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BAT RESEARCH NEWS

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FRONT COVER

During this silver anniversary year, the **Bat Research News** salutes its founder and first editor, Dr. Wayne H. Davis. Photograph courtesy of University of Kentucky Information Services.

BAT RESEARCH NEWS

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Instructions to Contributors

1. *Bat Research News* is published four times per year, each year consisting of one volume of four numbers. Publication dates, February, May, August, and November. Sometimes the numbers are combined. *Bat Research News* publishes short papers, general notes, etc., which are rigorously edited and reviewed. Manuscripts dealing with original work should be submitted in triplicate following the latest *CBE Style Manual* or following the style used in Journal of Mammalogy. In addition, latest news on bat research, correspondence, book reviews, meeting announcements, reports and recent literature citations are included. Communications concerning all these matters should be addressed to Kunwar Bhatnagar. Reprints of articles can be purchased.

2. Subscriptions to individuals are U.S. $6.00 per year mailed 3rd class to U.S. addressed, 1st class to Canada and Mexico. All other countries, bulk rates unless $1.00 per issue air mail is prepaid.

3. Institutional subscriptions are U.S. $10.00 each world wide

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BAT RESEARCH NEWS

The Silver Anniversary Issue

Volume 25 | 24 February 1984 | No. 1

EDITORIAL

Twenty five years of service to the scientific community involved in bat research is nothing to brag about, yet it is an important milestone in the annals of **Bat Research News**. It began in 1960 as **Bat Banding News**, a brainchild of Wayne Davis in response to a questionnaire he developed for bat banders. The single issue that year contained four pages which carried the well-known names of chiroptologists such as Mohr, Constantine, Cope, Wayne Davis, Glass, Goehring, Griffin, Hitchcock, Mumford, Orr, Sister Talitha, E.W. Smith, Trapido, Myers, John Hall, and Tuttle. Where was I? Around that time I was busy collecting bats in palaces, ruins, and caves in Madhya Pradesh, India, equipped with appropiate defense against tigers and snakes! Twenty five years later, here I am writing my felicitations to the journal which has been my favorite ever since I received it the first time. In contrast then, the November 1983 issue contains 24 printed pages, and publishes only reviewed and rigorously edited articles while the annual subscription for members still remains a paltry $6. One can readily see the enormous growth in **Bat Research News.** It is appropriate to thank the past editors (Davis, Martin, Humphrey, and Fenton), the contributors, and above all our supporters—the subscribers all over the world—for carrying **Bat Research News** to its present healthy state.

Would you not join us in wishing continued success to **Bat Research News**? Send me your sentiments, related anecdotes, and even suitable illustrations for consideration. Any one out there in the wings with good unpublished photographs of the silver-haired bat, *Lasionycteris noctivagans*? It would be highly appropriate if the silver-haired bat adorned at least one of the four silver anniversary issues. I do have suggestions for the golden anniversary covers of **Bat Research News** (see for example, the short-eared trident bat, *Cloeotis percivali* in Fenton and Fullard, *American Scientist*, 1981, and the "golden-haired" bats, *Hipposideros larvatus* and *Hipposideros ruber* in Schober's *Mit Echolot und Ultraschall*, 1983). Alas, that is far in the future! I may not be around for making decisions then, but my fervent wish is that **Bat Research News** be there and be flourishing.

Kunwar Bhatnagar

The Early History of *Bat Research News*.

Wayne H. Davis
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"It seems as if a Bat Banders' News has never yet appeared on this planet. Imagine! How could the world have gotten along for so long without some form of a Bat Banders' News?"

Thus began Volume 1 Number 1 of **Bat Banding News**, Fall 1960, compiled by Wayne H. Davis, Editor, Biology Department, Middlebury College, Middlebury, Vermont. It was mailed to all bat banders in the United States and to a few other individuals in October. With the next issue I started a new volume with the calendar year in January 1961.

The first issue contains article headings of Editor's Column; Band Injuries; Tips on Techniques; Here and There; and Be Careful!!

The first article introduces the new newsletter, talks about banding activities, and tells us there are 38 active banders. Here and There tells about the current research of Merlin Tuttle, Richard Myers, John Hall, Sister M. Talitha, Bryan Glass, Russ Mumford, and H.H. Goehring. Be Careful!! is a short note about rabies.

The second issue contains a directory of bat banders and diagrams of the Myers Net and the Myers Cage. The Editor's Column noted that several non-banders have indicated interest in the News and desire to receive future issues. This trend escalated rapidly and was a factor leading to the change in title to **Bat Research News** with the January 1964 issue.

The introductory paragraph of Volume 5 Number 1 January 1964 gave two reasons for the change of title. "First I am interested in all phases of bat biology..." The second was political. Bat banding sounds too much like nit picking to some people, whereas research sounds important. The Administration at the University of Kentucky had discovered molecular biology and actually used the phrase "nit picking" to refer to those of us who made up the Department of Zoology in 1964. Seem familiar to any of you readers out there today?

My first experience with bats was December 14, 1947 when I was junior in high school. I entered Cornwell Cave near my home in West Virginia and emerged with a pipistrel and an *Eptesicus* which I made into specimens. My next chiropteran adventure was April 3, 1949 when I entered the cave and came out with a couple of dozen *Myotis*. I noticed the sex ratio was heavily skewed to males, a fact which aroused my curiosity. To study the possible differential survival of the sexes I applied for bands and in May of 1950 banded my first bat. Finding that *P. subflavus* had the most skewed sex ratio, I decided to concentrate on that species. This study became my Ph.D thesis and resulted in my papers on the sex ratios of bats (J. Mamm. 40: 16-19, 1959) and on the population dynamics of *P. subflavus* (J. Mamm. 47: 383-396, 1966).

While I was a graduate student at Illinois I banded bats in the caves of Illinois and neighboring states, aided by William Lidicker. When he arrived a couple of years later John Hall joined the bat banding forays. John Winkleman, John Warnock, and Robert E. Lewis sometimes helped. During this time I corresponded with other banders including Russell Mumford, James Cope, Richard Myers (a student of Cope's at Earlham College who was then in graduate school at Missouri) and Donald Griffin. I had met Dr.Griffin in 1949 when he gave a Sigma Xi lecture on bats at West Virginia University. I told him about my findings on sex ratios and he encouraged my banding ambitions.

After a couple of post doctoral years at Minnesota when my banding was restricted to annual visits to my West Virginia pipistrel caves, I got a job in 1959 as instructor at Middlebury College where Dr. Harold Hitchcock was chairman of the Biology Department. Dr. Hitchcock had been a graduate student at Harvard when Griffin, as an undergraduate there, began his bat banding studies on Cape Cod. Hitchcock and I initiated a massive banding project which resulted in our paper on *Myotis lucifugus* in New England (J. Mamm. 46: 296-313, 1965).

While corresponding with several banders during my first year at Middlebury I got the idea of a general newsletter. I wrote to Dr. Richard Manville of the U.S. Fish and Wildlife Service Bat Banding Office and got a list of names and addresses of all active banders. I prepared a questionnaire and sent it to each bander. It asked how many bats they had banded, where they had banded, what species they banded, and what research projects they had underway. I asked if they would be interested in a newsletter about bat banding. Those questionnaires are no longer extant, but as best I can remember the response was 100% and enthusiasm for a newletter was high. Therefore I simply sat down and wrote one, and **Bat Research News**, nee **Bat Banding News**, was born.

Received September 27, 1983

The Palatability of Reconstituted Freeze-Dried Blood when used as a Food Supply for Vampire Bats (*Desmodus rotundus*)

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ABSTRACT—Eighteen vampire bats (*Desmodus rotundus*) were used in a replicated switchback design for three treatments to test the relative consumption (palatability) of (1) Fresh whole defibrinated blood, (2) Reconstituted freeze-dried defibrinated whole blood and (3) Reconstituted freeze-dried defibrinated whole blood with a taste potentiator (5' nucleotide) added. There was no significant difference (P ► .05) in consumption between fresh whole blood (18.7g/bat/day) and reconstituted freeze-dried blood (18.2g/bat/day). There was, however, a significant decrease (P. ◄ .05) in consumption when the taste potentiator (5' nucleotide) was added to the reconstituted freeze-dried blood. The results and their ramifications are discussed in the paper.

In its native habitat, the vampire bat (*Desmodus rotundus*) subsists entirely on blood that it obtains from living animals. This unique characteristic poses a difficult problem in the maintenance of a captive vampire bat colony since few labs have facilities capable of housing a herd of host animals for the bats to feed on, even if the humane aspects of this practice were not considered. The time-honored alternative to host animals is to find a local slaughter house, collect the blood when the animal is slaughtered, defibrinate it by stirring to prevent clotting, pour it into containers and store it under refrigeration until it is fed. Some workers (Wimsatt, 1978) have found that refrigerated fresh blood will retain its palatability for approximately one week. It has been my experience, however, that consumption decreases after only 3 or 4 days. Dickson and Green (1970) have extended this time by adding an anticoagulant (trisodium citrate) to the fresh blood and freezing it. Now, however, we have the problems of storing large quantities of frozen blood and the time-consuming job of thawing it before feeding. It has been demonstrated that both fresh and frozen blood are nutritionally adequate for the maintenance of vampire bats (Wimsatt and Guerriere, 1961; Dickson and Green, 1970; Quintero and Rasweiler, 1974). The problems connected with feeding blood in these forms, however, make it important that a more convenient way of handling the blood ration for vampire bats be developed.

In 1961, Wimsatt and Guerriere successfully maintained vampire bats for several days on freeze-dried blood. They considered it a short-term emergency ration to be used only if the supply of fresh blood was interrupted. Recent advances in freeze-drying, however, should convince us to take another look at freeze-drying as a more convenient way of handling the blood ration for vampire bats. Freeze-drying is the removal of water (dehydration) by sublimation, i.e. water is removed as a vapor from a frozen substance (blood in this case) without passing through the liquid phase. The rapid freezing and low temperature used in this process, together with the lack of a liquid phase, effectively prevent the loss of volatiles and the denaturation of protein (Flink and Karel, 1970; King and Labuza, 1970). Goldblith and Tannenbaum (1966) have shown that the quality of the blood protein, which is the blood constituent metabolized by the vampire bat to the almost complete exclusion of fats and carbohydrates (Breidenstein, 1982), is unaffected by the freeze-drying process resulting in a reconstituted blood ration equal in protein quality and nutritional value to whole fresh blood.

A traditional long-time feeding trial could have been used to test the difference among blood rations in this study; however, it would have required that all treatment groups be balanced as far as age, weight, and sex are concerned. This is im-practical with captured wild bats since ages are unknown, and the numbers of bats required per group for a valid test are generally not available for long-time study. It was therefore decided to use an efficient reversal design where each bat served as its own control. Since reconstituted freeze-dried blood is equal in protein quality and nutritional value to refrigerated whole blood or thawed frozen blood, we have used a switchback design (Lucas, 1956; Gill, 1978) for this study with consumption (palatability) as the test criteria.

Eighteen vampire bats, captured in Mexico, were used in a 21-day, replicated, switchback design to test the relative consumption (palatability) of three rations (Lucas, 1956). Each bat was caged singularly, and since each bat served as its *own control*, there was no need to group the bats according to age, sex, weight, or condition. None of the bats used were pregnant. The switchback design was chosen because of its efficiency in studies using relatively few animals. The three treatments are:

1. Fresh whole blood defibrinated replenished every 3 or 4 days.

2. Reconstituted freeze-dried blood defibrinated whole blood consisting of 22 grams of freeze-dried blood in 100 ml of water.

3. Reconstituted freeze-dried blood defibrinated whole blood plus a taste potentiator (5' nucleotide). Reconstituted the same as ration 2 with the addition of 25 ppm of 5' nucleotide.

Ration 1 is the standard maintenance ration for vampire bats. A taste enhancer (5' nucleotide) was added to ration 3 at the rate of 25 ppm in an attempt to increase the consumption of the reconstituted blood. The three rations are considered nutritionally equivalent.

The results of the test indicate that there was no significant difference in consumption between fresh whole blood (18.7g/bat/day) and reconstituted freeze-dried blood (18.2g/bat/day) suggesting that, since they are nutritionally equivalent, reconstituted freeze-dried blood can be substituted for fresh whole blood as the maintenance ration for vampire bats. It must be pointed out, however, that the total replacement of fresh blood with reconstituted freeze-dried blood for the permanent maintenance of vampire bats should be done with caution until information from long-term maintenance studies using reconstituted freeze-dried blood is available. Apparently the vampire bats did not like the taste of 5' nucleotide since its addition significantly decreased ($P = 0.02$), rather than increased, the consumption of freeze-dried blood (16.2g/bat/-day).

Freeze-dried blood is prepared by commercial dehydrating plants, that are often general purpose plants that freeze-dry solid as well as liquid foods. As a result, they generally quick freeze liquids (blood) in thin layers (pans), granulate and sublimate them by the use of a warm platen. The rapid freezing and low temperature used in the process provide a high quality granulated product that is readily soluable and can be packaged in small, one to two pound plastic jars (one pound of freeze-dried, when reconstituted, yields 75-80 twenty-five gram feedings) and stored under cool (less than 24°C) dry conditions for extended periods of time. Freeze-dried blood, packaged in plastic jars, can be shipped anywhere in the United States providing a particularly convenient source for small facilities keeping only a few bats; or, for that matter, any facility keeping vampire bats that has difficulty in obtaining a supply of fresh blood. To feed, it is necessary to simply open a container of freeze-dried blood, weigh out 22 gms per 100 mls of water, mix, stir (it is readily soluable) and feed. In a recent article on the maintenance of the hairy-legged vampire (*Diphylla ecaudata*) in captivity (Hoyt and Altenbach, 1981), the authors kept a flock of chickens to supply the avian blood required by this species. The use of freeze-dried avian blood would have been much more convenient. Routine feeding procedures would be greatly simplified by using freeze-dried blood that can be reconstituted and dispensed in minutes. In fact, with freeze-dried blood, the entire feeding sequence could be accomplished with automatic dispensers. A vampire bat display could easily be built around such an automated feeding system.

Unfortunately, in spite of its potential as a vampire bat maintenance ration, freeze-dried blood suitable for feeding to vampire bats is not on the market at the present time. The high development costs and relatively low demand for this product make it economically unfeasable for large commercial dehydrating plants to market it. This could all change however, if and/or when long-term feeding studies confirm the potential of freeze-dried blood, and more people turn to this convenient source of food for the maintenance of their vampire bat colonies.

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Causes of Depauperation of the Molossid Fauna in the Indo-Australian Region

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ABSTRACT—The percentages of molossids in the insectivorous bat faunas in Australia, the Indo-Australian region, Africa, and South America were compared. Further, the proportions of *Taphozous* species to molossids in the Indo-Australian region and in Africa were compared. Also, the distribution of *Collocalia* in Australia was taken into account. It is concluded that the competition from *Taphozous* with molossids is significantly stronger in the Indo-Australian region than in Africa. It appears to be the main cause of depauperation of molossid fauna in the Indo-Australian region.

The molossid fauna in the Indo-Australian region accounts for less than 10% of the insectivorous bat species, while corresponding percentages for Africa and South America are 35 to 40% (Fenton, 1975; Freeman, 1981). Fenton (1975) noted that the depauperation molossid fauna coincided with the presence of *Collocalia*, the echolocating swiftlets, since these birds might use echolocation to gain access to the night skies when they could use vision to locate their prey.

I tried to verify Fenton's hypothesis by considering Australia where two species of echolocating *Collocalia* breed along the NE coast of Cape York Peninsula (Slater et al., 1972), about 1% of the area of Australia. Based on Hill (in Corbet and Hill, 1980) and on later corrections (Goodwin, 1979; Kitchener, 1980; Maeda, 1982; McKean and Friend, 1979) one obtains 10% (5:50) as a proportion of molossids to all insectivorous bat species, *Macroderma* included, in Australia. However, because of the small number of molossids there any future change in numbers of species recognized would substantially influence the above percentage. Accepting this percent as trustworthy, Fenton's hypothesis finds some support. According to my calculations, the proportion of molossids to the whole insectivorous bat fauna (the two partly carnivorous megadermatids included) amounts to 6.4% (19:299) in the entire Indo-Australian region (Bergmans and Rozendaal, 1982; Hill, 1980; Hill and Koopman, 1981; Peterson, 1981; Smith and Hill, 1981).

I also calculated proportions for the mainlands of Africa and South America, based on Hill (1980). For Africa, I included the two partly carnivorous bats there (Fenton et al., 1981) and the result has been 20% (34:171) of molossids among insectivorous African bats. In calculating for South America I considered half of the phyllostomids arbitrarily because all of them take mixed diet (Gardner, 1977), but the two noctilionids which also take mixed diet(Howell and Burch, 1974) were included as insectivorous species. The result for South America has been 22.4% (33:147). According to Fenton (1975) the corresponding percentages for these two regions are from 35 to 40%.

