BAT RESEARCH NEWS

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Front Cover

The illustration of *Rhinolophus ferrumequinum* on the front cover of this issue is by Philippe Penicaud from his very handsome series of drawings representing the bats of France. He has kindly given his generous permission to display some of these as our front covers. Mr. Penicaud resides at 16 bis, Route de Port, F – 29252 Plouezoc'h, France. Tel/FAX 33/2 98 67 29 39

We are always eager to find new cover illustrations so if you have great line drawings or sharp contrast photos of bats that you would like to submit, please send them to us. If we use your artwork, we will add one free year to your subscription.

BAT RESEARCH NEWS

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Front Cover

It seemed fitting that a bat on a postage stamp should represent our efforts at keeping our publishing costs to a minimum. As you learned from the flier insert in this issue, an electronic version of Bat Research News will be available to those who have the facility for on-line reception. This may be the last stamp you see!

If you have a good illustration you would like to see on our front cover, send it to me. If it is selected you will receive a free one-year extension of your subscription. G. Roy Horst

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Front cover

The lovely bat appearing on the front cover is the artwork of Morgan Anderson from Nelson, BC, Canada. Morgan is a high school student who has worked with Robert Barclay and Mark Brigham on their projects. Happily for us, she combines her enthusiasm for bats with her considerable talents as a wildlife artist. Thank you Morgan for sharing your work with us.

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The front cover of this issue is the work of Adrian Tejedor and was the official logo of the 30th North American Symposium on Bat Research held in Miami, Florida in September 2000.

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Instructions for Contributors and Subscribers

Bat Research News is published four times each year, consisting of one volume of four issues. Bat Research News publishes short feature articles and general interest notes, which are reviewed by at least two scholars in that field. In addition, Bat Research News includes a "Recent Literature" section which cites many bat related publications in English worldwide; the abstracts from Bat Conferences around the world; Letters to the Editors, News, Notes submitted by our readers; and "Announcements of Future Bat Meetings, Symposia, and Conferences" worldwide.

Communications concerning feature articles and "Letters to the Editor" should be sent to Kurta; recent literature items should be addressed to Griffiths; book reviews and conservation education items should be submitted to Morton; subscription questions and all other items should be referred to Horst.

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A Resolution Concerning Bat Bites and Rabies

At the 29th Annual North American Symposium on Bat Research held at the University of Wisconsin in October 1999, Merlin Tuttle proposed a resolution concerning the responses to incidents of bat bites. After much discussion and careful review of this resolution the Board of Directors of the Symposium adopted the following resolution.

Be it resolved on this 30th day of October 1999, that researchers gathered at the 29th North American Symposium on Bat Research find no credible support for the hypothesis that undetected bites by bats are a significant factor in transmitting rabies to humans, as implied by the January 16, 1998 issue of the Morbidity and Mortality Weekly Report.

In our collective experience, bats seldom are aggressive, even when sick, and humans typically feel and recognize any bites they receive. The undetected bite hypothesis appears to be derived from the inability of medical professionals to interview patients due to late moribund or postmortem diagnoses. In the rare cases in which humans contract rabies from bats or other animals, the available evidence strongly suggests that bites were involved and could have been remembered had the patients been coherent. We are deeply concerned about the impacts and resulting negative consequences for bats stemming from the undetected bite hypothesis, which has apparently moved from theory to fact without adequate testing. The consequences are both economic and social. The economic costs are clear, and the social impact is seen, both in the way that people react to bats and in the way that conservation efforts are impeded. The undetected bite hypothesis is not supported by evidence, and it should not drive public policy nor public health responses.

We recognize the need for reasonable precautions against rabies, including vaccination of all who handle bats professionally, and public education that: 1) cautions never to handle bats or other animals; 2) warns to seek immediate medical evaluation of any actual or suspected animal bite; and 3) places risks in perspective with values.

Respectfully submitted: Thomas A. Griffiths, Symposium Director

Members of the Board of Directors: Hecto Arita, Robert M. R. Barclay, Mark R. Brigham, Theodore Fleming, Patricia Freeman, G. Roy Horst, Thomas H. Kunz and Patricia Morton

E-Mail Directory of Bat Workers

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RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths, Dept. of Biology, Illinois Wesleyan Univ., Bloomington, IL. 61702-2900, U.S.A.) for inclusion in this section. If reprints are scarce, please send a complete citation (including complete name of journal and author mailing address) to **tgriff@titan.iwu.edu** by e-mail. Receipt of reprints is preferred at it will facilitate complete and correct citation. Our Recent Literature section is based on several bibliographic sources and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome. Recent Literature for this issue was compiled by Margaret Griffiths.

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Wright, A. J., R. A. Van Den Bussche, B. K. Lim, M. D. Engstrom, and R. J. Baker. 1999. Systematics of the genera *Carollia* and *Rhinophylla* based on the cytochrome-*b* gene. Journal of Mammalogy, 80: 1202-1213. [Baker: Dept. Biol. and Museum, Texas Tech Univ., Lubbock, TX 79409]

The following titles were published in

Plecotus et al No.2

as the proceedings of

The 7th Bat Research Conference of the Independent States of the FSU, Moscow, 14 - 16 of April, 1999.

Each of these titles was accompanied by an English abstract or summary.

If any readers of *Bat Research News* would like a photocopy of any of these abstracts **in English**, please contact Roy Horst and he will copy and mail them to you. Please include payment of a copying charge of $1.00 for each requested abstract and a mailing charge of $3.00. Please note that this does not constitute sale of published and copyrighted material, but is only a fee for copying services and mailing costs. Individuals may request a complete copy of ***Plecotus et al, No. 2*** from Eugenia I. Kozhurina, Severtsov Institute of Ecology and Evolution, Leninsky Prospect 33, Moscow 117071, Russia No information is available as to cost or availability. Dr. Kozhurina [Editor] may be contacted via e-mail at: kefa@orc.ru

Ecofaunistical Investigation of Bats. Strelkov, P. P. Zoological Institute, Russian Academy of Science, Univeritetskaya nab. 1, St. Petersburg 199034, Russia [English abstract]

A Mobile Trap for Capturing Bats in Flight. Alex V. Borrisenko. Division of Mammals. Zoological Museum of Moscow State University, ul. Bolshaya Nikitkaya 6, Moscow 103009 Russia. [English abstract]

Fifty Years of Bat Ringing in Estonia. Matti Masing[1], Linda Poots[2], Tiit Randla[3] and Lauri Lutsar[4]. [1]Estonian Bat Group, Box 352, Tartu 50002, Estonia; [2]Estonian Naturalists' Society, Struve 2, Tartu 51003, Estonia; [3]West-Estonian Archipelago Biosphere Reserve, Läänemaa Centre, Kiltsi tee 12, Haapsalu, Estonia; and [4]Estonian Fund for Nature, Box 245, Tartu 50002, Estonia [in English]

Contribution to the Study of Trophic Biology of Three Bat Species[*Pipistrellus nathusii, Myotis dasycneme and M. daubentoni*]. Alex V. Borissenko [1], N.I. Sessina [2], I.R.Zakeeva [3] and A.N. Bukia[4]. [1]Division of Mammals. Zoological Museum of Moscow State University, ul. Bolshaya Nikitkaya 6, Moscow 103009 Russia; [2,3,4] Department of Biology Moscow State University, Leneinskie Gory, Moscow 117234, Russia. [English abstract]

Bats of Nizhny Novgorod Region. Angelina Bakka[1] and Sergey V. Bakka[2]. [1]Laboratory of Biodiversity Conservation, Ecological Center 'Dront' ul. Kostina 2, komm.157, Nizhny Novgorod 603134, Russia and [2]Nizhegorodsky State environmental committee, ul. Garshina 30, Nizhny Novgorod 603001, Russia. [English abstract]

Nathusius' Pipistrelle *Pipistrellus nathusii* in the Viatka-Kama Interfluve. Vladimir I. Kapitonov and Larissa V. Abramova. The Chair of Animal Ecology, Udmurt State University, ul. Universitetskaya 1, Izhevsk 426034, Russia E-mail: kvi@uni.udm.ru [English abstract]

Dynamics of the Number and Spatial Distribution of Bats Hibernating in a Mine of Samarskaya Kuka. D.G. Smirnov[1], N.M. Kurmaeva[1], and V.P. Vekhnik[2]. [1]The Chair of Zoology, Penza State Pedagogical University, ul. Lemontova 37, Penza 440602, Russia and [2]Zhiguli Reserve, p/o Bakhilova Polyana, Stravropolsky District, Zhigulyovsk 446351, Samara Region, Russia. [English abstract]

New Records of Bats in the Western Caucasus. Ekaterina A. Tsytsulina, Zoological Institute, Russian Acad. Sci., Universitetskaya nab.1, St. Petersburg 199034, Russia. [English abstract]

Bat Records from the Taupse River Valley. Sergey V. Kruskop and Svetlana S. Anissmova. Zoological Museum of Moscow University, ul. Bolshaya Nikitskaya 6, Moscow 103009, Russia and All-Russian Research Institute of Agricultural Biotechnology, ul. Timiryazevskaya 42, Moscow, Russia. [English abstract]

New Data on the Occurrence of Schreiber's Bat *Miniopterus schreibersi* in the Western Caucasus. Suren V. Gazaryan. A. N. Severtsov Institute of Ecology and Evolution, Russ. Acad. Sci., Leninsky Prospect 33, Moscow 117071, Russia. [English abstract]

The Bats of Nokalakevi, Western Georgia. Eugenia I. Kozhurina and Andrei V. Filchagov. A. N. Severtsov Institute of Ecology and Evolution, Russ. Acad. Sci., Leninsky Prospect 33, Moscow 117071, Russia. [English abstract]

Bat Remains in Caves of the Irkutsk Region. Andrei G. Filippov and Michail P. Tuinov. Institute of Earth's Crust, Siberian Branch of

Russian Acad. Sci. ul. Lermontova 128, Irkutsk 664033, Russia, and Institute of Biology and Pedology, Far Eastern Branch of Russian Acad.Sci., Prospect 100-letiya Vladivostoka 159, Vladivostok 620022, Russia [in English]

Ikonnikov's Bat *Myotis ikonnikovi* in the Baikol Area (Distribution, Relative Abundance, Roost Sites and Behaviour). Alexander D. Botvinkin. Plaague Control Research Unit, ul. Trilissera 78, Irkutsk 664047, Russia [English abstract]

Short Communications

On the Distribution of Leiler's Bat *Nyctalus leisleri*. Andrei K. Grigoryev and Alexander V. Vassilyev. Institute of Applied Ecology. Ul. Universitetskaya 1,korpus1, The Udmurt Republic 426037, Izhevsk, Russia. [English abstract]

The First Record of a Nursery Colony of the Particoloured Bat *Verspertilio murinus* from Udmurtia. V. I. Kapitanov, A.A. deryugin and M.V. Vassilyeva, Udmurt State University, ul.Universitetskaya 1, The Udmurt Republic 426037, Izhevsk, Russia. [English abstract]

Bat Hibernaculae in Caves of the Cheliabinsk Region. Vladimir P. Snitko, Ilmensk Reserve, 456017 Cheliabrinsk Region, Miass, Russia. [English abstract]

The following titles are papers presented from platform, but not published as feature articles.

All have English summaries.

Wintering Bats in Underground Shelters of Lvov City and its Surroundings. A.T. Bashta, Institute of Ecology of the Carpathians, Lvov, Ukraine

Age Determination in Small Bat Species by the Lamellar Tooth Structures. D. Batulavicius, Department of Natuiral Sciences, Vitautas the Great University, Kaunas, Lithuania, and D.H. Pauza, Laboratory of Electron Microspy, Medical Academy, Kaunas, Lithuania

Notes on the Bat Community of the Vu Quang Reserve, North Vietnam. A.V. Borissenko and S.V. Kruskop, Zoological Museum, Moscow State University, Moscow, Russia.

A Bat Hibernation Site in the Moscow Region. A.V. Borissenko[1], S.V. Kruskop[1], and V.N.Chernyshev[2] Zoological Museum, Moscow State University, Moscow, Russia and [2]Biological Department, Moscow State University, Moscow, Russia.

The First Record of the Particoloured Bat from the Irkutsk Region. A. D. Bodvinkin, Plague Research Control Institute, Irkutsk, Russia, and I.V. Boyarkin, Irkutsk State University, Irkutsk, Russia

The Possible Role of Heterochronous Transformations in the Evolution of Cranial Structures of some Palearctic Species of *Myotis*. I. I. Dzeverin, Schmalghausen Institute of Zoology, Kiev, Ukraine

The Canyon Cave – A Unique Hibernation Site for Bats. S.V. Gazaryan, Severtsov Institute of Ecology and Evolution, Moscow, Russia.

The Bat Fauna of the Udmurt Republic and Perspectives ofor its Investigation. A.K. Grigoryev, Udmurt State University, Izhevsk, Russia.

On the Ecology of *Nyctalus noctula* during Breeding and Nursing Periods. E. Yu. Ivancheva, Oksky State Reserve, Ryazan Region, Russia.

Daily Activity of Egyptian Fruit Bats *Rousettus aegyptiacus* in Captivity. O.G. Ilchenko[1], E.I. Kozhurina[2] and A. Selivanova[1], [1]Moscow Zoo, Moscow, Russia and [2]Severtsov Institute of Ecology and Evolution, Moscow, Russia.

Topography and Bats. V.Yu. Ilyin and D.G. Smirnov, The Chair of Zoology, Penza State Pedagogical University, Penza, Russia.

On the Northern Distributional Limit of *Pipistrellus nathusii* in the Viatka-Kama Interfluve. V. I. Kapitonov, Udmurt Stste University, Izhevsk, Russia.

Bats of Middle Asia and Their Protection. T.K. Kabilov, Khujand State University, Khujand, Tajikstan.

The Chiropterofauna of Vladikavkaz City. N.N. Kuryatnikov, North-Ossetian State University, Vladikavkaz, Russia.

New Data on Bats of the Omsk Region. I.V. Kuzmin[1], A.D. Botvinkin[2] and V.V. Yakimenko[1], [1]Institute for Natural Foci Infections, Omsk, Russia and [2]Plagues Control Research Institute, Irkutsk, Russia.

New Records of Bats from Cambodia. V.A. Matveev, Biology Department, Moscow State University, Moscow, Russia.

The Potential Epidemiolgical Role of Bats and Their Parasites in Kazakhstan. A. Yu. Polkanov, Tulpar Munai, Ltd., Almaty, Kazakhstan.

Vertical Distribution of Bats in the Eastern Transcaucasia. I.K. Rakhmatulina, Institute of Zoology, Academy of Science of Azerbaijan, Baku, Azerbaijan.

Sex Composition of a Hibernating Population of *Pipistrellus pipistrellus* from Kara-Klapakia. A. R. Reimov, S.M. Mambetullarva, and R.R. Rreimoz, Kara-Kalpak Branch of Uzbekistanian Academy of Science, Nukus, Uzbekistan.

The Types of Circadian Activity of *Myotis blythi* in Southeastern Kazakhstan. R.T. Shaimardanov, Institute of Zoology and Genofund of animals, Almaty, Kazakhstan.

The Present State of the Bat Fauna of the Cheliabinsk Region. V. P. Snitko, Ilmensky Reserve, Miass, Cheliabinsk Region, Russia.

The Bat Fauna of Underground Shelters in the Middle Dniestr, Reut and Ikel Valleys (Moldova). A.G. Vasilyev and S.P. Andreev, Institute of Zoology, Moldovian Academy of Science, Chisinau, Moldova.

Results and Perspectives for Studying the Bat Fauna of Samarskaya Luka. V.P. Vekhnik, Zhiguli reserve, Zhiguliovsk, Russia.

The Distribution of *Eptesicus serotina* in the South-east of the European Part of Russia. E.V. Zavyolov, Saratov State University, Saratov, Russia.

The Dynamics of the Northern Distribution Border of *Pipistrellus kuhli* in the European Part of Russia. E.V. Zavyalov and G.V. Shlyakhtin, Saratov State University, Saratov, Russia.

Bats as Biopredictors of Earthquakes. E. G. Yavruyan, Yerevan State University, Yerevan, Armenia.

Submitted by G. Roy Horst at:
horstgr@potsdam.edu

Letters to the Editor

Editors' Note: Unlike technical articles, letters are not peer-reviewed, but they are edited for grammar, style, and clarity. Letters provide an outlet for opinions, speculations, anecdotes, and other interesting observations that, by themselves, may not be sufficient or appropriate for a technical article. Letters should be no longer than two manuscript pages and sent to the Editors, Allen Kurta or Roy Horst.

From Barbara French and Amanda Lollar

We would like to describe our observations and offer some comments on "the language" of the Mexican free-tailed bat *Tadarida brasiliensis mexicana.* We have maintained captive colonies of Mexican free-tailed bats *(T. brasiliensis mexicana)* since 1991 (Lollar [AL]) and 1993 (French[BF]). Observations of these colonies resulted in the identification of specific vocalizations associated with reproductive behavior. These vocalizations subsequently proved useful in uncovering mating activity in wild colonies. We[AL] observed similar vocalizations in association with copulatory acts in a colony in a building in Mineral Wells, Texas, on March 17, 1996, and subsequently in that same year, [BF] observed similar activity associated with the vocalization at Bracken Cave. After listening to the our recordings of this vocalization, Brian Keeley also recognized the call at a bridge in central Texas on March 22, 1996. Again, the call was associated with a copulatory act. All three sites served as summer maternity colonies, leading the authors to suspect that mating activity was common in such sites in the U.S., an idea that was further supported a couple years later by mating activity documented in Texas bridges by Annika Nicklaus. We have subsequently recorded nineteen distinct vocalizations that appear to be associated with specific behaviors in these two captive colonies. It is our hope that this information will also prove useful in the study by other investigators of wild colonies of the Mexican free-tailed bat. As of March 1,'00, our captive colonies included 77[AL] and 58[BF] bats. We have assigned the following categories to the vocalizations we recorded in these colonies as given below.

1) Territorial announcement buzz--emitted by reproductively active males that were observed rubbing their gular glands and anal regions on roosting pouch surfaces and surrounding cage walls. Secretions from the penis were also used to mark these areas. These males behaved aggressively towards other males that approached the areas being marked and frequently emitted the buzz while chasing after the intruder. An aggressive male sometimes bit the intruder after chasing and catching up with it. In addition, a territorial male would emit this buzz while hanging from the opening of his roosting pouch and flapping his wings whenever a female left or was removed from his pouch (fabric pouches are provided as roosting sites).

2) Warning call--emitted when two males confronted each other face to face with lips drawn back and teeth bared. These calls often took place inside of, or just outside of, roosting pouches used by territorial males and appeared to be associated with disputes over mating territories.

3) Screeching--usually emitted by two bats engaged in actual physical confrontation with jaws locked onto one another. These disputes involved at least one reproductively active male(sometimes two) and started within a short distance (10 cm) of a roosting area being used by one of the males as a mating area. We have recovered or received injured males from the wild that had been observed in similar confrontations. These males had visibly enlarged gular glands.

4) Mating song--a quiet song emitted by reproductively active males while females were roosting with them in the males' established territories just prior to copulation. Females did not appear to resist copulatory acts initiated by most males with established territories.

5) Modified mating song--a much louder somewhat modified version of the mating song, emitted by reproductively active males on the periphery of the roosting cages outside of the established territories of other males. The males often remained hidden behind caging materials and, when a female passed by, the male would jump out, emit the call while aggressively grabbing the female with its mouth, and attempting to copulate. Females often struggled during copulatory attempts by these males. The call and associated behavior was also sometimes emitted by males who did establish (by marking) and defend territories, but who were unsuccessful in attracting females.

6) Female response call--a series of quiet clicks emitted by some reproductively active females in response to (immediately following) male territorial calls.

7) Dominance scold--a series of notes emitted by reproductively active males when females approached the territories being occupied by the males. The male would leave his roosting pouch to meet the approaching female, jump on her back, and repeatedly jerk his entire body sharply as he pressed his face into the female's shoulders while emitting this series of notes. These interactions did not involve copulation. A female would take on a passive posture during this activity, lying crouched against the cage wall with ears lowered. When the vocalization stopped, the female would enter the roosting pouch, followed by the male. Young males less than one year of age often jumped onto the back of other bats, both females and males, and pressed their muzzles into the other bats shoulders. During this time, they emitted a sound very similar to the dominance scold made by reproductively active males.

8) Herding buzz--a series of buzzes emitted by territorial males while inside their roosting pouches. The male would emit the buzz while forcefully pushing his face into the bodies of the females that shared his roosting pouch and chase the females around until they formed a tight cluster in one corner.

9) Directive call--emitted by some females during the birthing process and by all females immediately after giving birth. A female would emit this call while facing her newborn infant and intermittently as she rubbed her muzzle back and forth from side to side across the infants, face and body. Females also emitted the call in response to their infants, isolation calls as they approached their infants to nurse. In addition, females who gave birth to stillborn pups continued to emit these calls periodically for up to four days following the birth. One female who did not give birth to a viable infant was subsequently observed nursing the infant of another female. Both females responded to the isolation call of this pup and continued to nurse the infant over a period of three weeks. The practice of calling after a pup has died could possibly be a method by which these mothers are able to establish relationships that allow them to assist in raising other pups or perhaps even to adopt pups who have lost mothers in wild colonies. Such behavior could account for the small percentage of non-parental nursing observed in wild colonies by McCracken.

10) Parturition distress call--emitted by females experiencing difficulty during birth. These females required our intervention during the birthing process.

11) Isolation call--emitted by neonates immediately following birth in response to the mother's directive call and by pups prior to weaning whenever their stomachs appeared to be empty (milk is visible through the translucent skin of the abdomen after a pup has nursed).

12) Practice flight call--emitted by pups between three to five weeks of age, during episodes of rapid wing flapping prior to the time they were able to fly.

13) Squabbling--often emitted simultaneously, by both males and females, as they appeared to jostle for roosting positions. Although we have not deciphered the specifics, there appear to be preferred roosting

positions within a cluster that are somehow related to internal versus peripheral and higher versus lower positions in the roosting cluster.

14) Chittering--emitted by both males and females during periods of physical contact when the bats appeared to be at rest. Bats often rub their muzzles against the body of another bat when making this sound.

15) Exaggerated chittering--a modified or exaggerated version of chittering emitted by both males and females during activity that resembled a kind of play. While emitting this sound, a bat would hop a few centimeters forward towards another bat, sometimes firmly pressing its muzzle into and quickly back and forth from side to side across the other bat's body. These bats would also sometimes gently tap the other bat with a folded wing while making this sound, although no real aggression took place during this time.

16) Alarm call--a series of loud clicks only emitted by a very limited number of bats, either male or female, when first received by the authors. The bat would raise up by extending the elbow, open its mouth wide and bare its teeth, jerking its entire body repeatedly while emitting these sharp clicks. The behavior appeared to be elicited in response to a perceived threat from unfamiliar handling attempts.

17) Irritation buzz--emitted by both males and females at times when they were physically disturbed in the roost area by an outside source. For example, fabric roosting pouches had to be laundered and so bats had to be periodically removed from one pouch and placed in a clean one. Bats often emitted irritation buzzes during this transition. Care had to be taken to replace bats to the same location and in the same group to prevent disputes between aggressive territorial males.

18) Anticipation click--emitted by bats in the early evening just prior to the time when feeding activity took place. Bats also emitted these clicks again in the early morning when handlers entered flight cages for the purpose of hand-feeding bats. Bats in these colonies are hand-fed in the evening and again in the early morning; some of them also self-feed from trays. We have heard similar sounds in wild colonies of this species just prior to their evening emergence from daytime roosts.

19) Food solicitation buzz--emitted by adult males during hand-feeding sessions. This call is somewhat similar to the territorial announcement buzz and was emitted while a male hung on a roosting pouch or cage wall and flapped his wings until given a mealworm. After eating the mealworm, he repeated the call and wing flapping behavior until given another worm.

We have heard vocalizations in wild colonies of this species that are similar to many of those recorded in our captive colonies. Behaviors associated with the vocalizations recorded in the captive colonies suggest that they are mainly associated with mating activity, territorial defense, the process of giving birth, individual recognition/location, food solicitation, and both passive and playful social interactions. These observations may offer a cursory view of the social communication system used by this colonial species. The recorded calls described above are being analyzed by Brian Keeley using Pettersen's Bat Sounds software.

Submitted by Barbara French, Bat Conservation International, Austin, TX. E-mail: french@batcon.org and Amanda Lollar, Bat World, Mineral Wells, TX. E-mail: batworld@wf.net

Notes on the Behavior of a Building-dwelling Colony of Mexican Free-tailed Bats *Tadarida brasiliensis mexicana* in Mineral Wells, Texas

I have observed a colony of Mexican free-tailed bats *T. brasiliensis mexicana* occupying a crawl space and crevices created by shifting sandstone in a two-story building from January of 1993 to present. In mid-January of each year, bats (mainly males) begin arriving in the building and roost within these crevices on both the west and southeastern sections of the building. By the end of February, an estimated 2000 bats are roosting in these crevices. Most females begin appearing in the building in April. In early June, approximately 500 females form a maternity colony within the crevices in the central section of the south wall, separate from the rest of the colony. Copulation was first observed in the building on March 17, 1996. Young are born each year between mid-June and mid-July.

The number of bats in the building begins increasing in early August when flightless young are still present, with a sudden (overnight) and dramatic increase in numbers occurring anytime between August 18th and August 24th of each year, when an estimated 20,000 bats, both males and females, occupy the building. Bats are subsequently seen circling both inside and outside of this and similar buildings in the town. This apparently "swarming" activity takes place from dusk until about midnight and again briefly in decreased numbers at dawn. Brbara French (of B.C.I.) has observed similar "swarming" activity of this species during the same time near a bridge that serves as a maternity site in Austin, Texas. The population fluctuates in the building in Mineral Wells throughout September and October, numbers varying from an estimated two or three thousand to five thousand bats. The numbers gradually diminish from November through mid-December, at which time all bats have left the building.

These observations lead me to speculate that bats of this species gather at maternity sites prior to their migration to Mexico, and that this behavior may serve as pre -migratory orientation for young.

(Some of the information in this letter also appears in "Captive Care and Medical Reference for the Rehabilitation of Insectivorous Bats" by Lollar and French, 1998)

Submitted by Amanda Lollar, Bat World, Mineral Wells, TX. E-mail: batworld@wf.net

News from Arkansas

In 1996 the people of Arkansas approved an amendment to the Arkansas constitution that established a 1/8 cent sales tax for conservation purposes. The increase of funding following this vote has allowed the Arkansas Game and Fish Commission to substantially expand our nongame program. In early January I assumed the duties of the new Nongame Mammal Program Coordinator position. Karen Rowe, who had been our only nongame wildlife biologist, will now be working with nongame migratory birds along with another ornithologist that hasn't yet been hired.

Of course, Arkansas has had an active bat research program for many years, supporting annual monitoring of endangered bats by Dr. Michael Harvey (Tennessee Tech.) since 1978. This summer we will be helping in several other projects. Dr. Ron Thill, of the U.S. Forest Service's Southeastern Experiment Station, is beginning a study of bat roosting ecology as part of a large-scale experiment examining the effects of management practices on wildlife in the Ouachita National Forest. The Commission is also helping David Saugey, U.S. Forest Service, continue his long-term research on the Rafinesque's big-eared bat in southern Arkansas.

Shawn Cochran and Vernon Hoffman, who have been studying Rafinesque's big-eared bats and southeastern bats in the Black Swamp Wildlife Management Area under Dr. J.D. Wilhide of Arkansas State University, have finished fieldwork and their theses should be completed and available this spring. Dr. Richard Grippo, also of Arkansas State, is finishing a study of mercury levels in bats found in areas with mercury-related fish consumption advisories.

The Commission has begun to develop 10-year management plans for all species programs (deer, turkey, etc.) to guide research, management, and regulatory efforts within our organization. I will be heading up the effort to write a statewide nongame mammal plan in with the help of a multi-agency committee that is being assembled for this purpose.

Submitted by Blake Sasse, Nongame Mammal Program Coordinator
Arkansas Game and Fish Commission 501-219-4141 dbsasse@agfc.state.ar.us

Announcing a Free Booklet on Bats of the United States

The Arkansas Game and Fish Commission, in cooperation with the U.S. Fish and Wildlife Service, Dr. Michael J. Harvey, Dr. Troy Best and Dr. Scott Altenbach, has produced an outstanding new booklet on the bats of the United States. The purpose of the Service's cooperation in this project was to make available to the general public an informative, attractively illustrated, and free publication that would increase general awareness and appreciation for this unique group of mammals. This booklet will benefit the bats that are currently listed as endangered, bats that are of special concern and may be listed as endangered or threatened in the future, and bats that are not currently in trouble but are being adversely affected by human activities.

The Service purchased a large number of these booklets and at this time they are available, free of charge, to anyone that wants a copy. If you would like to receive a copy please contact Robert Currie at the e-mail or mailing address shown below.

Robert R. Currie, Fish and Wildlife Biologist, Asheville Field Office,
U.S. Fish and Wildlife Service, Asheville, NC 28801
e-mail: Robert_Currie@fws.gov tel: 828-258-3939, Ext. 224 FAX: 828-258-5330

Future Meetings, Symposia, Conferences, Workshops, etc.

June, 2000 **The American Society of Mammalogists**

will meet at the University of New Hampshire in Durham, NH June 17th to 21st.
for information and registration materials contact:
H. Duane Smith, Monte Bean Life Science Museum, Brigham Young University, Provo, UT 84602-0200

September, 2000 **The Bat Conservation Trust -National Bat Conference**

Will meet 1st - 3rd September, 2000 at The Queen's University, Belfast, Northern Ireland.
For information and registration materials contact: Marie-Claire Edwards,
The Bat Conservation Trust, 15 Cloisters House, 8 Battersea Park Road, London, SW8 4BG.
Tel: +44 171 627 2629 FAX: +44 171 627 2628 E-mail: enquiries@bats.org.uk

September, 2000 **The 30th Annual North American Symposium on Bat Research**

will meet at the University of Miami, Miami, FL September 27th to 30th, 2000

for information and registration materials contact:
Thomas A. Griffiths, Department of Biology, Illinois Wesleyan University, Bloomington, IL 61702
E-mail tgriff@titan.iwu.edu tel. 309-556-3230

All subscribers to Bat Research News are already on the Symposium mailing list
and will receive registration forms by June 1, 2,000.

March, 2001

A Special Conference

The Indiana Bat: Biology and Management of an Endangered Species

29 March to 1 April 2001

The ***Northeast Bat Working Group*** and the ***Southeastern Bat Diversity Network*** will host a symposium on the biology and management of the Indiana bat, from 29 March to 1 April 2001, at the Radisson Hotel, in Lexington, Kentucky. The purpose of the Symposium is to aid in recovery of the species by fostering dissemination of information among academic biologists, environmental consultants, and resource managers. This Symposium will consist of invited papers, as well as submitted papers and

continued >>

posters, dealing with any aspect of the ecology, behavior and natural history of the Indiana bat, in summer or winter. The proceedings of the Symposium will be published with Allen Kurta as editor.

The meeting will begin with arrival of attendees and informal social activities on Thursday, 29 March, and end with an optional field trip to the Daniel Boone National Forest on Sunday, 1 April. Oral presentations will begiven on Friday and Saturday, and a poster session and social will be held on Friday evening. The local host is Michael Lacki, and the organizing committee consists of Sybil Amelon (U. S. Forest Service), Bob Currie (U. S. Fish and Wildlife Service), Alan Hicks (New York Sate Department of Environmental Conservation), Jim Kennedy (Bat Conservation International), Dennis Krusac (U. S. Forest Service), Allen Kurta (Eastern Michigan University), Michael Lacki (University of Kentucky), and Annette Scherer (U. S. Fish and Wildlife Service). The call for papers will be issued, along with more detailed information on registration, housing, etc., in spring 2000.

More details on the following meetings in 2001 will appear at least one year in advance of the meeting

June	**2001**	The American Society of Mammalogists, Missoula, MT
August	**2001**	12th International Bat Research Conference, Bangi, Malaysia
October	**2001**	31st Annual North American Symposium on Bat Research, Victoria, BC, Canada
August	**2002**	9th European Bat Research Symposium, Le Havre, France
October	**2002**	32st Annual North American Symposium on Bat Research, Burlington, Vermont

If you know of other meetings, large or small, concerning bats, please send us the details for inclusion in the next issue. Thank you. G. Roy Horst

STUDENT SCHOLARSHIPS FOR BAT CONSERVATION RESEARCH

Bat Conservation International hereby announces the availability of student research scholarships. Approximately 15 grants ranging from $500 to $2,500 will be made in 2000. Grants will go to research that best helps document the roosting and feeding habitat requirements of bats, their ecological or economic roles, or their conservation needs. Students enrolled in any college or university worldwide are eligible to apply. Projects must have bat conservation relevance. The application deadline for 2000 scholarships is 15 January 2000.

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BAT RESEARCH NEWS

Volume 41 **Spring 2000** **Number 1**

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We are always eager to find new cover illustrations so if you have great line drawings or sharp contrast photos of bats that you would like to submit, please send them to us. If we use your artwork, we will add one free year to your subscription.

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A Quantitative Method for Selection of Identifiable Search-phase Calls Using the Anabat System

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Department of Biology, Southwest Missouri State University, Springfield, MO 65804 (KLM)

The Anabat system has been used increasingly to identify bats using search-phase echolocation calls (e.g., Murray et al., 1999). This is because search-phase calls commonly are produced by free-flying bats, are consistent in structure, and have species-specific characteristics (Fenton and Bell, 1981; O'Farrell et al., 1999; Simmons et al., 1979). The first step in the identification process is selection of identifiable search-phase calls (Barclay, 1999).

With the Anabat system, two methods have been used to select search-phase pulses. Commonly, pulses are selected manually and "cleaned" based on the experience of the researcher (Murray et al., 1999; O'Farrell and Gannon, 1999; O'Farrell et al., 1999). Cleaning is the process that allows the researcher to select pulses deemed as identifiable and remove echoes and extraneous noise. However, manual selection of calls adds subjectivity to the process and can severely limit comparability among studies (Barclay, 1999). Betts (1998) quantified the selection of pulses by selecting the middle 50% of the recorded echolocation call. This method has two problems. First, it does not provide a method to clean echoes and extraneous noise. Secondly, it fails to account for variability in pulse quality within a call sequence (i.e., the middle 50% of the call may not always be the best part of the sequence). This variability can be quite extensive, especially when using passive-monitoring techniques. An objective way of selecting search-phase pulses, while still removing unwanted background noise, has yet to be found.

In this paper, we investigate the use of a new filter in the analysis program "Analook" to quantify selection of identifiable search-phase calls of bats in the eastern United States. A filter is a mathematical function that removes unwanted material from a recorded Anabat file. Previous versions of Analook contained preset filters that were of limited value because they could not be modified and were often too coarse in their editing. Newer software (Analook version 4.7j) contains a feature that allows the user to modify parameters that define the filter. With this new ability, a custom filter may be constructed to quantify cleaning and selection of search-phase calls.

Methods

Currently, only frequency-modulated calls can be used for quantitative identification of echolocation calls to species in the eastern United States. Thus, before acoustic identification can be accomplished, FM pulses must be separated from constant frequency pulses, approach and terminal-phase pulses, and call fragments. We customized the Analook filter to remove these parts of the sequence using menus

opened by the "ALT-B" command. After preliminary testing, we chose to modify only four parameters: smoothness (smooth), minimum duration (mindur), minimum sweep (minsweep), and bodyover (Table 1). The resulting filter allowed quantitative selection of search-phase pulses and removal of echoes, fragmentary calls, and extraneous noise from calls made by seven species: *Eptesicus fuscus*, *Lasiurus borealis*, *Myotis grisescens*, *M. lucifugus*, *M. septentrionalis*, *M. sodalis*, and *Pipistrellus subflavus*.

We tested the effectiveness of the new filter using calls of four species (*M. lucifugus*, *M. septentrionalis*, *P. subflavus*, and *E. fuscus*) from our library of known calls. Calls of these species were used because they represent a wide range in the structure of echolocation calls. Each Anabat file was cleaned manually by two researchers (the authors) and automatically by the Analook filter. For each call, Analook calculated the number of pulses retained and the mean values of five parameters: duration (Dur), minimum frequency (Fmin), mean frequency (Fmean), characteristic frequency of the body (Fc), and slope of the body (Sc). The body was defined as the flattest portion of the echolocation pulse. For each species, we compared the number of pulses retained and the mean of the parameters obtained after manual and automatic cleaning.

Results and Discussion

For all four species, total number of pulses selected per sequence by the filter and the authors varied considerably (Table 2). This variation indicates that the filter selected search-phase pulses somewhat differently than the two biologists. It also shows that the two authors selected search-phase pulses differently, even though both have extensive experience with Anabat. The variation in duration was higher than variation in the other parameters (Table 2). The increased number of pulses and shorter mean duration of pulses retained by the filter probably represents the inability of the filter to remove pulses that were deemed fragmentary by the authors. The inability of the filter to remove fragments has little impact because variation in observed parameters (Table 2) was less than documented levels of intraspecific variation (Brigham et al., 1989; Obrist, 1995). Although effects of the filter on quantitative identification were not explicitly examined, the relatively small amount of variation imposed by use of the filter (compared with intraspecific variation) suggests that the filter would provide suitable cleaning for the process of acoustic identification.

Our results show that there are differences between researchers in selection of identifiable pulses. These differences illustrate the subjectivity involved in cleaning echolocation calls and demonstrate the need for an objective method of cleaning sequences. Use of the filter provides several advantages over manual selection and cleaning. First, it quantifies the selection of identifiable pulses, thereby eliminating subjectivity among researchers. Second, the filter quantifies the cleaning of extraneous noise from useable pulses and yields precise data on parameters of the echolocation calls. Finally, the filter greatly reduces the amount of time required for cleaning echolocation calls.

This paper simply explores the possibility of quantifying call selection and the cleaning process using Analook software, a process that is otherwise difficult with the Anabat II system. Though the method should be broadly applicable, the specific values of the filter that we describe (Table 1) are applicable only to the aforementioned species found in the eastern United States. The filter should be modified before additional species are included or before its use with other bat communities.

Acknowledgments

We thank C. Corben for writing the new filter into Analook and for assistance in understanding and

using the filter. We also thank L. Robbins for helpful discussion on use of this filter throughout its development and for comments on an earlier version of this manuscript.

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Table 1. Values, definitions and functions of the four parameters used to construct the Analook filter.

Parameter	Value	Definition	Filters out
Smooth	15	Sets the maximum distance between two successive points for them to be considered part of the same echolocation pulse	Echoes, extraneous noise, poor quality pulses
Bodyover	240	Removes echolocation pulse if the number of data points in the body (narrow band component) are less than the set value	Fragmentary pulses, approach-phase pulses, feeding buzzes
MinDur	1	Removes pulses that have a shorter duration than the Set value	Feeding busses and some fragmentary pulses
MinSweep	6	Removes pulses with a bandwidth (difference between Maximum and minimum frequency) below the set value	Fragmentary and CF pulses

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Table 2. Mean parameters for the four species cleaned by two experienced Anabat users and the customized Analook filter. N = number of call sequences. Parameters were measured after cleaning, from top to bottom, by the filter, ERB and KLM.

Species	N	# of pulses	Duration (ms)	F_{MIN} (kHz)	F_{MEAN} (kHz)	F_C (kHz)	SC (OPS[a])
E. fuscus	14	28.4	5.6	29.7	35.5	30.2	81.9
		17.7	6.4	29.4	36.3	29.8	76.3
		9.9	7.2	29.1	37.0	29.4	70.0
P. subflavus	16	13.1	5.6	42.0	43.8	42.2	19.9
		16.6	5.8	41.9	43.4	42.0	17.0
		8.2	6.2	41.9	43.5	42.2	14.9
M. lucifugus	21	21.9	4.7	40.5	47.2	42.0	88.4
		15.5	5.1	40.5	47.7	40.9	86.1
		12.0	5.3	40.4	47.9	40.8	85.3
M. septentrionalis	14	19.2	3.0	41.2	53.6	45.8	254.6
		26.1	2.8	41.1	52.3	45.9	256.0
		14.1	3.3	40.7	54.6	45.6	255.6

[a] Octaves per second

Roosting Behavior and Foraging Activity of a Female Red Bat with Nonvolant Young

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Although foraging behavior and roost selection of the red bat (*Lasiurus borealis*) have been examined in some detail (Hickey and Fenton, 1990; Hutchinson and Lacki, 1999, 2000), little information exists on diurnal behavior and nocturnal activity of female red bats with young. The red bat is a solitary species that occurs in groups only when females are nursing and perhaps during migration (Shump and Shump, 1982). In this report, we describe behavioral interactions and temporal activity of a single female red bat with nonvolant young.

On 11 July 1996, we captured a lactating red bat in a mist net, near Sandy Hook, Kentucky, and attached a 0.51-g transmitter (Holohil Systems, Ontario) using surgical cement. We monitored foraging activity from 12 to 20 July and roosting behavior from 12 to 23 July. Over the 12 days, time of sunset varied from 2102 h to 2055 h. Foraging activity was monitored from 2000 to 0400 h each night by two or

more persons that were equipped with a receiver (Wildlife Materials, Inc., Carbondale, IL), 3-element yagi antenna, and two-way radio. We defined foraging activity as any time that the adult was in flight. After we determined the specific location in the tree where the female was roosting, we checked it for the presence of bats and observed their behavior between 1400 and 1600 h (n = 9 days), using binoculars and a spotting telescope.

The adult weighed 14.5 g, so mass of the transmitter was only 3.5% of body mass. On the day after capture, she was tracked to a pignut hickory (*Carya glabra*), 400 m from the capture site. Use of this tree was verified by watching her emerge on 12 July, but the actual roosting location was not determined until the 3rd evening, when we spotted the adult and her nonvolant young ca. 15 m aboveground in the outer canopy. The adult exhibited strong fidelity to this roost and was present for 11 of the 12 days. The one exception occurred on 14 July following a severe thunderstorm the previous night.

Although three teats of the adult were swollen, only two young were present. Based on development of the young, we suspected that they were 3-4 weeks old (Shump and Shump, 1982). During midday, the young were very active, grooming themselves, interacting with one another, and often stretching their wings for periods >30 sec. Both frequently opened and closed their mouths while in apparent eye contact with each other, suggesting that they were vocalizing. The adult occasionally awakened, appearing to swat at or groom the young, but for the most part, she remained inactive. Persistent activity of the juveniles during midday was surprising considering the prevalence of blue jays (*Cyanocitta cristata*), a known predator of red bats (Shump and Shump, 1982), in the immediate area. Although we heard calls of blue jays on several occasions, we saw no change in the bats' behavior. McClure (1942) stated that families of red bats contracted into bundles at the slightest disturbance, but we did not observe this behavior during the day. On 2 occasions, one bat was being nursed by the adult while the other remained stationary nearby, but there was no sign of strife or competition between the young as one was being nursed. After the mother left to forage, the juveniles typically became inactive between 2045-2130 h, huddling together, as described by McClure (1942), and hanging pendent from a small branch.

The adult was in flight for ca. 33% of the nightly tracking period (2000-0400 h) spending a mean of 2.6 ± 0.2 (*SE*) h/night (n = 9) in flight or roosting in an alternate location. Total time in flight ranged from 1.4 h to 3.4 h each night (Table 1). The adult had an average of 4 ± 0.3 foraging bouts/night (n = 9); bouts lasted 5-90 min, with a mean duration of 40 ± 4 min. Foraging periods for this bat are considerably shorter than those observed in Ontario (Hickey and Fenton, 1990). On several nights, the adult roosted in locations other than her primary day roost for short periods (<20 min), but whether she used a night roost to rest, digest food, or process large prey is not known. Over the 9 nights, she was within range (ca. 3200 m) of our receivers for all but 10 min, indicating that this lactating bat generally remained close to the day roost while foraging. Other female red bats radiotracked earlier in summer or in mid-summer without nonvolant young behaved differently, frequently leaving the range of receivers while foraging and using multiple day roosts (Hutchinson and Lacki, 1999, 2000).

Acknowledgements

The University of Kentucky College of Agriculture and the E. O. Robinson Trust Fund provided funding. J. P. Adams, M. H. Frisby and R. Mowrer contributed assistance in the field. G. Conley allowed access to the research site. This research (KAES # 00-09-54) is connected with a project of the Kentucky Agricultural Experiment Station and is published with the approval of the Director. The University of

Kentucky Animal Care and Use Committee (# 96-0006A) approved all methods.

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Table 1. Average time spent foraging, by hourly periods, for an adult female red bat in Kentucky.

	Time spent foraging (min)		
Hour	*n**	Mean	*SE*
2000 - 2059	9	7.8	2.4
2100 - 2159	9	36.9	5.6
2200 - 2259	9	34.1	5.9
2300 - 2359	9	25.4	6.1
2400 - 2459	9	18.0	6.8
0100 - 0159	9	25.7	7.6
0200 - 0259	9	10.2	6.5
0300 - 0359	9	2.1	2.1

*Number of nights during which activity was monitored

Letter to the Editor

Typically, when bats are taken into captivity for a period of time, it is never known for sure how well they adapt when released back into the wild. It is possible that flight and or echolocation skills might deteriorate while in captivity. Herein we report an observation suggesting that a bat held captive for several weeks was able to quickly re-establish "normal" behaviour after being released.

We held an adult female big brown bat (*Eptesicus fuscus*) in captivity from 18 April – 6 May 2000. We presume she left the hibernacula prematurely and was caught outside in very cold weather. She was in poor condition when found. While captive, she was flown every second day for 5 to 10 minutes, and was then given 10 to 15 mealworms coated in "cricket dust". At the beginning of each flight session, she was always torpid (T_b approx. 20°C) and required several minutes to warm up.

We released the bat at a public presentation for the Regina Natural History Society with a light tag attached to the interscapular region. The bat immediately flew from the hand and based on its erratic flight style, began foraging immediately. Output from a QMC mini-2 and a Pettersson D-100 detector included feeding buzzes within seconds of the bat's release, whereas previously we had heard no bats at all. These observations lead us to suggest that bats held in captivity for a period of several weeks are able to resume normal feeding behaviour immediately following release.

Darren Sleep & Craig Willis. Dept. of Biology, University of Regina, Regina, SK S4S 0A2 Canada

Abstracts of the papers and posters presented at:

THE NINTH AUSTRALASIAN BAT RESEARCH CONFERENCE APRIL 2000, TOCAL COLLEGE, MAITLAND, N.S.W.

The abstracts are arranged alphabetically by first author.
Any errors are unintentional and "my fault." I offer my apologies. GRH

Bat Roosting Boxes And Factors Affecting Their Success in Organ Pipes National Park 1992-1999

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At Organ Pipes National Park (Vic) 34 bat roosting boxes have been installed between 1992 and 1999, initially to provide roosts for any bat species in the area. Box acceptability to bats, and their impact on the population of species using the park have been assessed via 57 monthly monitoring inspections and 7 harp trappings (annual since 1996). Installation of boxes with smaller entrance slits and internal volumes has attracted a few smaller bats, as well as discouraging competition from Sugar Gliders. Boxes made with 45 mm timber have induced Chalinolobus gouldii to use them through the winter of 1999 and seem to be enabling an increase in the carrying capacity of the park. By any measure these roosting boxes have been overwhelmingly successful.

* with a maximum of 105 bats being found in one monthly inspection .
* the duration of use by bats has expanded from just a few warmer months to across the whole year.
* five of the seven bat species in the park have been found in the boxes.
* the newest boxes with smaller slit size have been occupied within two weeks

We will continue to develop measures of success of a roost box, and to distinguish factors making for greater success. (It's fun!)

Systematics of the Large Bentwing Bat *Miniopterus shreibersii* in Australia

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A combined molecular and morphological analysis was undertaken to resolve the systematics of the *Miniopterus schreibersii* complex in Australia. The study of skull morphology and sequence analysis of two mitochondrial genes, nicotinamine dehydrogenase subunit 2 and cytochrome-b, revealed three distinct Australian forms of *M. schreibersii* which are treated as subspecies. *M. s. orianae* occurs in northern Australia, *M. s. oceanensis* occurs in eastern Australia from Queensland through to central Victoria *and M. s. bassanii sp. nov.* occurs in Western Victoria and eastern South Australia. The biogeographical history of the complex in Australia is discussed in the light of this new revision.

The Use of Anabat Detectors and Harp Traps in Broadband Surveys: The Victorian RFA Experience

Ryan Chick, Angela Duffy, Lindy Lumsden, Graeme Newell, Natasha Schedvin, John Silins, Campbell Beardsell. Arthur Rylah Institute, Department of Natural Resources & Environment, 123 Brown St, Heidelberg, Victoria, 3084

Microbat surveys were performed as part of the Regional Forest Agreement process for the Central Gippsland, North-east and South-west regions of Victoria, Australia. Between October 1997 and March 1999, 312 sites were sampled using both harp traps and Anabat detectors. Echolocation calls were recorded throughout the whole night using automated detector units. Approximately 6,000 bats were trapped and 25,000 calls recorded. Detectors and harp traps proved to be complementary techniques in terms of the suite of species recorded. Significant capture results include the extension of the known range *of Mormopterus sp.* (eastern form) by 200 km and extension of the distributions of *Nyctophilus gouldi and Falsistrellus tasmaniensis* in western Victoria. Computer based units developed for the South-west survey proved far more successful than the units utilising tape recorders and delay switches used in Gippsland and the North-east. They resulted in higher quality recordings, eliminated the problem of the tape finishing before dawn, and removed the time consuming step of manually down-loading calls to computer. A reference library of several hundred echolocation calls obtained from bats captured during the study was used to develop a key for the identification of the unknown calls recorded at survey sites. The key was based on the differences in characteristic frequency and qualitative features discernible between species. There was a high degree of intra-specific variation in reference call characteristics and a significant amount of overlap in the calls of different species. As a result, a lower proportion of unknown calls was conclusively identified to single species than that reported in other studies. Nevertheless, the development of a key was useful in alleviating potential problems of subjectivity and lack of repeatability associated with qualitative call identification and enabled identifications to be made with confidence. Suggestions for the collection and use of reference calls are provided.

What Determines The Distribution Of Bats In The Australian Wet Tropics?

Chris Clague, Vision Touch and Hearing Research Centre, University of Queensland, St Lucia, Brisbane

The distribution of bats in the wet tropical region is determined by a number of factors including history and climate. The mechanisms by which both of these factors interact to create the distribution patterns observed in tropical bats are demonstrated at regional and local scales. A special emphasis is placed on the role of ecotones in the creation of areas of high diversity and as a tool to investigate the forces acting to structure microchiropteran communities.

Distribution of the Tube-nosed Insectivorous Bat (*Murina florium*) in Australia

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The most recent Australian specimen of *Murina florium* was collected in October 1999 (on a radiator grille) from the lowland region of the Alexandra Range in north Queensland. This brings to 26, the total

number of known localities for *M. florium* in the wet tropics, based on captures and by acoustic detection of echolocation and social calls; there remains a single outlying specimen from Iron Range on Cape York. Sites occur between 60-1120m above sea level, in rainforest or wet sclerophyll forests. A common feature at each site, or in close proximity (within about 4km), is the presence of mixed wet sclerophyll forest or a close structural equivalent. BIOCLIM modelling was used to describe the climate variation between sites and predict a distribution. The climate profile suggests that *M. florium* prefers forested areas with the following key parameters (annual average): precipitation 1852mm (range 1197-2574mm), rainfall in the driest period 39mm (range 20-59mm), temperature range of 17.7°C (range 13.9-19.0°C), maximum temperature of the warmest period 28.6°C (range 27.3-31°C). The predicted distribution of *M. florium* in the wet tropics is restricted to a relatively narrow, elongated band running approximately north-south. It corresponds to regions with a steep rainfall gradient that include ecotones, largely on the western side of mountainous areas and several plateaus, and encompasses the upland wet sclerophyll forests.

