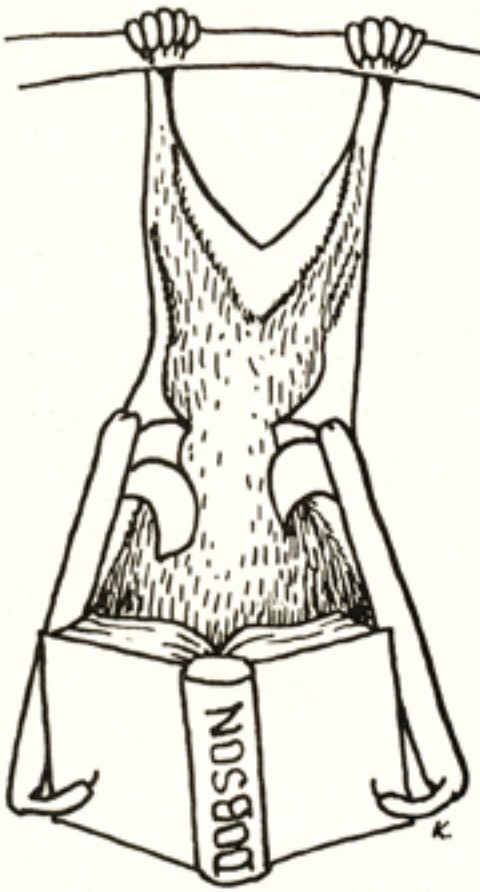
BAT RESEARCH NEWS



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BAT RESEARCH NEWS

Table of Contents for Volume 30, 1989

BAT RESEARCH NEWS

Table of Contents for Volume 30, 1989

(continued)

Volume 30: Number 4, Winter 1989

BAT RESEARCH NEWS

Publisher and Managing Editor

Dr. G. Roy Horst
Department of Biology
State University College at Potsdam
Potsdam, New York 13676 USA
Tel.: 315–267–2259

Editor

Dr. Thomas Griffiths
Department of Biology
Illinois Wesleyan University
Bloomington, Illinois 61702 USA
Tel.: 309–556–3230

Editor for Reviews

Dr. Peter V. August
Department of Natural Resource Science
University of Rhode Island
Kingston, Rhode Island 02881
Tel.: 401–783–4032

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BAT RESEARCH NEWS

Volume 30 Spring Number 1

A Portable Mist Netting System for Capturing Bats with Emphasis on *Myotis sodalis* (Indiana bat)

James E. Gardner, James D. Garner and Joyce E. Hofmann

Illinois Natural History Survey
172 Natural Resources Building
607 E. Peabody Drive
Champaign, Illinois 61820
(JEG and JEH)
and
Division of Natural Heritage
Illinois Department of Conservation
Lincoln Tower Plaza
524 South 2nd St.
Springfield, Illinois 62706
(JDG)

INTRODUCTION

Biologists have used Japanese mist nets to capture bats ever since they adopted the idea from ornithologists. Although there have been some exciting advances in the techniques and equipment used to study bats (e.g., ultrasonic detectors and superminiature transmitters), mist netting remains the most reliable and effective method of capturing bats at foraging sites and along flyways. Basic netting techniques have changed very little over the years, but heavy nylon nets of terylene have been replaced by lighter, less visible monofilament nets.

Black, monofilament Japanese mist nets of 1 1/2-inch (38-mm) mesh are the best available for capturing small- to medium-sized bats. Each net usually has four shelves and can be spread to a maximum height of 7 ft (2.1 m). Nets are available in lengths of 18 ft (5.5 m), 30 ft (9.1 m), 42 ft (12.8 m), and 60 ft (18.3 m) but stretch 2-3 ft longer with use. Although monofilament nets greatly increase the potential for capturing wary species (i.e., *Myotis*), techniques for positioning the nets greatly affect capture success. For instance, single nets placed over isolated water holes or along flyways are likely to capture only those species that fly below 7 ft (2.1 m) to drink or forage. When the nets are positioned higher, the problem becomes how to retrieve entangled bats in an expedient and responsible manner.

In the past, nets had been raised into the forest canopy to capture bats as they foraged, but not without great difficulty and expense. Furthermore, these ar-

rangements usually were fixed at one location and suitable only in limited situations (e.g., where tree limbs were available). Humphrey *et al.* (1977) were among the first to suspend four mist nets above one another between steel poles 30 ft (9.1 m) high. The nets were positioned permanently and raised and lowered by a hand winch, ropes, and pulleys. During ecological studies of Missouri bats, LaVal and LaVal (1980) stacked three mist nets vertically and used a portable, pulley-operated device for raising and lowering them. Their system proved successful but was expensive to construct and difficult to assemble and position in the field. Other researchers have successfully employed other stacking methods using rope and pulley devices (Cope *et al.*, 1978; Brack, 1979; Clawson, 1986; Clark *et al.*, 1987). More recently, Kunz and Kurta (1988) described how mist nets could be stacked on poles to capture bats more than 7 ft (2.1 m) above ground.

In 1980, Gardner and Gardner conducted a study to determine the presence of the Indiana bat (*Myotis sodalis*) in riparian habitat in west-central Illinois. To capture bats as they foraged high above the stream, they developed a high net-set that allowed a wall of four mist nets to be raised to a height of 30 ft (9.1 m) and then lowered quickly and easily to retrieve bats captured in the upper shelves. This same inexpensive high net-set has proved durable and reliable throughout seven years of field work; only once have the nylon ropes had to be replaced. Since 1980, no less than fifteen net-sets, with only minor modifications, have been made. These replications were used to capture bats during research projects located in a variety of situations (e.g., Rabinowitz, 1982; Klaas,1986; K. Tyrell, University of Illinois, pers. comm.).

Thirty-foot poles were not used at every netting site because canopies at some sites were lower. In these instances, a 20-ft set was used. Procedures to modify the basic 30-ft high net-set to a 20-ft set are explained below.

CONSTRUCTION

The netting equipment described below allows mist nets of equal length to be stacked vertically with the end loops attached by a rope and pulley to pairs of interlocking antenna masts. The interlocking sections of antenna mast (each 10 ft in length) can be purchased from most radio, television, and electronics outlets. The remaining materials (see list) can be acquired at a hardware store. Construction requires only ordinary tools, and the entire assembly (excluding the mist nets) costs less than $150.00.

Pole Assembly

Connect three 10-ft mast sections to make a 30-ft pole; repeat for the second pole. Drill a 3/8-inch hole one inch from the top of each pole. Drill another 3/8-inch hole two inches from the top of each pole; make sure these holes are parallel to each other. Drill a 3/8-inch hole approximately 24- inches up from the bottom of each pole; make sure these holes are parallel to the top holes. Attach three 5/16-inch stainless steel eye bolts to each pole, using lock washers and nuts. Take care that the uppermost eye bolt and the eye bolt at the bottom of the unit face the same direction. The eye bolt two inches from the top of each pole must face the opposite direction. Attach the 1/4-inch lap link to the top eye bolt of *one* pole. When you position the poles, the lap link will allow the top line to be pulled through freely without pinching between the pulley eye and the eye bolt. Strips of self-adhesive reflective tape may be attached to each pole at 1-m intervals (beginning from the bottom) so that the height of bats captured in the nets can be determined easily. Mark sections that belong together for faster and easier assembly in the field. To disassemble, disconnect the poles and bind them together securely with strong straps.

Materials needed to construct a portable mist-net system 30 ft high

Quantity	Size	Description
6	10' x 1 1/2"	interlocking, aluminum antenna mast
6	2" x 5/16"	stainless steel eye bolt (+lock washer and nut)
4	1 1/2"	swivel eye pulley (fixed eye may be substituted)
4	1/4"	trigger snap (dog leash snap)
4	5/16"	rope clamp (compression type)
3	3/4"	snap hook
1	1/4"	lap link (cold shut)
2	54' x 3/8"	solid nylon rope (pulley rope)
2	6' x 3/8"	solid nylon rope (tension rope)
2	100' x 1/4"	solid nylon rope (guy rope)
1	120' x 1/8"	solid nylon rope (top line)

3	8" x 3" x 3/4"	length of wood (rope spool)

Additional materials needed to construct 20-ft pulley ropes

4	1 1/2"	swivel eye pulley
2	1/4"	trigger snap
4	5/16"	rope clamp
2	3/4"	snap hook
2	34' x 3/8"	solid nylon rope (pulley rope)
2	6' x 3/8"	solid nylon rope (tension rope)

Pulley Rope Assembly (Figure 1)

Feed one end of a 54-ft nylon rope through two pulleys and attach it to the fixed end of a 1/4-inch trigger snap using a rope clamp (knots will work if tied securely). Use another rope clamp to make a 3-inch loop with the other end of the rope, and hook the trigger snap into this loop, creating a 27-ft pulley rope assembly. Finally, tie a 6-ft tension rope securely to the eye of one pulley. Repeat for the second pole. To prevent tangling, coil the pulley rope assemblies and bind with the attached tension rope. If desired, 20-ft pulley ropes can be assembled in the same manner using 34-ft rope lengths.

Guy Rope Assembly

Locate the middle of a 100-ft rope and firmly attach it to the fixed end of a 1/4-inch trigger snap. Holding the free ends of the rope together, wind them simultaneously around a wooden spool. End the wrap with the trigger snap free on the spool so that the snap can be hooked into the eye bolt first during assembly in the field and the guy ropes will unwind without tangling. Repeat this step for the other pole.

Top Line

Attach one end of the 120-ft rope securely to a 3/4-inch snap hook. Wrap this rope around a wooden spool, beginning with the free end so that the snap hook is on top.

FIELD ASSEMBLY AND POSITIONING

Fully assembled and adjusted, the high netting poles are free-standing and extremely stable (Figure 2). They have withstood floods, buffeting by heavy branches and high winds, and the curiosity of livestock. Two persons can maneuver the 48-lb (22-kg) bundle of six

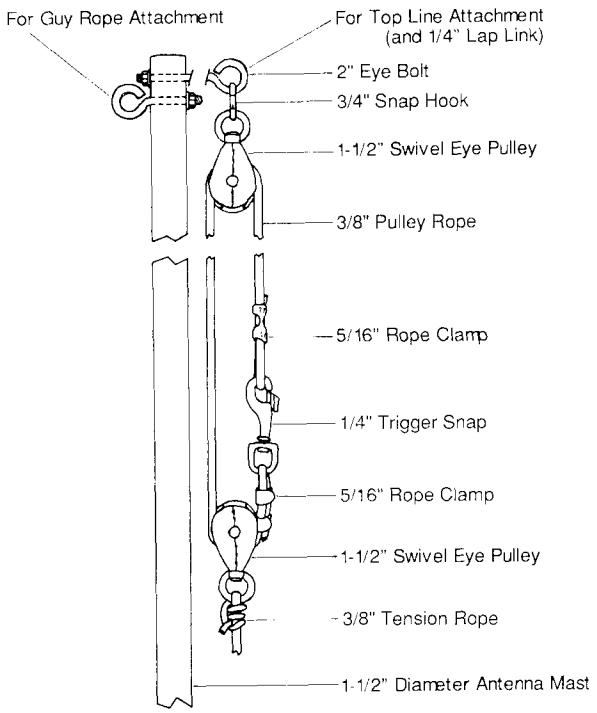

Figure 1. Diagram showing pulley rope assembly for the high net-set and its attachment to the pole.

poles through dense brush and over moderately rough terrain. The two pulley ropes, the two spools of guy rope, the spool of top line, and the mist nets fit easily into a small daypack.

The high net-set can be positioned immediately behind or underneath natural canopies created by tree limbs overhanging streams or other flyway corridors. If the correct pole height and length of mist nets are chosen, a netting plane can be created between the canopy and the ground (water) level that effectively closes off the flyway. In addition, the investigator may choose to position a single net at ground (water) level, adjacent to the high net set, to close the lower 3 ft of the flyway.

Some situations do not allow 30-ft poles to be positioned. In these instances, the middle sections of the 30-ft poles are removed and pairs of 17-ft pulley ropes substituted for the 27-ft ones. This option and an assortment of mist-net lengths give the investigator a great deal of flexibility in choosing the best netting position.

Assembly

Interlock the poles and lay them on the ground with the uppermost eye bolt pointing up (the lowermost eye bolt will also point up). Attach the pulley for each pole,

without the tension rope tied to it, to the uppermost eye bolt using a 3/4-inch snap hook. Unravel the pulley rope and tie the 6-ft tension rope to the bottom eye bolt. Remove most of the slack in the pulley rope by applying only moderate tension at this time (less tension makes attaching the mist nets easier).

Attach the trigger snap of each guy rope to the lower of the two eye bolts at the top of each pole. Unwind the guy ropes from the spool and lay them parallel to the pole. Untangling the two strands now will facilitate securing the free ends when the poles are upright.

On the pole *without* a lap link, fasten the snap hook of the top line to the topmost eye bolt to which you have already attached the pulley. Unwind the entire top line from its spool, pass the free end through the lap link on the other pole and tie the end temporarily to the eye bolt at the bottom of the other pole (slack will be taken out of the top line when both poles are positioned).

Positioning

Two persons are essential to position the poles. Mark the positions for the poles so that the distance between them will equal the length of mist nets plus 2 - 3 ft. Place the bottom of one pole on one mark and slowly raise the pole. One person steps firmly down on the base end of the pole while the other person raises the pole. Take care that the guy ropes and the top line don't become entangled. As one person holds the pole perpendicular to the ground, the other ties the free ends of the guy ropes to a tree, root, or other anchor. When tension has been put on the guys, the pole can be leaned into tree branches or against a steep bank while the second pole is positioned. (A third person to hold the first pole upright is helpful but not necessary.)

Place the bottom of the second pole on the other mark and raise it in a similar manner. Tighten the guy ropes, taking care to position the pole perpendicular to the ground. With each person holding one pole upright, remove the slack in the top line by pulling down on the end tied to the eye bolt. Adjust the tension and retie the top line. The poles should now be free-standing; however, tension on the guy ropes and/or the top line may need adjustments to ensure perpendicular positioning and correct spacing. When extremely soft substrate is encountered, a board, log, or flat rock may need to be placed beneath the poles to prevent them from sinking excessively. A soft substrate can be a great advantage because the bottoms of the poles can be shoved into it to hold them upright while tying ropes.

Mist Net Attachment

Four mist nets can be stacked onto a 30-ft pole but the lower two shelves of the bottom net cannot be spread into a capture position. When 20-ft poles are used, only three mist nets can be stacked onto the pulley ropes.

When the top strand (usually a double line) of the mist net is found and the end loops have been arranged in proper order, the net is ready to be attached to the pulley rope. Unhook the trigger snap from the three-inch loop, pass the rope loop through the end loops of the mist net, and rehook the trigger snap. Then carefully unfold and attach the net to the pulley rope on the opposite pole in the same manner. The top strand and its loops must remain on top along the entire length of the net. Attach the other nets in a similar fashion. After all nets are attached, place more tension on the nets by tightening the 6-ft tension rope. Thirty-foot poles may bow up to 8 inch from vertical when tension is applied. There should be enough tension in the mist nets to create ample friction in the end loops and prevent them from sliding freely on the pulley rope when they are spread apart and raised.

Although often disregarded, an important detail in increasing netting efficiency is tying together the bottoms and tops of successive nets. Tying prevents bat-sized gaps between nets. After the mist nets have been stacked onto the pulley ropes, the bottom strand of the topmost net and the top strand of the second net can be tied together with small pieces of string. The bottom strand of the second net and the top strand of the third net can then be tied, and so on. Eighteen-foot nets need be tied in this manner only in the middle, but 30-ft and 42-ft nets should be tied every 10 ft and 60-ft nets every 15 ft. Refer to Kunz and Kurta (1988) for further descriptions of techniques for handling mist nets.

RESULTS USING HIGH NET SETS

High net-sets were used to capture bats at 189 sites in Illinois during a seven-year period (Table 1). During 249 net nights, 1,421 bats were captured. Twelve species known to have breeding populations in the state were represented: *Myotis austroriparius*, *M. grisescens*, *M. keenii*, *M. lucifugus*, *M. sodalis*, *Lasiurus borealis*, *L. cinereus*, *Lasionycteris noctivagans*, *Pipistrellus subflavus*, *Plecotus rafinesquii*, *Eptesicus fuscus*, and *Nycticeius humeralis*. High net-sets for mist netting were considered especially effective because 125 individuals of the federally endangered *M. sodalis* were captured.

More than 57% of 1,052 bats of eleven species (excluding *M. sodalis*) captured from 1985 through 1988 (Table 2) were captured at heights exceeding 7 ft (2.1 m). Of 103 *M. sodalis* captured during the four year period (Table 2), 65% (n=66) were captured at heights exceeding 7 ft (2.1 m). Forty-seven *M. sodalis* (46% of the total captures of this species) were captured between 7 ft and 13 ft (2.1 m to 4 m) above ground (water).

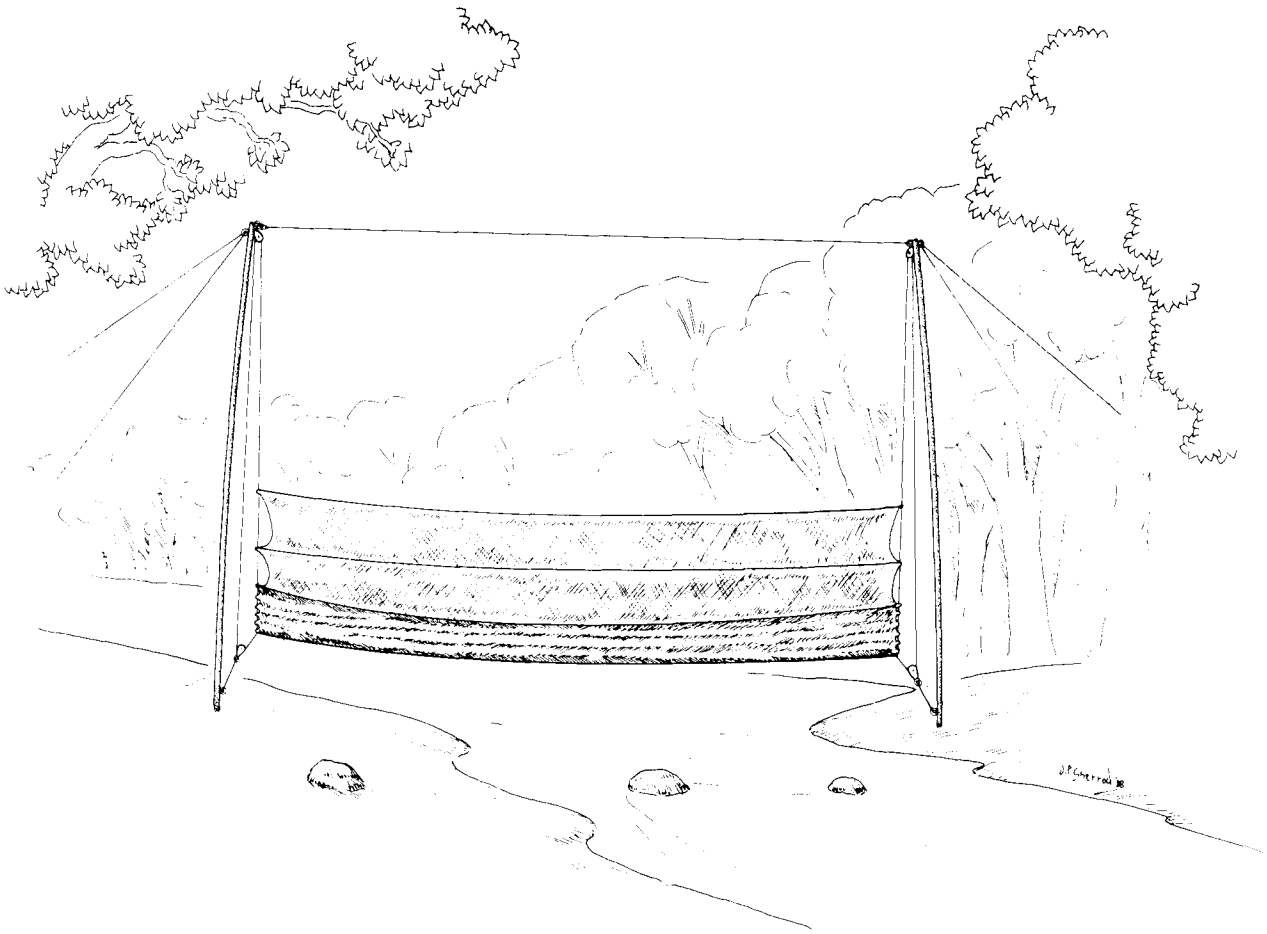

Figure 2. Diagram of free-standing net as it appears when correctly assembled and positioned over a stream with the mist nets partially raised.

Nineteen *M. sodalis* (18%) were captured above 13 ft (4.1 m).

DISCUSSION

The advantage of stacking three or four nets vertically is evident from the heights at which bats were captured in the nets during four years of mist netting in Illinois (Table 2). If single, low nets had been used instead of high net-sets, 672 bats might not have been captured. In fact, *Myotis sodalis* would not have been captured at 14 of 28 netting sites where they were captured if high net-sets had not been used. This observation applies at a few sites for other species as well (e.g., *M. austroriparius* and *P. rafinesquii).*

Poles from the high net-set with pulley ropes attached are useful for purposes other than mist netting bats over streams or other flyways. For instance, when bat traps were used to capture bats at large cave and mine entrances in Illinois, high net-sets were positioned on either side of the cave or mine entrance and heavy garden netting was attached to the trigger snap of each pulley rope. The netting was raised up beyond the ceiling of the entrance and the bottom of the netting was draped around the trap to seal-off the large opening. In this manner, bats exiting the cave or mine could be captured more safely and more easily than if mist nets had been used. In other situations, *M. sodalis* were captured from tree roosts by forming a "tepee" of heavy garden netting around the tree using the high net-set to position the netting. Once flushed from beneath the bark, the bats were unable to escape and were captured easily.

Clearly, high net-sets are efficient for capturing bats flying and foraging high above ground. The system is inexpensive, easy to assemble, portable, and adaptable to a wide range of field situations. When the netting

Table 1. Summary of captures using high net-sets to mist net bats in Illinois during a seven-year period.

Year	No. Sites	No. Net Nights	No. Bats Captured	No. *M. sodalis* Captured	No. Species
1980^	8	8	49	14	7
1983+	13	13	58	2	9
1984~	16	16	104	4	7
1985	30	37	295	35	11
1986	37	47	247	25	10
1987	31	60	283	21	10
1988*	54	68	385	24	11
Total	189	249	1421	125	12

^Gardner and Gardner, 1980
+Gardner and Taft, 1983
~Gardner and Taft, 1984
*includes 20 nights and 20 sites by T. A. Griffiths, Illinois Wesleyan University

plane is positioned properly, the potential for bat captures can be increased by more than 50%. Although the use of high net-sets does not eliminate the inherent biases associated with mist netting, it does provide the investigator with a much more dependable and effective sampling alternative.

ACKNOWLEDGMENTS

The original high net-set equipment was constructed and field tested during a 1980 contract study (#DACW 43-80M2247) for the St. Louis District, U. S. Army Corps Engineers. Investigations conducted in 1983 and 1984 were supported by the Illinois Department of Transportation (IDOT). We thank John B. Taft, the co-investigator during the IDOT studies. Investigations conducted from 1985 through 1988 were funded through a cooperative research project with the IDOT, the Illinois Department of Conservation, and the Illinois Natural History Survey (INHS). Thanks are due to Thomas A. Griffiths for allowing us to use data he collected during 20 nights of mist netting in 1988 as part of an IDOT/INHS study. John P. Sherrod graciously provided the illustration for Figure 2. Audrey Hodgins, Larry Page, Jim McNamara and Mark Wetzel provided many helpful editorial suggestions during the preparation of this manuscript.

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Table 2. Percent of capture by height of 1,155 bats mist netted during research conducted from 1985 through 1988 in Illinois.

Height above ground (water) surface					
feet	≤7	7-13	13-20	20-26	>26
meters	≤2	2- 4	4- 6	6- 8	> 8
1985					
M. sodalis (n=35)	40%	37%	17%	6%	
other species (n=251)	29%	41%	17%	11%	2%
1986					
M. sodalis (n=25)	28%	56%	4%	12%	
other species (n=197)	40%	46%	10%	4%	
1987					
M. sodalis (n=21)	38%	38%	10%	10%	4%
other species (n=275)	48%	38%	9%	4%	<1%
1988*					
M. sodalis (n=22)	36%	55%	9%		
other species (n=329)	49%	38%	9%	3%	<1%
Total					
M. sodalis (n=103)	36%	46%	11%	6%	1%
other species (n=1052)	42%	41%	11%	5%	<1%
Total					
all species	42%	41%	11%	5%	<1%

*includes 104 bats (1 *M. sodalis*) captured by T. A Griffiths, IllinoisWesleyan University

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Attempted Predation of a Red Bat *(Lasiurus borealis)* by a Blue Jay

Dennis A. Meritt, Jr.
Lincoln Park Zoological Gardens
2200 N. Cannon Drive, Chicago, IL 60614-3895
U.S.A

On 20 August 1977 at 1400 h a small group of blue jays *(Cyanocitta cristata)* were observed vocalizing loudly and repeatedly. There were six adult birds in all. The sky was clear, the sun obscured by clouds and the ambient temperature was 26.5° C. One adult blue jay landed within 5 m of the observer and was observed carrying a furry mass in its beak. The mass was at first unidentifiable but clear vocalizations identified it as a bat. The blue jay dropped the bat to the ground where it immediately assumed an open-wing position, lying on its back. The jay made repeated stabs at the bat and tried to pick it up in its beak. The bat flapped its wings, bit in the direction of the bird's head and vocalized continuously. Five other jays landed in low shrubbery around the bat, all vocalizing loudly and repeatedly. None joined the attacking jay, but all moved actively about the shrubbery hopping from branch to branch facing the jay and the bat on the lawn area some 3 m away. The entire episode lasted 8 min.

The jay was unable to pick up the bat while the bat was lying on its back, wing-flapping and biting. The attacking jay flew up and off at the end of this time. All the jays then left the shrub and lawn area together, vocalizing as they went. They did not reappear during the next 30 min of observation. The bat continued to vocalize and remained on its back, wing-flapping and vocalizing. This occurred despite the absence of the jays or any other apparent disturbance.

The bat was hand caught and closely examined. It was an adult male red bat *(Lasiurus borealis)* in good condition. No wounds or tears were noted on the body or wing membranes. The jay had not externally injured the chiropteran. After holding for 36 h observation the red bat was released, apparently uninjured, to continue its flight.

The area of northwestern Evanston, Illinois where the above incident occurred has elm, oak, maple, and green ash trees predominant. Active nests of the blue jay were observed during the 1977 rearing season. A viable breeding group of red bats also inhabits this area. Adult female bats with clinging babies were observed flying during June 1977. Adults were seen flying nearly every night through early September. Red bats frequently rest or sleep during daylight hours attached to the trunks of large elms and oak trees in the immediate area. Adult females with single offspring are commonly found near the base of trees during the birth season. The capture of this adult red bat was not witnessed but presumably was accomplished while the bat was asleep or resting on a tree trunk in the immediate area.

Editor's Note: The following article by Gary McCracken was written for *The Encyclopedia of American Folklore and Superstition* (Univ. of Calif. Press) and will ultimately appear there. Because publication of the *Encyclopedia* was delayed by the sudden death of its editor, Dr. Wayland Hand, Gary asked permission of the present editor to submit the manuscript to *Bat Research News*. The article is such a fine example of scholarship on myths and superstitions concerning bats, we decided to preprint it in its entirety in *BRN*. The article appears in the form it will take in the *Encyclopedia*. Used by permission of the *Encyclopedia* and the University of California Press.

BAT. Early evidence of a Western tradition associating bats with evil spirits is provided by Homer when Hermes conducts squeaking, bat-like souls to Hades.[1] Artisans of medieval Europe also typically represented devils with bat-like wings and pointed ears, and Gustave Dore's vision of death depicts a host of bat-like souls following the reaper.[2] Similarly, the Mayas of Central America had a bat god, "Cama-zotz" or "death bat," depicted as a man with bat wings and a bat-like leaf-nose, and living in a region of darkness through which a dying man had to pass enroute to the nether world.[3] Notions that bats are the devil,[4] children or creations of the devil,[5] or ghosts[6] persist in American culture, being recently illustrated by the title of a best-selling rock music recording.[7] Traditions of bats as evil spirits probably result, in large part, from bats' activity at night, a time of danger and mystery to normally diurnal human beings, from bats' habits of roosting in caves which are often viewed as places of demons and as entrance ways to the dark side of the world beyond, and from physical features of bats, such as pointed ears, leaf-noses, wart-like protuberances on their chins, and the human-like shape and placement of their two breasts, all of which lead easily to the perception of grotesque parody of the human form.