As can be seen there is a significant difference between 10% of molossids in the almost swiftletless Australia and those for Africa and South America (20% and 22.4% respectively). This difference suggests at least one additional factor (besides swiftlets) limiting molossids in the Indo-Australian region. It can be the genus *Taphozous* (Emballonuridae). All species of this genus are excellent fliers and together with molossids replace the swifts during the night. However, nothing can be said about competition for food between *Taphozous* and molossids as yet. Although important contributions have been made (Fenton, 1972, 1982), the time and level of hunting of the species concerned are yet to be determined. Stomach analyses are also lacking.

According to Hill (1980) and others cited above there are 14 species of *Taphozous* in the Indo-Australian region (viz., *australis, capito, flaviventris, georgianus, hilli, kapalgensis, longimanus, melanopogon, mixtus, nudiventris, perforatus, pluto, saccolaimus,* and *theobaldi*). Basing of the same sources one finds six species of *Taphozous* (viz., *hamiltoni, hildegardae, mauritianus, nudiventris, peli,* and *perforatus*) in Africa. The above ratio, 14:6, is probably evidence that competition pressure on molossids from *Taphozous* is much stronger in the Indo-Australian region than it is in Africa.

To return to the *Collocalia* hypothesis, its weak points are, (1) even in Australia, where echolocating *Collocalia* are almost absent, the percentage of molossids among insectivorous bats is very low, (2) the possible night feeding in *Collocalia* does not necessarily mean any significant competition with molossids since flight characteristics in *Collocalia* are distinctly different from the swift-like flight of molossids, and (3) night-feeding in *Collocalia* remains to be proven. The alleged competition is greatly diminished by the fact that molossids take substantial quantities of non-flying insects (Vestjens and Hall, 1977), a feat apparently difficult for swiftlets.

I am grateful to Drs. Kunwar Bhatnagar, M.B. Fenton, and K.F. Koopman for their critical comments.

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NEWS AND VIEWS

GIFT OF *BAT RESEARCH NEWS* TO LIBRARIES—Dr. Wayne H. Davis has a good supply of most of the back issues 1960-1970 and will provide as near to complete set as he can *free to any library* upon request. If your library is subscribing to **Bat Research News** now and you want to acquire back issues, please write to Dr. Davis, School of Biological Sciences, University of Kentucky, Lexington, KY 40506 USA.

A NEW NEWSLETTER—BATS, a new newsletter of the Chiroptera Specialist Group, Species Survival Commission, International Union for the Conservation of Nature and Natural Resources, and Bat Conservation International, a group of the Fauna and Flora Preservation Society, has made its debut under the able editorship of Dr. Merlin D. Tuttle, Milwaukee Public Museum, Milwaukee, WI 53233 USA (Tel: 414-278-2775). The 1983 issues consists of four pages, has an article "Can rain forests survive without bats" by Tuttle, interesting news items, a column on books of interest, and several black and white photographs. The format is 216 × 279 mm. The newsletter is expected to be issued on a quarterly basis beginning in 1984 and is supplied at no charge to members. Our welcome and greetings to all concerned with this venture.

NOTICE

The Dorset Bat Cave, also known as the Dorset Cave and Aeolus Cave in Dorset, Vermont, and 150 acres have been given to The Nature Conservancy by its owner, National Gypsum Company.

This cave is a significant bat hibernaculum. Disturbance of hibernating bats can increase winter mortality. The protection of the bats utilizing this cave during the winter months is of foremost importance.

We ask your cooperation in considering the Dorset Bat Cave closed from September 1 through April 30, except by special permission from the Vermont Field Office of The Nature Conservancy.

For further information, please contact:
Marc R. DesMeules, Staff Biologist
Vermont Field Office
The Nature Conservancy
7 Main Street
Montpelier, VT 05602

ANNOUNCEMENT

The **Fifteenth Annual North American Symposium on Bat Research** will meet on October 19 and 20, 1984 (Friday and Saturday) at Rockford College in Rockford, Illinois. Larry Foreman of Rockford College will be in charge of local arrangements and Roy Horst will be in charge of the program.

Rockford College is located approximately 90 miles northwest of Chicago. Dr. Forman will, in due time, provide detailed travel instructions, a description of the housing and dining facilities and other pertinent information. He has arranged for our stay at the campus conference center at very reasonable rates.

You will receive a formal call for papers, preregistration materials and other information from Dr. Horst in early June.

We are especially interested in a series of presentations on the biology of the alimentary canal and on new analytical techniques. If you are interested in organizing either of these, contact Roy Horst at your earliest opportunity.

AUSTRALIAN BAT RESEARCH NEWS—
We are printing the following table of contents for your interest and information.

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ANNOUNCEMENT

The Smithsonian Foreign Currency Program, a national research grants program, offers opportunities for support of research in Burma, Guinea, India, and Pakistan in the following disciplines:
Systematic and Environmental Biology, and Museum Programs.
Grants in the local currencies of the above listed countries are awarded to American Institutions for the research of senior scientists. Collaborative programs involving host country institutions are welcome. Awards are determined on the basis of competitive scholarly review. The deadline for submission is November 1 annually. For further information write the Foreign Currency Program, Office of Fellowships and Grants, Smithsonian Institution, Washington, D.C. 20560, or call (202) 287-3321.

General Fellowship Information

The Smithsonian Institution offers fellowships in residence to support independent research and study in fields which are actively pursued by the various bureaus of the Institution. Individuals are selected competitively and are appointed to work under the guidance of professional staff members and to use the collections and facilities of the Smithsonian. The Institution does not generally support work to be done at other institutions. It does not offer courses nor does it award degrees. The Smithsonian does not discriminate on grounds of race, color, sex, religion, national origin, age or condition of handicap of any applicant.

Six to twelve month pre- and postdoctoral fellowship appointments and ten week graduate student appointments are awarded. Proposals for research in the following areas may be submitted:
Earth Sciences and Paleobiology
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BAT RESEARCH NEWS

VOLUME 25 No. 2 May 1984

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BAT RESEARCH NEWS

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FRONT COVER

Macrotus waterhousii californicus

Collected by Bill Warner and Steve Turza on December 10, 1975 in mine tunnel four miles north of Cave Creek, Arizona and flown to the laboratory of Kunwar Bhatnagar at Louisville, where a colony of seven *Macrotus* (six females and one male) thrived for over two years until sacrificed.

Photographed by Don MacGregor, Coordinator, Biomedical Photography, University of Louisville Health Sciences Center.

BAT RESEARCH NEWS

Volume 25 May 1984 No. 2

Martin Eisentraut - Philosopher, Scientist, and Explorer: A Tribute

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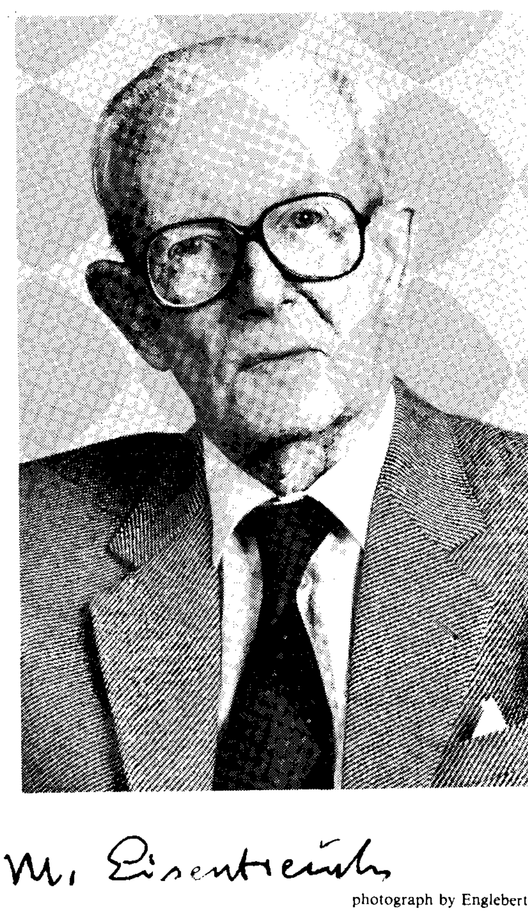
Martin Eisentraut was born in October 1902 in the village Gross-Topfer, Thuringia, very close to the present boundary between West and East Germany, on the Eastern side. Early in his childhood, from his mother, he learned to love and study animals, especially birds. Later in high school, he studied the art of taxidermy. In 1921 he entered the University of Halle/Saale and began studies in Zoology, Botany, and Geology, graduating in 1925 with the degree of Doctor of Philosophy. His thesis research dealt with chromosomes of the Orthoptera, under the guidance of the geneticist, Prof. Valentin Haecker. Shortly after receiving his doctorate he entered the Zoological Museum of Berlin University on the advice of his friend Bernhard Rensch first as a scientific assistant, then in 1939 as curator for the herpetological, and later for the mammalian collection. During World War II, Martin Eisentraut had the good fortune to be appointed to carry out research on malaria and spotted fever control. He lived in West Berlin but the museum where he worked was in the Soviet sector. From June 1948 to May 1949 he had to face difficulties because of the Berlin blockade and subsequently there were problems caused by his living in West Berlin but being paid by the East. So he left Berlin in 1950 and moved to Stuttgart. There he became the chief curator of mammals. In 1957 he was appointed as director of the Zoological Research Institute and Museum Alexander Koenig at Bonn, which he guided until 1977.



photograph by Englebert Schmitz

His first employment at the Berlin Museum was very important for the development of his research interests. The director of this well known German museum at that time, Prof. Carl Zimmer, entrusted him with the development of new concepts for public displays of museum materials. Eisentraut added the exhibit on hibernation in mammals to this concept. He began with a well known European hibernating rodent, the common hamster (*Cricetus cricetus*). Following up this theme in the biological exhibition hall he became aware of hibernation in bats. He was impressed to see the large number of hibernating bats in caves and mine tunnels around Berlin and immediately began asking the question where these animals might go in spring. The idea of bat-banding was born. Eisentraut thus became the "father of bat-banding" in Europe.

Further developments of his research interests were quick to follow. He investigated the thermoregulation and physiology of hibernation in bats including the tropical species. Not only European bats species, but tropical bats also intrigued him in terms of physiological problems,their biology and systematics. Out of his 130 or so scientific papers, 43 are exclusively devoted to bats; many others, however, deal with physiological, faunistical, historical, and zoogeographical questions. Among these papers are several that highlight the economic importance of bats, the experiences of banding experiments, the entire bat faunas (e.g., of Fernando Poo = Bioko), or the contributions to an encyclopedia ("Grzimek's Animal Life"). Of his 10 papers which collectively appeared in a book form, two are devoted exclusively to bats, one being his early and most important work, *Die Deutschen Fledermause, eine biologische Studie*" (The German Bats, a Biological Study, Leipzig, 1937), the other *Aus dem Leben der Fledermause und Flughunde*" (Life of Micro- and Megachiroptera, Jena 1957). Again, in all of his other books, bats played an important role (except in the one on the evolution of Mediterranean lizards) either in terms of physiology of hibernation, or of systematics and faunal history.

One important factor that makes Eisentraut's scientific work so interesting is that for him the word "expedition" had always a most fascinating sound. He had the ability and initiative to organize many great expeditions. The first enterprise was his visit to the Gran Chaco of Bolivia in 1930-31 where he went with his wife - just after getting married. He revisited this region in 1979 and wrote an interesting book in which he made observations on the situation then and 50 years ago, not only on the local flora and fauna, but also on the Indian population.

Many detailed studies, however, link Eisentraut with Africa, especially with the Cameroons. In 1938, he got the opportunity to go there by banana boat and see Mt.Cameroon with its fascinating vertical faunal zonation. In 1954, he was one of the first Germans after the war whom the British allowed to visit this ex-German colony, the western part of which was in British hands from 1918 to 1960. Five further expeditions to West Cameroon and to Fernando Poo were subsequently organized in which the exploration of remote mountain ranges often required walking tours of several days. In 1973, I had the opportunity to accompany Professor Eisentraut to the Cameroons where I assisted him - apart from my own herpetological collections- in his mammalogical fieldwork.

As was the case with the book on the Bolivian Chaco, Eisentraut summarized all of his Cameroon expeditions and excursions in an informative book *"Im Schatten des Mongo-ma-loba"*(In the Shadow of Mt. Cameroon, Bonn 1982), where he described not only his biological experiences but also the philosophical attitudes which make the life of a field biologist like himself so fascinating. The reader can feel how a rich and extremely productive phase of his life was inspired by the numerous visits to this tropical country. His scholarly pursuits were not only acknowledged by awards like the honorary membership of the German Mammalogical Society of the Commander's Cross of the Order of Merit of the Federal Republic of Germany, but more important for him is the certainty that the coming generations of zoologists in his Museum Koenig will carry on the great work he has so painstakingly and firmly established.

Received August 23, 1983

A Synopsis of the Families of Bats - Part VI

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In the first five parts of this synopsis, I have covered all the recent families of bats indicating their characters as derived from the hypothetical primitive bat condition. In part 6, I will try to point out characters by which various families can be grouped into superfamilies, infraorders and suborders on the basis of shared derived characters. As will be seen, this attempt is not entirely successful, but I think some progress can be made.

The first separation is obviously between the Megachiroptera and the Microchiroptera, the former represented by the single family Pteropodidae. The Microchiroptera can be divided into two groups (here considered infraorders), according to whether the premaxillaries are moveable in relation to the maxillaries (Rhinopomatidae, Craseonycteridae, Emballonuridae, Nycteridae, Megadermatidae, Rhinolophidae) or fused with them (all other microchiropteran families), both characters being derived.

Within the infraorder with movable premaxillaries, the Rhinolophoidea can be separated from the remainder by fusion of at least the first thoracic vertebra with the last cervical. They also all show reduction of the nasal branch of the premaxillary, reduction in number of phalanges on the second digit, and freeing of the periotic from surrounding bones, but these have all (presumably independently) been acquired by the Rhinopomatidae, Craseonycteridae, or Emballonuridae. I have been unable to find any shared derived character uniting the latter three families to the exclusion of the Rhinolophoidea. The Rhinopomatidae and Craseonycteridae share the reduction of the palatal branch of the premaxillary and loosening of the periotic (neither found in the Emballonuridae), but, as mentioned above, both characters are also found in the Rhinolophoidea. I have also not been able to group any two of the rhinolophoid families satisfactorily. Each of the three families has its owned derived chaaracters and there are also shared derived characters such as the loss of all phalanges on the second digit of the wing (uniting the Nycteridae and Rhinolophidae) and the presence of a noseleaf (uniting the Megadermatidae and Rhinolophidae), but I see no nonarbitrary basis for making a choice.

Turning to the other infraorder (with fused premaxillaries), we can separate the Phyllostomoidea on the basis of three rather weak derived characters shared by the Noctilionidae, Mormoopidae, and Phyllostomidae. These are the shortened tail (presumably secondarily lengthened in *Lonchorina* and *Macrophyllum*), and the reduced number of lower incisors and upper premolars. All three characters have, presumably independently, been similarly modified in various vespertilionids. Within Phyllostomiodea the Noctilionidae and Phyllostomidae are more derived than the Mormoopidae in the more enlarged trochiter (in which they parallel the Vespertilionoidea). This last character is the only derived one that I have found to unite all seven families of the Vespertilionoidea. The Natalidae, Furipteridae, Thyropteridae, and Myzopodidae share the derived character of loss of the single remaining phalanx on the second digit of the wing (independently lost in the Emballonuridae, Nycteridae, and Rhinolophidae). Of these four vespertilionoid families, the Natalidae have remained primitive in the characters examined, but each of the other three (particularly the Furipteridae) have derived characters of their own but no very convincing shared derived characters. Two of the three remaining vespertilionid families share the reduction of the palatal branch of the premaxillary (presumably independently reduced in the Furipteridae), though, apparently secondarily, enlarged in some molossids. The Mystacinidae occupy a rather anomalous position. They are primitive for some characters (retention of a phalanx on the second digit of the wing, absence of rostral shortening, a well-developed palatal branch of the premaxilla) which have been modified in some other vespertilioniod families. On the other hand, the family is derived in its short tail and in various other unique characters. Based upon derived (and where possible shared derived) characters, I here present a tentative key to the families of Chiroptera. In the next (and final installment) I will present a revised classification of Chiroptera.

Key to the families of Chiroptera

I. Usually with a claw on the second digit of the wing; molar teeth highly modified for fruit or nectar feeding, cusp homology with tribosphenic tooth unrecognizable; tragus absent.