The Protection Of Cave Dwelling Bats In North Queensland
The Construction And Usage Of Bat Gates

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A review of recent bat gating in North Queensland will be presented including historical perspective, site identification, trial gates, gate experimentation and gate construction. Gate designs were developed for a number of species including *Rhinolophus megaphyllus, Rhinolophus philippinensis, Hipposideros diadema, Hipposideros ater, Hipposideros cervinus, Myotis moluccarum, Miniopterus schreibersii* and a number of occasional mine roosting species. A design of bat gate which uses no vertical bars or components will be presented and specific focus will be made on the methodology used to design the structures and on the field construction techniques utilized.

Factors Influencing The Roost- Site Selection Of Mineshaft Dwelling Bats In Victoria

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An investigation into the physical and microclimatic properties of abandoned mine adits in four main regions of Victoria was conducted from September 1999 to February 2000. Mine adits in Victoria are used as non-breeding roost sites by the Large Bent-wing Bat *Miniopterus schreibersii* and Eastern Horseshoe Bat *Rhinolophus megaphyllus*. A total of 103 mine adits were examined, with *M. schreibersii* present at 29, and *R. megaphyllus* present at 12. A further 16 adits contained bats scats indicating use by bats at some previous time. Characteristics of these adits were compared to 46 adits that showed no evidence of use by bats, to investigate factors influencing roost site selection. The position of roosting bats within the adits was recorded to investigate if bats were selecting particular sections of the mine in which to roost. The variables measured included temperature, relative humidity, internal dimensions, geology, and presence of water, elevation, entrance aspect, entrance accessibility and level of disturbance. Preliminary statistical analyses reveal that the only variable influencing the presence or absence of *M. schreibersii* was aspect, and no variables were useful in explaining the presence of *R megaphyllus*. In adits where bats were absent

at the time of the survey but scats were present, humidity and visitation were significant predictors for the presence or absence of bats. Within the mines containing bats, patterns have emerged regarding selection of roosting position. Within cooler mines both species tended to roost in areas warmer than the mean mine temperature, and in warmer mines to roost in areas cooler than the mean mine temperature. Both species roosted in areas within the mine that had humidities higher than the mean mine humidity. It therefore appears that both species are showing selection for roosting position within mines, but the reasons why particular mines are used as roosts while others are not, has not yet been identified.

Fruit Hardness, Feeding Behaviour, And Resource Partitioning In A New Guinea Frugivore Community.

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Fruit bat communities in New Guinea include species with a variety of body sizes, morphologies, and foraging styles. These suites of characteristics define the ways in which sympatric species partition fruit resources. Studies of resource partitioning focus on morphological variation among animals, but few evaluate the role of variation in food resources. Fruits eaten by pteropodids vary in hardness; small bats tend to use softer fruits while larger bats consume fruits with a wide range of textures. This study investigates the relationship between fruit hardness and feeding behavior in five sympatric pteropodid species from New Guinea (*Syconycteris australis*, *Dobsonia minor*, *Paranyctimene raptor*, *Nyctimene albiventer*, and *Pteropus conspicillatus*). Several individuals of each species were presented with soft and hard fruits of the same size. Both biting style and chewing behaviour vary significantly among species for both fruit types. Approaches to fruit processing are similar among *Pteropus* and *Dobsonia*, and among *Paranyctimene* and *Nyctimene*. *Syconycteris* is unique. *Pteropus*, *Dobsonia* and *Syconycteris* exhibit significant shifts in feeding behaviour in response to changing fruit hardness. These results suggest that fruit hardness plays a role in resource partitioning within chiropteran frugivore communities.

TOOTH STRUCTURE AND SALIVARY CHEMISTRY IN BATS.

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Teeth are the primary tools that mammals use to physically break down foods. For example, insectivorous bats have sharp cusps and elongated crests for fracturing insect exoskeletons, while fruit bats have broad cusps and basins for crushing plant tissue. In addition to resisting the physical wear and tear encountered during food processing, teeth need to resist chemical erosion of the enamel that can result from acidic foods and/or relatively acidic salivary secretions. This is particularly true of fruit bats, which frequently consume acidic fruit and have the lowest oral pH values known for mammals. This study addresses the hypothesis that the structure of fruit bat teeth minimizes their exposure to potentially harmful acids by minimizing exposed surface area relative to tooth volume. Tooth surface area and volume of lower molar teeth representing 33 bat species were determined using confocal microscopy and 3-D reconstruction. While there is no relationship between tooth structure and salivary pH among insectivorous species, both frugivore lineages (pteropodids and phyllostomids) exhibit a significant decrease in surface/volume ratios with decreasing salivary pH. These results indicate that molar tooth structure reflects not only the mechanical demands placed upon the teeth but also their chemical milieu.

How Stable Is The Structure Of Grey-Headed Flying Fox Roosts?

Peggy Eby and Vivien Jones (no addresses given)

The numbers of Grey-headed flying foxes in a roost vary, largely in relation to changing patterns of food availability. While general models of roost structure have been proposed, little is known of changes that occur in the demographics of roosts or the specific roosting locations of individuals. This paper reports the methods and preliminary results of a study of stability in the structure of Grey-headed flying fox roosts. The work is pertinent to understanding migration, social organization and mating systems of flying foxes. Six colonies, distributed from 34°S to 29°30'S, were selected for study on the basis of patterns of occupation. Five colonies have been occupied continuously for at least three years. The colonies are visited monthly (from September 1999), the size of the population estimated, and the distribution of animals mapped on aerial photographs. At least 20 target areas (sections of trees) distributed through each colony are monitored for the numbers of animals present, their sex, age (adult, sub-adult, current season's young), and the reproductive status of females. The presence and position of identifiable individuals are also monitored. In one colony, 30 target areas and several identifiable individuals are photographed twice weekly using a Canon EOS1N with 100 - 400mm IS lens, 2 x extender and flash. Early results confirm the view that sedentary populations roost separately from migratory populations, suggest a high degree of stability in the demographics of target areas, and a high degree of specificity in the roosting locations of individuals, particularly males in mixed-sex groups.

Assessing the Abundance and Distribution of Grey-headed Flying Foxes

Peggy Eby, Patrina Birt, Linda Collins, and many others (no addresses given)

Grey-headed flying foxes are highly mobile and have irregular migration patterns. These characteristics inhibit efforts to assess abundance and habitat requirements. A program of synchronous counts made throughout the area occupied by the species aims to estimate abundance with sufficient accuracy to monitor significant trends; and to identify critical habitat in winter when food resources are limited. Synchronous counts were conducted in July and September 1998, and April and July 1999. With the exception of September 1998, counts were scheduled when available food resources were confined to coastal areas, where colony sites are best known. 129 colonies were assessed for the presence of animals. In New South Wales and northern Victoria, volunteers counted animals at occupied sites as they emerged at dusk. Variance in estimates between counters was low (percentage deviation from the mean from paired counts <13%, mean 8.4%, n= 24). A single person estimated population size in Queensland by on-ground surveys. Results for July 1998: 27 colonies occupied, estimate of total abundance = 400,400, 21% of animals in NSW; April 1999: 56 colonies occupied, abundance = 356,300, 85% in NSW. Estimates from other counts were substantially lower due to occupation of sites away from the coast (September 1998) and impact of heavy rain (July 1999). These are the most accurate estimates of abundance of Grey-headed flying foxes available. They are considerably lower than recent predictions of >1,000,000. Annual counts in April will be used to validate these estimates and monitor trends. In winter 1998 and 1999 Grey-headed flying foxes were dependent on floral resources in small areas of coastal woodland that are threatened by poor reservation status and clearing for coastal development. These results support the listing of Grey-headed flying foxes as Vulnerable in the *Action Plan for Australian Bats.*

Applications Of Confocal Microscopy To Functional Morphology: The Effect Of Diet And Wear On Tooth Sharpness And Function In Two Microchiropterans *Chalinolobus gouldii* And *C. Morio*

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Three-dimensional topological data were gathered from the molars of the microchiropterans *Chalinolobus gouldii* and *C. morio* using confocal fluorescence imaging. This allowed computer reconstruction of the teeth in three dimensions. Morphological measurements such as lengths, areas and volumes of whole teeth, crests and basins were made. Surface curvature of the whole tooth was calculated using geological mapping software. These data were then used to calculate the range and mean of sharpness along functional crests. Comparisons were made between *C. morio*, which specialises on moths, and *C. gouldii*, which takes some foods such as beetles which have sclerotised cuticle, to explore differences between teeth that may be due to differences in the physical properties of the foods. The effect of changes in wear of the teeth and scaling with body size within species were also investigated. Scans of upper and lower teeth were animated using Virtual Reality Modelling Language to simulate occlusion of teeth, indicating how occlusion varied between the two species, and how it changed with increased wear of the teeth.

An Assessment of Known Habitat and Comparison With CRA Modeled Habitat for *Kerivoula papuensis*.

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Targeted surveys of *Kerivoula papuensis* are conducted as part of the regular pre-logging assessment of all compartments within estate managed by State Forests of NSW within the Lower North East Comprehensive Regional Assessment region. Habitat models developed during the CRA process are used as part of the pre-survey assessment of compartment to determine areas considered to contain suitable habitat. Surveys conducted since 1996 used harp traps placed strategically at 130 sites within the Hunter and lower North Coast Forestry Regions. At each site stream order, % rainforest within a 200m radius, capture over streams or away from streams, altitude, weather conditions and month of the year were recorded. *Kerivoula papuensis* was detected at 32 sites. Statistical analysis of the difference between the above recorded variables for each *Kerivoula papuensis* detection site was undertaken. Results of this analysis were used to compare the known detection sites with the CRA modeled habitat. Implications for microbat management within State Forests will be discussed.

Torpor In Australian Long-Eared Bats

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Previous studies have suggested that Australian long-eared bats differ from Northern Hemisphere bats with respect to their thermal physiology and patterns of torpor. To determine whether this is a general trait of Australian bats, we characterised the temporal organisation of torpor and quantified metabolic rates

(MR) and body temperatures (T_b) of normothermic and torpid *Nyctophilus geoffroyi* (7 g) and *N. gouldi* (10 g) over a range of air temperatures (T_a) and in different seasons. The basal MR (BMR) of normothermic bats was about 65% of that predicted by allometric equations (corresponding T_b about 36 °C). Below T_a of about 25 °C bats usually remained normothermic for only brief periods and typically entered torpor. Arousal from torpor usually occurred shortly after the beginning of the dark phase and torpor re-entry occurred almost always during the dark phase after about 2-h normothermic periods. At T_a<10 °C, bats remained torpid for more than one day. Bats that were measured overnight had steady-state torpor MR (TMR) representing only 2.7% (*N. geoffroyi*) and 4.2% (*N. gouldi*) of the BMR, and their T_b fell to minima of 1.4 and 2.3 °C. In contrast, bats measured entirely during the day, as in previous studies, had TMR that were up to 10 times higher than those measured overnight. The steady-state TMR of thermoconforming torpid bats was exponentially related to T_b (r^2= 0.94), suggesting that temperature effects are important for reduction of MR below BMR. However, the 75% reduction of MR at high T_b in torpor suggests that metabolic inhibition is also important. TMR showed little or no seasonal change. Our study suggests that patterns of torpor in Australian *Nyctophilus* bats are similar to those measured in bats from the Northern Hemisphere. The low BMR and the high proclivity of these bats for using torpor suggest that they are constrained by limited energy availability and that heterothermy plays a key role in their natural biology.

Bat Images And Postage Stamps

Elery Hamilton–Smith
Chair, IUCN / WCPA Working Group on Cave and Karst Protection

An interesting source of bat images on a world scale is provided by postage stamps and related materials. These have recently been extensively reviewed by Lera (1995) and Stepanek & Friedrich (1998,1999). This paper will present examples these, including the diversity of species depicted and there relationship to good luck, witchcraft and terror or other folklore.

The IUCN And Protection Of Bat Habitat

Elery Hamilton–Smith
Chair, IUCN / WCPA Working Group on Cave and Karst Protection

The International Union Commission of Nature is probably best known to those concerned with bats for the work of the Chiroptera Group of the species survival Commission. However, its World Commission on Protected Areas probably has a broader impact on habitat protection through its responsibilities in relation to National Parks, Nature Reserves, and other protected areas. This paper will review major initiatives of the working group on caves and karst as an example of the ways in which IUCN can have an impact upon bat protection.

You Too Can Be An International "Batpacker."

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Bats can open doors to unusual places and during a recent stay in the Netherlands for 12 months I discovered that having a common interest in bats means an instant contact with other people of like interests. Holland has the same population as Australia but within an area half the size of Tasmania, studying bats takes on an entirely different angle. Some of the activities I discovered: Assisting with the Dutch Annual National Bat Survey and Bat Atlas; Learning how the Dutch have been running a bat census

detectors and recognising calls by their rhythms; Wandering around Wales with a "night scope" trying to see bats. Fringe benefits: Access to places normally out of bounds to the public of the Netherlands; Climbing through winter hibernation sites in Castle cellars, World War II bomb shelters, building ruins, railway tunnels, Ice cellars; Free drinks while monitoring town summer bat roosts in the middle of the night; Attending the British Bat Conference and Dutch Bat Conference; Find out how to make your next holiday a bat holiday!

The Effects of a Walk-About Saw Mill an the Bat Fauna Of a Lowland Rainforest in Papua New Guinea.

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25% of PNG forests are under active logging concessions. Other forests are threatened with the use of walk-about sawmills. These mills are used to access areas unprofitable for clear felling, and often promoted as a sustainable method of extracting timber, yet in practice, they are capable of extracting all timbers. In 1996, an area of $1km^2$ of lowland rainforest was surveyed for 8 weeks using mist-nets. This area is a continuum of, the largest remnant of lowland rainforest left on the north coast. In 1997 and 1998, all canopy trees were logged with the exception of three strangler figs. With the large trees removed an area of $300m^2$ was subsequently cleared for gardens and three families moved in. In 1999, I resurveyed at the same time of year. In addition six 50m x 2m vegetation plots were set up to classify the degrees of disturbance on each transect. Overall, bat species diversity increased from 10 to 14 species. *Hipposiderous* increased in relative abundance, whereas the tube-nosed bats (*Nyctimene* and *Parancytimene*) and blossom bats (*Scyonycterus* and *Macroglossus*) decreased in relative abundance. Mark- recapture data on tube-nosed bats showed six individual bats utilizing the same places as previously despite this impact. Radiotracking revealed these bats did not feed or roost in the disturbed area. Netting in adjacent non-impacted forest showed relative abundance and species diversity estimates similar to those obtained in 1996. Harp trapping added four more species to the inventory bringing the total present to 18. Comparisons of these observations with data from other forests in New Guinea are discussed

Evidence For A Shift In Timing Of Reproductive Events In Tasmanian Bats

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The characteristic reproductive pattern for temperate Microchiroptera is to mate in autumn, hibernate through winter, gestate in spring, and give birth in late spring or early summer. This pattern has been confirmed for the majority of Australian hibernating bats, but limited evidence has been gathered for Tasmanian species. Prior to this study, information on the reproductive cycles of Tasmanian microbats was based on anecdotal information and comparison with studies of the same species on mainland Australia. This study found that in the three *Vespadelus* species and *Nyctophilus geoffroyi* in southern Tasmania, birth occurred in late December to early January, approximately one month later than their mainland counterparts. All four species appear to wean in mid- to late February, mirroring weaning in mainland populations. Lactation appears to last for only five to six weeks, which presents evidence of a shortened duration of lactation in Tasmanian bats. Parturition in southern Tasmanian *Chalinolobus morio* occurred up to one month later than other Tasmanian microbats, and two to three months later than the same species

on the mainland. However, weaning appears to occur at the same time in this species as other Tasmanian bats and mainland populations, presenting further evidence of a decreased duration of lactation in Tasmanian microbats

The Use of Paddock Trees by Bats,
with Preliminary Radio-Tracking Observations on *Scoteanax rueppellii*

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We investigated which wildlife use paddock trees on farmland in northern NSW with a dusk stag-watching technique. Trees were stratified as isolated, in small patches, remnants, riparian strips, and adjacent forest. Bat roosts were found 13 % of isolated trees and 8 % of all trees watched. Despite the survey being under taken in spring, only one maternity roost (*Chalinolobus gouldii*) was found. Although paddock trees were used infrequently for roosts at this time, ultrasonic detectors recorded 21 species (7 threatened in NSW) foraging in these locations. It is suggested that remnant red gums (*Eucalyptus tereticornis, E. amplifolia, E. seeana*) represent high quality habitat for some bats as they were associated with high bat activity, particularly of threatened species. This association may be due to the fact that these trees usually grow on fertile soil. In one study region the Greater Broad-nosed Bat *S. rueppellii* was the most frequently recorded species. This bat is listed as Threatened in NSW and has rarely been recorded in previous surveys of surrounding forests. Attempts to capture and radio-track this elusive species will be discussed. Data will be presented on their foraging movements in farmland and roost locations in nearby forest.

Long Tailed Bats In The Rural Landscape Of New Zealand

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The long-tailed bat (*Chalinolobus tuberculatus*) is one of two extant species of bat found in New Zealand. Both species are classed as "threatened" and have undergone significant population declines since the 1880s. Remaining populations of *C. tuberculatus* are scattered throughout New Zealand and in almost all cases found in association with native forest. One notable exception is the small remnant population at Geraldine, South Canterbury. This population numbers approximately 100 bats and persists in a highly modified agricultural landscape. A considerable amount of research has been invested in this population in order to delineate the factors that allow this population to survive, identify threats, and develop suitable monitoring techniques to assess short- and long-term population trends. Threats faced by bats at this site include human-associated activities (removal of roost trees for firewood, habitat clearance and/or degradation), predation, and potentially, a lack of adequate roosting sites. During the 1999/2000 breeding season, *C. tuberculatus* used a combination of trees (76%) and cavities in limestone bluffs (24%). They used the oldest cavity-bearing trees in the landscape including standing dead trees (15% of tree roosts), native trees (35%, *Kunzea ericoides, Cordyline australis*), and introduced trees (50%, predominantly *Salix fragilis* but also *Pinus radiata, Acacia* species, *Populus alba*). Whether these roosts represent adequate micro-climates for successful breeding is currently being investigated by comparing roost tree characteristics from this area to those from native trees used by *C. tuberculatus* in the Eglinton Valley, Fiordland.

The Christmas Island Pipistrelle *Pipistrellus murrayi* – An Endemic Species Currently In Decline.

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The Christmas Island Pipistrelle *Pipistrellus murrayi* is endemic to Christmas Island, an Australian territory in the Indian Ocean. It is the only species of insectivorous bat on the island. In the 1980s it was considered common and widespread, with little concern over its conservation status. However, studies in 1994 and 1998 found it had declined markedly in both distribution and abundance. An intensive study undertaken in 1998 using ultrasonic bat detectors, harp trapping and radiotracking investigated its status and ecology across the islands habitats. It was found to be absent from more than half of the 84 sites sampled using stationary detectors, and high levels of activity were recorded at only four sites. A similar pattern was revealed from driving detection and incidental records. Compared to its distribution in the 1980s the species had disappeared from the north-eastern section of the island and records were now concentrated in the western section. Roost sites were located under exfoliating bark on dead trees, in tree hollows and under palm fronds. The cause of the recent decline is currently unknown, however two introduced species, the Common Wolf Snake *Lycodon aulicus capucinus* and the Yellow Crazy Ant *Anoplolepis gracilipes* are likely to be impacting on this rapidly declining species. The Wolf Snake was introduced to the island in 1987, and the Crazy Ant has recently exploded in numbers and both are potentially capable of killing individuals within their roosts. The pipistrelle is currently listed as endangered in the Bat Action Plan, and urgent action is required to determine the cause and halt the current decline.

Habitat Selection by Microchiroptera in the Logged, Burnt, Drought-affected Mumbulla State Forest on the South Coast of New South Wales

Daniel Lunney and Peggy Eby

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Mumbulla State Forest, on the south coast of New South Wales, was logged for woodchips and sawlogs from 1978 to 1982, burnt in a major fire in 1980, and subject to a severe drought from 1980 to 1983. In February 1982 the numbers of microchiroptera in adjacent logged and unlogged coupes, which formed an alternating pattern through the forest, were compared. Repeat trapping between 1982 and 1983 showed that numbers of both individuals and species declined after 1982, which is most simply interpreted as an adverse impact of drought. In January 1983 in five habitats were investigated, ranging from an unlogged, unburnt creek, through the alternate logged and unlogged-coupes logged in the forest, then an adjoining young regenerating forest, to and a logged, burnt creek. The complicated pattern of the distribution of the bats in these habitats clouded the interpretation of their habitat selection and did not allow a ready cause and effect with logging and fire to be determined. Subsequent bat research world wide has enabled a better understanding of the data to be made, and while an effect of logging and fire can be concluded, validation will require the resolution of questions in bat biology still in need of investigation. However, the results indicate that the conservation of forest bats requires the setting aside of habitats, such as tracts of forest with large trees, especially along creeks and gullies, and the recognition that the diversity of bats will require a diversity of management provisions.

A Researchers' Guide for the Ethical Care and Handling of Micro Bats (Sub-Order Microchiroptera) in the Field

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At the bat conference in Rockhampton in 1998 we started compiling an ethical guide to handling bats during field research projects. The compilation was based on the considered opinion of 15 colleagues responding to our questionnaire on this subject. We have now prepared a draft, identified some of the gaps and difficulties and are seeking refinement, again from conference participants. The primary uses of the guide will be threefold- assist researchers in selecting best practice field techniques; assist Animal Ethics Committees (AECs) consider applications by researchers to study bats; and provide a teaching guide to newcomers to the world of bat research. Since it is compulsory to present a cogent research protocol dealing with set questions to an AEC it is in the interest of researchers to know best practice to every question. The aim of this field guide is to do that, and have the names of all contributors listed, and show where differences of opinion lie on any issue, such as marking methods, radiotelemetry, and length of time a bat can be held in a bag.

Foraging Movements of the Black Flying-Fox *Pteropus alecto* in an Urban Environment

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Foraging movements of thirteen Black flying foxes *Pteropus alecto* from three permanent roosts in the Brisbane urban region were monitored over two seasons. Using radio - telemetry, the flying-foxes were tracked over 23 nights and confirmed at previously established foraging locations a further 33 times during summer 1998 and winter 1999. Average distances travelled from roost to foraging site did not differ between summer (5.9km, S.D. 2.8, n=19) and winter months (6.Okm, S.D. 3.7, n=16). However, distances traveled to forage differed between camps, with the camp located closest to the city centre requiring bats to travel the least distance to forage. Foraging sites were revisited over weeks and sometimes months, and specific food sources within a range were often visited repeatedly in one night. Eleven plant species were visually confirmed as food resources for the tracked bats. Of those eleven, four were introduced, seven were native and one native but cultivated out of its natural range. Preliminary results indicate that Black flying foxes in urban areas utilize any *available* food resources and thus avoid long distance travel or potential starvation at times of poor native food availability. Further data are needed to assess potential differences in foraging between the sexes.

Bats Of The Southern Carnarvon Basin, Western Australia.

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We present the results of the first systematic survey of bats in the southern Carnarvon Basin. Two megabat and eleven microbat species were recorded. A twelfth microbat species, *Macroderma gigas*, is known from sub-fossil material. We demonstrate tight, functionally appropriate relationships between species' foraging microhabitats, flight performance indices, and echolocation call parameters. Patterns in the species composition of microbat assemblages across the study area conform with a 'temperate to tropical' climatic gradient, but are modified by variation in the structural complexity of the vegetation.

Within the study area, these relationships allow the species composition of microbat assemblages to be predicted from vegetation structure and local availability of roost sites.

Investigation Of Physical Processes And Bat Requirements In Bat Caves.

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Cave environments have some special properties that have attracted bats to use them as maternity sites or shelters. The pressure of human land "development" on populations of cave occupying bats is discussed with consideration of what can be done to restore bat populations. A multi-disciplinary approach to solving these problems is advocated, integrating life science, physical science and engineering science. Problems associated with the restoration of old habitats and the recruitment of new habitats are discussed. Objective physical measurement of both bat behaviour and cave physical processes is expected to enable progress in answering many questions of bat requirements and restoration strategies. Recent issues and advances in the study of cave physical environments are outlined.

Survey of Columnar Cacti and Carrying Capacity for Nectar-Feeding Bats

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We estimated the population sizes of the three species ofcolumnar cacti on Curacao using ground and aerial transects, and we examined the island's carrying capacity for two species of nectar-feeding bats that depend on the cactus flowers. We calculated carrying capacity based on the daily availability of mature flowers between January and December 1993 and the estimated field energy requirements of bats. Body mass, pregnancy, and lactation were taken into account. We estimated that 461,172 columnar cacti were present on Curacao (38% *Subpilocereus repandus*, 51 % *Stenocereus griseus*, and 11% *Pilosocereus lanuginosus*). May through September are the critical months when bats rely most heavily on cactus for food. July 1993 was a bottleneck with the smallest number of mature flowers per day. July and august were months of greatest energy demands because females were lactating. We estimated the carrying capacity for *Glossophaga longirostris*, when the population of *Leptonycteris curasoae* was 900, to be near 1200, fitting the observed population sizes of nectar feeding bats on the island. We suggested that the extensive removal of native vegetation occurring on Curacao be strictly regulated because further destruction of the cacti will result in a decrease and potential loss of the already low populations of nectar-feeding bats.

Population Size of Southern Bentwing Bats

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The majority of Southern bentwing bats *Miniopterus* sp (here defined as those populations which were formerly ascribed to M. *schreibersii* that occur from Melbourne Victoria, west to Naracoorte, South Australia) congregate each summer in Bat Cave at Naracoorte to give birth and raise their young. This is probably the only circumstance in Australia where most members of a single bat species gather in one cave and where it is the only bat species inhabiting that cave. The occasion of this assembly provides an oppor-

-tunity to estimate the total size of the population. We report here our attempt to estimate the peak population size at Bat Cave using mark-recapture methods. Our estimate of 65 000 – 90 000 is considerably less than the 300 000 currently espoused as the true size, and significantly less than the only other previous estimate (100 000 –200 000) made in the 1960s. The implications of this result are discussed as are the problems associated with the mark-recapture method for large bat populations.

Molecular and morphological systematics of the Australo-Papuan *Miniopterus* (Chiroptera:Vespertilionidae)

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Taxonomy of south-east Asian *Miniopterus* has historically been complicated by morphological overlap and ill-defined geographic variation amongst the constituent taxa. The research presented here partially resolves the systematics of this genus in Australia and Papua New Guinea through the concordant application of multivariate morphometrics, allozyme electrophoresis and mitochondrial DNA sequencing. We recognise four species in Australia, *M. australis, M. orianae, M. oceanensis* and *M. bassanii.* A minimum of five species are recognised from Papua New Guinea; *M. australis, M. pusillus, M. tristis, M. blepotis* and *M. magnater.* While most previous authors recognise *medius* as occurring in PNG, all specimens in museums labelled as such, were referable to one of the five other species. Phylogenetic analysis shows European *M. schreibersii* to be on a separate lineage to Australian and Papuan species formerly ascribed to *schreibersii.* Concordant evidence from morphology and genetics suggest that Australian and *Papuan M. australis* differ at the subspecies level.

Bat Activity In Known Aged Logged Forests In Southern Tasmania

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We examined the levels of nocturnal bat activity in mature and regrowth forest in southern Tasmania in March and April 1996. Bat activity was sampled at two sites with Anabat bat detectors and harp traps in mature forest, and in 5- and 20 year old regrowth (5 yo, 20 yo). From 304 hours sampled during full and dark moon at the first site, Tahune State Forest, we recorded 7 species in mature forest, 7 in 20 yo, and 8 in 5 yo. The total activity levels at this site were 3.5 passes/hour in mature forest, 1.5 in 20 yo, and 1.6 in 5 yo. No species showed significant differences in activity between treatments. There was no significant difference in activity between full and dark moon for any species. The total activity levels varied significantly between moon phases (χ^2 $p=4.49x10^{-9}$, df=5). At the second site, Wielangta State Forest, in 172.1 hours of sampling we recorded 6 species in mature forest, 5 in 20 yo and 7 in 5 yo. The highest activity was again in mature forest, being 6.9 passes per hour, compared to 3.9 and 5.3 in 20- and 5-yo regrowth. *Only F. tasmaniensis* showed significant differences in activity levels between treatments with the highest activity in 5 yo (χ^2 p=6, p=0.028, df=2). No all night recordings were possible at full moon. Although a total of 24 harp trap nights at Tahune and a total of 12 harp traps in Wielangta were made

giving a total of 108 trapping hours, the overall trapping success was very little: Three individuals from two species were captured at Tahune, while four individuals from three species were caught at Wielangta.

Towards Defining Adequate Bat Survey Methodology:
Why Electronic Call Detection Is Essential Throughout the Night
G.C. Richards

The method for identifying free-flying bats by their species-specific echolocation calls is one that has become standard in the last decade, and the Anabat system has received world-wide acceptance as a valuable sampling tool. The Anabat system can be automated to commence call detection at dusk in the absence of the operator, and will operate for an entire night. However, many bat surveys are still conducted by manually operating a detector, whether it is an Anabat system or not. Over the last few years it has become apparent that some surveys are deficient, through a short time period of detection and a consequently low number of recorded passes and species numbers. This paper analyses data taken from 49 field samples in three bioregions where delay switches have allowed the recording of calls throughout the night, or at least a major portion of the bat activity period. The proportion of the total site species was averaged in consecutive half-hour blocks, and these points were fitted with a polynomial regression. Only two-thirds of the species that were present, were recorded in the first hour of detection, with just over half being recorded in the initial half-hour period after dusk. It took nearly 3 hours to accumulate presence data for 90% of the site species, and all night to record all of them. When data was extracted for species listed in the NSW Threatened Species Conservation (TSC) Act, or species listed nationally under IUCN categories, varying detection times were observed. *Chalinolobus, Myotis, Mormopterus* and *Miniopterus* were recorded atsome sites within the first half hour. However, at other sites it took at least one hour and on several occasions three hours to record these taxa. Of significance is that it took at least two hours of recording, and sometimes as much as three to four hours, to record *Saccolaimus flaviventris*. The average time taken to record TSC species was 94 minutes. The situation was somewhat different in tropical Northern Territory and Queensland. The implications of the TSC data is extremely important when attempting to establish standards for bat fauna surveys and assessments. Considering that many bat surveys carried out for Environmental Impact Assessments are known to be relatively brief (less than one hour) and many consultants do not use Anabat delay switches or laptops, it can be confidently stated that many past bat surveys would have certainly missed species that are listed in the Threatened Species Conservation Act.

A Re-Assessment Of The Origins And Evolution Of Australian Microchiroptera
In Light Of Modern-Day Ecological Patterns
G.C. Richards

This paper discusses the evolutionary relationships of forest bats through a re-examination of the fossil record, an assessment of the different climatic and vegetative phases that the continent has undergone over time and new knowledge of the community structure patterns of Microchiropteran bats. It is proposed that the origins of the modern Australian bat fauna are a result of radiation throughout the continent by Gondwanan endemics that were habitat generalists, followed by waves of invasion from the north by habitat generalists and specialists, with retraction into refugia by the latter group. The origins of the *Rhinolophidae* are obviously the New Guinea region, but the treeless and cave-less Carpentaria Gap appears to have acted as an ancient barrier. The *Hipposideridae* appear to have originated through two routes (via the Top End and via Cape York). Two extant endemic *hipposiderids, Rhinonicteris aurantius* and *H.stenotis* are representatives of the originalPaleocene fauna and have been restricted to the wet-dry tropics since the Pliocene. Species such as *H. diadema* and *H .ater* arrived on the Australian continent

during the Mid Miocene (15 mybp) when the leading edge of the Australian plate first collided with the Sunda Arcs and then New Guinea. In our fauna today we see the results of this dual invasion with what are now sibling species, such as *H.diadema reginae – H.inornatus* and *H.ater aruensis - H.gilberti.* Emballonuridae distribution patterns indicate an early occupation of the continent from the north, via the NT. After radiation across the continent there was some minor infiltration back into New Guinea, where *Taphozous* and *Saccolaimus* are still apparently rare. Although emballonurids have been in the world's fossil record for 42 million years, it was only until the Pliocence that they appeared in the Australian fossil record, at the stage when the continent-wide Miocene rainforest had been replaced by eucalypt forest, which was far more suitable for large emballonurid species. The "successive waves" theory explains current patterns in the Molossidae. It is known that the Molossidae has been present in Australia for longer than many of the other extant families, having been found in fossil deposits at Riversleigh with representatives of the Hipposideridae and Megadermatidae. It is proposed that the modern Molossidae genera *Mormopterus* and *Tadarida* arose from the ancestral (Oligo-Miocene) cave dwelling *Petramops* stock, and that *M.beccarii* and *T.australis* are the modern representatives of this lineage. The nine smaller (primarily endemic) *Mormopterus* species arose from an ancestral *M.beccarii* form, with some radiating into New Guinea, and one to Indonesia. The allopatric distribution of *Chaerephon jobensis* and *Tadarida australis*, with a distinct boundary along most of the Tropic of Capricorn, is concluded to be the result of a recent invasion from the Top End by *C.jobensis.* Through competitive exclusion, it sent *T.australis* southwards, and severed the *Tadarida* population in New Guinea which gave rise to *T.kuboriensis* (considered by some authorities to be a subspecies of *T.australis*).

How Disk-Winged Bats Stick

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Spix's disk-winged bat (*Thyroptera tricolor*) is a neotropical species that frequently roosts in unfurled leaves, adhering to these smooth surfaces using specialized disks on its wrists and ankles. To determine the mechanisms of sticking, in 123 trials I tested the adhering ability of 31 *T.tricolor* on four surfaces, medium grade sandpaper, lexan polycarbonate, solid sheet aluminium, and porous sheet aluminium. The *T. tricolor* could not stick to porous sheet aluminium (a surface which makes suction impossible) as well as it could cling to solid sheet aluminium, indicating the importance of suction. But in 54.8% of trials (n=31) the *T. tricolor* could cling to the porous surface when its center of gravity was below that of the surface, eliminating friction. The ability of the bats to cling without suction or friction indicates that wet adhesion and/or gluing is used in addition to suction. For comparison to *T. tricolor*, in 461 trials I tested the sticking ability of 121 bats (18 species; 3 families) without disks on the same four surfaces. *T. tricolor* was better able to cling to smooth surfaces, but did not cling as well to rough ones as the other bats studied. This may represent an evolutionary tradeoff: in the course of adapting to smooth roost surfaces, *T. tricolor* appears to have lost some ability to use the more traditional roosts of other bats.

Long-Term Population Dynamics Of A Hollow-Dwelling Microchiropteran

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Bat boxes erected in Organ Pipes National Park, Victoria provide an unusual opportunity to investigate the population dynamics of a breeding colony of Gould's Wattled Bat, *Chalinolobus gouldii.* This study

was initiated in December 1994, when the Friends of Organ Pipes National Park discovered that there were bats occupying the ten boxes they had installed two years previously. There are now 34 bat boxes within this 5 ha area of the park. Systematic monitoring of these boxes has been conducted on a monthly basis over the last five years. Five species of Microchiroptera have been recorded roosting in the boxes. *Chalinolobus gouldii* is easily the most abundant, representing 97% of adult individuals recorded. The sex ratio of these adult *C. gouldii* is highly skewed, with females comprising 78% of the total. By comparison, the sex ratio of young born into the colony is closer to parity (males 42%, females 58%). Juvenile males apparently disperse away from the area, while many of the young females are philopatric, returning to breed in the boxes in subsequent years. The sex ratios of adults occupying the boxes fluctuates seasonally. During winter months, when the number of bats using the boxes is small, adult sex ratios are balanced (males 47%). The potential for multiple recapture of bats has enabled preliminary calculation of long-term survivorship. In the January 2000 breeding season, sixteen (22%) of the adult females had been first banded in prior to winter 1997, and nine of these were banded as adults during 1995. This study establishes the foundation for an unusually long-term research project on hollow dwelling bats, in which details of population dynamics and social organisation can be determined efficiently.

Low Voltage Open Aerial Conductor Separation To Reduce Flying Fox Electrocutions.

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As a result of a suggestion made at the first Australian Bat Conference, I was prompted to investigate the possibility of increasing Low Voltage open aerial conductor separation with a view to discovering a practical and efficient distance that would minimise Flying Fox electrocutions. Over a number of years, I have been able to confirm that increasing Low Voltage open aerial conductor separation (horizontally) from the old 18" (450 mm) to 30" – 32" (750-800 mm) will significantly reduce Flying fox electrocution in urban areas where the reticulation configuration is suitable.

Threatened Species Conservation Act Recovery Plan For Microchiropteran Bats

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Under the NSW *Threatened Species Conservation Act* 1995 nineteen species of bat are listed as Vulnerable. Of these, sixteen are microchiropteran species and only two of these species are listed in the Action Plan for Australian Bats as nationally vulnerable. In NSW, the vulnerable status indicates that these species are likely to become endangered unless the circumstances and factors threatening its survival or evolutionary development cease to operate. For a species to be listed as Endangered, it is considered likely to become extinct or it is in immediate danger of extinction in NSW unless the circumstances and factors threatening its survival or evolutionary development cease to operate. The NSW National Parks and Wildlife Service is currently preparing a recovery plan for threatened NSW microchiropteran bats. In view of the broad range of the species covered by this plan, the dearth of ecological information on many species and the variety of threats to microchiropteran bats, the plan will be encouraging research into threatened bat species, identifying key habitat features, developing strategies to mitigate the impact of known and potential threats, and raising the public profile of bats. To achieve these aims, I am seeking the assistance input of the ABS in the preparation of the Recovery Plan and advocate the establishment of a sub-committee to provide input into the plan's preparation.

Thermal Biology And Roost Selection Of Long-Eared Bats, *Nyctophilus geoffroyi*

Christopher Turbill, Gerhard Körtner and Fritz Geiser
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Torpor allows heterothermic endotherms to conserve energy during cold conditions or times of low prey abundance. Captive Australian forest microchiropterans are known to readily enter torpor, yet their thermal biology in the field is largely unknown. This information is important for understanding roost selection according to microclimate. We used temperature-telemetry to examine roost selection and monitor skin temperatures of *Nyctophilus geoffroyi* during summer on the Northern Tablelands of NSW, Australia. Roosts were mostly below 3 m from the ground in relatively exposed and ephemeral locations. Skin temperatures ranged from 8.3 °C to 39 °C, and torpor was used by males on 100% of roost-days. Torpor bouts usually commenced near sunrise, and most commonly bats aroused at midday, before re-entering torpor in the late afternoon. On cool days bats remained torpid throughout the day, whereas on warm days torpor was only observed in the morning. Final arousals often occurred shortly after sunset, although bats occasionally remained torpid for up to 40 h. Lactating females used torpor on 75% of roost-days, and maintained higher skin temperatures than males at the same time of the year. Our study suggests that torpor plays a pivotal role in the biology of Australian forest bats.

The Conservation Status of the Spectacled Flying-Fox *Pteropus conspicillatus* in the Australian Wet Tropics as Determined by Camp Fly-Out Census

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Concern over the status of the Spectacled Flying fox has highlighted the need for more information on population trends. The conservation status of the Spectacled Flying-fox was investigated by flyout counts at all known camps from Cardwell to Bloomfield including the Atherton Tablelands. Although the counts only produce an index of abundance it is important to note that in the period between November 1998 and November 1999 the number of flying foxes counted leaving camps decreased by 35% from 114, 000 +/- 14, 000 to 74, 400 +/-8650. November counts should represent a minimum population. At this time young flying foxes will still be in their camps at night while many young bats born during the previous season are likely to have died in their first 8 months of independence. If the counts reflect a genuine 35% mortality in the wild population, two explanations are most likely: excessive numbers of bats are being killed in orchards or bats have starved as a result of food shortage. An alternative explanation is a change in bat behaviour that reduced the number in known camps. These factors and other potential factors will be discussed as well as future steps being undertaken to protect the species.

Methods for The Objective Interpretation of Species Distribution Data Using *Scoteanax rueppellii* as an Example

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A necessary precursor to good environmental management decisions is sound information on the distribution and habitat requirements of species. Information here means the outcome of interpreting raw obse56rvational data. Information may exist at two scales determined by the scale of the underlying data:

fine-scale or microhabitat (eg roost tree characteristics) occurring at scales from 1 m or less to several kilometers, and broad-scale or biogeographic (eg climatic correlates of a species' distribution) occurring at scales from several kilometres to hundreds of kilometres or more. Each can have a significant role to play in environmental decision-making. Using the Greater Broad-nosed Bat *Scoteanax rueppellii* as an example, I review and analyse a wide array of data from three primary broad-scale sources: published accounts of the species' distribution and occurrence, museum records, and data held in observational databases such as the NSW National Parks and Wildlife Service's "Atlas of NSW Wildlife". I demonstrate simple but effective methods for analysing data from these sources to extract basic information such as broad patterns of seasonality or distribution (eg altitudinal or latitudinal limits). More sophisticated analyses of correlations between recorded distribution and climatic and topographic factors are also explored. These analyses provide a framework for continually refining, updating and testing interpretations of factors relating to species distribution. The value of using objective tools to aid interpretation of primary distribution data is stressed using published views on the distribution of *Scoteanax rueppellii* as an example.

News From Our Readers

From Costa Rica

I have been working on bat pollination of Balsa in Costa Rica. This past winter I've been looking at bats that visit the enormous flowers of Balsa trees in Costa Rica. Balsa trees are common in disturbed areas, each tree can produce 40 or more flowers a night during a 1-2 month period, and each flower produces around 22 ml nectar nightly. This enormous wealth of nectar attracts a number of bat species, those that specialize on nectar as well as species that are generally considered frugivores. Each balsa flower may receive 400 or more bat visits during its one night life-span. Bats are not the only animals that take advantage of the sweet flowers, squirrels, monkeys, coatis, parrots, macaws, and nearly anything that can reach the flowers or buds visits the trees. But only bats are effective pollinators as the flowers must be out-crossed with pollen from a different tree.

Submitted by Anne Brooke Research Associate, University of Tennessee, Department Ecology and Evolutionary Biology Knoxville, TN 37996

From California

As always we're involved in surveys of foraging and roosting ecology of California leaf-nosed bats. After 32 years I guess it's a life work. Recent band recoveries have shown longevity in excess of 15 years for this species. We're preparing a large manuscript for California Department of Fish and Game on their status in California, and working on a United States Geological Survey (USGS) Species at Risk grant (administered by BCI) to look at the current status of the Macrotus (and other sensitive species) across the southwest. We will be spending a lot of time this spring and fall in Arizona and southern Nevada, and would welcome any information that BRN readers can provide on current roosts of *Macrotus*. As part of the USGS grant, this August we will be conducting a radio telemetry study of Allen's big-eared bat *Idionycteris* to determine foraging and roosting behavior near Kingman, Arizona . We are conducting mine surveys for bats at the request of Bureau of Land Management incentral Nevada. In southeast California we are continuing to monitor the *Macrotus* populations in the Cargoes where we have data from

ten years before open pit mining, through active mining, and into reclamation (now two years after mining has ceased). We are working with several mining, companies in California and Nevada to do bat surveys, exclude bats when necessary and design customized mitigation and monitoring for the impacts.

We will participate in teaching the Bat Conservation International sponsored Bats and Mines class, this year held in Grand Junction Colorado from July 19-20 (this is our 14th class). I continue to give bat conservation talks to Sierra Club, Audubon Society, Rotary, school groups etc., as our schedule permits. For the past twelve years, I taught a class each spring on California Desert Bats for California State University-San Bernardino Extension. We are just starting a bat survey on Catalina Island (where I surveyed 25 years ago), where we will check old survey localities using new equipment such as infrared video and the Anabat system. We're working on a project to inventory bats in southeastern Orange County, with the goal to help to select a preserve area in a sea of development.

We hope to go to the XII International Bat Research Conference in Malaysia next year, and would love to join a group of people doing bat research there either before or after the meeting.

Submitted by Pat Brown and Bob Berry. e – mail: PATBOBBAT@AOL.COM

From Wisconsin

It's a boy! Bjorn Joseph Lewis Larson was born Dec. 2nd, 1999, weighing in at a hefty 10 lbs, 5 oz. (in case anyone missed the fact that I was pregnant at the bat meetings in Wisconsin!). We're all doing fine. I'm planning to start some fish behavior projects in the fall, but fieldwork on bats is pretty tough at this point. I am now the Director of the Greene Field Station, Carroll College which is another thing that keeps me occupied.

Susan E. Lewis e - mail: lewiss@carroll1.cc.edu

From Kentucky

For students and post-doctoral fellows - University of Louisville is moving toward a Carnegie classification of Research I. As a result, in our department many new positions for MS, Ph. D. and post-doc opportunities (some with substantial scholarships and salaries) have opened up in the field of Anatomical Sciences and Neurobiology on subjects which may include bats as well as other experimental models . Interested persons can send inquiries to me for directing them further as the case may be.

Current research projects in my laboratory - My long-term interest with the study of vomeronasal structure and function in bats has yielded very good results for human work too. A series of papers, Letters, and commentaries are in various stages of publication and preparation. With my collaborator Timothy Smith (Slippery Rock University, PA) we are taking the myth and the fiction out from the human VNO replacing it with facts which are that the organ is consistently present from about day 33 embryonic to the last days in life, and that it is non-chemosensory. Details are to be watched in Journal of Anatomy and other sources.

With collaborators in the USA, India, and elsewhere, I am actively involved in the accessory olfactory structural studies using *Scotophilus* (*heathi*, and *kuhlii*), *Anoura* (several species), *Pteronotus*, the naked mole-rat, the flying lemur *Cynocephalus* (pineal gland structure and the brain), several Old World primates, and the ever-so-interesting *Desmodus*. We have contributed chapters on early embryology and brain ontogeny for Rick Adams and Scott Pedersen's book "Ontogeny, Functional Ecology and Evolution of Bats" slated for publication this summer by the Cambridge University Press. The study of placental ultra-structure is in progress in several species of bats. Studies on pineal gland calcification in humans and bats are slow. Another ongoing project is the pattern of expression of sodium-phosphate co-transporters in developing human kidneys. We have studied and published several papers on human gross anatomical

anomalies dealing with the ligamentum arteriosum, accessory lobe of thyroid gland, right-sided aorta, the displaced superior cervical sympathetic ganglia, and the levator claviculi muscle.

I do not teach courses dealing with bats, but occasionally get called to local schools for talks on these furry and 'blind' animals, a fascinating subject for the young minds and adults alike. Last year, while visiting India, I had great opportunities of visiting camps of *Pteropus giganteus* at Pinjore Gardens, on the outskirts of Chandigarh, Punjab. These giants among bats are endemic and can be observed almost anywhere in India. Since this species openly roosts under daylight and under high temperature conditions, its pineal physiology and melatonin connection is of extreme interest. I also visited colonies of *Megaderma, Rhinopoma, Hipposideros, Taphozous,* and some other species. Truly speaking India is heavenly for bat studies. In Brazil, with a small group of bat researchers we had great fun spending a week in the great Pantanal region observing *Desmodus, Noctilio, Saccopteryx* and other species. Pat Brown ought to write a note about our experiences there with bats, alligators, piranhas, the 118 or so wooden bridges knowingly kept in great disrepair, beautiful Brazilian birds and boas! Just last week I caught a silver-haired *bat (Lasionycteris noctivagans)* from our building. We have pointed its connection with human rabies. The bat was quickly and respectfully released back to nature.

Submitted by: Kunwar Bhatnagar, Anatomical Sciences & Neurobiology, University of Louisville Health Sciences Center, Louisville, KY 40292 Tel: 502-852-5174 Fax 852-502-6228

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From Nebraska

Throughout the 1990s, I have been working on several research projects involving bats at Carlsbad Caverns National Park. Although much is known about the biology of Mexican free-tailed bats inhabiting Carlsbad Cavern, it was not known where individuals from the cavern actually go to forage for insects and to drink. Using radiotelemetry, Troy Best (Auburn University) and I have been determining the foraging range of this colony since the summer of 1997; we plan to continue our study next summer. We also will continue a study on fringed myotis that we began in 1995. Unlike free-tailed bats from Carlsbad Cavern, little information is known about a maternity colony of fringed myotis that lives more than 700 feet below the surface in another section of the cavern. Using various methods, we have been determining the underground route taken by the bats from their roost to the surface. I am just about finished with the Mammals of Carlsbad Caverns National Park (includes 16 species of bats). In Nebraska, Russ Benedict (Christopher Newport University, VA), Frank Kock (Westside Middle School, Omaha, NE) and I finished a 13-year study on reproduction and seasonal activity of bats from eastern Nebraska.

Submitted by Ken Geluso, University of Nebraska at Omaha.

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More From Nebraska

I just returned from visiting the American Museum and the Museum of Comparative Zoology where I was looking for specimens to borrow for my next big project. It is an insectivore project (zounds!), but it will eventually tie in with my bat research. It was a great trip. I saw lots of folks at AMNH including Syd Anderson, Guy Musser, Nancy Simmons, Bill Schutt, Rob Voss, Ross MacPhee and others who worked there when I was a Scientific Assistant about 30 years ago. I was delighted to see that we were all growing older gracefully. However, because it was my first trip back to AMNH in a long while, I very much felt the loss of Karl Koopman, my friend and former mentor.

It was my first visit to the MCZ collection, and I was impressed with the quality and organization of the material. Maria Rutzmoser and her small staff have done a pretty fantastic job of keeping the collection

active. I also saw the field station where the alcoholic specimens are stored and the bug colonies do their thing. Judy Chupasko maintains that facility and it is in good shape. My visit to Harvard field station was with Sharon Swartz from Brown who is maintaining a live colony of *Rousettus* there. She is flying them in an incredibly neat wind tunnel and getting all sort of data on flapping flight - not just static airplane-wing fight. I have to admit watching those *Rousettus* from underneath, they could be mistaken for large moths. It was very cool to see them in action, up-close and personal.

Now I am back home and still catching up. Last week I shared the hosting of a visit from Mike Rosenzweig, an ecologist evolutionary biologist-mathematical theorist came to give a biology seminar as well as a seminar for our Scholarly Journal Symposium. Mike, as some of you may have heard, and his entire board of directors resigned from the editorial board of directors for Evolutionary Ecology and formed a new journal (both online and in print) called Evolutionary Ecology Research (they will be side by side in the library). The mass resignation took place because the publishing house sold the rights the EE to its third publisher who charged libraries more and quality suffered a second time. Some of the big publishing house are making a great deal of money from our free reviewing, free editing and free submission of scientific papers. In this last case the profit was becoming obscene; costs for publishing the journal were about $80,000 and income from libraries and personal subscriptions between $250,000 and $300,000 . It is an incredible money maker for many of the big publishers in Canada and Europe. So be careful who you are reviewing for; you may simply be an academic slave. Also, be careful about giving away your copyright to your paper. You can amend it to your needs right on the paper some publishers send out. Societies have been known to lose the title of their own societies' journal because of these big publishing houses. By the way if you want to see a good bat paper in EER in volume 2, number 3, page 317: Macroevolution; in Microchiroptera by yours truly; check it out: http://www.evolutionary-ecology.com reprints are EASY to send and tell me if you want a color version of the critical figure. If you like the journal you can get 8 issues for $33.00 if your library subscribes. It is a huge bargain. I presented the rudiments of this paper at the Bloomington meetings in 1996.