However, in contrast to this association of bats with evil, Americans of European ancestry also view bats as harbingers of good fortune[8] and fair weather,[9] and, in Chinese tradition, the predominant view is that bats are agents of beneficence.[10] Figures of bats are common in Chinese art, embroidery, and jewelry, and on furniture, and utensils, and to the Chinese these figures symbolize happiness and good wishes. In fact, while the Chinese characters for "bat" and "good luck" are written differently, they have identical pronunciations ("fu"). The "wu-fu" is a common emblem in Chinese art, consisting of 5 bats surrounding a traditional symbol of longevity. The five bats symbolize health, wealth, long life, good luck, and tranquility.[10]

A frequent theme in fables concerning the origin of bats is the perceived ambivalence in the nature of a mammal which flies like a bird. Stories from Cherokee, Seminole, and Creek Indians convey this ambivalence in the context of a ball game played between birds and four-footed animals.[11] In the Cherokee legend, the first bat is fashioned by an eagle from a mouse-like creature that is rejected by the animals. The bat then plays with the birds and helps them to win the ball game. In the Seminole and Creek legends the bat is rejected by the birds because it has teeth, and it plays on the side of the animals. This ambivalence also is seen in tradition from India in which bats are said to have been birds who were unhappy and prayed to become men. The results of their prayers was a partial transition in which they obtained teeth, hair, and the faces of men, but otherwise remained bird-like. They were then ashamed to again meet the other birds and, as a result, are active only at night.[12] In two of Aesop's fables concerning bats, ambivalence apparently is transposed into duplicity.[13] One of these tales also exists, with slight variation, among tribes in Southern Nigeria[13], among Australian aboriginals,[14] and among ancient Romans.[13] The basic scenario is that in a battle between the beasts and the birds the bat repeatedly changes allegiance so as to be on the side which appears to be winning. When a truce is declared, the bat is rejected by both sides because of this deceitful behavior. In another tale attributed to Aesop, a bat borrows money for a business venture which fails. The bat must then hide during the day to avoid meeting creditors. Ancient Greeks and Romans often referred to people who were active at night, apparently as a strategy to avoid creditors, as "bats."[15] A variation on a commonly held belief that bats are rodents which obtained wings[16] comes from an Ohio woman of Polish ancestry who related that "the bat was from a mouse that had eaten blessed Easter food."[17] Christianity and the origin of bats also are intertwined in a Mohammedan legend which relates that Christ created a bat while keeping the fast of Ramadan. In this legend, the appearance of the bat each evening at sunset helped Christ maintain the precept that no food or drink be taken between sunrise and sunset.[18]

Of the folklore concerning bats, a prominent portion in modern time concerns vampirism. The distribution of folklore linking vampirism to bats is of particular interest because there are, in reality, three species of vampire bats, all restricted to the New World Tropics, which subsist exclusively on the blood of birds or mammals. The Arawak Indians of Guyana, South America have stories of bats sucking the fluids of both men and their fowls,[19] and the Makusis of the same area have a story about a large bat which carried off and ate men and women.[19] Guyanese Indians also maintain that oil from the seeds of a Iliana (called "bat's bane") will cause attacking bats to die.[19] There is also extensive vampire tradition in India and among gypsies in Eastern

Europe. These vampires are active at night or lurk in dark places and are able to transform into various animals, and even into vegetables and household tools.[20] However, prior to the publication of Bram Stoker's novel *Dracula* (1897, England), there is apparently no Old World mythology of vampires taking the form of a bat. *Dracula* is based on an historic character, Vlad the Impaler (c. 1431-67), who, although reputed to be very evil, was not known as a vampire.[20] By the time Stoker was writing, European explorers had already published several accounts of vampire bats,[21] and it is evident that these influenced the Dracula novel.[22] In modern American folklore, vampires frequently assume the form of a bat,[23] a tradition which often functions to frighten children,[24] and, even if they are not thought of as vampires, it often is believed that bad consequences result from being bitten by a bat. These consequences include: death,[25] blindness,[26] decay of the hand that is bitten,[27] and that "your ears and nose will change places."[28]

Another prominent myth occurring in all regions of the U.S., in Europe, and in Japan, is that bats become entangled in hair. The consequences of this are not always specified;[29] however, common beliefs are either that the person will never get rid of the bat,[30] or that to do so all hair must be cut off.[31] Other consequences of bats getting into hair are that the hair will snarl[32] or turn gray,[33] that the person will become bald,[34] or that the bat will pull out the person's hair.[35] It is also a widespread belief that bats in hair will cause infestation of "bugs,"[36] bedbugs,[37] or lice.[38] In Illinois and Ohio it is thought unlucky to get a bat in your hair,[39] while a woman from Missouri related that if a bat gets into your hair insanity will result.[40] In France, a bat getting into a woman's hair presages a disastrous love affair,[15] while it is an Irish belief that if a bat carries off strands of a person's hair, that person will go to hell.[41] Similarly, a woman from Ohio related that if a bat flies off with a strand of a person's hair and puts it in a tree, the tree will begin to die, and when the tree dies, so will the person.[42] Hair is not mentioned in a superstition from North Carolina; however, life-long headaches are predicted if a bat strikes a person's head.[43] In another legend from Ohio, parents are cautioned that if a bat flies over the head of a child the child should drink a mixture of its own hair, a piece of clothing, some oils, and some coffee, otherwise the child will stop growing.[44] Bats overhead are also said to "sew up children's ears."[45]

We can only speculate on why superstitions relating bats and hair are common. They may result from the hunting behavior of insect-eating bats which occasionally fly low over a person's head. It is also possible that someone walking in a field or on a forest trail may flush insects and make it profitable for bats to hunt overhead. The fact that the skin of bats' wings is essentially hairless may also contribute to bat-hair superstitions. The French word for bat is "chauve-souris," or "bald mouse," and there are many beliefs in Europe and the U.S. regarding the value of bats' blood[46] or their excrement[47] as a depilatory. There are also reversals in beliefs, such that in England and North Carolina the use of bats' blood has been advocated to prevent baldness,[48] or in India, the use of a mixture of crushed bat wings in coconut oil as a hair wash is said to prevent baldness and graying of hair.[49]

Bad luck is thought to result if a bat enters a room or house.[50] The superstition that a bat in a house presages death, often within specified time limits, has been reported from throughout the U.S.[51] Once in the house, the behavior of the bat also may determine whether death or only sickness is foretold,[52] or whether it is someone in the house, or a relative who will die.[53] A man from Las Vegas[54] was told that death could be averted by killing the bat; however, superstition in Illinois predicts death if the bat is killed, and only sickness if it escapes alive.[55] In other superstitions, killing a bat can bring bad luck[56] and blindness.[57] A woman of Scottish ancestry from Ohio related that a person who has a bat fly over head in a doorway can avoid serious illness by drinking a mixture of his or her own burned hair and coffee,[58] and a report from North Carolina states that a bat flying into the home of a sick person will be fatal to that person unless a handful of salt is thrown into the fire.[59] In some superstitions, death is also foretold by a bat at a window,[60] by a bat flying over a house,[61] by the mere presence of flying bats,[62] or by dreaming about bats.[63] A woman in California stated that if a pregnant woman sees a bat her child will die.[64] Another myth is that the child of a pregnant woman who is scared by a bat will be born with a mole on its face, or with the bat's form on its back.[65] In western New York State, it was said that bats flying near a house at the same time as a dog howled indicates death for a resident of the house,[66] while in Arkansas and North Carolina it was related that bats flying near buildings are a sign of rain.[67] Other maladies portended by bats in a house are that someone in the house will go insane,[68] become blind,[69] be missing the next day,[70] that a letter with bad news will arrive,[71] that the people in the house will move,[72] and that the bats will bring bedbugs.[72] Bats in a house also are said to indicate that the house is haunted,[73] or that the devil is after someone.[74] It is reported from Arkansas that a horseshoe in the fireplace will scare bats away,[75] and a Black woman from Ohio advised that if a bat flies into a house, the bat should be killed, burned in the fireplace, and sprinkled with salt.[76] Bats in churches also are thought to be bad luck, particularly if they enter the church during a wedding. Reports from Kentucky, Arkansas, and Illinois all affirm that a bat flying into a

church during a wedding means very bad luck.[77]

Bats in buildings are not always viewed as bad omens. An Ohio woman of Russian-Jewish extraction related that a bat in a house was good luck,[78] and Indians from California believe that a bat in a house portends a good hunting season.[79] In a superstition from Montreal,[80] a bat in a house will bring financial prosperity to the household, provided that the bat is caught and certain things are done to it. A legend from Illinois relates that if a bat enters a house where a baby is present the baby will cut teeth better, provided that the bat is killed and kept in the house overnight.[81] It is thought that a play will be a success if a bat flies over the stage during rehearsal,[82] and in tradition from Nevada, a mine will be safe if a bat remains in the mineshaft after blasting.[83]

Bats also have a persistent association with witchcraft and magic, Shakespeare's *Macbeth*[84] providing a prominent example. In 1332, a Lady Jacaume of Bayonne was publicly burned because "crowds of bats" were about her house and garden,[85] while as recently as 1957, bat blood was sold in California for use in witchcraft.[86] Other references to bats and witchcraft include a report from Ohio that bat blood can call evil spirits,[87] and from Illinois that bat blood gives witches "the power to do anything."[88] Bats also are used for witchcraft in Yucatan,[89] and bat wings are in the conjure bag of Blacks in Georgia.[90] Bat hearts[91] and bones[92] are carried as charms. In variations of a German superstition repeated in Pennsylvania and Illinois, good luck at cards or a lottery will result if the heart of a bat is kept in a wallet,[93] in a pocket,[94] wrapped in a silk handkerchief and kept in a pocket,[95] or wrapped in a red ribbon and tied to the hand with which the person deals cards.[96] Similarly, in Ohio, a person of German-English heritage related that a silk string around a bat's heart will bring money.[97] Superstition from Germany also tells us that a gun swabbed with a bat's heart will hit whatever it shoots at,[98] and, according to Albertus Magnus,[99] the same effect can be achieved by mixing lead shot with the heart or liver of a bat. Ozark pioneers carried the dried, powdered hearts of bats to protect them from being shot, and to keep wounded men from bleeding to death.[100] In many parts of Europe, live bats are nailed, head downwards, above doorways. This practice is said to prevent misfortune, and to ensure wakefulness and the protection of livestock.[101]

Potions, and spells also make frequent use of bats. An ancient belief,[85,99] repeated in Ontario, Illinois, and Trinidad, W.I.[102] is that a person will see in the dark if they bathe their eyes in bat's blood. It has also been reported in Trinidad that drinking a bat's blood will make a person invisible.[102] In the Tyrol, gypsies related that carrying the left eye of a bat would make a person invisible,[104] while in Brasil it was said that a person carrying the hearts of a bat, a frog, and a black hen would be invisible.[105] It was said in Oklahoma that a person can be invisible by carrying a bat's right eye pierced with a brass pin.[106] In Texas, similar treatment to a bat's left eye is said to remove warts.[107] Greco-Roman tradition says that sleep can be prevented if the engraved figure of a bat is placed under a person's pillow, or if the head of a bat is tied in a black bag and placed near a person's left arm.[101] Alternatively, traditions of Indians from Canada state that placing the head or the dried intestines of a bat in an infant's cradle will cause the infant to sleep all day.[108] Mescalero Apaches said that the skin of a bat attached to the head of a cradle would protect a baby from being frightened[109]. In colonial North Carolina, eating roast bat was a recommended cure for children who ate dirt.[110] Bats also are used in love potions. In Texas, a man is directed to place a bat on an anthill until all flesh is removed, to wear the wishbone around his neck, pulverize the remaining bones, mix them with vodka, and give the drink to the woman he loves.[111] A similar recipe from Europe recommends dried, powdered bat in a woman' beer.[112] Pliny maintained that a man could induce a woman's desire by placing a clot of bat blood under her pillow.[113]

Bats are also ingredients in many medicinal preparations, with, as also is the case in potions and spells, the desired effect often reflecting real or imagined characteristics of bats, or, perversely, characteristics opposite to those perceived. For example, problems with vision have been treated with a variety of bat preparations, including: the powdered heads of bats mixed with honey,[113] bat urine mixed with fish gall and the juice of wild rue,[112] bat brain or blood mixed with the juice of buckthorn and honey,[113] equal parts of frankincense, lizard's blood, and bat's blood,[113] bat gall,[114] and "titurated" (=triturated?) eyes of bats.[115] Other ancient bat potions include: bat blood mixed with thistle juice to cure snakebite,[113] macerated bat cooked in a metal pot in jasmine for asthma,[113] bat dung with vinegar for tumors,[113] ashes of burned bat mixed with urine to promote lactation,[113] and bat cooked with sesame oil for sciatica.[113] Sir Theodore Mayerne (d. 1655) prescribed "balsam of bats" as an ointment for hypochondriacs; his recipe consisting of "adders, bats, suckling-whelps, earthworms, hog's grease, stag marrow, and the thigh bone of an ox."[116] In 1752, the physician, R. James, recommended the flesh of bat for "schirrus" (=scirrhus?) and gout.[113] In more modern times, folklore from Texas recommends drinking bat blood to cure rheumatism and consumption.[117] Folklore from Brasil recommends taking dried, powdered bat as a remedy for epilepsy.[118]

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Gary F. McCracken
Department of Zoology
University of Tennessee
Knoxville, TN 37916

NEWS

AUSTRALIA

University of New South Wales, Kensington: Two lines of research are currently being carried out in the School of Biological Sciences at the University of NSW in Sydney, Australia. Dr. Sue Hand is working in the area of systematics of modern and extinct bats, particularly in relation to the exciting new fossil material being collected in Riversleigh, Queensland. Dr. Michael Augee has several projects in the area of flying-fox ecology. Kerryn Parry-Jones is completing a Ph.D. thesis on factors involved in movements of Grey-headed flying-foxes in NSW, and a new project is soon to begin on nutrition in this species. In a country where zoological research has long been dominated by the pouch, bat research has only recently become established at university level and there are many interesting lines of research that are wide open. The University of NSW welcomes overseas graduate students. There is certainly room for some in bat research.

Interest in megachiropterans has greatly increased in Australia with the recent work of Prof. J. D. Pettigrew (Queensland University) supporting a diphyletic origin for the Chiroptera, and with the growing concern for conservation of rainforests. Our work in NSW shows clearly the interdependence between Grey-headed flying-foxes and remnant patches of rainforest in the subtropical areas. [**Michael L. Augee**]

CANADA

Queen's University, Kingston, Ontario: The bat research department at Queen's is rather quiescent, as it consists of only one member who is trying to complete a Ph.D. on the feathered relatives of bats. However, I am still finding some time to write a few short papers using accumulated data on Malaysian bat communities, one of which has so far survived the referees. Sometime in 1990, if my Ph.D. behaves itself and anybody deigns to offer me a post-doc, I plan to return to Malaysia to continue research on the structure and dynamics of bird and bat communities in the rainforest. I also intend to help write a new field guide to the mammals of peninsular Malaysia. [**Charles M. Francis**]

York University, North York, Ontario: Research on bats continues to be the focus of interest of a group of biologists at York University. At this time, the group includes Brock Fenton and graduate students Lalita Acharya, Doris Audet, Joe Cebek and Brian Hickey, and undergraduate assistants Brenda Forbes and John Taylor. In June 1989, we expect Martin Obrist to arrive to begin a postdoctoral stay, while in July 1988, Mark Brigham completed his Ph.D. and left for Calgary, a city whose hockey team sometimes wins (games).

Lalita arrived in September 1988 to begin her M.Sc. study which will focus on the feeding buzzes of bats that feed on airborne prey. She will use direct observation of animals in the field to determine if length of feeding buzz reflects investment in prey pursuit and the influence that prey size has on this phenomenon. She may also collect data to determine if long silent periods at the end of a feeding buzz represent successful attacks.

Doris Audet first registered in the Ph.D. program in May 1988 and she is studying the foraging behaviour and reproduction of *Myotis myotis* at a nursery colony in Bavaria. Doris has been using radio-telemetry to collect data on the time budgets, movement patterns and changes in skin temperature of the bats. In March 1988, Doris and colleagues from Gerhard Neuweiler's laboratory in Munich spent some time in southern India using radio tracking to study the foraging behaviour of *Megaderma lyra*.

Joe Cebek, who first joined the laboratory in January 1987, is working on a Ph.D. thesis designed to explore the genetic structures of colonies of *Eptesicus fuscus*. To this end, Joe has been using electrophoretic analyses of blood samples to study a number of allozyme loci from bats from different colonies. At this time he also is exploring the possibility of using DNA fingerprinting to determine the specific relationships between known individuals. The behavioural component of his study is an examination of variations in echolocation calls of bats from different colonies.

Brian Hickey first registered in the Ph.D. programme in May 1988 after he completed his M.Sc. thesis on the foraging behaviour of *Lasiurus borealis*. His Ph.D. research is focussed on the foraging behaviour of *Lasiurus cinereus*, specifically the way that ambient conditions affect the foraging patterns of these bats. The work involves the use of telemetry to monitor activity patterns, foraging areas and skin temperatures of the bats.

Brenda Forbes has been using stroboscopic photography to assess changes in the flight behaviour of *Eptesicus fuscus* and *Macrotus californicus* as they carry different-sized prey items in their mouths. John Taylor spent the summer of 1988 working on the population of *Myotis lucifugus* at Chautauqua, New York. This study will continue through the summers of 1989 and 1990.

Brock Fenton continues to be interested in the foraging behaviour and echolocation of bats. At this time, he is exploring the possibilities of field studies of *Noctilio leporinus* in Cuba, and is still searching for a field site to study *Otonycteris hemprichi*. As background to the foraging studies, Brock also has been doing some work with specimens in the collections of the Department of Mammalogy at the Royal Ontario Museum.

In 1988, we enjoyed a visit from Paul Racey who appeared to act as the external examiner for Mark Brigham's Ph.D. thesis. In August Jiri Gaisler spent a week in the field with a group of field course students and Brock Fenton. From September to December 1988, we have been running a graduate course in bat biology which has involved a variety of bat and non-bat people at York. [**Brock Fenton**]

INDIA

Madurai Kamaraj University, Madurai: I have been doing research on bats for the past 11 years. At present, I am working on (1) detection and capture of prey by the Indian false vampire bat *Megaderma lyra*, (2) breeding, mother-young relations and development of vocalization of *M. lyra*, (3) spatial organization of roosting in closely related species of hipposiderid bats, and (4) a breeding spectrum for different species of bats. I worked under Prof. M. K. Chandrashekaran for my Ph.D., which I obtained in 1984. Together we established that there is a clear cut case of social tuning of the biological clock in *Hipposideros speoris*. At the end of 1987, I joined Prof. Chandrashekaran's Department of Animal Behaviour as a Lecturer, but I have not yet taken on any students. We have been actively involved with bat conservation by explaining the myths and realities of bats to students and to the public. [**G. Marimuthu**]

UNITED STATES

FLORIDA

University of Florida, Gainesville: Jackie Belwood, in addition to writing her doctoral thesis on South American bat-insect interactions, has been doing some good public relations work for the bats of Florida. According to a column by Jeff Klinkenberg in the *St. Petersburg Times* (October 26, 1988), Jackie has been interviewed on television talk shows, and has appeared at garden club meetings and at schools. [From a newspaper column sent to TAG by **Roy Horst**]

HAWAII

Honolulu Group, Sierra Club: Gary Andersen wrote a nice article on 'Ope'ape'a, the Hawaiian Hoary bat *Lasiurus cinereus*, which appeared recently in the *Journal of the Hawaii Chapter, Sierra Club*. The article explains what is known of the natural history of this bat and others, and makes a case for conservation of all bats. [From a clipping sent to TAG by **Roy Horst**]

ILLINOIS

Illinois Wesleyan University, Bloomington: Tom Griffiths is continuing to dissect the hyoid region of emballonuroid bats. In addition to a study in progress of phylogenetic relationships between all genera of New and Old World emballonuroids, he is working on a paper with Karl Koopman on specific relationships between species of *Emballonura* and *Coleura*. The latter paper nears completion and should be submitted soon.

Tom continues to recover from the unknown intestinal parasite that laid him low in October (and caused him to miss the Calgary bat meetings). Whatever the

assailant parasite was, it was a virulent little bug that hung on through several different treatments while defying all attempts to identify it. Thanks very much to all the persons who wrote to wish good health and a speedy recovery. The notes were much appreciated. [**Tom Griffiths**]

MASSACHUSETTS

Boston University, Boston: Tom Kunz has been working on a collaborative NSF-funded project with Gary McCracken entitled "Kin-recognition and parental investment in the Mexican free-tailed bat, *Tadarida brasiliensis*." Kunz's part of the study has focused on using milk energy output as an index of maternal investment. Milk output throughout different stages of lactation is estimated using the doubly-labeled water method to measure both daily water flux and field metabolic rates in sucklings of known age. Results from these studies, combined with estimates of milk composition (in collaboration with Olav Ofledal at the National Zoo in Washington D.C.), is then used to estimate milk energy intake (= milk energy output).

Kunz is also studying the energetics of reproduction in the greater spear-nosed bat, *Phyllostomus hastatus* in Trinidad, West Indies. In this study he is using radio telemetry and doubly-labeled water to examine the time and energy investment in harem maintenance by males, the cost of pregnancy and lactation in females, and the energetics of post-natal growth.

With support from a NSF Biological Instrumentation Grant, Kunz will soon be setting up a new Stable Isotope Laboratory at Boston University. This new analytical laboratory will be available to analyze samples of body fluid (blood and urine) where oxygen-18 and deuterium is used in doubly-labeled water studies. By the fall of 1989 they expect to be in full operation and in a position to accept samples from colleagues for analysis either upon contractual arrangement or as collaborations. Interested investigators should contact Kunz for further information.

Simon Robson is a third year graduate student at Boston University working toward his Ph.D. under the direction of Tom Kunz. Simon, an Aussie who hails from Queensland, did his undergraduate honors thesis under the direction of Peter Dwyer on feeding habits of *Myotis australis*. His dissertation research will focus on intraspecific variation in social organization in a, yet to be determined, neotropical bat. He is currently exploring suitable species and localities for study and would welcome suggestions. Other research in which he is involved includes studies on mammalian (mostly chiropteran) spermatozoan ultrastructure and its phylogenetic implications, including investigations on the diphyletic theory of bat origins. With this end in mind, he is also investigating the postulated homology of the occipito-pollicalis muscle in mega and micro bats and is making comparisons of flight and flight musculature between members of these two suborders.

Carlos Diaz is a fourth year graduate student at Boston University working toward his Ph.D. under the direction of Tom Kunz. Carlos, who hails from Puerto Rico, is doing his dissertation research on social behavior and folivary in *Artibeus jamaicensis* in Puerto Rico. In addition to this research, Carlos is on the staff at the Caribbean Field Office of the USFWS in Boqueron, Puerto Rico.

Armando (Mandy) Rodriguez is a fifth year graduate student at Boston University working toward a Ph.D. degree under the direction of Tom Kunz. His research has focused on the environmental physiology of three bat species *(Pteronotus quadridens, Monophyllus redmani,* and *Mormoops blainvillii)* that typically roost in hot caves in Puerto Rico. He has recently completed his field and laboratory studies and is concurrently writing his dissertation and teaching Biology at the InterAmerican University in Aquadilla, Puerto Rico.

Jane Winchell is a second year graduate student at Boston University working toward a MA degree under the direction of Tom Kunz. Her research is on the roosting ecology and daily time-budgets of the eastern pipistrelle *(Pipistrellus subflavus)*. She has been using low-light level video monitoring to document roosting behavior throughout a 24-hour period each week from mid-May through mid-August at a maternity colony in Massachusetts. In 1988 she observed that the small barn colony periodically deserted its roost and chose a nearby spruce tree where it remained during unseasonably warm days during the summer. She would be interested in hearing from others who may have made similar observations.

Ruth Utzurrum is a first year graduate student at Boston University working toward a Ph.D. under the direction of Tom Kunz. Ruth hails from the Philippines (Negros Island) and recently completed a MA degree at Siliman University, under the guidance of Larry Heaney and Paul Heideman. She expects to begin her dissertation research in the Philippines this coming summer on feeding ecology of pteropids.

Becky Porter is a first year graduate student (January 1989) at Boston University beginning to work toward a Ph.D. under the direction of Tom Kunz. Becky, who hails from Wichita, Kansas, holds a BS degree in Wildlife Biology from Kansas State University and a MA degree in Education from the University of Kansas. She is interested in conservation biology of bats, especially in the Megachiroptera.

Gary Vaner, a senior in the Electrical Engineering

Department at Boston University, is currently developing new circuitry for miniature radio transmitters that can be used on bats and other small animals. He is exploring the use of new technologies that will reduce the size and increase the power and longevity of currently available transmitters. [**Tom Kunz**]

WISCONSIN

Entomology, University of Wisconsin, Madison: Patricia Gegick finished writing her thesis at the University of New Mexico on the effect of weight of developing embryos on flight muscles in the red bat *Lasiurus borealis*. She has begun a Ph.D. in the Entomology Department at Wisconsin working on insect-plant interactions, but is still very interested in bats. [From a letter by **Patricia Gegick** to TAG]

RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths) for inclusion in this section. Receipt of reprints will facilitate complete and correct citation. Our Recent Literature section is based upon several bibliographic sources, and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome.

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ANNOUNCEMENT

The 19th North American Symposium on Bat Research will meet on October 19, 20, 21, 1989 in Knoxville, Tennessee. Our hosts will be Gary McCracken of the Zoology Department at the University of Tennessee and Michael Harvey of Tennessee Technical University, Cookeville, Tennessee. The meetings will be held at the Holiday Inn in downtown Knoxville, adjacent to the Worlds Fair site.

Gary has made arrangements for the participants to stay at the Holiday Inn. The Holiday Inn has given us a much reduced rate of $49 for a single occupant room. Surprisingly, if two people share a room the rate is still $49 or only $24.50 per person. There is a $4.00 discount for students. Enclosed you will find a reservation form. Complete it at your earliest convenience and send it to the hotel. The hotel address is:

Holiday Inn Worlds Fair
525 Henley Street
Knoxville, TN 37902
Telephone: 615-522-2800

You have already received forms for registration in the symposium, title transmission page, and student hororaria. A duplicate set is enclosed. All forms except that for hotel reservations should be returned to:

G. Roy Horst
Department of Biology
Potsdam State College - SUNY
Potsdam, NY 13676

Registration fees will be returned in full if for some reason you cannot attend.

You will notice that the tax on rooms is a vary outrageous 12.75%. This is a temporary tax on hotels and entertainment to help defray the costs of a new sports facility in Knoxville. I have contacted the Tennessee Department of Taxation and Finance and they agreed to send me the forms required so that tax exempt institutions need not pay this exorbitant tax. I will keep you informed as to progress on this topic.

Gary and Mike are arranging several special features. Brock Fenton will conduct a workshop on teaching echolocation techniques on Thursday at 14^{00} hours. If you plan to participate please contact Brock at 416-736-5243 by phone or at:

Department of Biology
York University
Downsview, Ontario
Canada M3J-1P3

There will be a lecture on Histoplasmosis and its risks to bat researchers presented by an expert from the Center for Disease Control. This lecture will be scheduled for Saturday forenoon if possible.

On Thursday evening there will be a no host cocktail party from 7:30 until the police arrive.

On Friday evening there will be a banquet-barbeque at which the student awards will be made. We are also planning to roast one of our own. Don't miss it, it could be you.

If you have any further questions (about anything) contact me and I'll try to resolve them!

Gary, Mick and I are eagerly looking forward to seeing you in Knoxville.

Warm regards,

Roy

BAT RESEARCH NEWS

Volume 30 Spring 1989 No. 1

CONTENTS

FRONT COVER

The cartoon, by David Klingener of the University of Massachusetts, has a subtle humor to it. If you don't get it, consult your friendly local bat systematist for assistance.

BAT RESEARCH NEWS

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BAT RESEARCH NEWS

Publisher and Managing Editor

Dr. G. Roy Horst
Department of Biology
State University College at Potsdam
Potsdam, New York 13676 USA
Tel.: 315–267–2259

Editor

Dr. Thomas Griffiths
Department of Biology
Illinois Wesleyan University
Bloomington, Illinois 61702 USA
Tel.: 309–556–3230

Editor for Reviews

Dr. Peter V. August
Department of Natural Resource Science
University of Rhode Island
Kingston, Rhode Island 02881
Tel.: 401–783–4032

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BAT RESEARCH NEWS

Volume 30 Summer Number 2

Gestation Period in some Indian Hipposiderid Bats

N. Badwaik

Department of Zoology, Institute of Science, Nagpur 440 001, India

A study of the carefully preserved records of pregnancy of several species of Indian bats maintained in this laboratory during the past 40 years revealed that among the microchiropterans *Hipposideros lankadiva* in Central India has the longest gestation period. All the adult females in the colony conceived between 24th August and 5th September, and all deliveries in the colony occurred between 10th May and 24th May. The development of the implanted embryo is retarded until about the end of December after which the embryonic development progresses normally. Calculating from the earliest date of conception to the earliest date of delivery, the gestation period appears to be about 260 days. This is probably the longest gestation period for any microchiropteran species so far recorded. *Hipposideros lankadiva* is a large bat with an adult body weight of 76 g for males and 55 g for females. The gestation periods of a few other hipposiderid bats, whose records are available in this laboratory, are given in the Table below.

It is evident that there is no relationship between body weight and gestation period. Hipposiderid bats seem to have an unusually long gestation period.

Name of Species	Body Weight	Gestation Period
H. ater ater	5–6 g	190-200 days
H. fulvus fulvus	9–10 g	150-160 days
H. speoris	9–12 g	135-140 days

NEWS

INDIA

Madurai Kamaraj University, Madurai: We are currently deeply immersed in research relating to the behaviour of bats. The following are the main topics: (a) neurophysiology of echolocation in microchiropteran bats of Madurai—Dr. K. Sripathi, presently lecturer in neurophysiology, is working on this problem; (b) circadian organization in the activity/rest patterns of microchiropteran bats and the relationship of light to the patterns—Dr. R. Subbaraj, now reader in our Department of Animal Behaviour and Physiology, works on this area; (c) spatial memory and marking of personal space, a comparative study of some features of roosting ecology of two hipposiderid bats, *H. speoris* and *H. bicolor;* and (d) prey capture by the Indian false vampire bat, *Megaderma lyra.* The last two lines of work are being carried out by Dr. G. Marimuthu, Lecturer in Animal Behaviour with me. All three gentlemen are my former students and obtained their Ph.D. working on problems of biological rhythms in bats. Dr. Marimuthu has made some very interesting findings on prey capture by *Megaderma.* He has found that on land they locate prey by passive hearing, but in the water they use echolocation to detect ripples of water caused by their prey (frogs).