Pteropodidae

II. Without a claw on the second digit of the wing; molar teeth usually adapted for insect feeding, cusp homology with tribosphenic tooth almost always recognizable; tragus usually present.

A. Premaxillary bones only loosely attached to maxillaries.

1. Last cervical vertebra not fused with first thoracic; usually no special modification of the muzzle or rhinarium.

a. Reduction of nasal but not palatal branch of premaxillary; periotic sutured to surrounding bones; tail present but shorter than uropatagium.

Emballonuridae

b. Reduction of palatal but not nasal branch of premaxillary; periotic largely free from surrounding bones; tail either absent or much longer than uropatagium.

a' Only one phalanx on second digit of wing; trochiter well developed; no noseleaf; tail absent.

Craseonycteridae

b' Two phalanges on second digit of wing; trochiter poorly developed; small noseleaf present; tail very long.

Rhinopomatidae

2. Last cervical vertebra at least partly fused with first thoracic; always either a slit opening into an extensive epinasal chamber or a noseleaf present.

a. Epinasal chamber opening to the outside by a slit; no noseleaf.

Nycteridae

b. No epinasal chamber; well developed noseleaf.

a' Premaxillary vestigial; trochiter poorly developed; tragus present.

Megadermatidae

b' Fairly well developed palatal branch of premaxillary; trochiter well developed; tragus absent.

Rhinolophidae

B. Premaxillary bones fused to maxillaries.

1. Tail, if present, usually shorter than uropatagium; rhinarium and/or muzzle always modified; never more than two pairs of lower incisors.

a. Rostrum always at least slightly tilted upwards in relation to the braincase; trochiter poorly developed.

Mormoopidae

b. Rostrum not tilted upward in relation to the braincase; trochiter well developed.

a' Palatal branch of premaxillary bone reduced; full lips and somewhat tubular nostrils but no noseleaf.

Noctilionidae

b' Palatal branch of premaxillary bone not reduced; almost always with a true noseleaf at least as represented by its basal disc around the nostrils (if not, then face covered with small cutaneous processes).

Phyllostomidae

2. Tail almost always as long or longer than uropatagium; rhinarium and muzzle rarely modified; usually three pairs of lower incisors.

a. Second digit of wing represented only by metacarpal; ears more or less funnel-shaped.

a' Wrists and feet equipped with large suckers

a'' Fusion of first and second thoracic vertebrae; rostrum unshortened

Thyropteridae

b'' No thoracic vertebral fusion; rostrum shortened.

Myzopodidae

b' No suckers on the wrists or feet.
a''Palatal branch of premaxillary reduced; tail somewhat shortened, thumb clawless.
Furipteridae

b''Palatal branch of premaxillary not reduced; tail long; thumb clawed.
Natalidae

b. Second digit of wing with a single metacarpal; ears rarely funnel-shaped.
a' Tail much shorter than uropatagium.
Mystacinidae

b' Tail as long or longer than uropatagium.
a''Uropatagium considerately shorter than tail.
Molossidae

b''Uropatagium as long or nearly as long as tail.
Vespertilionidae

(to be continued)

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Use Of Nest Boxes on Revegetated Surface Mines by Bat, *Myotis Keenii*

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The use of roost boxes by bats is well known in Europe (Greenhall, 1982; Krzanowski, 1955). However, in the U.S. the use of man-made roosting structures designed expressly for bats has been reported by LaVal and LaVal (1980) for Missouri and Storer (1926) for Texas. The Missouri structures were used by *Myotis lucifugus* and the Texas structures by *Tadarida mexicana*.

While conducting a study of nest box preference by eastern bluebirds (*Sialia sialis*) on Falcon Coal Company's surfacemines in the Quicksand area of Breathitt County, Ky., we found some boxes used by bats. An individual of *Myotis keenii* was collected from a bluebird box on 18 August 1983. The same species was observed, but not collected, in a different box within 1 km of the collected specimen. In the summer, *Myotis keenii* has been reported previously in tree cavities, beneath loose bark, and in buildings (Barbour and Davis, 1969), but not in artificial roosting cavities.

The two August 1983 observations were the only two records of bats in boxes during weekly inspections of the 50 boxes from March to September. Additionally, we observed bat droppings in four of the boxes during inspections on this site in 1982. There may have been more use of boxes by bats than we have indicated because most of the bluebird inspectors were not trained to identify bat guano, which could be easily overlooked. All boxes used by bats had slot entrances, which ranged in width form 1 to 1.5 inches, rather than the circular entrance of standard bird boxes.

The use of nest boxes by *Myotis keenii* is important because it suggests that they can be attracted to artificial roost sites. It is also important in that the boxes were located on a revegetated surface mine. The use of surface mines by many wildlife species is still poorly known. The vegetation of reclaimed surface mines, in its early stages, provides few if any potential roost sites for hole- and crevice-roosting bats. Thus it is clear that the use of roost boxes to attract bats to such revegetated mines needs further investigation.

Myotis keenii is known in Kentucky from only a few scattered localities (Barbou and Davis, 1974). Our findings represent a new county record.

We would like to thank Falcon Coal Company for the use of their property.

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From the Managing Editor

Bat Research News has entered its 25th year of publication with an article by Wayne Davis on its origin and an editorial on the same theme by Kunwar Bhatnagar. What began as a simple newsletter has slowly evolved into a rather more elaborate production. When Brock Fenton and I assumed responsibility for **Bat Research News** with Volume 18 in 1977, we simply used the best typewritten copy we could obtain, duplicated it, stapled it together and off it went to the subscribers. It really was a "side desk" operation. However, during the last eight years it has grown from about 24 pages per Volume to approximately 60 pages. In addition it is now typeset which allows nearly twice as much material per page, as well as a more professional appearance. As Dr. Bhatnagar pointed out in his editorial, we publish two to four feature articles in each issue; some of these have tables, figures or other illustrations which require considerable production time. All in all, **Bat Research News** has taken on a rather more professional appearance, but is now also more time-consuming from a publishing point of view. I have calculated that an issue of 12-16 pages requires approximately 200 hours of work from the time the editor's manuscript arrives until that issue is in the mail. In the past my campus was kind enough to provide some assistance with typing, duplicating, and mailing. These donated services are no longer available and we must now do all this ourselves. We use student help where it's practical and commercial services for typesetting, printing and binding. These commercial services are more costly than student help but are also more professional. We are confronted with the necessity to increase our subscription rates to meet these added costs.

We are making a renewed effort to expand our circulation and this will keep our costs down by allowing us to distribute fixed costs such as typesetting and layout over a larger number of copies. We do not anticipate any additional cost increases in the near future unless inflation becomes really rampant, or we have a serious drop in the number of subscribers (or Kunwar decides to use color illustrations).

The cost of an annual subcription will be ten dollars per volume of four issues beginning with Volume #25. We are offering an opportunity to subscribe to Volume 25 and Volume 26 for a combined price of $16.00 if you respond before September 1, 1984. If you have already renewed and paid $6.00 for Volume 25, we thank you for your early attention to this, and your reward is $4.00 saved!

We appreciate your support and your continuing interest in our efforts. We are enthusiastic about the future of **Bat Research News**.

G. Roy Horst
Managing Editor

ANNOUNCEMENTS

The **Fifteenth Annual North American Symposium on Bat Research** will meet on October 19 and 20, 1984 (Friday and Saturday) at Rockford College in Rockford, Illinois. Larry Foreman of Rockford College will be in charge of local arrangements and Roy Horst will be in charge of the program.

Rockford College is located approximately 90 miles northwest of Chicago. Dr. Forman will, in due time, provide detailed travel instructions, a description of the housing and dining facilities and other pertinent information. He has arranged for our stay at the campus conference center at very reasonable rates.

You will receive a formal call for papers, preregistration materials and other information from Dr. Horst in early June.

We are especially interested in a series of presentations on the biology of the alimentary canal and on new analytical techniques. If you are interested in organizing either of these, contact Roy Horst at your earliest opportunity.

If you are interested in receiving registration materials and other information about the Symposium, please contact G. Roy Horst, Department of Biology, State University College of Arts and Science, Potsdam, N.Y. 13676. You should have already received this information if you are on the subscription list.

A number of bat biologists (Horst, Kunz, Phillips) have recently been supported by Earthwatch and the Center for Field Research in Belmont Massachusetts. This non-profit organization serves as a source of funds and provides teams of volunteer workers of all ages and professional backgrounds for field studies worldwide in zoology, geology, anthropology and other disciplines. They are currently supporting 330 research teams in 32 countries and 22 states. Their funds are provided in large part by their 13,500 members who are keenly interested in scholarly research in many areas of science. Research teams consist of the Principal Investigator, one or two professional assistants, and up to 15 volunteers. Teams are usually in the field for 2 weeks. A typical project might have four successive teams of eight volunteers each and the project would be funded for $20,000.

If you are interested in this program contact Dr. Sarah Bennett at Center for Field Research, 10 Juniper Road, Box 127, Belmont, MA 02178.

OBITUARY

Dr. Josefine Contantia Rauch, Professor in the Department of Zoology at the University of Manitoba suddenly passed away on February 22, 1984.

Dr. Rauch was born in St. Margarethen/Raab, Steiermark, Austria where she attended school and obtained a diploma in Medical Diagnostic and Therapeutic X-Ray Technology.

She immigrated to Canada in 1956, completed her schooling at Red Deer, Alberta, and then the University of Saskatchewan. After graduating with a B.A., in 1962, she commenced graduate studies at the University of Alberta, Edmonton. She completed her M.Sc. degree in 1968, and subsequently her Ph.D. (magna cum laude) in 1971. As a graduate student at the University of Alberta she was awarded a number of prestigious scholarships and fellowships.

Following graduation, she joined the Zoology staff at the University of Manitoba as an Assistant Professor. She was promoted to the rank of professor in the spring of 1983. While at the University of Manitoba, she was well-liked and held in high regard by students and colleagues. She was an enthusiastic, dedicated researcher in mammalian temperature regulation and an authority on the subject of hibernation. Dr. Rauch gained international recognition for her detailed studies of the topography, vascularization, and hemodynamics of brown adipose tissues in small mammals. Truly a comparitive zoologist, she published on a variety of topics, ranging from cutaneous circulation in snakes to bioenergetics of mammalian torpor.

Dr. Rauch was a member of a number of scientific societies, and was active on the executive committee of the Canadian Society of Zoologists. She also served as a Senator on the University of Manitoba Senate. She held honary memberships in the Royal Society (London) for the Promotion of Health and in the Manitoba Natural History Society.

Dr. Rauch had attended several of the North American Symposia on Bat Research and presented her findings on thermoregulation and metabolism in brown adipose tissue in bats. Her friends and colleagues from the international community of chiroptologists sadly share this sense of loss with her department and with her friends.

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FRONT COVER
Craseonycteris thonglongyai
(Kitti's Hog-nosed bat)

A very small, bumble-bee sized bat (length of head and body, 29-33 mm; weight 1.7-2.0 g; length of forearm 22-26 mm), dorsally greyish brown, ventrally greyer, membranes dark, eyes small, ears very large and membranaceous, no external tail. A cave dweller in western Thailand. Discovered by the late Kitti Thonglongya in 1973, this bat now holds the distinction of being the world's smallest mammal and constitutes the sole member of the new family Craseonycteridae (Superfamily, Emballonuroidea). Poachers and souvenir hunters reduced its population to about 150 at the last count. *Bat Conservation International* has been instrumental in pointing out its endangered status. This excellent photograph of a perched bat comes from Dr. Merlin Tuttle, *Bat Conservation International,* Milwaukee Public Museum.

(Data from: J.E. Hill's monograph on the species, 1974; *Bats,* BCI, 1983; Schober, W. The Lives of the Bats, 1984.)

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A Synopsis of the Families of Bats – Part VII

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In the first six parts of this synopsis, I have covered all the Recent families of bats and have given a key to the families based as nearly as possible on shared derived characters. In this final installment at the suggestion of the Editor, I am here giving an updated version of the classification of Recent bats down to the level of genus. Numbers in parentheses are numbers of species in each family and in each genus. Numbers in superscript refer to notes at the end of the classification. The families are in the same order as they appear in the key.

Suborder Megachiroptera
  Family Pteropodinae (162)
    Subfamily Pteropodidae
      Tribe Pteropodini
        Subtribe Rousettina
          Eidolon (1)
          Rousettas (incl. *Lissonycteris*) (9)
          Myoncyteris (3)
          Boneia (1)
        Subtribe Pteropodina
          Pteropus (57)
          Acerodon (6)
          Neopteryx (1)
          Pteralopex (3)
          Styloctenium (1)
        Subtribe Dobsoniina
          Aproteles (1)
          Dobsonia (1)
      Tribe Harpyionycterini
          Harpyionycterini (1)
      Tribe Epomophorini
          Plerotes (1)
          Hypsignathus (1)
          Epomops (3)
          Epomophorus (8)
          Micropteropus (8)
          Nanonycteris (1)
          Scotoncyteris (2)
          Casincyteris (1)
      Tribe Cynopterini
        Subtribe Cynopterina
          Cynopterus (5)
          Magaerops (4)
          Ptenochirus (2)
          Dyacopterus (1)
          Chironax (1)
          Thoopterus (1)
          Sphaerias (1)
          Balionycteris (1)
          Aethalops (1)
          Penthetor (1)
          Latidens (1)
          Alionycteris (1)
          Otopteropus (1)
          Haplonycteris (1)
        Subtribe Nyctimenina
          Nyctimene (13)
          Paranyctimene (1)
    Subfamily Macroglossinae
      Tribe Macroglossini
          Eonycteris (2)
          Megaloglossus (1)

Macroglossus (2)
Syconycteris (2)
Tribe Notopterini
Melonycteris (incl. *Nesonycteris*) (3)
Notopteris (1)
Suborder Microchiroptera
Infraorder Yinochroptera[1]
Superfamily Emballonuroidea
Family Emballonuridae (47)
Subfamily Emballonurinae
Emballonura (10)
Coleura (2)
Rhynchonycteris (1)
Saccopteryx (4)
Centronycteris (1)
Peropteryx (incl. *Peronymus*) (3)
Cormura (1)
Balantiopteryx (3)
Taphozous (incl. *Liponycteris*) (12)
Saccolaimus (5)
Subfamily Diclidurinae
Cyttarops (1)
Diclidurus (incl. *Depanycteris*) (4)
Family Craseonycteridae (1)
Craseonycteris (1)
Family Rhinopomatidae (3)
Rhinopoma (3)
Superfamily Rhinolophoidea
Family Nycteridae (14)
Nycteris (14)
Family Megadermatidae (5)
Megaderma (2)
Macroderma (1)
Cardioderma (1)
Lavia (1)
Family Rhinolophidae (124)
Subfamily Rhinolophinae
Rhinolophus (incl. *Rhinomegalophus*) (63)
Subfamily Hipposiderinae
Tribe Hipposiderini
Subtribe Hipposiderina[2]
Hipposideros (48)
Anthops (1)
Asellíscus (2)
Asellia (2)
Subtribe Rhinonycterina[2]
Rhinonycteris (1)
Cloetis (1)
Triaenops (2)
Tribe Coelopsini
Coelops (3)
Paracoelops (1)
Infraorder Yangochiroptera
Superfamily Phyllostomoidea
Family Mormoopidae (8)
Pteronotus (incl. *Chilonycteris*) (6)
Mormoops (2)
Family Noctilionidae (2)
Noctilio (2)
Family Phyllostomidae (138)
Subfamily Phyllostominae
Micronycteris (incl. *Glyphonycteris, Barticonycteris*) (10)
Macrotus (2)
Lonchorhina (3)
Macrophyllum (1)
Tonatia (6)
Mimon (2)
Phyllostomus (4)
Phylloderma (1)
Trachops (1)
Chroptopterus (1)
Vampyrum (1)
Subfamily Lonchophyllinae[3]
Lionycteris (1)
Lonchophylla (2)
Platalina (1)
Subfamily Brachyphyllinae[3]
Brachyphylla (2)
Subfamily Phyllonycterinae[3]
Erophylla (2)
Phyllonycteris (2)
Subfamily Glossophaginae[3]
Glossophaga (5)
Monophyllus (2)
Lichonycteris (2)
Leptonycteris (3)
Anoura (3)
Scleronycteris (1)
Hylonycteris (1)
Choeroniscus (4)
Choeronycteris (incl. *Musinycteris*) (2)
Subfamily Carolliinae
Carollia (4)
Rhinophylla (3)
Subfamily Stemoderminae
Tribe Sturnirini
Sturnira (12)
Tribe Stenodermatinae
Uroderma (2)
Vampyrops (9)
Vampyrodes (1)
Vampyressa (5)
Chiroderma (5)
Ectophylla (incl. *Mesophylla*) (2)
Artibeus (incl. *Enchisthenes*) (14)
Ardops (1)
Phyllops (1)
Ariteus (1)
Stenoderma (1)
Pygoderma (1)
Ametrida (1)
Sphaeronycteris (1)
Centurio (1)