For those of you who need information about the vertebrates in my collection, I have searchable online databases: http://www.museum.unl.edu/research/zoology/zoology.html A new online paper for March 2000: http://www.evolutionary-ecology.com

Submitted by Trish Freeman,
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RECENT LITERATURE

Authors are requested to send reprints of their papers to the Editor (Tom Griffiths, Dept. of Biology, Illinois Wesleyan Univ., Bloomington, IL. 61702-2900, U.S.A.) for inclusion in this section. If reprints are scarce, please send a complete citation (including complete name of journal and mailing address) to **tgriff@titan.iwu.edu** by e-mail. Receipt of reprints is preferred at it will facilitate complete and correct citation. Our Recent Literature section is based on several bibliographic sources and for obvious reasons can never be up-to-date. Any error or omission is inadvertent. Voluntary contributions for this section, especially from researchers outside the United States, are most welcome. This edition of Recent Literature was compiled by Margaret Griffiths.

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If your e-mail has changed, or is incorrect, or if you notice any other errors please contact me by e-mail with the corrections. A complete updated e-mail directory will be published in the first issue of each volume. The last published directory was in volume 41: No.1, Spring, 2000.

Thank you, G. Roy Horst. e-mail is: **horstgr@potsdam.edu**

BOOK REVIEW

Bats of Papua New Guinea.

Bonaccorso, Frank. 1998. Conservation International Tropical Field Guide Series. Conservation International, Washington, D.C. price: $40.00 University of Chicago Press

As Curator of Natural History at the Papua New Guinea National Museum and Art Gallery, and the author of numerous articles on the physiology and ecology of tropical bats of both hemispheres, Frank Bonaccorso is uniquely qualified to write a book on the bats of Papua New Guinea. And, indeed, he has written a marvelously useful and attractive field guide that supplies the detailed information on bats that is tantalizingly sparse in Tim Flannery's broad-brushed books, Mammals of New Guinea, and Mammals of the South-West Pacific and Moluccan Islands.

Introductory sections of Bats of Papua New Guinea include analyses of the bat fauna by diet, body size, and elevational distribution, as well as a comparison of bird and bat size classes. The natural history sections of the species accounts are a mine of information. For example, in the megachiropteran accounts we learn of male lactation in Pteropus capistratus, and that several species of the genus Pteropus supplement their mineral nutrition by drinking seawater. Further, it is noted that Pteropus gilliardorum are attracted to the squeaks of an Audubon bird call. Included are hard-to-find standard measurements and body mass data, much of these from the author's extensive
field work. The species accounts also contain identifying features, geographic ranges, conservation notes, complete locality records and lists of specimens examined.

Keys to major groups and to species are included. These are clearly written and rely on characters useful to the field biologist. Identification is facilitated by many line drawings, and by a glossary. Distribution maps accompany the species descriptions, and show all locality records in Papua New Guinea. A quick scan of these reveals that most species are known from fewer than two dozen localities, and many from only half a dozen. This should be a clear invitation to biologists interested in the systematics and ecology of tropical bats.

One of the few errors in the book is that the legend for Fig. 1.6 (p25) should refer to elevation, not body mass. A second error occurs in the range map for Pharotis imogene (p 356). The locality shown in Western Province should instead be in Central Province, along with the other two known localities for that species.

Fiona Reid's color plates include twenty-four of the thirty-four megachiropterans and thirty-four of the fifty-seven microchiropterans known from Papua New Guinea. These illustrations are quite up to the high standards set by those in her Field Guide to the Mammals of Central America and Southeast Mexico, and like those, their accuracy makes them very useful in identifying specimens in hand. I find fault with only one: based on my experience, the head and mantle of Dobsonia minor are too pale as shown.

Frank Bonaccorso has achieved a remarkable blend of style, substance and accuracy in this ambitious book. It should be owned and treasured by tropical biologists of all kinds.

J. R. Winkelmann, Department of Biology, Gettysburg College, Gettysburg, PA 17325

The Bats of Papua New Guinea by Frank Bonaccorso can be ordered from:
Steve Wing Curator of Mammals, Riverbanks Zoo, P.O. Box 1060 Columbia, SC 29202
Or from: The University of Chicago Press, 5801 South Ellis Avenue, Chicago, IL 60637

Future Meetings Concerning Research and Conservation of Bats Around the World

SEPTEMBER 1-3, 2000.

The Bat Conservation Trust -National Bat Conference

will meet 1st - 3rd September, 2000 at The Queen's University, Belfast, Northern Ireland. For information and registration materials contact: Marie-Claire Edwards, The Bat Conservation Trust, 15 Cloisters House, 8 Battersea Park Road, London, SW8 4BG. Tel: +44 171 627 2629 FAX: +44 171 627 2628 E-mail: enquiries@bats.org.uk

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SEPTEMBER 27-30, 2000.

The 30th Annual North American Symposium on Bat Research

will meet at the University of Miami, Miami, FL September 27th to 30th, 2000 for information and registration materials contact:

Thomas A. Griffiths, Department of Biology, Illinois Wesleyan University, Bloomington, IL 61702
E-mail tgriff@titan.iwu.edu tel. 309-556-3230

PLEASE NOTE: All subscribers to Bat Research News are already on the Symposium mailing list and will receive registration forms by June 15, '00.
Tom Griffiths has created a comprehensive web-site with all details of the symposium at: NASBR.com

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NOVEMBER 6 – 10, 2000

Vth National Congress of Mammalogy

will meet in Merida, Yucatán, Mexico. The conference details can be obtained from:
M. en C. Javier Enrique Sosa Escalante at e-mail: mastoyuc@tunku.uady.mx
The conference language will be Spanish

* * * * * * *

MARCH 29-APRIL 1, 2001.

A Special Conference on *Myotis sodalis*

The Indiana Bat: Biology and Management of an Endangered Species will meet 29 March to 1 April, 2001. The Northeast Bat Working Group and the Southeastern Bat Diversity Network will host a symposium on the biology and management of the Indiana bat, from 29 March to 1 April 2001, at the Radisson Hotel, in Lexington, Kentucky. The purpose of the Symposium is to aid in recovery of the species by fostering dissemination of information among academic biologists, environmental consultants, and resource managers. This Symposium will consist of invited papers, as well as submitted papers and posters, dealing with any aspect of the ecology, behavior and natural history of the Indiana bat, in summer or winter. The proceedings of the Symposium will be published with Allen Kurta as editor. The meeting will

begin with arrival of attendees and informal social activities on Thursday, 29 March, and end with an optional field trip to the Daniel Boone National Forest on Sunday, 1 April. Oral presentations will be given on Friday and Saturday, and a poster session and social will be held on Friday evening. The local host is Michael Lacki, and the organizing committee consists of Sybil Amelon (U. S. Forest Service), Bob Currie (U. S. Fish and Wildlife Service), Alan Hicks (New York Sate Department of Environmental Conservation), Jim Kennedy (Bat Conservation International), Dennis Krusac (U. S. Forest Service), Allen Kurta (Eastern Michigan University), Michael Lacki (University of Kentucky), and Annette Scherer (U. S. Fish and Wildlife Service). The call for papers will be issued, along with more detailed information on registration, housing, etc., in spring 2000.

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JUNE 2001.

The American Society of Mammalogists 81st Annual Meeting

will meet in Missoula, MT.

AUGUST 2001.

12th International Bat Research Conference, Bangi, Malaysia

will meet in Bangi, Malaysia Host: Dr. Zubaid Akbar For additional information contact Dr. Akbar at Dept. of Zoology, FSH, University Kebangsaan Malaysia 43600 UKM Bangi, Malaysia
e-mail: zubaid@pop.jaring.my

AUGUST 12 – 17, 2001

Eighth International Theriological Congress

will meet in Sun City, South Africa. For additional information contact: Sandra Collier, 8th ITC Congress c/o Event Dynamics, P.O. Box 411177, Craighalla, 2024 Johannesburg, S.A.
e-mail: sandra@eventdynamics.co.za

OCTOBER 2001.

The 31st Annual North American Symposium on Bat Research,

Will meet in Victoria, BC, Canada Host: R. Mark Brigham

AUGUST 2002.

Ninth European Bat Research Symposium,

will meet in Le Havre, France.

NOVEMBER 2002.

The 32nd Annual North American Symposium on Bat Research

will meet in Burlington, Vermont. Hosts: William Kilpatrick and G. Roy Horst

If you know of other meetings, large or small, concerning any aspect of Bat Biology , please send us the details for inclusion in the next issue. Thank you. G. Roy Horst

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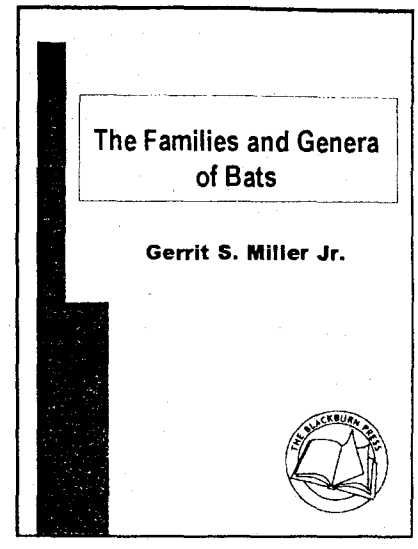

The Families and Genera of Bats

By Gerrit S. Miller Jr.

First published in 1907 by the Smithsonian, this classic has long been out-of-print and very difficult to find.

It is a classification of the families and genera of bats, based primarily on skeletal and dental identifiers and was based on Miller's extensive travels and study of the *Chiroptera.*

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BAT RESEARCH NEWS

Volume 41 **Summer 2000** **Number 2**

Contents

Front Cover

It seemed fitting that a bat on a postage stamp should represent our efforts at keeping our publishing costs to a minimum. As you learned from the flier insert in this issue, an electronic version of Bat Research News will be available to those who have the facility for on-line reception. This may be the last stamp you see!

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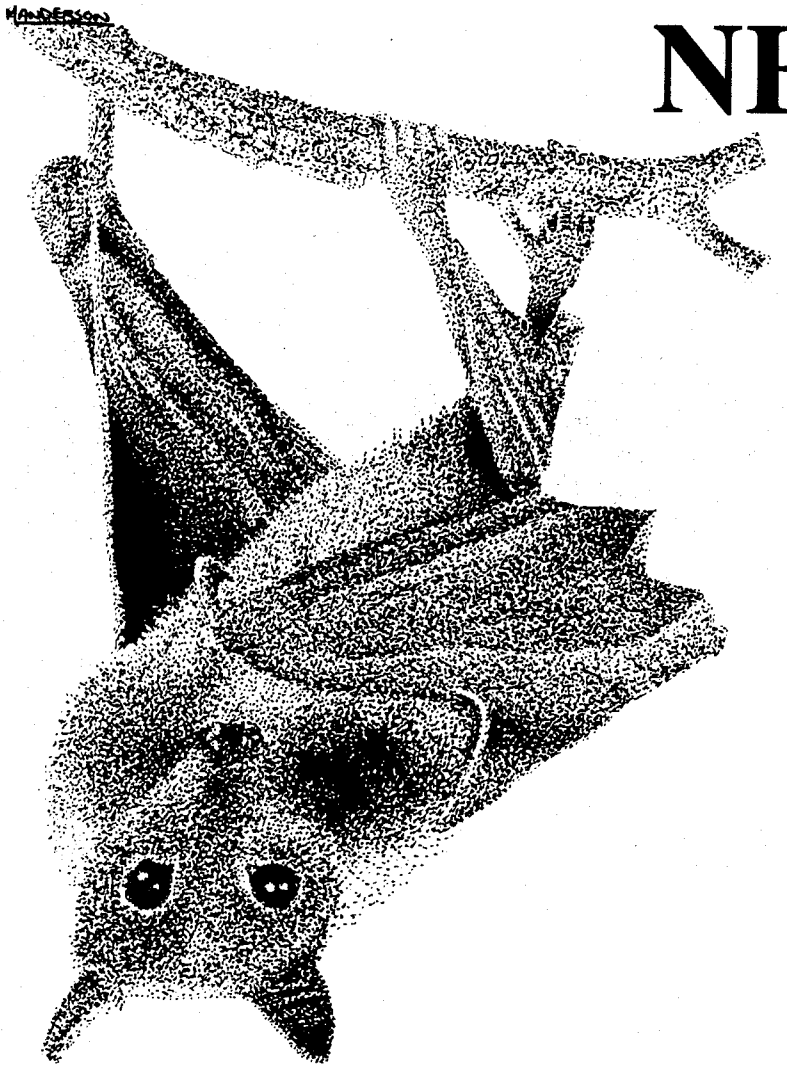
BAT RESEARCH NEWS



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Ectoparasites Observed on Northern Long-eared Bats, *Myotis septentrionalis.*

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During May-August 1993-1994, we studied summer roosting ecology of northern long-eared bats (*Myotis septentrionalis*) in the White Mountain National Forest in northern New Hampshire (Sasse and Pekins, 1996). Using mist nets placed over forest roads and trails, we captured 75 individuals (45 female, 30 male), all of which were inspected visually for ectoparasites. Thirteen adult females and one juvenile male were infested with the batbug, *Cimex adjunctus*. Most parasites (86 %) were found behind the ears of the bats, whereas the others were on the wings. Fifty-seven percent of infested bats had only one batbug, and the remaining had two. Rates of infestation among females during early summer (41%, May and June) were nearly double the rate observed after maternal colonies dispersed in July and August (21 %). It was possible to identify the sex of nine batbugs (seven male, two female).

As part of the larger radiotelemetry study of bat-roosting ecology (Sasse and Pekins, 1996), 12 female northern long-eared bats that had been infested with batbugs were fitted with transmitters and tracked to their roost trees. Mean maximum colony size at the 13 roosts where bats were observed during evening emergence counts was 16 (range = 2-36bats). Four roost trees used by infested bats—three beech (*Fagus grandifolia*) and one sugar maple (*Acer saccharum*)—were used on multiple occasions by radiotagged individuals. In 1993, two uninfested females were tracked to one beech, whereas in 1994, two other females from this roost had been captured with batbugs. Another beech roost had one of two bats infested in 1993 and two of five were infested in 1994. One of three females found at a third beech and two of three bats that used the sugar maple harbored batbugs. These roosts represent four of the five roosts with the highest exit counts observed in the larger study (27-36 bats) and may be representative of infestation rates of *M. septentrionalis* primary maternity roosts.

Our data concurred with the general assumption that bat ectoparasites are more often found on females than males of colonial roosting species because the concentration of bats in one location makes it easier for the parasite to locate new hosts. Ectoparasites occur less on males because they tend to roost by themselves or in small groups (Marshall, 1981). Most cimicids spend their lives in the roosts of colonial species and do not seem to affect adversely the health of the host. *C. adjunctus* is one of the few ectoparasites that has been found attached to bats in flight and is commonly seen on *Eptesicus fuscus*, *M. lucifugus*, *M. sodalis*, and *Nycticeius humeralis* (Usinger, 1966; Marshall, 1982). The only previous report of this species of parasite on *M. septentrionalis* comes from Indiana, where Whitaker (1973) inspected 33 bats and found one male infested with this batbug. We thank A. Eaton, University of New Hampshire for identification of parasites.

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Ametrida centurio Visiting Flowers of *Parkia pendula* (Mimosaceae) in Brazil

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Introduction

Parkia pendula (Mimosaceae) occurs in the Neotropics from Honduras to southeastern Brazil (Hopkins, 1986). It is a tree growing to 40 m and has traits associated with a "chiropterophilous pollination syndrome," including pendant flowers displayed in a flattened crown and an abundant production of nectar during the first half of the night (Hopkins, 1984; Fischer, 1999). *P. pendula* blooms in central Amazonia from June to August (Fischer, 1999), with individual flowers lasting 2 weeks; about 150-200 flowers open every night on each plant over the blooming period. Fischer (1999) estimated that this species has an average density of only one individual per 10 ha in Reserva Ducke, Brazil, making it relatively rare. The purpose of our study was to document the types of bats that visited the flowers of *P. pendula* in central Amazonia, Brazil.

Methods

We caught bats at a flowering individuals of *P. pendula* during the nights of the 10-14 August 1999 at the "Reserva km 41" of the Projecto Dinámica Biológica de Fragmentos Florestales (PDBFF, INPA/Smithsonian), 80 km N of Manaus (02° 24'S, 59° 52'W). The study site is a "terra firme" lowland tropical rainforest, with very high species diversity (Oliveira, 1997).

To catch bats, we used a mist net (10-m long and 2.5-m high) hung in the canopy, about 28 m above the ground and at the same height as the flowers. We lowered and checked the net every 40 minutes. The net was positioned in the canopy for a total of 42 hours over the 5 nights. The net had to be removed during rain and thus capture time varied between nights (Table 1). Each captured bat was identified and time of capture, sex, weight, and other measurements were recorded. When pollen was present, it was collected with sticky tape and identified under a microscope using a photographic reference collection.

Results and Discussion

We captured a total of 22 bats from five species belonging to the phyllostomid subfamilies Phyllostominae or Stenodermatinae (Table 1). Thirteen of these had pollen of *P. pendula* present on their bodies. Fischer (1999) showed that peak nectar production occurred between 2100 and 2300 hours, and we noted that most bat activity occurred before midnight, with the highest peak between 2200 and 2300 hours. The few bats collected after midnight did not have pollen on their bodies and, thus, probably were not landing on the flowers.

Prior to our study, species of bat recorded as visitors to flowers of *Parkia pendula*, included *Phyllostomus discolor*, *P. elongatus*, *P. hastatus*, *Carollia perspicillata*, *Artibeus lituratus*, *Koopmania concolor*, and *Uroderma bilobatum* (Carvalho, 1961; Hopkins, 1984; Fischer, 1999). Hence, *A. centurio* is the only one of the five species that we captured that was not previously known to visit flowers of *P. pendula*, and in fact, it has not been reported to visit flowers of any species before. This bat has no obvious adaptations for nectar feeding (e.g., elongate rostrum, vibrissae, long tongue), but Brosset and Charles-Dominique (1990) also reported *A. centurio*, close to blossoming Mimosaceae in the forest canopy of French Guiana. Thus it is possible that *A. centurio* is an opportunistic species that feeds upon nectar when this resource is abundant. However, its morphology and a few recorded observations suggests that fruits are an important item in the diet (Gardner, 1977; Eisenberg, 1989; Lee and Dominguez, 2000), although there is little information available on its specific dietary habits. It is a rare species of bat throughout its distribution (Lee and Dominguez, 2000), occurring in evergreen forest, near streams, lowland rainforests and adjacent clearings and forest edges (Emmons, 1997; Reid, 1997; Simmons and Voss, 1998).

Hopkins (1984) and Fischer (1999) found that *Phyllostomus discolor* was the most abundant visitor to *P. pendula*, classifying it as the principal pollinator of this species. Although *P. discolor* is present at Reserva km-41 (E. Sampaio pers. comm.), we did not record it during our fieldwork. *A. centurio* was the most common visitor, and all seven individuals had pollen on the ventral part of the uropatagium and on the toes, i.e., the same location reported for other bat species described by Hopkins (1984). We collected a single fecal sample, in which the only solid material present was pollen. Our observations represent the first record of *A. centurio* visiting flowers, and the first record of it feeding on both nectar and pollen of *Parkia pendula*.

Acknowledgments

We thank Marcelo, Juruna, and Eduardo Venticinque for all their help and all the members of the team who came to the tree each night. J. Arroyo-Cabrales, G. Barrantes, R. K. LaVal, R. M. Timm and M. Tschapka provided helpful suggestions. We also thank the Ecologia da Floresta Amazônica course (Instituto Nacional de Pesquisa da Amazônia and Smithsonian Institution, PDBFF, UNICAMP, OTS) for financial support.

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Table 1. Species and number of bats captured on each night.

	Captured individuals							Animals with Pollen
Species \ Date	10 Aug	11 Aug	12 Aug	13 Aug	14 Aug	M/F	Total	
Ametrida centurio	0	1	2	2	2	0/7	7	7
Artibeus lituratus	0	1	3	1	1	1/5	6	3
Koopmania concolor	0	1	1	1	4	2/5	7	2
Phyllostomus elongatus	1	0	0	0	0	1/0	1	1
Phyllostomus hastatus	0	1	0	0	0	0/1	1	0
Total Caught per Night	1	4	6	4	7	4/18	22	13
Capture effort (hours)	3	11.5	11.5	4.5	11.5		42	

Pollen= pollen on body, M= males, F= females

Book Reviews

Churchill, S. 1998. Australian Bats. New Holland Publishers. 230 pp.

Reviewed by
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and Department of Botany, University of Queensland, Brisbane, 4072 Australia

Overall, this is a wonderful little book that we heartily recommend to amateurs and professionals alike. Although there are field guides to bats of various regions of Australia, this is the first to cover all of Australia, including its island territories. For those headed to this remarkable continent, buy a copy before you go. Not only will you learn a thing or two about the continent's bats, but also you will pick up a bit of Aussie vernacular in the bargain. The book retails for $30 Australian, but it is not always readily available there, so we recommend purchasing it before departure. In 1999, we paid only $26 US for a copy at the North American Bat Research Symposium in Madison, Wisconsin.

Sue Churchill is uniquely placed to write a guide to the bats of Australia. She has a huge amount of survey experience, including completion of the first Australia-wide survey of bats almost 20 years ago. Most of this work has been in central and northern Australia, where gaps in knowledge about bat distribution and biology are considerable. In addition, she has carried out detailed research on the ecology and distribution of several species, most notably the orange leaf-nosed bat and ghost bat.

Like many recent bat guides, there are three basic sections to the text. About 50 pages are dedicated to an introduction, which includes sections on bats' unique features, roosting, diet, foraging, reproduction, echolocation, beliefs and misconceptions, disease, and catching and handling. Right up front, Churchill lets the reader know what the purpose of the book is and how to use it. It was a nice touch to include her address so that new information from amateurs could find its way to her and hopefully into future editions. However, the book does not attempt to link amateur naturalists with an interest in bats with bats themselves. By this we mean that there will be people who read this book and want to be more involved with bats, but they will have no idea how to go about doing so. The address or web site of the Australasian Bat Society would have been a useful start, as would a list of sites where tours of bat roosts are available (there are a variety of such sites around Australia).

The introductory sections on echolocation, beliefs, and disease were excellent. The analogies that Churchill uses make the conceptually difficult topic of echolocation understandable to all. The story of Aboriginal Australians and their relationship with ghost bats was touching, and particularly appropriate given the evolving relationship between Aborigines and Europeans in Australia as the 21st century begins. The disease section provides a balanced account of the potential risks of lyssavirus, coupled with information about just how ignorant we are of these viruses. All this is done without the "lecturing" found in similar volumes.

The second section of the book is a list of species and keys to their identification. Given taxonomic problems surrounding Australian bats, we thought that the keys were exceptionally clear and well done. The idea of having separate keys to families, genera (where necessary), and species is good. Due to taxonomic problems with some species and extreme similarities between others, some readers undoubtedly will find the task of keying out species to be intimidating, but this is certainly not Churchill's fault. Having personally tried to differentiate among *Vespadelus* based on shape of the glans penis, our only criticism is that the author should have encouraged workers in Australia to find a) easier characteristics to differentiate between species and b) something to distinguish the females!

The last 150 or so pages are dedicated to species accounts. These are short and concise, filling at most two pages each. Each account is always on facing pages, so one never has to flip the page to finish an account. Each outlines the distribution of the species both in Australia and overseas and is followed by a description of the species with key discriminating characteristics highlighted in bold. When data are available, there are sections on roosting, habitat, diet and foraging, reproduction, and notes of special interest. These notes are useful and illustrate how much work Churchill has done on bats, but occasionally, the personal touches go a bit too far. For example, *Hipposideros ater* is decribed as "perhaps the most delightful Australian species." Not only is this highly subjective, but exactly what does "delightful" mean? The species accounts conclude with data on a variety of characteristics, including body mass and forearm length. Much of this is the author's own data, and it is a welcome addition to the literature. All accounts have a distribution map (the scale is perfect and we like that only the current distribution is shown), and most have a photograph. Most photos are excellent, although, unfortunately, the ones that are poor (pp. 117, 121, 123, 139, 151, and 187) belong to the author. What is more disappointing is that some good cropping could have made most of these photos acceptable.

Australian Bats is remarkably free of errors or inaccuracies. The ones we spotted are mostly minor in nature and concentrated in the introduction. The term "weight" is used throughout, even though "mass" is the correct term. At one point, the author encourages readers to keep specimens to confirm records, but this might lead to more bats being killed than is necessary. Churchill states that Chiroptera is the most abundant order of mammals on the planet, but sadly, we must give top spot to the rodents, although bats do get the silver! In the flight section, Churchill states that "it appears" that flight evolved twice in the Chiroptera, and thus, betrays her support for the diphyletic hypothesis of bat evolution; however, we feel that diphyly should have been presented as a hypothesis, not as fact. In the reproduction section, Churchill could have put the reproductive strategies of bats into a more solid evolutionary framework (it is a shame she did not use the same magic as in the echolocation section to explain evolution), rather than passing off adaptations as "ingenious solutions." Finally, although it may happen, we are not aware of substantial evidence suggesting that newly fledged young follow mothers to foraging sites as a means of learning, yet Churchill presents this as a fact.

There also are a few problems in the species accounts. In the account for *Syconycteris australis*, as well as the literature cited, "Geiser" is misspelled. Further, we were surprised not to see greater reference to the substantial work that Brad Law has done on this species. The call frequencies of the two subspecies of *R. philippinensis* are mixed up; the larger form has the lower frequency call. Finally, in the account for *Chalinolobus morio*, Churchill invokes competition as the explanation for the timing for entry into and arousal from hibernation. Again, although this may be true, we are unaware of strong evidence for direct competition for food between insectivorous bats.

If this book has a real weakness, it is the way that it handles the systematics of Australian bats. Nowhere is it clearly stated that the systematics of Australian bats is a work in progress, although others might use the term "mess." Although the keys occasionally indicate that taxonomic revision is taking place or that identification of species is difficult, no mention is made of the likelihood that two-thirds of the recognized bat species in Australia need taxonomic clarification (Parnaby, 1991, Duncan et al., 1999).

In a number of places, it is unclear why Churchill follows particular taxonomic schemes. First, although Churchill rarely mentions subspecies in the accounts, she provides separate accounts for each of two subspecies for both *R. philippinensis* and *Hipposideros diadema*. Clearly the author feels that these taxa deserve full specific status, but this is not explained clearly or justified. Second, in her coverage of Australian *Myotis*, Churchill ignores recent work indicating that at least two (and possibly three) species of *Myotis* are present in Australia. Although she mentions this possibility, Churchill only recognizes *Myotis adversus*. Given that many workers currently recognize *M. macropus* and *M. moluccarum* as Australian species, this choice will cause confusion for foreign visitors. Another unsupported decision is use of *Dobsonia magna* for bare-backed fruit bat rather than *Dobsonia moluccensis magna*.

Overall, we highly recommend this book to anyone who lives in Australia or who is going there. Even if you have no plans to visit, this volume will give you an excellent feel for the fabulous bat fauna Down Under. Churchill is to be highly commended for her efforts and all of those contemplating similar volumes for other parts of the world would be well advised to use this book as a model.

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Neuweiler, G. 2000. The Biology of Bats.

Oxford University Press, Oxford. Translated from the German by E. Covey 310 pages.

Reviewed by

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

Anyone looking for a good and thorough introduction to the biology of bats should have this book on their shopping list. As indicated in the Preface, however, the book is intended as a text for students and is the information is presented accordingly. After a brief Preface and Introduction, there are 10 chapters dealing with: 1) functional anatomy and locomotion; 2) circulatory and respiratory systems; 3) heat and water balance; 4) diet, digestion, and energy balance; 5) central nervous system; 6) echolocation; 7) vision, olfaction and taste; 8) reproduction and development; 9) ecology; 10) phylogeny and systematics.

The combination of subheadings and an effective index make **The Biology of Bats** easy to use. The presentation of bibliographic references at the end of each chapter facilitates tracking down the sources of the information that is presented (the sources are not cited in the text). Two other features make the book particularly useful. First abbreviations are clearly defined. Second extensive use of graphs, tables and other figures which are well articulated with the text makes it easy for the reader to appreciate and understand the information that is presented. The sources of graphs, tables and other illustrations are usually presented.

The chapter on echolocation (> 60 pages) dominates the book, reflecting the author's fascination and experience. Echolocation is presented primarily from the bat's standpoint although the business of hearing-based defenses in insects is briefly covered. The information in most chapters is presented thoroughly without exploring the full range of diversity that one encounters in bats. I was pleased to see that the question of the monophyly of bats was left as an open topic rather than dismissed as a resolved one.

Although Professor Neuweiler indicates that the production of the English version allowed him to update the earlier edition, there are several recent discoveries that I did not find covered in the book. For example, the role of folivory in the diets of bats, lactation by male bats, the discovery of a cryptic species of *Pipistrellus* in the UK, the documentation of the costs of arousal from hibernation in *Myotis lucifugus*, and the description of ultrasonic nectar guides in the flowers of some bat-pollinated plants.

The book would be more useful if it presented a more thorough catalogue of sources of information about bats. This could have been a more comprehensive listing of general books about bats or a presentation of web sites where the interested reader can find out more about bats and the instruments for studying them.

I highly recommend this book to anyone who is interested in bats or who is about to embark on bat research.

News and Letters from our Readers

From Talmaza, Moldova

[Herman Limpens sent me the following account of his trip with Peter Lina to Moldova and asked that I share their adventure with all of you. GRH]

The fifth Bat Detector Training Workshop for colleagues in south east Europe in 2000 was held in Moldova from July 5th until July 10th (2000). Local organizers were Sergiu Andreev and his colleagues from the Grupul Fauna and Angela Sochirca from the International Relations Division of the Moldovan Ministry of the Environment and Territorial Development. Olga Kiseliova from the Moldova State University did most of the translation work and Peter Lina accompanied me and assisted in the workshop. 10 Moldovan bat workers (zoologists and students) and two people from a radio station took part.

On the 6th of July we traveled with two small busses in the direction of Talmaza about 100 km's to the south east of Chisinau. A long and hot journey over sometimes difficult roads brought us to the border of the floodplain of the Dniester River. The people of the village hosted us. The mayor of Talmaza and the school's principal – a biologist - welcomed us and organized everything. Lectures and discussions were at the local school, where some very friendly people of Talmaza also took care of all the meals. Lodging was at the peoples' houses. Although communication constantly needed a translator, there was a warm contact and we were very well taken care of. It could not have been better.

In the evening we went to a beautiful floodplain forest directly by the Dniester which was going to be our field site for the workshop. Part of the flood plain was excluded from the river by dikes and destroyed by agriculture. The margins of the river were still quite natural, although through regulation of the river the natural dynamics, which once must have been the developing force behind this beautiful forest, were now no longer active. It was good to hear that a GEF-project was proposed to restore and develop the natural site along the river and the water management, and even try to get flooding in the agricultural area again. Our data on the bats could be of some help to demonstrate the value of the area. The journey to the river with a large bus with 'off the road' tires was an adventure in it self again. We were quite late because travelling was difficult and just took time. The new detectors for Moldova were unpacked and stocked with batteries while bouncing over muddy field roads. Upon leaving the bus we were immediately greeted by noctules (*Nyctalus noctula*) flying over our heads. We immediately started to practice tuning.

Serotines (*Eptesicus serotinus*) were discovered and enhanced our training opportunities. At the forest edge we found *Pipistrellus* species. On 38 kHz in the open, on about 40 kHz closer to the forest. Some Pipistrelles (*Pipistrellus*) passed by to show us that this species is on about 45 kHz. So these '38 kHz' pipistrelles were *Pipistrellus kuhlii*. Kuhl's pipistrelles are hardly known from Moldova; we found many. It became necessary therefore to try and find roosts and catch some animals. Later, on the river bank, again in the open, we found a few Nathusius' pipistrelles (*P. nathusii*) with QCF-frequencies (best listening frequencies) on 35 kHz and their typical two syllable social call. Again adding evidence that those on 38 kHz must be something else i.e. Kuhl's pipistrelles.

The first rain since April - came up and we sought shelter inside the forest. Upon entering the forest this other pipistrelle - expected but not yet recorded in Moldova, the Pygmy pipistrelle - was heard. Everybody was excited, everybody tuning and experiencing where one gets it and where one doesn't. I made TE recordings for later analysis and evidence. In the shelter of the trees also Whiskered Brandt's bats (*Myotis mystacinus brandtii*) were observed and differences to the 'tonal quality species' we heard before were studied. We had to pause for some time because of the heavy rain and strong wind. After the storm had settled the night was quiet, warm and humid. Excellent for mosquitoes who fed on us – despite the repellent - to later on feed the bats. So we had nothing to complain about, really. We tried the river and found a lot of Daubenton's bats (*Myotis daubentonii*), among which we sometimes thought we observed a bigger and faster bat - possibly the Pond bat? No clear evidence for them however. Towards the morning we entered the forest again. A lot of Pygmy pipistrelles, but no other species. Then we heard loud social sounds and started working our way through the vegetation of the track. We found a large white popular tree, which was broken and bend over at a height of about 6 meters to form an arch. At the bend of the arch small bats where swarming with relatively dry FM sounds. Whenever a bat was further away from the tree tonal quality appeared on about 55 kHz: Pygmy pipistrelles! They went in and out at the many small crevices in the tree exactly at the bend. Plans for catching some the next evening were made. We went on to find two other trees - again giant white poplars - which, judging from the social sounds heard from the tree, housed noctules.

On the evening of the 7th of July we were in the forest early to set up mist nets and to fabricate a hand net on a 5 m long stick. Two groups were sent off to check on and count the emerging Noctules. A small party stayed with the mist net. And I handled the hand net under the bent in the poplar tree from which we hoped to catch Pygmy bats. We were waiting for the bats and somehow surviving the mosquito attacks. Awful! Then the bats started to emerge and the mosquitoes were forgotten for a while. After about 5 bats came out, I gently held the net just below a crevice from which one of them had just emerged. Now, of course, the next bats emerged from other crevices. But eventually one jumped in the net. The net was carefully lowered to Sergiu and Peter who took the bat out, and then the net was brought in position again and soon second bat was captured. Both were lactating pygmy pipistrelle females. This was the first record of this species and the first maternity roost of this species in Moldova, and the first maternity roost of this species found in a tree. Sergui and I continued counting the bats - while waving our hands around our heads to drive away the mosquitoes. During the time that the net was lowered and the bats were handled, the counting was less accurate, so the number of 166 between 21.00 hours and 21.55 was the minimum number of adult Pygmy bats in this tree. Wow! The other groups returned and reported 17 and 24 emerging noctules. They all had a look at the Pygmy bats that were then quickly released. Hiking along the river and through the forest brought us the same species as the previous night again. In the morning a small group of us - it is hard to stay awake all night in the field - tried to find flight directions of returning Daubenton's bats on the river. They all headed for the forest. An now suddenly there definitely were bigger and very fast bats among the bats passing over the water, with their best listening frequency at 35 kHz. Some of the very typical tonal quality 'Pjiep poup pop' sounds gave them away: Pond bats (Myotis dasycneme). A pity that not everybody had seen them.

In the late afternoon of July 8th we were at the river early for a traditional shaslik meal with the mayor, the school's principal and the people that hosted us. It was great. Good food in a beautiful floodplain forest. Looking at kingfishers, bee-eaters and rollers. We were planning to stay one more night in this forest with all its bats. At the end of the meal a thunder storm and strong rains came. We had to hurry to get out of the flood plain before the roads would be so muddy that the bus would get stuck. It poured all our slippery way back to the village. But then the sun broke through again and under the rainbow we decided to concentrate at the village bats. The flood plain was too inaccessible to return at the moment. The school's housekeeper showed us a spot were droppings were found. Here we counted 25 emerging serotines and caught a sub-adult male. We started wandering through the village and had some very short contacts with Pipistrelle species around 40 kHz, too short a time to really identify them. New thunderstorms and rain came and we all fled to our beds and were too tired to be bothered by the thunder and lightning and unbelievable rain which poured all night. The next morning, on Sunday we now had

more time to finish the last bits of theory and have a round table discussion on the future of bat conservation in Moldova. A challenge which now, through the contacts established with the Moldovan bat workers, has become - at least a little bit more of a challenge for the whole network of European bat workers. Respectfully, Herman Limpens

Announcements

To Readers of Bat Research News

I want to let everyone know that the BCI Literature Database has just been updated on our webpage. The database contains bibliographic references to over 9000 journal articles, agency reports, books, theses, dissertations, symposium abstracts, posters, brochures, and other materials relevant to bat science and conservation. You can run keyword searches on any word, including date, author name, or journal. We have tried to add keywords to each record to facilitate searching by topic.

This database is by no means exhaustive, nor complete. I have a stack of papers several feet high waiting to be entered, but we're getting to it as fast as our volunteers can type!

Go to: http://www.batcon.org for our main web-page, then down the side navigation bar to Literature References. Or, the direct link to the database is:

http://www.batcon.org/bibsearch.html

If you have trouble accessing the database or with the searches, e-mail me. If you see any errors or misspellings, please email the details to me, and we'll try to get them fixed in the main in-house database. I'll try to keep up with updating the on-line version every few months.

If you don't see something you wrote, please email me with the date and title, so I can check the Waiting-to-be-Entered stack (it is sorted by year, and we're doing the most recent years first). If we don't have it, I will ask you to send us a copy.

Happy searching, Angela England, Educational Resources Coordinator
Bat Conservation International, PO Box 162603 Austin, TX 78716-2603 U.S.A.
Phone 512-327-9721 FAX 512-327-9724 aengland@batcon.org

Scholarships

Student Scholarships for Bat Conservation Research

Conservation International hereby announces the availability of student research scholarships. Approximately 15 grants ranging from $500 to $2,500 will be made in 2001. Grants will go to research that best helps document the roosting and feeding habitat requirements of bats, their ecological or economic roles, or their conservation needs. Students enrolled in any college or university worldwide are eligible to apply. Projects must have bat conservation relevance. **The application deadline for 2001 scholarships is 15 December 2000.**
Application information and forms are available on our web page at
<http://www.batcon.org/schol/schol.html>http://www.batcon.org/schol/schol.html
or write to
Bat Conservation International, Student Scholarship Program, P.O. Box 162603, Austin, TX 78716
or email: aengland@batcon.org

Equipment Grants

Sandpiper Technologies, Inc. is accepting grant applications through December 31, 2000. The company offers three types of grants to wildlife biology graduate students:

1) Equipment Grants.
   Students receive the STI rental equipment free of charge for one full field season.
2) Equipment Discount Grants.
   Equipment is sold to graduate students or universities at a discount.
3) Cash Grants
   Information about how to apply for the grant is available in the grants/rentals section of the STI website: http://peeperpeople.com.

Formerly operating as Christensen Designs, Sandpiper Technologies develops wildlife research equipment and specializes in burrow probes, underwater and elevated video systems and time-lapse surveillance devices. For additional information contact:
Sandpiper Technologies, Inc. 535 W. Yosemite Ave. Manteca, CA 95337 Phone: (209) 239-7460
Email: Ann@peeperpeople.com. Specializing in research equipment, video systems and innovative Designs. Ann Christensen

Acta Chiropterologia

Wieslaw Bogdanowicz has suggested that Bat Research News present a "review" of the new Journal "Acta Chiropterologica". While one does not ordinarily review a journal, it was agreed to prepare an "evaluation or description" instead. This would hopefully inform some of our readers about the existence of this excellent new scholarly publication.

Volume 1, No.1 of Acta Chiropterologica first appeared in August 1999 as the first of two issues in each annual volume. Volume 1: No.2 has also been published in late 1999. Volume 2: No. 1 arrived in September, 2000.

The frontispiece of the initial issue contains (in part) the following introduction: *"Acta Chiropterologica will publish reviews, full-length papers, short notes (limited to four printed pages), opinions, technical comments, book reviews, short announcements, and advertisements. It is my dream that each issue will include an invited article that addresses current trends in some area of bat biology. Manuscripts will be considered for publication in all areas of study, without taxonomic or geographical biases. Two issues of Acta Chiropterologica are planned for publication each year. Plans are being made to index the journal in several bibliographic data bases. A website for the journal will be listed in the next (December) issue"*. [signed: Wieslaw Bogdanowicz].

The Editorial Board contains 21 biologists whose names read like a "Who is who" of Chiropteran biology worldwide. With these esteemed individuals responsible for the editorial excellence of the papers presented, it can be assumed that articles will be of the highest quality. It is remarkable that of the 20 full-length papers in the Volume 1, seven are authored or co-authored by members of the board. An additional two articles are by students or former students of the board members. This demonstration of confidence bodes well for the reputation and future of the journal, and assures that the following articles will continue to meet the high standards established by the first volume.

The introduction (cited above) expressed hope that not only full-length articles would appear but also reviews, short notes, opinions, technical comments and book reviews would be included. The first three issues contained 29 full-length feature articles but only one book review, the announcement of one scholarship, and the announcements of two meetings. Hopefully as the journal continues to mature, such articles as short notes, opinions, and technical comments will begin to appear as well.

When a new journal appears there is often the question as to what special directions of interest the journal will take as it develops: Will it become weighted in some particular direction and favor some special area, such as *ecology*, and slight some other area as *development* or *physiology*? The wide range of articles by sub-discipline, so far, is impressive for such a small number of titles. Comparison of these 29 articles with the most recent 535 references in the Recent Literature Section of Bat Research News is interesting and shows good agreement with the current general interests of the world of bat research. The following table was constructed by assigning each article (in Volume 1:1, 1:2, and 2:1) of "Acta" to one of

the large subject categories in the Recent Literature Section of Bat Research News. The table gives a percentage of titles in each of these categories in "Acta" and in BRN's recent literature list, and a "rough" estimate of agreement between these two lists.

Subject	# titles BRN	% of total	# titles Acta	% of total	agreememt*
Anatomy-Morphology	31	5.80	3	10.34	1.784
Behavior	34	5.35	1	10.34	1.934
Conservation	69	12.90	2	6.88	0.535
Development,Reprod.	40	7.48	2	6.88	0.922
Distribution	74	13.83	6	20.69	1.496
Echolocation	17	3.18	3	10.34	3.256
Ecology	121	22.62	2	10.34	0.457
Evolution, Systematics	70	13.08	2	6.88	0.572
Paleontology	15	2.80	1	3.45	1.230
Parasitology, Disease	22	4.11	0	0.00	0.000
Physiology	36	6.73	3	10.34	2.229
Zoogeography	6	1.12	1	3.45	3.075
Total	535	100%	29	100%	NA

*This "agreement" was obtained by dividing the percentage of titles in a given category in "Acta" by the percentage of titles in that same category in the BRN recent literature section. If this agreement figure is much less than 0.500 it would seem that Acta includes fewer of these titles than one would predict. Conversely, if this figure is much greater than 2.0 these topics appear to be favored. However, at least in some cases the number or titles in a group are too small to be significant. Since the numbers for "Acta" are still quite small, this agreement will, in all likelihood, improve with the publication of subsequent issues. Clearly these calculations have "next to zero" significance, but do show an interesting correlation and surprisingly good agreement between these two lists.

The physical appearance of the journal is pleasing. The type size and font is optimal and does not require a magnifying glass for these old eyes. The graphs, tables and illustrations are clear, well organized and easy to follow. Black and white photos are always a publisher's nightmare (separating the light grays from the medium light grays is always difficult) and the quality of these must ultimately rest with the authors. However the resolution of the electron micro-graphs (Bhiwgade,et al) is excellent. The color plates are very well done. The bright yellow cover makes the journal easy to find amid the drab colors of all the other accumulated clutter that characterizes so many of our desks. There was an extra copy available to subject to the "durability test"; it is impossible to tear a page from the binding and the covers remained perfectly attached through rather abusive "testing".

The price at $40.00 (U.S. funds) for individuals is reasonable. It remains to be seen if this price in *euros* can be maintained. Acta Chiropterologica should be required reading for all serious students of bats and their biology. It would make an outstanding gift to that special bat person, whether a full professor, college undergraduate or interested amateur. The web-site is: http://www.miiz.waw.pl

Submitted by G. Roy Horst, Publisher and Managing Editor, Bat Research News

Future Meetings Concerning Bats

March 29th – April 1st, 2001 A Special Conference:

The Indiana Bat: Biology and Management of an Endangered Species

The Northeast Bat Working Group and the Southeastern Bat Diversity Network will host a symposium on the biology and management of the Indiana bat, from 29 March to 1 April 2001, at the Radisson Hotel, in Lexington, Kentucky. For additional information contact the local host, Michael Lacki (University of Kentucky),

June 18th – 22nd, 2001

The American Society of Mammalogists will meet at the University of Montana, Missoula, Montana, U.S.A.

August 5 to 9, 2001

The 12th International Bat Research Conference, Bangi, Malaysia. All information concerning the conference can be obtained at : http://www.ukm.my/ukm/seminar/bat/index.html

August 12 to 17 , 2001

The 8TH International Theriological Congress will meet in Sun city, South Africa. The Organizing Committee is chaired by Professor John Skinner in conjunction with Event Dynamics as the professional Congress organizers. For additional information contact: Sandra Collier, 8th ITC Congress, c/o Event Dynamics, PO Box 411177, Craighall, 2024, Johannesburg, South Africa Tel: +27 11 442 6111 - Fax: +27 11 442 5927 E-mail: Dona Plotz at: www.sandra@eventdynamics.co.za Visit the website at www.eventdynamics.co.za/itc

October 24 to 27, 2001

The 31st Annual North American Symposium on Bat Research will meet in the beautiful city of Victoria, British Columbia, Canada, October 24-27, 2001, hosted by Mark Brigham, University of Regina. All formal sessions of the 31st Symposium will be held at the Victoria Conference Center, which is immediately adjacent (and connected) to The Empress Hotel, one of the grandest, most spectacular hotels in the world. We have obtained outstandingly good room rates for conference attendees at the Empress. Mark has also arranged that our conference banquet will be held in the Crystal Garden. This promises to be a truly memorable symposium. For details see the website at www.nasbr.com

August, 2002

9th European Bat Research Symposium, Le Havre, France

November, 2002

The 32st Annual North American Symposium on Bat Research, Burlington, Vermont

If you know of other meetings, large or small, concerning any aspect of bat biology please send us the details for inclusion in the next issue. Thank you. G. Roy Horst

Abstracts concerning the biology of the Chiroptera presented at the 80th Annual Meeting of the American Association of Mammalogists, 17-20 June 2000 University of New Hampshire

The following abstracts represent those presentations related to the biology of the Chiroptera at the 80th Annual Meeting of the American Society of Mammalogists, 17-20 June 2000, at the University of New Hampshire. The abstracts are arranged in alphabetical order of first authors. These abstracts are presented here with the generous permission of James O. Richman, President and Thomas H. Kunz, President–elect. Any errors in transcription are inadvertent and the responsibility of the Editor. GRH

The utility of hair structure for taxonomic discrimination in bats, with an example from the bats of Colorado

Brian Amman. Dept. Biological Sciences, Texas Tech University, Lubbock, TX 79407.

Hair structure can vary greatly among mammalian genera, and has been used with varying degrees of success as a taxonomic or discriminatory characteristic at the specific level. The objective of this study was to determine whether hair structure can be used as a supplemental taxonomic tool to identify, at the specific level, the bats of a moderate-sized geographic region in mid-temperate latitudes, using the bats of Colorado as the exemplar group. Hair samples were taken from 58 specimens representative of the 20 bat species known or suspected to occur in Colorado, and examined using light and electron microscopy. Measurements of scale length and width, and filament length were analyzed using ANOVA and Fisher's pair-wise comparisons to evaluate differences. The differences in scale form patterns developed by Benedict (1957), as well as scale dimensions, were used as criteria for the construction of a dichotomous key to the identity of Colorado bats. The two Colorado families, Molossidae and Vespertilionidae, were clearly distinguished using scale form, as was *Lasiurus* from the rest of the vespertilionid bats.
m one another.

Phylogenetic relationships among Phyllostomid genera: Data from the nuclear RAG-2 gene

Robert J. Baker[1], Calvin Porter[1], John C. Patton[1], and Ron A. Van Den Bussche[2].
[1]The Museum and Dept Biological Sciences, Texas Tech University, Lubbock, TX 79409;
[2]Dept. Zoology, Oklahoma State University, Stillwater, OK 74078.

As part of a long-range plan to examine the macrotaxonomy of the new world leaf-nosed bats, family Phyllostomidae, we have sequenced approximately 1,400 base pairs from a single exon of the recombination activator gene (RAG-2). Data from 35 genera from the family plus some outgroups produce a tree which includes the following results. *Noctilio, Pteronotus*, and *Mormoops* were used as outgroups. *Macrotus* is basal to all other genera including the vampire bats. *Micronycteris* (sensu Miller) represents two divergent clades. The first clade (includes *schmiditorum, minuta, megalotis, hirsuta,* and *brachyotis*) is basal to most of the other Phyllostomid genera. The second clade (*daviesi, nicefori*, and *sylvestris*) is monophyletic and sister to the genus *Carollia* which is basal to the remainder of the Sternodermatini. Other possible relationships are also indicated including a possible diphyly among nector feeders. The RAG-2 gene is conservatively evolving and many of the supposed relationships will undoubtedly be documented by minimal steps which means that data from other sources (genes as well as non-molecular studies) will be needed for confirmation.

A survey methodology for bats ustilizing ultrsonic and mist net techniques.

Timothy E. Blackburn and Michael Gannon.
Dept of Biology, The Pennsylvania State University, Altoona College, Altoona, PA 16601 and IDGP Ecology Program, The Pennsylvania State University, University Park, PA 16802.

We present a methodology for elucidating the population of bat communities using mist nets and bat detectors that is both quantifiable and repeatable. Previous bat community surveys usually relied on either mist nets or bat detectors, but not both simultaneously. Either method can undersample a community, and

bat detector sampling relied on a qualitative analyses of recorded sonograms. The results of such analyses were often not repeatable and subject to researcher biases. Over three years, more than 150 survey-nights were conducted in northern Pennsylvania, south central Pennsylvania, and West Virginia. From these surveys, a call library of known species was created to allow the use of discriminant function analysis as a statistical means of identifying bat species from their echolocation calls. The accuracy of the methodology in identifying bat species increased both temporally and as the quality of the calls in the library improved. Neither mist nets nor the bat detectors consistently identified all species using any study area. Bat detectors did, however, identify a greater diversity of species and generally identified the species composition earlier than the mist nets alone. Our results provide strong support for the necessity of using both mist nets and bat detectors to accurately identify the species present in bat communities.

Roosting Ecology of *Myotis septentrionalis* in northeast North America.

Hugh Broders, New Brunswick Cooperative Fish and Wildlife Research Unit, and
Graham Forbes, Dept. Biology, University of New Brunswick, Fredericton, NB, Canada.

Roosts are essential for the viability of bats , they provide sites for mating, hibernation, and rearing young as well as providing refuge from predators and inclement weather. The distribution of suitable roosting sites has been suggested to be a factor limiting the distribution of some species. As a result, understanding the roosting ecology of a species is essential for ensuring its viability. We are currently conducting our second of three field seasons on *Myotis sp.* bats in the Greater Fundy Ecosystem of New Brunswick. As part of this research we have located radiotagged bats on 44 days and found 31 roost trees of seven adult male (n=27) and two adult female (n=4) *M. septentrionalis* bats. Males roosted under loose bark of dead or dying *Picea rubens* (16), *Betula alleghaniensis* (4), *Abies balsamea* (3), *Acer rubrum* (2) and *B. papyrifera* (2) and changed trees regularly. Adult females with young used *B. alleghaniensis* (2), *P. rubens* (1), and *A. rubrum* (1). One female, which was located on four days, used three different trees. Unlike females, males roosted alone and seem to be much less restricted in roosting requirements than females. Further work on the roosting ecology *of M. septentrionalis* females is ongoing with the object of determining their roosting requirements and the potential impacts of forestry operations on their viability.

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Hunting of flying fox fruit bats *Pteropus tonganus* on Niue Island, South Pacific Ocean.

Anne Brooke, Newfields, NH 03856; and Marco Tschapka, University of Ulm, Ulm, Germany.