I would further like to add that a new research project of mine entitled "Neurophysiological and Biochemical Studies on the Behaviour of Bats" has been sanctioned for 1989-92 by the Department of Science and Technology, Government of India and the funding is to the tune of Rs.11,83,780/- which is good by our standards. Dr. G. Marimuthu has submitted a project entitled "Behavioural Ecology and Measures for Conservation of Bats" to the Department of Environment, Forests and Wildlife, Government of India, for funding. So you see, it is bats all the way over here in Madurai. **[M. K. Chandrashekaran]**

UNITED STATES

CALIFORNIA

San Diego Natural History Museum: G. E. Cosgrove sent a reprint of the script of "Bats, Beautiful Bats," a children's musical bat program that shows children they need not fear bats while teaching them a lot about the natural history of bats. The program, produced and arranged by Susan M. Barnard of Zoo Atlanta, Georgia, contains cartoons, lyrics and music, slides (including some by Merlin Tuttle), and apparently some video sequences. The script appeared in *Animal Keepers Forum* (Vol. 14, pp. 485-492, Dec. 87). From a letter to Tom Griffiths by **G. E. Cosgrove.**

BOOK REVIEW

Greenhall, A.M. and V. Schmidt (eds.). *Natural History of Vampire Bats.* CRC Press, Inc., Boca Raton, Florida, 246 pp., illustrated, 1988. Price (hardbound), $145.00.

This volume contains a diverse array of chapters, united by their focus on the biology of vampire bats, with particular emphasis on *Desmodus rotundus.* Unlike *The Vampire Bat* (Turner, D.C., Johns Hopkins University Press, Baltimore and London, 1975, 145 pp.), which was a monographic presentation of a 15 month field study of *Desmodus* ecology, this book is the long overdue answer to the call issued by La Val *(The Southwestern Naturalist,* 21:415-416, 1976) to publish a work on the "ecology, behavior and management of vampire bats throughout their geographic range." It contains 17 chapters; each begins with a short table of contents (with the exception of the Introduction) and ends with a list of references. Citations within the text unfortunately are designated by numeric superscript rather than by author's name and date. Numerous figures and tables appear throughout the text, allowing the liberal inclusion of many photographs, most of high quality, of vampires under a variety of circumstances. Although the title seems to limit the content of the book to works on natural history, the chapters on genetics, anatomy, locomotion, salivary antihemostatic factors, and orientation and sensory function clearly exceed the most liberal interpretation of "natural history," unless that term is considered to be synonomous with "biology" itself.

Although the chapters are not organized into formal sections, the order of the contributions suggests five general areas of coverage. The first section (Chapters 2, 3, and 4) considers the evolutionary history of vampires from a systematic (Koopman), paleontological (Ray, Linares, and Morgan) and phylogenetic (Baker, Hon-

eycutt, and Bass) perspective. The second section (Chapters 5 and 6) reviews the general anatomical adaptations of vampires (Bhatnagar) and provides a detailed consideration of the functional morphology of locomotion (Altenbach). The third section (Chapters 7, 8, and 9) encompasses a variety of aspects of the behavioral ecology of vampires with particular focus on sociality (Wilkinson), reproduction (Schmidt), and foraging behavior (Greenhall). Physiological adaptations of *Desmodus* are considered in section four, wherein sensory functions in general (Schmidt) and antichemostatic factors in particular (Hawkey) are reviewed in detail. The final section of the book (Chapters 12-16) has a more applied focus, directed toward topics concerning disease (Constantine), parasites (Mendez), economic loss (Acha and Malaga Alba), and control (Lord). The introductory chapter by Tuttle provides a general overview of the study of vampire bats and the final chapter by Villa C. and Cavela R. reviews the folk history of vampires (real or imagined) in both the New and Old Worlds.

Clearly, the bulk of our knowledge regarding vampire bats is derived from studies of *Desmodus;* nonetheless, the authors have made heroic efforts to include data or references on *Diaemus* or *Diphylla* wherever possible. The format and style of the text are harmonious; Greenhall and Schmidt did a remarkable job of making the eclectic contributions as uniform as possible from an editorial perspective. Perhaps the only exception affects the bibliographies, which are frequently alphabetic with out-of-order citations appended at the end, or, in the case of the Introduction, not alphabetically arranged at all. A single bibliography at the end of the text would have been more utilitarian to most readers.

Natural History of Vampire Bats provides comprehensive coverage of the biology of the Desmodontinae. Most topics for which adequate information has been published, with the possible exception of metabolism and physiology, are included and considered in a balanced fashion. As a result, little original research appears in the book, and in many places reading the text is reminiscent of browsing through an encyclopedia. In contrast, *The Short-tailed Fruit Bat* (Fleming, T.H., University of Chicago Press, Chicago, 1988, 365 pp.) summarizes current knowledge of a common neotropical phyllostomid but does so with a vigor and enthusiasm that is lacking in most of Greenhall and Schmidt's collection. Clearly, this impression may be a bias related to my own research interests. Nonetheless, I would guess that most biologists will find the *Natural History of Vampire Bats* is more of a book to refer to than a book to read.

The inclusion of many Latin American authors as well as contributors from Europe is a noteworthy accomplishment which adds a diversity of perspectives to the volume. Like most books from CRC Press, the cover is garish with a contrasting brick red and black background and silver letters. Otherwise, *Natural History of Vampire Bats* is a handsome tome. It is a shame that its price and distribution will probably make it difficult for most Latin American bat biologists to include it in their libraries. Moreover, the heterogeneous range of topics and price will probably prohibit even the most affluent scientists from including it in their personal libraries. Those fascinated by the unique and specialized adaptations of vampires, or interested in a detailed accounting of the biology of the Desmodontinae, will be certain to consider this book a critical reference

Michael R. Willig, Department of Biological Sciences and The Museum, Texas Tech University, Lubbock, Texas 79409-3131.

BOOK REVIEW

Kunz, Thomas H. (ed.). *Ecological and Behavioral Methods for the Study of Bats*. Smithsonian Institution Press, Washington, D.C. 533 pp., 1988. Price $50.00 (cloth).

Accomplished researchers and enthusiastic students in the fields of animal ecology and behavior will benefit greatly from the wealth of information compiled and systematically presented within each of the twenty-nine chapters of this volume. The contributors are leading authorities in their fields and present the latest methodologies in bat research. This book gives direction to chiropteran research by providing continuity in procedures, techniques, and the analysis of data. The brief chapter synopses that follow should convince readers that this book is a valuable milestone in bat research.

An excellent review of the techniques used to capture and hold bats is given by Thomas Kunz and Allen Kurta. They illustrate many capture devices and discuss the effectiveness of various capture techniques. Suggestions for protecting bats and minimizing stress while handling, holding, and transporting them are

provided. An appendix of selected laws and regulations is included to encourage researchers to uphold professional and legal obligations.

Paul Racey offers reliable guides to the determination, in the field, of the reproductive status of bats. He provides explanations and illustrations that will enable readers to identify secondary sex characteristics such as facial features and integumentary glands and makes suggestions for their study. Reproductive maturation in males and changes in nipple condition in females are included among the many topics he discusses.

Investigators overwhelmed by the difficulty of estimating age in bats will appreciate Edythe Anthony's common-sense approach to age determination. She discusses the limitations of certain techniques and considers reliable procedures to determine age, noting their pitfalls and warning against the collection of erroneous data.

In the chapter on marking and observational techniques, Robert Barclay and Gary Bell offer solutions to some of the most difficult obstacles for bat researchers. They provide a comprehensive background on marking methods and comment on the shortcomings and potential problems of each technique. These pioneering researchers present new avenues for ecological studies of bats through acoustic monitoring and review the latest visual monitoring equipment and its uses.

Donald Thomas and Richard LaVal provide a detailed overview of the many techniques and types of equipment used to survey and census bats. They discuss new technologies and their applications to bat studies and consider associated errors and biases. They also suggest new approaches for estimating bat populations.

In his chapter on detecting, recording, and analyzing vocalizations of bats, Brock Fenton provides in-depth descriptions of relevant equipment and discusses the strengths and weaknesses of many popular devices. The author is sensitive to the technical complexity of the subject at hand. He addresses issues of terminology and offers clear and concise descriptions of such topics as ultrasonic recordings, playback experiments, and analysis of sound parameters.

Gerald Wilkinson and Jack Bradbury introduce radiotelemetry techniques and focus on one method for the analysis of data. A schematic of the basic Cochran transmitter is included for the do-it-yourselfer. Although brief, their descriptions of receivers and antennas are adequate. A more detailed account of additional equipment and discussions of the sources of errors and biases in the collection and analysis of data, in combination with an expanded review of previous studies on bats, might better serve bat researchers.

Scott Altenbach's fine photograph of a foraging *Noctilio leporinus* on the book's jacket is testimony to his qualifications to author a chapter on photographing bats. He delves into natural and artificial lighting, time-lapse photography, and cinematography, and discusses their applications and adaptations to field situations. Altenbach frequently draws from his rich personal experience in the subject and gives practical recommendations and cost considerations.

Gary McCracken and Gerald Wilkinson review the extensive literature on the use of allozymes to establish kinship. They provide logical steps for sample collection (including non-lethal techniques), gel preparation and scoring, and the interpretation of allozyme polymorphs. Discussions of kinship and a list of species that have been studied are included.

In a chapter on mark-recapture estimates of bat survival, Robert Keen explores the pathways taken by previous investigators and discusses pitfalls of these methods. He presents an age-specific approach to the analysis of variation in survival and discusses the implications of certain assumptions and their validation.

John Whitaker, Jr. addresses the potential problems in analyzing food habits of insectivorous bats. He combines a thorough review of the literature with an easy-to-use, illustrated key to arthropods commonly eaten by insectivorous bats. He describes material preparation, identification, and analysis with informative comments on techniques and their potential problems.

Thomas Kunz outlines methods for assessing the availability of prey to insectivorous bats—procedures applicable to investigations of other aerial insect-foraging animals as well. From goals and techniques through implementation and analysis, he reviews many types of insect trapping devices and discusses weaknesses and biases associated with different sampling methods.

Donald Thomas addresses the analysis of diets of plant-visiting bats. He explains how food materials are collected from frugivorous and nectarivorous bats and examines sampling biases. He describes innovative techniques for dietary studies by relating his experiences from two years of research on a pteropodid colony in west Africa.

Methods of estimating the availability of fruit to frugivorous bats are presented by Edward Stashko and Eric Dinerstein. Written for investigators unfamiliar with tropical forest ecology and fruit-bat ecology, they review the sparse literature on this relatively new subject. Methods for collecting, preserving, and identifying samples are provided in combination with suggestions for promising investigative directions.

Lawrence Herbst provides a critical review of the techniques for analyzing nutrition. He also discusses practical topics such as how to determine digestibility and methods for measuring the energy content of food.

Don Wilson presents the results of a questionnaire he sent to bat researchers and zoological parks concerning the maintenance of bats for captive studies. Recom-

mendations on suggested food items and dietary supplements for insectivorous, carnivorous, piscivorous, sanguinivorous, frugivorous and nectarivorous bats are provided. A list of species kept in captivity with data on success ratings along with discussions of housing considerations and health precautions for captive bats combine to make Wilson's chapter a valuable reference.

The chapter by Connie Gaudet on training bats for behavioral studies is an excellent accessory to Wilson's contribution on maintaining captive bats. She discusses the training of bats with reference to bat behavior and conditioning. Gaudet also provides examples of experiments and training stages in combination with suggestions for innovative techniques that have worked well for her and other investigators.

Thomas Kunz and Kenneth Nagy review field and laboratory methods of energy budget analysis for free-ranging bats. They present practical considerations and procedural assumptions in combination with discussions of techniques and their inherent errors. Cost estimates and suggestions on how to avoid problems are provided with strong recommendations for particular study procedures.

George Bakken and Thomas Kunz detail various approaches to the examination and measurement of bat roost microclimates. Beginning with the basics of thermoregulation, they discuss instruments and procedures used to make measurements in the field and introduce such topics as the application of National Meterological Service data. Researchers will find the list of mathematical symbols and units especially useful.

Allen Kurta and Marty Fujita provide an extensive, up-to-date review of new techniques in the design and interpretation of laboratory thermoregulation studies. Their discussions include the applicability, limitations, and constraints of various apparatus. They explore the potential physiological and behavioral modifications of captive bats and their effects on thermoregulation—factors often overlooked by investigators.

In their chapter on respirometry, Holly Stack and David Rossi focus on measuring metabolism through gas analysis. Their lucid discussions of terminology and apparatus are followed by descriptions and graphic representations of the necessary components and possible configurations of these components.

John Bassett and Eugene Studier review methods and theories relating to the determination of water balance in bats. They describe innovative approaches that enable investigators to quantify the water economy of bats, both in the laboratory and in the field. They discuss the assumptions, limitations, and costs of the different approaches.

A practical guide to the techniques used in analysis of body composition is provided by Elizabeth Pierson and Holly Stack. Their discussions, including reviews of previous techniques and research, focus on *in vivo* and *in vitro* methods for analyzing five basic components: water, lipids, proteins, carbohydrates and inorganic (ash) constituents. Their chapter ends with a presentation of possible approaches to studying energy budgets that integrate methods discussed in previous chapters.

Lawrence Forman and Carleton Phillips introduce methods for preserving and preparing tissues. With the assumption that most researchers are not experts in the techniques of histology and histochemistry, they explain basic practices that are germane to field situations and are useful in ecological and behavioral studies.

The techniques used to obtain chiropteran karyotypic preparations from bone marrow and primary cell cultures are described by Robert Baker and Mazin Qumsiyeh. They explain how to obtain materials and how to prepare them for slides and chromosomal banding (including recipes for media). They also alert the reader to the complexities of cell culture techniques.

Charles Handley, Jr. provides a complete guide to the preparation of bat specimens. His statement, "no other mammal is as easily prepared," is indeed true if the specimen preparer follows Handley's step-by-step, fully illustrated guide. Such topics as equipment and materials for wet and dry preservation, conventions in preparing and attaching tags, and descriptions of how to pin bats for further study are covered thoroughly.

Current methods of collecting and preserving ectoparasites for ecological study are presented by John Whitaker, Jr. His excellent introduction to identifying ectoparasites includes descriptions of major groups with sources for further reference. Whitaker is one of few contributors who provides a list of potential ecological studies for his area.

In a sister chapter, James Coggins reviews methodologies used in conducting ecological studies of bat endoparasites. He describes the preservation of bats, how and where to look for endoparasites, and techniques for specimen preparation and staining.

Denny Constantine concludes the volume by discussing health precautions and protective measures for bat researchers. He updates information on health hazards that most bat researchers recognize and addresses others of which most are possibly unaware. He alerts the reader to threats to bat health caused by biologists introducing disease-producing microorganisms into bat roosts or directly into bat populations.

Ecological and Behavioral Methods for the Study of Bats is not intended as an exhaustive treatise on every conceivable technique in modern ecological and behavioral research on bats. However, because it was written by professional biologists with their colleagues in mind, it covers most major areas of interest. Descriptions of

traditional approaches and more recent state-of-the-art procedures are presented. In the increasingly complex and technologically advancing field of bat research, suggestions for further study are valuable to future investigators and were included by a few authors. Useful and time-saving references to equipment and supply vendors, frequently combined with directions for the construction of unique field equipment, are included by many authors. This comprehensive, thought-provoking volume is a valuable reference for those who study bats. This book will influence significantly the direction of future research in bat biology.

James E. Gardner
Illinois Natural History Survey
Champaign, Illinois 61820

RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths) for inclusion in this section. Receipt of reprints will facilitate complete and correct citation. Our Recent Literature section is based upon several bibliographic sources, and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome.

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ECOLOGY

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ANNOUNCEMENT

The 19th North American Symposium on Bat Research will meet on October 19, 20, 21, 1989 in Knoxville, Tennessee. Our hosts will be Gary McCracken of the Zoology Department at the University of Tennessee and Michael Harvey of Tennessee Technical University, Cookeville, Tennessee. The meetings will be held at the Holiday Inn in downtown Knoxville, adjacent to the Worlds Fair site.

Gary has made arrangements for the participants to stay at the Holiday Inn. The Holiday Inn has given us a much reduced rate of $49 for a single occupant room. Surprisingly, if two people share a room the rate is still $49 or only $24.50 per person. There is a $4.00 discount for students. Enclosed you will find a reservation form. Complete it at your earliest convenience and send it to the hotel. The hotel address is:

Holiday Inn Worlds Fair
525 Henley Street
Knoxville, TN 37902
Telephone: 615-522-2800

You have already received forms for registration in the symposium, title transmission page, and student hororaria. A duplicate set is enclosed. All forms except that for hotel reservations should be returned to:

G. Roy Horst
Department of Biology
Potsdam State College - SUNY
Potsdam, NY 13676

Registration fees will be returned in full if for some reason you cannot attend.

You will notice that the tax on rooms is a vary outrageous 12.75%. This is a temporary tax on hotels and entertainment to help defray the costs of a new sports facility in Knoxville. I have contacted the Tennessee Department of Taxation and Finance and they agreed to send me the forms required so that tax exempt institutions need not pay this exorbitant tax. I will keep you informed as to progress on this topic.

Gary and Mike are arranging several special features. Brock Fenton will conduct a workshop on teaching echolocation techniques on Thursday at 14^{00} hours. If you plan to participate please contact Brock at 416-736-5243 by phone or at:

Department of Biology
York University
Downsview, Ontario
Canada M3J-1P3

There will be a lecture on Histoplasmosis and its risks to bat researchers presented by an expert from the Center for Disease Control. This lecture will be scheduled for Saturday forenoon if possible.

On Thursday evening there will be a no host cocktail party from 7:30 until the police arrive.

On Friday evening there will be a banquet-barbeque at which the student awards will be made. We are also planning to roast one of our own. Don't miss it, it could be you.

If you have any further questions (about anything) contact me and I'll try to resolve them!

Gary, Mick and I are eagerly looking forward to seeing you in Knoxville.

Warm regards,

Roy

cut here

NINETEENTH ANNUAL NORTH AMERICAN SYMPOSIUM ON BAT RESEARCH

October 19-21, 1989
University of Tennessee
Knoxville, Tennessee

REGISTRATION FORM

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Includes Program, Abstracts, Attendance at all Sessions and
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Spouses and friends who attend the sessions are considered as participants and are requested to register.

To register please return this form **before September 1, 1989** with a check payable to **North American Bat Symposium** to:

G. Roy Horst
Department of Biology
State University College of Arts and Science
Potsdam, New York 13676

BAT RESEARCH NEWS

Volume 30 Summer 1989 No. 2

CONTENTS

FRONT COVER

Sketch of the South American bat *Lonchophylla handleyi* showing the grooved tongue used in nectar-feeding. *L. handleyi* was named in 1980 by J. E. Hill of the British Museum in honor of Charles Handley of the National Museum (Smithsonian). Sketch by Tom Griffiths.

BAT RESEARCH NEWS

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Publisher and Managing Editor

Dr. G. Roy Horst
Department of Biology
State University College at Potsdam
Potsdam, New York 13676 USA
Tel.: 315–267–2259

Editor

Dr. Thomas Griffiths
Department of Biology
Illinois Wesleyan University
Bloomington, Illinois 61702 USA
Tel.: 309–556–3230

Editor for Reviews

Dr. Peter V. August
Department of Natural Resource Science
University of Rhode Island
Kingston, Rhode Island 02881
Tel.: 401–783–4032

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BAT NEWS RESEARCH

Volume 30 Fall Number 3

Some Abnormal Behaviour in the Infants of *Rhinopoma microphyllum kinneari*

B.S. Gaur and M.G. Shahrokh

Department of Zoology, University of Jodhpur, Jodhpur- 342001, India

A unique suicidal behaviour in the infants of *Rhinopoma microphyllum kinneari* was observed between 13th September and 4th October, 1987 while studying the ecophysiology of the rat-tailed bat, *R. m. kinneari*. Rat-tailed bats inhabit a tunnel (109 m x 9 m) in Mandore, 10 km N of Jodhpur (26° 18' N, 73° 04' E), where the first author has studied these bats since 1967.

R. m. kinneari has two roosting sites: (i) summer or natal (the tunnel), where they feed and give birth to young ones and (ii) winter or rest-site (an unused well about 7 km from the tunnel), where they undergo a period of cyclic rest in a semi-torpid condition throughout the winter (Gaur, 1981). The migrations between these sites are regular and probably controlled by a self-imposed time schedule (Gaur, 1981). At the summer site nearly all adult females give birth in July, nurse their infants for 2-3 weeks and then abandon them. Adult bats start migrating to their winter site in September, and continue throughout October and sometimes into November. The infants left behind in the tunnel hide themselves in crevices, under stones, or in some other safe place.

In 1987 an unusual behaviour was observed. When the mothers abandoned the infants, a flock of at least 500-700 infants left the tunnel and roosted openly in a shady corner of a water channel (approximately 70 m x 15 m with stagnant water) about 200 m away from the normal exit side of the tunnel. Here the flock was directly exposed to predators, and the infant bats became a delicious dish of the Indian house crow, *Corvus splendens splendens* in the morning and afternoon. We observed *Corvus s. splendens* attacking the infants for four days (23rd, 24th, 28th and 29th September, 1987) between 0700-0900 h and 1700-1900 h. We noted that within 10 minutes 3-4 bats were killed by the crows, for an average kill of 30-40 bats each day. *Corvus splendens splendens* employed two methods of attack: (i) direct attack and (ii) by watching the bats closely from a distance of 2-3 meters and then skillfully capturing them in the mouth. The infants, which emitted a cry of "chi- chi- chi- chi-" during the capture (fig. 1), were taken to a nearby tree or to a wall of a bridge or building. There they were killed by the beak and claws of the crows. Some infants who could not be captured but were frightened by the attack slipped into the water and were seen swimming.

Table 1. Rainfall (mm) in different years at Jodhpur.

Year	Rainfall (mm)
1983	554.0
1984	220.5
1985	196.6
1986	175.0
1987	103.0

Data from the Central Arid Zone Research Institute (Climatological Division), Jodhpur.

Figure 1. Indian *Corvus splendens splendens* attacking and lifting the infant of *Rhinopoma microphyllum kinneari*.

We believe that this unusual infant behaviour has not been previously observed or recorded. What induced the infants to leave their normal roosting site and expose themselves directly to predators? Possibly the poor rainfall of the last three years (Table 1) and little or no rain this year (1988) had an effect. The rainfall has been so sparse, the area is presently experiencing one of the severe droughts of the century. The rain water, which used to flow and wash the tunnel, could not wash it. This might have resulted in changes in the microclimatic and other ecological conditions, causing an intolerable ecophysiological condition which compelled the infants to leave their normal roosting site.

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Parental Care in Two Insectivorous Bats: *Rhinopoma microphyllum kinneari* and *Taphozous perforatus*

B.S. Gaur and M.G. Shahrokh

Department of Zoology, University of Jodhpur, Jodhpur – 342 001, India

To look after infants until they become self-sustaining is a well established instinctive behaviour in many oviparous and viviparous animals. This parental care is species-specific and differs markedly among species of flying mammals-the bats. In *Rhinopoma microphyllum kinneari* and *Taphozous perforatus* (both insectivorous bats) the females, as usual, are responsible for nursing and caring for the infants. During pregnancy and the lactation period (the Cool-Wet Season in July-September), both species give birth in such a fashion that during delivery the infants attach to the mother's breast. After the delivery the infants remain attached to the mother's breast for 2-3 weeks, sucking milk from either of the teats. The females have two pairs of teats, one abdominal and the other thoracic. The newborn is helpless, deaf, dumb, naked and depends on the mother for all its activities.

The infant-mother attachment differs markedly in the two species. In *R. m. kinneari* the infant clings tightly to the mother with its head pointed toward the mother's tail. Its hind feet clasp round the mother's neck forming a chiasma, and it sucks the milk from an abdominal nipple (fig. 1). In *T. perforatus* the condition is just the reverse. The infant head is towards its mother's head, its hind feet clasp the interfemoral membrane of the mother while the thumb holds on to the region of mother's fore-arm. The infant perches in the ventral abdominal region and sucks milk from a thoracic nipple (fig. 2). The mother carries out all the normal activities of life—flying, foraging and homing—while the infant remains firmly attached to the breast. These observations were recorded from the roosting sites of these bats (inside a tunnel 109 m long and 9 m wide, located about 10 km N Jodhpur, India) where both these species roost under the same ecological conditions.

The difference in the mode of attachment of infants is probably due to certain anatomical differences between the species. *R. m. kinneari* (the rat-tailed bat) has a long tail and the inter-femoral membrane is poorly developed. *T. perforatus* (the sheath-tailed bat), on the other hand, has a short protrusible tail. The differences in the way the young are carried may allow full protection for the infant while not hindering the normal activities of the mother. Since the infants soon after parturition start sucking milk from the different teats,

we think that the mammary glands of these regions start functioning at different times.

Because the mother carries the infant to the foraging area and catches flying insects, it provides an opportunity for the infant to explore the home and foraging areas and the path between. It also trains the infant in how to attack and catch the prey. We therefore assume that the instinctive behaviour of parental care is followed by adopted or learned behaviour of the infants in catching prey in these two bats.

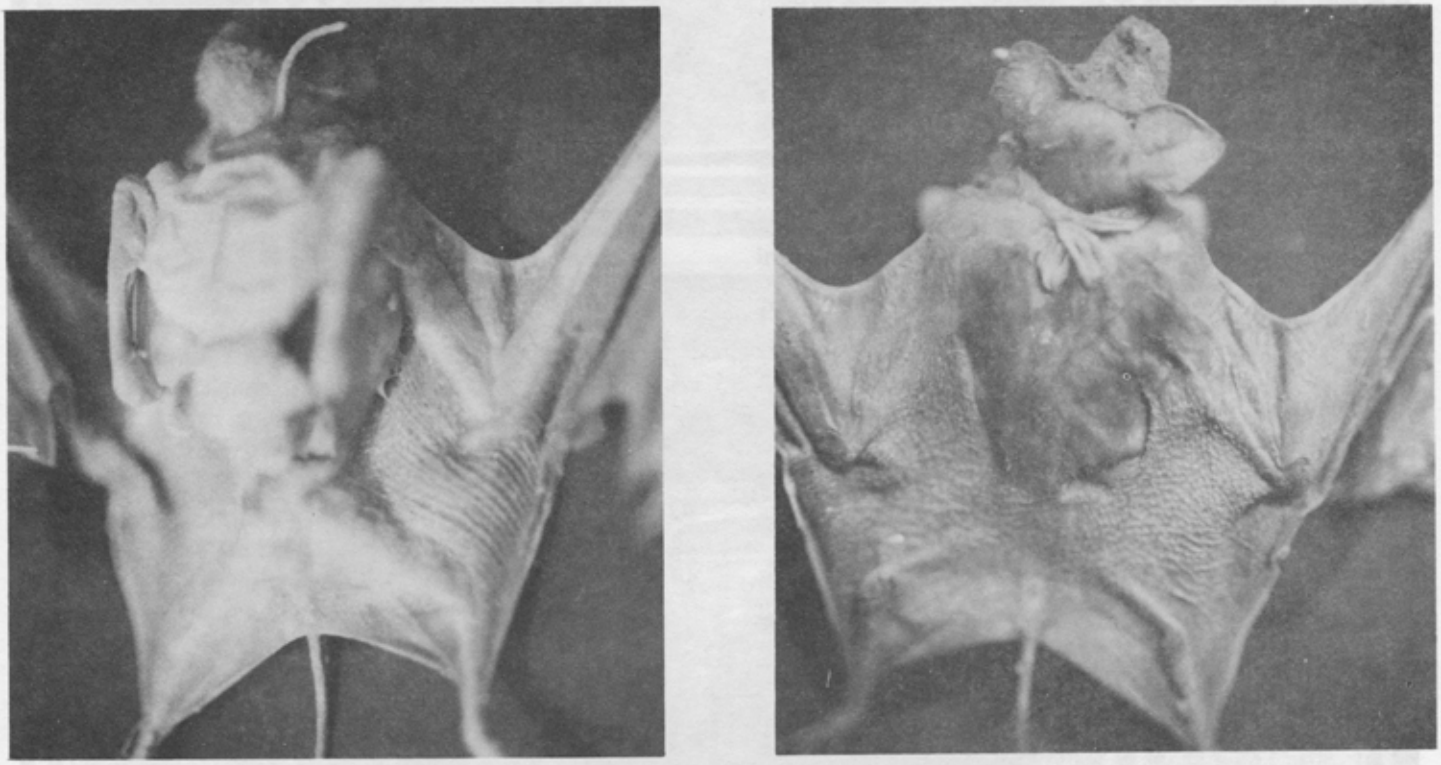

Figure 1. *A*. Infant of *Rhinopoma microphyllum kinneari* attached to mother four days after birth. Infant is sucking milk from the abdominal nipple. Mother and infant heads lie in opposite directions. (ventral view) *B*. Hind feet of infant *Rhinopoma microphyllum kinneari* clasped around the mother's neck forming a chiasma. (dorsal view)

Figure 2. Infant of *Taphozous perforatus* attached to mother four days after birth sucking milk from thoracic nipple. Mother and infant heads lie in the same direction. (ventral view)

Jan van Kessel's Seventeenth-Century Painting "America" Depicts Bats

Kunwar P. Bhatnagar
Department of Anatomical Sciences and Neurobiology
University of Louisville School of Medicine
Louisville, KY 40292 USA

A December 1988 visit to the Cincinnati Art Museum's traveling exhibit, the Masterworks from Munich's Alte Pinakothek collection of Sixteenth to Eighteenth Century paintings, turned up an interesting allegorical work by the Flemish artist[1] Jan van Kessel, the elder, who lived from 1626-1679 in Antwerp (fig. 1). This work entitled *AMERICQUE* ("America") is oil on copper.[2] Completed in the year 1666, it is a composite of sixteen small scenes (each panel 14.5 x 21 cm) clustered around a central, much bigger, scene (48.5 x 67.5 cm).[2] Each of the sixteen scenes is assigned a number and each one is identified by captions on the frame. One panel, number eleven, titled *Cartagene* (Cartagena, Colombia) depicts bats (see *BRN* cover). This latter scene includes an excellent reproduction of a bat with extended wings and shows two baby bats, one on each side on the breast, in addition to two other young and two adult bats. The presence of a tragus would reveal these bats to be a microchiropteran species, but beyond that it was futile further to attempt to identify or classify the bats in *"Cartagena."*

The depiction of bats is true to life. The following account of *"America"* and its creator is based on Brown and Wheelock (1988),[2] Bernt (1970),[1] and Wilenski (1960).[5]

Jan van Kessel's *America* is one of the series, *Four Quarters of the World*[5] representing the four continents, Europe, Asia, Africa, and America, exhibited in their original frames. *America* identified the distant continent with savage Indians, exotic animals, and richness of the land. The panels show representative cities of the time in the background (a familiar theme of the era), whereas in the foreground are shown strange animals such as bats, monkeys (some bearded), an armadillo, a tapir, a macaw, a turkey, other birds, alligators, lizards, snakes, fish, Guaperna—the four-legged Brazilian fish,[1] butterflies, beetles and other insects, spiders, and even elephants, giraffes, a zebra, and a unicorn.