Subfamily Desmodontinae
Diphylla (1)
Desmodus (incl. *Diaemus*) (2)
Superfamily Vespertilionoidea
Family Thyropteridea (2)
Thyroptera (2)
Family Myzopodidae (1)
Myzopoda (1)
Family Furipteridae (2)
Furipterus (1)
Amorphochilus (1)
Family Natalidae (5)
Natalus (5)
Family Mystacinidae (1)
Mystacina (1)
Family Molossidae[4] (80)
Moropterus (incl. *Platymops, Sauromys*) (11)
Molossops (incl. *Cynomops, Neoplatymops*) (7)
Cheiromeles (1)
Myopterus (2)
Tadarida (7)
Chaerephon (13)
Mops (incl. *Xiphonycteris*) (14)
Otomops (5)
Nyctinomops (4)
Eumops (8)
Promops (2)
Molossus (6)
Family Vespertilionidae (293)
Subfamily Kerivoulinae
Kerivoula (incl. *Phoniscus*) (16)
Subfamily Vespertilioninae
Tribe Myotini
Myotis (incl. *Pizonyx, Cistugo*) (85)
Lasionycteris (1)
Tribe Vespertilionini
Eudiscopus (1)
Pipistrellus (incl. Ia, Scotozous) (48)
Nyctalus (5)
Glischropus (2)
Eptesicus (32)
Vespertilio (3)
Laephotis (4)
Histiotus (4)
Philetor (1)
Tylonycteris (2)
Mimetillus (1)
Hesperoptenus (4)
Chalinolobus (incl. *Glauconycteris*) (15)
Tribe Nycticeini
Nyctoceius (6)
Rhogeesa (incl. *Baeodon*) (6)
Scotoecus (3)
Scotomanes (2)
Scotophilus (4)
Otonycteris (1)
Tribe Lasiurini
Lasiurus (incl. *Dasypterus*) (7)
Tribe Antrozoini[5]
Bauerus (1)
Antrozous (1)
Tribe Nystophilini[5]
Nyctophilus (incl. *Lamingtona*) (7)
Pharotis (1)
Subfamily Murininae
Murina (16)
Harpiocephalus (1)
Subfamily Miniopterinae
Miniopterus (12)
Subfamily Tomeatinae
Tomopeas (1)

[1]As indicated in the previous installment, I believe that the most fundamental division of Microchiroptera is into those superfamilies in which the maxillary bones are movable and those in which they are fused. These divisions are here considered Infraorders. For the names of these infraoders, I have followed the example of Chow and Rich (1982, Australian Mammalogy 5: 127-142), who recognized two new Legions of therian mammals as the Yinotheria and Yangotheria. The names for the two bat infraorders are particularly apt since in Confucian philosophy, Yin is an active, Yang is a passive element in any pair of concepts.

[2]I follow Hill (1982, Bonn. Zool. Beitr. 33: 165-186) in separating *Rhinonycteris, Cloetis*, and *Triaenops* from other Hipposiderini.

[3]I follow Griffiths (1982, Amer. Mus. Novitiates 2472) in his arrangement of New World nectar-feeding genera.

[4]I follow Freeman (1981, Fieldiana Zool., n.s. 7) in her arrangement of molossid genera.

[5]It has become increasingly evident that the "Subfamily Nyctophilinae" has no real validity so I am here adding its two tribes to the Vespertilioninae.

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Editor's note: This is the concluding installment in a seven-part synopsis of the families of bats. The total number of bat species recognized by Dr. Koopman is 888! This exact figure is ever changing as new species are described. So far, numbers from 800 to 1,000 are frequently quoted for the bat species. Also to be noted are new names — Yinochiroptera and Yangochiroptera — the microchiropteran Infraorders. It is my belief that bat researchers will find this work useful. I remain grateful to Dr. Koopman for providing this synopsis at my request.

I will welcome suggestions from our readership as to WHAT NEXT in this splendid idea of multi-installment contributions.

Comments on Training *Eptesicus fuscus*

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Many zoologists presume that the easiest North American bat to maintain in captivity is the big brown bat, *Eptesicus fuscus*. This note relates to the training of this species. Although laboratory experiments do not always require the use of tame bats, such animals can prove very useful for behavioral studies. Because bat learning ability is poorly understood, this field of bat ethology is especially inviting for a young bat enthusiast.

I collected big brown bats from a large courtyard where they roosted behind drainpipes. Ten different bats were used over a period of six months. Each bat was trained in 6 days. After capture, I began training the bats right after catching them. At first, I handled the bats with gloves, and held them so that their heads protruded between my gloved fingers. With one bare hand, I stroked the fur on the head until they calmed down and ceased their frantic squeaking. This procedure lasted anywhere from 30 minutes to an hour, depending on the individual bat.

Once a bat had stopped squeaking and squirming, I allowed it to crawl about on my arm. Inevitably the bat attempted to fly, but I discouraged this by using a hand fan of woven reeds swiftly placed in front of the bat at the moment of takeoff. This procedure caused the bat to collide with the fan, resulting in its landing on the fan or falling to the ground. Bats usually landed on the fan and again tried to fly. I repeated this flight-capture-flight procedure until the bat learned to stop trying to fly away. Ten trials per bat usually produced a positive result.

The day after capture, the bats were allowed free flight in the laboratory. Attempts were made to retrieve flying bats by using the fan rather than a net. After some practice, I was able to retrieve a flying bat in a matter of seconds. One individual became very accustomed to the fan and flew to it immediately to receive a mealworm reward. I handled bats daily eventually without gloves and from tame bats received bites only as they tried to take a mealworm from my hand. These bites did not break the skin.

One female was trained to fly to her cage on command and became a pet. She was the easiest to tame. Most of the training of this bat was done in full light, which did not seem to inhibit her ability to learn. It did, however, lessen the time for experimentation. She normally was ready to "hang up" after about 30 minutes of flight-feeding work. Certain bats clearly have exceptional ability for rapid learning, and when one takes time to sort these out, behavioral experimentation is more fruitful.

When training my one special bat in the laboratory, I would capture her with the fan method, and then give the bat the bat a mealworm. During the first 3 months of training, I did not train her to fly to her cage. This particular training took place in my home. The bat began flying to its cage without my prompting it. I reinforced this untaught behavior with mealworms. After 3 weeks I returned the bat to the laboratory and upon release there she flew in her usual circular pattern around the room. Within two minutes the circle tightened, until the bat landed perfectly in her cage, without any prompting.

Gaudette (1982) used methods similar to the above. She clearly showed that bats can be trained and that they may even surprise the experimenter with accomplishments not taught. These observations illustrate considerable potential for training bats for experimentation in a laboratory setting.

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Report on the joint American Society of Mammologists and Australian Mammal Society meeting, Sydney, Australia, July 9-13, 1984.

This historical first joint meeting was held at the University of New South Wales, Kensington, under the organization and management of Drs. William Z. Lidicker, Jr., and M.L. Augee. Nearly 125 delegates from the North American continent participated. A day-long session on bat biology organized by Les Hall, Department of Anatomy, University of Queensland, was well attended. The pre- and post-convention tours, social programs, and all the rest of the meeting were meticulously planned. Even the weather cooperated. For its success the organizers deserve our compliments.

The following papers were presented at this special session:

ANATOMY AND PHYSIOLOGY

Bhatnagar, K.P. Comparative morphology of the vomeronasal nasal receptor-free epithelium of some phyllostomid bats.

Harding, H.R., C.D. Shorey, W. Phillips and S.J. Inwards. Australian vespertilionid bats: comparative ultrastructure of spermiogenesis and spermatozoa.

Allison, A., and P.A. Woolley. Reproduction in a New Guinea pipistrelle.
Towers, P.A., and L. Martin. Studies on ovarian function in Australian fruit bats.
Inwards, S.J. Rates of water influx of some tree-dwelling bats.
Prociv, P. *Toxocara pteropodis* in Australian *Pteropus* species.
Constantine, D.G. Recently-recognized disease-related precautions for bat researchers.

SYSTEMATICS

Koopman, K.F. Tropical Australian bats: The New Guinea connection.
Hand, S. Australian fossil bats: a review.
Baverstock, P., C.H.S. Watts and M. Adams. Electrophoretic resolution of species boundries in some Australian bats.
Lidicker, W.Z., Jr. and S. Byrne. Systematics of the blossom bats *Syconycteris* (Pteropodidae).
Peterson, R.L. Some zoogeographical puzzles in the genus *Miniopterus*.
Pierson, E.D., V. Sarich, J. Lowenstein and M. Daniel. *Mystacina*'s taxonomic association with the phyllostomoid bats.

ECOLOGY AND GENERAL TOPICS

Herd, R. Relationships between *Myotis lucifugus* and *Myotis yumanensis* in British Columbia.
Svoboda, P.L. Biology and geographic relationships of a Brazilian free-tailed bat colony in Colorado.
Wilson, P. Movements of *Miniopterus* spp. in SE Australia.
Phillips, W.R., and S.J. Inwards. The ecology of a temperate-zone, tree-dwelling bat community.
Tidemann, C.R. Roost preferances in forest bats.
Lunney, D., J. Barker, P. Eby and B. Cullis. Habitat preferances of bats in a logged, burnt, drought affected forest on the NSW south coast.
Lawlor, T.E. Mammals on islands: tests of island biogeographic theory.

BEHAVIOR AND ULTRASONICS

Robson, S. *Myotis adversus*: an opportunistic piscovore.
Woodside, D. Echolocation and foraging behavior of Microchiroptera in S.E. Australia.
Coles, R.B., and A. Guppy. Comparative aspects of sonar in Australian bats.
Guppy, A., R.B. Coles and J.D. Pettigrew. Acoustic bevavior of the ghost bat, *Macroderma gigas*.
Tuttle, M. Bat Conservation International.

BAT BIOLOGY POSTERS

Crichton, E.G., and P.H. Krutzsch. A morphological examination of storage and clearance of intrauterine and cauda epididymal spermatozoa in *Myotis lucifugus* and *M. velifer*.
McGuckin, M.A., and A.W. Blackshaw. Reproduction of the male fruit bat *Pteropus poliocephalus* in Southeastern Queensland.
O'Shea, J. Innervation of the bat cardiovascular system: modifications for flight or hibernation.
Tedman, R.A., and L. Hall. The absorptive surface area of the small intestine of *Pteropus poliocephalus*: an important factor in relation to the rapid food transit time in this megachiropteran bat?
Lane, R. Mother-young relationships in the grey-headed flying fox.
Phillips, W.R., and J. Bishop. Use of infrared light beams in bat ecology.

Abstracts of papers presented will be published in volume 8, No. 2 of the **Bulletin of the Australian Mammal Society**.

Submitted by Kunwar Bhatnagar

NEWS AND VIEWS

NEW SPECIES OF BATS?

According to a report by Sharon Begley (*Newsweek*, April 16, 1984, p. 57) bats are among the bizarre fauna and flora of Neblina, the "Mountain of the Mists" — a 250-square-mile Venezuelan *tepui* which is a land-locked Galapagos and is being explored by U.S. and Venezuelan scientists. This report included a photograph of an unidentified phyllostomid bat. New finds, if any, will prove to be very interesting and might "hold the key to two persistent questions of evolution: how do species form and at what speed?"

NEW BOOKS

The Lives of Bats by Wilfried Schober, ARCO Publishing, Inc., New York, 1984. $24.95 (English translation of a beautifully illustrated book *Mit Echolot und Ultraschall* by Sylvia Furness).

Bats: A Natural History by John Edwards Hill and James D. Smith (British Museum, Natural History/University of Texas Press).

ERRATA

Mr. John E. Hill of the British Museum (Natural History) has called my attention to two errors in my "Synopsis of Bats" series. In Part II (BRN 23:26), on the third line from the bottom, "palatial" should read "nasal." In Part IV (BRN 25:16), in entry II A1, "palatial, but not nasalbranch of premaillary reduced" should be added. In entries II A1 a and b, references to the premaxillary should be deleted. In entry II A2, "nasal branch of premaxillary reduced or absent" should be added. The author regrets these errors in the original accounts.

Karl F. Koopman

NOTICE

SEVENTH INTERNATIONAL BAT RESEARCH CONFERENCE
THIRD EUROPEAN BAT RESEARCH SYMPOSIUM
Joint Meeting
19 - 24 AUGUST 1985
UNIVERSITY OF ABERDEEN, U.K.

Conveners: Paul A Racey Adrian G Marshall
Postal address: Department of Zoology, University of Aberdeen, Aberdeen, AB9 2TN, U.K.
Telephone number: 0224—40241 Telex: 73458 UNIABN G

To all those interested in attending the Aberdeen Conference:

UPDATE: December 1984

We have received 150 provisional registrations and will be sending out final registration forms, travel details, etc. early in 1985 to all those who have filed provisional registrations and all those in the BRN address list.

The conveners of the three symposia on Echolocation (Fenton and Nenweiles), Flight (Norbeg and Rayner), and Social and Reproductive Biology (Kunz and Racey) have secured excellent speakers, and Cambridge University Press will be publishing all three together in a single volume, within ten weeks of receiving camera ready copy. Professor J.D. Pye will also convene a Workshop on Observational Techniques. About 100 registrands wish to present papers so we will have some programming problems, and unless more people switch to posters in their final registrations, the spectre of parallel sessions appears before us.

The Department of Zoology, University of Aberdeen, will contribute 100 pounds and **Bat Research News** will contribute 150 dollars (U.S.) to a prize for the best presentation by a graduate student.

A 200 page issue to Myotis has been allocated for publication of submitted papers.

The abstracts of all the papers presented will be published as the November issue (Volume 26:4, 1985) of **Bat Research News**.

QMC Instruments will host a social event (such as drinks with a poster session), and there will be a closing dinner.

Our only regret is that we are unable to organise the sort of spectacular bat excursion that formed such a memorable part of previous international gatherings. Instead, we will substitute Scottish culture and take those of you who wish to attend on a day excursion at the end of the conference to witness The March of the Men of Lonach — a private army who parade with pikes and Lochaber axes in full Highland regalia and accompanied by pipers, down the beautiful valley of Strathdon to the Highland Games at Bellabeg.

The provisional cost for the five nights of the Conference, with full board, will be in the region of 120 pounds. We hope to reduce this for students. With sterling so weak this must be a good value, so we hope to see many North American colleagues in Aberdeen.

Paul A. Racey
Adrian G. Marshall

RECENT LITERATURE

(Authors are requested to send reprints of their papers to the editor for inclusion in this section. Receipt of reprints will facilitate complete and correct citation. Our Recent Literature section is based upon several bibliographic sources and for obvious reasons cannot ever be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from foreign bat researchers, are most welcome.

ANATOMY

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PROGRAM FIFTEENTH ANNUAL NORTH AMERICAN SYMPOSIUM ON BAT RESEARCH

October 19-20, 1984
Rockford College, Rockford, Illinois

The 15th North American Symposium on Bat Research met at Rockford College in Rockford, Illinois on October 19 and 20, 1984. There were 121 registered participants from the United States, Canada, Mexico, and Australia. There were 42 papers presented as well as several informal reports.

Dr. Thomas Kunz was presented with the Garrit S. Miller Award "In recognition of oustanding service and contribution to the field of Chiropteran Biology." Martha Fujita of Boston University and M.K. (Kitty) Gustin of the University of Tennessee shared the award for the best paper by a graduate student. Mark Brigham of Carleton University also received an award for his outstanding presentation.

At the business meeting the members of the Symposium elected to forego a meeting in North America in 1985 so that we will not be in conflict with the Seventh International and Third European Bat Research Conference in August. This Conference will meet in Aberdeen, Scotland from August 19-24, 1985. (Those interested will find detailed information elsewhere in this issue.)

Invitations for the Sixteenth Annual North American Symposium on Bat Research, to meet in October 1986 were received from Boston University (Thomas Kunz), University of Massachusetts (David Klingener) and University of Toronto (James Fullard). No decision was made as to which one of these invitations would be accepted. The members of the Symposium expressed their appreciation and gratitude to Larry Forman for his excellent organization of the entire Symposium. We would also like to thank again Dr. Norman Stewart for making us feel welcome on Rockford Campus. Special thanks are due Tom Kunz, Karl Koopman, Brock Fenton, Kunwar Bhatnagar and Al Gardner for chairing the sessions; and to Peter August, Kunwar Bhatnagar, Theodore Fleming, Roderick Suthers and Don Wilson for evaluating the presentations by the graduate students. Many others have contributed to the success of this meeting; to those unsung heroes, our appreciation and gratitude.