Flying-fox fruit bats, *Pteropus tongamus*, are hunted in an annual two-month season in the small island country of Niue in the South Pacific Ocean. In recent years, the sustainability of this traditional hunt has been questioned. We conducted 63 dusk surveys within a three-week period to determine the location of colonies, two months before the opening of the 1998-1999 hunting season. We estimated the island-wide population, from evening dispersal counts at colonial roosts, to be between 1,900 and 3,555 animals. From interviews with 60 hunters at the close of the hunting season, we estimated that a minimum of 1,555

bats were taken. Flying-foxes are also hunted illegally in small numbers throughout the year. We used three models to assess overhunting, using data from *P. alecto* and other Pteropodid species for longevity and reproductive potential. Although the current rate of hunting is clearly unsustainable, many Niueans believe that an infinite number of bats live in two small "taboo" areas. People are forbidden to enter the taboo areas and believe they will die if they knowingly trespass. The taboo areas originally acted as wildlife sanctuaries as the bat population was an important resource for people in times of famine. However, we saw little evidence of colonies in the taboo areas. The islanders belief that an unlimited number of bats live in the taboo areas is irrefutable because the areas cannot be visited. Consequently, few people believe that the population is being overharvested.

Biogeographical patterns of Chiropterans in Mew Mexico.

M. Scott Burt, William L. Gannon, and Timothy Sanchez Brown.
Dept. Mammalogy, Museum of Southwestem Biology, Dept. Biology,
University of New Mexico, Albuquerque, NM 87131.

Bat surveys were conducted during summers of 1994 through 1998 across New Mexico using traditional trapping techniques and acoustic monitoring methods. One hundred eighty-six mist-netting nights at 115 localities across the state yielded 1744 individuals representing 20 different species (20 out of 21, or 95% of bat species that are known to occur in New Mexico). Captured bats were sampled for ectoparasites, endoparasites, and prey composition by fecal analysis, and basic life-history information (mass, sex, reproductive condition, and length of forearm). Calls were recorded from hand-released and free-flying bats using the Anabat echolocation detection system. Additional data were recorded from surrounding habitat where bats were captured and included vegetative community, temperature, wind, moon phase, precipitation, and cloud cover. Specifically, this paper summarizes 1) geographical distributions of bats captured during the survey period, 2) morphological measurements for 20 species, and 3) ecological and geographical conditions of the "best" and "worst" sites surveyed. We predicted, based upon GIS analyses, where bats might be resident but have not been sampled historically. In addressing the above results, certain caveats in interpretation are addressed, such as sampling bias and effort, as well as whether these data truly reflect the natural history and biogeography of New Mexican bats.

Habitat characteristics of foraging bats in bottomland forests of southern Illinois.

Steve K. Carroll, Tim C. Carter, and George A. Feldhamer.
Dept. Zoology, Southern Illinois University, Carbondale, IL 62901-6501.

Bats were mist-netted for 123 net nights in bottomland forests of southern Illinois, from May through July 1999. Netting procedures followed the Indiana Bat Protocol. Bottomland forest consisted mainly of pin oak, bur oak, green ash, red maple, sycamore, and sweetgum. Nets were set in forest interior (79) or edge (44), and over either water (77) or dry land (46). Nine species and 130 individuals were captured: *Myotis septentrionalis* (58), *Eptesicus fuscus* (19), *Lasiurus borealis* (16), *Pipistrellus subflavus* (15), *Nycticeius humeralis* (10), *M. sodalis* (8), *L. cinereus* (2), *M. lucifugus* (1), and *Lasionycteris noctivagans* (1). Two foraging patterns emerged. *Eptesicus fuscus*, *L. borealis*, and *N. humeralis* were caught predominantly at sites near edges and over water. Understory density at these sites was low to moderate and canopy closure was <60%. These species emerged and foraged at different times. *Lasiurus borealis*, *P. subflavus*, and *E. fuscus* appeared earliest. *Eptesicus fuscus* peaked between 2100 and 2230h, whereas *L. borealis* and *P. subflavus* had no significant peaks. *Nycticeius humeralis* emerged mainly between 2200 and 2400h. *Myotis septentrionalis* and *M. sodalis* foraged in interior forests with a dense understory and canopy closure >70%. *Myotis sodalis* foraged over water, whereas *M. septentrionalis* foraged mainly over dry habitat. Peak foraging in *M. septentrionalis* occurred between 2100 and 2200 h. Small sample sizes of the remaining species precluded analyses.

Food habits of the northern long-eared Myotis *Myotis septentrionalis* across space and time.

Timothy Carter[1], Steven Carroll[1], Sheldon Owen[2], Alex Menzel[3], Mark Ford[4], George Feldhamer[1], and Brian Chapman[2].
[1]Dept of Zoology, Southem Illinois University; [2]Wamell School of Forest Resources, University of Georgia; [3]Wildlife and Fisheries, Division of Forestry, West Virginia University; and [4]USDA Forest Service, Northem Research Station.

Baseline knowledge of bat food habits exists for many species of bats that occur in the southeastem United States. How diet varies through time, among habitats, or across geographic space is not well understood. The food habits of northem long-eared myotis *Myotis septentrionalis* have been examined. However, the effects of differences in capture time and location on the diet of this species have not been examined. In order to examine the effect of capture location on the diet of northem long-eared myotis, we compared fecal samples collected from this species simultaneously from two states, Illinois and West Virginia. To investigate geographically induced variation over a smaller spatial scale, we also compared samples collected from two physiogeographic regions in West Virginia, the Allegheny Plateau and the Ridge and Valley. We examined the effects of temporally induced variation in the diet of the northem long-eared myotis by comparing fecal pellets collected from the Allegheny Plateau of West Virginia in 1998 to those collected from the same physiographic region in 1999. We report on the effects of the space and time on the diet of northem long-eared myotis and make suggestions for improving future studies conceming the foraging habits of insectivorous bats.

A preliminary analysis of genetic variation among North American long-eared *Myotis* species.

Tanya Dewey. Museum of Zoology, University of Michigan, Ann Arbor, MI 48109-1079.

This research proposes to analyze intra- and inter-specific levels of genetic variation in the mitochondrial genes cytochrome-b and ND1 of the six long-eared *Myotis* species of North America (*M. auriculus, M. evotis, M. keenii, M. milleri, M. septentrionalis,* and *M. thysanodes*) in order to identify the boundaries of independently evolving populations. These ecologically and behaviorally unique species are primarily found in boreal habitats and their distributions suggest that latitudinal and elevational habitat shifts associated with pluvial-interpluvial cycling during the late Quaternary have resulted in disrupted gene flow among Ipopulations. The impact of this climatic history on within and between species diversity is expected to be highest in the mountainous regions of westem North America where areas of suitable habitat have been, or continue to be, isolated to higher elevations. By analyzing pattems of intra- and inter-specific variation it is possible to assess the relative roles of dispersal and geographic isolation on population structure and on relationships among species. This information can also be used to focus conservation efforts directed at these species on biologically meaningful units.

Conservation strategy for the eastern small-footed bat *Myotis leibii* : A preliminary assessment.

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The eastem small-footed bat *Myotis leibii* is found throughout much of the northeastem United States. It ranges from southern Quebec, southwest along the Appalachian Mountains to northem Georgia, and west to eastern Oklahoma. Populations of this tiny bat have declined in recent years, and it is now recognized as a species of concern across its range. Due to the nature of their roost sites and inherent problems with location and identification, few opportunities exist for comprehensive surveys. In an effort to develop information about the current status and draft a preliminary conservation plan for the eastem small-footed bat, we interviewed researchers and other knowledgeable individuals, and collected information from available sources of both white and gray literature. Funding support from the USDA Forest Service and George Washington/Jefferson National Forests will assist development of a range-wide conservation strategy.

Molecular sysematics of the long-tongued bats of the genus *Glossophaga*

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The genus Glossophaga comprises 5 species of neotropical bats: *G. commissarisi* (ranging from west-central Mexico, to eastern Peru and Brazil), *G. leachi* (ranging from western Mexico to Costa Rica), *G. longirostris* (ranging from southern Central America to northern South America, including some Carribean Islands), *G. morenoi* (ranging from southern Mexico to Central America), and *G. soricina* (ranging from Mexico to northern Argentina, including populations from Jamaica, Trinidad and Tres Marias Islands). Karyological studies have reported the same diploid and fundamental number for all species studied (Baker, 1967 and 1979) and provide little help in elucidating phylogenic relationships within the genus. All species in the genus are morphologically similar, a condition that has complicated the use of morphologic data to address intrageneric relationships (Webster, 1993). Our study uses the 1140 base pairs (bp) of the mitochondrial cytochrome-b gene to address the monophyly of the group, systematic relationships within the genus and the pattems of intra and interspecific variation with special emphasis of *G. soricina*, the most geographically widespread species in the genus.

Inter-and intraspecific variation in proximate, mineral, and fatty acid composition of milk in four species of old-world fruit bats.

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Proximate composition of milk and variation between species are described and compared among four species of Old-World fruit bats, *Pteropus pumilus, P. rodricensus, P. hypomelanus*, and *P. vampyrus*, maintained in captivity on similar diets. In addition, the concentration of minerals and fatty acids in the milk of *P. hypomelanus* and *P. vampyrus* are evaluated and compared. Our findings suggest that milk composition is relatively constant across lactation for most proximate, mineral, and fatty acid components. We found a significant increase in dry matter and energy during lactation in the concentration of dry matter and energy in *P. pumilus* and fat *in P. hypomelanus*. In *P. hypomelanus*, we found a significant increase in the concentration of fatty acids 10:0 and 20:1n9 and a significant decrease in Isol5 and 20:1n7. No other differences associated with day of lactation were found. There were significant although small differences in the protein content of milk among species, with the protein content significantly greater in *P. rodricensus* milk than in *P. pumilus* and *P. hypomelanus* and significantly less in *P. hypomelanus* than in *P. rodricensus* and *P. vampyrus*. There were no differences in mineral content between *P. hypomelanus* and *P. vampyrus* in milk minerals, but minor differences were evident in fatty acids 12:0, 14:0, 18:0, 18:1nll and 18:2n6. These findings suggest that milk composition is generally similar within the genus *Pteropus*, independent of a 6.5 fold difference in body mass between species evaluated in the present study.

Phylogenetic affinities of the old world sucker-footed bat *Myzopoda urita* inferred from mitochondrial ribosomal sequences.

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The Old World sucker-footed bat *Myzopoda aurita* is the sole member of the family Myzopodidae and is restricted to Madagascar. Phylogenetic affinities of Myzopoda have been difficult to resolve, although several researchers have recognized a possible close relationship between Myzopodidae and three New World families (Thyropteridae, Furipteridae, Natalidae). Strong support for a clade containing these four families was found in a recent cladistic analysis of 180 cranial and post-cranial characters of all chiropteran families. The study recognized the monophyly of these families by designating them to a distinct superfamily (Nataloidea). In this study, we tested the monophyly of Nataloidea with the use of molecular data obtained from representatives of nearly all chiropteran families. We examined approximately 2.7 kilobase pairs of mitochondrial DNA encompassing the 12S rRNA, tRNA-Val, and 16S rRNA genes. Preliminary phylogenetic analysis indicates paraphyly of Nataloidea. We will discuss phylogenetic affinities of Myzopodidae relative to other families as inferred from mitochondrial ribosomal sequences.

Individual variation in the nightly time-budget of the little brown bat *Myotis lucifugus*.

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The little brown bat, *Myotis lucifugus* (Chiroptera: Vespertilionidae) is a common insectivorous species in North America that forms maternity colonies of pregnant females in early spring. Previous efforts to characterize activity-budgets were based primarily on visual observation techniques, making identification of some individuals difficult or impossible when bats move quickly or cluster together in overlapping layers. Injecting subcutaneous radio transponder identification tags (PIT tags) into mother-pup pairs enabled us to precisely monitor their nightly activity and migration behavior. In 1997 individuals in a colony in southern New Hampshire were monitored at three commonly used exit/entry holes and two night roosts using a custom-designed antenna coupled with a computer for continuous data acquisition. In 1998 and 1999, individuals were monitored at the most commonly used exit/entry hole, after two alternate exit/entry holes were blocked. These data were supplemented with observations using infrared video, and continuous recordings of roost temperature, humidity, ambient light, and fecal collection beneath night roosts. Emergence times were associated with ambient light, temperature, and date. Night-roost use was significantly associated with minimum nightly ambient temperature. Individuals may divide their nightly activity into more than one night-roosting session and more than two foraging periods. Juvenile bats depart the maternity roost later in the season than many adults do. The use of PIT tags has made it possible to evaluate individual differences in nightly activity, seasonal activity, and order of nightly emergence with respect to age, sex, and reproductive condition, as well as roost fidelity and philopatry.

Getting the facts straight: The *Sturnira ludoyica* complex and its allied species.

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By combining morphological and molecular data from individuals throughout the geographical range of *Sturnira ludovici* (sensu lato), *S. oporaphilum, and S. hondurensis*, we resolved the philogenetic relationships among these three taxa. A; Morphological data implied a close relationship between *S. oporaphilum and S. bogotensis*, linking them to *S. erythromos*. A second clade formed by *S. hondurensis* and *S. ludovici* is well defined (concurring with Koopman, 1994), with *S. magna* as a sister taxon of the clade and *S. tildae* as a sister taxon of the entire group. Trees based on morphology are weakly supported (low bootstrap and decay values), with the exception of *S. magna* and *S. oporaphilum*. B; Molecular data support a close relationship between *S. oporaphilum* and *S. ludovici* and suggested a rather distant position for *S. hondurensis* (sensu lato). Here, we recognize *S. oporaphilum* and *S. ludovici* as separate species with no subspecies and with distribution restricted to South America. *Sturnira hondurensis* is recognized as a valid species ranging from southern Central America to Mexico. *Sturnira bogotensis, S. erythromos, S. tildae,* and *S. magna* do not belong to this clade and are included only as outgroup species. Bootstrap and decay values (on terminal branches) are high, but some clades are unstable and incongruent with morphological data. C; When both data sets were combined, one clade is formed by *S. ludovici, S. oporaphilum* and *S. hondurensis*, whereas the sister clade is made of individuals belonging to *S. erythromos* and *S. bogotensis*. All clades in the combined analysis have strong bootstrap and decay values (much higher than either morphological or molecular data sets). This last, combined tree depicts our preliminary conclusions.

Ecomorphology of a guild of Rhinolophid bats from Malaysia: Evidence for competitive structuring.

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We assessed the ecomorphological structure of a guild of rhinolophoid bats in a Malaysian rainforest first described by Heller and von Helversen (1989). These authors found that the distribution of echolocation call frequencies used by 12 syntopic species was more even than expected from allometric relationships or in randomly generated communities, and that the observed minimal ratio was greater than

expected by chance alone. In this study we were able to expand their guild to 15 species, but in doing so it became apparent that call frequencies might be less evenly distributed across the total frequency range than previously proposed. We replicated Heller and von Helversen's (1989) analyses with the full 15-species complement but were unable to support their suggestion that rhinolophoid bats exhibit resource partitioning through differences in frequency bands. We adopted a multivariate approach and incorporated measures of body size and wing morphology into the analysis. We used phylogenetic autocorrelation to ensure that the species were statistically independent and Principal Component Analysis to describe the morphological space occupied by the fifteen species in the community and four additional species representing the extremes of phenotypic variation. We derived interspecific Euclidean distances and tested the mean values and standard deviations of these distances against those of 100 guilds of'synthetic' species created randomly within the principal component space. The guild of Rhinolophoidea was not distributed randomly in multivariate space. Instead we found evidence of morphological overdispersion of the most similar species, which suggests niche differentiation in response to competition. Less similar species were nearer in morphological space than expected, and we suggest this is a consequence of ecological constraints on parameter combinations. Despite this underdispersion, many of the more distant neighbors were evenly rather than randomly spaced or clumped in morphospace, suggesting that, given the environmental constraints on morphology, species in this guild do experience limits to their similarity.

Indiana bats (Myotis sodalis: Journeys in space and time.

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From 1995 through 1998, we studied the movements and behavior of a maternity colony of Indiana bats *Myotis sodalis*, along the border of Jackson and Washtenaw counties, in southern Michigan. During the study we banded 32 individuals. Twenty seven of those were banded from 1995 to 1997 and, therefore, had the opportunity to be recaptured in subsequent years. Eleven of the 27 (41%) were recaptured on their summer range in subsequent years, either at the initial capture site (2 bats) or at a nearby location that usually was less than 2 km from the original site (9 bats). All were recaptured within the known home range of this colony, indicating high inter-year fidelity to a highly localized area. Three of the 32 banded bats (9%) were recaptured while in hibernation in caves more than 250 km from the maternity location. However, each of the three bats hibernated in a distinctly different geographic area—one in eastem Kentucky, east of Cincinnati, Ohio; one in central Kentucky; and one in southern Indiana, west of Louisville, Kentucky. These winter returns indicate that members of the same maternity colony may hibernate in different caves separated by more than 300 km. One of the bats was banded in Michigan in July '96 and recaptured in Kentucky in January '97, in Michigan in May '97 and again in Michigan in June '98.

Physical theory and the origin of flight, with particular reference to bats.

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A better explanation of the origin of powered flight is gliding instead of a leaping process, which is physically not feasible in space or time considering air resistance. Body symmetry favors gliding. Also, gliding utilizes a great potential energy, i.e., gravity. In mammals gliding evolved using patagia, observed in several kinds of mammals, possibly used for camouflage, certainly to soften impacts and eventually to glide. With their specialized hands the bats attained powered flight, and with them and the uropatagium attained great maneuverability useful in hawking the apparently abundant insects.

Vertical distribution of a bat community in the Amazon forest and its relation with environmental variables.

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During 13 nights, mist nets were located simultaneously in the understory, (0 - 4 m) and the canopy, (21.8 - 38.5 m) of a Peruvian Amazon mature forest; at the same time, the temperature, precipitation and lunar phase were registered. Eighty-two individuals from 29 species where collected (67% understory and 33% canopy). I found significant differences in composition among the two strata. A high diversity of species and feeding habits were found in the understory. In both strata there was a dominance of the nomadic frugivores. The sedentary frugivores, foliage insectivores and the sangivores were absent from the canopy samples, showing a restriction in the trophic range in the upper layer. I found a positive correlation between the differences in temperature among the two strata and the rate of captures along the night. The higher bat activity in the understory coincided with the larger differences in temperature in the early night, while the peak of captures in the canopy happened later in the night, when the temperature among the two layers became homogeneous. I suggest that this behavior allows bats to evaluate the degree of concentration, ripeness and type of crop for each subjacent forest sector covered by their foraging flights, since the aromas of the crops have been dragged from the interior layers by ejection and are trapped in the layer immediately above the canopy later in the night. The negative effects of precipitation and lunar brightness on capture rates were attenuated by the effect of the forest layers in the understory.

Comparative analysis of nectar-feeding performance in four Phyllostomid bats.

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To test the hypothesis that nectar -feeding performance is associated with morphological specialization in New World flower-visiting bats (Phyllostomidae), three nectarivorous glossophagines *Choeronycteris mexicana, Leptonycteris curasooe, Clossophaga soricina* and one understory frugivore *Carollia perspicillata* were filmed at clear plastic feeders of three lengths (20, 30, 40mm) and two diameters (19, 26mm) with "unlimited" nectar available. Rate of nectar extraction significantly decreased within each species as feeder length increased (Wilcoxon matched-pairs tests), but diameter had no significant effect on feeding rate. Species varied significantly in the rate of nectar extraction (Kruskal - Wallis tests) at all feeder lengths. Rate was highest in *Leptonycteris*, and decreased from *Choeronycteris, Glossophaga,* to *Carollia*. The nectarivores fed for less than one second while hovering, and took 0.05-0.30 grams/visit, while the frugivore usually landed on the feeder for 2-8 seconds and took up to 1.50 grams/visit. Differences in feeding rate among glossophagines are associated with different feeding techniques, including the number of licks taken and how deeply the bat inserts its head into the flower. Morphological specialization of the skull appears to be associated with the ability to extend the tongue, which was assessed by recording bats feeding from 9mm diameter tubes without replacing the nectar. Maximum tongue extension beyond the snout was approximately 46-5Omm in *Choeronycteris*, 37-40mm in *Leptonycteris*, 26-28mm in *Glossophaga*, but only 5-7mm in *Carollia*. Differences in tongue extension among the glossophagines are roughly proportionate to palate and mandible lengths. *Carollia* lacks the morphological specializations to protrude the tongue that characterize glossophagines.

Bat ectoparasites and other symbiotic arthropods from the Trans-Pecos of Texas.

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A qualitative and quantitative analysis of the ectoparasites from 13 species of Molossid, Mormoopid, and Vespertilionid bats was conducted in the Trans-Pecos region of Texas. The study took place in Brewster, Crockett, Culberson, Hudspeth, Presidio and Reeves Counties, from September 1997 through October 1998. A small sample of bats was also examined from Big Bend National Park during May 1998, encompassing nine bat species. Ectoparasites recovered included fleas, streblids, nycteribiids, cimicids, and acari. A roosting site for *Myotis velifer* in Presidio Co. was examined and revealed the presence of fleas,

cimicids, dermestids, and acari. Mean intensity, prevalence, and site prevalence of ectoparasite on the host are presented for the three most numerous bat species encountered in the study. New host and host locality records are presented.

Mechanisms of coexistence in bats of the Philippines.

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Within the framework of optimal foraging theory, I consider three mechanisms of coexistence that may contribute to the diversity of insectivorous bat communities. Structural complexity among habitats provides one axis of environmental heterogeneity. Species can co-exist along this axis if there is a trade-off in foraging efficiency among habitats. The second and third mechanisms involve the partitioning of the temporal and spatial variation in nightly insect abundance through a trade-off in maintenance and foraging efficiencies and one in flight speed and foraging efficiencies. I tested these mechanisms in a Philippine insectivorous bat community by simultaneously sampling bat foraging activity with an Anabat II detector and insect abundance along spatially and temporally explicit transects. Rhinolophids and Vespertilionds separated along an axis of habitat complexity, the former biasing its activity to more closed habitats and the latter in less cluttered habitats. Among the Vespertilionds, *Myotis horsfeldii* coexists with *Myotis muricola* and *Pipistrellus javanicus* by partitioning the spatial variance in insect abundance. Among the Rhinolophids, *Rhinilophus arcuatus* and *R. subrufus* coexist via microhabitat selection, the former selecting perches in the understory and the latter in the subcanopy. The mechanism of coexistence approach has proven successful in elucidating bat community structure. By recognizing only the most salient environmental attributes that may promote coexistence, a bat community which may appear overwhelmingly complex may be understood with only a handful of simple mechanisms. Furthermore, because of the generality of this approach, these mechanisms may provide insights into the structure of other vertebrate communities as well.

A comparison of vitamin D levels in five species of neotropical bats:Evidence for steroid hormone resistance?

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The vitamin D status of five species of free-ranging neotropical bats(*Artibeus jamaicensis,Brachyphylla cavernarum, Desmodus rotundus, Monophyllus redmanii*, and *Noctilio leporinus*) was assessed using plasma 25-hydroxyvitamin D (25-OHD) as an index. All animals were captured from caves in Puerto Rico or Brazil, South America. Blood was taken by venipuncture within eight hours of capture and all animals were subsequently released. Plasma 25-OHD determination was made by absolute ethanol extraction followed by a protein-binding assay using the plasma vitamin D binding protein. Though all animals that were sampled had detectable levels of 25 OHD, *A. jamaicensis, B. cavernarum*, and *M. redmanii* were found to have very low levels (7 +/- 6.2 ng/mL, 9 +/- 6.5 ng/mL and 15 +/- 3.5 ng/mL respectively) while *D. rotundus* and *N. leporinus* exhibited very high levels (247 +/- 130.8 ng/mL and 236 +/- 60.5 ng/mL). We suggest that the extremely high plasma level of 25-OHD in *D. rotundus* and *N. leporinus* is a consequence of the greater vitamin D content of their diet (*D. rotundus*, blood and *N. leporinus*, fish) and may provide evidence for steroid hormone resistance in these two species.

Behavorial correlates of swarming bats.

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For the past thirty years, the literature has been dominated by the hypothesis that the bats of eastern North America mate during an activity known as swarming. Our goal is to test this hypothesis by examining the behaviors of these animals. We conducted studies aimed at assessing this hypothesis at Copperhead Cave, an abandoned clay mine in Indiana, where northem myotis *Myotis septentrionalis*, little brown myotis *Myotis lucifugus*, and eastem pipistrelles *Pipistrellus subflavus* are known to swarm. Swarming cities are perhaps reminiscent of the leks of prairie grouse in three ways: 1) they are dominated by males; 2) they are used for many years; and 3) they are thought to be mating sites. If swarming sites are

indeed leks for bats, we predict that males should spend more time than females at the sites. Light-tagged male and female bats, however, spent virtually identical amounts of time at the site. We also examined the males at these sites for erect penises. We predicted that the proportion of sexually aroused males should decrease over time. As predicted, the proportion of sexually aroused males did significantly decrease over time. Finally, we sampled for modified echolocations similar to those used by at least three European members of *Pipistrellus* to attract mates. Such calls were virtually absent from our samples. Together, these data do not strongly support the traditional hypothesis of the function of swarming.

Functional determinants of macroecological patterns in body-size and shape of new world bats: A preliminary assessment.

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Variation in interspecific body-size distributions represents a major component of macroecological study. Body size is a multivariate phenotypic attribute that captures information regarding the overall size and mass of an organism, as well as the size of constituent ecological apparati. Although univariate approaches (e.g., length of particular morphological feature or mass) most often are used to characterize variation in body-size, quantifying pattems of body-size and understanding their underlying mechanisms may be enhanced by assuming a multivariate perspective. Moreover, if multivariate statistical analyses are applied to a number of quantified phenotypic traits to estimate body-size, residual variation can be used to estimate and investigate associated variation in shape. The size and shape of 255 continental New World bats was estimated by scores generated from a principal components analysis conducted on forearm length and six cranial distances for each species. Distributions of body-size and shape were similar. Both distributions were skewed and deviated significantly from lognormality. Bats, on average, were relatively small, with short and wide trophic apparati. Moreover, significant differences in body-size and shape among feeding guilds as well as between each of the guilds and the entire distribution for New World bats were determined. Distributions of body-size and body shape are not the same among feeding guilds and the distribution for all bats is not representative of many of these ecological groups. This suggests that the shape of phenotypic distributions that represent large numbers of organisms from different ecological groups or evolutionary lineages may not be the product of processes occurring over the entire distribution, but may emerge from different mechanisms affecting distinct groups in disparate ways.

Influence of the mating system on genetically effective population size in a polygynous tent-making bat *Cynopterus sphinx* (Megachiroptera)

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Polygynous mating is one of the most salient features of mammalian social structure and has potentially far-reaching consequences for a diverse array of evolutionary processes. Polygyny affects the genetically effective population size (Ne) by reducing the absolute number of breeding males and by skewing the proportional representation of male ancestors in the gene pool of subsequent generations. The objective of this study was to test the hypothesis that polygynous mating and harem social organization promote enhanced rates of genetic drift. Specifically, I ask whether polygyny results in significantly reduced Ne relative to expectations of a more egalitarian mating system. This hypothesis was tested empirically in a natural population of the short-nosed fruit bat, *Cynopterus sphinx* (Megachiroptera), in western India. The influence of the mating system on Ne was assessed using a mathematical model designed for age-structured populations that incorporated demographic and genetic data. Using microsatellite genotypes of adults and progeny from consecutive breeding periods, variance in male mating success was inferred from the size distribution of paternal sibships comprising each offspring cohort. Pattems of patrilineal relatedness among offspring revealed that variance in male mating success was considerably lower than that predicted by census data. The unexpectedly low degree of genetic polygyny, in conjunction with an extensive overlap of generations resulted in an estimate of Ne that approximated $^1/_2$ the adult census number. The magnitude of genetic drift attributable to polygynous mating may be lower than previously imagined in populations of many mammalian species.

Evidence of migration of *Leptonycteris curasoae* in the Mexican tropics.

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Migratory movements of *Leptonycteris curasoae* have been questioned recently on the basis of records of occurrence and phenological vegetation data. Hence, it has been proposed that only northern populations are migratory, while populations in the Mexican tropics do not migrate and are year-round residents. To test this hypothesis we examined seasonal changes in the population, reproductive conditions, and diet of *L. curasoae* in four caves located in Chiapas and Balsas Basin; all in Tropical Dry Forest: TDF. Stable carbon isotope ratios (SCIR) of bat tissue were used to determine the most important food source in the diet of *L. curasoae*. We hypothesize that migratory movements of bats to TDF caves from Cactus-dominated landscapes would result in significant increases in the number of bats in TDF in the fall, concurrent with SCIR that reflect a change from a CAM to a C3-dominated diet. Our results indicate that *L. curasoae* populations in the Balsas caves show up in late summer and early fall and use both caves as matemity roosts in fall and vvinter. As populations in these caves begin to swell between late summer and early fall, the SCIR decreases from dl3C (PDB) -15.52 °/°° to -23.53 °/°° These values are consistent with a change from a CAM to a C3-dominated food source. By early spring, the number of bats starts dropping and the SCIR indicate the population is feeding almost exclusively on C3 plants. Thus, both population and dietary pattems are consistent with the migration of major populations of *L. curasoae* from columnar cacti concentrations in Central Mexico to westem Mexico in search of food resources. In Chiapas, the caves are occupied year-round by small *L. curasoae* populations feeding primarily on CAM resources dl3C (PDB) in the range -16.03 °/°° to -18.62 °/°°. In early fall, the populations swell by several orders of magnitude (from 200 to 150,000 in Laguitos and to 5000 in Tempisque caves) and form matemity roosts. These bats have a lower fat index and markedly different dl3C (PDB) values than the smaller summer population (in the range -21.34 °/°° to -21.52 °/°°); indicating a C3 plants diet. These data also suggest migration of major populations of *L. curasoae* between ecosystems in the Mexican tropics.

Population trends of wintering bats in Vermont.

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We report the results of all available inventories of wintering bats in Vermont. Surveys at 23 hibernacula were compiled from the literature and unpublished data of numerous field researchers. The earliest records go back to 1934. Only five hibernacula were surveyed over more than 45 years. Despite the data's limitations, several trends are seen. Since the 1930s, wintering populations of *Myotis sodalis* have dramatically declined but not entirely disappeared, wintering populations of *M. lucifugus* have increased, and wintering populations of all other *species (M. leibii, M. septentrionalis, Eptesicus fuscus,* and *Pipistrellus subflavus*) have remained small. The relationship of the trends since the 1930s to those in the preceding years of large-scale forest clearing and the beginnings of afforestation is unknown.

Allegheny bats:A study of species richness, activity and distribution in Virginia.

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[4]Virginia Department of Game and Inland Fisheries, Verona, VA 24482.

Several recent studies have shown that mature forests support higher bat activity levels and species diversity than young forests. In an effort to examine the degree of benefits mature forests provide to bats, we used portable Anabat detectors to compare bat activity, richness, and distribution in different forest age classes and moisture regimes on Allegheny Mountain, Virginia. We predicted that species richness and bat

activity levels would be higher in mature and mesic stands, and lower in young and xeric stands. Overall bat activity was significantly higher ($P < 0.05$) in mature than in young stands, but there were no differences among moisture regimes. Species richness did not vary significantly among age class or moisture regimes, but richness was significantly higher ($P < 0.05$) over linear features such as streams and logging roads than in stands with no linear feature. Eighty-two percent of unknown calls were identified by discriminant function analysis, with the model able to significantly predict species at a 95% acceptability level. Nine of the 10 species in the call library were identified by discriminant function analysis at least once, including *L. cinereus*. Three species, *M. septentrionalis, M. sodalis*, and *M. lucifugus*, comprised 71% of all identified passes. The large number of *Myotis* identifications was not unexpected due to the forested nature of the study region. Stands of mature forest may represent important foraging and/or commuting areas for clutter-adapted bats, surrounded by younger stands of poorer quality. Forest managers should implement harvesting strategies that preserve mature forest patches, especially along linear features such as streams and old logging roads.

Relative activity of forest bats related to opening size in the Bartlett Experimental Forest, New Hampshire: A preliminary examination.

Mariko Yamasaki, USDA Forest Service, Durham, NH 03824
and Rachel Stevens, NH Fish and Game Department, Stratham, NH 03885.

Work to-date on forest habitat associations of the nine bat *species (Eptesicus fuscus, Lasiurus cinereus, L. borealis, Lasionycteris noctivagans, Pipistrellus subflavus, Myotis lucifugus, M. septentrionalis, M. leibii, and M. sodalis*) present in the White Mountain National Forest (WMNF) shows a significantly higher level of forest bat activity in regenerating hardwood stands (mean 7.3 ha) and softwood group cuts (range 0.1-0.8 ha) than in sapling-pole and mature stands of both hardwoods and softwoods. The creation of various sizes of temporary forest openings stems from managing the timber resource across the heavily forested landscapes in the WMNF to meet a variety of wildlife habitat and timber objectives. Substantial public controversy over the years continues to effectively reduce the average size of forest openings created through clearcutting under the current Forest Plan. We used 10 Anabat II detectors to survey flight activity in pairs of newly harvested patch cuts intermediate in size (1.2-2.4 ha) and adjacent mature hardwood stands in the Bartlett Experimental Forest. We used prototype software to identify unknown echolocation sequences in a statistically repeatable manner. Myotid species were identified to genus and non-myotids were identified to species. The results of this survey add to the baseline description of species distributions and bat community structure associated with managed forests in the northeastem United States. Preliminary results suggest a relationship between size of forest opening and bat species morphology.

Abstracts of the presentations at the annual national meeting of the Bat Conservation Trust

September 1-3, 2000 Queens College, Belfast, Northern Ireland

Bats and wildlife corridors - the importance of landscape features.

Nick Downs & Paul Racey UniYersity of Aberdeen,
Department of Zoology, Aberdeen AB24 2TZ.

Wildlife corridors have been widely used by land managers in advance of real proof concerning their effectiveness in wildlife conservation hypotheses. This project has provided quantitative data showing that in most cases pipistreile bats in northeast Scotland prefer to commute and feed along linear landscape features as opposed to open space. Extensive use has been made of automatic bat detection stations to provide this data (which can be directly downloaded into a computer program). Similar techniques have been employed to assess what factors may affect the use bats make of ponds and wide river corridors. With regard to ponds bats were found to select for wide areas of large ponds. Concerning river corridors, bat activity occurred first at wooded sites in comparison with open sites. In addition, a decreasing amount of bat activity was found with an increasing distance away from the river.

Geographical differences in the foraging activity of British greater horseshoe bats *Rhinolophus ferrumequinum.*

P. L. Duverge, The Vincent Wildlife Trust, 27 Higher Street, Cullompton, Devon EX15 1AJ, U. K.

Greater horseshoe bats have been studied since the 1950s in the UK. Having been primarily studied at breeding roosts and hibernacula until the early 1980s, the emphasis has gradually shifted to 1. studies of foraging activity and habitat use by means of radio-telemetry, 2. studies of their diet through faecal analysis and 3. studies of paternity and relatedness through genetic techniques.

Radio tracking and other studies in the 1990s, throughout the range of this species in the UK, have revealed a number of similarities and differences in their diet and foraging activity. From a dietary point of view, primary prey items (e.g. *Melolontha melolontha*, moths, *Aphodius* dung beetles and hymenopteran wasps) remain similar across the range, whereas secondary prey items (e.g. Geotrupes dung beetles, trichoptera and small diptera) vary somewhat depending on the individual site.

This similarity among the species taken as main prey items is also reflected in the fact that cattle-grazed pastures remain the most favoured habitat type used by greater horseshoe bats, across their range. Deciduous woods and meadows have also been shown to be very important habitats, and the importance of well-developed hedgerows, as field boundaries, has been highlighted by all the studies to date. However, research in the Mendips region of England (SE of Bristol), and in SW Wales, have also shown that aquatic habitats (the edges of estuaries, wet meadows and drainage channels in these cases) can form important foraging areas and/or travel routes for this species, as has been reported in continental Europe.

The greatest variation observed during the course of recent studies, however, has been the foraging distances covered by these bats. Contrary to theoretical predictions, adult greater horseshoe bats have been found foraging at up to 13.9km from their breeding roost, and juveniles of 55-80 days old at around 5.0km. In so doing, greater horseshoe bats have been shown to use specific landscape features (e.g. enclosed river channels, thick hedges, tree lines and drainage channels) to travel several kilometres very quickly in order to reach their feeding areas.

The use of the features described above, to forage at several kilometres from the roost, has necessitated changes in the original conservation strategies proposed by L. Duverge and G. Jones in 1994 (which will be expanded upon during the presentation), in order to enable statutory bodies to provide long-term protection to key foraging areas around the breeding roosts of this species.

"I want them out!"

Brian Keeley, Bat Conservation Group, Dublin, Ireland

Despite more than a decade of concentrated efforts by the bat groups in Britain and Ireland, bats are inextricably linked to a very poor image in the minds of the generai public. The associations with blood-

sucking, hair-entangling and evil are enduring notions that appear to survive all attempts at overthrow. Improving the image of bats necessitates devising practical solutions to some of the problems that are created by large roosts of bats in in-accessible places. Difficulties can arise in a number of ways.

1. Smells from the accumulated droppings.
2. Noise throghout the day or concentrated into emergence and return times.
3. Incursions into bedrooms, bathrooms, sitting rooms, etc.
4. Accumulation of droppings on windows, patios, doorsteps.
5. Genuine terror of roost owners; fear on behalf of new-born or young children (consumption of droppings, etc.).
6. Interruption of building repairs - do they ever go away?
7. Drowning in water tanks and the subsequent mayhem.
8. Roost owners may feel that their house is overrun.
9. Other personal problems lead to an exacerbation of the antagonism towards the bats.
10. A house is for sale and the owner is anxious about the impact of the bats' presence .
11. A holiday accommodation owner fears loss of business due to bat presence.

While some of these problems can never be easily addressed, others have their solutions. Often the solutions cannot be enacted at the time that the bats are present. In many of these cases, the roost owner fails to carry out the proposed solutions before the return of the bats. The two main problems that face the Dublin Bat Group are the issues of the smell of droppings and the noise created by the bats. No easy answers to these problems are forthcoming. Bats would be much more welcome lodgers if solutions to these problems were to be found.

Ecology and evolution of tent-making bats.

Thomas H. Kunz, Department of Biology, Boston University, Boston, MA 02115

Tent-making and tent roosting behavior has been described for 15 species of the microchiroptern family Phyllostomidae(subfamily Phyllostomatinae), three members of the megachiropteran family Pteropodidae and one member of the microchiropteran family Vespertillionidae. I review evidence for tent-making/tent-roosting behavior, summarize current knowledge of bat-tent architecture, examine the evidence for convergence in tent-architure and discuss the function of tents. Over 100 plant taxa are used by bats for tent construction although there are a limited number of leaf forms that can be modified into tents. Eight architectural styles of tents have been described: seven from the Neotropics (conical, palmate umbrella, apical, bifid, pinnate, paradox, and boat-tents, three from both the Neo- and Paleotropics (conical, palmate umbrella, and apical tents) and one (stem tent) exclusively from the Paleotropics. Stem tents are constructed by bats from altered vines, leaves and branches of trees, flower and fruit clusters, and root masses of epiphytes, and are among the most variable and durable of tents. The similarity of tent architecture observed in the Neo- and Paleotropics may be a consequence of convergence in leaf morphology, but the similarity in the life history traits among the micro- and megachiropteran tent-making taxa (small, <60 g, mostly foliage-roosting frugivores) supports a hypothesis based on convergence. High congruence in tent-making/roosting behavior oserved within the Stenodermatinae and within the Pteropidae (genus Cynopterus) also suggests a strong phylogenetic influence.

What is striking about tents and their use by bats is that most are occupied (and probably constructed) by species with harems. Both males and females have been observed roosting alone in tents, although each species commonly forms groups of varying size, consisting of a single male and several females. Our current understanding of mating systems in tent-roosting species suggests that they are based on resource defence strategies. Tents potentially offer bats protection from inclement weather, predation, and they can be effectively defended against conspecific intruders. Although tent-making has been observed for only one species(*Cynoterus sphinx*), observations and inferences drawn from this and other taxa suggest that males construct tents, recruit females, and defend these structures and their female occupants to gain reproductive access. Evidence from DNA markers in *C. sphinx* suggests that harem males father approximately 70% of the pups born in a harem.

The ecology of Malaysian fruit bats

Rob Hodgkison

The aim of this project was to investigate the hypothesis that the smallest (13.5 g) Malaysian pteropodid bat, the spotted-winged fruit bat *Balionycteris maculata* is an understorey specialist within primary lowland rain forest. Vertical partitioning of the forest, by fruit bats, was investigated using mist nets. These nets were set at all heights up to 29 metres using a pulley system. Of the ten species of pteropodid bat caughts within the study site, five were commonly caught below the 30 to 50m forest canopy. Whereas four species (*Chironax melanocephalus. Cynopterus brachyotis, Cynopterus horsfieldi,* and *Megaerops ecaudatus*) were most active within the middlestorey (between 10 and 20 m). Balionycteris maculata was the only species most frequently caught within the understorey (below 10 m). The roosting ecoiogy of *B. maculata* was irvestigated using radio telemetry. This species roosted in a variety of places in the forest (including termite nests, ant nests? epiphytes, and branches), all of which were located within the understorey - between 1.5 and 6.0 m above ground. Fruit size was an important parameter for food partitioning amongst fruit bats within the study site. Whereas small species fed predominantly on smail fruits, the largest species fed almost exclusively on large fruits. Consuming fruits with a maximum mass of approximately 4.0 g, *B. maculata* fed on the smallest fruits of any species. For forest tree species exploited by fruit -bats, fruit size was positively correlated with tree height (i. e. Iarge fruits were generally associated with tall trses). The small fruits included in the diet of *B. maculata* were therefore mainly associated with small trees in the understorey. In conclusion, B. maculata roosted and foraged mainly within the understorey. Therefore the results of this project have demonstrated that this species is an understorey specialist in primary lowland rain forest. Habitat partitioning is an important mechanism by which *B. maculata* reduces competition for vital resources with other species.

The work of the Vincent Wildlife Trust in Ireland

Kate McAney, Donaghpatrick, Headford, Co. Galway, Ireland

The Vincent Wildlife Trust is an independent British charitable body engaged in wildlife research and conservation. Since June 1995 it has employed a full-time field officer in the Republic of Ireland, based in Galway. Additional staff have been employed each summer since 1997 to survey specific regions for lesser horseshoe bat roosts. The work undertaken by The Trust in Ireland covers three main areas: (1)conserving and monitoring the lessor horshoe bat population, (2) a bot box scheme and, (3) dealing with queries.

(1) Although the national lesser horseshoe population is estimated to be in the region of 12,000 animals, there is increasing evidence to indicate that loss of suitable summer roosting sites is now becoming a problem for this species. To help counteract this, The Trust has secured the future of 11 summer roosts, accounting for approximately 1,500 bats, either by buying, ieasing or carrying out remedial repair work. Many more roosts in private ownership are checked each summer. Over 30 hibernation sites are monitored each winter. Intensive summer surveys of areas of counties Limerick, Clare, Kerry and Cork have taken place since 1997 resulting in the discovery of a range of sites, from single bats in night roosts to nursery colonies numbering 150 bats.

(2) In March 1999 The Trust extended its Tree Bat Box Scheme to Ireland when 162 Schwegler boxes were erected in three mixed woodlands in County Galway. Bats moved into the boxes by May of that year. Leisler's, brown long-eared, whiskered and pipistrelles have een recorded.

(3) Although not advertised as such, The VWT is a first contact point for a wide range of people seeking information on bats, including "frantic" roost owners in summer, government departments, companies conducting environmental impact statements, architects, timber treatment companies, schools, and third level institutes, and last but by no means least – the media. However, the award for "The Most Memorable Call of the Year 2000" goes to the woman who rang and simply said,"I was told you had a cure for bats".

Monitorinq the persistence of lonq-tailed bats in forest-farmland mosaics in New Zealand

Colin O'Donnell, Marieke Lettink, Jane Sedgeley and Brice Ebert
Department of Conservation, Private Bag 4715, Christchurch, New Zealand

The long-tailed bat *Chalinolobus tuberculatus* is one of two extant species of bat found in New Zealand. It is classed as "threatened" and has undergone significant population declines since the 1880s.

Remaining populations are almost exclusively found in native rainforest areas. However, two small, remnant populations have been discovered in agricultural landscapes. Research is focusing on determining why long-tailed bats have persisted in these rural landscapes and not others. Threats faced include human-associated activities (removal of roost trees for firewood, habitat clearance and/or degradation), predation by exotic mammals, and a lack of adequate roosting sites. *Chalinolobus tuberculatus* in the Geraldine area used a combination of trees (76%) and cavities in limestone bluffs (24%). Trees were the oldest cavity-bearing trees in the landscape and included standing dead trees (19%), native trees (11%) and introduced species (46%). Bats selected indigenous forest remnants and shrublands and willow woodlands along river edges for foraging but avoided plantations, exotic scrub, pastoral and urban habitats. Long-tailed bats persist in these highly modified agricultural landscapes because there are numerous limestone bluffs and caves that provide roosts that are safe from introduced predators; there are numerous corridors of vegetation and linkages in woodland habitats that enable the bats to forage widely in the landscape and there is an abundance of invertebrate food. Long tailed bats have smaller ranges and forage for less of the night compared to bats in forest areas indicating that food is easier to find. Future work will focus on designing roost boxes that have the correct microclimate for breeding, restoring vegetation cover, developing monitoring techniques that will tell us if bat populations are responding to our management, working with farmers and local residents, and producing education material to communicate the value of bats in the rural landscape.

Is it a cock-up? The identification of whiskered and Brandt's bats.

Phil Richardson
Northants Bat Group 10 Bedford Cottages, Great Brington, Northampton NN7 4JF

Bat identification guides suggest identifying these similar species by looking at ear and tragus shape, muzzle shape, size, fur and skin colour, tooth shape and penis shape. Some individuals fit these characteristics well and can be confidently recognised as a species, but others do not show all the recognised characters or show a mix of the characters and it is tempting to try to make them fit one or the other species. To add to the confusion indivual bats do change appearance during the year (skin and fur), and there are variations between different populations as well. Looking critically at individuals is beginning to produce some evidence that we may have another species present which is causing the confusion. Direct parallels can be drawn with the recent separation of pipistrelles. The moral being not to assumme that we have only 18 species of bats in Britain.

Captive maintenance of short-tailed bats and monitoring of wildlife activity during a kiore eradication programme on Codfish Island, winter, 1998

Jane Sedgeley, Dept. Zoology, University of Otago, Dunedin, New Zealand

During the winter of 1998 the New Zealand Department of Conservation aerially broadcast brodifacoum peliets onto Codfish Island Nature Reserve (Whenua Hou) to eradicate kiore (introduced rat pest, *Rattus exulans*). Whenua hou supports a large population of short-tailed bat (*Mystacina tuberculatus*). The bats are active in winter and their diet includes a large proportion of ground dwelling invertebrates which are known to consume poison baits. To ameliorate a risk of secondary poisoning, 400 bats were held in captivity on the island for the duration of 15 weeks. This talk will outline the successful processes of capture, captive husbandry and subsequent release and integration back into the wild. Activity and behaviour of wild batswere monitored throughout the eradication operation by following 26 radio-tagged bats and using time-lapse infra-red video recorders at 73 roosts. Roosting groups numbered up to 1,813 which were generally active throughout the night (max. nightly traffic rate = 7,169) radio-tracked bats were active on 61% of nights monitored and used an avarage of 4 different roosts. Behaviour alternated between using communal roosts occupied by large numbers of bats for short periods of time and using solitary roosts for longer periods. We could detect, no significant statistical differences in measures of activity at roosts and roosting behaviour of radio-tagged bats among the pre- and post-poison bait drop periods, or between that of wiid bats and released captive bats.

Pollen from Poo:
An unique record of an ancient flora preserved in 2000 year old bat guano.

Michael Simms
Dept. Geology, Ulster Museum, Botanical Gardens, Belfast BT9 5AB, Northern Ireland

The Ogof Draenen cave system in southeast Wales contains accumulations of lesser horseshoe bat (*Rhinolophus hipposideros)* guano on a scale unmatched by any other British cave, although very few bats now occupy this site. In places the guano covers many square metres to a depth of several centimetres, while elsewhere it forms conical heaps up to 4.5 m^2 in area and more than 0.5 m deep. The area has experienced major enviromental changes associated with coal mining and iron smelting since the beginning of the Industrial Revolution (= 1760). However large-scale abandonment of the roost much earlier than this, with Carbon 14analysis indicating a radiocarbon age of 1883+/-45 years. The reasons underlying the large-scale abandonment of this roost remain unknown; was it due to climatic deterioration, habitat change or the catastrophic blocking of access to the system?

Preliminary analysis of the guano reveals a rich palynoflora of insect-transported taxa and a more poorly preserved insect fauna. Both pollen and insects provide important data on surface environments when the roost was active. Furthermore, the ingested pollen has preserved a unique record of the insect-pollinated component of the local flora which otherwise is largely unrepresented in pollen spectra derived from blanket peats, lake sediments, etc. The palynoflora of the ancient guano will be compared with samples from an extant Lesser Horseshoe colony in Siambre Ddu, a cave chamber immediately above the main Ogaf Draeene 'paleoroost', with samples from modern lake sediments a few hundred meters away, and with a detailed survey of the present hillside vegetation, to assess how guano-derived palynofloras might reflect actual vegetational composition. It is already evident that the ancient guano contains abundant *Ilex*, a taxon not now represented in the adjacent woodland.

Less than 5 km to the north-west lies the Agen Allwedd cave system, which is one of the most imortant roosts for Lessor Horseshoe Bats in Britain today and lies close to the present northern limit of this species. Recorsd show their numbers to have increased to several hundred over the last decade. Understanding the fate of the Ogof Draenen bat roost may have significant implications for the management of the Agen Allwedd roost.

Bats in and around the country estates of Northern Ireland

Mark Smyth, Northern Ireland Bat Group, Belfast

I have been a bat worker for 10 years but intensely so over the past 5 or 6 years. Turning up pipistrelles every time can be a bit monotonous until a rarity turns up like a whiskered bat in the attic of a bungalow. A couple of years ago I was introduced as "an authority on bats" to a country estate owner. The owner replied that she had bats in the attic of her home, which is a very large 'gentleman's residence'. An appointment was made to return and a large roost of pipistrelles was counted. While chatting I was told that her mother had bats (in her house?) and so had some of her friends that also lived in large estates. By following up these leads I have found roosts of the following bats: Nathusius pipistrelle, *Pipistrellus nathusii*, Daubenton's bat, *Myotis daubentonii*, Natterer's bat, *Myotis nattereri*, Whiskered bat, *Myotis mystacinus* and Brown long-eared bat, *Plecotus auritus.* Country estate-owners are very happy with their bats and accept them as part of country life but rarely report bats to those of us who are interested. These places nearly always have a good range of habitats and roost sites that suit most of our bats. By visiting these places many of our rarer bats can be found and help give a better picture of bat distribution. Over the last couple years I have almost doubled the number of known roosts for *Myotis nattereri Plecotus auritus* and *Myotis mystacinus.*

A snapshot of serotines in Kent

Shirley Thompson, Kent Bat Group, 5 Manor Road, Tankerton,Whitstable, Kent CT5 2JT

The serotine bat *Eptesicus serotinus* is found mainly south of a line from the Wash to parts of South Wales. Observers consider it to be in serious decline in the southeastern counties, whilst in some areas further to the west it is referred to as a common bat. No attempt has so far been made to assess its relative abundance in different areas. The serotine is the largest species in the Kent Biodiversity Action Plan, and the Kent Bat Group is working to develop a survey method which will provide a snapshot of serotines in

Kent. A number of areas acropss the country have been surveyed, with details of habitats present recorded along planned routes. Using a bat detector held just inside the car window, recordings have been made of the bats heard. By analysing results we hope to assess the most important foraging habitats for serotines in Kent. This presentation describes the methods used, discusses some of the problems encountered, and makes suggestions for improvements in the protocol. Initial results are considered briefly; full analysis will be published later. It is hoped the the protocol developed will allow repetition in future years to assess changes in numbers as well as comparison with other counties. By repeating the surveys in other counties it should be possible to look at availability and use of habitats by serotines across southern England in order to better focus conservation efforts. (The poster displays examples of recording forms and maps used in this study).