A brief note on the Flemish artist will be appropriate here.[1,2,5] Jan van Kessel, son of Hieronymus van Kessel, Master Antwerp Guild 1645 and Captain in the Civic Guard, was born in Antwerp in 1626 and died there in 1679. He is well known as an artist who painted still life, animals, birds, insects, flowers and town views in the style of his master Jan Brueghel. He was the pupil of his uncle Jan Brueghel, the younger, and Simon de Vos. His paintings are often attributed to J.D. de Heem, and especially those of animal species, to the more careful artist Jan Brueghel, the elder.[1] Many of his works were sent for high prices to places like Vienna in his lifetime.[5] From his several biographies it does not appear that he ever traveled abroad. According to Brown and Wheelock (1988),[2] Kessel obtained his information from books published at that time and from other sources. Such a book about Brazil was *Historia naturalis Brasilae* by Georg Margkraf and Wilhelm Piso published in Amsterdam in 1648. A number of animals in the smaller panels in *America* are said to be based on K. Gesner's *Historia Animalium* published in Zurich in 1551.[2] Kessel's paintings are housed in many museums, primarily in the Alte Pinakothek, Schleissheim Castle, Munich; Prado, Madrid; and the Kunsthistorisches Museum, Vienna.

Some interesting questions remain to be explored. Did Kessel include bats in his other continents of the series? Do any of his other works depict bats? Did his master Jan Brueghel also include bats in his paintings as did Goya[3] and Teniers?[4] And finally, which other Classical Painters have depicted bats in their works? Why did Kessel choose *seventeen* scenes in his series *America*, no more and no less; are the other three series also composed of seventeen panels each? The answer may be in an interesting speculation that he was completing this work in the Seventeenth Century, and the number Seventeen itself was considered a lucky number!

The author is grateful to Professor Charles Wagner, Ms. Kanti Lall, Indu Bhatnagar and Professor Gail Gilbert of the Allen Hite Art Institute, University of Louisville, for help in the preparation of this article. Grateful thanks are also extended to Professor Dr. Erich Steingraber, Generaldirektor, Alte Pinakothek and Dr. Cornelia Syre, Oberkonservatorin, Bayerische Staatsge-

Fig. 1 (Opposite) Jan van Kessel's *AMERICQUE* (1666). Reproduced by permission

maldesammlungen, Munich, FRG for permission and for providing the excellent photographs reproduced here. Ms. Susan Hodge kindly prepared the typescript.

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Some Notes on Bat Conservation in Central America

Editor's Note: Roy Horst recently received a clipping of an article on bats from *The Tico Times*, a widely-circulated newspaper published in Costa Rica. The article, written by a columnist named Cyrus Reed and based on interviews with *Bat Conservation International's* Patricia Morton, is an excellent update on conservation efforts in Central America. Roy suggested that we obtain permission from *The Tico Times* to reprint it, and that we ask Pat Morton to write an introduction. Here 'tis. (TAG)

The article, "Beneficial Bats are Victims of Vampire Fear," with front page color photographs, is a good example of what a difference education can make when trying to change attitudes about bats. My first contact with the *Tico Times*, Central America's leading English-language newspaper, was in June, 1987, when they published an error-filled article, "Vampire Bats Bite 21, Who Needs Killer Bees?" At the time I was in Costa Rica working on an 18-month educational campaign about the importance of bats. Part of my project was to provide the news media with factual and helpful information about the diverse and important fauna resident in that country. I immediately wrote a letter to the editor, correcting the errors and providing facts about the many beneficial and unique species found in Costa Rica. The next week they published my letter with an apology and an offer to follow-up with an article on the benefits of bats. In September they indeed did publish a full page article with photographs, including a large color shot of a bat pollinating a flower that took up most of the front page.

That was the beginning of a new relationship between bats and the *Tico Times*. The paper again featured bats in their "Year in Review" issue as well as in several smaller articles such as one on the Costa Rican bat postage stamps and advice to readers on how to exclude unwanted bats from houses. I lost contact with them when I returned to my graduate studies in Wisconsin in January 1988. Then, this past June, *Tico Times* reporter Cyrus Reed tracked me down in Texas, and requested an interview for an article he was doing on vampire bats. This led to a more in-depth interaction and I was able to provide him with new photographs and additional information about bats.

Another behind-the-scenes anecdote is the story of Dr. Victor Hugo Sancho, the veterinarian quoted in the article. Early in my project I was fortunate to meet this man who I found tucked away in a small office in a remote lab at the Ministry of Agriculture and Cattle. His job is to respond to rabies outbreaks as well as help farmers eradicate local vampire bat colonies. At our initial meeting I came armed with literature expecting to find a uninformed ministry bureaucrat. To my surprise and delight he not only was well-informed about the control of vampires but was also a first class bat aficionado. He had made his own portable glass-cased exhibit of Costa Rican bats to help farmers distinguish vampires from the many beneficial species. During my tenure in Costa Rica I was invited many times to accompany him to ranches where I spoke with people about their beliefs and attitudes regarding bats. This information was vital to the subsequent educational materials I developed.

Dr. Sancho was provided with all the materials I produced, including a Spanish slide/tape program. He continues to report to me regularly about his lectures given to schools, veterinarians and cattlemen's organizations. He recently showed the audiovisual program at an international animal health meeting in Brazil that

was attended by veterinarians and other people from 30 countries.

Despite concerted efforts by myself, Dr Sancho, and others, it is obvious from the following article that even in a country as small as Costa Rica much education still needs to be done. Indiscriminate practices, such as the torching of bat roosts, are still common and continues to decimate countless colonies of highly beneficial bats.

Patricia A. Morton
Director of Education
Bat Conservation International
Austin, Texas

Beneficial Bats Are Victims of Vampire Fear
(reprinted by permission of *The Tico Times)*

by Cyrus Reed

"...as she arched her neck, she actually licked her lips like an animal, till I could see in the moonlight the moisture shining on the scarlet lips and on the red tongue as it lapped the white sharp teeth. I could feel the soft, shivering touch of the lips on the supersensitive skin of my throat, and the hard dents of two sharp teeth, just touching and pausing there. I closed my eyes in a langorous ecstasy and waited—waited with a beating heart."—"Dracula," by Bram Stoker.

"They circle their victim, making all sorts of swoops, and emit some sort of substance so you sleep. You don't wake up. Then they land on the wall or wherever, and they drag themselves down with this arm on their wing, looking for the best way to bite you."—Venancio Gomez, a wizened Costa Rican vampire victim on Isla Venado.

The overwhelming majority of Costa Rica's 103 bat species are beneficial to man and the environment, but *Desmodus rotundus*, also known as the common vampire bat, is one of three species which lives off the blood of vertebrates. Like Dracula of legend, it can nourish itself with human blood. But human ignorance (vampire bats do not emit substances to make you sleep) and fear have hurt Costa Rica's other bats—and, ultimatly, man—far more than the tiny winged mammal ever has.

"Most people tend to think of bats and vampires as one and the same," complained Patricia Morton, who spent 18 months on a grant for the World Wildlife Fund in Costa Rica trying to explode some of the myths about bats (TT Sept. 4 1987).

Venancio Gomez is an 18-year resident of Venado (Deer) Island, a five-by-two kilometer, heavily-foliaged, hilly isle located in the Gulf of Nicoya across from the Pacific port city of Puntarenas. The approximately 700 residents, who live from fishing and related activities, have been fending off bat attacks for years.

After a rash of attacks about two months ago, a group of some 15 men, brandishing gasoline and torches, organized a search-and-destroy mission, circling the island for two days. They smoked caves and burned trees, but no one could be sure how many bats—or what type—they killed.

"People are quick to grab at anything that's a bat," explained Dr. Victor Hugo Sancho, a veterinarian who heads the Agriculture Ministry's anti-vampire bat campaign.

U.S. zoologist Morton said she has witnessed the massacre of thousands of beneficial fruit bats poisoned from eating bananas laced with strychnine. Vampire bats do not eat fruit.

"What's tragic is that human disturbance has caused vampire bats to switch to cattle—an animal that has no defense against its attacks. The growth of the cattle industry, and consequently deforestation, only leads to more vampire bats. So because humans destroy whatever (bats) they find, they just make the situation worse," explained Morton, the education coordinator of Bat Conservation International.

Vampire attacks on humans are most common during the early part of the rainy season, beginning in May.

"They frequently roost in very humid caves, and the caves fill up with water when the rains come," explained the bat expert. "They must look for new homes, and a new reliable source of food, since they must eat every day. If they are not able to find cattle and horse blood—which they overwhelmingly favor—they do occasionally bite humans."

"There's a general increase in population at this time, because a lot of the vampires are born in March, so by May or June, (the young bats) start to get hungry for blood," Sancho added. He said the two biggest outbreaks of bat attacks on humans this year were reported near the northern town of Los Chiles, and in the northern hills of Guatuso.

According to "Costa Rican Natural History," edited by U.S. biologist Daniel Janzen, the vampire bat makes the inital wound with its two upper incisors, a pair of V-shaped "fangs." An anti-coagulant in the bat's saliva keeps the blood from clotting, and the bat spends between 10 and 40 minutes lapping up the freely-flowing blood. Like the legendary Dracula, the vampire bat returns to a successful feeding place night after night, reopening and widening existing wounds.

The wingspan of an average *Desmodus rotundus*

measures a mere seven inches, but the bat's agility and speed make it hard to catch.

What worries health officials is not the bat's high-protein diet or the size of its bite—approximately 15-20 ml (about three to four teaspoonsful) of blood are extracted per feeding, and an additional 25 ml (five teaspoonsful) are lost as the wound dries—but the deadly diseases it can transmit. The most serious of these is paralytic bovine rabies, a viral infection which affects the central nervous system of mammals. Like its counterpart, the "furious rabies" spread almost exclusively by dogs, paralytic rabies can infect humans.

While only 0.5 percent of bats contract rabies, studies estimate that vampire-transmitted rabies has cost cattle farmers hundreds of millions of dollars in the bat's range, which stretches from Mexico to the southernmost regions of Argentina and Chile.

"The disease can appear a year after it is transmitted, but once the symptoms appear, there is nothing you can do," noted Dr. Sancho.

Bitten humans and livestock are vaccinated against rabies with a series of injections. In humans, between three and seven shots are administered, usually near the spine, for three to seven days. According to Sancho, the last time a person died from bat-transmitted rabies in Costa Rica was in 1969, while about 250 cattle a year die from the disease.

"The shots are not bad," shrugged Venado Island resident Francisco Peralta, 18, who during the latter part of April woke up several mornings in a row with "little streaks of blood running down my toes" and knew a vampire had been there.

In May 1987, nearly 80 people were bitten on the island's east side. A health offical, Vicente Chaverri, was quickly dispatched to administer the anti-rabies shots, and now regularly visits the island. This year about a dozen residents have been bitten.

Islanders say the bats roost in the small fissures in the steep rocky cliffs of the island during the day and feed at night, except during a full moon, when the light-shy vampires will not emerge. While nearly everyone on the island has a scar to show or a story to tell, few actually awaken to witness bats biting their feet (where most of the bites occur).

Ramona Matarrita, a Venado resident whose son Carlo Eduardo was bitten in the toes several nights in a row, began to stay up late in anticipation of the unwelcome visitor.

"It was small and hopped around the walls, dragging itself with this little finger on its wing," she recalled. "And they know you are there, but they don't go away, they just hop around, waiting." Matarrita said she finally left an oil lamp burning all night to protect her son.

Instead of the slash-and-burn tactics used by the local population, the Agriculture Ministry eradicates vampire bats by placing nets in areas frequented by the bats—cattle pastures and human homes. Then they anoint the netted bats on the chest or back with a sticky red paste trademarked "Vampirisan," and release them. The bats are greeted by their cohorts, who lick and groom each other's coats. The paste induces massive internal hemorrhaging five to six days after the bats ingest it, and they bleed to death.

Farmers also apply the poisonous paste to their cattle's bat wounds, to surprise the vampire bats upon a return feeding.

"The trouble is, this kills only one bat instead of 20 or 25," explained Sancho.

Sancho defends the diabolical extermination method, noting that, in addition to transmitting rabies, the vampire bat's bite results in a chronic loss of blood, which reduces the weight of cattle and depreciates the value of hides used for leather. He added that open wounds also provide an open door for secondary infections, including the screwworm. He estimates that 80 percent of screwworm cases result from vampire bat bites.

The vampire's biggest danger, however, is the bad name it gives other bats.

Morton explained that local rain forests could not survive without the nightly foraging which take Costa Rica's bats up to 50 km from their sleeping dens, making them vital to both pollination and seed dispersal for hundreds of species of plants and fruit-trees. In clear-cut lands, Morton says, bats drop the very first seeds. The resulting "islands of vegetation" bring birds and eventually natural reforestation.

Costa Rica's largest bat, with a wingspan of two feet, is a bird-eating carnivore known as the "false" vampire bat. The tiny White Honduran bat, weighing in at 5 to 6 grams, is content to eat insects when not roosting in banana leaves, resembling a white puff ball. More than 50 percent of Costa Rican bats feed on fruit and nectar.

The "true" vampire bat can be distinguished from other bats principally by the long "thumb" extending from the mid-point of the top of its webbed wing, an inch-long, three-jointed prong which helps the bat pull itself down walls and under doors with its characteristic stunning alacrity. Other distinguishing features include its Pekingese dog-shaped face, and its "V"-shaped fangs.

Judging by a quick sampling of the Isla Venado residents, however, distinguishing bats is no easy task.

"I'm not really sure," admitted the oft-bitten Santo Matarrita, who did note that islanders know that fruit-eating bats tend to live under the crooks of mango and

coconut trees, rather than in caves.

Understanding the difference is crucial.

"Bats are extremely vulnerable to extinction for two reasons: they reproduce very slowly, and they roost in large numbers," Morton said.

Jose Antonio Sonano, a 24 year old fisherman from the isle, said residents might learn a lesson from the island's name.

"There used to be a lot of deer on this island, but around 25 years ago, these very stupid people hunted them all down, and the dogs they brought also killed them."

Today, Jose Antonio says, there are no deer on the island.

Book Review

Tuttle, M. D. *America's Neighborhood Bats*. University of Texas Press, Austin, viii + 96 pp., 1988. Price $9.95 (paper).

Have you ever needed a clearly written, handsomely illustrated short book on bats to loan to the rattled homeowner who has discovered a solitary bat on the front porch or to the curious student wishing a readable introduction to bat biology? Merlin Tuttle has written such a book. *America's Neighborhood Bats is* a concise survey of common North American bats and their natural history. The book is richly illustrated with color photographs, mostly by the author, and fine line drawings by Charles Shaw and Priscilla Vogt.

The introductory sections of *America's Neighborhood Bats* succinctly review the natural history of bats. Special attention is given to public health issues. Tuttle describes in detail how homeowners can safely remove unwanted chiropteran visitors from the inside of a building. Careful attention is given to how and when to permanently exclude bats from a dwelling. In the section entitled "Living in Harmony" Tuttle explains how bats benefit homeowners, and sometimes whole communities, by eating mosquitoes. A long section provides detailed instructions on the construction and placing of bat boxes. Brief descriptions of the life history of a dozen or so common North American bats is offered in the section "Getting to Know Your Neighbors." A clearly written and well-illustrated key to many species and all genera of North American bats is presented. Finally, a complete list of references is provided for readers who wish to continue their studies of bats.

This inexpensive little book will find a niche in the libraries of *BRN* readers, especially those who are frequently called upon to allay public fears and misconceptions about bats. *America's Neighborhood Bats* will be an effective public education tool. Should that loaner copy disappear, the modest price of $9.95 will make it easy to buy another.

—Peter V. August, *Department of Natural Resources Science, University of Rhode Island, Kingston, Rhode Island 02881.*

NEWS

AUSTRALIA

From *Macroderma*, vol. 4, no. 2 (1988): Our sister publication reports that the papers presented at the First National Flying Fox Symposium (held in Brisbane in August 1986) have been bound into a booklet which is available from Dr. Les Hall, Department of Anatomy, University of Queensland, St. Lucia, Queensland 4067, Australia. The booklet consists of 80 pages and contains 24 papers on "all aspects of flying fox biology." The price of each copy is $6.00 (Australian) for copies ordered in lots of up to 10; for 10 or more copies ordered together, the price drops to $4.50 per copy. Please add $1.85 per copy for surface mail overseas shipment or $6.60 per copy for air mail overseas shipment. Checks/money orders should be made payable to: Australian Mammal Society Flying Fox Symposium and sent to Les Hall at the address above.

FRANCE

Fédération Rhône-Alps de protection de la Nature, Grenoble: Jean-Francoise Noblet, a self-made amateur naturalist, has been made director of the Rhone-Alps Federation of Nature at Isere, one of France's most important environmental organizations. Noblet, who

has long been interested in bats, is presently working on surveys of bat populations around France, mainly in the county and national parks of that country. He is particularly interested in the problem of how bats react to the intoxicating chemicals used by builders to protect carpentry. He has also been busy in conservation efforts: building artificial nests, attempting to close important hibernacula to human disturbance, and preparing newspaper articles and radio/television presentations on the importance of bats. Some of Noblet's recent publications are listed in the Recent Literature section of this issue of *BRN*. [From a letter to TAG from **J. F. Noblet**]

MEXICO

Instituto de Biologia, Universidad Nacional Autonoma de Mexico: At the moment I'm on my sabbatical here in the lower sierra of northern Puebla: 400 m, tropical, rainy as Venus and all or almost all the jungle destroyed. Only the mountain tops and gorges (barrancas) have any real vegetation left at all. So you can imagine what is left of the original bat fauna. Add to that the fact that at this latitude we are in the northern (and eastern) limit of a great quantity of filostomid bats: *Artibeus, Carollia, Sturnira, Glossophaga, Chiroderma,* and then, with luck, a few insectivores such as *Molossus* and two species of *Myotis*. Because so much insecticide is used here, there is hardly an insectivorous bat population. Caves have been depopulated, and mostly all you find in them is *Desmodus*, the original trouble-maker for which the caves were originally cleaned of bats. Years ago (7) we banded a series of filostomids here, and I'm still trying to recapture a few. I am also studying their feeding habits, and by now I have a good idea of the local flora. I will have the opportunity of traveling to Rome this year for the Fifth [Theriological Conference]. [From a letter to Roy Horst from **William Lopez-Forment**]

UNITED STATES

ARKANSAS

Womble Ranger District, Mount Ida, AR: I recently borrowed a harp trap from Gene Gardner in order to have a pattern for fabrication of one for my use in the Forest Service. The gentleman building the trap for me indicated he would be willing to fabricate additional traps (all aluminum) for sale. The cost of the trap, excluding the bat retention bag, is $490 plus shipping (UPS). Traps will be shipped within three (3) weeks of order placement. For additional information, interested persons should contact: JOE SWINDLE, P.O. BOX 164, MT. IDA, ARKANSAS 71957, TEL. 501-867-4295 (home) or 501-867-2174 (work). Backpack type carrying bags for the entire trap, the bat retention bag and several other bags for specific portions of the trap can be purchased as a unit (about $250) from: GRADE 6 OUTDOOR ENTERPRISES, INC., 112 SOUTH RACE, URBANA, IL 61801, TEL. 217-328-6666. I had a hard time finding anyone interested in fabricating this trap and thought others might find this information useful. [**David A. Saugey**]

VIRGINIA

1522 Philmont Ave., Chesapeake, VA 23325: Bat conservation, education, and rehabilitation are thriving in southeastern Virginia, thanks to the efforts of Barbara McCane, her daughter Tina, and friend Ann Landis. In letters to Brock Fenton and TAG, Ms. McCane has described their remarkable success in the early summer of 1988 in caring for injured bats, including some infants. As of late June, they were caring for a total of 15, including two red bats (both with young), two evening bats (one with young), one hoary, one little brown, and a variety of orphaned infants. Tina McCane and Ann Landis each hold state wildlife rehabilitation permits and Landis holds a federal permit as well. All three women have received considerable press coverage as word of their efforts has spread, and they have increasingly become involved with bat education programs around eastern Virginia. They have spoken to groups of girl scouts/brownies, organic gardeners, cavers, and visitors at a state park. Ms. McCane writes that they would be interested in sharing what they have learned about bat rehabilitation with others, and would appreciate hearing from others with similar interests. *Bat Research News* would certainly be happy to receive information about notable successes in bat care, and would publish new techniques in care or feeding if submitted to Tom Griffiths. Meanwhile, it's delightful to hear of successes in the difficult art of caring for injured bats. [From letters to Brock Fenton and TAG from **Barbara McCane**]

A Report on the Eighth International Bat Research Conference Sydney, Australia, July 9-15, 1989

Kunwar P. Bhatnagar
Department of Anatomical Sciences and Neurobiology
University of Louisville School of Medicine
Louisville, KY 40292 USA

The Eighth International Conference, convened by Michael Augee, was sponsored by the Royal Zoological Society of New South Wales, Sydney. From the very first day after the adjournment at Aberdeen in 1985, the International Organizing Committee (Michael Augee, Kunwar Bhatnagar, A. Gopalakrishna, Les Hall, Sue Hand, Darrell Kitchener, John Nelson, Kerryn Parry-Jones, Paul Racey, and Chris Tidemann) planned every phase of the Sydney conference in its tiniest detail, so much so that it came to be a roaring success. Some 170 scientists representing 18 countries registered. The largest group of delegates (numbering 78) was from the land down under, followed by the United States of America (22), India (14), United Kingdom (12), West Germany (9), Canada and Sweden (4 each), Spain and South Africa (3 each), Korea, Portugal, and South Africa (2 each), and one delegate each from Denmark, France, Israel, Italy, Netherlands, and Poland. The meetings comprised a preconference bus tour, the meetings themselves, and a postconference workshop at Cairns.

The Preconference Bus Tour, better called the "Sundowner Workshop on Wheels," attracted 40 on board from among the delegates and was led by Leslie Hall, University of Queensland, Brisbane. Leaving Cairns on 29th June, the scenic cruiser took the group through Townsville, Great Barrier Reef (Orphaeus Island, where several of us received coral cuts while snorkling - with infections resulting in some cases), Cape Hillsborough, Mackay (the home of the ghost bat, *Macroderma gigas),* Rockhampton ("save the bat colonies on Mount Etna" fame), Carnarvon Gorge, and Bunya Mountain national parks. The tour terminated at the relaxing Oxley Motor Inn, Brisbane, ending the 10 days of camping and traveling through temperature zones of between 27° and below 0°C! During this travel the group was kept highly entertained in every possible way. Memorable experiences include: the guided tour by Les Hall, the companionship and drive through 3,500 kms and four-meals-a-day treat provided by the coach captain Ron Garland and his wife Eileen, the visits to several poorly negotiable bat caves, talks by several conservationists, campfires, the celebration of the American Independence Day, and the incessant attacks of chiggers! The wildlife observed and photographed at all hours was phenomenal. This preconference "workshop" will always be remembered by the famous forty on board, thanks to the care and courtesy of its planners.

The Meetings opened with an informal dinner at the Australian Museum on Sunday, the 9th of July. Next day, on the University of New South Wales campus, Dr. Dan Lunney, President of the Royal Zoological Society of NSW welcomed the delegates. The opening address was given by Professor Leslie Hall on "Bat Conservation in Australia." The meeting then continued from 9 a.m. to 5 p.m. every day, with appropriate breaks for ample and delicious refreshments. There were no concurrent sessions, and no conflict with the poster sessions (3 sessions at which 29 posters were presented). Among the 82 platform presentations, the largest number of papers presented were on reproduction (18), followed by conservation (10), acoustic behavior and echolocation (8), flight modes and foraging strategies (7), bat-plant interactions, ecology, ecology and behavior, energetics (6 each), and anatomy and physiology, functional morphology, and systematics and biogeography (5 each). The largest number of presentations (six) were from Len Martin's laboratory in Brisbane. The megachiropteran phylogeny colloquium held after dinner on Wednesday was well attended. Despite the forceful and often dualistic presentations by some seven speakers for and against the diphyletic origin of bats, the three-hour long session adjourned without conclusions. The lavish conference dinner on Thursday was at the Randwick town hall. A delicious red wine bottled specially for the 8th IBRC (with a motif of *Pteropus poliocephalus)* by Kerryn Parry-Jones was flowing freely. Professor Racey offered a tribute to Mike and Diane Augee and their entire team of organizers. Other highlights of the meeting were: the presence of live *Pteropus* and *Tadarida,* baby Kangaroos, and a wombat, which often participated in the proceedings with their joyous shrieks; the spouses' hospitality program personally escorted every day by Diane Augee; the continuous chauffeuring to and from the airport and the Esron Motel by Mike Augee; the skillful conduct of the business meeting by

Mike Augee at which Madurai, India (Aligarh, India and Toronto were other prospects) was selected to be the venue for the 9th, 1992 IBRC; and the grandeur in which the meetings were held in general. Nothing lacked with the exception of a group photograph. Meeting abstracts are due to be published in *Macroderma*. The conference adjourned on Friday, at which time a large group of delegates visited the nearby Gordon colony of *Pteropus poliocephalus*.

The week-long *Post Conference Workshop* at Coles Vila Park at Cairns was organized by John Nelson and Chris Tidemann, and attended by 53 registrants. They visited Chillagoe *Pteropus* colony, mist netted bats (studying them by radiotelemetry and tritiated water), and examined several other aspects of bat biology. Lorain Jansen and Steven Hamilton contributed greatly in the success of the venture. Tom Kunz kindly provided these notes on the workshop.

Bat researchers around the world greatly appreciate the intensive planning and the conduct of the eighth IBRC by Mike Augee and his team. Our high compliments and many thanks for giving us such a wonderful treat. We now look forward to the 9TH IBRC in 1992, to be hosted by Dr. M. K. Chandrashekaran in Madurai.

LIST OF PAPERS PRESENTED, WITH AUTHORS AND ADDRESSES, AT THE EIGHTH INTERNATIONAL BAT RESEARCH CONFERENCE SYDNEY, AUSTRALIA 9-15 JULY 1989

The journal of the Australasian bat group, *Macroderma*, will be publishing the complete abstracts of the 8th IBRC sometime in the near future. But for the convenience of those North American and other readers of *Bat Research News* who were unable to attend, we have asked permission to print the titles of those papers presented at the meetings. We thank Dr. Michael Augee and the other conveners of the 8th IBRC for their cooperation and permission to run the following list. Special thanks to Kunwar Bhatnagar for all of his efforts. [TAG]

Changes in LHRH Neurons Associated with Ovulation in the Little Brown Bat.
E. L. P. Anthony[1], P. J. Weston[1], J. A. Montvilo[1], T. O. Bruhn[2], K. Neel[1], J. C. King[3]. [1]Dept. of Biology, Rhode Island College, Providence, RI 02908, USA; [2]Div. of Endocrinology, Rhode Island Hospital, Providence, RI 02903 USA;[3]Dept. of Anatomy, Tufts University Schools of Medicine, Boston, MA 02111, USA.

***Pteropus poliocephalus*—What is a Colony?**
M. L. Augee and K. Parry-Jones. School of Zoology, University of NSW, Australia.

Observations on the Ovaries of Some Indian Monotocous Bats.
N. Badwaik. Department of Biology, Institute of Science, Nagpur 440 001, India.

Behaviour of *Megaderma lyra* in a Nursery Colony.
J. Balasingh. Department of Zoology, St. John's College, Tirunelveli 627 011, South India.

Field Studies of Echolocation Behaviour: Foraging and Echolocation Flexibility - The Case of "Gleaners".
Robert M. R. Barclay. Biological Sciences, University of Calgary, Calgary, Alberta, Canada T2N 1N4.

Plasma Progesterone, Ovarian Steroidogenesis, and Delayed Implantation in the Long-Fingered Bat *(Miniopterus schreibersii)*.
R. T. F. Bernard. Department of Zoology and Entomology, Rhodes University, Grahamstown 6140, South Africa.

Vampire Bats Do Have Fully Developed Enamel.
Kunwar P. Bhatnagar & William A. Wimsatt (Deceased). Anat Scs & Neurobiology, University of Louisville Sch Med, Louisville, KY 40292 USA; Div of Biol Scs, Cornell Univ, Ithaca, NY USA.

The Chiropteran Pineal: Remarkable in Comparative Morphology and Ultrastructure.
Kunwar P. Bhatnagar. Department of Anatomical Sciences & Neurobiology, University of Louisville School of Medicine, HSC, Louisville, KY 40292 USA.

Anatomical Specializations of Bats for Fruit-Nectar-Pollen Feeding.
Kunwar P. Bhatnagar. Department of Anatomical Sciences & Neurobiology, University of Louisville School of Medicine, HSC, Louisville, KY 40292 USA.