The Symposium closed with high hopes that most of us would meet again next year in Aberdeen.

Respectfully submitted,

G. Roy Horst,
Program Chairman

ABSTRACTS OF PAPERS PRESENTED
Arranged alphabetically by first author

Immunocytochemistry as a Tool For the Study of Hypothalamic and Pituitary Hormones in Bats.
Edythe L.P. Anthony and Joan C. King, Department of Biology, Rhode Island College, Providence, RI 02908 and Department of Anatomy and Cellular Biology, Tufts University Schools of Medicine, Boston, MA 02111.

The detection of specific peptide and protein hormones by immunocytochemistry has made possible a wide variety of morphological studies related to the structure and function of the vertebrate hypothalamic-pituitary complex. In bats, we have used immunocytochemistry at both light and electron microscopic levels to identify the neurons within the forebrain that synthesize and secrete luteinizing hormone releasing hormone (LHRH). We have also identified the pituitary cell population that is responsible for synthesis and secretion of luteinizing hormone (LH). These studies have yielded intriguing results that suggest several potential modes of interaction between these two systems. They have also revealed morphological evidence for an ultra-short feedback mechanism along LHRH neurons in bats. In addition, immunocytochemistry has been a valuable tool for examining seasonal changes in hypothalamic LHRH neurons and pituitary LH cells. Comparative studies of these systems across phyla have provided new insight into unique and common features of this neuroendocrine complex in bats and other mammals. We have recently adapted double immunocytochemical labelling techniques to identify both LHRH- and catecholamine-containing neurons in the same section using reaction products of different colors. With this expanded capability, we are now investigating potential sites of interaction between these two neural systems. Studies of this nature have been made feasible only by this versatile and powerful technique.

Magnetic Cues and Bat Orientation. Peter V. August, Department of Zoology, University of Rhode Island, Kingston, Rhode Island 02881.

The navigational mechanisms used by migrating or homing bats are poorly known. The story is different for birds. Ornithologists have demonstrated that homing pigeons and nocturnal avain migrants use a suite of environmental cues in navigation (stellar, solar, chemical, geomagnetic, etc.). Our understanding of bird navigation and orientation is far more complete than for bats, due in large part to the use of a number of very simple, predictable, and repeatable behavioral assays developed by ornithologists. One of these, the vanishing bearing, has been especially important in experimental studies of bird orientation. The ultimate goal of this study is to determine if bats have a "magnetic sense" and use geomagnetic field information in compass orientation. One of the immediate goals of this research is to evaluate if the vanishing bearing technique is a viable means of studying bat orientation. Preliminary results are: (1) tissues from *Eptesicus fuscus* and *Myotis lucifugus* yield measurable magnetic remanence (using cryogenic SQUID magentometry) and may contain biogenetic magnetite; (2) when released at night over relatively cueless terrain (sod fields and open sea), *Myotis* and *Eptesicus* do not show homeward-bound vanishing bearings. These results do not prove or disprove the existence of a magnetic sense in bats; further experimental work needs to be done. Vanishing bearings may be a useful orientation assay for bat biologists, however, careful attention should be given to increasing the motivation of bats to fly directly home. Simple capture, displacement, and release does not work.

Roosting and Foraging Behaviors of Silver-haired and Hoary Bats. Robert M.R. Barclay, Biology Department, University of Calgary, Calgary, Alberta, Canada T2N 1N4.

Roost searches, radiotelemetry, fecal analysis and observations with ultrasonic microphones and a night vision scope were used to study the behavioral ecology of silver-haired (*Lasionycteris noctivagans*) and hoary (*Lasiurus cinereus*) bats near Delta Marsh, Manitoba. In May and June, migrating silver-haired bats roost singly or in groups of up to eight under folds of bark or in tree crevices. Although marked individuals were rarely observed more than one day, certain roosts were used consistently by a series of individuals all spring, despite the apparent abundance of suitable sites. No bats were located in the roosts after the spring migration period although individuals were present in the study area all summer. Silver-haired bats emerge to forage 20-45 minutes after sunset and feed on a variety of insects, apparently exploiting swarms of insects such as chironomids when available. Family groups of hoary bats (female and two young) were located roosting on branches 4-20 m from the ground. Although some groups used the same roost for up to five weeks, others moved amongst up to five roosts prior to and after the young were volant. Movements were rarely more than that 100 m and appeared to be at least partly associated with wind conditions and possibly the first flights of the young. Family groups remained intact for up to two weeks after the young began flying. The foraging activity of hoary bats appears to be quite variable. Both adults and juveniles forage continuously for two to four hours starting 30-45 minutes after sunset. This first foraging period usually involves long distance flights (up to 40 km round trip) and is followed by several shorter, local foraging bouts ending approximately one hour before sunrise. Preliminary information suggests that females and their young do not forage together. On some nights, individual hoary bats forage in restricted areas, particularly around the lights where insects are abundant. Such individuals are highly aggressive and chase conspecifics and individuals of other species. In my study area, unlike elsewhere, hoary bats are not "moth strategists." They feed primarily on beetles, moths and dragonflies, apparently ignoring or not perceiving the extremely abundant smaller insects such as chironomids. Thus in general, the foraging behavior of this species appears to be extremely flexible.

Winter Energetics, and the Temperate Distribution of *Macrotus californicus* (Phyllostomatidae). Gary P. Bell, George A. Bartholomew, and Kenneth A. Nagy, Department of Biology, and Laboratory of Biomedical and Environmental Sciences, University of California, Los Angeles, CA 90024.

The field metabolic rates (FMR), feeding rates, and water turnover rates of free-living California leaf-nosed bats are measured by means of double labelled water between November 1983 and March 1984. This data was combined with field measures of daily activity and laboratory measurements of basal metabolism to formulate a daily energy budget. Bats emerged form their roost sites, in abandoned mine adits in mountains in the Colorado desert, approximately 30 to 45 minutes after dusk, and fed for approximately 2 hours before returning to their roosts. The thermoneutral zone was narrow and not sharply defined. Below the T_{lc} (approximately 33 °C) V_{o_2} increased linearly with decreasing T_A body temperature varied directly with T_A but the slope of the regression of T_B on T_A did not differ significantly from zero. Attempts to induce torpor in *Macrotus* by prolonged exposure to a T_A of 15 °C accompanied by reducing their food intake to 50% of maintenance resulted in hypothermia and death within 36-48 h. Ambient temperatures in the northern range of this species frequently drop below freezing during the winter. Mean annual temperatures in the study area are approximately 17-19 °C, however roost temperatures recorded during the study period ranged from 27.5-30 °; all known winter roost sites are located within moderate temperature geothermal zones. *Macrotus californicus* are able to extend their range into the temperate zone by using naturally heated roost sites to minimize energy expenditures during the inactive period. While metabolic costs could be reduced further by roosting at higher temperatures, roosts at 29 °C allow them to balance daily water budgets without requiring the use of free water.

The Significance of Coloniality in *Eptesicus Fuscus*. Mark Brigham, Department of Biology, Carleton University, Ottawa, Canada K1S 5B6.

A number of theories have been proposed to explain animal aggregations. Using *E. fuscus* I investigated whether these bats aggregate due to a limit in the available roost resources, access preferred roosts where offspring can be more efficiently raised, to avoid predators, to transfer information about resources or to minimize travel time to feeding locations. As of 1 August 1984, I had attached 76 radio-transmitters to 70 different individuals; of these, 51 were adult females, 7 were adult males and 12 were subadults. The tagged bats were monitored for a total of 453 transmitter nights. My results show no evidence of a limited number of roost resources in my study area (20 km south of Ottawa). On 59 occasions, evicted or disturbed individuals moved a mean distance of 105.8 M, SE = 9.94, to a new roost site. In no instance did an individual join a preexisting colony when it switched roosts. I found that the number of young raised to flight age was significantly greater in control colonies (undisturbed, where no closure took place) x = 0.97 young per adult, SE = 0.21, N = 2 colony sites. In 1983, in control roosts, I found that radio-tagged animals returned to the same day roost 94.4% of the time (N = 143 transmitter nights). I predicted that a clumped exit behavior pattern would be found if ambush predation was a major selective force. On 14 nights at control colonies, the mean number of bats leaving within four seconds of the previous animal was only 35.5%. On over 300 observer nights, there was no incidence of ambush predation seen. The information-center hypothesis also predicts a clumped exit behavior, as well as following behavior to occur. On nine nights I monitored colony departures where following behavior could be recognized. On average, only 8.4% of the individuals in each colony **could** have been following the previously departed individual using visual cues. The fact that forced roost switches by radio-tagged animals covered such short distances, is consistent with the closeness to foraging area hypothesis. My data regarding foraging behavior however, although incompletely analyzed, indicates that this species is an opportunistic feeder and as such, has no defined individual feeding areas. I conclude that *E. fuscus* roost together in "preferred" roost sites to take advantage of factors such as microclimate that enhance their reproductive output. The remaining four hypotheses did not seem to explain the bats gregariousness.

Low Frequency Auditory Sensitivity in the Pallid Bat (*Antrozous pallidus*). Patricia E. Brown, Alan D. Grinnell, amd Peter M. Narins.

Echolocating bats exhibit exceptional high-frequency auditory capabilities in response to the ultrasonic frequencies contained in their orientation sounds. Some bats appear to use low frequencies also to locate calling frogs and insect prey. Several species utilize audible (to humans) sounds in communication. Using behavioral techniques, Poussin and Simmons (JASA 72, 340, 1982) have documented a low frequency sensitivity at 1 kHz in *Eptisicus fuscus*. Pallid bats, *Antrozous pallidus*, use high-frequency signals for echolocation, but also appear to utilize lower frequency prey-produced sounds while foraging on or near the ground for anthropods and moths (Bell, Behav. Ecol. Sociobiol. 10: 217-223, 1982, and Brown, unpubl. data). We now present neurophysiological evidence that bats of this species detect sounds as low as 1 kHz, and are extremely sensitive at 9-11 kHz. Adult pallid bats are anesthetized with Nembutal and the inferior colliculus exposed. Tungsten electrodes were used to make multi-unit recordings from known depths below the surface in response to tone bursts for which the frequency was incremented in 100 Hz steps and presented via free-field calibrated loudspeakers (an ADS-300 with output equalized ±5dB from 200kHz to 20kHz and a Polaroid ultrasonic transducer from 15kHz to 90kHz). For each frequency, the threshold for the multi-unit responses was determined. The frequency of peak sensitivity increased systematically with electrode depth. At or near the surface, maximum sensitivity was approximately 0-10 dB SPL at 9-11 kHz, and 70 dB SPL at 2 kHz. At greater depths, comparable sensitivity was seen at frequencies as high as 40-50 kHz. Our evidence of low frequency sensitivity in the pallid bat is consistent with the behavorial observations of the passive use of prey-produced sounds in foraging and the active use of low frequency communication signals (Brown, Zeit. Tierpsychol. 41:34-54, 1976).

The Timing of Ovulation and Implantation in *Myotis lucifugus*. G. Dale Buchanan, McMaster University, Hamilton, Ontario, Canada L8N 3Z5.

Since environmental factors (e.g., temperature, food supply) can alter the duration of pregnancy in bats, data obtained in one locality and circumstance may not apply to the same species in other geographic or experimental situations. Thus, in conjunction with other physiological experiments in this laboratory, the timing of early pregnancy in *Myotis lucifugus* has been examined as described below. Forty-two female *M. l. lucifugus* were collected from Craigmont Mine during the week that departure from hibernation began. Bats were caged at 20-22 °C within 90 minutes of collection, transported to Hamilton the next day, and maintained in large cages in a warm (28-30 °) room. Ten bats, maintained in an artificial hibernaculum for a month since collection were also aroused and studied. Bats not killed on the first day were taught to eat mealworms and fed 10-15 worms/day thereafter. Autopsies were performed at intervals of 24 ± 1 hours after arousal, except for day 0, when they were done 2 hours after activation. Reproductive tracts were examined *in situ* for evidence of ovulation and implantation, excised, photographed, and processed for further study. Four bats killed on day 0 had preovulatory follicles. In one, the ovum was entering meiosis I. Two bats examined on day 1 had fertilized ova in the oviductal ampulla. Two of four with pre-ovulatory follicles had first polar bodies present. Three of four bats killed on day 2 had ovulated, and all bats with mature follicles examined on day 3 and later had ovulated save one. This bat, killed on day 4, had a large follicle in the left ovary; however, the cumulus and granulosa cells were small and compact and there was no evidence of meiotic division. Bats killed on days 2 and 3 had 2-cell and 4-cell conceptuses in the oviductal isthmus; a 27-cell morula was present in the right uterine horn of a bat killed on day 4; and blastocysts were found in the uteri of bats killed on days 6 through 10. All ovulated bats examined on day 12 and subsequently were implanted. Bilaminar-disc embryos were present in bats autopsied on days 12 and 15; a trilaminar-disc embryo and early primitive streak stage were found on day 14; and embryos of four and eight somites were present in bats killed on days 16 and 18 respectively. These results, obtained under stable experimental conditions, agree with the minimum estimates of others of the timing of early pregnancy in *M. lucifugus*, and provide a basis for measuring environmental influences on gestation.

Bat Rabies in Illinois, 1965–1983. Christopher D. Burnett, Illionois Natural History Survey.

Bat rabies was first reported from Illinois in 1959. Since 1965, samples of the specimens submitted to the Illinois Department of Public Health for rabies testing have been sent to the Illinois Natural History Survey for species identification. Of the 1,926 specimens that have been identified to species during the 19-year study period (1965–1983), 4.8% (N = 93) were positive for rabies virus. Annual variation in the incidence of rabies ranged from a high of 16.3% in 1971 to a low of 0% the next year. The overall temporal trend suggests a roughly cyclical pattern with peaks at approximately 10 year intervals. For the seven species with sufficient sample sizes (N is greater than 10), the percentages of rabies-positive specimens over all years were, in ascending order: *Myotis keenii* 0% (N = 41), *Nycticeius humeralis* 1.8% (N = 56), *Eptesicus fuscus 3.6• (N* = 615), *Lasionycteris noctivagans* 3.6% (N = 167), *Myotis lucifugus* 4.9% (N = 82), *Lasiurus borealis* 5.4% (N = 717), and *Lasiurus cinereus* 8.5% (N = 234). Within species, the incidence of rabies was well below these rates in most years; overall rates were largely determined by apparent outbreaks in a few years. The incidence of rabies was higher in females than males of most species, but only in *Eptesicus fuscus* was this difference statistically significant. Maps of the geographic distribution of various classes of specimens were generated by a computerized geographic information system.

Comparative Analysis of the Echolocation Calls of Australian Bats. Roger B. Coles and Anna Guppy, Acoustic Laboratory, Department of Behavioural Biology, Research School of Biological Sciences, Australian National University, Canberra A.C.T., Australia.

Interest in the sonar systems of Australian bats has only developed recently. For many species the echolocation call has never been recorded. In an attempt to characterize the sonar signals of all Australian bats, we have at present recorded and analyzed the echolocation calls of 28 species. This represents 15 of the 17 genera in Australia. Sonar recordings have been collected in the field and in the laboratory (anechoic). Many bat species can be identified by their echolocation call, and the results can be use to assist field surveys. However, certain genera such as a *Nyctophilus* and *Eptesicus spp.* have very similar calls which makes species identification by sonar difficult. The highest frequency is used by *Hipposideros ater*, which uses a CF-Fm signal based on a second harmonic CF component near 145kHz. In contrast the free-flying cruising pulse of *Tadaruda australis* has the lowest frequency with a fundamental of 11kHz, which is clearly audible at night. The echolocation calls of five Molossid species have been compared (*T. australis, Chaerophon jobensis, Mormopterus beccarii, M. planiceps, M. loriae*). When flying in captivity Molossid bats always use a multiple harmonic FM pulse, however in the field a single harmonic (the fundamental) is usually expressed when cruising. In Molossids, the frequency of the fundamental of the echolocation call increases with decreasing body size. The wavelength of the fundamental frequency in the echolocation call corresponds closely to the length of the pinna for each species. The importance of this relationship is determined by the sound diffraction properties of the pinna. The fundamental frequencies used for sonar in the Molossid bats are at a lower limit for which the ear is highly directional.

Roosting and Foraging Areas of *Epomophorus wahlbergi* (Pteropodidae) and *Scotophilus leucogaster* (Vespertilionidae) in Kruger National Park. M.B. Fenton, R.M. Brigham, A. Mills, and I.L. Rautenbach, Department of Biology, Carleton University, Ottawa, Canada K1S 5B6.