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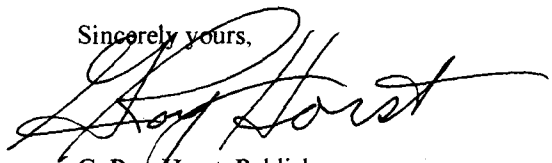

G. Roy Horst, Publisher horstgr@potsdam.edu

Seeking: Wildlife Rehabilitation Program Director

The Monroe County Humane Association, located in Bloomington, Indiana, is seeking a new Wildlife Rehabilitation Program Director to administer all aspects of its program. In 1999, more than 1100 injured and orphaned wild animals were admitted into the Wildlife Rehabilitation Program. Approximately 60% of the animals in the program are song birds, though the program is also open to all wild animals generally found in or indiginous to Indiana. In recent years, the program has successfully released more than 60% of the animals admitted into the program.

Responsibilities would include training, monitoring and retaining volunteers, developing and maintaining proper program procedures, securing all necessary supplies, permits and licenses, maintaining program records, generating reports, coordinating activities, and providing direct care to injured and orphaned wildlife.

Working knowledge of issues central to wild animals and their environments required. Must have familiarity with animal handling techniques and a commitment to animal welfare. Must be able to work effectively with a variety of people, have excellent organizational and problem-solving skills, and be able to work with minimal supervision.

Previous experience in rehabilitating injured and orphaned wild animals preferred, especially with songbirds and birds of prey. Supervisory experience and experience working with volunteers and non-profit agencies preferred.

Salary is mid- to low- twenties, depending on experience and qualifications.

To apply, send resume, cover letter and at least 3 references to:
Monroe County Humane Association,
Wildlife Director Search Committee,
3410 South Old Highway 37 Bloomington IN 47401
For more information, call (812) 332-0123 or email mcha@bluemarble.net

About Bloomington:

Bloomington is a warm and friendly community, nestled in the rolling hills of southern Indiana. Including the student population of Indiana University's flagship campus, the area population is approximately 65,000. The city is the administrative seat of Monroe County, an area that embraces roughly 115,000 residents.

The ambiance of Bloomington makes a lasting impression on all who live or visit here. There are many opportunities for work and pleasure. The stable economic base provides one of the lowest unemployment rates in the state, lending to the city a productive, yet peaceful environment. An abundance of restaurants provides a wide variety of offerings, from international cuisine to down-home cookin'.

Inspired by a love of the arts, Bloomington is recognized as the state's center for cultural and artistic expression. World-class performances by IU School of Music students can be heard almost nightly at no charge. The IU Art Museum is one of the best university art museums in the world, and the IU Auditorium features the best of local talent along with celebrity artists and professional touring companies.

Bloomington is home to three lakes including the state's largest, Lake Monroe, many open green spaces and one of the nation's most beautiful college campuses. With so many areas for recreation and sports, Bloomington is the ideal place for residents and visitors to go fishing, swimming, hiking, biking, boating, caving, golfing, skiing and horseback riding.

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Front cover

The lovely bat appearing on the front cover is the artwork of Morgan Anderson from Nelson, BC, Canada. Morgan is a high school student who has worked with Robert Barclay and Mark Brigham on their projects. Happily for us, she combines her enthusiasm for bats with her considerable talents as a wildlife artist. Thank you Morgan for sharing your work with us.

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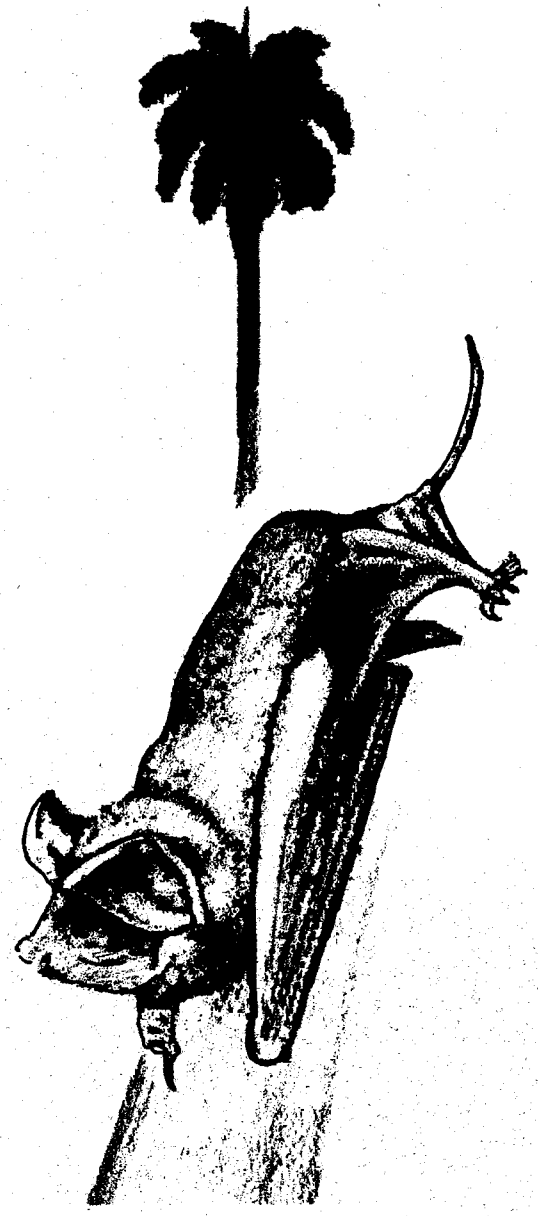

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A Software Assistant for Measuring Bat Wings

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INTRODUCTION

Morphometric analyses of bat populations in the field can be fraught with the practical problems of handling a small, struggling animal, in cramped or uneven-surfaced conditions, usually in poor light. Such conditions are not conducive to the accuracy of the operator trying to trace around the bat's wing on a piece of paper on which the bat is being held. Hand-drawn wing tracings are not only time-consuming but also stressful to the bats. Furthermore, accuracy of each wing tracing is highly dependent on the skill of the person doing the tracing, and there can be great variation from one researcher's tracings to those of another, thus limiting the ability to compare data from different studies.

We have developed a practical, alternative technique in which the bat's outstretched wing is held briefly over a contrasting surface, next to a reference ruler, and photographed using a digital camera with flash attachment. All area and linear measurements are then made and calculated using a combination of a general graphics editing program (in this case, Paint Shop Pro, preferably version 5 or 6) and a custom-written program "BatWing.exe" (version 1.0, copyright 2000, E. H. Harley). In this way, a large number of bats can be caught and photographed in a shorter period of time than when the wing is traced in situ. Handling of bats is minimized, and image processing can be performed later in more comfortable conditions, which leads to improved accuracy and efficiency.

FIELD TECHNIQUE

Photographs are taken from a position vertically above the bat. A wing and the tail are extended, with the wing held in a slightly forward position (Saunders and Barclay, 1992). Orientation of the bat is not critical, because the image can be rotated or flipped during processing. The ruler, which should have easily visible markings, is placed close to and just above or below the wing, with the 0-cm and 10-cm positions visible. It does not matter if the ruler is strictly horizontal or not. For first-time users, it may be advisable to use two rulers, one above and one below the bat, to check for parallax distortions caused by an incorrect camera angle. The bat preferably should be photographed against a contrasting surface (e.g., a sheet of white paper), and care taken to ensure that the tip of the wing and midline of the body are not obscured when the photograph is taken.

PROCESSING IMAGES

The digital images are downloaded into a personal computer using conventional software, which usually comes with the camera. Before loading images into Paint Shop Pro (with which a degree of familiarity is advisable), a series of files containing small, colored squares are loaded. These files are supplied with the BatWing program and are most rapidly loaded by using the "browse" option. These squares will be used as position markers and are referenced as A1, A2, B1, C1, and C2, each with a ".ppm" (for portable pixelmap) file extension. In addition, three files which display a block of solid color are loaded: "blackfil" (pixel rendering Red 0, Green 0, Blue 0), "greyfill" (pixel rendering Red 192, Green 192, Blue 192), and "redfill" (pixel rendering Red 255, Green 5, Blue 5).

Load each image into Paint Shop Pro (Fig. 1a). Resize the image at this stage so that, in 1:1 size format, the image occupies about half the screen area (about 500 by 350 pixels is a suitable size). Larger images take unnecessarily long to process. The next step is to select and mark each of three wing regions for area determination (Fig. 1b), following the approach

of Saunders and Barclay (1992). Trace the hand-wing area using the freehand tool, which is depicted on the toolbar as a button with an inscribed lasso. Speed and accuracy are improved by using the point-to-point option, available in Version 5 and above of Paint Shop Pro. Select pure black color by clicking on the "blackfil" file with the dropper tool, change the tool to flood-fill, and fill the section with black. Appropriate adjustment of the tolerance setting of the flood-fill tool selects the wing more accurately for filling than is possible manually because it can be adjusted to fill only areas of approximately similar hue; it also enables the tracing to be performed much more quickly if the wing is against a contrasting surface, because accurate tracing is then necessary only when crossing the wing itself. After filling the hand-wing area, select and fill the next two areas, referenced as "arm-wing" and "shoulder-midline" regions (Fig. 1b), with red and grey, respectively (the redfill and greyfill files are for this purpose). Note that it is essential to use the blackfil, redfill and greyfill files provided, because BatWing.exe recognizes only the particular pixel renderings of these colors.

Mark the reference positions on the ruler by copying the markers (colored squares) from files A1 and A2 and pasting them (using Control + C, then Control + E) onto the 0-cm and 10-cm ruler positions, respectively (or 1 and 11, etc.). If a complete 10-cm length on the ruler is not visible, a third square, A3, can be used instead of A2 to mark a position that is 5 cm from the A1 marker. BatWing.exe will differentiate between the A2 or A3 marker and automatically adjust subsequent calculations accordingly. The program measures from the left border of the markers, and the markers should be placed with this in mind. Mark the wing positions for the linear measurements of the wing with the small, colored markers loaded from the B1, B2, C1, and C2 files (Fig. 1b). The markers should be placed just outside the wing area, because the program will calculate wing areas minus the area of these markers, and if they are placed within the outline of the wing, which a small error would result.

Store the processed image in portable pixel (.ppm) format, which is a format that can read by the next stage of the process. Do not save files in a compressed format, such as JPEG, or resize the image after processing, because this may alter the pixel color combinations; even if these files are later converted to a .ppm file, BatWing may not recognize these colors. If desired, the image may be cropped at this stage, however, which will speed up subsequent processing. If a number of wing images are to be processed, they should be given a common name with sequential numbers appended, e.g., bat1.ppm, bat2.ppm, bat3.ppm, etc. It does not matter if some numbers in the sequence are missing. Files should be saved in or copied into the same directory that contains the program BatWing. All that then remains is to run the program "BatWing.exe." The program will ask if you wish to do single or multiple analyses. If the latter, the base name ("bat" in the above example) is entered, and all files with this prefix to a number will be found and processed, and the results will be printed or stored to a file with a ".res" extension, which can then be imported into a spreadsheet, such as Excel.

The program measures areas by finding and counting all pixels with the exact settings for black, red, and grey given above, converting to a proportion of the total pixel count, and after making a length measurement using the dark and light blue markers (A1 and A2, or A1 and A3), converting the proportion to an area. BatWing uses the markers B1, B2, C1, and C2 to determine hand-wing, arm-wing and shoulder-midline lengths for calculation of wingspan (Saunders and Barclay, 1992). An example of an output file is shown in Table 1. The program also contains on-line instructions, available as an option on the main menu, which walks the user through the image processing with the help of animated graphics.

BatWing.exe can be used in a similar way to analyze hand-drawn wing tracings. A 10-cm reference line is drawn on these wing traces, close to and below the wing, and the traces are then scanned into a computer. They may be saved as JPEG images initially and as .ppm files after processing in Paint Shop Pro. Traces are processed as described above for digital images, although the wing outline must be traced exactly with the freehand tool. With no

contrast between the color of the "wing" and the background, the flood-fill tool will not be able to select the wing automatically using only the tolerance setting. The time taken for scanning and for the more careful use of area selection makes working from wing tracings significantly longer than working from digital images of wings.

COMPARISON OF METHODS

To determine the precision of the method, a photograph of a bat's wing, similar to that depicted in Fig. 1a, was separately processed ten times, and areas and linear measurements calculated with the BatWing program. From these measurements, the coefficient of variation was calculated to be 0.005 for linear measurements and 0.008 for areas. To compare measurements using BatWing with a more conventional method, 10 photostatic copies were made of a printed version of the above photograph and areas determined by cutting out the wing areas, weighing them, and comparing the weights to the weight of a square (10 cm by 10 cm) cut from similar paper. Mean total wing areas were 146.2 cm^2 and146.5 cm^2, with variances of 1.3 and 1.2 for the BatWing and weighing methods, respectively, which were not significantly different ($P > 0.05$) using a t-test. In addition, a comparison of wingspan measurements, using either BatWing or by simply measuring with a ruler on a wing trace, was performed on 15 separate wing traces. The means for BatWing and the ruler method were both 30.5 cm, with variances of 3.3 and 3.1, respectively, which were not significantly different ($P > 0.05$) as indicated by the t-test. Accuracy also may be improved in practice, because photographs can be reprocessed repeatedly in a way which a wing tracing cannot, if it is cut up for weighing.

OBTAINING THE PROGRAM

The BatWing program is available free of charge as an executable file, plus the attendant .ppm marker files, on application to E. H. Harley, on condition that they are not redistributed to third parties without the author's permission. A zipped package of these files also can be sent by e-mail on application to harley@chempath.uct.ac.za.

ACKNOWLEDGMENTS

We thank the National Research Foundation for financial assistance and David Jacobs for critical review of the manuscript.

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Table 1. Example of printout from BatWing analysis of an image file named "Bat5.ppm."

Image bat5
Time Taken = 6.15 secs

Area 1 (Black) = 11.5 % of image = 19.22 sq cms

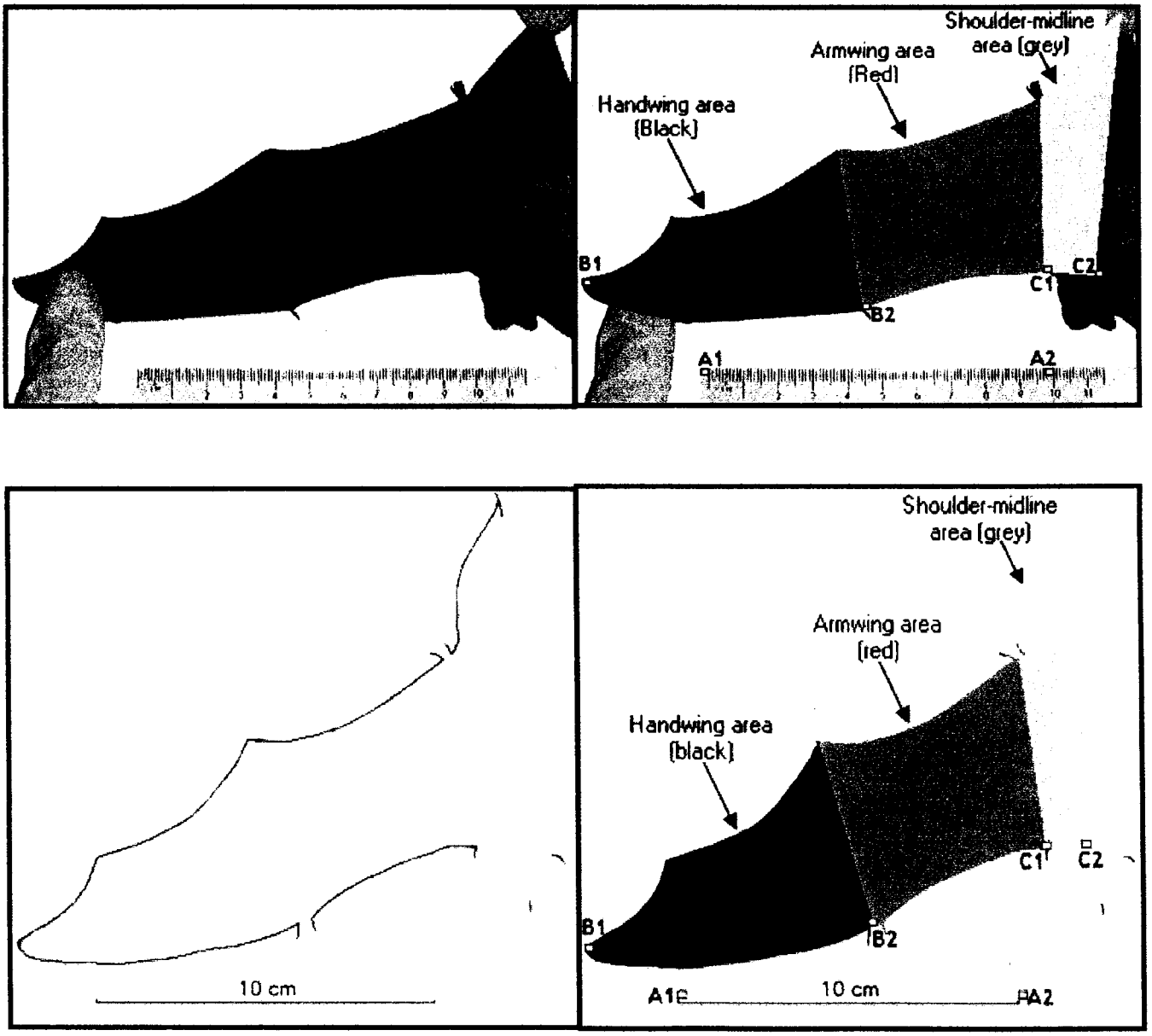
Area 2 (Red) = 15.0 % of image = 25.09 sq cms

Area 3 (Grey) = 4.8 % of image = 8.06 sq cms

Handwing length (dark red to light red markers) = 8.22 cms
Handwing length corrected (red line in diagram) = 8.06 cms
Armwing length (light red to green markers) = 5.09 cms
Shoulder to midline length (green to cyan markers) = 1.65 cms
Total Wingspan (tip to tip) = 29.60 cms

Harley and Miller-Butterworth continued>>

Figure 1. a) Photograph of an extended wing of a *Miniopterus schreibersii*, taken during a with an Olympus digital camera (model C-800L), in low-resolution mode (512 by 384 pixels) and with built in flash illumination. b) The same photograph after processing. Marker boxes are different colors normally, but for this black-and-white illustration, they are depicted as open squares. c) Hand-drawn wing tracing of an extended wing of a *Miniopterus schreibersii*. b) The same tracing after processing.



Letters to the Editor

Editor's Note: Unlike technical articles, letters are not peer-reviewed, but they are edited for grammar, style, and clarity. Letters provide an outlet for opinions, speculations, anecdotes, and other interesting observations that, by themselves, may not be sufficient or appropriate for a technical article. Letters should be no longer than two manuscript pages and sent to the Feature Editor, Allen Kurta.

Possible Ground Roost of the Silver-haired Bat *Lasionycteris noctivagans.*

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Recent notes suggest eastern red bats (*Lasiurus borealis*) commonly roost on the forest floor beneath deciduous leaf litter (Saugey et al., 1998; Moorman et al., 1999). On 27 September 2000, we discovered a male silver-haired bat (*Lasionycteris noctivagans*) under leaf litter at the Fernow Experimental Forest of the United States Forest Service, in Tucker Co., West Virginia. The bat was found on a logging road, ca. 5 m from a small stream, at an elevation of ca. 850 m. The bat was disturbed by one of the authors while walking along the road. The bat was active and alert. The sky was overcast, and air temperature was ca. 21°C. The logging road, which occasionally is used by the Forest Service for maintenance of a weir, is located in a northern hardwood community dominated by American beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), and sugar maple (*Acer saccharum*). The road runs along the side of a hill with a southeastern aspect.

Roosts of silver-haired bats have been found under loose bark and in hollow trees, rock crevices, and buildings (Kunz, 1982), but this is the first report of a silver-haired bast roosting under leaf litter on the forest floor. The phenomenon of roosting in leaf litter may be more widespread than originally thought. Because most ground roosts of eastern red bats have been located during the winter, some forest managers are concerned about possible impacts of prescribed fires on this species (Carter et al., 2000). Prescribed fire is rarely used to manage northern hardwood communities. However, the range of the silver-haired bat includes many forest communities in the southeastern United States where prescribed fires are used. Future studies need to determine if silver-haired bats commonly roost under leaf litter, and, if they do, the impact of prescribed fire on this species needs to be assessed.

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The 30th Annual North American Symposium on Bat Research

The 30th symposium met at the Sheraton Biscayne Bay Hotel in Miami from September 27-30, 2000, sponsored by the University of Miami, Coral Gables. Ted and Marcia Fleming were the conference hosts, assisted by the members of their Local Committee: Laura Finn, Nat Holland, Christina McCain, Nate Muchhala, and Lyndsay Newton. There were 221 registered participants, not counting the educators who attended the special Bat Conservation Workshop on Saturday morning. One hundred and seventeen scientific papers were presented at the Miami meeting, not counting the special presentations for teachers made during the Saturday morning workshop. Thirty-three of these were poster presentations.

Once again this year, graduate and undergraduate student participants were invited to enter their platform papers and poster presentations in a competition which judged their merits. A special committee headed by Roy Horst judged thirty-five student platform and nineteen student posters. Four cash prizes of $250 each were awarded at the Friday evening banquet. Jacques Pierre Veilleux of Indiana State University won the Bat Conservation International prize, Josephine Wong of Leeds University, Leeds, U.K. won the Bat Research News prize, Nathan Muchhala of the University of Miami won the LuBee Foundation prize, and Cassandra M. Miller-Butterworth of the University of Cape Town, Cape Town, South Africa won the Karl F. Koopman prize. The special SPELEOBOOKS merchandise prize was awarded to Mariella Freitas of the University of Brasília, Brasília, D. F., Brazil for the best poster. Generous monetary donations from Bat Conservation International, from Roy Horst at Bat Research News, Roger Haagenson and John Seyjagat of The Lubee Foundation, and Emily Davis and Michael Warner of SPELEOBOOKS made the first three prizes possible. Donations from a number of individuals made the Karl F. Koopman Prize possible.

The symposium was visited this year by Dave Barry, Miami resident, noted humorist and nationally syndicated columnist. Dave wrote a column on the bat conference which appeared in the Sunday, October 29th, 2000 editions of newspapers across the country. Featured in the column were observations by host Ted Fleming, Tom Kunz's culinary comments on bats, and Dave Barry's impressions of SPELEOBOOKS (see especially the accompanying). If you haven't seen the column, it's worth the effort of finding it!

At the business meeting Gary McCracken and Nancy Simmons were elected to the Board of Directors to succeed Pat Morton and Roy Horst whose terms expired this year. The Board passed a resolution of gratitude to Margaret Griffiths for her generous and invaluable assistance in making the meeting a success.

Pat Morton of Texas Parks and Wildlife once again organized and ran a special bat education workshop on Saturday of the conference. Her co-organizer this year was Cyndi Marks of the Florida Bat Center. The workshop very well attended by Miami-area teachers, conservation workers, and other local persons interested in the conservation of bats. This was the fifth year in a row that Pat has organized and run this workshop in conjunction with the NASBR. I thank Pat and Cyndi for their efforts which made the workshop possible. Finally, let me extend special thanks to Ted and Marcia Fleming, to Margaret Griffiths (my wife and co-Program Director), and to Roy Horst for all the hard work they did to make this meeting a success.

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Florida Teacher Workshop a Big Success

This year's Teacher Workshop associated with the North American Symposium on Bat Research meeting in Miami was filled to capacity. Thirty-five people were pre-registered and extra chairs provided for walk-ins were occupied as well. The workshop's local coordinator, **Cyndi Marks** of the Florida Bat Center, did a terrific job of recruiting area educators—teachers, education specialists from groups like Audubon, educators from nature centers and even a pest control operator participated. Our faculty provided nearly five hours of instruction. Many of these folks took time out of the regular meeting to help and I'd like to recognize them: **George Marks** (Florida Bat Center), **Denise Tomlinson** (Florida Bat Center and Organization for Bat Conservation), **Jeff Gore** (Florida Fish and Wildlife Conservation Commission), **Jim Kennedy** (Bat Conservation International), **Laura Finn** (Fly By Night and Bat Conservation International), **Rob Mies and Kim Williams** (Organization for Bat Conservation) and **John Seyjaget** (Lubee Foundation, Inc.). The FBC, OBC and LUBEE provided live bats in their presentations that were a bit hit with participants. Cyndi prepared a substantial notebook for each teacher filled with information about Florida bats along with classroom activities.

The workshop would not be possible without the financial contributions and in-kind donations provided by many sponsors. The contributions help fund take-home materials provided to each pre-registered teacher (posters, activity guides, videos, etc.) This year our much appreciated sponsors included **LUBEE Foundation** (has been a financial supporter of every NASBR workshop!), the **Florida Bat Center, Bat Conservation International, Organization for Bat Conservation, Florida Fish and Wildlife Conservation Commission, Bat Research News** and **Speleobooks**.

Special thanks goes to the Organization for Bat Conservation and Bat Conservation International for sending education staff to the meeting in order to assist with the workshop. Each person and organization helps to represent our Society and the goal we all share for educating the public about the natural history and conservation needs of bats. With the annual teacher workshop we make a contribution to each community where we meet.

Finally, an e-mail from one of this year's participants, "Just a short note to let you know how much my husband and I both enjoyed the teacher workshop on the Bats of Florida that was held on Sept. 30 in Miami. All the speakers were very interesting. The free materials were terrific and much appreciated. (The posters are a hit with my third graders). We certainly enjoyed being able to see some live bats up close too. Gold Stars to all those involved in making the workshop such a success!!!"

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Abstracts of Presentations to the 70th Annual North American Symposium on Bat Research
September 27 – 30, 2000 at the University of Miami

These abstracts are printed in alphabetical order by first author

More on the Complexities of Water Hole Use by a Coloradan Bat Community

Rick A. Adams, University of Wisconsin-Whitewater

Further investigations into patterns of water hole use among nine species of a Coloradan bat assemblage reveal the influences of the biotic and abiotic components of resource utilization. By categorizing water holes as either high usage (>100 captures total over five years) or low usage (<100 captures total over five years), degree of temporal spacing among species visiting water holes is discerned using one-way analysis of variance (ANOVA). In addition, by categorizing water hole approachability relative to amount of abiotic clutter (open = flyways > 3 m in diameter; closed = flyways < 3 m in diameter), within species analysis of body weights of bats captured at each site type show significant differences between type of site used relative to body weight. These data have particularly significant consequences for reproductive female bats that increase in body weight, and, therefore, in wing loading, during June and early July. I also offer a follow-up report on the relationship of differential calcium and other mineral levels present among water holes as correlated with visitation patterns of reproductive females and juveniles.

Habitat Use and Roost Selection of Forest Bats on the Mark Twain National Forest, Missouri

Sybill K. Amelon, Frank R. Thompson, and William D. Dijak,
North Central Research Station, Columbia, MO

National Forests in the eastern U. S. are assessing the status of forest bats and their habitat selection. As part of this effort, 2 *Nycticeius humeralis*, 6 *Myotis septentrionalis*, 1 *Myotis sodalis*, 1 *Lasionycteris noctivagans* and 2 *Lasiurus borealis* were fitted with radio transmitters to determine roost and habitat selection. We followed these bats from 3 to 22 days to observe roosting and foraging behavior. Using Geographic Information System (GIS), habitat used by each species was evaluated. Characteristics including home range, landcover within home range, habitat characteristics of each location, and roost descriptions were evaluated.

Utility of Hair Structure for Taxonomic Discrimination in Bats with Examples from the Bats of Colorado

Brian R. Amman, Texas Tech University, Lubbock, TX

Hair structure can vary greatly among mammalian genera, and has been used with varying degrees of success as a taxonomic or discriminatory characteristic at the specific level. The objective of this study was to determine whether hair structure can be used as a supplemental taxonomic tool to identify, at the specific level, the bats of a moderate-sized geographic region in mid-temperate latitudes, using the bats of Colorado as the exemplar group. Hair samples were taken from 58 specimens representative of the 20 bat species known or suspected to occur in Colorado, and examined using light and electron microscopy. Measurements of scale length and width, and filament length were analyzed using ANOVA and Fisher's pair-wise comparisons to evaluate differences. The differences in scale form patterns developed by Benedict (1957), as well as scale dimensions, were used as criteria for the construction of a dichotomous key to the identity of Colorado bats. The two Colorado families, Molossidae and Vespertilionidae, were clearly distinguished using scale form, as was *Lasiurus* from the rest of the vespertilionid bats. Means of scale measurements were used to separate the remaining vespertilionids and the two molossid species from one another.

Bats of Antigua, West Indies

Jon Appino, Vicki J. Swier, and Scott Pedersen, South Dakota State University, Brookings, SD

We performed a mist-netting survey of the bats on the island of Antigua, West Indies during the summer of 2000. The motivation for this effort was to compare the biogeography of Montserrat and Antigua with respect to their response to natural disasters; Antigua being a natural control for Pedersen'

ongoing study of the impact of natural disasters on the bat population on Montserrat. Antigua is the obvious choice for several reasons: 1) Antigua's proximity to Montserrat, 2) equidistance and direction of Antigua and Montserrat downwind from Guadeloupe (Guadeloupe being the most likely source of storm dispersal of animals, and 3) Antigua has not been damaged by major storms or volcanoes. Two previous surveys (Ray, 1963; Morton and Day, 1994) indicated 7 species of bat were on island. However, Morton and Day's 1994 survey was primarily a conservation effort to identify roost sites that would benefit from possible protection through local conservation efforts. As such, our survey was the first recent attempt at mist-netting bats in a variety of foraging habitats. Six species of bats were collected: *Noctilio leporinus*, *Monophyllus plethodon*, *Artibeus jamaicensis*, *Ardops nichollsi*, *Brachyphylla cavernarum*, *Natalus stramineus*, and *Molossus molossus*. *Tadarida brasiliensis* was not captured in 2000 possibly because netting efforts were directed at fruit orchards rather than dry lowland habitats and water holes. We present radio-tracking data for *Brachyphylla cavernarum*, and provide a description of their large maternity colony (n = 20,000) in the southwest corner of the island. In contrast to the *Brachyphylla* maternity colony on Montserrat, the *Brachyphylla* colony on Antigua was not fragmented into separate male/female caves, nor was there any obvious evidence of male/female territoriality in this very large cave.

Morphological Structure in Bat Communities of the Yucatan Peninsula

Hector T. Arita and Leonor Solis, Institute of Ecology, UNAM, Mexico

Ecomorphology, the study of form and structure of organisms to answer ecological questions, is a valuable tool in the analysis of bat communities. One current topic in this field is the study of the relationship between species diversity and the morphological structure of assemblages of species. Ricklefs and Miles, in 1994, stated that one of the few generalizations in ecomorphology is that as the number of species increases in animal assemblages, the average distance between species in morphospace remains constant, while the volume increases. In other words, as species are added to the community, new niche space is created, while the average niche overlap does not change. We tested this generalization for the bat fauna of the Yucatan Peninsula using data on wing morphology. Previous studies had shown a close relationship between wing morphology and diet and habitat, fulfilling the basic assumption that morphology reflects ecology. We compared the morphological structure of 50 assemblages using as basic data the mean wing loading, aspect ratio and wing-tip index for each of the 67 species, based on measurements taken from museum specimens. We calculated the mean nearest-neighbor Euclidean distance between pairs of species and the volume of morphospace as the product of the standard deviations in each variable. We found that as the number of species increases, the average distance in morphospace diminishes and the volume increases, suggesting changes both in the available niche space and in the niche overlap. Observed distance and volume are different from expected even when compared against a null model. These results indicate that bat communities in the Yucatan might be more structured than previously found.

Influence of Availability of Snags and Roost Trees on Presence and Habitat Use of Bats in the Oregon Cascades

Edward B. Arnett and John P. Hayes, Oregon State University, Corvallis, OR

We initiated a study in 1999 to determine (1) influence of availability of snags and roost trees (large, damaged, old-growth trees) on richness of bat communities and abundance of bats, (2) types of structures (e.g., snag) used by female and male long-eared myotis (*Myotis evotis*), female long-legged myotis (*Myotis volans*), and female big brown bats (*Eptesicus fuscus*), and to determine if use of these structures differs among species and landscapes with varying availability of roosts, and (3) characteristics of structures used as day-roosts by bats and to determine factors influencing selection of roosts at multiple spatial scales. Landscapes offering a range of available large snags and roost trees were identified and randomly selected for sampling. Bats were captured with mist nets placed over small ponds, and radio transmitters were attached to a sample of individuals of the 3 target species. A total of 885 bats of nine species were captured during simultaneous mist net surveys in 1999 and 2000. The mean number of all bat species captured (± 1 standard error) in landscapes categorized as low, medium, and high, with respect to availability of snags and roost trees, was 3.6 (± 0.87), 7.0 (± 1.99), and 6.6 (± 0.87), respectively.
Radio transmitters were attached to 119 bats and a total of 312 day-roosts have been located to date; 77, 68, 93, and 74 roosts for female and male long-eared myotis, female long-legged myotis, and female big

brown bats, respectively. Preliminary results indicate that use of different types of structures for day-roosts varied by species and among landscapes with different availability of snags and roost trees. Female big brown bats and long-legged myotis used snags and live trees almost exclusively among all landscapes. Big brown bats used houses for day-roosts more frequently in low landscapes. Male and female long-eared myotis used snags more frequently in medium and high landscapes and readily used stumps, downed logs, and rock outcrops as day-roosts in low landscapes. Future research direction and implications for management will be discussed.

A Classification for the Family Phyllostomidae Based on the Ribosomal mtDNA and the RAG-2 Nuclear Genes

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We generated a gene tree for all genera of phyllostomid bats based on DNA sequences from three mitochondrial genes (12s rRNA, $tRNA^{Val}$, and 16s rRNA) and one nuclear gene (RAG-2). Our tree differs substantially from any previous phylogeny for Phyllostomidae. We extended our tree into a preliminary Linnean classifciation with nine subfamilies. Subfamilies with respective genera in parentheses are **Macrotinae** (*Macrotus*); **Micronycterinae** (*Lampronycteris*, *Micronycteris*, *Neonycteris*); **Desmodontinae** (*Desmodus*, *Diaemus*, *Diphylla*); **Lonchorhininae** (*Lonchorhina*); **Phyllostominae** (*Chrotopterus*, *Macrophyllum*, *Mimon*, *Phylloderma*, *Phyllostomus*, *Tonatia*, *Trachops*, *Vampyrum*); **Glossophaginae** (*Anoura*, *Brachyphylla*, *Choeroniscus*, *Choeronycteris*, *Erophylla*, *Glossophaga*, *Hylonycteris*, *Leptonycteris*, *Lichonycteris*, *Monophyllus*, *Musonycteris*, *Phyllonycteris*, *Scleronycteris*); **Lonchophyllinae** (*Lionycteris*, *Lonchophylla*, *Platalina*); **Carolliinae** (*Carollia*, *Glyphonycteris*, *Trinycteris*); **Stenodermatinae** (*Ametrida*, *Ardops*, *Artibeus*, *Ariteus*, *Centurio*, *Chiroderma*, *Dermanura*, *Ectophylla*, *Enchisthenes*, *Phyllops*, *Platyrrhinus*, *Pygoderma*, *Rhinophylla*, *Sphaeronycteris*, *Stenoderma*, *Sturnina*, *Uroderma*, *Vampyressa* (includes *Mesophylla*), *Vampyriscus*, *Vampyrodes*). Our greatest difficulty in transferring the information in the gene tree to a classsifcation was defining **Stenodermatinae**, where *Rhinophylla* and *Sturnina* could have been assigned to the **Stenodermatinae** or to monotypic subfamilies. Assigning them to subfamilies would be based on classical morphology more so than is justified by our gene tree. Also, the first two branches in our tree (**Macrotinae** and **Micronycterinae**) include genera with primitive dentition and insectivorous (at least partially) feeding habits. The large clade for the remaining subfamilies and genera include all feeding strategies known for the family. It is logical to hypothesize that the ancestor for this large clade after the divergence of the **Macrotinae** and **Micronycterinae** shared many morphological features with *Macrotus* and *Micronycteris*. Many of these primitive morphological features have been retained in some genera (*Glyphonycteris*, *Lonchorhina*, *Trinycteris*) that shared a common ancestry with the vampire bats. Our tree offers no support for vampire bats sharing a common ancestor with any of the other specialized feeding morphotypes after divergence from the phenotype of the *Micronycteris/Macrotus* clade, but does support that nectar-feeding evolved twice. Finally, our tree does not resolve the debate of the generic status of *Mesophylla macconnelli* because *Mesophylla* was sister to *Vampyressa pusilla* but not to *Vampyressa bidens*.

A Case Study: Bat Conservation through Partnership

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Loss of habitat and a general lack of public understanding and undeserved widespread negative reputation results in stress and life-threatening situations for Northwest bats. Of particular concern is the shortage of natural bat maternity roosts, as the Northwest is short on caves and long on diminishing old-growth forests. Female bats will often choose human habitation for their maternity roosts, as building attics provide the heat needed for successful pup raising. This proximity to humans often puts the maternity roosts at risk. A long-standing maternity roost of several thousand big brown bats was successfully offered new housing by way of a partnership between Bats Northwest, the Hovander Park in Ferndale, Washington, and the State Department of Fish and Wildlife.

Year-to-year Reuse of Tree Roosts by California Bats (*Myotis californicus*) in Southern British Columbia

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To document the year-to-year reuse of roost trees by forest-dwelling bats, we monitored trees in southern British Columbia that we first identified as maternity roosts of California bats (*Myotis californicus*) in 1995. We initially identified roost trees by tracking radio-tagged females. We then revisited each tree in subsequent years up to 2000. At the start of the study, the bats roosted under loose bark or in cavities in dead trees. Seven of eight trees were still standing in 2000, although all had lost bark relative to what was present in 1995, particularly the ponderosa pines (*Pinus ponderosa*). In 1995, after radio-tagged bats had moved and the tags had fallen off, roosts were occupied by colonies of *M. californicus* ranging from 5 to 52 individuals, or they were unoccupied. In contrast, roost counts in subsequent years indicated that colonies rarely used the trees and most observations were of one or two bats. Thus, while bats continued to use most of the trees over a five-year period, the numbers of individuals declined and much of the use may have been by males or non-reproductive females. Although our study is preliminary, our results suggest that the suitability of roosts of tree-dwelling bats may decline relatively rapidly compared to the loss of the snags themselves. More intensive studies are required given the current focus on preserving roosting habitat for forest-dwelling bats.

Use of Cranberry Mines, NC as Bat Hibernacula

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The Cranberry mine complex was excavated to supply iron ore for the Confederacy, but has been abandoned since the 1950's. The mine was visited 23 times throughout the past three winters to correlate species diversity and abundance of bats with environmental factors. In 2000, movements of individual bats within the mine were studied. This mine provided hibernacula for four species. Numbers of bats ranged from 0 to 398 individuals. These included the endangered Virginia big-eared bat, *Corynorhinus townsendii virginianus*. All bats eventually moved during a 7 week interval during the winter of 2000. Northern myotis (*Myotis septentrionalis*) moved the most, while all other species were found repeatedly in the same site. Cranberry mine complex appears to be important winter habitat for several species of bats.

Effective Use of an Aircraft for Collection of Radio-telemetry Data for a Bat Foraging Study in Roadless Terrain

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During August, 2000, ten Allen's big-eared bats (*Idionycteris phyllotis*) were fitted with 0.5 gm Holohil transmitters for determination of their foraging area and habitat use in the Black Mountains of western Arizona. After two nights of ground-based telemetry tracking with limited success, it became apparent that aircraft support would considerably enhance the study. All ten bats were detected from the air whereas less than half were located by land-based receivers. Airborne data consisted of a GPS file of second-by-second recording of time, position, and velocity and with a thirty frame per second time coded digital video recording of signal frequency, signal strength, and voice notes. The Communication Specialists R-1000 telemetry receiver was programmed to scan all ten frequencies with a delay of 3 seconds per channel. Aircraft speed was about 150 feet per second and each channel was scanned every 30 seconds amounting to a sample of each frequency at 4500-foot flight intervals. Estimated location of each bat was accomplished by merging and analyzing the GPS and video files at the end of the flight. A total of 14 flight hours of data collection were accomplished during the study.

Can Skull Morphology Be Used to Predict Ecological Relationships between Two Cryptic Species of Pipistrelles? A Test Using Three-dimensional Morphometrics

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The morphological structure of the cranium as well as the dentary apparatus in bats may, to some degree, influence diet and habitat use. The expected relationships are more complicated in the case of cryptic species, which morphologically are very alike but still, as in the 45 kHz and 55 kHz cryptic species

of the vespertilionid *Pipistrellus pipistrellus sensu lato*, hunt different prey and show resource partitioning. The former eats larger prey items and occurs in a wide range of habitats, while the latter consumes smaller prey and almost exclusively forages over water. The differences between the two species were studied in a sample of 26 skulls from Great Britain using 70 three-dimensional homologous coordinates derived from the cranium, mandible, and teeth. The new traits provided more accurate descriptors of interspecific variability than traditional measures, and were related to mechanisms of resource partitioning.

The Use of Partial Warp Scores as Cladistic Characters in Testing Evolutionary Relationships among the African Fruit Bats, *Rousettus egyptiacus*, *Eidolon helvum*, *Myonycteris torquata*, and *M. brachycephala*

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There is serious disagreement concerning the use of partial warp scores derived from the shape differences among organisms as cladistic characters for phylogenetic inference. To test this methodology we depicted the skull morphology of the four African megabats (*Rousettus egyptiacus*, *Eidolon helvum*, *Myonycteris torquata*, and *M. brachycephala*) by means of the thin-plate spline (TPS) of 40 three-dimensional homologous landmarks describing the cranium. The decomposition of TPS by its partial warps resulted in features that can be subjected to cladistic analysis. The most parsimonious tree was compared with the evolutionary hypothesis derived from the genetic literature-based data, and the methodology evaluated and discussed in terms of its effectiveness at retrieving phylogenetic signal from bat morphology. Another test included comparisons between the mainland populations of these bat taxa and some island populations (of presumably known history), to evaluate whether phylogeographic information can be extracted from these data as well.

Nutrient Preferences of *Glossophaga soricina*

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Nectar-feeding bats, like hummingbirds, have high energy requirements but their need for other nutrients is less well known. Minerals such as calcium and nitrogen are believed to be limiting factors for bats. To test whether nectar-feeding bats can discriminate and have preferences over food sources differing in the nutrients they offer, we are testing the responses of two groups of long-tongued bats (*Glossophaga soricina*) bearing transponders to three solutions: nectar, nectar supplemented with vitamins, and nectar supplemented with minerals. The first group (n=20 males, 20 females) is captive, having access to the artificial feeders only for food. To drink from the one aperture left opened on the feeder, flying bats have to reach through a circular antenna allowing the receiver to record visits made by each micro-chipped individual. In the first trial, the bats showed a clear preference for straight nectar by making 70% of their visits to this treatment and 15% to both kinds of supplemented nectar ($\chi^2_{(2)} = 61.1$, $p<0.001$). In the second trial, after 11 days on the liquid diet only, the bats made more visits to the nectar (55%) followed by the vitamin-treatment (42%) but avoided the mineral supplemented nectar (3%) ($\chi^2_{(2)} = 44.4$, $p<0.001$). The second group (n=28 males, 24 females) will be released in a 2600 m^2 tropical forest replica at Montréal's Biodôme. The latter group will have access to the three artificial feeders and to "natural" food sources, i. e., to flowers/nectar, pollen, fruits and insects they naturally consume in the wild. The choices of the "free-ranging" bats should shed some light on their needs for supplementation when they are under a "natural" diet. The results of the previous experiments and of the trials to come will be discussed.

Foraging and Roosting Behavior of Allen's Big-eared Bat *Idionycteris phyllotis* in the Arizona Desert

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Allen's big-eared bat (*Idionycteris phyllotis*) is one of the rarest North American bat species. Limited information exists about its roosting and foraging habitats. Tumlison (1993) identified two geographically

distinct subspecies based on cranial characteristics. The larger nominate subspecies (*I. p. phyllotis*) occurs south of the Grand Canyon, with specimens collected along a southeast trending line across the mountains of central and southern Arizona, principally in yellow pine and oak woodland. Recent radio-telemetry of these bats (Rabe et al., 1997) suggests that they roost in tree snags. The newly-defined *I. p. hualapaiensis* occurs in Arizona in Mojave and Coconino Counties, typically in desert habitats. The only known roosts for this subspecies are in five mines in Mojave County. Extensive surveys by the authors in this area over the past three years have failed to discover additional roosts. Two of the colonies are imperiled by renewed mining operations. In August 2000, 0.5 g Holohil transmitters were attached to 10 banded *Idionycteris* (9 adult females and a sub-adult male) that were captured outside the mine as they departed at dusk. The bats were tracked for the next 10 nights to determine foraging habitat and alternate roosts. Most of the bats headed north of the mine into a roadless area of rugged terrain beyond the range of ground-based tracking stations. Night flights with a Cessna 172 located the bats at times over 15 km from the roost. Mesquite and juniper were present in the areas where the bats were foraging. Some of the tagged bats returned to their home roost nightly, while others would return every second or third night, suggesting an alternate roost to the north. By the end of the study, eight of the bats were recaptured and weighed at the mine where they were banded. No banded bats were ever seen in the other *Idionycteris* mines (three roosts were located within a mile of the home roost). This research was supported in part by BCI NABCP and USGS Species at Risk grants and the efforts of many volunteers.

Ecological Management and Restoration of Bat Trees

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Present day forests in Washington State significantly comprise a greater proportion of younger age tree classes than during historical times. The predominance of younger aged forests combined with expanding urban areas, elimination of dead and dying trees for a variety of reasons are leaving a forested landscape less capable of supporting viable populations of bats and other tree cavity associated wildlife. This presentation will illustrate unique techniques for modifying tree structure and function in younger forests and maintenance of existing trees in more mature forests. A variety of techniques utilizing chain saws, fire and logging are used to create special bat roosting and foraging features in Washington forests.

Field Discrimination between *Cynopterus brachyotis brachyotis* and *C. sphinx angulatus*

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Cynopterus brachyotis and *C. sphinx* are small fruit bats occurring sympatrically in the Indian subcontinent and South East Asia. They overlap in size which makes it difficult to separate them. Although the genus *Cynopterus* has been well studied, it still presents taxonomic uncertainties. In Thailand, the proposed subspecies are *C. b. brachyotis* and *C. s. angulatus*, which overlap in forearm length (*C. b. brachyotis*: 57.0-66.0 mm, *C. s. angulatus*: 64.9-73.0 mm). The aim of this study is to suggest reliable characteristics which could be used to separate these species in the field. Stepwise discriminant analysis selected four variables: forearm length, ear length, weight, and canine to canine width. Weight and canine to canine width were eliminated because the former correlates with forearm length and showed high variation, and the latter did not increase the incidence of correct classification. The 100 percent correct classification function derived from 206 *C. b. brachyotis* and 184 *C. s. angulatus* was applied to 92 individuals which were difficult to classify because of overlapping dimensions. Among these, 54 were classified as *C. b. brachyotis* and 38 were *C. s. angulatus*. These were remixed with their species and functions were recalculated. The final function, with cross validation, revealed 100 percent correct classification in males and 98.7 percent in females. Only 3 female individuals were misclassified. The final functions are:

For males, $z = 0.489*\text{forearm length} + 0.256*\text{ear length} - 36.478$

For females $z = 0.440*\text{forearm length} + 0.415*\text{ear length} - 35.188$

Where z is the canonical score calculated from the discriminant function.

If $z > 0$, then the individual is *C. s. angulatus*.

If $z < 0$, then it is *C. b. brachyotis*.

However, the practical use of these functions needs further clarification from genetic studies.

A Computer-based System for Recording and Analysis of Bat Echolocation Calls

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Recent advances in the price and performance of computer software and hardware have made it possible to use a laptop computer as a sound recording system. However, due to the high sampling rates required for recording ultrasonic sounds, such systems were limited in their ability to record bat echolocation calls. With the advent of PCMCIA analog-to-digital converter cards capable of sampling at ultrasonic frequencies, a laptop computer can now be used as a portable ultrasonic sound recorder. We describe the development of a system for recording, extraction, and analysis of bat echolocation calls. Using the software program CBDISK (Engineering Design), this system is capable of recording sounds containing frequencies greater than 160 kHz, with durations limited only by the amount of space available on the computer's hard disk. We have written custom programs using the SIGNAL programming language and Event Detector (Engineering Design) to automatically detect echolocation calls in the data file and save them to separate files. The calls are then analyzed using custom programs in MATLAB (Mathworks, Inc.) to record a number of variables that describe the time, frequency, and amplitude structure of the calls. This analysis produces a file that can be read in a variety of different statistical programs for further analysis.

Genetic Variability of *Nyctimene vizcaccia*, the Bismarck Tube-nosed Bat, from West New Britain (Papua New Guinea)

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There are approximately 14 species in the genus *Nyctimene* (Pteropodidae) ranging from the Philippine to the Solomon Islands. These species are not easily distinguished morphologically and therefore have been defined primarily by geographic range. The absence of well-defined traits has led to confusion about their taxonomic relationships. The tube-nosed bats occurring in New Britain (Papua New Guinea) have been most recently classified as *N. major* and *N. vizcaccia vizcaccia*. However, specimens now designated as *N. v. vizcaccia* have been classified as *N. cyclotis*, or as a subspecies of *N. albiventer*. To determine the distinctness of populations I sampled on New Britain, I analyzed the genetic diversity within and among those populations using amplified fragment-length polymorphisms (AFLP). AFLP fingerprinting can help to resolve taxonomic questions by characterizing gene flow among populations when the defining morphological characteristics are subtle. Preliminary AFLP data show considerable genetic differences suggesting two genetically distinct groups within New Britain's *N. v. vizcaccia*. This information can help address the current taxonomic problems that are common throughout the Pteropodidae.

Habitat Use by Northern Long-eared Bats in Southern Illinois

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Bats were mistnetted two consecutive summers in the Shawnee National Forest of southern Illinois. Netting efforts were concentrated in bottomland hardwood forests in 1999, and in upland hardwood forests in 2000. Bottomland forests were also sampled in 2000 for comparison. Netting primarily consisted of four net sets, two on edge habitat usually over water, and two net sets in interior forests. Distinct differences in the activity patterns of Northern long-eared bats (*Myotis septentrionalis*) occurred. Bats were captured almost exclusively in interior net sets in bottomland forests. However, in upland forests bats were captured most frequently over edge stream corridors. Capture numbers also suggest that *M. septentrionalis* is much more prevalent in bottomland forests.

