the winter, suggesting that hollows may be important winter roost sites. Distance of the hollow to a major interstate highway that bisected the area did not influence guano deposition, nor did the dbh of the tree. However, guano weights in trees with large hollow volumes exceeded those of small volume trees and hollows that were closest to permanent water, during summer only, had significantly higher guano weights. The second phase of the work, recently undertaken, compared guano weights, vocalizations and mist-net captures in and around hollows located in either small (<25 ha), isolated stands of old-growth created by timber harvest, or in a large (1,280 ha), contiguous stand. Ninety-nine hollows were sampled; 45 in isolated stands and 54 in the contiguous stand. This work is in progress and the effects of stand size and isolation on use of hollows as roost sites will be summarized.

BAT RESEARCH NEWS

Volume 34 **Winter 1993** **Number 4**

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Front Cover

The cover illustration on this issue is the official logo of the Lubee Foundation, Inc., of Gainesville, Florida, and was made available to us by John Seyjaget, who with Frank Bonoccorso served as our hosts for the symposium.

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