Histochemical and Biochemical Analysis of Placenta in the Indian Fruit Bat, *Rousettus leschenaulti* (Desmarest).
D. A. Bhiwgade, Hemalatha N. Menon, and S.N. Menon. Department of Zoology, Institute of Science, Bombay 400 023, India.

Immunolocalization and Ultrastructural Changes of LH Gonadotropes in Relation to the Reproductive Cycle of *Miniopterus schreibersii.*
C. Bojarski. Zoology Department, Rhodes University, Grahamstown, RSA.

Foraging Behavior and Echolocation in the Diadem Horseshoe Bat *(Hipposideros diadema).*
Patricia E. Brown and Robert D. Berry. Department of Biology, University of California, Los Angeles, CA 90024, USA.

Histological Appearance of the Terminal Phalanges in the Wing of *Myotis lucifugus* as an Indicator of Age.
G. Dale Buchanan and Alnoor S. Nathoo. Department of Biomedical Sciences, McMaster University, 1200 Main Street West, Hamilton, Ontario, Canada, L8N 3Z5.

Cytoarchitecture and Neuronal Composition of Flying Fox Hippocampus.
E. H. Buhl and J. F. Dann. Vision, Touch and Hearing Research Centre, Dept. of Physiology and Pharmacology, University of Queensland, St. Lucia, Qld 4067, Australia.

Listening and Foraging by Gleaning in Echolocating Bats.
R. B. Coles. Zoologisches Institut, Universitat Munchen, Munchen, West Germany.

Echolocation and Doppler-Shift Compensation in *Rhinonycteris aurantius* and *Hipposideros ater.*
R. B. Coles and Anna Guppy. Zoologisches Institut, Universitat Munchen, Munchen, West Germany.

Identification of Australian Bats by Echolocation Calls.
R. B. Coles and Anna Guppy. Zoologisches Institut, Universitat Munchen, Munchen, West Germany.

Computer-Based Call Analysis for Microbat Identification.
Chris Corben. Forestry, PO Box 631, Indooroopilly, Queensland 4068, Australia.

Alpha and Beta Type Ganglion Cells in the Retina of the Flying Fox—*Pteropus scapulatus.*
J. F. Dann and E. H. Buhl. Vision, Touch and Hearing Research Centre, Dept. of Physiology and Pharmacology, University of Queensland, St. Lucia, Qld 4067, Australia.

Nightly and Seasonal Movements of *Pteropus poliocephalus* (Chiroptera: Pteropodidae) From Rainforest Remnants in Northern New South Wales.
Peggy Eby and Carol Palmer. NSW National Parks and Wildlife Service.

John Gould and John Gilbert's Australian Bats.
Miss Clem Fisher, Curator of Birds and Mammals, Department of Zoology, Liverpool Museum, William Brown Street, Liverpool L3 8EN, England.

Revision of the Genus *Melonycteris.*
T. F. Flannery. The Australian Museum, Sydney.

Feeding Mechanisms in Microchiropteran Bats: A Review.
Patricia W. Freeman. University of Nebraska State Museum, Lincoln, NE 68588-0514, USA.

Moth Defences Against Insectivorous Bats: An Update.
James Fullard. Department of Zoology, University of Toronto.

Ban on DDT in the United States: Its Effect on Bats from Carlsbad Cavern.
Kenneth N. Geluso. Department of Biology, University of Nebraska, Omaha, Nebraska, 68182, USA.

Breeding Habits of *Megaderma lyra lyra* (Geoffroy) at Different Places in India.
A. Gopalakrishna. Department of Zoology, Insitute of Science, Nagpur - 400 001, India.

Bats vs. Birds: Comparisons Among Peruvian Volant Vertebrate Faunas Along an Elevational Gradient.
Gary L. Graham. Bat Conservation International, PO Box 162603, Austin, TX 78716-2603.

***Cheiromeles torquatus*, A Spectacular Molossid in Trouble.**
Leslie S. Hall and J. D. Pettigrew. University of Queensland, Brisbane.

Bat Conservation in Australia.
Leslie S. Hall. University of Queensland, Brisbane.

Australian Fossil Hipposiderids: New Evidence about the Evolutionary History and Radiation of Old World Leaf-Nosed Bats.
S. Hand, M. Archer, and H. Godthelp. School of Biological Science, University of NSW, Kensington, NSW, Australia 2033.

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RECENT LITERATURE

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BAT RESEARCH NEWS

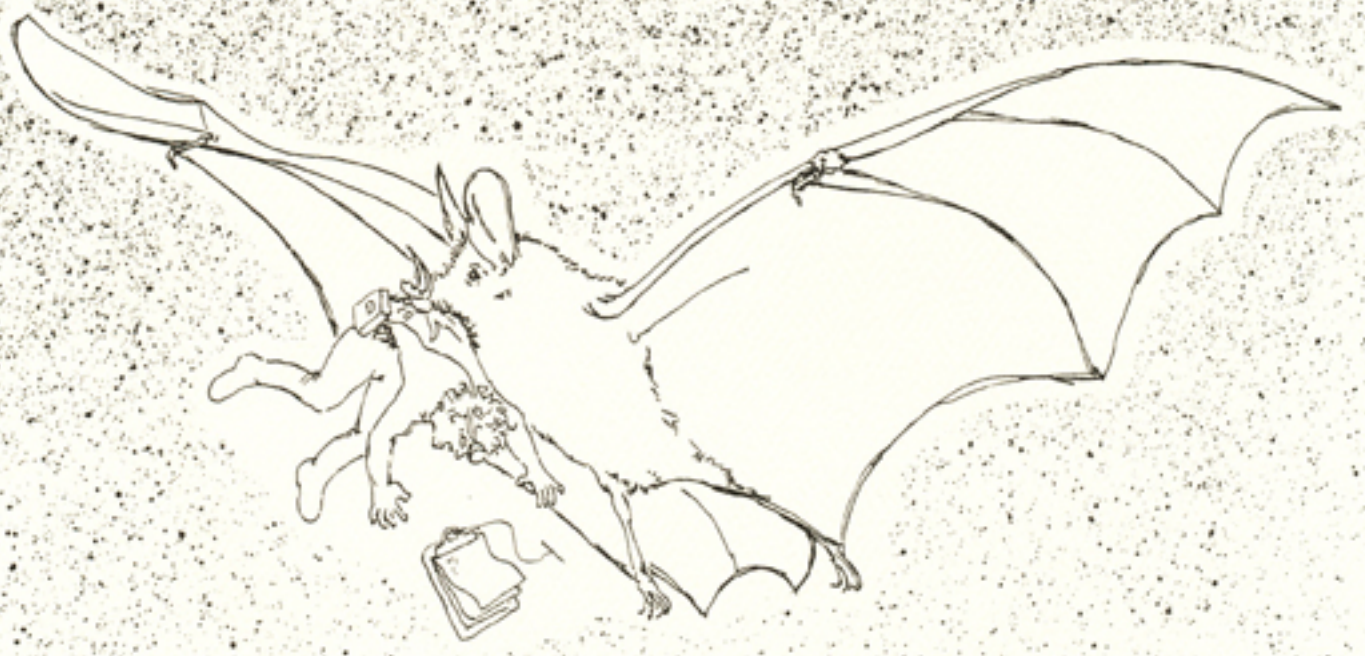
Volume 30 **Fall 1989** **No. 3**

CONTENTS

FRONT COVER

Panel number 11, entitled "Cartagene" (Cartagená) in Jan van Kessel's painting "AMERIQUE" (1666). Reproduced by permission. See accompanying article on page 35.

BAT RESEARCH NEWS



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Publisher and Managing Editor

Dr. G. Roy Horst
Department of Biology
State University College at Potsdam
Potsdam, New York 13676 USA
Tel.: 315–267–2259

Editor

Dr. Thomas Griffiths
Department of Biology
Illinois Wesleyan University
Bloomington, Illinois 61702 USA
Tel.: 309–556–3230

Editor for Reviews

Dr. Peter V. August
Department of Natural Resource Science
University of Rhode Island
Kingston, Rhode Island 02881
Tel.: 401–783–4032

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BAT RESEARCH NEWS

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UNUSUAL COLORATION IN THREE MEXICAN BATS.

Cornelio Sanchez H., W. Lopez-Forment C.
and M. Antonio Gurrola H.

Instituto de Biologia, U.N.A.M.,
Departamento de Zoologia, Lab. Mastozoologia.
Apartado postal 70-153. C.P. 04510, Mexico, D. F.

Unusual coloration has been reported for different bats: Allen (1939) reported albinism in *Chaerephon plicatus*, *Molossus tropidorhynchus*, *Pipistrellus* sp., *Rhinolophus ferrumequinum*, and *Eptesicus capensis*. Setzer (1950) reported this condition in *Glossophaga longirostris* and in *Antrozous pallidus*, also citing albinism in the following genera: *Rhinolophus*, *Myotis*, *Pipistrellus*, *Lasiurus*, *Antrozous*, *Chaerephon*, and *Molossus*. Metzger (1956) and Smith (1982) reported albinism in species of *Myotis*. Kavim (1983) cited this coloration in *Rousettus leschenaulti*.

Partial albinism has been reported by Hamilton (1930) in *Myotis lucifugus* and by McCoy (1960) and Herried and Davis (1960) in *Tadarida brasiliensis mexicana*. Some authors indicated albinism was as rare as about one in 100,000 specimens. Here we give information on two albino bats and another with partial albinism from Mexico.

A male *Pteronotus parnelli mexicana* was captured under a group of fig-trees (*Ficus* sp.) in June, 1977, with a mist-net strung over an arroyo in the vicinity of Chamela, Jalisco. The specimen was entirely white; the eyes were reddish when alive. On Isla San Andres, 1.5 km away from this site, in the Bahia de Chamela, there is a cave with approximately 100,000 bats of this species and of *P. psilotis*, *P. davyi*, and *Leptonycteris yerbabuenae*. The coast is rocky and the vegetation consists mainly of semi-deciduous tropical forest.

In May, 1965, a specimen of *Macrotus waterhousii mexicanus* was captured during the day in the Cueva del Huarache, one km south of Palo Blanco, near Chilpancingo, Guerrero, at an altitude of 900 m. It was a young male, completely white, and the eyes were red. Ossification of the phalanges, wing articulations, rotula, and the tibio-tarsal bones was incomplete. The skull was broken, but the dentition was that of an adult. This bat was captured eight meters from the cave entrance as part of a group of approximately 400 individuals. At that time, the cave also harbored *Desmodus rotundus*, *Pteronotus p. mexicana*, *Natalus stramineus saturatus*, and *Leptonycteris* sp. Humidity and temperature were high in the cave. The area around the cave is mountainous with scattered agricultural plots.

The third specimen was a male frugivorous bat of the species *Dermanura phaeotis nanus* collected in May, 1975, in the vicinity of Rancho El Paraiso, 12 km southeast of Chamela, Jalisco, where it was

hanging from the fronds of a coconut palm. This specimen had dorsal and ventral hair with yellowish tips and a lighter base. The eyes were dark, the rostral lines lighter, and the wings and uropatagium were dark brown. The testes were scrotal, measuring four mm.

We thank Ma. de Lourdes Romero A. who provided field assistance.

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Twentieth Annual North American Symposium on Bat Research

The next meeting of the North American Symposium on Bat Research will be held October 25-27, 1990 at the University of Nebraska in Lincoln, Nebraska. Our hosts will be Dr. Patricia Freeman and Dr. Hugh Genoways of the Nebraska State Museum. Meeting facilities are available, both at the museum on campus and at the Cornhusker Hotel just a short walk from campus. A block of rooms has been set aside for us at the Cornhusker. The hotel is giving us very reasonable rates since on that weekend there is no football game on campus, "the raison d' etre" in Lincoln. Trish and Hugh are gathering information concerning airline service, highway routes, restaurants, campgrounds, etc. and this information will be passed along to you in the packet of registration materials that will be mailed in May.

Please consider this announcement the first call for papers. The deadline for the receipt of papers is September 1, 1990. All titles to be included in the formal presentation program will have to be postmarked on or before that date.The increasing number of papers that we are recieving each year makes it necessary to limit the number of platform presentations to no more than 50. Papers will be accepted in order of their arrival, any papers arriving after that number is reached and all papers postmarked after September 1, 1990 will be given space on the program as posters. We do not anticipate any upper limit on posters. Posters and papers are given identical treatment in the publication of the symposium. Graduate and undergraduate students are encouraged to enter their titles in the competition for honoraria for the best presentations from the platform. Several individuals have made generous contributions to encourage more students to present papers. This year the first place award will be a cash prize of $250. There will be two additional awards of $100 each. Each student who submits a paper in the student competition will also recieve a year's subscription to Bat Research News.

There will also be a banquet on Friday evening, October 26. Following tradition, the awards will be presented at the banquet. An additional attraction this year will be the presentation of the . . . . .

Garrit S. Miller, Jr. Award . . . . .'for outstanding service and contributions to the field of chiropteran biology." This year the

recipient of this award is one of the most distinguished and most beloved biologists to ever grace our symposium. There will of course be "selected readings" highlighting the exploits of the more notorious among us and the ever present threat that you might find yourself to be the object of our affection! A new feature of the post-banquet program is a section entitled " My favorite slides of bat people at work and play". Dr. Fenton has agreed to provide the narration. Please plan to attend the banquet. It will be a joyous evening.

G. Roy Horst

RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths) for inclusion in this section. Receipt of reprints will facilitate complete and correct citation. Our Recent Literature section is based upon several bibliographic sources, and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome.

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The Knoxville Symposium

The Nineteenth Annual North American Symposium on Bat Research met at the University of Tennessee in Knoxville, Tennessee on October 19-21, 1989. Our hosts were Gary McCracken, of the University of Tennessee, and Michael Harvey (from Tennessee Technological University in nearby Cookville, Tennessee). A total of 138 bat biologists and friends attended. Sixty- four papers were presented and seven posters were on display. Sixteen graduate students presented papers for honoraria. Paul Faure of the University of Calgary recieved the first place award for his paper entitled "The Sensory Basis of Prey detection in the Long-Eared Bat *Myotis evotis.*" This the third year in succession that Paul's presentation was among the winners and he deserves our heartiest congratulations. We also compliment Dr. Robert Barclay, who has been Paul's mentor. This record speaks very highly for the program in bat research, and graduate training generally, at the University of Calgary. Ruth Utzurrum of Boston University, studying with Dr. Thomas Kunz recieved the second award for her presentation entitled "Fruit Consumption and Seed Dispersal of Three Fig Species by Frugivorous Bats in a Philippine Primary Forest. Brian Hickey of York University , studying with Dr Brock Fenton, recieved the third award for his paper entitled "Use of Torpor by Free-Living *Lasiurus cinereus.*" The second and third awards were equal. These three young chiroptologists, and all the other graduate students gave an excellent accounting of their work. The future of bat research is in good hands indeed. All of the students who presented papers in the competition for honoraria recieved a year's subscription to Bat Research News. Those already subscribing, recieved a year,s extension of their subscription.

Everyone was enthusiastic about the treatment we recieved by our hosts. Everything was attended to, Tennessee style. The facilities were among the best we have ever had, the projectors always worked ,the food was excellent,the airport shuttle bus drivers were a marvel at figuring out which flights would be late and which on time, and the staff at the Holiday Inn were gracious, courteous, and helpful.

In the past these things often went unnoticed and those who deserved praise and gratitude were often slighted. This year an "Unofficial Resolutions Committee" has prepared the following resolution to help remedy that situation.

"Whereas all the people who claimed to have performed above and beyond the call of duty in making this meeting a success have already hogged the limelight and been praised and thanked in excess, and...

....."Whereas we really don't care if Brock is yet another year older, and Tom (Tom Who?) looks another year younger, and the new students are even younger than that, and...

....."Whereas Gary MaCracken promised a pint of moonshine to every registrant of legal age (12 years in Tennessee?) and Michael Harvey who was supposed to know where he was driving us to, but never did and invariably got lost and discharged his passengers on the median of a four lane interstate with a smug, "I know Calhoun's is around here somewhere", ...

"So be it therefore resolved that all the unsong heros now be offered the praise and thanks due them...

.....and be it further resolved that even though it was his birthday, of which he may not have many more, Fenton must remember that in Tennessee the word "moon" has more than one meaning, ... and that Kunz should not be so smug and vain about the fact that he is younger that most of his graduate students,(how does he think that makes Art feel?)...

.....and be it furthur resolved that the new grad students should remain appropiately subservient even though they may have been doctors, dentists, lawyers, or other such high-paying types in their former lives...

.... and be it further resolved that Gary and Mike trade places, since Gary couldn't find any moonshine and Mike obviously did, and Mike couldn't find any restaurants and Gary couldn't find his way out of one, and ...

....be it finally resolved that next year Trish and Dr.Hugh (not Dr. Who) take to heart all of these shortcomings of this year' affair and try very hard to duplicate in Lincoln the wonderful time that was had by all in Knoxville."

Again thank you very much, Gary and Mike and Anne and Kitty and John and Dan and all the people at the Holiday Inn and everyone else we forgot to mention. We are looking forward to seeing everyone this coming October in Lincoln.

Anonymous

Abstracts of Papers Presented at the Nineteenth Annual North American Symposium on Bat Research at the University of Tennessee, Knoxville, Tennessee

Abstracts appear alphabetically by first author

What Information Do Feeding Buzzes Provide About Bat Foraging Behavior?

Lalita Acharya, Department of Biology, York University

I observed the echolocation and hunting behavior of *Lasiurus cinereus* and *L. borealis* in the field to assess what information about foraging behavior an observer could obtain by monitoring feeding buzzes. In Pinery Provincial Park in Ontario, both species forage around street lights where the outcomes of attacks on prey by the bats are clearly visible. I tested the hypothesis that longer feeding buzzes are associated with larger prey by measuring the lengths of feeding buzzes and relating them to the sizes of culled moths' wings (an indicator of prey size) dropped by the bats after successful attacks. Analysis of 173 feeding buzzes from *L. cinereus* and 56 from *L. borealis* did not support the hypothesis. Using analysis of 187 *L. cinereus* and 63 *L. borealis* feeding buzzes, I also tested the hypothesis that the silent period following the last call in a feeding buzz reflects prey handling time. The mean lengths of silent periods after successful attacks was significantly greater than those following unsuccessful attacks for both species, but there was no threshold value for the duration of the silent period clearly separating successful from unsuccessful attacks.

Growth and Development of the Forelimb of the Brown Bat, *Myotis lucifugus*

R. A. Adams, Department of Environmental Population, and Organismic Biology,. University of Colorado

Without an understanding of how morphology unfolds during ontogeny we cannot fully evaluate its adaptive significance. It follows that studies concerning the adaptiveness of adult morphology analyzed in the absence of developmental data may make unwarranted assumptions. Many studies have concerned the form/function relationship of flight morphology (adaptations) in adult bats. Exceedingly little is known, however, concerning the developmental biology of these adaptations. In fact, knowledge of chiropteran development is limited to a few studies, most of which rely on the use of external anatomical features only to describe development. The purpose of this study is to quantify the pre- and postnatal skeletogenesis and growth of the forelimb of *Myotis lucifugus* by using cartilage (alcian blue) and bone (alizarin red) sensitive stains on whole-mount embryos. In general, I describe the order of bone formation of the port-cranial skeleton. Specifically, I quantify pre-and postpartum growth in length of the forearm, growth of mid-shaft diameter of the radius and ulna as well as growth and ossification of the radius, ulna, metacarpals, and phalanges. In addition, I describe in detail changes in the elbow joint and proximo-distal fusions between the radius and ulna during development. Preliminary observations suggest that ossification of a radio-ulnar bridge distally may be a critical event in the ontogeny of flight for this species.

Functional Morphology of Primary Downstroke Musculature in *Tadarida brasiliensis*

J. Scott Altenbach and John W. Hermanson, Department of Biology, University of New Mexico and Department of Anatomy, Cornell University College of Veterinary Medicine.

The activity of M pectoralis, M. serratus, M. subscapularis and the short head of M. biceps during the downstroke in *Tadarida brasiliensis* differs somewhat from that observed in Vespertilionid *(Antrozous* and *Eptesicus)* and Phyllostomatid *(Artibeus)* studied. Serratus, subscapularis and biceps are distinctly biphasic and in sharp contrast to non-Molossid bats studied, the onset of activity of serratus precedes that of pectoralis. Although this does not support the hypothesis that a scapulo-humeral interlock occurs, support is provided by three lines of evidence. First, the serratus in *Tadarida* is not suited as a downward rotator of the lateral scapular border. Second, contraction of the pectoralis alone would establish the interlock which could be adaptive in increasing its in-moment arm for humeral adduction. Finally, implanted pins in the scapula reveal that the scapula and humerus move in synchrony during more than 60 percent of the downstroke. These data suggest that *Tadarida* may be unique among bats studied to date in utilizing the pectoralis as the prime adductive power for the downstroke.

The Bats of Jewel Cave National Monument

J.M. Anderson and J.R. Choate, Department of Biology, Fort Hays State University

The bat fauna of Jewel Cave National Monument, in the Black Hills of South Dakota, is poorly known and may be impacted by future road construction. Accordingly, I was contracted by the Black Hills Parks and Forests Association to locate, identify, and census bats residing in and around Jewel Cave, to determine whether any maternity colonies are located in the cave, and to locate and characterize foraging areas used by bats at the

monument. Nine species of bats *(Myotis ciliolabrum, M. lucifugus, M. volans, M. thysanodes, M. septentrionalis, Eptesicus fuscus, Plecotus townsendii, Lasiurus cinereus,* and *Lasionycteris noctivagans* in descending order of relative abundance) were documented at the monument. *Plecotus* and all species of *Myotis* used Jewel Cave both day and night, whereas *Eptesicus* used the cave only as a night roost. *Lasiurus* and *Lasionycteris* resided in the forest surrounding the cave. No maternity colonies were found, and 93% of all bats trapped or netted were males. Most bats foraged at the forest edge, especially near sources of water. The primary source of water was the monument's sewage lagoon, although some bats used stock tanks placed at springs to provide water for wildlife.

Non-Invasive Methods in Behavioural Ecology: How much Does it Cost a Bat?

Doris Audet, Department of Biology, York University

Biologists use results from techniques requiring capture and recapture of adult and juvenile bats (e.g. banding, radio-tracking and doubly-labeled water) but little attention has been paid to the effects of handling on the animals. The aim of this paper is to use data from *Myotis myotis* to evaluate the short and longer term consequences of the cpature and handling on the behavior and reproductive success of female bats.

Data were collected at two nursery colonies (ca 60 and 700 adults), between May and August 1989. Individuals were marked using 3 colour-coded plastic rings (total mass 0.2g), and 19 adult females were fitted with 0.9g radio-transmitters (8 during mid-pregnancy, 11 during lactation). Doubly-labeled water was injected subcutaneously to 112 bats (14 pregnant, 87 lactating females, 11 volant young). The accessibility of the bats in the roost allowed me to recapture treated animals and to recapture unmarked individuals used as control.

Banding, handling and weighing of banded animals, attachment of transmitters and injection of doubly-labeled water resulted in a reduction in roost site fidelity. Females radio-tagged in May were less site faithful than those tagged in July during lactation (77% vs 94%). During lactation, the treatments did not affect young survival directly, however 5 of 14 pregnant bats gave birth while kept captive during injection of doubly-labeled water (at least 2 premature). The mean mass of the animals (m) decreased following all treatments. Adults recaptured between 1 and 3 days following handling and weighing alone showed a m of -0.16 ±1.41g (n=10) and weaned juveniles -0.08±0.54g (n=7). For the same time interval, after injection of DLW, lactating females showed a m of -1±1.34g (n=31) and juveniles -1.55±0.98g (n=8). Lactating females recaptured between 7 and 20 days after attachment of a transmitter showed a m of -1±1.4g (n=6). Preliminary analysis of the data suggests that m for samples of non-banded animals associated with variations in environmental conditions (mass following night of good weather vs cold and rainy night). These changes in body condition appear to be of short duration.

Mother Directive Calls and Individual Recognition by Mexican Free-Tailed Bats, *Tadarida brasiliensis mexicana*

J. P. Balcombe, Department of Zoology, University of Tennessee

The existence of a call used by mother Mexican free-tailed bats during pup searches has been suggested based on evidence from in-cave video-taped observations. Mothers appear to utter vocalizations distinct from echolocation, and pups crawl toward mothers during reunions, suggesting vocal recognition of their mothers. During June and July, 1989, I studied this species at a maternity colony of about 5 million mother bats and their young near Mason, Texas. My study comprised two principal objectives: (i) to document and describe these putative mother 'directive' calls, and (ii) to test the hypothesis that these calls function in individual recognition by pups.

To document directive calls, I made simultaneous audio and video taped recordings of pup creches inside the cave at times when mothers were returning to find and nurse their pups. From 14 hours of cave recordings from eight different nights, I have obtained numerous records of mothers visibly and audibly uttering directive calls. Preliminary analysis shows directive calls to be intense, discrete, and highly variable among and stereotyped within individuals, features appropriate for their hypothesized function. Furthermore, despite similarities in pitch and timbre, these calls are distinct from pup isolation calls in temporal character. Whereas i-calls comprise single repeated pulses of typically 35 ms duration and 50 ms inter-pulse intervals, directive calls are rapid bursts of from 3 to 9 (typically 5) 65 ms pulses, each burst lasting 200-500 ms, with inter-burst intervals of 2,000-10,000 ms.

Despite numerous attempts to record directive calls of mothers in a variety of captive situations, I was unable to obtain any useable sequences for playbacks, and thus could not test directly the hypothesis that pups recognize their mothers' voices. However, a series of two-choice playbacks using in-cave recordings yielded pup responses consistent with this hypothesis. Pups (n=20) showed a very strong preference for recordings of pup creches made when mothers were present (i.e. with directive calls), over recordings of the same creches, recorded on the same night, when mothers were absent (without directive calls). To ensure that pups would not respond merely to the greater sound intensity of a directive stimulus, sound pressure levels of the two stimuli were matched for each playback by adjusting the gain knob on each amplifier. Future analyses of recordings of these bats will address the ontogeny of echolocation and communication calls, and the extent to which mother directive calls are 'vocal signatures.'

Why Are Aerial Insectivorous Bats So Small?

R.M.R. Barclay and R.M. Brigham, Biological Sciences, University of Calgary

Aerial insectivorous (AI) bats are small. In several faunas the mean mass of AI bats is between 10 and 15 grams and the median size is less than 10 grams. It has been suggested that AI bats are small because a) flight constrains size, b) the prey AI bats feed on are small, or c) bats in general are small (ie. phylogeny constrains size). Such arguments are not supported by comparisons with AI birds or with other bats, all of which are on average significantly larger than AI bats. Thus, it is being an insectivorous bat and catching prey on the wing that is associated with small size, not flight, prey size or phylogeny. We hypothesize that prey detection by echolocation restricts AI bat size. In order for large bats to detect insects far enough away to capture them, they use low frequency echolocation calls that are not attenuated by the atmosphere. Such calls, however, reflect poorly from small prey, especially from prey with diameters smaller than the wavelength of the calls. Thus, whereas prey size range increases with predator body size for most predators, it does not for AI bats. Large AI bats should be restricted to large prey and require long foraging times. Meagre field data support these two predictions and we suggest that it is prey availability dictated by detection which restricts AI bats to small body sizes.

Seasonal Variation in Microhabitat Use by Foraging *Myotis yumanensis*

R.M. Brigham, H.D.J.N. Aldridge and R.L. Mackey, Biological Sciences, University of Calgary, A.F.R.C., Wiltshir, Ct., Swindon England SN1 5AT

On 14 nights between 29 May and 19 August 1989 we attached light-tags to pregnant, lactating, post-lacting and juvenile *M. yumanensis* captured at a maternity colony near Oliver, British Columbia, Canada. We followed individuals with light-tags for a total of 12,900 seconds (215 min.) and assessed microhabitat use by classifying the aerial habitat into seven zones based on the amount of clutter. Concurrently we measured wing area, wing span, and body mass of captured individuals and for each night collected fecal pellets to assess diet. Preliminary analysis indicates that bats of all sex/age classes foraged primarily low over water (×1m) and in open areas above all clutter (×1m). The use of microhabitats varied amongst nights, however: bats spent between 2.0% and 90.0% of their time low over the water and between 5.3% and 50.2% of their time high over clutter. Lactating individuals did not forage in more cluttered habitats than pregnant individuals which might be expected based on differences in wing-loading. As could be expected, juvenile bats foraged in open areas away from clutter more when they were first learning to fly than later in the summer.

Sexual Signals in *Noctilio leporinus*; Scent and Color?

Anne Brooke, Department of Zoology, University of Tennessee

I am investigating the fishing bat, *Noctilio liporinus*, on the small island of Culebra, east of Puerto Rico. These bats appear to be polygnous roosting in small harem groups of 4-8 females in hollow trees and caves. The bats have two distinct color morphs: red to orange and brown to buff.

The harem roosts on Culebra are assorted by color: two red roosts (n=43) were located. A small roost of bachelor males (N=5) contained both color morphs. The significance of this color variation is as yet unknown; however a source of the color is evidently an oily and distinctive smelling secretion originating from a pocket-like fold under the wing in the sub-axillary region. The secretion is colored red or yellow and appears to color the pelage and toe-nails of the bats as well as anything else it touches. More of the secretion is present on males than on females; this seems to be responsible for the darker color of males which are red or brown while females are orange or buff. Prior to copulating a male was observed sniffing the mid-body (sub-axillary) region of a receptive female. Lactating females do not produce the secretion.