During April 1984 we used radio-tracking to study the foraging and roosting areas of two species of bats, *Epomophorus wahlbergi* and *Scotophilus leucogaster*. Both species are known to roost mainly in trees and we wanted to find out if either would adjust its roosting area to minimize commuting costs with respect to foraging areas. We studied eight *S. Leucogaster* (59 bat days in roosts), and 10 *E. wahlbergi* (164 bat days in roosts). Neither species showed evidence of adjusting roost site to minimize commuting costs. the *S. leucogaster* roosted in hollow mopane trees over 15 cm diameter breast height along the tops of ridges, and foraged widely over mopane woodland, riverine forest, and along river valleys. They consumed a wide range of insects, with beetles usually constituting 50% of their diet. The *E. wahlbergi* usually roosted in foliage in the riverine forest. One female, however, roosted in a shelter cave about 4 km from the riverine where she fed. The bats we studied frequently changed roost sites but there was no evidence of these changes being associated with feeding areas.

Refuging and Resource Roulette in *Carollia perspicillata*. Theodore H. Fleming, Department of Biology, University of Miami, Coral Gables, Florida 33124.

Refuging systems have been described as "the rhythmical dispersal of groups of animals from and their return to a fixed point in space" (Hamilton and Watt, 1970). A variety of organisms, including bees, birds, bats, and man, use refuging systems as a basis for their foraging or economic strategies. In most refuging species, density of foragers declines monotonically away from the refuge or roost, and an energetic tradeoff occurs between the distance traveled from the roost and the amount of intra-roost competition each individual experiences whenever food resources are limited. Whenever resources are homogeneously distributed around refuges, theory predicts that feeding sites at different distances from the refuge should be visited by a random sample of refuge inhabitants. I tested this prediction by examining the distribution patterns of marked individuals of the frugivorous bat *Corollia perspicillata* (Pthyllostomidae) roosting in three caves located up to 5 km apart in Santa Rosa National Park, northwestern Costa Rica over a year's cycle. In the year, bats were mist-netted, marked, and released at 17 sites at various distances from the three roosts, which contained 100-300 *Carollia* depending on the season. Results do not conform to predictions of refuging theory in at least two respects. First, bat density did not decline monotonically away from each roost. Instead, density of bats was more closely related to resource density than to distance from a roost. Second, non-roost sites did not contain random samples of the roost compositions, at least during the wet season (June through November) when resource densities are highest. Males tended to forage away from sites used by young bats. Spatial overlap between the foraging areas of the three roosts was relatively low in the wet season. Sex and age-related foraging differences disappeared during the dry season (December through May) when food resources are much more patchily distributed. At this time of the year, all bats flew long distances to ephemeral feeding sites, and spatial overlap between the foraging areas of the roosts was about twice as high as in the wet season. Seasonal changes in food availability thus appear to strongly influence the refuging behavior of *C. perspicillata*. Competition for food both within and between roosts appears to be higher in the dry season than in the wet season.

Sperm Morphology of Bats from 10 Families: Taxomonic Implications and Relationships at the Superfamilial Level. G. Lawrence Forman and James Dale Smith, Department of Biology, Rockford College, Rockford, Illinois 61101 and Department of Biological Sciences, California State University, Fullerton, California 92624.

The morphology of spermatozoa from males of 35 species representing 10 of the 19 currently recognized families is described. Spermatozoa from members of the following families are described and illustrated in detail for the first time; Pteropodidae, Emballonuridae, Noctilionidae, Nycteridae, Megadermatidae, Hipposideridae, Natalidae, Furipteridae, Thyropteridae, and Mormoopidae. Comparisons are made with other families for which descriptions are available. Within the Pteropodidae, subfamilies are highly distinctive, much more so than are the numerous subfamilies within the highly diversified New World Phyllostomidae, sometimes described as an ecological parallel to the Old World pteropodids. Spermatozoa of the Natalidae, Thyropteridae, and Mormoopidae are similar in general features, and all, especially the mormoopid studied (*Pteronotus parnelli*) are similar to the spermatozoa of phyllostomids. Sperm cells of *Noctilio albiventris* are remarkably distinctive in size, as well as structure. The cells of *Noctilio* stand apart as unusual within the mammalia, as well as amongst bats. The sperms of nycterids, a furipterid, and megadermatids readily distinguish each group at a familial level. Sperms of the Emballonuridae, Rhinolophidae, and Hipposideridae appear generalized, and perhaps represent retention of a primitive morphology.

Background Clutter Interference in Target Detection by Big Brown Bats, *Eptesicus fuscus*. Kristina Frederickson and Philip H.-S. Jen, Division of Biological Science, University of Missouri, Columbia, MO 65211.

Big brown bats, *Eptesicus fuscus*, use short multiple-harmonic frequency-modulated ultrasonic signals for detecting targets. A previous study showed that the bats reject clutter interference for moving targets more successfully than for stationary ones (McCarty and Jen, J. Comp. Physiol. 152:447-454, 1983). Another study indicated that when revolving and stationary targets were presented simultaneously, bats showed a preference to the revolving target over the stationary one. (Zhang and Jen, unpublished observation). In order to further study the effect of clutter interference on the bat's performance of detecting targets, we measured the correct responses of bats under the presence and absence of clutter interference, respectively. Four trained *Eptesicus fuscus*, were used for this study, which utilized an elevated Y-shaped platform containing a black box. The angle between two ramps was 60°. During the test, a semicircular brass target (thickness: 0.05 mm, radius: 16 mm) was randomly presented toward one ramp and the percent correct response was recorded. By means of electric motors the target was oscillated back and forth (amplitude: 3.8 cm, average speed: 6 cm) and revolved (300 or 1000 rpm) as desired. The initial bat-to-target distance was 30 cm, and this was then increased in 20 cm increments until it reached 110 cm. Frequency analysis of the background clutter (largely generated by the oscillating apparatus) revealed that it was mostly below 16 kHz. However, some noise with frequencies as high as 32-48 kHz were also included. Our results show that bats' correct response decreased with bat-to-target distance and increased with experience. As expected, the percent correct response of detecting a stationary target in the absence of the background clutter was higher than with the background clutter, regardless of the bat-to-target distance. In general, bats detected a stationary target more successfully in the absence of background clutter than a moving target in the presence of background clutter. In other words, the usual preference of a moving target over a stationary one by a bat can be overriden by the presence of the background clutter.

Excluding Housebats with Birdnetting. Stephen C. Franz, New York State Department of Health, Wadsworth Center for Laboratories and Research, Albany, NY 12201.

Circumstances frequently make it desirable to eliminate commensal bats from certain structures, particularly where there is a high risk of human contact (e.g. schools, hospitals, prisons). Most authorities agree that the best bat management strategy is exclusion (batproofing, denial of reentry) through some form of structural modification. From public health and conservation viewpoints, this is clearly superior to lethal measures. However, this approach has often been problematic because bats are able to enter very small openings and elimination of all such entry points often is not practical or economically feasible. The additional difficulty of high ladder work after dark required to close the last exit hole is a deterrent to many. A few exclusion devices have been developed for application when the exit holes are small in size and limited in number; these devices are not readily adaptable to many situations and may alter ventilation. Polypropylene birdnetting (originally developed to keep birds off orchard crops) was tested this past summer as a batproofing tool in four houses with roosting colonies of *Myotis lucifugus* and/or *Eptesicus fuscus*. This material can be readily applied to cover exit holes of various sizes, numbers and distribution. It can be used as a simple barrier to all passage or, perhaps more importantly, as a check-valve which only allows animals to exit and permits application during daylight hours. When used in this manner, bats were neither trapped inside nor driven into the occupied areas of the buildings. The method of attaching and draping the birdnetting is determined by architectural detail and flight pattern of the bats. The bats easily find their way out from under the flexible netting and do not become entangled in it. Upon returning, they swarm about near the hole nad repeatedly land on the netting. Since airflow and odor cues are not impeded by this material, bats' efforts to re-enter a building are not redirected to the margins of the netting and, ultimately, they go elsewhere. This material may be used as a temporary barrier in order to allow the homeowner time to seal the exit holes with caulking compound, repair a fascia board, etc. or it may be kept in place more or less permanently. Birdnetting proved to be (i) effective in excluding bats from structures, (ii) durable against climatic conditions and bats, (iii) practical and economical to apply, (iv) esthetically tolerable. As with other methods of exclusion, birdnetting should only be applied before the young are born or after they become volant. Most significantly, using birdnetting as a check-valve permits application while the structure is occupied by bats and people apparently without increasing the risk of bat-human contact.

Geographic Variation and Sexual Dimorphism in *Myotis lucifugus lucifugus*: Do Bigger Babies Make Bigger Mothers? M. Fujita, Department of Biology, Boston University, Boston MA 02215.

The wing and skull morphology of adult *Myotis lucifugus lucifugus* from Alberta and New England were examined. Two patterns of size differences were apparent, those associated with sexual dimorphism and those associated with geographic location. Principal component analyses were performed on 14 skull variables and three wing variables to generate separate factor scores describing the general size and shape of these morphological complexes. In addition, univariate character measures and ratios describing relative wing length and width adjusted for body size were compared between the sexes in each sample and between samples in each sex. Within the Alberta sample, females were significantly larger than males in characters describing wing morphology, but not those for the skull. Within the New England sample, females were significantly larger than males only in a few skull but no wing variables. Comparisons based on geographic location revealed that females from the Alberta sample were larger in all respects than those from the New England sample. Alberta males were also larger than New England males, but the differences were primarily in skull and not wing variables. The most striking pattern that emerged was the consistency with which Alberta females differed in wing morphology. Alberta females were larger in all pairwise comparisons, and especially in those characters which lead to greater lift capacity during flight. The increased size of the body (as measured by skull variables) and wings of Alberta females may be due to their larger offspring. In a separate study, I found that the growth rate (as measured by increases in forearm length) of Alberta juveniles was significantly less than that of New Hampshire juveniles. When growth rate is constrained by the lower ambient temperatures and shorter growing seasons found at high latitudes, increased size at birth may allow offspring to reach the same size as their lower-latitude counterparts before the first and most critical hibernation period. If this is the case, then selection favoring larger offspring in Alberta will also favor larger mothers who are capable of supporting and sustaining alarger fetus. Such selection would especially affect wing characters that result in a reduction of wing loading (Myers 1978). While a number of hypotheses exist which could explain size differences related to either sexual dimorphism or geographic variation as a result of selection operating on the adult phenotype, none explains the overall pattern of adult morphology described in this study of *Myotis l. lucifugus*. My observations on differences in adult size and on the development of offspring suggest that selection operating on the developmental stage may be at least as important in determining adult morphology as those factors affecting only the adult stage of the life history of this species.

Auditory Adaptations in Neotropical Moths: Coping with Quiet, High Frequency Bats. James H. Fullard and Jacqueline J. Belwood, Department of Biology, Erindale College, University of Toronto, Mississauga, Ontario Canada L5L 1C6 and Smithsonian Tropical Research Institute, APO Miami 34002, USA.

Two species of neotropical, notodontid moths from Panama (*Antaea lichyi* and *Hapigia curvlinea*) possess unique, external auditory structures that bear a striking resemblance to mammalian pinnae. The physiological effects of these structures were determined by a neurological examination of the moths' ears with the structures intact, obstructed or ablated. The modifications increase both the moths' ability to localize sounds and their sensitivity to high frequencies (greater than 70 kHz). In one species, *H. curvilinea*, interference with the structures resulted in total deafness to sounds above 115 kHz. The ears of *A. lichyi* were also examined responding to recorded echolocation calls of the insectivorous bats, *Myotis nigricans* (Vespertilionidae), *Tonatia sylvicola* (Phyllostomatidae) and *Pteronotus parnellii* (Mormoopidae) which are known to feed, at least in part, on moths. Large notodontid moths at the study site possess generally poor sensitivities and external auditory modifications may have evolved in these insects as a response to the predation pressures exerted upon them by the faint, high frequency echolocation signals emitted primarily by phyllostomatid bats.

The Barro Colorado Island Bat Project. Alfred L. Gardner, U.S. Fish and Wildlife Service, National Museum of Natural History, Washington, D.C. 20560

On Barro Colorado Island, Panama, a cooperative project of the U.S. Fish and Wildlife Service and the Smithsonian Institution marked bats and monitored seasonal and annual variation in their distribution, abundance, and natural history from 1975 through 1980. Data gathered shed light on population composition and stability; life expectancy and longevity; abundance; nightly, seasonal, and annual movements; synchrony of reproductive activity within and between species; timing of reproductive cycles; survival and dispersal of recruits; species diversity, flocking, and intra- and inter-specific relationships; day and night roost selection; roosting and feeding strategies; and social behavior. The project had the cooperation of the Smithsonian Tropical Research Institute, which provided facilities and access to an unmatched research reserve, and the National Zoological Park, which maintained colonies of bats that provided indispensable background information, particularly on reproductive cycles, growth rates, and feeding behavior. Barro Colorado Island harbors large populations of bats that feed on the fruit of canopy trees, especially figs. Although each fig tree fruits only once or twice per year, for about one week each time, these trees are abundant, and the asynchrony of their fruiting rhythms guarantees a fairly uniform abundance of figs over nine months of the year. From August to October, when figs are scarce, a variety of other fruits are available to replace them. This uniform food supply attracts a remarkably diverse guild of bats (body weights in parantheses): *Artibeus literatus* (69 g), *Artibeus jamaicensis* (50 g), *Vampyrodes caraccioli* (36 g), *Chiroderma villosum* (22 g), *Uroderma bilobatum* (18 g), *Vampyrops helleri* (16 g), *Artibeus watsoni* (13 g), *Artibeus phaeotis* (13 g), *Vampyressa nymphaea* (12 g), and *Vampyressa pusilla* (8 g). Although we marked all of the bats that we caught, we emphasized *Artibeus jamaicensis* because it is abundant (⅔ of the total bat catch on BCI), easily captured by conventional means (mist nets set at ground level), and responds well to handling and marking. Its range extends from Mexico south through Central and South America to Argentina, and includes most of the Antilles. Throughout this range, *A. jamaicensis* shows much diversity in feeding habits, roost sites, and activity patterns.

Bioenergetics of *Saccopteryx bilineata* (Emballonuridae). Michel Genoud and Frank J. Bonaccorso, Department of Biology, University of Florida, Gainesville, FLA 32611.

The thermoregulatory abilities if *Saccopteryx bilineata* and the microclimate in three daytime roosts were studied in lowland Moist Tropical Forest in Costa Rica. Sixteen individuals (mean body weight $= 8.3 \pm 0.5$ g) were mist netted either along trails in the evening or at their daytime roost in the morning. Their O_2-consumption, body temperature and thermal conductance at rest were measured at ambient temperatures ranging from 20 °C to 37.2 °C in an open air-flow respirometer. Oxygen concentration was measured with a 50cc Scholander gas analyzer. Between 20 °C and 30 °C, the animals usually remained normothermic (body temperature $= 35.5 \pm 1.2$ °C, $n = 11$) and their O_2-consumption was inversely related to the ambient temperature, T_a:VO_2 [mlO_2/gh °C] $=$ 12.26–0.35 T_a [°C] ($n = 11$). Their thermal conductance averaged 0.32 ± 0.03 mlO_2/gh °C, which is 92% of that expected from body mass. Two individuals entered torpor after the 2 hours of exposure to 20 °C, as evidenced by a lower rate of metabolism and a lower body temperature. The thermoneutral zone ranged from 30 °C to about 35 °C. The basal rate of metabolism equalled 1.86 ± 0.55 mlO_2/gh $n = 10$) which is only slightly lower (91%) than expected from body mass. An interesting feature is the very slight increase in thermal conductance that occurred at temperatures above 30 °C, leading to a steep increase in body temperature. *S. bilineata* utilizes the typical Emballonurid roosting posture, which minimizes contact with the vertical roost subtrate against which it clings, even at high experimental temperatures. Roost temperatures appeared to be very stable. Twenty-four hour recordings showed ambient temperatures ranging from 26.0 °C to 26.9 °C in two sites and temperatures from 26.4 °C to 27.5 °C were measured at noon in a third site.

Detection of a Target Under Different Conditions of Movement by the Big Brown Bat, *Eptesicus fuscus*. Carl Gold and Philip H.-S. Jen, Division of Biological Sciences, University of Missouri, Columbia, MO 65211.