Preliminary Work on Maternity Colonies of Indiana Bats (*Myotis sodalis*) in Illinois

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Preliminary work on maternity colonies of Indiana bats (*Myotis sodalis*) during summers of 1998 and 1999 yielded 23 roosts from three localities in Southern Illinois. All roost trees were located in bottomland, floodplain, or swamp habitats. Roosting areas for two maternity colonies were 11.72 ha and 146.5 ha using the minimum convex polygon method. The average distance traveled between consecutively used roosts was 578 m (max 2.14 km, min 10 m). All roosts were associated with areas that were more open than the surrounding forest. Open areas were usually created by one or more trees dying which created an opening

in the forest canopy. Roosts also were located along man-made openings such as roads or ditches. Percent canopy closure at the roosts averaged 26% (max 65%, min 0%). The species of snag used did not differ from those previously reported. Species used included green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), silver maple (*Acer saccharinum*), pin oak (*Quercus palustris*), and shagbark hickory (*Carya ovata*). The average decay class of the snags containing roosts was 4.25 (most branches gone with exfoliating bark; Thomas et al., 1979). The average diameter of roost trees was 35 cm (max 58 cm, min 18.5 cm) with an average height of 17.5 m (max 34.5 m, min 10 m). The average height of the actual roosts was 8.5 m (max 18.6 m, min 2.5 m). All roosts were located on the bole of the snags. Of these, 22 roosts were located under exfoliating bark; one roost was located in a crack covered by exfoliating bark. Bats averaged 1.5 nights per roost.

Morphological Variations of *Hipposideros armiger terasensis* Between Sex and Age

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Hipposideros armiger terasensis, an endemic subspecies of the island of Taiwan, is commonly distributed throughout the lowland and low altitude mountain area. A previous study on the reproductive ecology of this subspecies also evaluated the external morphology; it showed significant differences in forearm length and body length between males and females. Therefore, a study was designed to examine the morphological variation within *H. armiger terasensis*. Thirty skull features were measured on 89 specimens in the National Museum of Natural Science, Taichung, Taiwan. All specimens in this study were collected at one colony located in Zhong Liao, Nan-To county. Individuals were grouped in two ways: 1) male and female; 2) three age groups for further analysis. Data anaylsis is still in progress, and I will use one-way ANOVA, with a multiple range test to test for significant differences of each character between two sexes and age groups and compare their size and shape. In addition, I will do a principal component analysis to determine which characters contribute most to the morphological variation.

Effect of Two Different Systems of Natural Forest Management on Bat Community Structure and Diversity in Trinidad's Rainforests

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Human activites increasingly alter tropical forests leading to a loss of biodiversity. Bats may prove a model taxon for the study of deforestation on vertebrate communities. Trinidad is an ideal locality for such a study, with a well documented, rich, bat fauna of c. 67 species. Part of the rainforests in the Victoria-Mayaro Forest Reserve (VMFR) in southeast Trinidad is logged using two systems of natural forest management. The Open Range (OR) management in Trinidad involves felling all commercial trees over a certain girth and has been used in most tropical forests around the world. More recently, the Periodic Block (PB) system has been developed in Trinidad. The PB is a polycyclic felling system which includes a set of ecologically sensitive extraction procedures, which include, for example, leaving large numbers of fruiting trees which have a large wildlife value. The forest under this management system comprises 30 blocks of 300 ha, one of which is opened each year, and after closure will not be re-opened for 30 years. Fieldwork has recently begun to examine and compare the effects of the two different logging systems on bat community structure. I will discuss our objectives and will also present the results of a pilot project in the VMFR in which the bat fauna of *Mora excelsa*-dominated rainforest was determined.

A Preliminary Assessment of the Pest Control Service Provided by the Mexican Free-tailed Bat *Tadarida brasiliensis* in South Central Texas

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The control of agricultural pests is thought to be one of the most significant ecosystem services, yet analysis has been limited to anecdotal and "ballpark" assessments. A notable example of pest control are the populations of Mexican free-tailed bats (*Tadarida brasiliensis*) in south central Texas. These bats consume vast quantities of insects during their nightly foraging, some of which are important agricultural pests. One measure of the value of this service is the avoided cost of consumption, which is the value of the crops not consumed or destroyed by the pests that are eaten by the bats. Our preliminary assessment indicates that the value of this service is large, highlighting the need for a more scientific analysis of this

and other species, including their conservation needs, as well as more public education about the role bats and biodiversity in general play in supporting human life.

Microsatellite Analysis of Several Captive North American *Pteropus rodricensis* Colonies
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The Rodrigues fruit bat (RFB), *Pteropus rodricensis*, has long been known for its history of near extinction and subsequent captive breeding. Since inception of the captive breeding program in 1976, more than 600 RFBs, spanning up to 6 or 7 generations, have been born in captivity. Until recently, breeding was mostly unregulated at many institutions. The studbook records were extremely incomplete with paternity being almost impossible to determine due to the colonial nature of RFBs. Furthermore, maternity is often in question because of the difficulties of identifying specific individuals at some institutions, and is further complicated by aunting behavior. With the advent of microsatellite technology, it is now possible to determine parentage of all pups born in captivity, and to subsequently ascertain pedigrees and revise the species studbook. I will present pedigree information for several of the North American RFB colonies. Furthermore, I will use this information to address several issues such as mating success, founder contributions, levels of genetic variation lost over time, effective population sizes, and issues of reproductive biology.

Seasonal Distribution of Male and Female Hoary Bats *Lasiurus cinereus* in Continental North America
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Hoary bats (*Lasiurus cinereus*) are one of the most widely distributed bat species in the New World. Findley and Jones (1964; J. Mamm. 45:461-470) described patterns in the seasonal distribution of hoary bats and presented evidence of migratory movements by mapping occurrence records. I repeated this analysis using new records and mapping techniques. Mammal collections throughout the Americas contributed information on more than 3400 *L. cinereus*. Records from North America were categorized by month and mapped for both males and females. During the winter months (November - February), both sexes occur in Mexico and in coastal regions of the United States (US). However, females are less common than males in Mexico during January, suggesting movement further south. Females begin northward movements during March and April followed by similar movements of males in May and June. In general, concentrations of females exist north and east of the Rocky Mountains during June and July, while males are concentrated in the mountainous regions of the western US. Males apparently begin moving south before females during early fall, followed by the sudden disappearance of both males and females from central North America during November. Records indicate that hoary bats are absent from the southeastern coastal states of the US during much of the year.

The Basisphenoid Pits of Emballonurid and Molossid Bats (Chiroptera)
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The function of basisphenoid pits, depressions in the basisphenoid bones behind the palate in a variety of bats, remains unknown. If basisphenoid pits somehow are involved in the emission of echolocation signals, then species with different echolocation call designs would be expected to have different basisphenoid pit morphology. To explore this possibility I quantified intraspecific and interspecific variation in morphology of basisphenoid pits in 140 specimens representing 14 species (4 genera) of emballonurids and 24 species (10 genera) of molossids. Morphological variables were measured from the skulls of specimens in the collections of the Royal Ontario Museum, Toronto, Ontario. I used a Wild M5 binocular stereomicroscope, and traced the outlines of the depressions onto clear white paper using a camera lucida. I obtained area using an image processing and analysis program. I collected echolocation call parameter data from published literature (e.g. Fenton and Bell, 1980) and unpublished literature (Fenton, unpublished data). Using multivariate techniques, I found significant differences in variation ($p<0.05$) of basisphenoid pit morphology among genera and among the two families. I found a significant correlation ($r > 0.71$) between echolocation call parameters and basisphenoid pit morphology indicating a functional role in the processing of ultrasound along the vocal tract of microchiropteran bats.

Launching a Network of Acoustic Bat Inventories in Quebec

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In Quebec, we have very little data on the distribution and status of bat populations. Following the trend of the decline of bat populations in North America, four species of bats that are already considered rare (out of the eight species in Quebec) have been added to the list of species being considered for designation as **threatened** or **vulnerable** species. To preserve these small flying mammals in Quebec, the Biodôme de Montréal and the Société de la faune et des parcs du Québec joined forces during summer 2000 to launch a network of acoustic bat inventories in three regions around the province. The network is intended to monitor population trends of all species of bats living in and migrating through the various regions of Quebec. Observers or volunteers involved in conducting acoustic inventories were chosen from various ornithological associations already closely involved in observing and conserving bird populations. Volunteers were given training by a biological consulting firm (Envirotel Inc.), to ensure that the mobile acoustic inventories would be conducted properly. During the training sessions, people were given a theoretical background, followed by an immediate outing to put the knowledge acquired into practice. For the inventories, bat calls were sampled along a pre-selected road route. Each listening route had to be 20 km long and cover a variety of representative habitats in the region, while including some good bat habitats. Between 24 June and 10 July, 2000, observers drove along their listening routes at sunset and recorded bat calls using a tape recorder connected to an Anabat II echolocation detector. Call analysis and processing of the collected data will give us valuable preliminary information, such as the relative representation of the detected species, density of bats and species per km^2 and species distribution (mapping). By repeating the inventories in the same and new locations year after year, coupled with mist-netting, we hope to gather information on bat population trends in Quebec.

Habitat Use by the Evening Bat, *Nycticeius humeralis*, and the Big Brown Bat, *Eptesicus fuscus*, in Indiana

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The evening bat, *Nycticeius humeralis*, has never been common in Indiana, and is listed as endangered in the state. All of the early populations known from Indiana were in 11 total buildings. None of the building colonies are still active. One possible factor in this decline could be niche overlap with a well-adapted urban species, the big brown bat, *Eptesicus fuscus*. These two species are both adapted to eating hard-bodied insects, have very similar diets, and throughout their respective ranges, are able to roost in buildings. *Eptesicus fuscus* is a common species in Indiana and could be edging out *Nycticeius* in buildings, since Indiana is at the northern edge of its range. Evening bats are still present in forested wetlands of southwestern Indiana along the Wabash River floodplain. They are the most prevalent species found in a 650-hectare bottomland woods in southern Vigo County, Indiana. Since recent habitat alterations that opened up the forest, the big brown bat has become more common in the area and is now present during the maternity season. Habitat disturbances could be allowing the big brown bat greater access to the area, creating a zone of interaction between the two species. I intend to discuss habitat use by these two species based on data from mist-netting and preliminary radio telemetry data of bats captured in this area.

Tooth Structure and Diet: Correlates of Chemical Environment

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Teeth are the primary tools that mammals use to physically break down foods. For example, the molar teeth of insectivorous bats have sharp cusps and elongated crests for fracturing insect exoskeletons, while the molars of fruit bats have broader cusps and basins for crushing plant tissue. In addition to resisting the physical wear and tear encountered during food processing, teeth need to resist the chemical erosion of enamel that can result from acidic foods. This is particularly true of fruit bats, which consume primarily fruit and have little protection from dietary acids. This study investigates two mechanisms through which the erosive effects of exposure to dietary acids may be minimized. The first way teeth may be protected from erosion is by minimizing exposed surface area relative to tooth volume. Because enamel in bats is not replaced, tooth designs that expose as little enamel as possible to the oral cavity may ultimately last longer. Tooth surface area and volume of lower molar teeth representing 33 bat species were determined using

confocal microscopy and 3-D reconstruction. While there is no relationship between tooth structure and salivary pH among insectivorous species, both frugivore lineages (pteropodids and phyllostomids) exhibit a significant decrease in surface/volume ratios with decreasing salivary pH. The second way that teeth may be protected from chemical erosion is through modified tooth enamel structure. Compared to insectivorous bats, frugivores tend to exhibit more simplified enamel structure characterized by closely-packed apatite crystals. This arrangement should make the enamel less porous and therefore more resistant to acids penetrating the tooth surface. These results indicate that molar tooth macro- and microstructure reflect not only the mechanical demands placed upon the teeth but also their chemical milieu.

Picking the "Right" Bat Detector - Time Expansion Versus Zero-crossing

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Direct comparisons revealed that a bat detecting system using zero-crossing period meter analysis (the Anabat II Bat Detector with Anabat ZCAIM module and Anabat 6 software) was significantly less sensitive to bat echolocation calls than time-expansion bat detecting systems. One time expansion system involved recording the high frequency output of a QMC S200 Detector to a Racal Instrumentation tape recorder operated at 30 inches per second, with analysis of slowed down recordings by CanaryÆ. The other time expansion system was a Pettersson D980 bat detector with digitally time expanded output recorded on a SONY DCD 100 data recorder and analysed by Bat Sound ProÆ. In a variety of field settings, the time-expansion systems always recorded significantly more echolocation calls than the zero-crossing period meter system. Furthermore, under laboratory and field conditions, the zero-crossing period meter analysis presented significantly different pictures of frequency and time features of echolocation calls, including highest and lowest frequencies in the calls (kHz) and call durations (ms). The differences in performance between the two kinds of systems reflect the fact that to pure tone frequencies of 20, 30, 40 and 60 kHz, the threshold for signal detection by the Anabat system was 19 dB (SPL A @ 4 cm) higher than for either time expansion system. These results mean that zero-crossing systems should not be used to characterize the echolocation calls of bats and that they are of limited value in studies of distribution and habitat use.

The Bats in Buildings Program

Laura S. Finn, Bat Conservation International; Fly By Night, Inc.

Many bat species have adapted to the loss of natural habitat by roosting in man-made structures such as bridges, mines, buildings, and bat houses. These structures may be used as either day or night roosts, and the colonies using them may vary in size from less than a dozen Antrozous to thousands of *Tadarida*. Bats that roost in buildings are at risk from uninformed pest control operators who are often contacted by property owners or managers to handle bat nuisance problems. To address this issue, Bat Conservation International (BCI) has implemented "The Bats In Buildings" program in collaboration with Fly By Night, Inc. This program was designed to educate PCO's about bats and safe, conservation-oriented methods for evicting them from buildings. A set of bat exclusion guidelines was developed, and PCO's invited to participate in a certification program. Professionals who agree to follow BCI guidelines will receive an annually renewable "Professional Bat Excluder" certificate and will be listed on the "Bats In Buildings" web site. The web site will include designs of alternative roosting structures, as well as detailed information on proper exclusion methods. A Bats in Buildings Handbook has also been drafted, and will be published later this year in both English and Spanish.

Is *Leptonycteris curasoae* an Unreliable Pollinator?

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Many species of Mexican columnar cacti produce nocturnal, bat-adapted flowers. Throughout most of Mexico and the southwestern United States, the lesser long-nosed bat, *Leptonycteris curasoae*, is the major pollinator of these flowers. Experimental studies in south-central Mexico, Venezuela, and Curaçao indicate that bats are the nearly exclusive pollinators of flowers of night-blooming columnar cacti. Similar studies in the Sonoran Desert, however, reveal that lesser long-nosed bats are not the exclusive pollinators of "bat flowers." Diurnal pollinators, including birds and bees, are also effective pollinators of these flowers. This raises the question, why are the pollination systems of northern cacti more generalized than those of their

southern relatives? To answer this question, I discuss possible definitions of the term "pollinator reliability" and present data from a 10-year study in Sonora, Mexico, on diet specialization and population density variation in *L. curasoae*. Based on these results, I conclude that this bat is an unreliable pollinator in the northern part of its range only because of its chronically low abundance. In the face of low bat abundance, selection has favored subtle phenological changes in the flowers of columnar cacti that increase their exposure to diurnal pollinators. Migratory behavior, per se, does not make *L. curasoae* an unreliable pollinator. But chronically low population densities relative to cactus flower densities does.

Debunking Ghosts of Seasons Past: Emergence Counts of Brazilian Free-tailed Bats

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Indigo Systems, Inc.; Boston University

The Brazilian free-tailed bat (*Tadarida brasiliensis*) is often considered to form some of the largest aggregations of mammals known to mankind, with some caves in the southwestern United States reportedly housing upwards from 5 to 30 million individuals during the warm months (April through September). Notwithstanding, these and similar historical estimates have largely been based on questionable methods, untested assumptions, and limited sampling efforts, and at best are considered no better than "educated guesses." This paper describes a new method appropriate for censusing both small and large aggregations of emerging bats using novel detection, data recording, and data reduction techniques. This method involves detection of bats during nightly emergence flights using an advanced infrared thermal imaging system and recording the resulting high-fidelity digital data in real-time. Off-line, these data are subjected to a series of image processing procedures to estimate the total number of bats present. The reliability and precision (5% error) of this technique are far greater than previous methods used owing to the sensitivity of detection and high sampling rates. Our estimates derived for Eckert James River and Frio Caves in June and July 2000 suggest that previous censuses may be high by an order of magnitude.

Metabolic responses induced by fasting in the common vampire bat *Desmodus rotundus*

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The purpose of this work was to investigate the terminal fasting in captive vampire bats as well as evaluate parameters of their carbohydrates, protein and lipid metabolism and the adaptive changes induced by food deprivation. We analyzed data from one species of vampire bats: *Desmodus rotundus*, captured during dry and wet seasons of Brazilian environment. Comparison were made between fed animals and fasted for 24, 48, and 72 hours, and also between male and female bats during both seasons. The main results of this work are presented as follows. Although somewhat higher in female bats, blood glucose concentration did not differ significantly in fed male and female animals. Fasting induced a marked decrease (73%) in blood glucose levels, which was detected after 24 hours of food deprivation. These levels remained low until the end of the period of fasting (72 hours). As a consequence, animals started to die very soon, and most deaths occurred in animals fasted for 72 hours. Liver and muscle glycogen contents were very low in fed animals, and decreased markedly after 24 hours of fasting, remaining practically unchanged thereafter. Rates of protein stores on skeletal muscles were not affected by fasting, and liver and muscle contents of lipids decreased, but this fall was not considered important because of the low amounts of this body fuel in fed animals. In agreement to the low amounts of fat stores in several studied tissues, plasma levels of free fatty acids (FFA) of vampire bats were not increased by fasting, as is usually observed in other mammals. Actually, plasma FFA were high in fed state and progressively declined in response to fasting. Taken together, the data obtained here indicate that vampire bats have very low contents of energy stores as fat or glycogen in both seasons, and they seem to have problems with the proper maintenance of blood glucose during food deprivation. Factors other than this may overcome this inability and support the survival of this species, like reciprocal sharing food by blood regurgitation between bats from the same social unit.

Human Rabies Attributable to Bat Rabies Variants:
Three Hypotheses and Reflections on Prophylaxis Guidelines
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Human rabies in the United States is rare; there have been only 27 cases since 1990. Of these, 5 were due to transmission of the rabies virus from dogs in foreign countries. Of the remaining 22 cases acquired in the United States, 20 have been have been attributed to bat variants. The debate about how the bat rabies virus variant was transmitted to humans centers on three hypotheses. First, is there something extraordinary about the pathophysiology of the bat rabies virus variants? For example, a common perception is that rabies can be transmitted by aerosol. A review of the literature reveals that there is little support for aerosol transmission of rabies in nature and any type of nonbite transmission to humans is rare. Second, could the rabies virus "spill over" from the bats into other host animals who then transmit the rabies to humans? This alternate host hypothesis would require exposure to another rabid animal (presumably by bite). Studies have documented that almost all isolates from terrestrial animals have the variant associated with the predominate terrestrial carnivore in the area. Similarly, the rabies variant found in domestic animals is almost always that associated with local terrestrial variants. Third, is the rabies transmission occurring via bat bites that are minimized or not recognized? For example, a person may minimize the potential medical importance of a bat bite or they may not even realize they have been bitten. This last hypothesis (both scenarios) is based on our current understanding of the natural history of rabies and its transmission. Although it may be that the former scenario is more common, the potential for the latter scenario is why Advisory Committee on Immunization Practices (ACIP) recommends prophylaxis in the cases where a bite cannot be excluded. It is likely that most human cases associated with a bat variant of the rabies virus are due to minimized or unrecognized bat bites. Whereas a rare case could be due to the alternative host hypothesis, the aerosol transmission hypothesis is not a tenable hypothesis in nature and should not be routinely considered. The demands of public health, the treatment needs of individual patients, and education for health care providers require guidelines to assist in decision making regarding rabies prophylaxis.

Conservation of *Pteropus livingstonii* Based on Bat Roost Sites Habitat Characteristics
on Anjouan and Moheli, Comoros Islands
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Livingstone's fruit bats, *Pteropus livingstonii* (Pteropidae: Chiroptera), are endemic to only two islands, Moheli and Anjouan in the Comoros Islands. With an estimated population of less than 2000 individuals, *P. livingstonii* is listed as Priority Grade 1 - Endangered on the IUCN Red List. Yet the habitat characteristics of these giant fruit bats are poorly known. Therefore I conducted a field research project during five months in 1998 focused on searching for new roost sites, measuring characteristics of both the roost sites and roost trees at new as well as previously identified roost sites, and recording the same characteristics for a set of absence sites. Six new roost sites were identified allowing for study at 15 known roost sites and seven absence sites. The study spanned both dry and rainy seasons and found a significant increase in the number of individuals at roost sites from dry season to rainy season. Bat roost sites were associated with presence of water, southeast aspect, steep slopes, absence of the congeneric *Pteropus seychellensis comorensis* and presence of several native tree species, as well as the absence of an introduced tree species. Roost habitat was characterized based on biotic, abiotic and human factors. This research on habitat characteristics is contributing to the development of a conservation action plan for the Livingstone's fruit bats. However, further research on dry season roost sites and distribution as well as feeding sites is suggested in order to better understand their seasonal habitat requirements and therefore ensure the conservation of *P. livingstonii*.

A Pronounced Case of Inter-annual Variation in the Reproductive Phenology
of a Little Brown Bat Colony
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During the summers of 1999 and 2000, a colony of about 300 female little brown bats (*Myotis lucifugus*) was surveyed thanks to regular capture sessions at dusk, on a small island of the Saint Lawrence River. The parturition timing of the colony was extrapolated from palpation and nipple observations.

Global weather conditions were particularly contrasting from one year to the other. The first summer was more warm and sunny than usual, whereas the second one was exceptionally cold and wet. Thus, the parturition timing was affected in two ways: when compared to the mildest summer, birth dates during the bad summer were delayed and unsynchronized. In 1999, the lactation peak was reached as soon as the first week of July, and only 2 weeks later in 2000. The lactation period lasted 10 days and 1 month respectively for 1999 and 2000. However, in each case, according to our insect samplings, the beginning of the parturition corresponded to the increasing prey abundance. All in all, bad weather conditions of the summer of 2000 resulted in an increased inter-individual variation in the parturition dates. This variation was partly explained by the age of the reproductive females: yearling reproductive females were lactating significantly earlier in the summer than adult females. This underlies the fact that both extrinsic (weather conditions) and intrinsic factors could act on the reproductive phenology of female little brown bats.

Fruits and Insects as Sources of Protein in Neotropical Frugivorous Bats: Evidence from Stable Isotope Analysis

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Thomas (1984) suggested that phyllostomid frugivorous bats supplement their carbohydrate-rich diet with insects because fruits contain low levels of protein. We used stable-carbon and -nitrogen analysis to estimate the relative contribution of fruits and insects to the nutrition of five species of neotropical frugivorous bats, *Artibeus jamaicensis*, *Dermanura phaeotis*, *Carollia brevicauda*, *Uroderma bilobatum* and *Sturnira lilium*. An insectivorous species, *Pteronotus parnellii*, was also included for comparison. Stable isotope analysis of nitrogen($^{15}N/^{14}N$) and of carbon ($^{13}C/^{12}C$), are particularly useful to determine the relative contribution of animal and plant products to the diet of animals because there is trophic enrichment of the heavier isotope in food webs (fractionation). We found constant patterns in stable-carbon and -nitrogen isotope composition in blood that separated frugivorous from insectivorous bats. When we used these isotopic values, combined with those of dietary fruits and insects, to estimate the percentage contribution of fruits and insects to the diet of the bats, we obtained different results depending on assumptions and model adopted. We tested models using both delta^{15}N and delta^{13}C results simultaneously and separately and further used diet-tissue fractionation factors of 3% for nitrogen, and 1% and 3.5% for carbon. We found that a carbon-based model with a diet-blood enrichment factor of 3.5% produced the most parsimonious results. The model estimated that the five species of frugivorous bats obtained most of their dietary protein from fruits, whereas *P. parnellii* fed mostly on insects. We suggest that future studies better define isotopic fractionation between diet and tissues of bats using captive rearing and controlled diets.

The Effects of Hummingbird Feeders on Nectar-feeding Bats and Their Resource Plants in Southeastern Arizona

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Many species of bats rely on nectar and pollen for most or all of their diet. However, the presence of alternatives to these resources may affect not only the bats, but also the plants they visit. In southeastern Arizona, nectar-feeding bats use hummingbird feeders as a source of carbohydrates, often visiting a single feeder more than 1500 times a night. I have been studying the effects of this resource on the bats and on their use and pollination of the century plant, *Agave palmeri*. Two species of nectar-feeding bats commonly visit southeastern Arizona in the summertime, the lesser long-nosed bat, *Leptonycteris curasoae*, and the Mexican long-tongued bat, *Choeronycteris mexicana*, migrating from Mexico to the southwestern United States. The presence of these seasonal flower visitors has important effects on the plants that they feed on and pollinate, particularly those such as *Agave palmeri*, which are specialized for bat pollination. However, the presence of alternative resources for the bats may impact their use of the agave plants and thus their success as pollinators. Because the Chiricahua Mountains of southeastern Arizona are a popular destination with bird-watchers, there is a high concentration of hummingbird feeders in this area. The high rate of visitation by bats to these feeders suggests that their presence may influence the bats' use of natural nectar and pollen resources in the area. I will present results from ongoing studies of nectar-feeding bat use of hummingbird feeders and *Agave palmeri*.

Ontogeny of Torpor Use by Big Brown Bats, *Eptesicus fuscus*
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Torpor is defined as a state in which an endothermic animal allows its body temperature to fall below its active homeothermic level. Torpor can be used by bats as an energy saving mechanism, especially during times of energetic emergencies. Increases in the use of torpor by bats are most prevalent during poor ambient conditions, which reduce intake of food and foraging opportunities. Little information is available on the ontogeny of torpor use by juvenile bats. The few studies that describe development of torpor by juvenile mammals show that small mammals are ectothermic at birth but slowly develop endothermic abilities. The costs to juvenile development may be sufficiently high to reduce the use of torpor by juvenile bats. The purpose of the present study was to examine the development of torpor in temperate zone bats from natural roosts (i. e. rock crevices) located in southeastern Alberta, Canada. I determined the use of torpor by six prevolant and twenty-one fledged juvenile big brown bats, *Eptesicus fuscus*, using temperature sensitive radio transmitters. Preliminary data suggest that prevolant *E. fuscus* used torpor more than fledged young. The fact that suckling bats are poikilothermic (i. e. body temperature varies with environmental temperature) during early postnatal growth, and allocate little energy to thermoregulation, may be a reflection of their lack of insulation. Juveniles are naked at birth and can lose large quantities of body heat through thermal conductance, especially when their mothers leave the roost to forage. In addition, their small body size, and hence large surface to volume ratio, causes rapid heat loss. An additional focus of my study was to compare the use of torpor by juveniles to adult female big brown bats during lactation and postlactation. Future work includes dietary influences on torpor use by big brown bats.

Social Behavior and Kinship in the Grey-headed Flying Fox, *Pteropus poliocephalus*
Jennifer L. Holmes, University of Tennessee, Knoxville, TN

The grey-headed flying fox, *Pteropus poliocephalus*, forms large colonies of up to 200,000 individuals, yet little is known about the social organization within colonies. Previous research on social behavior of these bats has been hindered by the fact that individual flying foxes are extremely difficult to capture for purposes of marking for identification or taking tissue samples for genetic analysis. Recent research, however, shows that individual grey-headed flying foxes can be differentiated by such morphological features as facial markings, shade of fur, shape of ears, and color of eyes. Moreover, many studies have shown that an animal's DNA can be extracted from its feces so that genetic analyses can be performed without having to actually capture the animal. My research will focus on social organization and behavior within wild and captive flying fox colonies by targeting specific groups of bats within each colony that tend to roost in a group together. Individual bats within each of these subgroups will be identified; feces from each bat will be collected and analyzed to determine kinship of bats within each subgroup. Behavioral observations will be made to investigate patterns of mating behavior, territoriality, hierarchical structure, and other social behaviors to determine if kinship affects social interactions and social organization within colonies of these bats.

Evaluation of Monophyly of Nataloidea based on Mitochondrial and Nuclear DNA Sequences
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Although the order Chiroptera has received extensive systematic attention during the past century, due to incongruence among studies and a paucity of synapomorphic characters, many problems associated with higher-level phylogeny and taxonomy of bats still exist. One notable example regards the phylogenetic affinities of the Old World Myzopodidae and the New World Furipteridae, Natalidae, and Thyropteridae. Traditionally, these families are thought to have shared a most recent common ancestor, yet, until recently, no study has specifically tested this hypothesis. A recent study of morphology detected strong support for monophyly of these four families and recognized the superfamily Nataloidea to document this relationship. However, another recent study of mitochondrial DNA sequences detected no support for monophyly of Nataloidea, although it did support Furipteridae, Natalidae, and Thyropteridae being closely related to *Noctilio*noidea, and Myzopodidae being a basal lineage of Microchiroptera. Also, Furipteridae was sister to *Noctilio*nidae. We tested this hypothesis, as well as monophyly of Nataloidea, by examining DNA

sequence variation in coding regions of two nuclear genes (dentin, RAG-2). We will discuss preliminary results of this test and the congruence between the mitochondrial and nuclear datasets.

Assessment of Nightly Dispersal and Foraging Behavior of Mexican Free-tailed Bats *Tadarida brasiliensis* Using NEXRAD Doppler Radar

Jason W. Horn, Cutler L. Cleveland, and Thomas H. Kunz, Boston University, Boston, MA

The Mexican free-tailed bat (*Tadarida brasiliensis)* forms some of the largest known aggregations of mammals in the world and consumes upwards of half its body mass each night in insects. In spite of this knowledge, we know little about how and where they disperse over the landscape during these nightly foraging bouts. As part of a larger effort to assess the economic impact of *T. brasiliensis* on an agroecosystem in south-central Texas, we have used NEXRAD Doppler radar images to characterize emergence and return activity, dispersal, and relative population size of several large cave and bridge-dwelling colonies. One km^2 resolution images taken at 15-minute intervals provide large scale glimpses of where and when bats may intercept dispersing insects, and how foraging at higher altitudes is mediated by weather, prey density and other factors. Characterizing nightly foraging activity allows us to evaluate the complex spatial relationship between bats, their pest-insect prey, and agroecosytems.

Phylogenetic Affinities of the Nycteridae: Further Results from DNA-hybridization Studies of Bat Systematics

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We recently extended our molecularly based systematic survey of bats to 13 (of 17 recognized) bat families. In a result consistent with our previous DNA-hybridization studies and with several studies using gene-sequencing, we found that the nearest neighbor to the megachiropterans was a clade comprising three of the rhinolophoid families: Hipposideridae, Rhinolophidae, and Megadermatidae. Surprisingly, while virtually every classification of bats has also associated Nycteridae with the rhinolophoid superfamily (in one sense or another), and specifically with the Megadermatidae, our molecular analysis yields no such association. Rather, nycterids would appear to cluster with the Vespertilionoidea (*sensu lato*), a truly surprising result. However, the largely restricted distribution of nycterids -- similar to other small yangochiropteran families -- is consistent with the exclusion of Nycteridae from the pteropodid-rhinolophoid clade, which is more broadly distributed throughout the Old World tropics.

Systematic Revision of the Neotropical Fruit Bats *Sturnira* Phyllostomidae: A Molecular and Morphological Approach

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The Neotropical fruit bat tribe Stenodermatini consists of 68 species in 19 genera, eleven of which are monotypic and only two genera contain ten or more species. One of these two genera is *Sturnira*, which has a geographical range extending from México to Argentina. Because a comprehensive revision of this diverse and perplexing genus has not been attempted since 1961, and several new taxa have been subsequently described in recent decades, we attempt to resolve the systematic relationships among species of the genus *Sturnira* using combined parsimony analyses of molecular (cytochrome b gene) and morphological characters. Successively weighted heuristic analyses produced a single most parsimonious tree of 295 steps with a consistency index of 0.65 and a retention index of 0.72. Seventy-six percent of all clades had bootstrap support values greater than 85%. *Sturnira aratathomasi*, *S. lilium* (*sensu lato*), *S. parvidens*, *S. luisi*, and *S. thomasi* constitute a clade of closely related taxa. *Sturnira parvidens* is a valid species and the sister taxon to *S. lilium*, a relationship highly supported by bootstrap percentage and decay values. *Sturnira bogotensis* is also a valid species and forms a highly supported clade with *S. erythromos*. The highly derived *S. mordax* forms a moderately supported clade with *S.* sp. A, another highly derived taxon. *Sturnira ludovici* should only refer to specimens from Ecuador and constitutes a highly supported clade with *S. oporaphilum*. *Sturnira hondurensis*, a valid species represented by only Central American specimens, is a sister taxon to the *S. oporaphilum-S. ludovici* clade and its phylogenetic relationship is highly supported. The subgenus *Corvira* is distinct from subgenus *Sturnira* and should be recognized as

such. Both species that compose *Corvira* have numerous molecular and morphological apomorphies that separate them from the remaining species of *Sturnira*. The single most parsimonious tree lacks high bootstrap support at deeper nodes, therefore, additional data will be required to resolve relationships among clades.

Community Level Support for the Allotonic Frequency Hypothesis

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The allotonic frequency hypothesis proposes that some insectivorous bats increase their access to moths that can hear echolocation calls by using frequencies to which the ears of the moths are less sensitive. The hypothesis predicts that the frequencies of bat echolocation calls are positively correlated with the incidence of moths in the diet of these bats. Conversely, the incidence of non-hearing prey such as beetles should be inversely correlated with echolocation frequency. Several studies have provided evidence in support of the allotonic frequency hypothesis. However, most of these rely on data collected by a number of researchers, in a number of different ways and at different times. The aim of this study was to test the allotonic frequency hypothesis on a single African bat community so that data for the different species could be collected at more or less the same time and in the same way. This community consisted of three high duty cycle species *Cloeotis percivali*, *Hipposideros caffer*, and *Rhinolophus simulator*, and two low duty cycle species, *Miniopterus schreibersii* and *Scotophilus borbonicus*. As predicted by the hypothesis, echolocation frequency was positively correlated with the proportion of moths in the diet of the bats and inversely correlated with the proportion of non-hearing prey such as beetles and termites. I also consider the influence of morphology on these relationships.

North America's Largest Bat in the World's Smallest Mountain Range: Roosting Ecology of the Western Mastiff Bat (*Eumops perotis californicus*) in Northern California

Heather L. Johnson and Gene R. Trapp, California State University, Sacramento, CA

The northern limits to the range of the western mastiff bat (*Eumops perotis californicus*) have been reported as southern (sometimes central) California for the past 80 years. Very recently their known range was expanded and a large colony of this rare species was found residing in the middle of California's northern central valley. The colony occupies a topographically unique island of volcanic buttes which provide relatively undisturbed roosting and foraging habitat amidst a sea of agricultural and urban development. Little is known about the roosting behavior and occupancy patterns of the mastiff bat, a former candidate for listing under the Federal Endangered Species Act and a California Species of Special Concern. To determine seasonal patterns of roost occupancy and describe emergence behavior, the colony exodus was monitored on 47 nights from May 1998 through September 1999. A formal survey protocol was established including parameters for total survey time (2 h) and reasons for ending the count. Variation in occupancy, emergence times relative to sunset, and emergence rates were compared among nights, between seasons, and between years. In 1998, counts ranged from a low of nine (Dec) to a high of 150 individuals (Jul), and in 1999 counts ranged from a low of 27 (Jan) to a high of 149 (Aug). Population mean in summer was 98 (range 55-150; n = 27), and the winter mean was 55 (range 9-89; n = 11). Bimodal peaks in occupancy occurred in both years; one peak occurred in early-mid summer and a second peak occurred in mid-late summer. Emergence times varied on a seasonal basis, and ranged from 8 to 44 min after sunset ($\bar{X}$= 33, n = 47); the first bat emerged ≥30 min after sunset in summer (with one exception in 1998), and ≤30 min after sunset in winter (with one exception in 1999). The time of first emergence correlated closely with time of sunset ($r^2 = 0.94$). Emergence behavior was variable, and included classic molossid roost site reconnaissance. The results of this study provide important implications for management of this species and provide guidance for directing future survey efforts.

An Improved Technique to Capture Bats Using Macro Mist Nets

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The use of macro mist nets (6 m or 9 m high x 30 m long) enables investigators to increase the height and surface area of smaller, but easier-to-handle mist nets. However, when using macro mist nets, the horizontal tension on shelf cords is difficult to maintain without losing the ability to easily lower or raise net shelves. Current pole designs for using macro mist nets are either effective but expensive and cumbersome (e. g., sailboat masts and tracks with runners), or do not easily maintain proper shelf cord tension and manuverability (poles with continuous ropes and shower curtain rings). I built a portable pole system (1.5 m long and weighing 24.5 kg) for macro mist nets with materials costing just under $300 U.S. The new design was tested in 1998 near Tortuguero, Costa Rica and in 1999 and 2000 near Lamanai, Belize. Mean installation time = 52 min, and mean dismantling time = 50 min (n = 5 for each). Some bats (e. g., *Molossus ater* in Belize and *Micronycteris schmidtorum*) were caught in the macro net but not in smaller (3 m x 18 m and 2 m x 6 m) mist nets. The macro net caught more bats/hour/area than smaller nets under tall closed canopies, but could not be used in several situations. The combined use of macro and smaller-sized nets maximized the number of species and individuals caught.

Development of Echolocation Calls in Big Brown Bats, *Eptesicus fuscus*

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The echolocation calls of bats function in prey capture and navigation but they may also function in communication between bats. Several investigators have suggested that a functional overlap of sounds used for echolocation and communication exists during the development of echolocation calls, and that echolocation calls may develop from communicatory precursors. We examined the development of echolocation calls in captive big brown bats, *Eptesicus fuscus*. We were particularly interested in the development of individually distinctive echolocation signals. Bats were recorded just prior to the time of first foraging flights of young in the wild (three weeks of age) and for an extended period thereafter (118 weeks of age). Change in the fundamental frequency of echolocation calls was rapid with values stabilizing at approximately eight weeks of age. A more gradual change in call duration was found, with values stabilizing between 27 and 40 weeks of age. In agreement with the general developmental trend found by others, call frequency was found to increase with age. Call duration was also found to increase with age, in contrast with the trend found by others. We believe the reason for the difference between our findings and those of others is that we examined calls at a slightly later stage in development. Individuality of calls was assessed by discriminant function analysis (DFA). At several different ages, variables describing the calls of young were entered into DFA in order to classify individual bats. We obtained classification success rates that were well above the chance rate of 20% expected for five individuals. In addition, we found that discrimination among individuals significantly increases with age. Our findings suggest echolocation calls may continue to change well beyond the time of first foraging flights of young in the wild. In addition, individuals have distinct echolocation calls even at three weeks of age (the time of first recording), with discriminability among bats increasing as the bats mature.

North American Bat Conservation Partnership Update and Steering Committee Meeting

Brian W. Keeley, Bat Conservation International, Austin, TX

The NABCP update includes the announcement of newly elected Executive Steering Committee members, followed by a series of presentations about working group activities, development of state bat conservation plans, and this year's Conservation Fund activities. All NASBR attendees are considered NABCP Steering Committee members and are encouraged to attend the meeting immediately following the presentations. Steering committee member input is essential for guiding NABCP activities, especially to address future regional conservation issues. For a better understanding about the NABCP structure and function visit web-site http://www.batcon.org/nabcp/newsite/index.html.

Common Vampire Bat Management in Nicaragua

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The common vampire bat, *Desmodus rotundus*, occurs throughout Nicaragua. Following the devastation of Hurricane Mitch in 1998, concerns over vampire bat attacks on livestock and humans prompted the Organismo International Regional de Sanidad Agropecuaria (OIRSA), the Nicaraguan Ministry of Agriculture and Forestry (MAG-FOR), and the USDA-APHIS Screwworm Control Program to sponsor three workshops in May 2000. One workshop was given on the Isle de Ometepe and two were conducted in Esteli. The workshops covered bat biology, vampire bat biology and control, rabies prevention and management. The Nicaraguan technicians use three methods of managing common vampire bat colonies. (1) Mist netting at corrals with nets set from the ground up to a height of 2 m. This method reduces accidental capture of non-target bat species. Vampires are treated with a 1.5% Diphacinone topical vampiricide and released to contaminate the remainder of the colony. (2) Mist net at identified vampire roosts. Vampires are treated and released at the roost site. (3) Treat around bite sites on livestock to contaminate vampires that return to the same host animal. Future projects will be discussed.

Do Frugivorous Bats Provide Directed Dispersal for a Large-seeded Tropical Tree?

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While frugivorous bats create a widely scattered seed shadow for ingested small seeds, good for colonizing unpredictably spaced recruitment sites such as tree-fall gaps, large bat dispersed seeds are dropped beneath feeding roosts under palm leaves overhanging open ground, where conditions for tree recruitment may be good. I investigated the pattern of seed dispersal to feeding roosts by large frugivorous bats (*Artibeus lituratus* and *A. jamaicensis*) as part of a study of landscape-level population dynamics of a large-seeded bat dispersed tree, *Calophyllum brasiliense*, at Cocha Cashu Biological Station in Manu National Park, Peru. I censused feeding roosts weekly from Jan 1- Mar 20, 2000 (coinciding with the rainy season in Manu) along 21 km of trails and tested which microhabitats were favorable for germination, seedling survival and growth to 17 months. For each roost I recorded the species of seeds and number of *C. brasiliense* seeds present, and microhabitat characters. During the census period I found over 450 roosts containing up to five large seeded species, including *C. brasiliense*. Feeding roost density was higher in mid-successional forest than in either early successional or mature forest, while survival and growth of *C. brasiliense* was highest in early successional forest.

Seeing in the Dark: Recent Advances in Infrared Thermal Imaging

Thomas H. Kunz and Jeff Frank, Boston University; Indigo Sysytems, Inc.

One of the greatest challenges facing biologists who study the behavior, ecology, and physiology of nocturnal animals is to unobtrusively detect and observe their activities without causing disturbance. Recent advances in infrared thermal imaging now make it possible to observe and record the behavior and physiological responses of animals under a wide range of field or laboratory conditions -- either day or night. In contrast to night vision devices and near infrared cameras that can be used only at night and rely on some form of light, infrared thermal cameras (IRTC's) are designed to detect radiated heat. For the past three years, we have used an advanced IRTC to census Mexican free-tailed bats as they emerge nightly from caves, but we have also used this camera to 1) detect bats that roost in foliage (including tent-making bats), 2) document the physiological and behavioral responses of roosting and flying bats to ambient conditions, and 3) to observe and record social interactions of roosting bats. Thermal maps of roosting and flying bats are analyzed using advanced imaging software and displayed digitally or graphically, making it possible to document thermal gradients to the nearest 0.02°C.

Ed. note. The abstract of Kunz and Frank abstract has been move ahead of Kirsch and Hutcheon so that their fairly extensive table might appear on a single page.

Implications of Molecular Studies for the Higher-level Classification of Bats

John A. W. Kirsch and James M. Hutcheon, University of Wisconsin Zoological Museum, Madison, WI

Several molecular studies of bats, including those based on DNA hybridization and sequences of both mitochondrial and nuclear genes, provide a compelling new outline of chiropteran phylogeny at the highest levels. In particular, the categorical distinction between Megachiroptera and Microchiroptera is not supported; instead, three of the four rhinolophoid families (Rhinolophidae, Hipposideridae, and Megadermatidae) and Rhinopomatidae (Craseonycteridae has not yet been examined by molecular techniques) appear collectively to be the sister-group to Pteropodidae. All other microchiropteran families so far examined, including the putatively rhinolophoid Nycteridae, cluster apart from these, with the Noctilionoidea (Noctilionidae, Phyllostomidae, Mormoopidae, and Mystacinidae) apparently distinct from the remaining families. While many questions of interfamilial relationships remain to be resolved by molecular means, and the composition of the yangochiropteran vespertilionidan superfamilies in particular are uncertain, we believe it is not premature to propose a new formal framework for living bats. In so doing we have used (but redefined) Koopman's names for the suborders and adopted infraordinal and superfamilial ones based on the earliest-proposed included genera. An implication of our classification is that we repudiate the differing indications of "total-evidence" and many anatomical analyses. Thus:

Order Chiroptera Blumenbach, 1779
- Suborder Yinochiroptera Koopman, 1985
  - Infraorder Megachiroptera Dobson, 1875
    - Superfamily Pteropodoidea Erxleben, 1777
      (Pteropodidae only)
  - Infraorder Rhinolophida Lacèpëde, 1799
    - Superfamily Rhinolophoidea Lacèpëde, 1799
      (Rhinolophidae, Hipposideridae, Megadermatidae)
    - Superfamily Rhinopomatoidea Geoffroy, 1818
      (Rhinopomatidae, Craseonycteridae)
- Suborder Yangochiroptera Koopman, 1985
  - Infraorder Noctilionida Linnaeus, 1766
    - Superfamily Noctilionoidea Linnaeus, 1766
      (Noctilionidae, Phyllostomidae,Mormoopidae, Mystacinidae)
  - Infraorder Vespertilionida Linnaeus, 1758
    - Superfamily Vespertilionoidea Linnaeus, 1758
      (Vespertilionidae including Antrozous, Molossidae, Nycteridae)
    - Superfamily Emballonuroidea Temminck, 1838
      (Emballonuridae only)
    - Superfamily Nataloidea Gray, 1838
      (at least Natalidae)

Vespertilionida incertae sedis: Furipteridae, Myzopodidae, Thyropteridae

Philopatry and Migration of Indiana Bats (*Myotis sodalis*)

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From 1995 through 1998 and again in 2000, we studied movements and behavior of a maternity colony of Indiana bats (*Myotis sodalis*), along the border of Jackson and Washtenaw counties, in southern Michigan. During the study, we banded 35 individuals. Thirty two were banded from 1995 to 1998 and, therefore, had the opportunity to be recaptured in subsequent years. Twelve of the 32 (38%) were recaptured on their summer range in subsequent years, either at the initial capture site (2 bats) or at a nearby location that usually was less than 2 km from the original (9 bats). All were recaptured within the known home range of this colony, indicating strong inter-year fidelity to a highly localized area. Three of the 32 banded bats (9%) were recaptured while in hibernation in caves that were 467 ± 46 (SE) km from the maternity location. However, each bat hibernated in a distinctly different geographic area -- one in eastern Kentucky, east of Cincinnati, Ohio; one in central Kentucky; and one in southern Indiana, west of Louisville, Kentucky. These winter returns indicate that members of the same maternity colony may

hibernate in different caves separated by up to 300 km. One bat was banded in Michigan in July 1996, found hibernating in eastern Kentucky in January 1997, and recaptured in Michigan in May 1997, June 1998, and July 2000. Another was banded in Michigan in July 1998, found hibernating in central Kentucky in October 1999, and recaptured in Michigan in July 2000.

Morphology of the Axial Skeleton in Relation to the Style of Biosonar

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The axial skeletons of bats exhibit a wide range of features that may relate to respiration and vocalization. Perhaps the most striking variation is relative flexibility of the vertebral column and rib cage. Some bats have narrow ribs with broad intercostal spaces, and vertebral columns that allow a wide range of motion. In contrast, other species have broad ribs with reduced intercostal space and multiple fusions between vertebrae, ribs and the sternum. We examined the rib cages of 56 species of bats from 13 families in the collections of the Royal Ontario Museum. Selecting specimens with an articulated axial skeleton, we measured cranio-caudal diameter of each rib, total length of the rib cage and forearm length of one specimen per species. In two species, we measured multiple individuals to assess intraspecific variation. Using data from the archive of biosonar calls of the authors and descriptions from the literature, we categorized each species by the typical duty cycle and intensity of its calls. Categories were: no biosonar (NA); low duty cycle/low intensity (d/i); low duty cycle/high intensity (d/I); high duty cycle/high intensity (D/I). For each family, we compared the means of the proportion of intercostal space to the category of echolocation by one-way ANOVA. Results indicated differences across groups ($F_{3,50}$= 11.94, $p<0.0001$). Post hoc tests revealed that intercostal space proportions of NA and D/I were significantly different from each other and the other two categories. Intercostal space proportions of d/i and d/I were not significantly different from each other. Intercostal space proportions were not related to forearm length. In measurements from multiple individuals within a species, intercostal space proportion of all individuals fell within one standard deviation of the mean in *Molossus rufus*, whereas one individual of five fell out of this range in *Pteronotus parnellii*. Bats that use D/I have rib cages with significantly wider ribs and narrower intercostal spaces. We equate narrow intercostal spaces to reduced intercostal musculature, which with fusion of bones suggests a stiffer ribcage. These features may relate to the energetics and evolution of biosonar vocalization. (Funding provided by PCSOM).

Roost Selection and Thermoregulation in Rock-roosting *Eptesicus fuscus*

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I studied a rock-roosting population of *Eptesicus fuscus* in southern Alberta from May through August 2000. Reproductive females were tagged with temperature sensitive radio-transmitters and roosts were located and described. Preliminary results will be presented regarding roost selection and use of torpor. Females in early pregnancy and post-lactation used deep torpor to a much greater extent than lactating females. Lactating females tended to roost in groups as large as 37 individuals, while pregnant and post-lactating females more often roosted alone. Tagged pregnant and lactating females roosted in crevices within a 1.25 km stretch of river valley along the South Saskatchewan River. Post-lactating females roosted in crevices within a 4.5 km range. All females tended to switch roosts often. Seventy roosts were identified, and most roosts were located on one side of the river valley where the availability of roosts was highest. Roosts were in solid-mud erosion holes and in rock crevices. I measured the size and orientation of each roost and compared them to crevices randomly selected from the surrounding area. Microclimate (temperature and relative humidity) was measured for roosts and randomly selected crevices. I also examined the thermal conductance of the roost substrate.

Clumping Behaviour in Roost Emergences of *Myotis lucifugus*

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During their evening roost emergences from nursery colonies, little brown bats, *Myotis lucifugus*, often appear to exit in "clumps." In this study, I tested one of the hypotheses that attempt to explain this behaviour. Clumping behaviour during emergences may be an anti-predator response in that by grouping with others, bats decrease their individual risk of predation. If bats clump as an anti-predator behaviour, then clumping should increase following an attack by a predator. I observed and recorded emergences at three colonies of *M. lucifugus* in southern Ontario. I conducted the first night of observation without any stimulus. This night acted as a control emergence with which I compared the subsequent nights. On the second night, I exposed the colonies to a mimicked predator attack, which was a harp trap hung in front of the main roost exit for the duration of the emergence. The trap mimicked predation in that exiting bats struck it and were delayed. The third and fourth nights were recorded with no stimulus and were used to determine if there were any changes in the degree of clumping following an "attack." I repeated this sequence two or three times at each colony. I also looked for changes in the number of bats exiting, the starting times and the duration of emergences. The only significant difference I found was in the number of bats that left the roost and the raw data indicated that this difference stemmed from a decrease of bats exiting on the "attack" night ($F = 3.84$, $df = 3,4$, $p = 0.04$). This suggested that the bats did perceive the harp trap as a threat during their emergence. There was no significant difference in the degree of clumping over the four days at any of the colonies ($F = 4.18$, $df = 3,4$, $p = 0.06$). I did not see the expected increase in clumping after a predator attack; therefore, my data suggest that clumping during emergence is not an anti-predator behaviour in *M. lucifugus*.

Frequency and Intensity Effects on the Zone of Reception for the Anabat II Bat Detector

Kimberly J. Livengood, Ronald D. Drobney, Chris J. Corben, University of Missouri, Columbia, MO

Anabat detectors are becoming a widely used and valuable tool in bat surveys. The Anabat detector records bat species differentially based on their call characteristics. Some of the factors that affect call detectability include call frequency and intensity, as well as atmospheric attenuation. During the first year of this study, we evaluated how changes in frequency alter the shape of the zone of reception and how the intensity of the signal alters the size of the zone. Frequencies were chosen close to logarithmic octaves (40 and 75 kHz) and were tested at set intensities. We found that the shape of spatial reception changes with frequency and the size of the given shape is altered by intensity. The next step in this study is to define the role atmospheric attenuation (temperature, humidity, and pressure) plays in Anabat reception. These findings will be integral in defining where and how to effectively place the Anabat receiver to optimize reception, and will increase the utility of the Anabat field data by defining parameters that will aid in the analysis of activity indices.