The California Leaf-Nosed Bat *(Macrotus californicus)* Observations on Behavior, Population Status and Conservation

P. Brown, R. Berry and P. Leitner, Department of Biology, U.C.L.A., Naval Weapons Center, China Lake and St. Mary's College

The California leaf-nosed bat *(Macrotus californicus)*, the most northerly representative of the Phyllostomatidae, remains active yearlong in the deserts of California and Arizona. Since *Macrotus* cannot lower their body temperature for either daily torpor or hibernation, they require a warm humid roost environment, especially during the winter. Bell, *et al* found no special physiological adaptations in *Macrotus* for a desert existence and concluded that behavioral adaptations such as roost selection and foraging methods were important for their year-round activity. Geothermally-heated mine tunnels in the California desert provide a stable environment for this species, and may have contributed to their range expansion in the last century since natural caves in this area are very rare. The current mining industry however is endangering *Macrotus* in some areas due to the practice of demolishing old adits and shafts to create open pits for more economical extraction of ore for cyanide heap-leeching operations. Since 1964, a long-term banding study has been conducted to answer questions concerning population dynamics, movement, roost selection, and longevity in *Macrotus*. During the past 25 years, over 17,000 *Macrotus* from 14 mine roosts in California have been banded. On yearly trips, many of these bats have

been recaptured as many as ten times. This species exhibits strong roost fidelity, but may occupy different roosts on a seasonal basis. The longest distance recorded between the site of banding and recapture is 54 miles. The greatest time interval to date between initial banding and recapture is 14 years, giving a possible longevity of at least 14.5 years assuming the bat was born in the spring previous to the winter banding. Since long life in bats is attributed in some part to their ability to undergo daily and seasonal torpor, this record for *Macrotus* is remarkable. Little is known about the social structure of this species. Winter roosts typically contain males and females, and all female maternity roosts form during the spring and summer. Copulation is presumed to occur in the fall, and the delayed development of the embryo until the following spring is well-documented. However, in March of 1989, copulation was observed in a diurnal roost. At the same time, bats (presumedly male) were observed wing-flapping and calling while hanging from preferred roosting spots in a mine adit while other bats (possibly female) approached and hovered in front of them. Video tapes of this potential lek behavior will be shown.

Mechanisms of Prey-Tracking in the Fish-Catching Bat, *Noctilio leporinus*

K.A. Campbell, Biology Department, Albright College, and R.A. Suthers, School of Medicine and Department of Biology, Indiana University

Adult fish-catching bats were trained to dip their feet to catch a food reward which moved across a large rectangular pool at a constant speed perpendicular to the bat's flight path. The target was made to disappear beneath the surface of the pool before the bat reached it, so that the moving target was not detectable by the bat over the final meter of approach. The head aim and flight path of the bats during approach, and the position at which they dipped their feet relative to the point of target disappearance were all monitored by photographic means.

In 71% of all flights recorded (119/167), *Noctilio* flew towards the point of target interception along a path statistically different ($p<0.05$) from a calculated non-predictive path directed towards the position of the target. These flights were all directed at some point ahead of the current position of the target, and 60 flights (36%) were directed at the eventual point of target interception when the bat-to-target distance was approximately 2 meters. This behavior suggests the bats were using a predictive tracking strategy. Twenty nine percent of the flights recorded (48/167) were not statistically different from the calculated non-predictive paths, but even in these cases *Noctilio* always dipped their feet ahead of the point of target disappearance, apparently allowing for continued movement of the submerged target.

The head aim of the bats in all flights was directed at, or slightly behind the position of the target, both prior to its disappearance beneath the surface and afterward. It is suggested that although head aim is a good indicator of the direction in which a bat is emitting its echolocation pulses and therefore searching for a target, head aim may not be a reliable estimator of tracking strategy in *Noctilio*.

(Supported by NSF Grant BNS 8720192 to RAS.)

Bat Houses: Construction and Success by the General Public

Richard L. Clawson, Missouri Department of Conservation

During the period 1968-1988, hundreds of requests were received for bat house construction plans. Many were for the large "Missouri style" bat house; some were for smaller, generic bat house plans; and some were for both sets of plans. Four hundred sixty-eight follow up surveys were sent to people who had requested bat house plans to determine whether or not they actually built a bat house, and whether or not those that built houses were successful at attracting bats. Twenty-eight surveys were returned as undeliverable. Some 150 people (76.5% of usable replies) responded to the survey but hadn't built a bat house; while 46 (23.5%) indicated that they had built one or more bat houses. Those who hadn't built bat houses cited 1) lack of time and 2) complexity and size of the large house about equally as reasons for failure to construct one. The majority (80.4%) of the people who constructed bat houses built small ones. Of the bat houses, both large and small, erected by survey respondents, 14.8% were known to be used by bats, 57.4% were not used, and for 27.8% the status was unknown.

Observations on the Life History of Rafinesque's Big-Eared Bat, *Plecotus rafinesquii,* in Southern Arkansas

Daniel R. England, David A. Saugey, V.R. McDaniel, Stanley M. Speight, Department of Biology, Southern Arkansas University, United States Forest Service, Ouachita National Foreest, Hot Springs, AR, Department of Biology, Arkansas, Cossatot River State Park, Wickes, AR.

Rafinesque's big-eared bat is one of the least known North American bats and is currently designated a sensitive species (Category 2) by the U.S. Fish and Wildlife Service. Recent investigations into the natural history of this bat in southern Arkansas indicate that this species is locally fairly common. Almost every abandoned structure examined has yielded at least one individual. Observations of colony dynamics and pre- and post-natal growth and development of young have focused on three distinct maternity colonies. Maternity colonies average 30 adult females or less and form during March in dilapidated, abandoned buildings. Colony sites appear to be centered in areas where several suitable buildings are

located in close proximity. Newborns and larger, prevolant juveniles, up to 5 grams in weight, may be transported between these alternative roosts when disturbed and apparently when certain structures provide "more suitable" roosting conditions during fluctuations in weather conditions, particularly temperature. Use of different areas within a roost appears to be related to ambient temperature fluctuations which in turn modify internal roost conditions. Adult males are rarely encountered within maternity colonies when females are lactating, with those present being non-scrotal yearlings. Males do not breed during their first year. Adult males with enlarged testes and epididymides extending into the uropatagium are encountered in maternity clusters beginning in mid-August, but are more frequently found roosting alone in structures that do not contain a maternity colony. Juvenile mortality appears to be very low with only one juvenile carcass observed at maternity sites. During late fall, the number of bats found in houses declines; and use of abandoned water wells increases. Wells are used throughout winter months, with numbers of bats counted within individual wells often varying considerably from week to week. Wells are occasionally used during spring and summer months by adult males. Bats have not abandoned any maternity or roost site during the study even when observed on a weekly basis. Coordinated activities with corporate and private landowners have been successful in identifying and preserving critical habitat components.

The Sensory Basis of Prey Detection in the Long-eared Bat, *Myotis evotis*

Paul A. Faure, Department of Biological Sciences, The University of Calgary

This presentation was awarded first place in the student honors competition.

It is often believed that bats with large ears are substrate gleaners, and that they use their long ears to listen to prey-generated sounds while employing a gleaning foraging strategy. *Myotis evotis* is a small, insectivorous bat that possesses the largest ears of any North American *Myotis*. I examined the foraging behaviour and sensory cues used for prey detection by this bat under laboratory conditions at the Kananaskis Centre for Environmental Research (KCER), Alberta, Canada. Captive bats readily gleaned moths but were equally capable of capturing aerial prey, thus exhibiting a high degree of foraging flexibility. Individual bats were very reponsive (i.e. head and ear movement) to moth fluttering sounds. To determine which sensory cues were most important for prey detection, captive (naive) bats were challenged to find moth prey in a gleaning situation under experimental conditions controlling sensory input to the bats. Moths fluttering on a bark substrate, thus providing all sensory input (i.e. echolocation, vision, movement & sound), were almost always detected. Furthermore, prey-generated sounds alone were sufficient for prey detection. When bats were given echolocation or visual cues only, detection frequency was lower. The importance of prey sound was further emphasized by the fact that dead moths were detected significantly more often when a fluttering sound attractant was provided. However, flutter movement and flutter sound were not required for prey detection as captive *M. evotis* readily detected wingless moths crawling up a bark-covered trellis. Additionally, attact sequences were recorded to determine the importance of echolocation during gleaning. The echolocation calls used by *M. evotis* during attacks were low intensity (ca. 77 dB SPL @ 10 cm), frequency modulated calls (80-35 kHz) of extremely short duration ($\bar{X} \pm$ SD=0.66$\pm$ 0.28 msec). Current evidence suggests that these acoustic characteristics are common amongst gleaning bats. Echolocation was not always used during attacks by *M. evotis*. and when it was, call repetition rates were low($\bar{X} \pm$ SD=25.0$\pm$13.8 calls/sec)Feeding buzzes were never recorded for gleaning attacks. These data suggest that echolocation was not used for detecting prey, but rather to assess the background behind the prey.

Use of Different Foraging Strategies by *Nycteris grandis* and *Nycteris thebaica*.

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

In their foraging behaviour individually-marked *Nycteris grandis* (35g) and *Nycteris thebaica* (10 g) in Mana Pools National Park, Zimbabwe, alternated between hunting from perches and from continuous flight (Aldridge et al. in press; Fenton et al. in press). Radio-tracking revealed that *N. grandis* adjusted their use of these strategies according to the habitat in which they foraged, and light-tagging provided similar data for *N. thebaica*. A comparison of the incidence of foraging from continuous flight versus from perches revealed significant differences between individual *N. grandis*, and between habitats for both species. For *N. grandis* nightly prey consumption, transects, and opportunistic sampling in December 1985 and November 1987 showed marked differences in prey availability. In November 1987 there was no rainfall and each *N. grandis* took about 3 g of food per night (one solifugid). In November 1985 there had been 22 mm of rain and by the end of that month each *N. grandis* was consuming about 10 g of food per night (two frogs and one large arthropod). Both of these *Nycteris* are broad winged and use short, multiharmonic, low intensity broadband echolocation calls, features that could be usd to classify them as sit-and-wait hunters capable of operating in dense clutter. The 1987 data on their foraging strategies based on morphology and echolocation calls can underestimate the realized performance of bats -- particularly when times are tough.

Preliminary Observations on the Foraging Behavior of the Flower-visiting Bat, *Leptonycteris curasoae*

Theodore H. Fleming, Margaret A. Horner, and Merlin D. Tuttle, Department of Biology, Univerity of Miami; Chesapeake City, Maryland; and Bat Conservation International

We studied the foraging behavior of the flower-visiting bat *Leptonycteris curasoae* near Bahia Kino, Sonora, Mexico, in June 1989 by attaching 0.9 g radiotransmitters to the backs of 8 females. We obtained detailed information about foraging locations in relation to day roosts, fidelity to feeding areas, and activity schedules for 6 individuals. At least 6 of our tagged bats roosted by day on Isla Tiburon, 26 kms from the mainland and about 30 kms from their mainland feeding areas. These bats were highly predictable regarding the time of arrival at and departure from their feeding areas (2200 and 0200, respectively). They visited the same feeding areas, which were rich in Organ Pipe blossoms, each night for up to 2 weeks. They night-roosted in caves and abandoned mines 1 - 3 kms from their feeding areas and occasionally made long forays (of 5 - 10 kms) to other presumed feeding areas. In our study areas, *Leptonycteris* is a long-distance commutng bat and spends at least 5 hours in flight each night.

Preliminary Observations on the Importance of *Leptonycteris curasoae* as a Pollinator of Sonoran Desert Columnar Cacti

Theodore H. Fleming, Merlin D. Tuttle, and Margaret A. Horner, Department of Biology, University of Miami, Chesapeake City, Maryland, and Bat Conservation International

We studied the pollination biology of three species of night-blooming columnar cacti near Bahia Kino, Sonora, Mexico, in April-June 1989. We quantified the seasonal flower production schedules and daily nectar production schedules of Cardon *(Pachycereus pringeli),* Saguaro *(Carnegia giganta),* and Organ Pipe *(Stenocereus thurberi)* cacti and measured the visitation rates of nocturnal and diurnal pollinators. We conducted experiments to determine the relative pollination effectiveness of nocturnal and diurnal visitors in terms of percent fruit set and seed set per fruit. The flowering schedules of Cardon and Saguaro overlapped broadly, but their nectar production schedules differed. Peak nectar production in Cardon occurred between 2000 and 2200; Saguaro had two nectar peaks, 2400-0200 and 0800-1000. Organ Pipe flowered later in the spring than the other two species and had a nectar production schedule similar to that of Cardon. The glassophagine bat *Leptonycteris curasoae* was the major nocturnal visitor to the cactus flowers; it visited Cardon flowers at higher rates than those of Saguaro and Organ Pipe. Bees and birds were the major diurnal flower visitors. Bees visited Cardon flowers at higher rates than the other two species whereas birds visited Saguaro flowers at the highest rates. Exclusion experiments demonstrated that *Leptonycteris curasoae* was the most effective pollinator of Cardon and probably Organ Pipe whereas birds and bees were the most effective pollinators of Saguaro.

The Effects of Front End Loading on the Kinematics and Aerodynamics of *Eptesicus fuscus*

B. Forbes, Department of Biology, York University

I examined the effects of front end loading on the kinematics and aerodynamics of four *Eptesicus fuscus.* I photographed bats carrying different weights of prey in their mouths through a flight path to assess changes in the aerodynamics of each bat. I measured six different aerodynamics/kinematic parameters. These bats carried prey that were heavier than they would do so in the wild so that any effects on the aerodynamics were obvious. The results from these experiments were compared to those of a similar study using *Macrotus californicus.*

Trophic Structure of Bat Communities in the Understorey of Lowland Dipterocarp Rainforest in Malaysia

Charles M. Francis, Biology Department, Queen's University

Previous studies have shown that the understorey of Malaysian dipterocarp forest, at least in non-masting years contains low densities of fruiting and flowering trees. The bird community in this habitat contains very few frugivores, but little is known about other vertebrate communities. I used mist nets and harp traps to sample bat communities in the understorey of primary lowland dipterocarp forest in Peninsular Malaysia and Sabah, to estimate the trophic structure of those communities. Overall, 4 of 26 species (15%) at one site, and 6 of 33 species (18%) at the other site were frugivores or nectarivores, while the remainder were insectivores. Only 7-12% of all captured individuals were frugivores. Furthermore, because insectivorous species were much less susceptible to mist nets, they were certainly undersampled, and the true proportion of frugivores in the community was probably only about 1%. In contrast, previously published studies indicate that frugivores comprise up to 80% of individuals in bat communities in the undertstorey of Neotropical rain forests. These results agree with the hypothesis developed from bird studies, that the understorey of Malaysian dipterocarp forest is unable to support many frugivores. However, little is

known of canopy frugivores, and further data are required to estimate the absolute densities of bats, to determine whether the productivity of the dipterocarp forest is actually lower, or whether greater numbers of insectivores are supported in compensation for the low fruit production.

Morphometric Assessment of the Family Emballonuridae and a Comparison with Biochemical Data.

Patricia W. Freeman, University of Nebraska State Museum

Thirty-nine species of the family Emballonuridae were measured for 42 morphological characters including cranium, dentary, and appen-dages and analyzed with standard multivariate procedures. I ran the principal components analysis and experimented with both sizeout and shearing by genera to determine shape relationships within the family. The analysis that used "sheared" components to produce size-free morphological axes compared well with the groupings of a recent biochemical cladistic study. Emballonurids were more difficult to evaluate than molossids because distances separating species were not as great, meaning that there may not be as much diversity at the family level.

The Defences of Deaf Moths Against Insectivorous Bats

James H. Fullard, Department of Zoology, Erindale College, University of Toronto, and Scott B. Morrill, Department of Biology, Boston University

Most moths defend themselves against the in-flight attacks of insectivorous bats by listening for their echolocation calls and taking evasive flight manouevres. Not all moths possess ears, however, and the defences, if any, of deaf moths have not been experimentally examined. This summer, we tested two hypotheses regarding inauditive moth defensive behaviour (originally proposed by Kenneth Roeder): 1. inauditive moths will fly for less time than auditive moths and 2. inauditive moths will fly in areas (e.g., heights, habitats) less frequented by bats.

For the first hypothesis, we erected white moth sheets in forest, field and shoreline sites at a locale in southeastern Ontario. These sheets were illuminated by ultraviolet lights and attracted a wide diversity of both eared (mostly Noctuidae and Geometridae) and non-eared moths (mostly Saturniidae, Lasiocampidae and Sphingidae). At each sheet a given number of identified moths were marked, the light was extinguished and the time taken for each moth to leave was recorded. These observations, along with weather data, were taken nightly for three months and were subjected to a multivariate analyses. The results indicate a strongly significant tendency of inauditive moths to remain on the sheets compared to eared moths.

The second hypothesis was tested by erecting sticky traps at at 1, 3 and 6 meter heights above the ground in a forest and a field site. The traps were illuminated by ultraviolet lamps to increase total capture success and all moths caught in the traps were identified to family. Relative bat activity in the two sites was measured by counting bat passes with a QMC Mini-detector. The data from these studies indicate that: 1. inauditive moths (mostly Lasiocampidae) fly significantly closer to the ground that do auditive species (mostly Noctuidae) and, 2. deaf moths fly more in habitats (e.g., forests) not used by bats.

These experiments provide field data to support the general hypothesis that deaf moths have evolutionarily responded to the threat of flying bats by adopting flight behaviour which isolates them from bats. The results also complement those made of the seasonal emergence patterns of inauditive vs. auditive moths. We will discuss the possible effects these responses have had upon the natural history and mating systems of these insects.

Comments on the Nomenclature of Two Genera and Two Species of Neotropical Bats

Alfred L. Gardner and Carolyn S. Ferrell, U.S. National Museum of Natural Hitory.

We clarify the status of the names of *Platyrrhinus, Vampyrops,* and *Anthorhina;* comment on the names *Molossus burnesi* and *M. barnesi;* and identify the authorship of *Diclidurus albus.*

Platyrrhinus versus *Vampyrops*

Platyrrhinus was proposed by Saussure (1860) to distinguish three species of bats from *Artibeus* of authors. Peters (1865) and Palmer (1904) treated *Platyrrhinus* Saussure (two r's) as a junior homonym of *Platyrhinus* Clairville, 1789 (one r), a genus of anthribid beetles. Peters proposed *Vampyrops,* continuing the species *V. lineatus* and *V. vittatus,* as a replacement name for *Platyrrhinus* Saussure. Hershkovitz (1955) said that *Platyrrhinus* antedated *Vampyrops.* Hall and Kelson (1959) used *Platyrrhinus* without comment. The same year, de la Torre and Starrett (1959) claimed that the double r spelling of *Platyrrhinus* Saussure was a junior homonym of the double r spelling of *Platyrrhinus* by Fabricius (1801), which they claimed was an emendation of *Platyrhinus* Clairville, 1798. Hall (1981) countered by claiming that the double r spelling of *Platyrrhinus* used by Fabricius was an incorrect subsequent spelling and could not invalidate *Platyrrhinus* Saussure. Who is correct and what is the type of species of *Platyrrhinus*?

Status of *Anthorhina* Lydekker, 1891

Anthorhina was proposed as a replacement name for *Tylostoma* Gervais (1856), which is preoccupied by *Tylostoma* Sharpe (a mollusk). Originally *Tylostoma* contained two species (*Phyllostoma bidens* and

Plyllostoma crenulata); no type species was designated. By 1891, *Tylostoma* had become almost universally used for the species (and synonynms) known today as *Mimon crenulatum.* Palmer (1904) gave the type species of *Tylostoma* as *Vampyrus bidens* Spix. Is Palmer's designation valid and what is its effect?

Authorship of *Diclidurus albus*

When Wied-Neuwied (1820) described *Diclidurus* in Oken's Isis, he intended to apply the name *D. freyreisii* (in honor of the collector) to the only known species. Oken, as editor, changed *D. freyreisii* to *D. albus.* Carter and Dolan (1978) although crediting authorship of *D. albus* to Wied-Neuwied, suggested that perhaps Oken should be credited with authorship. Are they correct?

Molossus burnesi versus *M. barnesi*

The spelling *Molossus burnesi* used by Thomas (1905) was an error for *Molossus barnesi.* Cabrera (1958) chose the spelling *barnesi,* but Husson (1961) disagreed, citing Article 32(b) in the code of Zoological Nomenclature (Code), which says that if a name is spelled in more than one way in the original publication, the spelling adopted by the first reviewer is the correct original spelling. Husson claimed that Miller (1913), as first reviewer had selected the spelling *burnesi.* Carter and Dolan (1978) said Husson was wrong and, because it was an inadvertent error [Code Article 32a(ii)], cited Article 32(c) as the authority for correcting the spelling to *M. barnesi.* Which Article applies and what is meaning of the term "revisery" as used in the Code?

Evolution of the Hyoid Region of Emballonuroid and Other Bats

T.A. Griffiths, Department of Biology, Illinois Wesleyan University

The hyoid regions of emballonurid, rhinopomatid, and megadermatid bats contain some unexpectedly derived (=apomorphic) features not found in other bats. In rhinopomatids, the sternohyoid is a reduced, weak muscle. In megadermatids, the sternohyoid-geniohyoid-hyoglossus complex has detached from the hyoid bones, paralleling the "free-floating" condition found in advanced phyllostomids. Most remarkable of all, in emballonurids the sternohyoid has become attached to the posterior larynx and apparently functions as an extrinsic laryngeal muscle rather than as a primary tongue retractor. In all three families, changes in muscle morphology were facilitated by a mediad shift of the origin of another muscle, the omohyoid. It is possible that the differences observed in feeding habits and echolocation calls of yinochiropteran bats (Families Emballonuridae, Rhinopomatidae, and Megadermatidae) are in part the direct result of the shift of origin of a single muscle, the omohyoid, millions of years ago.

Automated Methods for Monitoring Bat Activity Using Frequency-Tunable Bat Detectors, Voice-Activated Tape Recorders and Talking Clocks

Scott C. Grossman and Gordon L. Kirkland, Jr., Vertebrate Museum, Shippensburg University

As part of a study of the ecology of tree bats (*Lasiurus spp.*) in southcentral Pennsylvania, we developed an automated method of monitoring bat activity throughout the night using frequency-tunable bat detectors, voice-activated recorders and talking (VOX) clocks. Each monitoring unit consists of a weatherproof wooden housing constructed to hold one Skye model 1210 frequency-tunable bat detector, one voice-activated microcassette recorder, and one VOX clock. The bat detectors were calibrated using a sound generator and period meter. The calibrated detector was tuned to the principal echolocation frequency used by the bat species being monitored. Once activiated, the system records all echolocation picked up by the detector, the microcassette recorder is activated and continues to record only while echolocating sounds are detected. The audible output of the VOX clock, which is programmed to give the time every half hour, is also recorded on tape. Each tape contains only a record of the bat passes and the times of those passes, within one-half hour. The tapes provide a condensed record of bat activity for an entire night, usually 2 - 30 minutes of tape, depending upon the amount of bat activity on a given evening at each site. Two monitoring units were employed at each study site, one tuned to 20 kHz for *Lasiurus cinereus* and the other to 40 kHz for *L. borealis.*

Histochemical and Myosin Electrophoretic Analysis of Muscles in the Little Brown Bat, *Myotis lucifugus*

John W. Hermanson, M.J. Daood and W.A. LaFramboise, Cornell University and University of Pittsburgh

Pectoralis muscles of *Myotis lucifugus* were studied histochemically by Armstrong and co-workers and found to contain only fast-twitch fibers that were highly oxidative. Although similar specialization for flight was demonstrated in the pectoralis of *Tadarida brasiliensis,* two fast-twitch fiber types were described in a Phyllostomatid bat, *Artibeus jamaicensis.* The present study used muscle histochemistry and gel electrophoresis of myosin heavy chains and of native myosin isoforms. Thus, we sought a biochemical correlation of histochemical data. The histochemcial findings were in agreement with the previous reports by Armstrong et al.: there was a single histochemical fiber type in the pectoralis. Biochemistry of adjacent pectoralis tissues also revealed apparent uniformity of the myosin components. Native gel electrophoresis of myosin isolated from pectoralis muscle yielded a single isoform, in contrast to the five isoforms found in a representative mixed fiber

type muscle, the rat diaphragm. This isoform comigrated with the FM3 isoform band of rat muscle. Similarly, heavy chain analysis of the *Myotis* pectoralis indicated the presence of a single heavy chain that migrates closely with rat Type IIa myosin heavy chain. This contrasts with the common condition of three heavy chains found in rat diaphragm. For comparison, the hamstring muscles were also studied and found to contain a mixture of histochemical fiber types, four native myosin isoforms (SM, FM2, FM3, FM4), and three heavy chains (one presumed slow and two presumed fast). Thus, the pectoralis muscle of *M. lucifugus* is extremely specialized for flight as exemplified at the histochemical, biochemical and morphological levels. Although the enzymatic and morphologic uniformity has been noted before in chiropteran pectoralis muscles, this is the first account of the apparent unitypic molecular specialization underlying the muscle's phenotype. Given this uniform population of muscle fibers it is not clear how force production within the muscle might be controlled. In terrestrial mammals, increased force requirements are met by recruiting, in a small to large order, motor units that innervate muscle fibers of correspondingly larger cross sectional area. It is not clear how the regulation of muscle recruitment in bat flight muscles occurs. Perhaps a range of motoneuron sizes underlies the ability to provide graded recruitment of uniformly sized muscle fibers in the chiropteran pectoralis. As a less likely alternative, might the muscles be functioning in an "on or off" mode?

Use of Torpor by Free-Living *Lasiurus cinereus*.

Hickey, C. Brian, Department of Biology, York University

I used temperature-sensitive radio transmitters to study the use of torpor by female *Lasiurus cinereus*. On 15 days during June and July 1988 and 1989 I measured ambient temperature and skin temperatures of bats every hour for 24 hours.

When daily low temperatures were 14.5°C or lower some bats entered torpor, while above 15°C all bats remained active. On a given night bats in the same reproductive state often used different thermoregulatory strategies (6 nights) and some individuals seemed to have a lower threshold for entering torpor. For example, one bat maintained a high body temperature even when ambient temperatures were as low as 5°C while another entered torpor whenever ambient temperature dropped below 13°C.

This presentation was awarded second place in the student honors competition.

Results of the New York State Bat Hibernacula Survey

Alan Hicks, Endangered Species Unit, Wildlife Research Center, Delmar, NY 12054

Between 1980 and 1989, 112 potential hibernacula, including 53 caves, 57 mines and two abandoned railroad tunnels, were surveyed to determine the distributions and abundance of bats wintering in New York. At each site, bats were counted individually and identified by species when possible. A total of 123,623 bats were counted and in three sites approximately 50,000 additional bats were observed but not counted. Multiple visits were made to some sites. Based on the visit in which the largest number of bats were counted at each site, *Myotis lucifugus* comprised 87% of the total count. It was followed by *Myotis sodalis* (6.8%), *Eptesicus fuscus* (1%), *Myotis septentrionalis* (1%), *Myotis leibii* (0.8%), *Pipistrellus subflavus* (0.3%), and unidentified (3.1%). Bats were found in 90 of the 112 sites checked. *Myotis lucifugus* was the most often encountered, occurring in 71% of the 90 occupied sites. It was followed by *M. septentrionalis* (65%), *E. fuscus* (61%), *P. subflavus* (55%), *M. leibii* (27%), and *M. sodalis* (9%). Five locations contained 58% of all bats actually counted and 70% of the estimated 174,000 that were counted or observed. The largest site contains an estimated 40,000+ bats and is the largest hibernating population of bats known in the Northeast. It is also one of two sites in which over 450 *M. leibii* were counted, both of which exceed the largest populations reported in the literature for that species. Although historical data are scarce, they do not suggest that dramatic declines in bat numbers have occurred in New York. Minor declines that have apparently occurred in caves have been more than offset by populations now established in man-made mines. Four of the state's five largest known wintering bat populations currently occur in mines. Banded bats were observed at 16 hibernacula; many had been banded in the early to mid 1960's. Four banded bats were recovered at sites other than their banding location.

The Bat Community of Mt. Makiling, Luzon Island, Philippines

Nina Ingle, Department of Natural Resources, Cornell University

Over 1400 bats were netted within 300 ha. of old second growth dipterocarp forest at 200-500 m elevation on Mt. Makiling, Luzon Island, Philippines, from January to August, 1989. Most of the bats were netted in pair of 6m x 2m mist nets set in gaps 4m to 14m above the ground. Net success averaged 15 bats per net pair per night. Captured bats were identified to species, sexed, aged, weighed, their forearm measured, and their reproductive condition assessed. They were marked with a numbered band on a ball-chain necklace before release. Frugivorous species captured were *Ptenochirus jagori, Cynopterus brachyotis, Macroglossus minumus, Haplonycteris fischeri, Rousettus amplexicaudatus,* and *Eonycteris spelaea.* Insectivores included *Hipposideros diadema, Megaderma spasma, Philetor brachypterus, Murina cyclotis, Emballonura alecto, Rhinolophus spp., Myotis spp.,* and *Pipistrellus spp. Ptenochirus jagori* accounted for 70% of the captures. The high net success rate and high proportion of frugivores captured could be due to net placement. The few nets set at ground level caught few bats although most of these were insectivorous, while higher nets caught many more bats, which were almost exclusively frugivouous. Capture and recapture data for *P. jagori* suggest that this species occurs in higher densities and has a larger home range than was previously suspected. The demographics of *P. jagori* will also be discussed.