Detection of a target presented under different conditions of movement by five trained *Eptesicus fuscus* was studied by utilizing an elevated Y-shaped platform containing a black box. The angle between two ramps was 60°. A semicircular target (thickness: 0.05 mm, radius: 10 mm) was randomly presented toward one ramp of the platform and the percent correct response was recorded. By means of electric motors, the target was oscillated back and forth (amplitude: 3.8 cm, average speed: 6 cm) and/or revolved (300, 600 or 800 rpm) as desired. The bat-to-target distance ranged from 30 to 110 cm. The frequency of the background noise was below 3 kHz which is outside the frequency range of the bat's echolocation pulses. The results showed that a bat's performance in percent correct response generally decreased with the bat-to-target distance. The percent correct response varied from 66% to 96% when the target was presented under different combinations of oscillation and revolution. The highest value was obtained when the target was oscillated at 6 cm/s and revolved at 600 rpm. Under all test conditions, the bats consistently showed a higher percent correct response for a moving target than for a stationary one. These data thus confirm previous findings that bats detect moving targets more successfully than stationary ones.

On the Geographic Distribution of Greater Antillean Bat Species. Thomas A. Griffiths and David Klingener, Department of Biology, Illinois Wesleyan University, Bloominton, IL 61702 and Department of Zoology, University of Massachusetts, Amherst, MA 01003.

Compilation and analysis of geographic distributions of all known living Antillean bat species reveal that there are two overall distributional patterns in Greater Antillean bats. The first, found among most of the earliest known bat colonizers of the Antilles, is a pattern where Cuban and Hispaniolan bats have a close taxonomic relationship, while Jamaican and Puerto Rican bats are more distantly related. This pattern supports either a limited vicariance model for early Antillean colonizers or, less likely, a dispersal model modified to take into account mid-Tertiary geography. The second, found among more recent bat colonizers, is a pattern of species buildup in the western Antillean islands of Cuba and Jamaica, with very limited dispersal eastward. The second pattern supports a dispersal model modified to take into account Pleistocene climatic cycles.

Hearing and Acoustic Communication in the Australian Ghost Bat. Anna Guppy, Roger B. Coles, and J.D. Pettigrew, Acoustic Laboratory, Research School of Biological Sciences, Australian National University, Canberra, A.C.T. 2601 Australia and Department of Physiology and Pharmacology, University of Queensland, St. Lucia, 4067 Australia.

The neural audiogram from the midbrain of the Australian ghost bat (*Macroderma gigas*) indicates that the auditory system has two frequency regions of high sensitivity. The high frequency region covers the range 32-45kHz which corresponds to the energy peak of the second harmonic of the echolocation call. The echolocation call is based on a modulated fundamental from 20-17kHz which is normally suppressed with most of the energy in the second and third harmonic. The low frequency region of the neural audiogram had extremely high sensitivity and occurs between 10-20kHz. This frequency band is used for social communication and several non-sonar vocalizations have energy peaks around 6-15kHz. The neural data indicates that auditory sensitivity is reduced sharply below 8kHz and above 50kHz suggesting that the frequency limits for hearing in the ghost bat extends from 3-100kHz. Social vocalizations such as the chirp, twitter and trill have song-like qualities with stereotyped amplitude and frequency modulated elements. Some communication calls such as the twitter, trill and rasp are used extensively within the day roost. The chirp call which has a main energy band between 8-15kHz also contains discrete ultrasonic elements. The frequency of chirping in the day roost increases towards dusk and at night the chirp is audible over long distances in the foraging areas. The chirp may function as a contact call or for spacing. There is also a "nocturnal scream" which is used by bats when they fly close to an object. The diet of the ghost bat indicates that it is an opportunistic feeder preying on small vertebrates such as birds, small mammals, frogs and other bats, as well as insects. The extreme sensitivity of the lower frequency hearing region in *M. gigas* supports the idea that Megadermatids may detect and localize prey by passive listening. In the field ghost bats are easily attracted by experimental sounds such as an Audubon bird caller or a played-back tape recording.

Scent Recognition Between Mother and Young *Tadarida braziliensis mexicana*. M.K. Gustin, Department of Zoology, University of Tennessee 37996.

Studies using genetic markers have shown that female *Tadarida braziliensis mexicana* selectively nurse their own pup or one of similar genotype. Several cues that females may use to relocate their young within maternity colonies are being investigated. These include memory of the pup's location in the creche, pup vocalization and, as will be discussed here, pup odor. Observations on captive colonies of several females and pups reveal that a female smells each approaching pup and accepts only her own pup for nursing. She pushes away or runs away from pups other than her own that attempt to nurse. Bioassays consisting of double blind, y-maze choice tests were conducted in which a mother was presented with odor from her own pup versus odor from a randomly chosen pup. Results show that mothers are very successful at discriminating odor from their own pups ($P > .001$). Since the mother's muzzle comes in contact with the pup repeatedly during the recognition and nursing, the pup may be marked with scent material produced by glands that are located on the mother's muzzle. To test this, bioassays were done to determine if lactating females could distinguish their own muzzle odor from that of a randomly chosen lactating female and if they responded similarly to to scent material from nonglandular areas of their own bodies. Females were significantly able to recognize their own muzzle odor (P .001), but they were not as successful at distinguishing between scent samples from lower back fur (P .076). Histological and biochemical analyses are currently underway to characterize the muzzle glands and the nature of the scent material used in marking pups.

Populations of Cave-Dwelling Bats in Pennsylvania. John S. Hall, Department of Biology, Albright College, Reading, PA 19603.

A survey of populations of cave-dwelling bats has been conducted in Pennsylvania since 1977. More than fifty caves and abandoned mines have been investigated. Emphasis has been placed on locating rare and endangered species of bats. Six species of bats can be found using caves and abandoned mines in the state, for winter hibernation and swarming activities throughout the summer months. The endangered Indiana Bat, *Myotis sodalis*, was originally found at 13 sites in the state between 1932 and 1945 by Charles Mohr, with the population numbering at least 5000 individuals. The little brown bat, *Myotis lucifugus* is the most abundant species in the state, with the largest hibernating colony found containing over 2000 individuals. The eastern pipistrel, *Pipistrellus subflavus*, is found in most caves, but usually only a few individuals in any one cave. Keen's bat, *Myotis keenii*, is rarely found hibernating in caves, but is commonly caught in mist-nets set up at cave entrances. The rare small-footed bat, *Myotis leibii*, has been found in less than ten caves in the state, with 15 individuals the most seen in any one cave. This species also is often caught in mist-nets at cave entrances.

Evolutionary Implications of Chromosomal Homology Among Four Genera of Emballonurid Bats. Craig S. Hood and Robert J. Baker, Department of Biological Sciences and The Museum, Texas Tech University, Lubbock, TX 79409.

Standard karyotypic data ara available for 9 of the 11 currently recognized genera of the chiropteran family Emballonuridae (Ray-Chaudhuri et al., 1971; Baker et al., 1982). In this paper, we examine the extent of chromosomal homology among seven species representing four genera (*Rhynchoncyteris, Saccopteryx, Cormura,* and *Taphozous*) using G- and C-band data. Heterochromatin is restricted to centrometric regions in all taxa except *Cormura*, which possesses large blocks of C-positive material extending proximally from the centromere. G-bands comparisons of euchromatic arms reveal that none of the arms of *Cormura* can be identified in the other emballonurids examined. Eight autosomal arms are shared among the genera *Rhynchonycteris, Saccopteryx,* and *Taphozous.* The autosomal arms of the three largest biarmed chromosomes are present in the three genera, but these have undergone translocation rearrangements to produce unique arm combinations. *Taphozous* and *Rhynchonycteris* share an unique arm combination, whereas the three species of *Saccopteryx* share another. *Saccopteryx bilineata* and *S. leptura* share two unique arm combinations when compared with *S. canescens*. G-band homologies between emballonurids and other microchiropteran families (Phyllostomidae and Rhinopomatidae) were not evident in our comparisons. Based on these results, chromosomal evolution within the Emballonuridae includes, 1) extensive reorganization of euchromatic linkage groups (e.g. *Cormura*), 2) conservation of autosomal arms in *Taphozous, Rhynchonycteris,* and *Saccopteryx*, and 3) translocation rearrangements of these autosomal arms within the latter genera.

Auditory Response Properties and Receptive Fields of Superior Collicular Neurons of Echolocating Bats. Philip H.-S. Jen, Xinde Sun, Tsutomu Kamada, Shangqing Zhang and Tateo Shimozawa, Division of Biological Sciences, University of Missouri, Columbia, MO 65211.

Echolocating bats have well-developed auditory systems to sense their environment. However, with the exception of the superior colliculus (SC), their visual centers are poorly developed. Because of this, bats probably do not make much use of their vision during hunting. Nevertheless, the moderate development of the SC suggests that it may play a role during echolocation. In particular, it may be involved in orienting a bat's head and pinnae toward an acoustic stimulus as suggested for other animals. We thus study the auditory response properties and the receptive fields of the SC neurons. We also examine how the auditory space is represented in this nucleus. Under free field acoustic stimulus conditions, electrophysiological properties of 279 SC neurons were studied by recording their responses to pure tone pulses and frequency-modulated (FM) stimuli. The SC neurons generally fired only a few action potentials to acoustic stimulus. The response latency of these neurons were between 3.6 and 20 msec, but the majority (253 neurons) were below 12.5 msec. According to the bandwidth, tuning curves of SC neurons were either narrow, intermediate or broad. $Q_{10\text{-}dB}$ values ranged between 1.21 and 68.9 but most were below 20. The minimum threshholds (MT) of SC neurons were between 15 and 105 dB SPL. SC neurons generally were most sensitive to downward sweeping FM stimuli and least sensitive to pure tone pulses. Each SC neuron had a circular or elliptical receptive field which could be defined in azimuth and elevation. The receptive field generally expanded with stimulus intensity although it was not always even in all directions. Within a receptive field, there is a best response center which is the point of maximal sensitivity. A study of the correlation of the best response center of each neuron with its recording site within the SC indicates that an orderly representation of the auditory space is not evident in this neural tissue. We suggest that an animal with highly mobile external ears may not need an orderly auditory space in its neural tissue for accurate sound locatization.

The Use of Doubly-Labeled Water for Measuring Energy Expenditure and Water Flux in Free-Living Bats. Thomas H. Kunz, Department of Biology, Boston University, Boston, MA 02215.

Until recently physiological measurements of field metabolic rate and water flux in free-living animals have been possible only by using various indirect estimates. Improvements in analytical methods, and reduced costs of isotopes and of isotope analysis makes it practical to apply the doubly-labeled water techniques in field situations. Field metabolic rates of free-living animals (including bats) can be determined accurately by measuring the differential turnover of isotopes of tritium or deuterium and oxygen-18 in body water. This approach is made possible because the oxygen of body water is lost as H_2O and CO_2, and the difference in turnover rates of hydrogen and oxygen isotopes provide a direct measure of CO_2 production. The doubly-labeled water technique has a sound biochemical basis and has been use successfully to accurately estimate metabolic rate and water flux in free-living animals, including insects, reptiles, birds, and small mammals. There have been no established studies on bats. There are some practical difficulties that must be overcome in the use of the doubly-labeled water technique. One is concerned with the organism itself, the other with isotope analysis and the verification of underlying assumptions. First, the organism needs to be captured twice, once for injection and initial isotope sampling and again for a second isotope sampling. Some bat species make ideal subjects for doubly-labeled water studies because of their strong roost fidelity, their synchronous reproductive cycles, and because selected individuals can be consistently captured and recaptured. Because of the solitary roosting habits of a few species and the highly gregarious nature of others, their use may be precluded in such studies. Potential errors associated with the use of doubly-labeled water are well known and they are by no means trivial. Some errors may be as high as ±70%, although careful choice of the study organism and of the sampling period can reduce overall errors to less than 10%. Some errors are unavoidable but their effects are considered to be negligible. Compared with indirect methods for estimating field metabolic rate, the use of doubly-labeled water in studies of bat ecology can yield direct estimates of field metabolic rates, foraging costs, and total body water flux (including milk output). When estimates of daily milk output are combined with estimates of energy content of milk, it will be possible to quantify the energetics of reproduction and post-natal growth in bats. Similarly, combined results from the doubly-labeled water method, field determined time-activity budgets, and measurements of roosting metabolism, can yield estimates of foraging in free-living bats.

The Insulative Value of Bat Nests: A Cooling Curve Analysis of Clustering within Wooden Cavities. Allen Kurta, Department of Biology, Boston University, Boston, MA 02215.

Although bats do not actually build nests, they do presumably take advantage of "ready-made" insulation such as leaves, hollow trees, or barn mortices. The extent of this potential insulation, however has never been quantified or experimentally examined. By using cooling curves of dead animals, I was able to determine the conductance and insulation of the little brown bat, *Myotis lucifigus*, under a variety of conditions. The insulation of a single bat is about 30.8°C/W. Cooling similar-sized bats within a 300-ml wooden cage showed a 29.9% increase in total insulation. The central bat within a cluster of seven animals had an insulation value 102.5% greater than that of a single bat. Placing the cluster within a wooden cage raised insulation to 110.3°C/W, an increase of 257.9%. In this last experiment, the tissue of the central bat provided 27.8% of the total insulation; another 28.4% came from the other six bats in the cluster, and the remaining 44% was attributed to the wood. Additional experiments showed that bats on the periphery of these small clusters cooled at the same rate as the central bats. Cooling curve experiments of single bats within wooden cavities of 900, 300, and 150 ml were also performed. The insulation of bats within the 150-and 300-ml cavities did not differ, but both provided about 28% more insulation than the 900-ml cavity.

Comparative Cytoarchitectonic Investigation of the Inferior Colliculus of *Eptesicus, Rousettus,* and *Cynopterus*. S.A. Larsen, Kunwar P. Bhatnagar and Ralph Lee Cox, Department of Anatomy, School of Medicine, University of Louisville, Louisville, KY 40292.

The Inferior colliculus (IC) is thought to localize sound in space and to process visual-auditory reflex activity. Bats demonstrate a great diversity of usage of the auditory system which is reflected in the unique anatomical features of the lower auditory brainstem. Unlike others mammals, bats may have an obligatory synapse in the IC. The purpose of this study is to correlate the inferior collicular cytoarchitecture with known behavioral differences in the auditory sense. Ten-micron thick serial paraffin sections of the brainstem of an echolocating bat (*Eptesicus fuscus*), a tongue-clicking bat (*Rousettus leschenaulti*), a non-echolocating bat (*Cynopterus sphinx*) were prepared in coronal, sagittal and horizontal planes and stained with cresyl violet. Another set of brainstems were prepared using rapid Golgi techniques. The entire extent of the IC in each series was drawn using a projection apparatus. Cytoarchitectonically, the IC of *Eptesicus* is highly cellular and densely packed with small neurons. There are larger neurons seen in a ventrolateral position exhibiting a dorsal and scattered arrangement as the rostral direction is reached. In *Rousettus*, the IC is also highly cellular with widely distributed large neurons seen throughout its extent. Some of these larger neurons form distant groups in the IC in a caudorostral direction. Compared to *Eptesicus* and *Rousettus*, the IC of *Cynopterus* is sparsely populated with both small and large sized neurons. The smaller ones are widely distributed, whereas, the larger neurons are gathered in small groups. Unlike the other two species, the IC of *Cynopterus* presents a distinct molecular layer with but few scattered neurons. Our preliminary observations based on the cytoarchitecture of inferior colliculus of the three species indicate that the organization of this structure exhibits distinct differences which can be readily correlated with echolocating behavior of the species.

Target Tracking by the Big Brown Bat, *Eptesicus fuscus*. W. Mitch Masters and Anne JM Moffat. Biology Department, University of Oregon, Eugene, OR 97403.

While echolocating bats are well-known to track and capture flying prey, little is known about the tracking strategy they use. Bats receive target position information non-continuously and might be expected to use one of two types of tracking strategies, predictive or non-predictive. With a predictive strategy the bat would try to anticipate the target's present or future position using, for instance, the last two known positions to compute its trajectory. Using a non-predictive strategy the bat would simply aim at the target's last known target and would always lag somewhat. Until now it has not been possible to distinguish between these two types of strategy because photographic techniques used hitherto have insufficient resolution. We have developed a new technique for monitoring one important part of the pursuit sequence, the bat's head aim, which gives us quite precise information on tracking accuracy. Two big brown bats were trained to sit on a platform and follow with their head the position of a target moving unpredictably along an arc in space in front of them. Head and target positions were both recorded. Generally the discrepancy between the two was at most a few degrees. By analyzing the 'errors' the bats make we conclude that they are most likely using a non-predictive tracking strategy and simply aim at the last known target position. While this at first seems like a sub-optimal technique it may actually be the most appropriate to use since prey may not fly in predictable patterns. Furthermore, by emitting sonar pulses at a high rate the tracking lag can be made very small.

Social Organization of *Artibeus jamaicensis* in Captivity. Elise Mayrand and Georg Baron, Department of Biological Sciences, University of Montreal, Montreal, Canada H3C 3J7.