The Conservation of Megachiroptera in Madagascar

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The Darwin Initiative for the Survival of Species is part of the British government's response to the 1992 Convention on Biological Diversity, and has established about two hundred major projects in those countries requiring assistance in preserving their biodiversity. Our project in Madagascar aims to:

1. Establish the conservation status of the three megachiropterans -- *Pteropus rufus*, *Eidolon dupreanum*, and *Rousettus madagascariensis*, all of which are endemic.
2. Produce a National Action Plan for fruit bat conservation together with individual species action plans.
3. Train Malagasy students and researchers to evaluate the role of fruit bats in forest ecosystems.

The results of surveys of the roosts of *Pteropus* in a range of forest types, and those of *Eidolon* and *Rousettus* in caves and rock fissures will be presented, together with an evaluation of the impact of hunting on local populations. Comparative observations on the diet of *Pteropus* and *Eidolon* will be presented, together with results of a series of investigations on the role of fruit bats in pollination and seed dispersal.

(This project has been co-funded by Bat Conservation International, The British Ecological Society, The Department of the Environment Transport and the Regions, The Lubee Foundation, National Geographic and the Peoples' Trust for Endangered Species).

Vertical Distribution of Bats in Tropical Forest and its Relationship with Environmental Variables

Hugo Mantilla Meluk, Organization for Tropical Studies

The present work contributes new data on the vertical distribution of bats in the canopy and the understory in a mature forest of the Peruvian Amazon, and the possible relationship between the preferences of chiropterans in the vertical use of space and environmental variables. During 13 nights simultaneous sampling was carried out in the understory (0 - 4 m) and the canopy (21.8 - 38.5 m). At the same time, the temperature, precipitation and lunar phase were recorded. In total, 82 individuals were captured (55 in the canopy and 27 in the understory), that represented 29 species, 16 genera and 4 families. I found significant differences in composition among the two strata. A high diversity of species and feeding habits were found in the understory, in comparison with the canopy. For the two strata there was a dominance of the nomadic frugivores, especially in the superior layers of the forest. The following feeding habits were found in the sample: aerial insectivores, nectarivorous, foliage insectivores, carnivores, sedentary frugivores, nomadic frugivores and sangivores. The sedentary frugivores, foliage insectivores and the sangivores were absent from the canopy samples, showing a restriction in the trophic range in the upper layer of the forest. I found a positive correlation between the differences in temperature among the two strata and the rate of captures during the night. The higher bat activity in the understory, represented by the highest number of captures, coincided with the larger differences in temperature at the beginning of the night, while the peak of captures in the canopy occurred later in the night, when the temperature among the two layers became homogeneous. I suggest that this behavior is based on sensorial selection parameters, from the bats' point of view, since the samples in the canopy and in the understory showed a prevalence of the nomadic frugivores, being more representative in the captures carried out in the superior stratum. These animals, that have to make long distance flights to find food resources, take advantage of the concentration of the ascendant warm moist matrix of air charged with aromas from ripened fruits that is trapped between the upper layers of the forest and the coldest upper layers late in the night. Through continuous flight over the canopy these animals can localize and evaluate the quantity of food many layers of forest below.

An Assessment of Bat Inventory and Management Activities on Defense Installations

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We conducted a survey of 60 Department of Defense (DOD) installations to determine the status of bat inventory and management efforts on military lands. Our sample included 35 Army installations, 15 Air Force bases, and 10 Navy and Marine Corps facilities located throughout the United States. Bat inventories had been conducted on approximately 70% of the installations sampled, but there was considerable variation in design and sampling intensity. The emphasis of most inventories was to determine the presence of threatened and endangered species such as the Indiana bat (*Myotis sodalis*) and gray bat (*Myotis grisescens*), but several installations have conducted extensive surveys for multiple species over a period of several years. For example, Fort Leonard Wood, Missouri, has recorded the occurrence of ten species, and 13 species have been documented for Yuma Proving Ground, Arizona. Approximately 40% of the installations sampled reported that bats were included to some extent in their habitat management plans. Habitat management activities reported for DOD lands included forest stand management, snag management, riparian zone restoration, installation of artificial roosts, establishment of buffers around roost sites, artificial water developments, and cave protection. Management activities are described for selected installations, and future research needs are discussed.

A Comparison of Bat Activity Among Thinned and Unthinned Second Growth and Old-growth Redwood Forests in Northwest California

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Redwood forests along the northern coast of California are largely managed for timber production yet little information is available about the influence of management activities on bats. We compared bat activity in 30-90 year old thinned and unthinned forest stands and old-growth forest stands in Humboldt County, California during the summer of 1999. To determine differences in the amount of use by bats, we recorded bat vocalizations using Anabat II ultrasonic detectors. The mean index of bat activity was higher in old-growth than in thinned or unthinned stands and higher in thinned than in unthinned stands. We used mist nets to assess species composition and captured six species of bats.

Genetic Analysis of the Species Status of the Indiana Bat, *Myotis sodalis*

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The Federally listed endangered Indiana bat, *Myotis sodalis*, and the abundant little brown bat, *M. lucifugus*, are sympatric sibling species, with the geographic range of *M. sodalis* located completely within the larger range of *M. lucifugus*. Species distinction is based on several behavioral characteristics and on variable and largely qualitative morphological traits. Experienced field workers frequently report difficulty distinguishing the species, morphologically intermediate forms are common in at least some parts of *M. sodalis*' range, and a recent multivariate morphological analysis of museum specimens has questioned whether *M. sodalis* is a distinct species. This issue is of some concern. Although the species has been listed as endangered since 1967, the continuing trajectory of population decline suggests that *M. sodalis* could be extinct within the next 20 years. Examination of 350 bp of mitochondrial DNA sequence in the hypervariable d-loop region of 25 *M. sodalis* from throughout the species range, and 7 *M. lucifugus* from New York, Kentucky, and California reveals two distinct mt-DNA lineages that correspond with the recognized species distinction [mean sequence divergence within *M. sodalis* (5.8%, range 0 - 13%); within *M. lucifugus* (7.5%, range 5 - 11%); between the species (23.9%, range 15 - 35%)]. Nuclear microsatellite data from a much larger number of individuals support the existence of *M. sodalis* and *M. lucifugus* as largely distinct gene pools. Mitochondrial DNA sequences from two morphologically intermediate bats place one (from Ohio) in the *M. lucifugus* lineage and one (from Arkansas) in the *M. sodalis* lineage. The possibility of hybridization between the species is under investigation.

Population Genetics of Schreibers' Long-fingered Bat, *Miniopterus schreibersii*, in South Africa

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Schreibers' long-fingered bat, *Miniopterus schreibersii*, migrates seasonally between wintering colonies (hibernacula) and summer (maternity) colonies in South Africa. Previous behavioural studies suggested that maternity colonies are focal points for bats from several different hibernacula, and that roost fidelity is well developed in this species. If males and/or females are strongly philopatric, this may lead to genetically distinct maternity colonies. We investigated population substructure in *M. schreibersii* in South Africa, using microsatellites and mitochondrial DNA, with the aim of determining the extent and direction of individual movement between colonies. A genomic library was constructed for *M. schreibersii*, and was screened for the presence of (CA)n and (GA)n microsatellite repeats. Primers were designed for six polymorphic loci, and used to amplify these microsatellites in 330 individuals from 11 colonies throughout South Africa. No significant deviation from Hardy-Weinberg equilibrium was found at any locus. Both R_{ST} and G_{ST} indicate statistically significant differences among colonies, suggesting that there are at least four partially discrete breeding subpopulations of *M. schreibersii* in South Africa. The locations of these subpopulations correspond broadly to four vegetation zones. Principal component analysis of morphological parameters (wingspan, wing area, aspect ratio and wing loading) support the microsatellite results, but suggest some degree of local adaptation within the vegetation zones. To examine possible differences in male and female migration patterns, approximately 500 bp of mitochondrial DNA control region were sequenced, from one individual per colony. All individuals sequenced showed different

haplotypes. As a consequence, additional sequencing of a larger sub-sample of individuals per colony will be required, in order to provide adequate information for defining details of phylogeographic clustering.

Feeding Ecology of the Naked-backed Bats, *Pteronotus gymnonotus* and *P. davyi*, in Venezuela

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The two species of naked-backed bats, *Pteronotus gymnonotus* and *P. davyi* (Mormoopidae), are widespread in the Venezuelan lowlands. Although *P. gymnonotus* is more frequent in humid and *P. davyi* in dry environments, both species can be found in the same region. Here, we discuss data resulting from our study of arthropod prey found in stomachs and feces of nearly 30 individuals from each bat species collected throughout Venezuela. To rank prey from soft- to hard-shelled, we used, for arthropod orders, Freeman's (1981) classification into five categories, and, for arthropod families, our own classification into six categories. To assess diet overlap, we used Pearson's coefficient of correlation (r). We found *P. gymnonotus* to consume 10 orders and 35 families of arthropods, with Coleoptera as the dominant order (70.4% of individual prey, $n = 135$), and *P. davyi* to consume 13 orders and 52 families of arthropods, with Coleoptera (29.1% of individual prey, $n = 148$), Diptera (24.3%), and Lepidoptera (18.9%) as the dominant orders. The taxonomic overlap between the diets of the two bat species was higher at order level ($r = 0.663$) than at family level ($r = 0.304$). According to Freeman's order-level hardness scale, 27.4% of the prey of *P. gymnonotus* belonged to the two softest-shelled categories, and 72.6% belonged to the two hardest-shelled categories, whereas these values for *P. davyi* where 59.5 and 37.8%, respectively. According to our own family-level hardness scale, 23.0% of the prey of *P. gymnonotus* belonged to the two softest-shelled categories, and 71.9% belonged to the two hardest-shelled categories, whereas these values for *P. davyi* were 60.8 and 29.05%, respectively. The softness-hardness overlap between the diets of the two bat species was higher in Freeman's scale ($r = 0.561$) than in our scale ($r = 0.138$). Other noteworthy findings are that, during mastication, *P. gymnonotus* fragments prey far more than *P. davyi*, and that both species prey on spiders (3.7 and 2.0% of individual prey, respectively). From these results, we conclude that: (1) dietary data are consistent with our notion, based on external morphology and field and echolocation data, that, although these bat species forage in open spaces, they do so very close to vegetation; (2) although morphologically both species are very similar, *P. davyi* has a weaker skull and dentition, which translates into the consumption of softer prey; and (3) a proper evaluation of the dietary differences among these bats requires arthropod prey to be identified at least to family level.

Flower Visitation by Bats in Cloud Forests of Western Ecuador

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Although the importance of bat pollination has been demonstrated in other environments, this mutualism is virtually unstudied in cloud forests. A bat-flower community was examined in cloud forests of the western slopes of the Andes. Of ten plant-visiting bat species caught, only *Anoura caudifera* and *A. geoffroyi* were carrying pollen. Unlike *Anoura* studied in other environments, which completely switch to a frugivorous diet during certain seasons, these *Anoura* are nectarivorous year round and were never found with seeds or fruit pulp in their feces. The pollen, collected from fur, stomachs, and feces of the bats, was identified using a reference collection compiled during the present study. Of the 13 morphotypes of pollen carried by the bats, 11 were identified to genus and 7 of these to species. This represents the first direct evidence of bat pollination for all of those plants identified to species, as well as the first record of bat pollination for a plant of the genus *Meriana*. Niche overlap for flower usage between the two species was moderate (0.43); while they utilized essentially the same set of flowers, frequencies of usage were different. The diet of the larger *A. geoffroyi* was more general, while *A. caudifera* specialized to an extent on the smaller Burmeistera flowers. The degree to which each of the bat-visited flowers fits the chiropterophilous syndrome is discussed.

Is *Lonchorhina aurita* a moth specialist? Evidence from the Atlantic Forest of Southeastern Brazil

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Research on the feeding ecology of Neotropical bats has largely focused on frugivorous and nectarivorous species. Relatively few studies have investigated bats that feed solely on insects. This study reports on a preliminary analysis of an insectivorous bat, *Lonchorhina aurita*. Bats were captured in a lowland rainforest in Intervales State Park, São Paulo, Brasil from July 6 to July 27, 2000. Individuals were captured in ground-level and canopy mist nets and held in cloth bags for a minimum of 30 minutes to collect feces. Fecal samples were stored in 70% ethanol until they were analyzed. Percent volume of insect orders was visually estimated for all fecal pellets from each individual bat. A total of 32 *L. aurita* were captured either over water or on trails adjacent to streams. Feces were collected from 25 individuals, and the number of pellets per individual ranged from 1-20. Preliminary analyses suggest that the diet of this species is dominated by Lepidoptera (84%), but it also includes some dipterans (13%), hymenopterans (2%), and coleopterans (1%). These results suggest that *Lonchorhina aurita* is a moth specialist; however, further analysis is needed to establish whether this finding is consistent throughout its range.

Spatiotemporal Dependence on CAM Plants in Venezuelan Arid Zone Nectar-feeding Bats

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We used stable carbon and nitrogen isotope analyses to test the hypothesis that the nectar-feeding bats *Leptonycteris curasoae* and *Glossophaga longirostris* are dietary specialists on CAM plants in Venezuela and to compare their trophic levels in arid habitats. We measured isotopic compositions of muscle tissue of the two species during one year at three distant localities within the arid region. Overall carbon isotopic composition ($\delta^{13}C$) differed significantly between *L. curasoae* (-11.76) and *G. longirostris* (-13.28). A small degree of geographic variation in $\delta^{13}C$ values was detected for *L. curasoae*, while no spatial variation was detected in *G. longirostris*. No temporal variation in $\delta^{13}C$ values was found in *L. curasoae*, while the carbon composition of *G. longirostris* varied seasonally. These results support the hypothesis that the two species of bats have a strong spatiotemporal dependence on CAM plants in Venezuelan arid zones, however, *L. curasoae* seems to be relatively more specialized on CAM plants than *G. longirostris*. Overall nitrogen isotopic composition ($\delta^{15}N$) did not differ between *L. curasoae* (15.87) and *G. longirostris* (15.37). Significant geographic variation in $\delta^{15}N$ values was found in the two species; only small seasonal differences in $\delta^{15}N$ values were detected. These results suggest that the two species of bats belong to the same trophic level. In conclusion, our results suggest that *L. curasoae* and *G. longirostris* are evolving in parallel with columnar cacti and agaves in arid regions of Venezuela where CAM resources are available for most of the year. The strong spatiotemporal interdependence evidenced between these bats and their host plants makes these mutualisms highly vulnerable to human disturbance in this region.

Functional Morphology of the Mandibular Symphysis in Glossophagine Bats

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Most models of symphyseal function in mammals suggest that fusion of the symphysis occurs to counteract masticatory stresses. However, such explanations seem inappropriate for glossophagines, which feed predominately with the tongue and likely generate relatively little stress during mastication. Bone densitometer (CT) scans were used to investigate the morphology of the mandibular symphysis for nine phyllostomid species (n = 4-10 individuals per species), including five glossophagines. Biomechanical properties (cortical bone area, second and polar moments of inertia, major axis orientation) were computed from bitmap images. The symphysis was completely fused in all species except *Phyllostomus discolor* and *Carollia perspicillata*, which showed only partial fusion. Glossophagines possess a more horizontal orientation of the symphysis relative to the molar toothrow than other phyllostomids. This may result from lengthening of the snout during ontogeny and may be an adaptation to assist in tongue extension. An anterior crest along the midline is well-developed in *Anoura geoffroyi* and *Hylonycteris underwoodi*. A smaller crest is intermittently developed in other glossophagines, and is absent in other phyllostomids. The symphysis of glossophagines is small (absolute and relative to mandible size), and cross-sectional moments

of inertia are less than in other phyllostomids, indicating a relatively weaker symphysis. Three possible explanations for fusion in glossophagines are discussed: Fusion (1) may act to strengthen a relatively small symphysis, (2) may be an osteological response to intermittent stresses caused by tongue extension, or (3) may be a product of phylogentic inertia.

In Situ Hybridization of the Chromosomal Distribution of LINEs in Phyllostomid Bats

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Long Interspersed Nuclear Elements (LINEs) are endogenous repetitive elements about 7 kilobases long that multiply in the genome via reverse transcription of an RNA intermediate. There are tens of thousands of LINE inserts in most mammalian genomes. Hypothesized benefits of LINEs are chromosomal repair, increased phenotypic variation, and X chromosome inactivation. Negative features include genic and chromosomal mutation and the burden of extra DNA in the genome. Bats typically have the smallest genome size among mammals, which is achieved by a reduction of centromeric heterochromatin, number of sites of rDNA, and copies of interspersed repetitive sequences. We studied the pattern of LINEs in phyllostomid bats to better understand their genome organization. Relative to in situ hybridization studies of rodents and humans, less signal is present on bat chromosomes, which we interpret as meaning that there are fewer copies of LINEs in the genome of bats. As has been reported for other mammals, there is more signal on the X and Y chromosomes than on the autosomes. However, the difference in amount of signal is not as pronounced as is observed in rodents and in humans. In *Carollia*, there has been a translocation of an autosome to the X chromosome. The original X has the greatest signal and the autosomal translocation does not differ significantly from the other autosomes. Therefore, this linkage to the X does not change the environment of the autosomal translocation sufficiently to result in an accumulation of LINEs. In taxa that have radically reorganized their karyotypes (Karyotypic Megaevolution), there is not an atypical LINE signal relative to species that have maintained chromosomal stasis. We conclude that LINE abundance is more intensively constrained in the genome of these bats than is typical in humans and rodents.

Habitat use by Bats in Logged Forests in Northern Alberta

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abitat use by forest dwelling bats poses many interesting questions. As in many systems there are trade-offs. Insect abundance tends to be higher in continuous stands of trees than in open patches (e. g. clear-cuts), but bats must maneuver around trees, as well as discriminate between obstacles and prey. Thus the optimal habitat may not be one with the highest prey abundance, but one where the costs of flight are outweighed by prey captures. Disturbances such as wildfire, windstorms and forest harvesting create a landscape with a mosaic of habitat patches consisting of open, thinned and intact stands of trees. These patches differ in insect abundance as well as in the level of clutter through which bats must fly. The use of open habitat (clear-cuts) versus continuous forest by bats has been studied extensively. However, partial removal of trees in an area is increasingly common in forestry, and results in thinned stands rather than clear-cuts. To date, no study has explored the use of thinned stands by bats. Thus, my primary objective was to compare bat foraging activity in clear-cuts, thinned and intact patches of forest. Studies have illustrated that bat activity is higher along the edge of a clear-cut than in the centre. Therefore, my aim was to determine whether this trend differs between the various habitat patches. My study took place in northern Alberta where I measured bat activity in three replicates of three different stand types, including aspen-dominated, conifer-dominated and mixed. Within each stand-type, I sampled in four harvest treatments, including 0 (clear-cut), 20, 50, and 100 (intact) percent retention. To assess habitat use by bats, I placed Anabat II remote systems along the edge and in the centre of four compartments each night. In summer 2000, I sampled each of the 36 (3 stand types x 3 replicates x 4 treatments) compartments on three separate nights. In accordance with previous studies, bat activity along the edge of clear-cuts was higher than in the centre. Preliminary analysis suggests that this trend held true in the 20% compartments in all three stand types, in addition to the 50% conifer and mixed compartments and the 100% mixed compartments. The opposite trend was observed in the remaining compartments. Overall activity (edge

and centre combined) was highest in the intact patches compared to the other treatments in the mixed and aspen stands. In the conifer stands, activity was highest in the clear-cuts.

The Influence of Habitat Type on the Ability to Detect Bats with Anabat II Detectors

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o address questions related to foraging behaviour of bats we rely on quantifying activity with ultrasonic detectors. It is understood that sounds of different frequencies attenuate more readily than others. In addition, sound travels shorter distances in areas with more obstacles. For example, sound will be more readily absorbed by vegetation in a forest than in an open area. However, no studies have investigated how this may affect the ability to detect bats in different habitats. Differences in bat activity between habitats may be influenced by differences in the range of detection in those habitats. Therefore, the objective of this project was to measure the detection ability of Anabat II detectors in various forest patches, including open, thinned, and intact patches. We produced bursts of 40 or 25 kHz sound through a speaker elevated eight metres above ground level and directed at 30^{o} below the horizontal. Using an Anabat II detector positioned 18m from the sound source, we gradually reduced the amplitude of the sound until it was no longer detected by the detector. We measured the minimum detectable intensity in four directions at three sites within a forest patch to yield a total of 12 measurements within a patch. In addition to a clear-cut, we measured the minimum detectable intensity in a thinned (50% of the trees removed) and intact patch in each of three stand types: aspen-dominated, conifer-dominated, and mixed. In the aspen stand, minimum detectable intensity did not differ between the clear-cut and the intact forest patch. In the conifer and mixed stands, however, the minimum intensity was lower (signal was more readily detected) in the clear-cut than in the intact patches. Signals were more rapidly attenuated in the conifer patches, followed by the mixed patches, with the aspen patches having the least attenuation. Interestingly, sound transmission was better in the thinned patches in all three stand types than in the clear-cut. Our results have important implications for surveys measuring bat abundance in different habitat types and habitat preferences.

Dietary Habits of Two Pairs of Sympatric Frugivorous Bats in the Dry Season in French Guiana

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Neotropical forests are characterized by many sympatric species of frugivorous phyllostomid bats. Little is known about why some species are less abundant in disturbed habitat whereas closely related species proliferate. Niche overlap for food resources is one possible explanation. The different core diets of *Carollia* and *Sturnira* reduce generic level niche overlap for fruit utilization but this may not be the case for congeneric, sympatric species in these genera. This study examines the similarities and differences in fruit consumption between two pairs of sympatric species of understory frugivorous bats (*Carollia perspicillata* and *C. brevicauda*, *Sturnira lilium* and *S. tildae*) in central French Guiana. *Carollia brevicauda* and *Sturnira tildae* are rarely caught in disturbed habitat whereas *C. perspicillata* and *S. lilium* are common in French Guiana. To determine their dietary overlap, fecal samples were collected from bats caught in ground-level mistnets in a primary forest matrix during two weeks in the dry season. Seeds in the fecal samples were identified by comparing them with a reference collection from fruit collected in the field and from herbarium specimens. Seed morphology was documented using scanning electron microscope photographs. Results indicated that *Carollia perspicillata* and *C. brevicauda* had a relatively high dietary overlap (41%) compared to the dietary overlap in *Sturnira lilium* and *S. tildae* (20%). Both *Carollia perspicillata* and *C. brevicauda* foraged on *Piper* whereas *Sturnira lilium* and *S. tildae* foraged on *Solanum* and *Philodendron*, respectively. Understanding the interactions between bats and plants in tropical forest ecosystems is necessary for preserving biodiversity in remaining primary forests as well as in the regeneration of degraded tropical forests.

Sub-lethal Pathology Correlated with Volcanic Eruptions on Montserrat, BWI

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Apart from the minor inconvenience of being incinerated by pyroclastic flows (300-500 degrees C), the bats of Montserrat have had to contend with acid rain, the deposition of volcanic ash on leaves, fruits, and flowers and its subsequent ingestion, and the accumulation of ash on the animal's pelage while foraging. Accordingly, our database (1500 captures: 1978-2000) documents a focal increase in sub-lethal pathologies associated with the accumulation of ash across the island of Montserrat. Before the onset of volcanic activity, only 3 of 641 (< 1%) fruit bat captures exhibited any evidence of tooth wear. Since the 1995 British census, 35 of 190 (18%) fruit-bat captures have demonstrated abnormal tooth wear that often includes the loss of the entire enamel crown and the exposure of the pulp cavity. Remaining occlusal surfaces exhibit abnormal wear, advanced dramatically by the incidental ingestion of volcanic ash while feeding and grooming. Until 1995, idiopathic hair-loss (alopecia) had only been observed on a single, very old *Artibeus* female (1/638 captures). In 1997 and 1998, alopecia was frequently recorded for *Brachyphylla, Artibeus,* and *Ardops.* Indeed, during a survey of a *Brachyphylla* maternity roost in 1998, 75% of the animals exhibited some degree of hair-loss. This alopecia is most likely related to physiological stress, high levels of roost-parasitism, and possible mineral deficiencies associated with the ingestion of ash. During our 2000 survey, alopecia was noted only in *Brachyphylla* females (50%), whereas males (located in an adjacent cave) exhibited no hair-loss whatsoever.

An Assessment of a Snag Model for Roosting Bats in Douglas Fir Forests

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Numerous radio telemetry studies have indicated snags selected by bats for day roost sites differ significantly from randomly selected snags. We have identified six characters which are common to all selected snags. Our hypothesis: significantly more bats will use snags which fit the model and exhibit all six characters than will use snags which do not fit the model. Fit snags numbered 36, unfit numbered 40. A simple statistical analysis using Chi-square indicated a significant difference for numbers of exiting bats between the two groups of snags ($p>0.009$). A contingency tables test indicated the two sets of snags were not from the same population based on exiting bat counts ($p>0.000$). We discuss implications for bat conservation efforts in light of timber management.

Is *Myotis lucifugus* the Mosquito Hunter of the Night?

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I conducted a diet analysis of a nursery colony of little brown bats, *Myotis lucifugus*, living in Reading, Pennsylvania, from 31 May to 29 July 2000, to determine whether or not mosquitoes (Diptera, Culicidae) constitute a major part of this species' diet. In the first component of this study, the effects of various factors, including weather, precipitation patterns, insect density and abundance, composition of local insect fauna, and habitat structure, were taken into account. Preliminary data analysis suggests that, although bats fed on volant prey within size spectrum of 3 to 25 mm total body length, there was a strong skew towards insects in the higher end of this size range. In other words, mosquitoes and other similarly sized insects (3-5 mm) did not constitute a major part of the diet at any time throughout the study period. I also observed that swarms of male midges (Diptera, Chironomidae) were ignored by the majority of individuals. Dissection of faecal samples reveals a high proportion of caddis flies (Trichoptera) and fluctuating proportions of moths (Lepidoptera), crane flies (Diptera, Tipulidae), beetles (Coleoptera), and flying ants and wasps (Hymenoptera). Statistical tests will conclude which factors affect diet composition most. In the second component, adult and sub-adult bats were caught, kept captive overnight in separate boxes, and their faeces collected to determine if a correlation exists between age and diet. Faecal composition suggests that juveniles fed mostly on a diet similar to that of adults, albeit more small insects were eaten and individual faecal pellets contained a wider variety of insect taxa as compared with faecal pellets collected from adults. I will further discuss my results using conclusive statistical tests and propose various theories for my findings.

Conditioned Taste Aversion in Two Species of Phyllostomid Bat

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A conditioned taste aversion (CTA) has developed when an animal consumes a food, subsequently becomes nauseated, and in future avoids ingesting this "unsafe food." The evolutionary significance of this behaviour is obvious. CTAs develop most readily when the food (the conditioned stimulus (CS)) associated with the gastrointestinal distress (the unconditioned stimulus (US)) has a novel flavour. "Safe foods," those an animal has had only positive experiences with in the past, do not generally act as effective conditioned stimuli. Favourable past experiences may override the association. CTA has not been adequately explored in bats. Heretofore, most studies have used rodents and, less frequently, carnivores. This concentration has led to an understanding of this learning mechanism perhaps paralleled only by vocal repertoire learning in songbirds. However, it has contributed to the assumption that CTA is a phenomenon ubiquitous to mammals. Using two phyllostomid bat species (*Artibeus jamaicensis* and *Brachyphylla cavernarum*), I have tried to address this relative void. Further, I have experimentally considered CTA in bats in a manner that is directly comparable to past research -- I have limited the CS/US pairings to a single episode for each subject. Both species were observed to develop a profound aversion to the novel food when the US immediately followed the CS and when the US followed the CS by one hour. These results shed light on the role of CTA in the foraging strategies of these two species and other frugivorous mammals. The results also provide a backdrop for experiments in progress considering insectivorous and blood-feeding species of bat.

Bat Diversity and Distribution in Orange County, California

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This study examined the effects of habitat fragmentation due to urbanization on bat species diversity, distribution, and activity levels in Orange County, California. Acoustic and mist-netting surveys were conducted in each of three habitat size classes (small isolated, large isolated and contiguous) to determine activity levels and species diversity at 12 sites -- four in each size class-- in 1997, and at six of those sites in 1998. Orange County Public Health Agency records of bat-human encounters from 1977-1999 were used as a baseline representative of species diversity within the county, and to examine patterns of change in relative abundance and distribution from the 1980s to the 1990s. The study's emphasis was on the descriptive aspect of the data, but three statistical tests were used to compare means in acoustic activity levels (one-way ANOVA, t-test, and Kruskall-Wallis), and a Spearman Rank Correlation test was performed on public health data to assess patterns between decades. The data from this study, combined with historical data from surrounding regions, indicate that large expanses of undeveloped habitat provide the best support of a diverse bat fauna.

The Influence of Clutter on Echolocation Calls and the Role of Call Libraries

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Anabat II systems are becoming widely accepted as a tool for species identification. The subsequent use of call libraries produced through the Anabat II system relies on the assumption that calls used for identification match calls found in these libraries. Library calls are largely produced by the hand-release of species in open habitats. These open situations may not accurately reflect the calls of bat species in all field situations. Three conditions were used to test the calls of the adult big brown bat (*Eptesicus fuscus*): an open field, a small 5-m-wide road through a forest, and a 2.5-m-wide road (two-track) through a forest. Bats were light-tagged and hand-released along each of these situations, and their respective calls were analyzed for differences in slope, frequency, and duration. A minimum of seven different calls from 10 different bats was used for each condition. Additional data from the smaller Northern bat (*Myotis septentrionalis*) will be used to further evaluate these findings. ANOVAs and multiple comparison analysis suggest significant differences among the calls. These preliminary findings suggest that limitations in call library data may bias identification in cluttered field conditions, and, while these data are helpful for species identification, they should be used with caution.

Host Specificity in the Neotropical Tent-roosting Bat, *Rhinophylla pumilio*
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The New World tent-roosting bat, *Rhinophylla pumilio* (family Phyllostomidae; subfamily Carolliinae), roosts in foliage tents apparently constructed by other bat species. Previous studies in French Guiana have shown *R. pumilio* to roost in tents believed constructed by *Artibeus watsoni*. In this ongoing investigation in Eastern Ecuador, *R. pumilio* has been found to roost in tents formerly occupied by *Vampyressa pusilla*, *A. gnomus* and at least one other as yet unidentified species. Although individuals with a preference for each tent style occur syntopically, preliminary results suggest that individuals of *R. pumilio* have a consistent preference for only one style of tent architecture, inferring host specificity. Using a combination of observational, mark-recapture and genetic data, I determined the level of specificity in individual's roost preferences and assessed to what degree there is genetic exchange between populations of individuals exhibiting different preferences.

Bats and Human Rabies in the United States
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Rabies is an acute, fatal encephalitis. Agents consist of viruses in the Family Rhabdoviridae, Genus *Lyssavirus*. Transmission occurs primarily by animal bite. All mammals are susceptible to infection, but reservoirs persist among the Carnivora and Chiroptera. Bats are primary reservoirs on all inhabited continents, and host to 6 of 7 described lyssavirus genotypes. Reported from Latin America in the early 20th century, insectivorous bat rabies was not diagnosed in the USA until the summer of 1953 when a yellow bat bit a Florida child. Retrospectively, one of the first apparent human fatalities occurred in 1951, when a 43-year-old Texas woman died from rabies after a bat bite. In all likelihood, other similar, albeit isolated human cases previously went unrecognized, owing to the lack of knowledge about the disease in bats, the confusion over potential fatalities because of the widespread distribution of canine rabies prior to World War II, and the insensitivity of older diagnostic techniques. To date, surveillance activities in the USA have documented at least 35 human fatalities associated with bat rabies over the past 50 years, based upon case history and/or viral characterization. Only nine (26%) of these human cases had a definite history of bat bite, but 16 (64%) of these patients had known or suspected contact with bats. Such observations are not restricted to the USA. Human rabies cases associated with non-hematophagus bats (but sans evidence of a bite) also have been reported from Europe, Canada, Chile, and Mexico. Circumstances surrounding each case make it unlikely that spillover infection from a rabid bat to another intermediate mammal to a human being was the precipitating chain of events, rather than direct contact with a bat. Although possible, thus far documentation is lacking of any human exposure to a known or suspected rabid animal, such as a dog, cat, cow, etc., in which a bat rabies virus variant was identified. Currently, a bite is considered the likely route of transmission of bat rabies viruses to humans, even in individuals with no documented history of a bite. Clearly, there is a continuing need for effective public health communications to not handle bats, to receive prompt and proper prophylaxis if exposed, to consider preexposure vaccination related to professional pursuits, to balance health risks and conservation needs, to promote responsible pet ownership, and to diminish hysteria that may surround this infamous and incurable illness.

Population Genetics of the Brazilian Free-tailed Bat as Determined by Mitochondrial DNA Sequencing
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The Brazilian free-tailed bat, *Tadarida brasiliensis*, is one of the most common and widespread bats in the Western Hemisphere. Within the continental Americas, *T. brasiliensis* is divided into four subspecies: *T. b. cynocephala*, *T. b. mexicana*, *T. b. intermedia*, and *T. b. brasiliensis*. The basis for this division is their behavioral differences in migration, hibernation, and roosting habits, as well as geographical locations. The two well-studied subspecies (*cynocephala* and *mexicana*) are not clearly differentiated by morphology, although *T. b. cynocephala* is, on average, slightly larger than *T. b. mexicana*. Previous studies using allozymes have yielded ambiguous results concerning the taxonomic status of *T. brasiliensis* in North America. One study has hinted at the possibility of a hybrid zone between *T. b. mexicana* and *T. b. cynocephala* in Arkansas. I am presenting data from a more rigorous examination of population

structuring in *Tadarida brasiliensis* using DNA sequence variation in the mitochondrial genome. This more sensitive technique, combined with a more geographically extensive collection of samples, will enable me to determine the proper taxonomic status of the subspecies and to answer questions of potential introgression. Although an abundant species, the life history and demography of the Brazilian free-tailed bat make their populations highly vulnerable. The Programma Para Conservacion Murcielagos Migratorios (PCMM) has targeted *T. brasiliensis* as a species that is in urgent need of conservation management. In order to intelligently prioritize populations for management purposes, it is necessary to know the genetic diversity within and between populations.

Genetic Structuring among Hibernating Colonies of Indiana Bats (*Myotis sodalis*)

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Genetic information can provide insights useful in making conservation and management decisions for endangered species. For example, studies of several bat species using microsatellite and mitochondrial DNA markers have demonstrated deep but cryptic structure among subpopulations, suggesting restricted gene flow and possible philopatry. The implications for conservation in such instances are that local extinctions may occur without repopulation by neighboring colonies. The purpose of this study is to examine the genetic structure of the endangered Indiana bat, *Myotis sodalis*, to aid in identifying units of conservation concern. Yearly censuses of known Indiana bat hibernacula have documented an alarming decline in overall numbers, but some hibernating colonies have remained stable or increased. Because most major hibernacula are now protected, variability in summer foraging and roosting habitat may be the cause of the differing success of hibernaculum colonies. Wing tissue samples have been collected (largely by efforts of federal, state and private researchers) from 491 *M. sodalis* in winter and summer habitats from 13 states. Analyses of 373 bp of mitochondrial d-loop sequence and three microsatellite loci reveal no evident geographic pattern of genetic structuring among hibernacula samples. Mating in *M. sodalis* is assumed to occur during "swarming" when both sexes aggregate at the mouths of caves just after returning from summer habitat and just prior to hibernation. Gene flow may be unrestricted, particularly if mating is not strictly associated with hibernacula. However, it remains possible that populations are structured by philopatry to summer foraging areas, and it is therefore important to examine the dataset for genetic structure among summer habitats. Completion of the dataset, including analysis of samples from summer foraging sites, is underway.

Morphology, Phylogeny and Behavior of *Cheiromeles*, the Naked Bulldog Bat

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Cheiromeles (Molossidae) is a large and extremely peculiar bat found in Southeast Asia. As its common name implies, it appears virtually hairless with loose, wrinkled skin. Although two species (*C. torquatus* and *C. parvidens*) were recognized by some authors, Koopman (1989 and in Wilson and Reeder, 1993) included *C. parvidens* within *C. torquatus*. Freeman (1981) used skull measurements and dentary characters (primarily) and regarded *C. parvidens* as phenetically closest to Molossops while Legendre (1984) placed *Cheiromeles* in its own subfamily. We examined fluid-preserved specimens of *C. torquatus* and *C. parvidens* and scored them for over one hundred morphological characters (cranial and post-cranial, skeletal and soft-tissue). Preliminary results of our phylogenetic analysis indicate that variation exists between the two species and that *Cheiromeles* is the sister-group to other molossines. We also examined a number of interesting and unique morphological features found in *Cheiromeles*. These include a pair of subaxillary pouches and an opposable first digit on the hind foot. Finally, it has been widely reported that *Cheiromeles* is associated with earwigs (Dermaptera) of the genera *Arixenia* and *Xeniaria*. The nature of this relationship has been the subject of some debate. On a related note, we found that while most molossids have sensory hairs on the lateral surfaces of hind foot digits I and V, both *C. torquatus* and *C. parvidens* have a complex, brush-like patch on the lateral surface of digit I only. Insect parts found within the long, stiff bristles of this structure suggest that the opposable hind limb digits of *Cheiromeles* may serve multiple functions including removal of ectoparasites.

Developing a Model for Long-lived Mammalian Sperm

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Bats provide a unique model for studying long-term sperm survival. Several species of bats are the only known mammals that successfully store sperm in the female reproductive tract at body temperature for as long as seven months. It also appears in some cases that bat sperm survive without intimate contact with the uterine or oviductal epithelium. This is also different from other mammals where sperm typically die within a few days unless they are attached to the epithelium. Very little is known regarding the physiological mechanism(s) of sperm storage in bats. One of the purposes of the present project is to determine if it is the bat sperm and/or some unique substance(s) secreted into the uterus that allows long-term survival. This question will be addressed by performing reciprocal xenogeneic transfer of sperm between bats and other mammal models. Microencapsulation technology is being adapted to prevent immunological rejection of the xenogeneic sperm by the host uterus in reciprocal transfers. Application to reproductive technology will be discussed.

The Atkinson Mine, Wisconsin, Bat Hibernaculum: A Non-standard Gate Design

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The Atkinson Mine, Wisconsin, sometimes called Adkinson's Diggings, was gated to protect bats and deter vandals in October 1993. While it was designed to be bat-friendly, the common American Cave Conservation Association designs were not known at the time. The resulting gate would seem to be more restrictive, with an I-beam construction and a 12.7 cm (5 in) rather than a 14.6 cm (5 3/4 in) vertical separation between bars. Additionally, the door is a solid plate at the bottom of the gate, which potentially restricts cold air movement. Despite these apparent short-comings, the population of *Myotis lucifugus* has generally increased since gating and the population of *Pipistrellus subflavus* has consistently increased. The most recent census, January 2000, of *P. subflavus* shows this site to be a relatively large hibernating colony, with 253 individuals found. This is especially significant since this hibernaculum is on the northern edge of the range of *P. subflavus*. While temperatures are not being continuously logged, temperatures measured throughout the mine during censuses do not show any major increases since gating. Factors that may compensate for the apparent design flaws are that the gate is within the entrance passage, reducing the risk of avian predation, the solid door reduces the ability of terrestrial predators to reach bats as they negotiate the bars above the door and finally, climatalogical data for the county shows that the mean annual temperature is in the 5 to 6 degree C range while entrance adit is several meters above the valley floor so that cold air following the valley floor is not as significant a factor for internal temperature as in warmer sites.

A Natural History of the Comoros rousette, *Rousettus obliviosus*

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Rousettus obliviosus (Chiroptera: Pteropodidae), the Comoros rousette, one of the smallest of the genus *Rousettus*, is endemic to three islands of the Comoros archipelago in the West Indian Ocean. We observed these secretive fruit bats at three roost sites on the island of Moheli. Here, we report on the natural history of *R. obliviosus*, which despite its first mention over 100 years ago, has been largely absent from the scientific literature. Our observations indicate that *R. obliviosus* is predominantly nocturnal, is strongly colonial, roosts in caves, and is associated with dense forest habitat. The bats were observed to have relatively high maneuverability in flight and to hover briefly. These flight patterns, combined with the bats' small size, suggest that they may exploit food resources differently than the other two fruit bats (both *Pteropus*) which occur within their range. This species has been considered common based on reports from incidental captures, and it has been accorded "Lower Risk/near threatened" status by the IUCN Red List of Threatened Animals. However, this status classification may fail to account for several potential threats to *R. obliviosus* populations, including possibly significant habitat loss and sensitivity to human disturbance at roost sites. We recommend further study focusing on the ecology of *R. obliviosus*, in particular its abundance, distribution, and feeding ecology, to fill in several of the large gaps in ecological

understanding. We also suggest that conservation measures be considered to protect dense forest habitat, especially near streams, and to limit human disturbance at known roosting sites.

Additional Support for the Monophyletic Origin of Bats

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Relationships among many mammalian orders remain poorly resolved and the hypothesis of a diphyletic origin of Chiroptera continues to provoke controversy and debate. To further test this hypothesis, we sequenced eight mitochondrial protein-coding genes and eight tRNAs from three megachiropterans (*Pteropus vampyrus*, *Cynopterus brachyotis*, and *Eidolon helvum*) and three microchiropterans (*Hipposideros bicolor*, *Peropteryx kappleri*, and *Macroderma gigas*). We combined these data with previously published sequences, including *Artibeus jamaicensis* (Pumo et al., 1996), to test alternative hypotheses for the placement of mega- and microchiropterans in the mammalian tree. A parsimony analysis with equal weights for all changes resulted in a tree with two separate bat clades, one including *Artibeus* and *Peropteryx* and one with the other five bats sampled. We found that base composition among microchiropterans varied greatly, with *Artibeus* and *Peropteryx* having a high proportion of T and low proportion of C relative to other bats. Parsimony analyses in which transitions were down-weighted, thereby reducing the effect of varying C-T base composition, resulted in a tree in which bat monophyly and reciprocal monophyly of mega- and microchiropterans is well-supported. We conclude that shifts in base composition among taxa may lead to convergent similarities that may mislead phylogenetic analyses based on mtDNA.

Phylogenetic Relationships of Extant Megadermatid Bats: Preliminary Results Based on Morphology

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Megadermatidae is a small family of insectivorous and carnivorous Paleotropical bats. There are five extant species, all characterized by a noseleaf, large ears that are fused medially at the base, and a long bifid tragus. The largest species, *Macroderma gigas*, is an Australian endemic. Two other species, *Lavia frons* and *Cardioderma cor*, are restricted to Africa. The remaining species, *Megaderma spasma* and *Megaderma lyra*, are widespread in the Paleotropics although neither occurs in Africa or Australia. Previous attempts to resolve relationships among megadermatids using limited data sets (i. e., craniodental characters or hyoid musculoskeletal morphology) resulted in completely incongruent cladograms. In this study, we combined morphological data from many anatomical systems in a simultaneous analysis to elucidate phylogenetic relationships among the extant taxa. Outgroup species included members of the families Rhinolophidae, Nycteridae, Rhinopomatidae, Craseonycteridae, and Emballonuridae. Preliminary results of parsimony analyses of 135 characters support monophyly of all families and superfamilies, and indicate that Rhinolophidae is the sister-group of Megadermatidae. Within Megadermatidae, we found moderate support for monophyly of an African clade (*Lavia* + *Cardioderma*) and a southeast Asian clade (*Megaderma*). *Macroderma* appears to represent the basal lineage in the family. Additional data will be required to provide more complete tests of these hypotheses, which differ from those proposed by previous workers.

Distribution and Habitat Associations of Bat Species in the Mountains of Southern California

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To learn more about the distribution, abundance, and habitat associations of bat species in the mountains of southern California, we conducted 123 nocturnal surveys at 76 sites in locations extending from San Luis Obispo County south to San Diego County. These surveys were conducted from May to September in 1996, 1997 and 1998. Several survey methods were used, but the primary approach was to erect mist nets over surface water to sample bats in flight at night. At 35 of the 76 sites, we supplemented the mist net sampling by simultaneously using an Anabat II high-frequency detector. Surveys were conducted across a wide elevational range (1100 to 7800 feet), extending from chaparral-covered coastal foothills through montane conifer forests to interior pinyon woodlands on desert-facing slopes. Overall,

sixteen bat species were observed, including four that were identified using only the Anabat detector or audible echolocation calls. Significantly more species were observed per survey when mist net sampling was supplemented with the Anabat detector. *Eptesicus fuscus* was the most commonly observed species, accounting for 43 percent of all observations; it was prevalent in all the major habitats and mountain ranges surveyed. *Myotis californicus* and *Myotis yumanensis* were the next most common species and also were distributed across a wide elevational and geographic range. *Pipistrellus hesperus* was found throughout the study area, but was particularly common in the low-elevation coastal foothills. Six species -- *Myotis thysanodes*, *M. evotis*, *M. volans*, *M. ciliolabrum*, *Nyctinomops femorosaccus*, and *Lasiurus cinereus* -- were observed primarily at elevations above 4000 feet within the areas surveyed. Abandoned mine surveys in the northeastern San Bernardino Mountains detected 253 individual bats in 19 mines. Seven species were identified, but 65 percent of the detected bats were *Corynorhinus townsendii*, reflecting the importance of abandoned mines to this sensitive species.

Phylogenetic Evidence for Involvement of *Lasionycteris noctivagans* and *Pipistrellus subflavus* in Recent Human Rabies Infections

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Because most human rabies cases in the United States lack an animal exposure history, the source of a rabies infection is derived from virus typing data that matches the human case sample to virus samples representing known animal reservoirs for rabies. Phylogenetic analysis of partial N gene sequence for 381 bat rabies samples representing 25 North American species matched the variant of rabies virus found in 22 (78.6%) of 28 human case samples with 43 (87.8%) of 49 samples from the silver-haired bat, *Lasionycteris noctivagans*, and the eastern pipestrelle bat, *Pipistrellus subflavus*. The disproportionate involvement of these two species in human rabies deaths can be explained by the small size and muted coloring of these bats which would allow an unnoticed contact to occur. Their use of tree roosts and foraging areas away from human dwellings would explain their infrequent contact with humans and the rarity of human rabies infections. Alternative explanations, such as an increased virulence of this variant of rabies virus (termed the LN/PS variant) or a greater than realized prevalence of the variant in other animals, would increase the risk to humans; however, human rabies cases would remain rare as long as most animal contacts carrying a risk of rabies are recognized and anti-rabies prophylaxis is given. We attempted to estimate this risk by testing for the LN/PS variant in rabies samples from house bats and domestic animals, the animals most often submitted for rabies testing in the United States. The finding of the LN/PS variant in 7 (5.2%) of 135 samples from the common house bats, *Eptesicus fuscus* and *Myotis lucifugus*, and 14 (1.8%) of 783 samples from cats, dogs, ferrets, and cattle indicates an infrequent occurrence in animals other than silver-haired or eastern pipistrelle bats. These data suggest that human rabies infections are most likely acquired through infrequent, unnoticed contact with bats. These types of infections, although difficult to prevent, will remain rare if appropriate precautions are taken to avoid unnecessary contact with bats.

Temperature Selection of Bats in a Thermopreferendum Chamber

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Hot caves serve as roosting sites for different species of bats. Five of the 13 species of bats of Puerto Rico are restricted to hot caves. These species usually share the same cave, forming large colonies distributed along the cave's gradient of temperatures. We captured two species of bats (*Erophylla sezekorni* and *Pteronotus quadridens*) in Puerto Rico. The two species are restricted to hot caves. They were taken to the laboratory and placed in a thermopreferendum chamber to examine their temperature selection. The thermopreferendum tests were conducted in an insulated aluminum chamber with a series of thermocouples to measure the temperature. The bats were placed in a wire mesh cage inside the chamber. We cooled one end of the chamber and heated the other, thereby potentially creating a 19° C to 40° C thermal gradient. On average, *P. quadridens* selected a temperature of 30.2° C (SD= 4.8; n= 48) whereas *E. sezekorni* selected 28.7° C (SD= 3.03; n= 33). These differences agree loosely with the microclimates selected by these species in the caves. We examined this pattern from the point of view of species coexistence in hot caves.

Growth and Development of *Myotis lucifugus* in Poland, Indiana

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We examined the reproductive biology of a colony of little brown myotis (*Myotis lucifugus*) in the attic of the Poland Historic Chapel, Poland, Indiana. We measured 120 neonatal bats from the roost between 2 June and 13 July 2000. The sex ratio at birth was equal. The average forearm length at birth was 14.27 mm (sd=1.25). Based on forearm length, we describe a logistic equation that provides a formula that can be used to age local bats. The average mass at birth was 2.2 g (sd=0.44). We found no evidence of sexual dimorphism in either forearm length or body mass. The forearm length of the bats we measured averaged 1.8 mm smaller than those reported by an earlier study in New Hampshire (Kunz and Anthony, 1982, J. Mammal., 63:23-32), while the mass averaged 0.1g less. These differences in birth size could reflect the effects of Bergman's Rule.

A Tale of Two Bats: *Ardops* and *Artibeus* on Montserrat

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Hurricanes and volcanic eruptions have had significant impacts upon the bat populations of the British Crown Colony of Montserrat, as underlined by the loss of three of its ten species: *Chiroderma*, *Sturnira*, and *Noctilio*. The declines were first observed in 1989 after Hurricane Hugo caused near total defoliation of the island which lead to a 10-fold decrease in the bat population. Then in 1995, the Soufriere Hills volcano erupted, causing destruction of major roost sites (caves) and foraging habitat which has depressed the populations even further. Seven surveys have been conducted (78, 84, 94, 95, 97, 98, 00), the last four during the recent volcanic activity. In the last two years (1999-2000), volcanic activity has declined and is reflected in a slight rebound in the fruitbat population, as estimated by bat captures per net per night (BNN). In 1995, 1.6 bats were captured per net per night, and 1.1 BNN during the 1997 to 1998 surveys. Capture data from the recent survey (2000) resulted in a slight increase to 1.3 BNN. Two species, *Ardops* and *Artibeus*, have experienced interesting population shifts within the frugivore guild. These tree roosting bats differ in that *Artibeus* is the larger of the two species (46 grams) and tends to consume larger fruit than *Ardops* (28 grams). Of these two species, *Artibeus* has remained numerically dominant in all seven surveys (range 64 - 94% of *Ardops* + *Artibeus* captures), however, during the 95, 97, and 98 surveys, the *Ardops* population increased at the relative expense of *Artibeus* (*Ardops* 36% of *Ardops* + *Artibeus* captures). During our recent survey, 2000, the trend has reversed and *Artibeus* are making a comeback. Volcanic activity may have affected each species differently. Several hypotheses will be explored to explain these shifts in the population balance.