Responses of Inferior Collicular Neurons of the Big Brown Bat, *Eptesicus fuscus* to Different Repetition Rate and Duration of Acoustic Stimulus

Philip H.-S. Jen, A. Daniel Pinheiro, Min Wu and Haibing Teng, Division of Biological Sciences, University of Missouri

In echolocation, as the big brown bat searches, approaches and finally captures insects, its emitted signals shorten in duration, and decrease in intensity. At the same time, as the bat narrows in on the insect, the repetition rate of its emitted signals increases up to as high as 200 pulses/sec. In order to examine how the bat auditory neurons may reflect these changes in signal parameters, responses of inferior collicular (IC) neurons to variation in stimulus repetition rate and duration were studied under free field stimulation conditions. The best frequency (BF) and minimun threshold (MT) of a recorded IC neuron to a sound (4 ms duration, 0.5 ms rise-decay times) delivered 23 cm in front of the bat were first determined. A BF stimulus was then raised at 10 dB increments above the neuron's MT and the number of impulses to acoustic stimulus delivered at different repetition rates were collected and processed by an IBM AT computer. The response pattern of each neuron was displayed in a post-stimulus time (PST) histogram when necessary. At a chosen stimulus intensity, the number of impulses of each neuron to different combinations of repetition rate and duration of the BF stimulus was again measured. Thus, responses of the neuron to different stimulus duty cycle was studied. A total of 171 IC neurons and 8 evoked potential responses were recorded at depths of 147 and 2280 u m from the exposed brain surface of 5 bats. Only 10 neurons were spontaneously active. While 7 tonic neurons discharged impulses throughout the stimulus, the remaining either discharged 1-3 impulses (N = 82, 49%) or a burst of impulses (×7) (N = 80, 48%) during the stimulus. BF ranged from 12.5 to 75.3 kHz with a majority (N = 121, 70%) between 20 and 60 kHz which corresponds to the frequency range of the predominant component of the bat's echolocation signals. All threshold curves measured from 42 neurons were inverted triangular shape with Q_{10}-dB values ranging between 1.9 and 54. Response latency was between 5.4 and 28.4 ms but most (N = 128, 77%) were below 12.5 ms. MT ranged from 7 to 102 dB SPL but the majority (N = 139, 81%) were below 60 dB SPL. The number of impulses of a recorded IC neurons generally varied with stimulus repetition and duration. For a given stimulus intensity, each neuron generally discharged maximally to a particular repetition rate (the best repetition rate). Furthermore, at a given stimulus intensity and repetition, each neuron also discharged maximally to a particular stimulus duration (the best stimulus duration). However, not all IC neurons studied showed significantly correlated responses to the variation in stimulus duty cycle. Nevertheless our study has demonstrated that IC neurons may respond maximally to a particular combination of repetition rate and duration of the acoustic stimulus at a given intensity. This finding provides some neural basis underlying reception of ultrasonic signals whose parameters change during different phases of echolocation. (Supported by NIH grant NS 20527).

Postnatal Development of Auditory Spatial Sensitivity of Inferior Collicular Neurons of *Eptesicus fuscus* Under Normal and Mon-aurally Plugged Conditions

Philip H.-S. Jen and Xinde Sun, Division of Biological Sciences, University of Missouri

Postnatal development of auditory sensitivity in the big brown bat, *Eptesicus fuscus* was studied by measuring the auditory spatial sensitivity of inferior collicular (IC) neurons of juvenile bats which were raised under either normal (control) or monaurally plugged condition. Manaural plugging was performed on different juvenile bats at 7, 14, 21, 28 and 35 days of age. Auditory spatial sensitivity was then determined for IC neurons of

monaurally plugged and control bats at 58-69 days after birth. The best frequency (BF) and minimum threshold (MT) of an IC neuron was first determined by delivering acoustic stimuli from a loudspeaker placed 23 cm ahead of the bat. Then a BF stimulus was delivered from the loudspeaker which was manually moved across the bat's frontal auditory space in order to determine the neuron's response center in azimuth and in elevation. At the response center, the neuron had its lowest MT (Maximal spatial sensitivity). The auditory spatial sensitivity of the IC neuron was then determined by measuring its variation in number of impulses and MT to a BF sound delivered from different azimuthal angles but at the same elevation. Our study showed that monarual plugging did not alter the discharge pattern, distribution of BF and latency of IC neurons, but it raised the MT of IC neurons of plugged juvenile bats by an average of 24 dB. Monaural plugging also appeared to modify postnatal develop-ment of auditory spatial sensitivity. The auditory spatial sensitivity of IC neurons was sharper when the earplug was intact than when the earplug was removed. Thus the spatial sensitivity of IC neurons of the monaurally plugged bats was more comparable to IC neurons of the control bats before the earplug was removed. These findings suggest that the neural circuits underlying auditory spatial sensitivity of IC neurons of the monaurally plugged juvenile bats have undergone modifications to compensate for the unnatural binaural disparity during postnatal development. The auditory spatial sensitivity was also determined for two control juvenile bats at 49 and 60 days of age and for an adult bat (more than 1 year). Our measurement showed that auditory spatial sensitivity of IC neurons sharpened with postnatal age. Furthermore, sharpening process appeared to be still in progress even at 49 days after birth. (Supported by NIH grant NS20527)

Tonotopic Organization and Spatial Sensitivity of Inferior Collicular Neurons of the Big Brown Bat, *Eptisicus fuscus*

Philip H.-S. Jen, Xinde Sun, Paul W.F. Poon and Tsutomu Kamada, Division of Biological Sciences, University of Missouri

The tonotopic organization and spatial sensitivity of 217 inferior collicular (IC) neurons of *Eptesicus fuscus* were studied under free field stimulation conditions. Acoustic stimuli were delivered from a loudspeaker placed 21 cm ahead of the bat to determine the best frequency (BF) and minimum threshold (MT) of isolated IC neurons. A BF stimulus was then delivered as the loudspeaker was moved horizontally across the frontal auditory space of the bat to locate the best azimuthal angle (BAZ) at which the neuron had its lowest MT. The stimulus was then raised 3 dB above the lowest MT to determine the horizontal extent of the auditory space within which a sound could elicit responses from the neuron. This was done by moving the loudspeaker laterally at 5° or 10° intervals until the neurons failed to respond. These measurements also allowed us to redetermine the BAZ at which the neuron fired a maximal number of impulses. Electrodes were placed evenly across the whole IC surface and IC neurons were sampled at as many locations as possible within each electrode penetration. Tonotopic organization and spatial sensitivity were examined among all 217 IC neurons as a whole, as well as among IC neurons sequentially sampled within individual electrode penetrations. The whole population of 217 IC neurons is organized tonotopically along the dorsoventral axis of the IC. Thus, low frequency neurons are mostly located dorsally and high frequency neurons ventrally with median frequency neurons in between. The BAZ of these 217 IC neurons tends to shift from lateral to medial portions of the contralateral frontal auditory space with increasing BF. Thus, the auditory space appears to have an orderly representation along the tonotopic organization and spatial sensitivity of sequentially isolated IC neurons within each electrode penetration may vary with the point of electrode penetration. This variation may be explained on the basis of the arrangement and thickness of each frequency lamina within the IC. (Supported by NIH grant NS 20527)

Reproductive Strategies in Relation to Seasonality of Food Resources

Catherine Koehler, Depatment of Biological Sciences, University of Calgary, Calgary, Alberta, T2N-1N4

Temperate microchiropterans can be ordered into three categories, HIBERNATORS, MIGRATORY HIBERNATORS, and MIGRATORS, regarding the manner in which seasonality of food resources is dealt with. Difference in dealing with this aspect of seasonality may correlate with variability in reproductive strategies.

HIBERNATORS, species which do not undergo distinct migrations to milder areas in the fall, are faced with short growing seasons. Typically, litters of one, occasionally two, are produced; the latter appears to impose greater stress on the mother (Burnett and Kunz 1982). Fledgling young are typically greater than 75% of adult mass, attaining near-adult proportions before hibernation. Young and adults must accumulate fat reserves before hibernation.

MIGRATORY HIBERNATORS migrate to warmer area, then hibernate come colder weather. MIGRATORS travel even greater distances to areas with a year-round food source. Essentially, these species elongate the juvenile growing season, as cold weather sets in later in warmer regions.

I predict that bats with longer juvenile growing seasons show a tendency to produce litters greater than one. If high growth rates comparable to those of species with more restricted growth periods need not be maintained, reproductive stresses on female may by lessened, allowing for larger litters to be produced.

Field data to test this theory were collected at the University of Manitoba Field Station (Delta Marsh), Manitoba, Canada. Growth rates of young *Lasiurus cinereus* (MIGRATORS) were recorded, with attention given to size at fledgling and throughout migration. Mass of females throughout lactation was monitored whenever possible. Migrating *L. cinereus, Lasiurus borealis* (MIGRATOR) and *Lasionycteris noctivagans* (MIGRATORY HIBERNATOR) were caught in mistnets starting mid July. *Myotis lucifugus* (HIBERNATOR) enroute to hibernacula north of the study site were also netted. Forearm and mass measurements of juveniles were compared to those of adult conspecifics. Data from other sources regarding the mentioned characteristics of other species was (and still is being) collected, with each species being placed into one of the three categories. Accumulation of data on as many species as possible will show if similarities within, and differences between categories exist with respect to growth rate and litter size.

Activity Patterns and the Use of Space in the Pallid Bat, *Antrozous pallidus.*

Dorothea Krull, Zoologisches Institut, Luisenstr. 14, 8000 Munchen 2, West Germany

The activity pattern and foraging behavior of the pallid bat, *Antrozous pallidus,* were studied using radio-telemetry from the end of May to mid-August 1989 in Lajitas, Texas. Six adult males, 10 adult females, and 5 juveniles were captured in their foraging areas or at a night roost and fitted with 0.7-0.9g radio-tags; 18 bats were tracked for a total of 101 bat-nights. The nightly activity pattern of the pallid bats is characterized by alternating periods of foraging and night roosting. Tagged individuals foraged over open dry and rocky desert terrain, between and along bushes close to the Rio Grande river and over the local golf course. Adults and juveniles of both sexes spent 53.4% (n=3 bats) and 46.7% (n=3 bats) respectively of the time night roosting (defined as resting periods longer than 20 min). Individuals showed between 1 and 5 resting periods per night. They either hung in bushes close to their foraging areas or used buildings traveling up to 3 km between foraging bouts. The bats did not always use only one night roost but visited up to three different locations per night. This study demonstrates the nightly activity patterns of pallid bats are variable between individuals as well as on a night to night basis for the same individual.

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

Thomas H. Kunz, Department of Biology, Boston University

The energy and material transfer between Mexican free-tailed bat mothers and their pups during the 6 week lactation period was measured using data from mass change, water flux and field metabolic rates (FMR) in pups and lactating females. Age-estimation equations were determined from growth analysis and used to assign ages of pups and stages of lactation to females (when mother-pup pairs were captured) in experiments on milk composition analysis, FMR, water flux, and body composition analysis. FMR and water flux were determined from the turnover of doubly labeled water (tritium and oxygen-18). As an index of maternal investment, data on daily water intake of pups and the proximate composition of milk from females were used to quantify milk energy output of lactating females. Daily energy budgets of lactating females were estimated from FMR, milk energy export, and radiotelemetry.

One hundred and sixteen milk samples were collected and subsequently pooled into 31 samples for analysis representing six stages (weeks) of lactation. Average fat content increased from 18% during the first week of lactation to an average of 29% by the sixth week. This level of milk fat is approximately two times greater than has been reported for other bat species and approaches levels reported for some marine mammals. Protein content was higher (8.5%) during mid-lactation and lower (7.5%) during early and late lactation. Lactose content decreased from 3.8% in early lactation to 3.2% in late lactation.

Estimates of FMR and total daily energy intake in lactating females (n=14) revealed that *T. brasiliensis* has one of the highest daily energy budgets reported for free-ranging insectivorous bats. These results are consistent with radiotelemetry data which indicate that lactating females (n=16) may spend an average of 8 h in flight each night. Radiotelemetry data also revealed that there are two nightly foraging periods during lactation, the first averaging 5 h 20 min and the second averaging 2 h 30 min. These two foraging periods are separated by a night-roosting (suckling) period averaging 3 hours. FMRs determined for 37 pups, ranging in age from birth to 43 days, increased from 200 ml CO_2 day-1 at birth to 600 ml CO_2 day-1 at weaning. By contrast the FMR of an average lactating female was 1293 ml CO_2 day-1, approximately twice the value reported for a mature bat (adult size) before it begins to fly (forage). When milk energy output (production) is added to assimilated energy (×maintenance), the daily energy budget of a lactating *T. brasiliensis* ranged from 43.7 kJ per day during early lactation to 111.7 kJ per day during peak lactation.

Torpor Pattern in Food-Deprived Little Brown Bats *(Myotis lucifugus)*

A. Kurta, Department of Biology, Eastern Michigan University

Temperate insectivorous bats commonly are prevented from foraging by cold or wet weather. This study examines the effect of missing a single night of foraging on the energetics of pregnant and lacting little brown bats *(Myotis lucifugus)* under simulated roost conditions. After not foraging, the dayroosting metabolic rate of

pregnant *M. lucifugus* was reduced by 61% and that of lactating bats by 46%. Although previous laboratory studies predicted that food-deprived bats should remain in torpor throughout the dayroosting period, *M. lucifugus* consistently aroused from torpor between 1100 and 1500 hours and maintained elevated metabolic rates for the rest of the day. When deprived of food for one night, *M. lucifugus* apparently used a hybrid thermoregulation strategy involving poikilothermy during the cool morning hours. and homeothermy during the relatively warm afternoon.

Echolocation Calls of Jamaican Mormoopidae

Winston C. Lancaster, O.W. Henson, Jr. and Arthur W. Keating, Department of Cell Biology and Anatomy, University of North Carolina at Chapel Hill

The family Mormoopidae is represented in Jamaica, W.I. by four species. The echolocation calls of *Pteronotus parnellii parnellii* have been intensely studied, but those of *P. fuliginosus,, P. macleayii* and Mormoops blainvillii are undescribed. As part of a study on the correlation between echolocation behavior and cochlear function, we recorded the calls of flying Jamaican mormoopids in the laboratory and studied them using digital signal processing techniques.

As previously described, Pteronotus p. parnellii pulses usually contain three components, a short, initial, upward frequency modulation (FM), a long constant frequency (CF) component and a terminal FM. Each component is represented by a series of four harmonics, with the majority of the energy concentrated in the second (ca. 61kHz). Search phase calls range from 17 to 40 ms in duration. Duration of the CF and terminal FM decrease progressively in the approach and terminal phases.

Other Jamaican mormoopids use FM signals and multiple harmonics. The searching calls of *Pteronotus fuliginosus fuliginosus* and *P. macleayii grisea* are composed of three harmonics; the second is usually the most intense. Four harmonics are sometimes present in the calls of *Mormoops blainvillii.* In *P. f. fuliginosus,* the second harmonic sweeps from approximately 81 kHz to 64 kHz starting with a slow sweep from 81 kHz to 77 kHz and then a fast sweep from 77 kHz to 65 kHz. A short, initial, upward FM (ca. 1 kHz) is occasionally seen. The search phase pulses of *P. macleayii grisea* are lower in frequency and more complex than those of *P. f. fuliginosus.* The second harmonic sweeps from 70 kHz to 51 kHz and is divisible into three portions: an initial slow sweep from 70 kHz to 68 kHz, a fast sweep from 68 kHz to 54 kHz and a terminal slow sweep from 54 kHz to 51 kHz. In these two species of *Pteronotus,* changes in sweep rates are marked by inflection points on frequency vs. time plots. Second harmonic sweeps of *Mormoops blainvillii* search phase calls typically range from 65 kHz to 45 kHz. The FM sweep rate changes gradually, but does not show an inflection point. Under laboratory conditions, search phase pulses of *P. f. fuliginosus* are usually 2-3 ms long, those of *P. macleayii grisea* 3-4 ms, and calls of *M. blainvillii* range from 2-4 ms.

Approach phase calls of *P. f. fuliginosus* decrease to 1.0 -1.5 ms and it is primarily the intital, slow FM that seems to be shortened. *P. macleayii grisea* decreases its approach phase calls to 2 ms, with initial components being abbreviated. These pulses sweep from 67 kHz to 51 Khz. Approach pulses of *M. blainvillii* shorten slightly, but show little change in sweep rate. Pulses emitted at high repetition rate and low intensity (terminal phase) were difficult to analyze by the methodology we employed. In all species except *P. parnellii,* repetition rate increased to approximately 190 per second during the terminal phase.

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Population Dynamics of *Uroderma bilobatum* During Maternity Roost Establishment

Susan E. Lewis, Department of Ecology and Behavioral Biology, University of Minnesota

The social organization of a population of Peter's tent-making bat, *Uroderma bilobatum* was studied in June and July, 1989, during the wet-season period of parturition. A total of 57 tents in a grove of 54 coconut palms (*Cocos nucifera*) in Palo Verde in the Guanacaste province of Costa Rica were surveyed daily for roosting bats. The number of bats in the grove increased from less than 10 to 30 during the six week study, with the increase in population apparently correlated with an increase in rainfall. As the population size increased, the proportion of bats roosting in groups also increased. Observations suggest that these groups were maternity clusters. All females captured by mist netting in late June (n = 10) were pregnant. Parturition began on 3 July and appeared to be synchronous among the colony. Most births occured within 10 days. Maternity group formation may provide thermoregulatory advantage, as bats were seen to cluster together within a tent in the cooler times of the day and separate when the sun was shining on the tent. Although individual tents fluctuated in numbers, observations of eight marked bats showed that each bat tended to roost in the same tent for several days. Factors that affect tent occupation, especially the height of the frond and the age of the tree, were investigated. The total population size and the number of females with nutritionally dependent offspring roosting in this area were lower in July 1989 than in July 1988. The effect of environmental factors including temperature and rainfall may be important determinants of roost site dynamics.

Time Delay and Cross-Correlation Delay Trade-Off in a Range-Discrimination Experiment With Big Brown Bats, *Eptesicus fuscus*

W. Mitchell Masters, Department of Zoology, Ohio State University

The question of whether FM bats like *Eptesicus* use matched filtering (cross-correlation reception, pulse compression) to determine the time of arrival of an echo has not been answered definitively, but there is some evidence that they do. Matched filter processing would imply that bats have a built-in template that specifies the expected signal (echo) and with which they compare (cross-correlate) incoming sounds. If bats have such a template, then a change in echo structure could, by changing the cross-correlation function (XCF), affect the bat's estimate of target range. To test this hypothesis, bats were trained to echolocate two electronically simulated ('phantom') targets using model echoes, i.e., echoes designed to mimic each bat's typical sonar emission. The bat's task was to select the nearer of two phantom targets, one of which (the correct choice) was always at an echo delay equivalent to a target distance of 80 cm, and the other of which appeared to be farther away. After bats learned this task, the original model echo was replaced by two others, one in which the frequency was shifted slightly upward, the other in which it was shifted slightly downward. Cross-correlating these shifted versions with the original model results in change in the position of the peak of the XCF (upward frequency shift delays the peak, downward shift advances it). If target distance is determined by the peak of the XCF, as matched filtering would imply, then moving the XCF peak should cause a shift in apparent range of the target. An experiment trading off echo time-of-arrival (time delay) and cross-correlation delay was carried out with three bats and four target-range differences (1.0, 0.75, 0.5 and 0.3 cm). Comparison of error rates when target distance was set entirely by time delay, entirely by cross-correlation delay, or when time delay and cross-correlation delay were in opposition, showed no significant difference for any bat for any range difference. This suggests that to the bats time delay and cross-correlation delay are inter-convertible, as matched filtering predicts.

Project X-Ray: the World War II Bat Bomb

Gary F. McCracken, Department of Zoology, University of Tennessee

During 1941-1944, the U.S. Military experimented with the possibility of using Mexican free-tailed bats *(Tadarida brasiliensis mexicana)* to invade Japan. I have obtained the Navy's World War II Command File records concerning this project as well as other references pertaining to it. The project is well described by the following quote taken from a letter to me from R.A. von Doenhoff, an officer in the Military Reference Branch of the U.S. National Archives. "Project X-Ray was an experiment undertaken by the Department of the Navy to determine if incendiary devices attached to bats would be useful if they were released by aircraft over major Japanese cities. The theory was that the bats would be released just before dawn with incendiary devices with timers attached to each bat. As daylight apporached, the bats would head for dark recesses of wooden Japanese houses. When the bats were safely asleep, the incendiary devices would ignite, thus producing a conflagration of unprecedented proportions. A test run of this theory was carried out in the southwestern United States. However, the advent of the atomic bomb rendered this experiment moot."

Patterns of Rarity and Commonness in Mexican Bats

Rodrigo A. Medellin and Hector T. Arita, School of Forest Resources and Conservation, University of Florida

A major issue for conservation biologists is to protect those species that are rare, as these are by definition more vulnerable to extinction. But the determination of whether a species is rare or not is frequently based on subjective and ambiguous criteria. This is especially true for little-known, large groups of species, as is the case of bats. To generate a ranking sequence of rarity for all 137 Mexican bat species, we used two variables: size of the distribution range was quantified from published distribution maps. To estimate the scarcity or abundance of each species, we examined a database of over 40,000 Mexican bat records from museums, analyzed by locality and by species to obtain an average proportion of individuals of each species for all localities where a given species has been recorded. Bivariate plots were then produced with those two variables, and these proved to be correlated. Then we examined the effects of body size, phylogeny, and diet, on whether a particular bat species was rare or not. There is no evident effect of body size. Some effects of phylogeny are evident; for example, most vespertilionids are common, and many molossids are scarce, but widespread. The effects of diet are interesting in that most pollinivorous species are common, but most gleaners are rare.

With this methodology we produced our lists of species: 1) Abundant but with restricted distribution, 2) abundant and widespread (=common), 3) scarce and with restricted distribution (=), and 4) scarce but widespread. This is a first approach to determining which species should be more closely looked at and probably considered fragile, vulnerable, or endangered, but these lists are only for the decision makers to evaluate on a case-by-case basis and resolve whether any given species is adequately allocated to a certain group or belongs in a different one. This is an objective method of detecting rare species and can be applied to virtually any area of the world and any group of mammals that is relatively well represented in museum collections.

A Comparison of Proportions of Tympanate and Atympanate Moths in the Diets of *Lasiurus borealis* and *Lasiurus cinereus*

Cathy Merriman, Department of Biology, Wilfrid Laurier University

Certain moths, particularly of the families Noctuidae and Arctiidae, are know to possess tympana. These sensory organs allow them to hear the approach of echolocating insectivorous bats, and to subsequently take action to prevent being captured. In order to examine the effectiveness of such strategies, I observed the foraging behavior of *L. borealis* and *L. cinereus* at Pinery Provincial Park near Grand Bend Ontario. The bats prey mainly on moths at well-lit feeding sites. From June to August 1989 I collected moth wings culled by bats, as well as moths that bats attacked unsuccessfully. A light trap sampled all moths available on each night. I am analysing the diet of the bats to determine relative proportions of tympanate and atympanate moths within both the culled wings and the missed moths. By comparing these proportions with the relative proportions of hearing and non-hearing moths in the light trap sample, I can test the hypothesis that the bats' diets will contain a high relative proportion of atympanate moths, and conversely a low proportion of tympanate moths.

Progress at Bat Conservation International

P.A. Morton, Bat Conservation International

Holy Batman, it's been a good year at BCI! In November of 1988, with the help of many members and friends, BCI's lobbying efforts paid off with passage of a bill to establish a national park in America Samoa and greatly aided the passage of the Federal Cave Resources Protection Act. Last April the National Geographic Society awarded a research grant to Merlin Tuttle and Ted Fleming to study bat-cactus relationships in the Mexican Sonoran Desert. Brock Fenton conducted BCI's first Bat Study Workshop in August, training wildlife biologists and naturalists in the use of bat field research techniques. Several education items were produced including a book, poster, slide show and video on the bats of North America, as well as a book in Spanish on tropical American bats. News media publicity continues to educate hundreds of millions of people. BATMAN publicity doubled BCI's normal rate of requests for information. One of BCI's most important projects over then next 12 months is the filming of a CBS primetime special on bats that will air in 103 countries. BCI is also sponsoring a conference on the conservation of Pacific Island flying foxes and is assisting Dixie Pierson and Bill Rainey with CITES listings and status surveys for flying foxes.

Population Ecology and Conservation of Little Brown Bat, *Myotis lucifugus*

Alison Neilson, Department of Biology, York University

Between 15 May 1989 and 29 August 1989, I studied the movements of individual *Myotis lucifugus* and that of the entire nursery colonies at several locations on the grounds of the Chautauqua Institution, Chautauqua, New York. Approximately 15,000 bats form nursery colonies during the spring and summer months. Bats were caught and banded as they left their roosts at dusk to forage. More than 95% of the bats that were banded and recaptured retruned to their original roosting site. I relocated bats and kept them in 5 various bat houses for 24 hours to encourage them to live there. Three seeding experiments were successful. One house that was built and seeded with bats last year had 4 bats living in it this summer. A house purchased from Bat Conservation International was seeded with 2 pregnant females who gave birth there. Both babies were eventually abandoned but one of the females returned and took up residency. The third house, mainly constructed of old wood from bat infested attics, was built from the design of the Missouri style bat house. Six of 94 relocated bats remained in this house after seeding.

Muscle Fibre Ultrastructure and Histochemistry, Wing Design and Flight Ecology in Bats and Birds

U. M. Norberg, Deptartment of Zoology, University of Gothenburg, Sweden

In flying vertebrates (bats and birds) there are apparent relationships between flight-muscle fibre ultrastructure and histochemistry (here reviewed from various sources) and body size, wing design and flight habits. The fibre structures of flight muscles have been extensively investigated in birds. For example, high aspect ratio (AR equals wing span^2/wing area) plus low wing loading (WL equals weight/wing area) in birds are correlated with slow continuous flight, soaring and gliding, and with fast-twitch oxidative-glycolytic (FOG, "red" and "intermediate") fibres for aerobic contraction and endurance plus slow tonic (ST) fibres for isometric economy. High AR plus high WL are correlated with fast continuous flight and with FOG ("red") fibres plus fast-twitch glycolytic (FG, "white") fibres for rapid isotonic contractions (e.g. take-offs). Low AR plus high WL are correlated with expensive flight within vegetation and perching and with FG ("white") and fast-twitch oxidative-glycolytic

(FOG, "red" and "intermediate") fibres. Low AR plus low or average WL are correlated with slow expensive flight within vegetation and with "red" (mainly in the smaller birds) or "red" plus "intermediate" FOG fibres. However, variations in catabolic enzyme activities have been found in the pectoral muscle in both birds and bats, showing that muscle histochemistry can change and adapt to various conditions. In bats there are similar relationships between fibre structure and histochemistry, wing form and flight ecology: high AR plus high WL are correlated with aerobic metabolism, and low AR plus high WL with anaerobic metabolism. Fast-twitch oxidative (FO, "red"), fast-twitch oxidative-glycolytic (FOG, "red" and "intermediate") and slow oxidative (SO, "red") fibres are found in bats with slow, manoeuverable flight (low or average AR plus low WL). The only bats which have been found to use gliding in slope lifts belong to the genus *Pteropus*, and the only *Pteropus* investigated has "red" and "intermediate" FOG fibres like many soaring and gliding birds.

Jamming Avoidance in Vespertilionid Bats

Martin Obrist, Deptartment of Biology, York University

Recognition of its own sonar signals is crucial for a successful hunt by an echolocating bat. However, bats probably only need clear discernability of their orientation calls in the immediate vicinity of echolocating conspecifics.

To assess the extent to which bats exchange their call design in these potentially jamming situations, recordings of individually known bats *(Euderma maculatum, Eptesicus fuscus, Lasiurus borealis* and *Lasiurus cinereus)* were obtained in two places in Canada. Recordings of 3545 search phase calls, including signals of 16 individual bats flying alone and in groups, were analysed for ten call measures (Obrist, 1988); and the signals of individuals were compared statistically for differences due to the presence of conspecifics.

Despite the mutual avoidance exhibited by *Euderma maculatum,* the analysis revealed that bats increased the overall variability of several signal measures when other bats were within audible distance. *Eptesicus fuscus,* foraging in dense groups at the recording site, showed only slight reactions to the close presence of conspecifics. Increases in the highest frequency, the frequency of maxiumum energy, and the coefficients of variation (CV) of frequency parameters and call intensity were most common. Significantly shortening the calls and slightly decreasing their bandwidth led to a higher rate of frequency swept per time and a decreased duty cycle in the echolocation calls of *Lasiurus borealis.* All measured frequency parameters are significantly shifted upwards and call duration and interval showed a significant increase of the variability in the presence of conspecifics. The change of frequency parameters in *Lasiurus cinereus* led to a drastic increase of the call's bandwidth and their rate of frequency swept per time. Variability (CV) of most echolocation signal parameters of this species decreased when conspecifics foraged close by. *Lasiurus borealis* and *Lasiurus cinereus* responded individually specific to the presence of other bats.

When conspecifics become audible, some species preferably keep the average call design constant and increase its variability, others clearly change the call design and decrease the variability, others again show intermediate changes in the mean and the variability of their signals.

The results strongly support the hypothesis that vespertilionid bats adjust the design of their orientation calls to the needs of interindividual jamming avoidance.

Systematics and Zoogeography of Antillean and North American *Tadarida brasiliensis*

Robert D. Owen, Ronald K. Chesser and Dilford C. Carter, Department of Biology, University of Missouri-Kansas City, and The Museum, Texas Tech University

In his dissertation, Carter (1962) concluded that the sedentary populations of *Tadarida brasiliensis* living in the southeastern United States were reproductively isolated from the migratory populations of the southwest. Few subsequent authors have followed his recommendation for specific status for *Tadarida cynocephala,* the sedentary form. Svoboda (1984) found an esterase locus with what appeared to be a fixed allelic difference between populations of *T. b. mexicana* (the migratory form) and *T. b. cynocephala* (the sedentary form from the southeast).

We have examined this esterase locus in bats obtained from *T. b. cynocephala* populations in Louisiana, Florida and North Carolina; from *T. b. mexicana* in Texas and Oklahoma; and from populations from the Antillean islands of Cuba, Jamaica, and Dominica. Based on this locus, and on the body of evidence assembled by Carter for his dissertation, we believe that there is little or no gene flow between *T. b. mexicana* and *T. b. cynocephala* and the nearest Antillian populations.

It will be of general interest to Antillean zoogeographers to determine the origin of the sedentary southeastern form of *Tadarida brasiliensis.* We are pursuing this and related questions with analysis of additional enzyme loci, and are planning collection of bats from additional localities.