A group of six *Artibeus jamaicensis* (2 males and 4 females) has been studied at the Centre de Recherches caraibes, Martinique, from April 1981 to August 1981. The bats, individually identified, were housed in an outdoor enclosure large enough to allow flight. A wooden roosting box communicated with the flight cage. Animals were fed ad.lib. with local fruits. Observations were made on a daily basis for a 2-hour period per night. Sessions were shifted in order to cover the whole night (from 18:00 to 6:00) in six days. The social interactions were recorded and the protagonists of each encounter were identified. The following behaviors were considered: sniffing, displacing, mounting, striking with the head or a folded wing, lateral contacts and forelimb appositions. Four scannings were done during each observation session in order to locate the bats in the enclosure and to identify the associations among them. In the roosting cage, *Artibeus jamaicensis* has social organization based on a polygynous system. Each male was seen to be associated with 1 to 3 females, but one of them (M1) had more success than the other since he has been seen more often together with females ($X^2 = 9.04$, $P = 0.01$, $df = 1$). M1 also showed more mounting, forelimb position, lateral contact and sniffing than M2 in his encounters with females. Mounting, striking of the head or the wing and displacing were frequently observed during male-male encounters, probably to prevent invasion of the territories. In contrast, females behaved quite independently. While the two males had moderately stable territories, females frequently relocated and changed partners. From these observations, females do not appear to (1) form stable social units or (2) to share a fixed area. Therefore the defense of the females by a male does not seem to be feasible and we can presume that polygyny must be based on resource defense (roosting places) rather than on female-groups defense. Resource-defense polygyny should evolve when a resource is limited so that only few males can benefit from it, or when its quality varies greatly in such a way that some of the males have better territories than others (Orians, 1969). In this study, the usable superficy for the establishment of territories was 2.5 m^2. As each male occupied a maximum of 0.25 m^2 we do not consider the roosting places to be limited. However, the quality of the roosting places within the enclosure is different. In fact, *Artibeus jamaicensis* strongly prefers roosts located at the top and in the corners of the cage probably to avoid disturbances. Since these differences are not prominent, other factors could be involved in this resource-defence polygyny. The harem system is not observed in the flight cage. Animals did not associate in social groups and showed significantly fewer interactions than in the roost ($X^2 = 247.14$, $P = 0.001$, $df = 1$) even if they were clumped in a corner of the flight cage. *Artibeus jamaicensis* probably does not defend territories on the feeding site as the only two individuals who had preferred roosts generally did not attempt to chase intruders. In the wild, the cost of territory maintenance on the feeding site is prohibitive for *Artibeus jamaicensis* because of the spatial and temporal distribution of the fruits which are available in locally superabondant patches (Morrison, 1979). Furthermore, males cannot support harems because they cannot energetically afford the defense of widely dispersed females. We can consider the situation in captivity to be similar to the situation in the wild: the fruits were presented in a single place preventing establishment of territories. In conclusion, harem organization is difficult to maintain outside the roosting place because (1) males cannot provide a protected resource to the females and (2) they cannot join a female group since the latter forage independently.

In-Cave Video Analysis of Pup Discrimination and Nursing Behavior in Maternity Colonies of *Tadarida brasiliensis mexicana*. Gary F. McCracken, Department of Zoology, University of Tennessee, Knoxville, TN 37996.

Recent research on nursing behavior in *Tadarida brasiliensis mexicana* has shown that auditory and olfactory information is available and may be used by a lactating female to discriminate and selectively feed her own pup within the enormous maternity colonies (creches) that are characteristic of these bats. Although colonies may consist of several million individuals, precise or approximately knowledge of where in the cave a female can expect to find her pup may greatly limit the number of pups a female must discriminate among. Study of the daily movements of marked individuals shows that juveniles are capable of moving substantial distances and that individuals marked while roosting adjacently move independently of one another. The mean straight-line distance moved during the first 24 hours after marking (Y = 44.45 ± 27.89 cm) was not significantly different from movements in subsequent 24 hour periods (Y = 49.40 ± 26.90 cm; .5 P .9; t-test), demonstrating that the disturbance caused by marking did not result in increased movement. Use of video within natural roosts has allowed observation of female behavior and mapping of female movements from when they land on the creche until they find and nurse their pups. For six searches that have been mapped to date, the mean straight-line distance from where a female landed to where she found her pup was 40.63 ± 31.84 cm. The longest search mapped involved a straight-line distance of 90.24 cm from the location of landing to the location of pup. Treating this distance as the radius of a circle with the landing location as its center, and given a mean density of 1 pup/5 cm^2 within the creche, I estimate that this female was capable of discriminating among approximately 5000 pups. These video analyses also are valuable in answering or providing insight to many other questions regarding the searching and pup discrimination behaviors that allow selective nursing in these colonies.

Lunarphilia: Goatsuckers Are Not Bats. A. Mills, Department of Biology, Carleton University, Ottawa, Canada K1S 5B6.

Most nocturnal flying insectivores are bats and all of them rely to some extent on echolocation for orientation and for the detection of prey. A significant number of birds, however, are also nocturnal insectivores, most of them in the family Caprimulgidae, the goatsuckers. There is no evidence that the insectivorous caprimulgiforms rely on echolocation for orientation or locating prey. I found that Whip-poor-wills (*Caprimulgus vociferus*) in Ontario showed a positive correlation of their territorial, feeding and reproductive activity with bright moonlight, suggesting that vision plays an important role in orientation. In contrast, lunar phobia seems more typical of bats.

Long-Term Changes in Harems of the Fruit Bat *Artibeus jamaicensis*. Douglas W. Morrison and Charles O. Handley, Jr., Department of Zoology, Rutgers University, Newark, New Jersey 07102 and Division of Mammals, Smithsonian Institution, Washington, D.C. 20560.

On Barro Colorado Island, Panama, the fruit bat *Artibeus jamaicensis* has a harem mating system based on male defense of tree hollows used as day roosts by females. Previously reported radio-telemetry and infrared observations made during an 8-week breeding season (Morrison and Morrison 1983; Ecology 49:684-686) revealed that: (a) harem females scatter widely when foraging and so are indefensible away from the roost; (b) harem males spend most (greater than 90%) of the night within 50-100 m of their roost hole, frequently flying to inspect the entrance, chase off intruders, or escort returning females. We here report the results of 2 longer term studies designed to determine when and why females join harems. STUDY 1: In 3 years of mark-recapture records on 88 adults from 2 roosts: (a) tenures of the 7 harem males ranged from less than 3 to greater than 17 months. One was able to regain his exclusive position after being replaced. Other males were tolerated only while they were juveniles; (b) tenures of the 44 females recaptured 1-6 times averaged 14 + 9 months, including 14 females in residence for greater than 2 years. Females seem to be more attached to the roost site than to the harem male; (c) juvenile females did not become members of their mother's harem, but joined other harems as subadults. STUDY 2: Forty artificial tree hollows were inspected for 14 months to determine whether suitable holes are first colonized by females (with a male appending himself later), or whether the holes are first used by a male who than recruits females. Unfortunately, no bats were among the many species found in the artificial hollows, so the question remains as to whether or not suitable tree holes are a limiting resource.

Distribution of Five Neuropeptides in the Stomachs of Selected Genera of Bats. Carleton J. Phillips, Department of Biology, Hofstra University, Hempstead, NY 11550.

Previous investigations have revealed numerous microanatomical, interspecific, differences in the gastric mucosa of bats. Some of these differences can be related to diet, whereas others can be correlated with systematic relationships. One area of special interest is the entero-endocrine cells, which differ in numbers and type. To elucidate such differences, immunohistochemical techniques were employed for localization if neurotensin, vasoactive intestinal peptide (VIP), glucagon, serotonin, and somatostatin in the gastric mucosa of species of *Cynopterus, Eonycteris, Megaderma, Rhinolophus,* and *Pipistrellus*. No two genera were exactly the same when compared as to presence or absence or distribution of this set of neuropeptides. Furthermore, distinct differences also were found in localization of neuropeptides in either 1) entero-endocrine cells, 2) nerve cell bodies, or 3) fine nerve fibers. Neurotensin was never found in entero-endocrine cells and seemingly is lacking in

Eonycteris and *Pipistrellus*. VIP was localized in either nerve cell bodies or fine fibers in all five species. Glucagon was not found in *Cynopterus* but was found in entero-endocrine cells of the remaining species. Serotonin (5HT) and somatostatin were found in entero-endocrine cells of all five species, but in differing abundance. *Rhinolophus* differed from all other genera in having positive reactions to all five neuropeptides in nerve cell bodies. Distribution and presence or absence of the five neuropeptides could not be correlated in a general way to diet or to systematics but instead seemed to correlate to general structural features of the gastric mucosa.

The G- and C-Band Karyotypes of the Rhinopomatidae (Microchiroptera). Mazin B. Qumsiyeh and Robert J. Baker, Department of Biological Sciences and The Museum, Texas Tech University, Lubbock, TX 79409.

G- and C-band karyotypes of *Phinopoma hardwickei* (2n = 36, FN = 68) and *R. microphyllum* (2n = 42, FN = 66) are presented and compared. The differences are explained by three fusion/fissions and two inversions. Heterochromatin is restricted to the centromeric regions in both species. To test the conclusion of Ray-Chaudhuri et al. (1968) based on standard karyotypes that the Megachiroptera should show close genetic affinities to the Rhinopomatidae, we have compared the G-banded karyotypes of *Rousettus* and *Rhinopoma* and found only five shared autosomal arms. On the other hand, there are many shared arms between *Rhinopoma* and *Macrotus waterhousii* proposed as primitive for the Family Phyllostomidae. Conclusions are 1) similarities in standard karyotype between *Rhinopoma* and *Rousettus* do not indicate a close genetic linkage relationship, and 2) during the evolution of the Microchiroptera, some linkage groups were conserved and can be identified in both the Rhinopomatidae and Phyllostomidae.

The Energetics of Reproduction in *Eptesicus fuscus*, the Big Brown Bat. Holly Stack, Department of Biology, Boston University, Boston, MA 02215.

The energy dynamics of reproductive female and juvenile big brown bats (*Eptesicus fuscus*) were investigated. The energy allocated to production was determined by body composition analysis and the energy devoted to maintenance was determined by metabolism studies. The large increase in mass of pregnant females seen was due not only to the growth of embryos, but also to a mid-pregnancy storage of fat, where the fraction of body fat increased by 68% in one week. By parturition, the energy content of embryo biomass (two embryos) was estimated at 8.04 kcal, and the average growth rate over the six weeks of pregnancy was 0.19 kcal/day. Lactation was characterized by a decline over the first two weeks in total mass (15%), fat (54%), lean dry mass (10%) and energy content (32%) due to the high energy demand by offspring. By 18 days of age (the oldest age at which juveniles are still fully dependent on the mother for energy), two juveniles had an energy content of 33.23 kcal, corresponding to an average growth rate over the first 18 days of lactation of 1.40 kcal/day. The maintenance cost of reproductive females was estimated for 3 hours of flight (5.37-7.34 kcal/day) and for 21 hours of roosting (1.69-2.53 kcal/day). The relatively large proportion of energy which was estimated to be allocated to production is likely due to the conservation of maintenance energy by daily torpor and a low basal metabolic rate.

Sensory Modalities Used in Food Location by Two Species of Phyllostomid Bats. Mike Stoneman, Department of Biology, Carleton University, Ottawa, Ontario, Canada K1S 5B6.

This is a preliminary report based on the initial findings of laboratory experiments on two species of Phyllostomids; *Glossophaga soricina* and *Artibeus jamaicensis*. *G. soricina* are small (about 9 gm.) nectar feeders while *A. jamaicensis* are much larger (40 gm.) frugivores. To examine this question, the bats are being trained to perform discrimination tasks designed to test the acuity of their senses. Manipulations of the expermental conditions will be performed to determine which senses the bats use to locate the target and to determine the degree of sensory flexibility the bats are capable of. One would predict that the nectarivorous *Glossophaga* and the frugivorous *Artibeus* would rely more on olfaction than would insectivorous bats. Records of *Glossophaga* pursuing and capturing flying insects at night suggest that they possess a well developed echolocatory ability while the relativel larger eyes of the *Artibeus* may indicate a greater role of visual cues. The correlation between feeding method and sensory modality will be examined in light of the findings available to date.

Vocal Efficiency of Echolating Bats. Roderick A. Suthers, School of Medicine and Department of Biology, Indiana University, Bloomington, Indiana 47405.

The energetic cost of echolocation is of particular interest since many bats continually emit high intensity ultrasonic pulses during flight. Our data indicate that echolocating bats have maximized the efficiency with which they convert fluid energy in the airways into the acoustic energy of the radiated sonar pulse. The ratio of the radiated acoustic power to the fluid subglottic power is termed vocal efficiency. The mean subglottic power during the peak amplitude CF portion of these 100 dB SPL (sound pressure level) sonar pulses was from 10.3 to 23.6 mW. This is equivalent to a sound power output of about 1 W/kg. The radiated acoustic power was estimated from the directivity of sonar pulses emitted under the experimental conditions. The acoustic power of the bat's sonar pulse was calculated as if all of the sound energy radiated uniformly over the area subtended by an angle of 20° around the principal acoustic axis. Based on this conservative assumption, the vocal efficiency of these four bats ranged from 7 to 16%. The moustache bat thus appears to be about two orders of magnitude more efficient than man, in converting subglottic power into radiated acoustic power. Efficient production of sonar pulses may be an important factor in the evolution of echolocation.

An Update on Bat Conservation and the Activities of Bat Conservation International. Merlin D. Tuttle, Vertebrate Division, Milwaukee Public Museum, Milwaukee, WI 53233.

Current problems, such as flying fox eradication in Australia and mine capping in the United States will be discussed, and Bat Conservation International progress will be reported. Thus far in 1984, 400 slide/tape programs and 100,000 brochures on bat conservation have been produced in cooperation with the U.S. Fish and Wildlife Service, and a million new color brochures have been published by Bacardi Imports. BCI additionally has begun publication of a quarterly newsletter and has greatly influenced the content of numerous media articles and programs about bats. Membership is steadily increasing. Top businessmen have been added to the board of directors, and a scientific advisory board has been established. Fundraising for conservation related to research will begin soon.

Mate Selection by Female *Myotis lucifugus*. Virginia Wai-Ping, Department of Biology, Carleton University, Ottawa, Canada K1S 5B6.

The mating system of *Myotis lucifugus* has been described as random and promiscuous and during active mating (as opposed to mating occurring when most of the bat population is hibernating), groups of bats form around adult males. There appear to be three weight categories of adult males during the period of active mating: males weighing less than adult females, males weighing the same as adult females, and males significantly heavier than adult females. The purpose of this study was to assess the role of male size in mate selection by females and preliminary results from sites in Ontario will be presented. The results of presentation experiments will be discussed in the light of female choice in this mating system.

Population Biology of *Artibeus jamaicensis* on Barro Colorado Island. Don E. Wilson, U.S. Fish and Wildlife Service, National Museum of Natural History, Washington, D.C. 20560.

Artibeus jamaicensis is a fifty-gram frugivore that eats roughly its weight in fruit every night. These bats prefer figs and often seek them out when other types of fruit they eat are far more abundant. They commute several hundred meters, on the average, to feeding trees, feeding from one to four trees in a single night, and returning to the same tree an average of four nights in succession. They tend to fly farther when fewer fig trees are bearing ripe fruit, and they feed from fewer trees, on the average, when the moon is nearly full. These bats, like their congeners, do not feed in the tree. They select a fruit and carry it to a feeding roost typically 100 m away before eating it, and bats are often netted while carrying fruit, revealing their diet. The juice and seeds of the fruit are swallowed, but the skin and pulp are spit out as pellets. Fruit passes through the alimentary tract of an *Artibeus* in about half an hour and the seeds remain intact, so the feces also reveal dietary information. Adult female *Artibeus jamaicensis* live in harems of three to twenty-five with a single adult male. On Barro Colorado Island these groups roost during the day in hollow trees. There is presumably a large population of surplus males that roost together with non-adults of both sexes in foliage. Females commute an average of 600 m from day roost to feeding site, and males travel less than half as far. Most females gave birth to a single young twice a year, once in March or April, and again in July or August. Gestation time averages about 19 weeks. Juveniles are first netted when they are about 10 weeks old, and females usually first bear young, thereby reaching the age of adultery, in March or April following their year of birth. We estimate that the population of *Artibeus jamaicensis* on Barro Colorado Island numbers about 4,000. Some of these individuals forage at times on the mainland, resulting in an estimated density of 200 *Artibeus jamaicensis* per km^2. The average survival rate of our marked animals is about 50% a year, and rarely do animals live longer than 10 years in the wild. In captivity, males outnumber females at birth by 54:46; in wild caught animals the ratio is 52:48. For subadult and adult animals, the ratio is reversed to 45:55, both in captivity and in the wild.