A Consistent Acoustic Feature to Discriminate *Myotis* Species

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Acoustic species recognition of many bats has focused on the terminal, or minimum frequency of calls. For example, with this method a *Myotis californicus* is described as a 50-kHz bat, and a *M. ciliolabrum* as a 40-kHz bat. However, high-resolution full-spectrum sonograms of calls from these bats reveal that the terminal portion of these calls consists of a downward hooked tail that fades in amplitude, and thus the minimum detected frequency can vary considerably according to the orientation and distance of the bat from the detector. For 151 *M. californicus* calls analyzed from 18 sequences recorded from four locations, the average minimum apparent frequency was 43.5 kHz with a range of 35.4 - 48.4 kHz. For 86 *M. ciliolabrum* calls analyzed from 11 sequences recorded from five locations, the average minimum apparent frequency was 34.8 kHz with a range of 29.7 - 40.9 kHz. The substantial overlap of the minimum apparent frequency from these two species raises concern regarding the use of this characteristic for species discrimination. For this data set, 13.9% of *M. californicus* calls overlapped within the range of *M. ciliolabrum* calls, while 34.9% of *M. ciliolabrum* calls overlapped within the range of *M. californicus* calls. This suggests that recordings within the overlapping range (21.5% of all calls) should be rejected as ambiguous. However, high-resolution sonograms reveal a separate, more consistent distinguishing characteristic. For many myotid calls, the terminal tail is preceded by a frequency modulated sweep of greater amplitude that is consistently resolved by ultrasonic recordings, even if the terminal tail is not. The frequency at which this sweep turns down to the tail, herein termed the "lowest characteristic frequency," is

a consistent morphological characteristic of these calls, and is not prone to variation from recording sensitivity. For the same calls described above, the lower characteristic frequency for *M. californicus* averaged 50.3 kHz with a range of 46.2 - 53.3 kHz, and for *M. ciliolabrum* averaged 41.8 kHz with a range of 38.6 - 44.7 kHz. Thus, while the apparent minimum frequency ranges overlapped by 5.4 kHz, the lowest characteristic frequency ranges were separated by 1.5 kHz. By using the lower characteristic frequency, calls from these species can be readily and unambiguously recognized. Furthermore, many other myotids exhibit this characteristic, suggesting a general approach for acoustic myotid recognition.

A Tethered Zip-line Method for Collecting Reliable Bat Echolocation Reference Calls

Joseph M. Szewczak, University of California White Mountain Research Station, Bishop, CA

Effective species recognition of bats using acoustic data depends upon representative reference calls with which to compare unknown calls. Search phase calls comprise the most characteristic and therefore the most useful reference calls. However, obtaining representative search phase calls from free-flying known species has proven to be notoriously difficult. Calls collected from hand released bats do not provide representative free-flying calls because the bats are accelerating, orienting and not in a steady mode of flight. Recording calls from free-flying, light-tagged bats fulfills the requirements for good reference calls, but in practice only a small fraction of tagged bats ever provide an ideal pass by a waiting detector. In some environments such as tropical forests, light-tagged bats are never again seen once released. A tethered zip-line arrangement offers a compromise solution for collecting reference calls from known bats. A zip-line can be readily established in the field by stringing 30 - 50 m of taut monofilament line between two poles (or other fixed objects). The tether consists of a light, elastic line to eliminate sudden shocks from reaching the end of the line and to gently pull the bat back along the zip flight path if it attempts to fly laterally. Elastic sewing thread works well for small bats. At one end, a one cm length of thread is glued to the pectoral fur and the opposite end is attached to the zip-line using a small snap-swivel. Small stoppers fixed to the zip-line about two m from either end prevent bats from tangling the tether around the zip-line supports. Hanging a mini cyalume light stick on the zip-line, to be pulled by the snap-swivel (but not carried by the bat), aids in tracking the bat's movement and locating the bat when it lands. The length of the zip-line enables bats to achieve a steady mode of flight before recording calls. Many bats will provide good flights along the zip-line on first try, however some need several attempts before achieving steady flights. Herein lies the advantage of the zip-line: the opportunity for repeated flights to record satisfactory calls. After flying, the tether is severed at the level of the fur, and the bat is released. Although some bats do not produce representative calls using this method, for many bats it yields high quality recordings comparable to free-flying bats without the associated difficulty of recording from known free-flying bats.

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Phylogenetic Relationships and Biogeography of Short-faced Stenodermatine Bats: Preliminary Results and Hypotheses

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The Tribe Stenodermatina includes eight monotypic genera of "short-faced" frugivorous phyllostomid bats (*Ametrida*, *Ardops*, *Ariteus*, *Centurio*, *Phyllops*, *Pygoderma*, *Sphaeronycteris*, and *Stenoderma*) that together form a well-supported clade within Stenodermatinae. These bats are characterized by remarkable primate-like skull morphologies, considerable sexual dimorphism, and development of a variety of unusual secondary sexual characteristics (e. g., the "visor" in *Sphaeronycteris*). Four genera are Antillean endemics, while the other genera have broad mainland distributions in Central and/or South America. Little is known about the ecology, behavior, or evolutionary history of these unique bats. We present preliminary results of a phylogenetic analysis of Stenodermatina species based on morphological characters and data from the literature on karyological and molecular characters. Species of *Carollia*, *Sturnira*, *Artibeus* (*Dermanura*), *Vampyressa*, and *Uroderma* were used as outgroups. Results of parsimony analyses confirm monophyly of Stenodermatina. *Ametrida*, *Centurio*, and *Sphaeronycteris* appear to form a clade, with *Pygoderma* as their sister-group. The Antillean endemic taxa apparently fall outside this clade of mainland taxa. Patterns of geographic distribution and phylogenetic relationships suggest a preliminary historical biogeographic hypothesis for the group that appears consistent with a recent paleogeographic reconstruction of changes in the Caribbean region since the Eocene.

Evidence of Migration of *Leptonycteris curasoae* in the Mexican Tropics

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Migratory movements of *Leptonycteris curasoae* have been questioned recently on the basis of records of occurrence and phenological vegetation data. Hence, it has been proposed that only northern populations are migratory, while populations in the Mexican tropics do not migrate and are year-round residents. To test this hypothesis we examined seasonal changes in the population, reproductive conditions, and diet of *L. curasoae* in four caves located in Chiapas and Balsas Basin; all in Tropical Dry Forest: TDF. Stable carbon isotope ratios (SCIR) of bat tissue were used to determine the most important food source in the diet of *L. curasoae*. We hypothesize that migratory movements of bats to TDF caves from cactus-dominated landscapes would result in significant increases in the number of bats in TDF in the fall, concurrent with SCIR that reflect a change from a CAM- to C3-dominated diet. Our results indicate that *L. curasoae* populations in the Balsas caves show up in late summer and early fall and use both caves as maternity roosts in fall and winter. As populations in these caves begin to swell between late summer and early fall, the SCIR decreases from $\delta^{13}C$ (PDB) -15.52% to -23.53%. These values are consistent with a change from a CAM to a C3-dominated food source. By early spring, the number of bats starts dropping and the SCIR indicate the population is feeding almost exclusively on C3 plants. Thus, both population and dietary patterns are consistent with the migration of major populations of *L. curasoae* from columnar cacti concentrations in Central Mexico to western Mexico in search of food resources. In Chiapas, the caves are occupied year-round by small *L. curasoae* populations feeding primarily on CAM resources ($\delta^{13}C$ (PDB) in the range -16.03 % to -18.62%). In early fall, the populations swell by several orders of magnitude (from 200 to 150,000 in Laguitos and to 5000 in Tempisque caves) and form maternity roosts. These bats have a lower fat index and markedly different $\delta^{13}C$ (PDB) values than the smaller summer population (in the range -21.34% to -21.52%), indicating a C3 plant diet. These data also suggest migration of major populations of *L. curasoae* between ecosystems in the Mexican tropics.

Strategies of Roost Use:
Implications for the Biogeography and Assemblage Structure of Temperate Bats
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Strategies of resource utilization have long been the focus of ecological research on small, autecological scales and large, macroecological scales alike. General predictions about the ecology and biogeography of a species can often be derived from the knowledge of a species' strategy of resource use. Evidence of community structure has also been found through analyses of the distribution of niche breadth across various levels of species richness and, thus, varying competitive pressures. In this study, I compile data on maternity roost type utilization, geographic range sizes, and body sizes of all temperate bat species of North America. Using the Simpson Index, I calculate niche breadth for all species for which I have data on roost type use. Human-made roosts are the most common, and species that frequently inhabit human-made structures tend to have larger geographic ranges than species that do not. In fact, species-specific strategies of roost type utilization prove to be better indicators of geographic range size than are body sizes, with generalists typically having larger ranges than specialists, except for the five species with the largest ranges, which specialize on either of the two ubiquitous roost types, human-made structures and trees. I also compiled species lists for twenty local assemblages throughout temperate North America and calculated mean niche overlap for all assemblages. Assemblages varied in species richness from three to thirteen, with all low diversity assemblages (i. e., < eight species) being found in the eastern and central portion of the continent and all high diversity assemblages in the western half. This pattern likely reflects the differences in the diversity of available roost types, for analysis of local body size distributions suggests that, unlike among other mammalian groups, body size does not exhibit significant effects on assemblage structure. Furthermore, the low diversity assemblages comprise primarily specialists, contrary to theoretical expectations, whereas the species-rich assemblages appear to follow the assembly rule of Fox (1989). These results provide 1) further support for the results of Humphrey's (1975) analysis, which demonstrated the significant limitations imposed on bat abundance and distribution by roost site availability, and 2) evidence for the structuring influences of strategies of roost type utilization.

Effects of Thinning Red Pine Forests on Bat Activity
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Many bats, perhaps the majority, rely on forests for foraging and roosting. However, despite the importance of forests in the life cycles of these ecologically and economically important mammals, researchers have just begun to investigate how bats are affected by timber management practices. Most studies have concentrated on the effects of clearcutting or have been performed in the extensive forested area of western North America. Thinning is a timber management practice that is used by forest personnel to maximize forest output, which results in opening of the canopy. Thinned forests could be considered less cluttered habitats and should have a higher amount of activity. This study was designed to determine the effects of red pine thinning on bat activity within the Manistee National Forest, Michigan. Ultrasonic bat detectors (Anabat II) were used to compare activity of bats in 12 pairs of thinned and unthinned red pine stands, as well as openings within those stands. Activity level of each site was quantified by number of bat passes per night. Although data are not totally analyzed, it appears that there is no significant difference in bat activity between thinned and unthinned red pine stands. Preliminary analyses suggest that there is higher bat activity in the openings within the stands. Presence or absence of a species was determined by comparing calls of unknown bats with previously recorded calls from known bats.

Biogeographical Patterns of Caribbean Bats: A Parsimony Analysis of Species Distributions
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We present a biogeographic analysis of Antillean islands and some continental areas using raw data of bat species distributions. The analysis takes into account the 190 species reported in 45 areas of the Greater, Lesser and Southern Antilles, the Bahamas, and the continental regions of Florida, Eastern USA, the Yucatan, and Northern Venezuela. The method we use is a parsimony analysis of species distributions (PAD), which produces the most optimum arrangement of areas based on their shared species. This method has been mainly used to infer historical relationships among biotas. In contrast, we use it with a

static approach, for the search of biogeographical affinities among areas and for the detection of biogeographical frontiers. The results show three main divisions for the Antilles: 1) Greater Antilles-Mona, seems to be an independent province with 15 endemic species; 2) The Bahamas-Grand Cayman, with no endemic species, are sister areas of the Florida Bank-Eastern USA continental areas (however, this group is sometimes linked with the Greater Antillean Group); 3) The Lesser Antilles-Virgin Islands, with six endemic species, are linked to the Northern Venezuela-Trinidad Bank-Yucatan. Two subgroups can be seen in this main cluster: from Trinidad to Dominique, and from Guadeloupe to Virgin Islands. Meanwhile, Southern Dutch islands (Aruba, Curaçao and Bonaire), as well as some smaller Lesser Antilles, which lack endemic species, have unresolved affinities. Analyzing the grouping patterns, these are concordant with geographic vicinity and island area. However, island groupings are constituted by islands or areas with diverse geological features and histories. Based on this, the biogeographical patterns obtained through PAD analyses do not seem adequate for inferring the biogeographical history of the Caribbean region. Rather, they give us good insight into the ecological factors that influence the bat biogeagraphical patterns. As a second step in the analysis, we look at the degree of differentiation of the area groupings through endemic and exclusive species. Our use of both shared and exclusive species implies a more thorough use of composition information for biogeographical analyses.

Rabies in Bats Encountered Indoors in New York State

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Rabies virus infection occurs in the nine indigenous species of bats in New York State and has been confirmed among bats in 61 of the state's 62 counties. Rabies prevalence in bats varies by species, gender and region, and reported rates are greatly affected by surveillance criteria. Among bats encountered by the public in New York and submitted for rabies diagnosis from 1981-1999, 1,170 of 29,745 (3.9%) were rabid. Notably, the positivity rate for any individual year during the period does not differ significantly from the overall rate. Bat-associated rabies virus variants have been identified in 14 rabid domestic or wild terrestrial animals in New York during 1981-99, predominantly in gray foxes (9) and domestic cats (3). A New York State resident died as a result of infection with a bat rabies variant in 1993, and a resident of a nearby Connecticut community died of bat rabies in a New York hospital in 1995. Neither patient had reported a known bat bite, but in both cases a bat had been observed flying in their dwelling in the weeks preceding onset of rabies. As modern molecular laboratory methods disclosed that nearly all of the human rabies deaths in the nation are associated with bat rabies virus variants, guidelines for managing potential human exposure to rabies have become more aggressive for bat encounters where rabies is not ruled out by laboratory testing. The prevalence of rabies infection in individual bats encountered indoors in human-occupied non-bat-roost areas of dwellings is therefore a meaningful rate for public health considerations. A review of original specimen submission data forms of 3,495 bats received for rabies examination in New York State during 1999 revealed that 1,345 (38.5%) were documented as having been captured in a human-occupied area of a dwelling. Of those bats, 42 were rabid, for a positivity rate of 3.1%. The rabies-positivity rate for bats not reported as encountered indoors was 3.5%, and among all bats received for testing during the period 3.3%. These data demonstrate that rabies infection in bats encountered in these circumstances is not uncommon, with potential exposure to rabies in approximately 1 in 30 of these encounters. It also reveals that in approximately 97% of these occurrences, capture and testing of the bat would eliminate the need for exhaustive investigation of the circumstances, avoid very difficult decisions, and preclude the unnecessary use of rabies post-exposure prophylaxis. Such testing practices also help assure that proper post-exposure management will be provided when contact with a confirmed rabid bat is disclosed.

Phylogeography of the Big Brown Bat (*Eptesicus fuscus*) Inferred from Mitochondrial DNA

Amy S. Turmelle, Michael D. Sorenson, and Thomas H. Kunz, Boston University

The big brown bat (*Eptesicus fuscus*) is widely distributed throughout North and Central America, occupying a diverse range of habitats. In eastern North America, maternity colonies typically are formed in buildings where females return each year and give birth to pups, whereas in western North America, maternity colonies are more commonly found in tree cavities. Female site fidelity suggests the potential for

significant phylogeographic structuring in this species. We sequenced the hypervariable 5' end of the mtDNA control region from 145 individuals sampled across North America. Consistent with morphological studies, eastern and western populations exhibited strong haplotypic divergence, but contrasting patterns of genetic variation. Eastern populations share a closely related group of haplotypes. In contrast, genetic variation in the west is highly structured, with mtDNA haplotypes from the Pacific Northwest and California and from Arizona, New Mexico and Northern Mexico forming two distinct clades. Within each of these regions, there is additional sub-structuring of genetic variation among localities, suggesting that topographic barriers strongly limit gene flow in western North America. Different patterns of genetic variation between eastern and western populations reflect the different movement patterns of big brown bat populations in these regions and the likely role of historical climate change.

Evaluation of Indiana Bat Hibernation Requirements as They Relate to Recovery Planning

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

For decades the endangered Indiana bat (*Myotis sodalis*) has ranked among America's most rapidly declining mammals despite protection at many of its last remaining hibernation sites. A comparison of average mid-winter roost temperatures at the nine protected caves and mines that are considered most important by the Indiana Bat Recovery Team, revealed that populations in locations where temperatures averaged 3-7.2 degrees centigrade increased by 97,339 bats over the most recent 20 years of monitoring, while those where temperatures fell outside this range declined by 185,083. This observation led us to initiate temperature and humidity monitoring at 15 of the most important current and past Indiana bat hibernacula in Illinois, Indiana, Kentucky, Missouri, Tennessee, and Virginia. Forty-six dataloggers were installed at the best defined roosts in these caves, including one outside at each location, in collaboration with the U.S. Forest Service, the U.S. Fish and Wildlife Service, state departments of natural resources, and local speleologists. Data are now downloaded each year in July or August, and initial results confirm that marginal hibernation conditions are a key factor in this bat's continuing decline. The primary originally occupied hibernation caves provided remarkable stability in the bats' preferred temperature range. For example, Rocky Hollow Cave, in Virginia, which prior to disturbance was occupied by over a million Indiana bats, provided temperatures ranging from 7.0-7.5 degrees centigrade in October and November of 1998-1999 and 5.6-7.4 from December through February. At the Magazine Mine in Illinois, which supports a rapidly growing population, temperatures for the same periods were 6.3-6.9 and 1.4-6.9. Throughout most of this species' southeastern range, the best hibernation caves or mines provide large-volume cold air traps below the lowest of multiple entrances. They must be capable of storing sufficient cold air to meet the bats' fall hibernation needs without risk of freezing in winter. Protection of such sites, and restoration of appropriate temperatures in now altered sites, is essential to Indiana bat survival.

Comparative Genetic Analysis of Island Populations of *Pteropus samoensis* and *P. tonganus*

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Genetic variation and gene flow are important indices of evolutionary and ecological processes, and thus are of conservation value. We are presently studying the relationships within and among island populations of *Pteropus samoensis* and *P. tonganus* in the south Pacific. Both species are generalist consumers with broadly overlapping resource requirements, but have significantly different social systems. *P. tonganus* is widely distributed from islands off New Guinea east to the Cook Islands. *P. samoensis* presently occurs only in Fiji and the Samoan archipelago, although prehistoric bones have been reported from Tonga. These oceanic islands represent highly disturbed ecosystems, subject to frequent hurricanes (two in the last decade) and long-term anthropogenic influence (shifting cultivation of native habitats and hunting). We are employing mitochondrial D-loop sequencing and microsatellite analysis to address the following questions: 1) Are populations geographically structured and can we resolve issues pertaining to subspeciation of *P. tonganus* and differentiation between Fijian versus Samoan populations of *P. samoensis*?; 2) Do the disturbance processes have genetic consequences and if so, do they differ between

the two species? and 3) Should populations be conserved and managed as a single unit and can we adopt a single strategy for the two species? Provisional parsimony and distance-based trees from mtDNA analysis of samples from American Samoa (3 islands), Samoa (2 islands), Fiji, and Niue: 1) reveal separation of the two species into two distinct clades, with the exception of *P. samoensis* from Fiji; and 2) indicate geographic structuring of *P. samoensis* but considerable gene flow among *P. tonganus* populations. It has been a commonplace assumption that pteropodids on oceanic islands lack genetic differentiation, and *P. tonganus* apparently fits this rule. However, the structuring in *P. samoensis* may represent a notable exception, perhaps due to its different social system. These results suggest the two species may require different approaches to their management and conservation.

Molecular Bat Scatology: Identification of Lepidopteran Prey Species

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Lepidopterans in the Family Noctuidae are economically important pests that cause significant economic damage to a variety of food and fiber crops. In particular, species in the *Helicoverpa* and *Heliothis* genera are considered to be among the world's most significant crop pests. The millions of Mexican free-tailed bats (*Tadarida brasiliensis*) that inhabit the caves of central Texas are major predators of these insect populations, consuming millions of moths nightly. The purpose of my project is to use molecular techniques (Polymerase Chain Reaction, PCR) to verify the consumption of specific Lepidopteran species by Mexican free-tailed bats. I have developed species-specific DNA markers for the moth species *Helicoverpa zea*, corn earworm, and *Heliothis virescens*, tobacco budworm. The marker sets have been tested against DNA isolated from feces of known moth content (acquired through controlled feedings of corn earworms and tobacco budworms to big brown bats (*Eptesicus fuscus*). When the *H. zea* marker set was tested against the DNA of feces from big brown bats fed only *H. zea*, the expected PCR product amplified from 100% of the samples. The *H. zea* primers were also tested against the DNA of feces collected from big brown bats fed only *H. virescens*. The expected *H. zea* product never amplified against *H. virescens* fecal samples. A separate *H. virescens* marker set was not species-specific and worked not only for feces containing *H. virescens* but also for feces containing *H. zea*. The PCR products are being sequenced for comparison. The *H. zea* marker set is presently being tested against field fecal samples from Frio Cave in central Texas (collections made by Ya-fu Lee).

Differences in Roost Fidelity Between Reproductive Classes of Female Eastern Pipistrelles, *Pipistrellus subflavus*, in Southwest Indiana

Jacques Pierre Veilleux, Indiana State University, Terre Haute, IN

Although the topic of roost fidelity within the Chiroptera has received attention during recent years, few studies have examined differences in fidelity throughout the summer roosting season, as well as between reproductive classes. I used radio-telemetry to examine differences in summer roost fidelity of adult female eastern pipistrelles, *Pipistrellus subflavus*, during May through September 1997-2000. Thirty-one adult females were radio-tagged: 18 reproductive (pregnant or lactating) and 13 non-reproductive (non-palpable or post-lactating). Individuals were monitored for nine days on average (range, 7-12). I used two measures to assess fidelity: 1) maximum consecutive days spent at a roost tree, and 2) number of roosts used over the monitoring period. Additional data will be presented which illuminate fidelity of individual pipistrelles at two larger temporal and spatial scales, i. e. fidelity to a general roosting area throughout a single year and across multiple years.

Tree-roosting by Reproductive Female Evening Bats, *Nycticeius humeralis*, in Southwest Indiana

Sherry L. Veilleux, Indiana State University, Terre Haute, IN

Evening bats, *Nycticeius humeralis*, occur throughout the eastern United States, with Indiana representing the near northern limit of its range. In Indiana, evening bats are listed as state endangered. All early colonies known from the state were located in buildings and as of 1992 were defunct. In 1993, a colony of 350 evening bats was found in a silver maple tree, *Acer saccharinum*, in the Prairie Creek area, Vigo County, Indiana. This area is associated with the Wabash lowlands physiographic region in southwestern Indiana and is characterized as a hardwood bottomland forest. The purpose of this study was

to examine the tree roosting habits, including specific attributes of roost trees as well as roost fidelity behaviors, of reproductive female evening bats. During April through October of 1999 and 2000, a total of 21 reproductively active female evening bats (12 pregnant and 9 lactating) were radiotracked to 46 roost trees, 40 of which were verified by evening dusk counts. Evening bats were found roosting only in trees, despite the availability of apparently suitable buildings. Twenty-seven trees were used by pregnant bats and 16 by lactating bats. A suite of roost tree and roost site characteristics was measured within a 0.1 ha plot centered on each roost tree. Bats roosted exclusively in hollows of trees. Silver maples accounted for 90% of roosts, 5% were green ash, *Fraxinus pennsylvanica*, and 5% were dead snags. The majority (70%) of roosts were in live trees with the remaining 30% found in trees of varying stages of decay. Both pregnant and lactating bats showed low fidelity to roost trees, switching every two to three days. Information concerning habitat use is integral to our understanding of requirements for forest dwelling bat species and has implications for land-use management and conservation strategies involving forested areas.

The United Kingdom National Bat Monitoring Programme: Turning Conservation Goals into Tangible Results

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ffective bat conservation relies on gathering reliable population monitoring information to identify changes that are of conservation concern at a sufficiently early stage. In the United Kingdom (UK), a paucity of quantitative historical data means that population trends of the 16 species of bats have been, in general, difficult to evaluate. The Bat Conservation Trust is running a government funded research program to develop monitoring procedures for eight target bat species and to assess how these (or other) techniques could be applied to all species in the UK. The programme started in 1996 and is designed to address obligations to conserve bats under national legislation and international agreements to which the UK is party, in particular to the Agreement on the Conservation of Populations of European Bats (Bonn Convention). Inherant in the programme approach is the importance of proper design: one that realistically produces abundance estimates with minimum bias and maximum precision, at a reasonable cost. The programme relies on data gathered by trained volunteers across a large number of sites, in a similar vein to the North American Breeding Bird Survey. In this paper we present the steps taken to identify a formal sampling strategy for the National Bat Monitoring Programme and discuss the use of power analysis to guide sampling designs that will make reliable inferences about population trends. We outline the strengths and caveats of the bat counting techniques employed and present figures illustrating the primary achievements of the programme to date. Although there are obvious difficulties in monitoring bats, it is essential to improve techniques and establish sustainable monitoring programmes that will contribute to conservation interests.

Ecological Characterization of Bat Species Distribution in Michoacan, México, Using a Geographic Information System

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Bat specimens collected during a two-year project in Michoacan, Mèxico were combined with museum specimens to form a data set of over 3,200 entries pertaining to 71 species of bats. Coordinates of the collection localities were recorded with GPS receivers or determined from maps. ArcView GIS was used to characterize the distribution of the species within four environmental factors (climate, precipitation, vegetation, soil type), by projecting coordinates of the collection sites onto digitized maps of the state and the four environmental factors. Correspondence analysis (CA) was used to evaluate the relationship between species distributions and the environmental factors. The CA results indicated that the order of importance of these factors is (from highest to lowest): climate, vegetation, precipitation, and soil. A predicted species distribution map was constructed for each species of bat based on the result of the analysis. Soil types, however, were excluded from the prediction models because soil type does not appear

to play an important role, according to the CA result. Distribution maps of the 71 bat species were then overlaid to generate a map of bat species richness for the entire state of Michoacan.

Bats of Prairie Creek Bottoms, Vigo County, Indiana: Their Food Habits

John O. Whitaker, Jr., Indiana State University, Terre Haute, IN

A study of the distribution and abundance of bat species in the lower Wabash and Ohio River bottoms of southwestern Indiana was conducted from 1992 through 1999. Bats were sampled by mistnetting. On 24 July 1994, six species of bats were captured along lower Prairie Creek near where it enters the Wabash River in southern Vigo County. This sample included one Indiana bat, *Myotis sodalis*, a federally endangered species, and six evening bats, *Nycticeius humeralis*, a state endangered species. The area involved comprises a 600 ha bottomland woods and is perhaps structurally similar to presettlement bottomland woods. Since a large bat community appeared to be present, long term monitoring was initiated in the area. Through 1999, there were 1439 bat captures of 9 of the 10 species of bats currently occurring in Indiana. Only the gray bat, which occurs in SE Indiana was missing. Nearness to Indiana State University has allowed extensive study of the relationships of the bats within this community. This paper will present information on the food habits of the species, based on guano collected by holding the bats in bags for up to ten minutes. Main foods of *Myotis lucifugus* (n=51) were Diptera (41.3% volume), Lepidoptera (22), Trichoptera (15.2); Coleoptera (15.1); of *M. septentrionalis* (n=107) they were Diptera (37.5% volume), Coleoptera (24.5), Lepidoptera (20.7); of *M. sodalis* (n=15) they were Diptera (45.8%), Coleoptera (26.7), Lepidoptera (21.5); of *Pipistrellus subflavus* (n= 27) they were Homoptera (35.7), Coleoptera (22.6), Diptera (21.7) and Lepidoptera (12.6); of *Eptesicus fuscus* (n=85) the main food was Coleoptera (84.2); of *Nycticeius humeralis* (n=147) the main foods were Coleoptera (60.1) and Homoptera (20.4); and of *Lasiurus borealis* (n=128) they were Lepidoptera (64.4) and Homoptera (10.7). Other projects underway on this bat community include studies of roosting habits and ectoparasites of *Pipistrellus subflavus*, *Nycticeius humeralis*, *Eptesicus fuscus*, *Myotis lucifugus*, *M. sodalis*, and *M. septentrionalis*. Also the foraging patterns of *Nycticeius* and *Eptesicus*, and also the ectoparasites of all of the species are currently under study. Finally, the spatial interrelationships of the colonies of the various species are being examined.

Bats of Wabash and Ohio River Basins of Southwestern Indiana

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Little information is available on the bats living in the bayous, swamps, and lower portions of streams near the Ohio and Wabash Rivers of southern Indiana. This study sampled these areas looking particularly for the five species considered rare or endangered in the state, the Indiana myotis (*Myotis sodalis*), gray myotis (*Myotis grisescens*), southeastern myotis (*Myotis austroriparius*), evening bat (*Nycticeius humeralis*), and big-eared bat (*Corynorhinus rafinesquii*). Sampling occurred by mistnet from 1992 through 1999 in the lower Wabash and Ohio River basins. At the outset of this study, no maternity colonies were known from Indiana for the southeastern myotis nor for the big-eared bat, only one each for the gray myotis and evening bat, and only a few for the Indiana bat. Ten of the twelve species previously known to occur in Indiana were taken, including three of the species targeted in this study. The evening bat was common in the lower Wabash basin along the western edge of Indiana, ranking second in abundance only to the northern myotis but was not found along the Ohio River. We suspect that bottomland woods as occurs in the lower Wabash basin may be similar to original evening bat habitat here in the northern part of its range. Nine gray bats, mostly males, were taken in the Ohio basin, and were probably associated either with the one colony known in the state or with colonies known in Breckenridge County, Kentucky. None were found in the Wabash basin. Indiana bats were not found in the Ohio basin and were found in the Wabash basin only in low numbers suggesting that few Indiana bats form maternity colonies in the southwestern bottoms of Indiana and explaining its greater abundance in summer in northern than southern Indiana. No southeastern myotis or big-eared bats were taken during this study and we consider these to be of accidental occurrence and/or nearly extirpated in the state. The other species expected in the bottoms areas were present, with the northern myotis and evening bat as the most abundant and widespread species in the Wabash basin and the red and eastern pipistrelle the most abundant and widespread in the Ohio basin. Low

numbers of big brown bats and little brown bats were found in both areas. These low numbers are probably explained by the close association of these bats with human structures, which are generally not available in bottomland woods.

Observations of Tongue Function and Feeding Behavior of Captive *Macroglossus minimus* and *Syconycteris australis* (Pteropodidae)

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Macroglossus minimus and *Syconycteris australis* are morphologically similar macroglossine bats that frequently share the same habitats. In Papua New Guinea *S. australis* feeds extensively on small-fruited fig species such as *Ficus bernaysii*, and on P*iper aduncum*, as well as on blossoms of various species of plants. *Macroglossus minimus* has been considered to be a banana specialist, but undoubtedly feeds on other blossoms as well. Our recent observations suggest more direct competition for food than had been supposed. We found *Piper aduncum* seeds in the feces of *M. minimus*. In addition, captives of this species readily seized and ate ripe *P. aduncum* fruits, using the tongue and chewing movements to strip the fruits from the stalk. The same individuals also ate very ripe papaya. Both species effectively used their highly extensible tongues to remove 15% honey-water from feeding tubes. We tested tongue extension and measured liquid removal using hand-held individuals of both species. The bats readily fed from a glass pipette (inside diameter 5.5 mm) that allowed free access of the tongue, but not of the snout. Feeding was videotaped and the tape was analyzed, using pipette gradations as a linear scale of tongue extension as well as a measure of volume. Maximum tongue extensions (beyond the snout) of 30.8 mm for *M. minimus* and 24.3 mm for *S. australis* were consistently achieved by bats attempting to reach depleted liquid levels in the pipette. Maximum extensions represent 135 percent and 95 percent of skull length (premaxilla-condyle) of *M. minimus* and S. *australis*, respectively. When feeding at liquid levels between 0 and 10 mm below the rim of the pipette, volume per tongue dip was 46µl for *M. minimus* and 40µl for *S. australis*. At extension ranges between 10 and 20 mm the volume removed by *M. minimus* (40µl) is double that of *S. australis*. This difference is undoubtedly largely due the greater extensibility of the tongue of the former species. Although hand held bats of both species varied greatly in the extent to which they immersed their tongues in the liquid, in the wild the greater extensibility of the tongue of *M. minimus* might give it an advantage in reaching protected nectaries or in reaching more flowers from a single position.

A Maternity Colony of Partially Hairless Bridge-roosting Rafinesque's Big-eared Bats in West-central Mississippi

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We located a maternal colony of Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) on 14 April 2000 under a cast-in-place bridge in Claiborne County, west-central Mississippi. The bridge was on a lightly traveled two-lane secondary road and consisted of three concrete box culverts on each side and flowing water below. The roost site was monitored from mid-April through August 2000. The maternal colony originally consisted of 32 bats and is particularly noteworthy because approximately half of the population displayed hair loss with no known explanation. The amount of hair loss ranged from mild patchy spots to complete loss of hair on the dorsal side. A scraping was performed on bats depicting signs of hair loss but no evidence of ectoparasitic infection was detected. Other species of bats using the bridge as a day roost were the big brown bat (*Eptesicus fuscus*) and the eastern pipistrelle (*Pipistrellus subflavus*); these species showed no signs of hair loss. Observed behavior of *C. rafinesquii* appeared normal and parturition occurred between 14 - 23 May. Based on counts made on 1 June, at least 20 pups were produced in the colony. Observations showed eventual dispersal of the adult "hairless" bats and an increased amount of juveniles utilizing the bridge as a roost site. Patchy hair loss was noted on one juvenile bat on 22 July. Two nearby bridges were also used as day roosts by *C. rafinesquii*, and *P. subflavus* in late July. A systematic monitoring program of all bridges in the watershed will be conducted in 2001.

Echolocation and Wingbeat Coupling during Approach flight in Soprano Pipistrelles *Pipistrellus pygmaeus*

Josephine Wong and Dean Waters, Leeds University, Leeds, U.K.

The coupling of wingbeat with echolocation during approach flight was investigated in soprano pipistrelles by using a high-speed digital video at 250 and 500 frames/s. We found that pipistrelles typically produce single or double pulses per wingbeat cycle. Single pulses per wingbeat occurred in two positions: immediately before the end of the upstroke or after the start of the downstroke. Double pulses per wingbeat were emitted in the same wingbeat positions on the upstroke and the downstroke as in single pulses per wingbeat. In addition, we found a bimodal distribution of pulse interval during approach flight. Longer pulse intervals (50-60ms) resulted from the emission of single pulses per wingbeat, and shorter pulse intervals (20-30ms) corresponded to the production of two pulses per wingbeat cycle. When pipistrelles were presented with a perspex disc target, an increase in mean repetition rate was achieved by producing a greater proportion of double pulses per wingbeat cycle. Previous studies have shown that during search flight, wingbeat, respiration and echolocation are synchronised in a 1:1 relationship. An efficiently integrated locomotor-respiratory system enables bats to produce intense echolocation signals at little cost above that required for flight. We suggest that the coupling of several echolocation signals with a single expiratory cycle and wingbeat enable echolocation to remain energetically economic during approach flight. Preliminary measurements of relative energy flux densities of pulses suggest that double pulses per wingbeat contain relatively less energy than single pulses per wingbeat.

NEWS ...

from Moravia, Czech Republic

In the No. 2, Volume 38 (Summer 1997) of BRN, my information concerning the numbers of the lesser horseshoe bat, *Rhinolophus hipposideros*, was published under the same title as above. For those who did not read it I repeat that Moravia is the name of a historical territory in the east of the Czech Republic and that this territory has harboured a relatively strong population of *R. hipposideros*. My concern was if heavy floods, which affected Moravia in the summer of 1997 and which were accompanied by unusually low temperatures for that time of year, had any negative impact on the numbers of *R. hipposideros*. Actually the question may be topical with other bats and other European territories affected by floods in this year. However, concerning the lesser horseshoe bats and Moravia my answer is "no". The numbers of bats recorded as hibernating in the Na Turoldu cave (mentioned in my previous letter) did not decrease following the flood year. In contrast, they were stable within the last winters as shown by 202 bats recorded in 1997, 201 in 1998, 200 in 1999 and 214 in 2000; all checks were made in January. The overall trend in the development of bat numbers within the years 1983-2000 is positive at that locality, $R^2 = 0.888$, $p < 0.001$. Monitoring the numbers of hibernating bats at other Moravian hibernacula brought similar results, mainly concerning the greater mouse-eared bat, *Myotis myotis*. Thus the floods apparently had no adverse effect upon bat numbers. On the contrary, certain climatic changes such as the gradual warming may have positively influenced the reproduction and survival of some bat species.

Submitted by Jiri Gaisler e-mail: gaisler@sci.muni.cz

RECENT LITERATURE

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Book Review

The Bats of Britain and Ireland: Echolocation calls, Sound Analyses and Species Identification.
Russ, Jon. 1999. Alana Books, Newtown, UK. 100pp. ISBN 0-9536049-0 X.

One could be excused for expecting a typical field guide if one only read the title of this book and not the subtitle, which is printed in small letters at the bottom of the cover. It is not a field guide. Instead, the author notes that it started as a "series of species identification notes and handouts for bat-detector workshops". Indeed it is more of a manual than a book, both in content and style. There are no drawings or photographs of species, no identification keys or range maps, and only limited information regarding natural history. Instead, the author presents six chapters dealing with sound, the use of sound by bats, bat detectors, details on the echolocation calls of Irish and British bats, and methods for analyzing such sounds. The book ends with a useful glossary, some equations related to sound, and the addresses of equipment manufacturers and local U.K. bat groups.

After a brief Introduction, there is a short chapter on the basic properties of sound (e.g. frequency, intensity). This is followed by a longer chapter discussing how bats use sound. While there is useful information here, there are also some inaccuracies and errors. For example, the author states that a feeding buzz "occurs when a bat catches an insect". While this is true, buzzes also occur when a bat approaches any target, only some of which are insects, and only some of which are captured. Likewise, the author notes that for a bat to detect an insect "the wavelength of the call...must be equal to or less than that [sic] of the size of the insect", referring to the diameter of the insect. While echo strength diminishes more rapidly when the size of the insect is smaller than the wavelength of the echolocation call, echoes still exist and may well be detectable by bats. These and other errors reduce the usefulness of the chapter as a primer on echolocation.

There follows a helpful section describing, in simple terms, the three main types of bat detecting systems. There is perhaps a little too much jargon for the interested amateur, and I would have appreciated a consideration of the advantages and disadvantages of each system.

The bulk of the manual is a species-by-species description of echolocation calls (and some social calls) as they sound or appear using heterodyne and time-expansion bat detectors. The sonograms of "typical" calls should be helpful for those conducting bat surveys in the UK and I appreciated the consideration of call variation within species, depending on the habitat the bats were flying in. On the other hand, such variation is lost in the tables of median call-characteristics for each species. Indeed, these sometimes do not agree with the text descriptions. For those trying to identify bats by their calls in the field, a key based on each detector-type would have been helpful. There are brief comments regarding emergence times, flight style, and foraging habitats, which, in combination with the call descriptions, may help in field identification.

The final chapter provides information on sound acquisition and analysis. It is pretty heavy going at times and likely too technical for many who will use the book. The author does state, however, that the book should be read selectively and that all parts need not be read by everyone. For those conducting bat surveys, suggestions on how to use detectors in the field (e.g. transects versus fixed points), make call libraries, and deal with call variation, would have been valuable additions.

The format of this manual is very much as the author describes it. The text has been printed double-spaced much like a manuscript, and the figures appear to have been scanned in. This gives them a rather "fuzzy" appearance. There are also a large number of grammatical errors that should have been picked up during proofreading. As it is, there is an insert listing numerous corrections to equations and figures.

Who would benefit from this book? I can not recommend it for bat biologists living outside the United Kingdom, as the general information on sound, echolocation, and sound analysis is not always accurate and can be found in other publications. For those involved in bat surveys in the U.K., the concept of the manual is a good one and there is information that may be helpful in introducing some basic concepts and distinguishing species. The manual would have been even more useful, however, if some of the omissions noted above (e.g. a key identifying distinguishing features of echolocation calls, for those species that can be distinguished) were not a problem.

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Book Review

Ontogeny, Functional Ecology and Evolution of Bats

Adams, Rick A. and Pedersen, Scott.C. 2000 Cambridge University Press, New York. 398pp. $100.00

Following the introductory chapter, a review of chiropteran systematics by Nancy Simmons establishes a taxonomic framework for the other chapters. The literature of the current understanding of chiropteran phylogenies (particularly amongst microchiropterans) are reviewed, including strengths and weakness of data sets, methodologies, and integration of data from fossils, ontogeny, morphology, and molecular biology. Kamar Karim and Kunwar Bhatnagar review patterns of implantation, placentation, and early development in some extant bat species. This chapter reminds us that there is a paucity of authors with an evolutionary or ecological perspective towards placentology. The chapter by Roger Reep and Kunwar Bhatnagar discusses the role neuronal connections and their development play in bat evolution. This is underscored by presentation of developmental and comparative mammalian data on layer VII of the cerebral cortex. Marianne Vater succinctly reviews the anatomy and evolution of the microchiropteran cochlea, the ontogeny of echolocation and the development of functional feedback between the larynx and auditory system. Scott Pederson next describes the morphogenesis of the chiropteran skull. He discusses the origin and evolution of nasal- versus oral-emitting taxa, arguing that evolutionary divergence between emission types is most likely a result of selective forces acting upon the form and function of the larynx rather than selection on cranial shape or head posture.

John Wible and Dianne Davis use new data from *Megaderma lyra* to provide an ontological model of the chiropteran basicranium for a dynamic interpretation of static adult morphology and for assessing interrelationships among taxa. Carleton Phillips reviews dental eruption patterns and utilizes them to discuss evolutionary mechanisms and pathways amongst bats. He claims that biochemical studies of the digestive system are important in understanding dental morphology and evolution. Rick Adams describes the ontogeny of the handwing and postnatal development of the wing and flight. He describes an age-specific model of resource partitioning and survivorship among juveniles and adults, thus providing a landscape model illustrating when the strongest selective pressures occur in juveniles. Rick Adams and Katherine Thibault provide new data on the development of the hindlimb and, in particular, the calcar. They provide an ontogenetic perspective of the role of the calcar in its evolutionary and systematic pathways in the monophyletic and diphyletic argument of mega- and microchiropteran origins. John Hermanson reviews flight muscle ontogeny and their biochemical maturation in a variety of vertebrates, and with respect to his own data and the data of others, considers the evolution of flight in mammals. Gareth Jones discusses the ontogeny, evolution and phylogeny of social behavior in bats, including social interactions amongst pups, maternal and allomaternal care, social learning, ontogeny of emergence times, and maternal care after weaning.

The references to studies of bat ontogeny are well developed in this volume, and therefore I recommend this book to anyone interested in bat ontogeny. I also recommend this book to all biologists who find themselves in the unique position where considerations of ontogeny, functional ecology, and evolution are warranted.

This book is a unique collection of chapters by a diverse group of bat biologists that attempts to emphasize the importance of integrating ontogeny into studies of bat ecology and evolution. As stated in the first chapter by the editors, the goal of this book is to present a "variety of works that incorporate ontogenetic data into studies of systematics, functional morphology, ecology and evolution". The editors contend that selective pressures are greatest during development and, therefore, evolutionary change is best understood in preadult organisms. The authors present the current state of research and understanding of ontogeny within the context of their own specialized fields.

This book will be of particular use to students and researchers with an interest in bat ontogeny. The combination of subheadings and an index make this book easy to use. All chapters contain an extensive literature review. The references cited in the text are located at the end of each chapter and facilitate the location of sources of presented information. The utilization of illustrations, tables and other graphic aids make it easier to follow the text for most chapters (some chapters lack adequate reader aids). The quality of graphic reproductions is sufficient to emphasize their salient features. In some chapters, analytical methodology of specific fields and their strengths and weaknesses with respect to ontogenetic studies are discussed.

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Future Meetings, Symposia, Conferences, etc.

March 29 to 1 April 1 2001

A Special Conference on The Indiana Bat:
Biology and Management of an Endangered Species

The Northeast Bat Working Group and the Southeastern Bat Diversity Network will host a symposium on the biology and management of the Indiana bat, from 29 March to 1 April 2001, at the Radisson Hotel, in Lexington, Kentucky. The purpose of the Symposium is to aid in recovery of the species by fostering dissemination of information among academic biologists, environmental consultants, and resource managers. This Symposium will consist of invited papers, as well as submitted papers and posters, dealing with any aspect of the ecology, behavior and natural history of the Indiana bat, in summer or winter. The proceedings of the Symposium will be published with Allen Kurta as editor. The meeting will begin with arrival of attendees and informal social activities on Thursday, 29 March, and end with an optional field trip to the Daniel Boone National Forest on Sunday, 1 April. Oral presentations will begiven on Friday and Saturday, and a poster session and social will be held on Friday evening. The local host is Michael Lacki, and the organizing committee consists of Sybil Amelon (U. S. Forest Service), Bob Currie (U. S. Fish and Wildlife Service), Alan Hicks (New York Sate Department of Environmental Conservation), Jim Kennedy (Bat Conservation International), Dennis Krusac (U. S. Forest Service), Allen Kurta (Eastern Michigan University), Michael Lacki (University of Kentucky), and Annette Scherer (U. S. Fish and Wildlife Service). The call for papers will be issued, along with more detailed information on registration, housing, etc., in spring 2000.

June 18th - 22nd, 2001

The American Society of Mammalogists will meet at the University of Montana, Missoula, Montana, U.S.A.

August 5 to 9, 2001

The 12th International Bat Research Conference will meet in Bangi, Malaysia.
All information concerning the conference can be obtained at :
http://www.ukm.my/ukm/seminar/bat/index.html

August 12 to 17, 2001

The 8TH International Theriological Congress will meet in Sun City, South Africa. The Organizing Committee is chaired by Professor John Skinner in conjunction with Event Dynamics as the professional Congress organizers. For additional information contact: Sandra Collier, 8th ITC Congress, c/o Event Dynamics, PO Box 411177, Craighall, 2024, Johannesburg, South Africa Tel: +27-11-442-6111. Fax:+27-11-442-5927 E-mail: DonaPlotz at: www.sandra@eventdynamics.co.za Visit the web-site at: www.eventdynamics.co.za/itc

August 31 to September 2

The British Bat Conservation Trust will hold its annual meeting in Nottingham, England at Nottingham University. Conor Kelleher is the organizer and can provide information about registration and hotel accommodations. For additional information and registration contact Marie-Claire Edwards at: mcedwards@bats.org.uk
or contact The Bat Conservation Trust, 15 Cloisters House, 8 Battersea Park Road, London SW8 4BG Tel: 020 7627 2629 Fax: 020 7627 2628

October 24 to 27, 2001

The 31st Annual North American Symposium on Bat Research will meet in the beautiful city of Victoria, British Columbia, Canada, October 24 - 27, 2001, hosted by Mark Brigham of the University of Regina. All formal sessions of the 31st Symposium will be held at the Victoria Conference Center, which is immediately adjacent (and connected) to The Empress Hotel, one of the grandest, most spectacular hotels in the world. We have obtained outstandingly good room rates for conference attendees at the Empress. Mark has also arranged that our conference banquet will be held in the Crystal Garden. This promises to be a truly memorable symposium. For details see our website at: www.nasbr.com

August, 2002

The 9th European Bat Research Symposium will convene in Le Havre, France. The Symposium Convenor will be Stephane Aulagnier, I.R.G.M., C.R.A. Toulouse, B.P. 27, 31326 Castenet-Tolosan Cedex,France. Aulagnier's e-mail is: aulagnie@teleirgm.toulouse.inra.fr

November 6-9, 2002

The **32nd Annual North American Symposium on Bat Research** will convene in Burlington, Vermont hosted by William Kilpatrick (University of Vermont) and Roy Horst (State University of New York at Potsdam) Arrangements have been made for participants in the symposium to stay at the Radisson Hotel at very reasonable rates. All symposium session, displays, etc., will be in the Radisson which overlooks Lake Champlain only a 5 minute walk away. Just 5 minutes away are historic St.Paul Street and Church Street, both famous for the great number of fine restaurants and the Burlington Brew Pub. Unfortunately the spectacular fall foliage season will be past (which incidentally is why we can get such reasonable room rates). For details see our web-site at www.nasbr.com

October 23-26, 2003

The **33rd Annual North American Symposium on Bat Research** is tentatively scheduled to meet in San Juan, Puerto Rico. The local host will be Armando Rodriquez-Moran. For details see our web-site at: www.nasbr.com

If you know of other meetings, large or small, concerning any aspect of biology please send us the details for inclusion in the next issue. Thank you. G. Roy Horst

Announcements

Database, Scholarships, Equipment Grants, etc.

Specimen Collection

Dr. J. F. Noblet is offering the following collection of bat guano samples with dates of collection, collection sites and species involved. The following species are included. *Rhinolophus hipposideros; R. ferrumequinum; R. euryale; Myotis daubentoni M. capaccinii; M. brandti(Corsica); M. mystacinus; M. emarginatus; ; M. natteri; M. myotis; M. blythi(Corsica); Nyctalus lasiopterus(Spain); N. leisleri; Eptesicus serotinus; E. nilssoni; Vespertilio murinus; Pipistrellus pipistrellus; P. kuhly; Hypsugo savii; Plecotus auritus; P. austriacus; Barbastella barbastellus; Miniopterus schreibersi; and Tadarida teniotus.*

Anyone interested in this collection please contact Dr. Noblet at:

J.F. Noblet, 486 route de Voiron, 38960 St Etienne de Crossy, France. Tel; o4 76 00 37 37. His e-mail is : jf.noblet@cg38.fr

Literature Database

I want to let everyone know that the BCI Literature Database has just been updated on our webpage. The database contains bibliographic references to over 9000 journal articles, agency reports, books, theses, dissertations, symposium abstracts, posters, brochures, and other materials relevant to bat science and conservation. You can run keyword searches on any word, including date, author name, or journal. We have tried to add keywords to each record to facilitate searching by topic. This database is by no means exhaustive, nor complete. I have a stack of papers several feet high waiting to be entered, but we're getting to it as fast as our volunteers can type!

Go to: http://www.batcon.org for our main web-page, then down the side navigation bar to Literature References. Or, the direct link to the database is:

http://www.batcon.org/bibsearch.html

If you have trouble accessing the database or with the searches, e-mail me. If you see any errors or misspellings, please email the details to me, and we'll try to get them fixed in the main in-house database. I'll try to keep up with updating the on-line version every few months. If you don't see something you wrote, please email me with the date and title, so I can check the Waiting-to-be-Entered stack (it is sorted by year, and we're doing the most recent years first). If we don't have it, I will ask you to send us a copy. Happy searching, Angela England, Educational Resources Coordinator, Bat Conservation International, PO Box 162603 Austin, TX 78716

Phone 512-327-9721 FAX 512-327-9724 e-mail: aengland@batcon.org

Scholarships

Student Scholarships for Bat Conservation Research

Bat Conservation International hereby announces the availability of student research scholarships. Approximately 15 grants ranging from $500 to $2,500 will be made in 2001. Grants will go to research that best helps document the roosting and feeding habitat require-

ments of bats, their ecological or economic roles, or their conservation needs. Students enrolled in any college or university worldwide are eligible to apply. Projects must have bat conservation relevance. **The application deadline for 2001 scholarships is 15 December 2000.** *If past this date call BCI [editor]*

Application information and forms are available on our web page at:
http://www.batcon.org/schol/schol.html or http://www.batcon.org/schol/schol.html
or write to: Bat Conservation International, Student Scholarship Program, P.O. Box 162603, Austin, TX 78716 or email: aengland@batcon.org

Equipment Grants

Sandpiper Technologies, Inc. is accepting grant applications through December 31, 2000. The company offers three types of grants to wildlife biology graduate students:

1) Equipment Grants.

Students receive the STI rental equipment free of charge for one full field season.

2) Equipment Discount Grants.

Equipment is sold to graduate students or universities at a discount.

3) Cash Grants

Information about how to apply for the grant is available in the grants/rentals section of the STI web-site: http://peeperpeople.com.

Formerly operating as Christensen Designs, Sandpiper Technologies develops wildlife research equipment and specializes in burrow probes, underwater and elevated video systems and time-lapse surveillance devices. For additional information contact:

Sandpiper Technologies, Inc. 535 W. Yosemite Ave. Manteca, CA 95337 Phone: (209) 239-7460

Email: Ann@peeperpeople.com Specializing in research equipment, video systems and innovative designs. Ann Christensen

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The front cover of this issue is the work of Adrian Tejedor and was the official logo of the 30th North American Symposium on Bat Research held in Miami, Florida in September 2000.