Tracking Insect Prey From the Roost: Bats and Barometric Pressure

Ken N. Paige, Karen Tyrell, Tom Juenger and Garth Fuller, Institute for Environmental Studies and Department of Ecology, Ethology and Evolution.

Experimental and observational results suggest that insectivorous bats track barometric pressure metabolically. With a drop in barometric pressure bats respond by lowering metabolic rate independent of torpor (i.e., without a drop in body temperature). Such intricate tracking allow bats to conserve energy and yet, remaining cognizant, extend a previously obtained meal, and indirectly track aerial insect prey from the roost (insects decrease activity concurrent with a drop in barometric pressure). Barometric pressure tracking is viewed as an alternative evolutionary strategy to torpor.

Comparative Development of the Skull in *Artibeus jamaicensis* and *Eptesicus fuscus*

S.C. Pedersen, University of Nebraska

I compare the early development of the skull in *Artibeus jamaicensis* and *Eptesicus fuscus,* each bat being a common and well studied representative of the Phyllostomatidae and Vespertilionidae, respectively. Developmental series (limb bud stage through volant young) of *Artibeus* (n=20) and *Eptesicus (n*=25) were cleared and differentially stained for bone and cartilage. For each species, I describe the sequential appearance of each bone in the skull and compare the developmental trajectories of several standard morphometric characters using bivariate and multivariate approaches. Similarly, I describe the dynamic volumetric relationships between the different functional units of the cranium (e.g., rostrum, bullae, basicranium, and cranial vault) throughout development. These data are preliminary to a larger comparative eco-morphological study of chiropteran skeletogenesis.

The Mitochondrial Genome in the Jamaican Fruit Bat, *Artibeus jamaicensis*

Carleton J. Phillips, Dorothy E. Pumo, Colleen Millan, May Nouri, Alexandra D. Warmhold, and Hugh H. Genoways, Department of Biology, Hofstra University, and University State Museum, University of Nebraska-Lincoln

The mitochondrial DNA (mtDNA) in *Artibeus jamaicensis* is a maternally inherited molecule of about 16.5 kilobase pairs. As in other mammals, the mtDNA in these bats evolves rapidly and consequently can be used for high resolution genetic comparisons in disjunct populations. We are using restriction site mapping, Southern blot hybridization, and DNA sequencing to analyze mtDNA in this species. Specimens have been collected and studied from Mexico, Cuba, Jamaica, Puerto Rico, Anguilla, St. Lucia, St. Vincent, Barbados, Trinidad, and French Guinea. The following highlights of this research will be sumarized: 1) maternal relationships among traditionally recognized subspecies; 2) dispersal patterns in the Caribbean; and 3) unusual features of the mitochondrial genome in *Artibeus.* Funded by NIH grant R01GM42563-01 (DEP and CJP) and Hofstra University HCLAS grants.

Postnatal Histochemical Development of Three Muscles in *Myotis lucifugus* and its Relation to the Behavioral Development of Flight

Lauren V. Powers, Department of Biology, Boston University

Three muscles, the pectoralis, the acromiodeltoideus and the superficial quadriceps, of *Myotis lucifugus* were studied during postnatal development (birth to 30 days) using histochemical analysis of three metabolic enzymes, succinate dehydrogenase (SDH), alpha-glycerophosphate dehydrogenase (α-GDPH), and myosin ATPase. Changes in fiber area were also recorded. To determine the behavioral development of flight, young bats of various ages were dropped from a predetermined height and their performance was recorded using a video camera. These data were compared to determine the correlation between behavioral and muscular development of flight.

Muscle fibers at birth were small and stained darkly in an alkali preincubation for myosin ATPase in the acromiodeltoideus and in the pectoralis, indicating a homogeneous population of fast fibers. By the time that bats first began to fly (at the age of 17 days), fibers in these muscles had increased dramatically in size and were comparable in area to adult fibers. All fibers continued to stain darkly for myosin ATPase, although the intensity decreased with increasing age. Quadriceps fibers at birth were homogeneous for myosin APTase and were larger in area than the two flight muscles. Early in development, weakly staining fibers of the quadriceps were observed, indicating that a mixed population of fast and slow fibers was forming.

Fibers that stained for SDH and α-GPDH were homogeneously dark at birth for each of the three muscles. Early in development, larger fibers began to appear in the acromiodeltoideus and in the quadriceps that stained darkly for α-GPDH and lightly for SDH. Small fibers stained darkly for SDH and weakly for α-GPDH in these two muscles. In the pectoralis, the staining intensity for SDH was so dark that no change could be detected throughout the postnatal period. Larger fibers, however, appeared at about the same time as in the acromiodeltoideus and stained more intensely for α-GPDH.

In the highly specialized primary flight muscle such as the pectoralis, metabolic development is not expected until the onset of flight. The same should hold true for accessory flight muscles such as the acromiodeltoideus. By contrast, early development in the quadriceps is expected since this muscle is essential for baby bats to cling firmly to their mothers and the roost substrate.

The Superior Colliculus in the Rufous Horseshoe Bat, *Rhinolophus rouxi*

Katrin Reimer, Zoologisches Institut, Luisenstr. 14, 8000 Munchen 2

The superior colliculus (SC) of mammals is known as a center of sensori-motor integration. Electrical stimulation studies in the horseshoe bat by G. Schuller suggested that the SC might be involved in vocalization. The aim of this study was to characterize neural response properties during vocalization, and also to define auditory properties of the SC in the horseshoe bat.

During the recording sessions the animals were awake and vocalized spontaneously. No neural activity specifically related to the bat's own vocalization could be recorded. Neural activity correlated to the vocalization could always be identified as a response to stimulation of the auditory system by the bat's own vocalization.

Acoustic response properties were studied using closed field stimulation. Most units recorded (74%) had best frequencies in the range of the constant frequency component of the echolocation call. Units were as sharply tuned as neurons in classical auditory centers of the horseshoe bat with Q_{-10}dB values up to 200. The main response pattern, an onset response with a single spike discharge per stimulus, corresponds to the main response type found in the SC of other mammals.

Neurons were mainly driven by contralateral stimuli, when stimulated monaurally. With binaural stimulation, however, 70% of the units proved to recieve binaural input. The main binaural effect consisted in suppression of the contralateral excitatory response by the ipsilateral stimulus. The degree of inhibition was dependent on the interaural intensity difference (IID). Most units were completely inhibited at IID-values of 10 or more dB favoring the ipsilateral ear. A significant gradient of IID-values was observed along the medio-lateral axis of the SC.

All in all, properties of SC neurons in the horseshoe bat do not appear to be very different from those in other mammals. Specializations, like overrepresentation of the CF-frequency, seem to depend on the specializations of the bat's peripheral auditory system.

Connections of the SC were studied using horseradish peroxidase. The main possible sources of auditory input to the SC appear to be the paralemniscal zone, as defined for the horseshoe bat by W. Metzner, and the nucleus of the central acoustic tract. Structures of the classical auditory pathway, such as the inferior colliculus, including the external nucleus, and the auditory cortex contain only a few retrogradely labeled cells. No cells were labeled in any of the nuclei of the lateral lemniscus.

The SC also has several connections with centers assumed to be involved in the control of vocalization. These structures include cingulate cortex, hypothalamus, pretectal area, cuneiforme nucleus, and again, the paralemniscal zone.

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Variation in the Isolation Calls of Infant Evening Bats, *Nycticeius humeralis*

J.A. Scherrer, Department of Zoology, University of Maryland

Vocalizations of sibling infant *Nycticeius humeralis* were analyzed to determine whether the variation in isolation calls is greater betweeen unrelated individuals than that between siblings. Over 300 recordings were made from wild pups that were captured in the roost and seperated from their mothers long enough to record approximately 100 calls. Pups nursing from the same mother at the time of capture were treated as siblings. In addition, nine pregnant females were captured from each of two colonies, and kept until pups were volant. Ages of wild bats were estimated with a regression of captive pup forearm and weight on age ($r^2_{females}$=.91, r^2_{males}=.94).

Fourteen call variables that describe frequency, time and spectral characteristics of the first and second harmonics were measured on at least seven calls from each pup. The pattern of frequency change over time exhibits high repeatability within individuals but extensive variability between individuals of the same age. Classification of calls of 39 individuals into 19 families by discriminant function analysis reveals that the calls of 3 day old sibs can be assigned to their correct family 80% of the time. Furthermore, males differ from females in those variables related to spectral characteristics. These results indicate that isolation calls can serve as vocal signatures that contain information about pup sex and family identy. Repeated measures analysis of the calls of captive bats will describe the ontogeny of vocalizations and explain how call variables change as pups mature.

Postnatal Growth Curves and Predictive Age Equations For *Antrozous pallidus* and *Eptesicus fuscus* in Arizona

Ronnie Sidner, Department of Ecology and Evolutionary Biology, University of Arizona

Measurements of weight, forearm length, and the epiphyses of wing bones were recorded in the field from marked juveline bats of known age. Individuals were captured from one to twelve times during the summer of postnatal development. From these data, empirical growth curves were drawn and linear portions of the curves were used in regression analyses to construct age predictive regression equations for the two species of insectivorous bats. Predictive age equations provide the necessary tools for determining age in unknown juvenile animals, the importance of which has been discussed previously. The pallid bats and big brown bats in this study utilize the same maternity sites and are subjected to similar environmental conditions during post natal growth. Comparisons of the growth curves between these species and between geographically separated populations of these species will eventually be used to test hypotheses about adaptive changes in closely related populations under different environmental selection pressures. In addition, the significance of these patterns to the evolution of other life history phenomena will be evaluated.

An Integrated View of Acoustic Imaging by the FM Echolocating Bat, *Eptesicus fuscus*

James A. Simmons, Department of Psychology and Section of Neurobiology, Division of Biology and Medicine, Brown University

The big brown bat, *Eptesicus fuscus,* emits frequency-modulated (FM) echolocation signals and perceives spatial images derived from auditory processing of echoes. The initial neural representation of emissions and echoes is a spectrogram composed of discharges marking the time-of-occurrence of different frequencies in FM sweeps. The integration-time for FM signals being converted to spectrograms is about 360μsec. Target range is determined from echo delay and represented as a frequency-by-frequency set of estimates of the time between the emission and echo spectrograms. The image formed from these spectrogram delays is the crosscorrelation function of echoes. The shape of targets is perceived in terms of range profile, or the distribution of reflecting points along the range axis. Shape is thus quantified by range separation within the target. If two reflecting points in a target are closer together than 6 cm, they return echo components separated by less than 350 μsec. (the insects pursued by *Eptesicus* usually have linear dimensions smaller than 6 cm.) The spectrogram representations of the echo components mix together and are no longer separable in time. Mixing of echo components within the 350-μsec integration-time window creates an interference spectrum whose peaks and notches are related to the original time separation of the echo components. Although the sectrum ot the combined echo components is related to the target's range profile, the bat nevertheless transforms spectral peaks and notches into an estimate of the time separation of the echo components. *Eptesicus* explicitly perceives the target as having two parts located at different ranges. The image that is derived from the spectrum-transformed-into-time-separation is also the crosscorrelation function for echoes, in this case for echoes from the second reflecting surface. The bat thus uses two signal-processing paths to the complete crosscorrelation function of echoes: Echoes from the target's leading edge follow a direct path from the spectrogram delays to the crosscorrelation function. Echoes from the target's trailing edge modify the spectrum of the echo from the target taken as a whole, and an indirect path leads from this spectrum to the crosscorrelation function. The second crosscorrelation function is then added to the first to form the image perceived by the bat. The perceived dimension of delay-time supports construction of the whole image and is perceived with an accuracy of about 10 nanoseconds by *Eptesicus.*

The Energetics of Lactation in the Evening Bat, *Nycticeius humeralis*

S.R.E. Steele, Department of Zoology, University of Maryland

Female *Nycticeius humeralis* raise two offspring in a reproductive season while many other North American bat species raise only one. The reproductive biology of *N. humeralis* was studied at four maternity colonies in northern Missouri to determine whether the pattern of reproductive investment differs from species that raise only one offspring in a season. The energy expended by females during lactation was measured as an indication of reproductive investment. Females gave birth to 2.2 offspring in early June. The combined weight of the newborn offspring was approximately 40% of the female's weight and exceeded 130% when they began foraging 3-4 weeks later. A juvenile was considered to be foraging after the last date it was caught without insect debris in its mouth. Field Metabolic Rates (FMR) of 20 free ranging females were obtained using doubly labeled water. The mean FMR for early (12 June), mid (22-24 June), and late lactation (10-15 July) were 96.07, 139.31, and 89.29 ml CO_2/gram day respectively, while the mean post lactation level was 77.90 ml CO_2/gd (24 August). The energy expended in milk production will be measured by determining the caloric content of milk by bomb calorimetry and the volume produced estimated by isotope dilution in the pups. Factors that may allow *N. humeralis* to use a different reproductive investment pattern and reproduce at a higher rate than many other North American species are discussed.

Electrical Stimulation of the Auditory Cortex Facilitates Acoustically Evoked Responses of Cerebellar Neurons of the Echolocating Bat, *Rhinolophous pearsoni^ chinesis*

Dexue Sun, Xinde Sun and Philip H.-S. Jen, Department of Biology, East China Normal University, PRC and Division of Biological Sciences, University of Missouri

The influence of the auditory cortex on the cerebellum of the CF-FM bat, *Rhinolophus pearsoni chinesis* was studied by examining the effect of electrical stimulation of the auditory responses of 284 neurons isolated from the cerebellar vermis, hemispheres, and paraflocculus of *Rhinolophus pearsonic chinesis* were first studied under free field acoustic stimulation conditions. The BFs of these cerebellar auditory neurons ranged from 24 to 76 kHz but they mostly fall either betrween 48 and 64 kHz or between 65 and 76 kHz. However, the BF distribution varies among vermal, hemispheric and paraflocculer neurons. Threshold curves of cerebellar neurons are generally broad but those tuned to the frequency of the predominant CF component are extremely narrow. Response latencies of cerebellar neurons ranged from 2 to 48 ms suggesting multiple auditory cerebellar pathways. The latency distribution also varies among vermal, hemispheric and paraflocculer neurons. Although both the vermis and hemispheres contain a disproportionate number of 65-74 kHz neurons, the response latencies of those neurons isolated from the vermis are generally stabilized between 5 and 12 ms. Electrical stimulation of the auditory cortex evokes discharges from a recorded cerebellar auditory neuron. Cortical stimulation also facilitates the response of an acoustically evoked cerebellar neuron by increasing its number of impulses. The degree of facilitation is dependent upon the amplitude of the acoustic stimulus. For a given electrical and acoustic stimulation condition, the facilitative latency and the degree of facilitation varied with the inter-stimulus-interval. Among 23 neurons studied, most of them (19 neurons, 82.6%) had a maximal facilitative latency between 2 and 10 msec. By examining the difference in the facilitative effect in each isolated cerebellar auditory neuron before and after a topical application of local anesthetic, procaine, onto the point of electrical stimulation in the auditory cortex, we found that the pathways to vermal and hemispheric neurons may be different from the pathway to paraflocculer neurons. The facilitatative influence of the auditory cortex on the cerebellar auditory neurons is assumed to enhance the cerebellar role in acoustic motor orientation. (Supported by NIH grant NS20527).

Ultrastructural Variation in Chiropteran Salivary Glands

Bernard Tandler and Carleton Phillips, Case Western Reserve University and Hofstra University

Mammalian salivary glands are functionally complex being involved in diverse biological roles, including digestion, behavior, protection of the digestive mucosa and teeth and control of oral bacteria and viruses. The histology and ultrastructure of salivary glands in some ways relate to each of these manifold roles. We have selected bats as a model system for evaluating the structure-function relationship in salivary glands. We have examined more than 150 species, representing nine families of bats. No two species are exactly the same at the ultrastructural level. For intance, the granules in the secretory cells in the endpieces often are highly structured; they vary in ways that correlate with genetic relationships. This is significant because the granule contents include the macromolecules that form the organic component of the primary saliva. Variation in these contents might relate to specific requirements, dietary or otherwise, of individual species. The duct system also is highly variable and seems to be more closely correlated to diet than are the secretory cells. For example, vampire bats possess a brush border-like array of microvilli on the luminal surface of the striated duct. This complex may be related to the sodium load taken on by these animals by virtue of their blood diet. In contrast, striated duct cells in many fruit bats lack microvilli, but have leaf-like apical processes whose limiting plasma membrane is underlaid by a series of repeating subunits, the portasomes, which have been shown to play a role in sodium conservation in other organs in a variety of animals. In addition to their role in electrolyte homeostases, striated ducts cells have a secretory function elaborating organic macromolecules that probably include several growth factors and vaso-active and pheromone-like substances. We have found that comparisons of chiropteran salivary gland ultrastructure have taxonomic utility, may suggest novel features of chiropteran behavior and could clarify a number of aspects of secretory cell evolution and function. Supported by N.I.H. # DE 07648.

Detecting Doppler Shift

John Taylor, Department of Biology, York University

The term "constant frequency" (CF) is often used to describe narrow band signals used by echolocating bats. Although a variety of signals have been labelled "CF" there appears to have been little effort to define this term. For bats with the appropriate auditory specializations an important advantage of CF calls is the ability to exploit Doppler shifted echos generated by the beating wings of insect prey. My investigation was designed to determine the characteristics of an artificial signal that produced appreciable Doppler-shifted echoes off of a fluttering target. I considered signal frequency, duration and bandwidth as well as the rate of fluttering and the influence of background clutter. The results will be discussed in the context of the auditory systems of bats and the echolocation calls used by bats.

Response Properties of Neurons in the Dorsolateral and Lateral Pontine Nuclei of the Big Brown Bat, *Eptesicus fuscus*, to Acoustic Stimuli

Haibing Teng, Division of Biological Sciences, University of Missouri

In acoustic signal transmission, the outflow from the auditory cortex and the inferior colliculus terminates at the pontine nuclei (PN) which in turn project fibers upon the cerebellum. Some cerebellar fibers also project onto the PN. Thus, auditory information can be intergrated at the PN before it reaches to the cerebellum which is involved in motor orientation. To understand how the PN are involved in acoustic signal integration, response properties of 501 pontine neurons to pure tone stimuli (4 msec duration, 0.5 msec rise-decay times) in 9 *Eptesicus fuscus* were studied under free-field stimulation conditions. Pure tone pulses were delivered from a loudspeaker placed 68 cm in front of a bat. 3M KCl glass micropipette electrodes were inserted ventrally at an angle of about 60° to the horizontal plane of the exposed bat's brain. A tungsten wire electrode was always used for the last recording so that two small lesions on the first and last recorded neurons were made for reconstruction of the recording track. All 501 neurons were recorded at the dorsolateral and lateral PN. The response pattern of 493 neurons was examined. Most of them (N=423, 86%) discharged either less than 3 impulses (phasic responders, N=143, 29%) or 4-7 impulses (phasic bursters, N=280, 57%). The remaining (N=69, 14%) were tonic neurons which fired many impulses throughout stimulus. An off responder which discharged upon the cessation of the stimulus was also recorded. The response latency of these neurons ranged between 3 and 38 msec. Neurons in the rostral PN had a longer latency (N=285, mean=10.63±4.24) than those recorded in the caudal PN (N=208, mean=7.38±2.76) ($P < 0.001$). This observation suggests that the PN receive auditory inputs from different auditory centers. The minimum threshold of these neurons was between 4 and 91 dB SPL but most (N=423, 84%) were below 50 dB SPL. The best frequency (BF) of these neurons ranged fron 14 to 100kHz with most (N=39, 78%) between 30 and 60 kHz. All threshold curves of 164 neurons measured were broad with their Q_{10}-dB values less than 15 (mean=4.65±2.74). Furthermore, the distribution of BFs of recorded pontine neurons was not orderly organized. The fact that all these response properties are similar to those of cerebellar auditory neurons suggests that the PN have intergrated incoming auditory information before sending to the cerebellum. (supported by NIH grant 1RO1-NS20527 to P H-S Jen).

The Supression of the Alarm of the Hibernating Bat Clock by Light and the Stimulation of Arousal from Hibernation by the Cessation of Light.

John W. Twente and Janet Twente, Division of Biological Sciences, University of Missouri

We have reported a powerful biological alarm clock that arouses hibernating big brown bats *(Eptesicus fuscus)* only in the afternoon and evening hours, even after periods of hibernation of 38 days in duration. Despite maintenance in continous darkness, the rhythm did not become free-running and, where tested, persisted without significant deviation from November to April. The rhythm was independent of the duration of the period of hibernation; temperature; time of entry into hibernation; time of day of sunset; changes in air pressure; and other obvious environmental variables. We have been unable to establish whether this remarkable rhythm was under exogenous or endogenous regulation.

Attempts to rephase this rhythm by exposing hibernating bats to different light regimens were negative, but they resulted in the following unexpected and unexplained results: (1) daily exposure of hibernating bats to 8-12 hours of light, irrespective of intensity (1×10^{-3} to 1×10^{-8} watts/cm^2) suppressed arousal at the expected times; virtually never did a bat arouse during illumination; (2) arousals, if they were to occur (bats frequently hibernated many days through as many exposures) always proceeded within two hours after the extinguishment of light; (3) shifting of the time of day of exposure had no effect upon the previous two observations: light always inhibited arousal and arousal, if it occurred, always did so within two hours after the lights were abolished; (4) exposure to light did not rephase the rhythm to hibernating bats: when the bats were returned to continuous darkness after experiments with light they reverted to previous arousal times.

The stimulation of arousal after the cessation of the light stimulus would seem to be a unique, behavioral adaptation which may have adaptive significance. *E. fuscus* often hibernate near cave entrances in dimly lighted places (e.g., ca. 1×10^{-7} watts/cm^2). The low levels of light effective in stimulation arousal upon extinguishment under experimental conditions are within the levels naturally experienced. Bats in lighted zones would be aroused for evening flight for movement of feeding at propitious times, whereas those in darkness deeper within the cave would rely upon the biological alarm clock for the same signal.

A Technique for Monitoring Insect Abundance and Biomass in Real-Time

Karen Tyrell, Department of Ecology, Ethology, & Evolution, University of Illinois at Urbana

Bat researchers may be interested in the activity and abundance of flying insects in areas where bats are foraging. I have developed a technique by which both the number of flying insects present and the biomass of these insects can be quantified in real-time, allowing these data to be correlated with changes in the environment which occur over time. Furthermore, the investigator need not be present to collect samples.

A "bug zapper" (electronic insect killer) was placed in the area of interest. A microphone was placed 0.25 m from the bug zapper, and connected to the mic input of a cassette tape recorder. Out-put from the tape recorder (set on "record") was fed into a chart recorder via the "monitor" output jack. (The circuit diagram for connecting the cassette recorder and the chart recorder will be made available.) An extension cord (125 m) connected the mic to the cassette tape recorder, so that the recorders could be housed in a rain-proof enclosure near an AC poser source. The bug zapper came equipped with a photocell on/off automatic timer; a photocell could also be used to turn on the chart and tape recorders.

Insects were attracted to the blacklight at the center of the "zapper" and electrocuted as they near the metal grid surrounding the light. This produced a brief, intense sound (relative to background) which was transduced and displayed as an easily-recognizable peak on the chart recorder printout. The number of peaks appearing on the printout was approximately equal to the number of insects killed. Relative biomass of these insects could be determined by calculating the area under the curve of each peak (a straightforward measurement due to the near-linear onset of the peaks): the greater the area, the greater the biomass.

Results of control experiments showed that on nights where more insects were captured using conventional insect trapping methods, more insects were zapped, and that biomass estimates from the techniques used were similar. However, this technique had a few drawbacks: only positively phototaxic insects will be attracted to the blacklight; insects zapped simultaneously cannot be distinguished; very large insects were probably underrepresented because they cannot easily reach the killing grid. While the chart printout cannot be used to directly identify species, a tray can be attached beneath the zapper to collect the dead insects for identification.

Fruit Consumption and Seed Dispersal of Three Fig Species by Frugivorous Bats (Pteropodidae) in a Philippine Primary Forest

Ruth C. B. Utzurrum, Department of Biology, Boston University

Patterns of fruit consumption and seed dispersal around individuals of three fig species (i.e., *Ficus chrysolepis, F. crassicalyx,* and *F. pubinervis*) were documented in a partially disturbed primary rain forest surrounding Lake Balinsasayao (800 m elev.) in Negros Oriental, central Philippines. Diurnal and nocturnal visitors were recorded, bat-generated seed shadows were examined; and sample seeds from ejecta, splats, and fallen fruits were germinated on moist filter paper in petri dishes.

Eight of ten pteropodid frugivores in the area were found to consume the fig fruits. *F. chrysolepis* and *F. pubinervis* were eaten by potentially all 8 species, from a 20 g *Haplonycteris fischeri* to a 1000+ g *Acerodon jubatus.* Only the three largest bats consumed *F. crassicalyx* fruits. All three fig species were canopy trees. Except for *F. crassicalyx* (which turned red and mushy), fruits remained generally green-colored and firm upon maturity. A total of 1,088 seed aggregates (22.8% in splats) were collected from the *F. chrysolepis* transects over a 25-day period; 45.5% were taken beneath the crown. 1,605 aggregates were collected from *F. pubinervis* transects over a 22-day period; 1% was in splats, and 75.5% were beneath the crown. Only 15 aggregates of *F. crassicalyx* were collected over 81 days: 46.7% as splats and 100% as beneath-crown deposits. Macacques *(Macaca fascicularis)* were the only diurnal visitors in *F. chrysolepis;* none were observed at the *F. pubinervis.* Small doves *(Phapitreron spp.)* made infrequent feeding visits to *F. crassicalyx.*

Mean germination percentages of *F. chrysolepis* seeds were 27.83%, 39.38% and 60.0% for samples taken from fruits (N=20), ejecta (N=16), and splats (N=16), respectively. Splats had higher seed content per unit mass than either fruits or ejecta; they also had higher proportions of mature and intact seeds (85-99%) than do fruits (35-50%) and ejecta (0-35%)

These results indicate the importance of fig fruits as a resource for frugivorous bats in the area, and probably elsewhere in the Philippines. They indicate interesting physiological and nutritional aspects to observed differential patterns of consumption that need investigating. Although seed shadows are highly skewed towards the tree base and reflect a localized pattern of seed fall, since a high percentage are in the form of ejecta containing fewer viable seeds (based on germination results), it is most likely that the fruit bats do contribute significantly to effective dispersal of fig seeds in the form of splats. These findings bear important implications to Philippine forest conservation, especially on aspects of natural regeneration of disturbed areas that adjoin remnants of primary forest.

This presentation was awarded second place in the student honors competition.

Innervation of the Lips of the Fringe-lipped Bat, *Trachops cirrhosus*

Allison Weiss, Robert S. Gilley, and Carleton J. Phillips, Department of Biology, Hofstra University

The fringe-lipped bat *Trachops cirrhosus*, is best known for its use of neotropical anurans as a major part of its diet. *Trachops* is distinguished by the presence of finger-like projections on its lips. Immunohistochemical techniques were used to localize neuron specific inolase (NSE), which revealed the innervation of these projections. Fine nerve fibers and nerve bundles, in various arrangements, were highly concentrated in the projections relative to all other regions of the lips. NSE-immunoreactivity was prominent in the dermis, especially in dermal papillae. Nerve fibers in the dermis frequently made contact with basal epidermal cells, and appeared to synapse with some of thee cells. Some nerve fibers alternatively terminated as free nerve endings in the outer layers of the epidermis. Additionally, some basal epidermal cells were NSE-immunoreactive, suggesting their possible paraneuron function. We obtained no evidence that any of these nerves also contain vasoactive intestinal polypeptide or neruopeptide-Y, both of which are known to be present in nerves associated with skin in humans. We postulate that these data reflect an evolutionary attempt to cope with the specialized feeding habits of *Trachops*. For example, this sensory innervation might provide an enhanced tactile sense, or perhaps help *Trachops* recognize potentially poisonous prey. Funded by NIG grant R01 DE 07648-01A1 and Hofstra University HCLAS grants.

Nonparental Suckling in the Evening Bat: Effects of Food Availability and Foraging Success

Jerry Wilkinson, Department of Zoology, University of Maryland

Female evening bats have been reported to nurse indiscriminately after their young reach two weeks of age. For the past two summers we have observed nursing among color-banded females and pups in an attic nursery colony in northern Missouri to confirm or refute this claim. After over 150 h of observations our results indicate that most young nurse from a single female. However, at least 28 of 433 nursing bouts were nonparental because pups nursed from more than one female, had maternally incompatible electrophoretic genotypes or were estimated to be at least 5 days older or younger than known offspring. These bouts were comparable in duration to those between same-aged pups and mothers. Although female evening bats return to their natal colony to reproduce, we do not have evidence that nonparental nursing occurs among kin or kin groups. The average relatedness between nonparental females and pups ($r = 0.025$) is indistinguisable from the average relatedness among adult females in a colony ($r=0.007$, based on 7 colonies). Although we did observe one case of reciprocal nursing, given the rarity of this behavior we doubt that reciprocal nonparental nursing can provide a substantial benefit to participants. At present we suspect that nonparental nursing, when it occurs, imposes a small cost on the female but provides a potentially large benefit to the pup. Nonparental nursing occurs near the age (average = 26 days) at which young are learning to fly and forage independently and their mother's milk flow is beginning to wane. By monitoring variation in nightly prey density throughout the summer with five Johnson-Taylor type suction traps we found that the frequency of nonparental nursing correlates with average prey density. These data are consistent with the hypothesis that pups which forage unsuccessfully seek milk from adults with an abundance of milk. We are currently testing this idea using video records of bat departure and arrival times and weights.

BAT RESEARCH NEWS

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CONTENTS

FRONT COVER

After many seasons of separating mother bats from their babies and causing them untold anxiety and grief, Gary McCracken is shown here being separated from the rest of us and carried off to his just rewards by the biggest "mother" of them all.