BAT RESEARCH NEWS

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BAT RESEARCH NEWS

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BAT RESEARCH NEWS

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BAT RESEARCH NEWS

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BAT NEWS RESEARCH

Volume 28 Spring-Summer Number 1-2

Additional Mammalian Prey of the Carnivorous Bats, *Chrotopterus auritus* and *Vampyrum sprectrum*

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The neotropical bats of the subfamily Phyllostominae represent a diverse grouping with animalivorous diets ranging from arthropods to vertebrates (Gardner, 1977). The taxonomic arrangement of this subfamily demonstrates a pattern of increasing body size, where *Trachops cirrhosus*, *Chrotopterus auritus*, and *Vampyrum spectrum* represent an end group of larger species that are obligatory carnivores. The insectivorous phyllostomines have been characterized as foliage gleaning strategists (Gardner, 1977; Humphrey and Bonaccorso, 1979), which suggests that the range of potential prey radiated to include vertebrates as increased body size evolved within this group.

I critically reviewed the field evidence and captive feeding observations in the literature for *Chrotopterus* and *Vampyrum*. Their diets appear to consist entirely of vertebrates. Because of the paucity of documented field accounts and the apparent opportunistic behavior of these carnivores, other potential food items can not be precluded. Prey items reportedly consumed by *C. auritus* include a "frog," a gecko lizard (*Thecadactylus rapicaudus*), a dove (as *Columbigallina*, *Columbina*), "birds," a mouse opossum (*Marmosa*), a bat (*Glossophaga*), a muroid rodent, and a "rodent" (Gardner, 1977; Sazima, 1978; Myers and Wetzel, 1983). Similarly, a variety of birds ("blue birds," doves, a piprid-possibly *Schiffornis*, unidentified passerines) were reported (Gardner, 1977; Navarro-L., 1079) for *V. spectrum*. Vehrencamp et al. (1977) systematically collected the culled remains of prey from below a tree roost and demonstrated a preference by *Vampyrum* for non-passerine birds, especially groove-billed anis. Other documented prey items included unidentified bats, a "rodent," and an unspecified oryzomyine rodent (Gardner, 1977; Vehrencamp et al., 1977).

Four specimens of *C. auritus* were mist-netted during my faunal studies in Parque Nacional Tikal, Guatemala, and in southern Belize (McCarthy, 1982; McCarthy, in press; McCarthy and Blake, in press). Only one female bat, from Columbia Forest Reserve, Belize, had fed prior to its capture and defecated while confined in a large bag. The feces were surprisingly dry and consisted of numerous small pellets of finely chewed hair and bone. No teeth were present, but a few toe nails remained fairly intact. Under high magnification, the uniform gray hairs from the *Chrotopterus* feces matched the color and texture of hairs belonging to the climbing rat, *Ototylomys phyllotis*. Relatively intact hair samples from the feces were also compared with hairs taken from specimens of *Marmosa mexicana*, *Oryzomys alfaroi*, and *Peromyscus mexicana*, besides *C. auritus*, that were collected in southern Belize. A microscopic comparison of hair scale patterns for the unknown and known species favorably confirmed *Ototylomys*. Hair impressions were made on a clear layer of nail polish spread over a microscope slide. Similarly, the size, shape, and the pigmented appearance of the nails found in the feces, when compared with the mentioned candidates, further supported my prey identification, which did not appear to be an adult.

Disney (1968), during his leishmaniasis studies in Belize, found at one locality that *Ototylomys* was trapped more than twice as often in the trees than on the ground. Available run-ways would

seem to be more limited in the vegetation than at ground level, which could explain the difference in trapping success. Along this same reasoning, *Ototylomys* may be more exposed and concetrated in the vegetation for possible predation by a bat.

During the mentioned fieldwork, a total of seven adult *Vampyrum* were mist-netted on five occasions. Only a male bat from Parque Nacional Tikal had fed prior to its capture between 1.2 to 1.3 hr following sunset. The assemblage of masticated remains in the feces provided diagnostic elemnets (i.e., loose teeth, right mandibular toothrow, nails) that identified the prey as a small vespertilionid bat, *Rhogeessa tumida*. Based on the available and identifiable fragments, the entire bat (29 ♂♂, $\bar{x}$ weight 3.6 g; 57 ♀♀, $\bar{x}$ weight 3.7 g) was consumed by the much larger *Vampyrum* ($\bar{x}$ weight 160.6 g; n=5). Teeth from the *Rhogeessa* remains were deposited (CM 74805) in the mammal collection of Carnegie Museum of Natural History.

There is a general belief that bats are a regular food item in the diet of *V. spectrum* (Goodwin, 1946; Bradbury, 1983; Fleming, 1983). Bats are eaten in captivity (Gardner et al., 1970; Howell and Burch, 1874; Bonaccorso, 1979; pers. observ.) and distressed bats, which were entangled in mist nets, became opportunistic meals for *Vampyrum* (Oeterson and Kirmse, 1969; Gardner et al., 1970). Except for the partial remains of two unidentified bats, which were obtained from below *Vampyrum* roosts (Goodwin and Greenhall, 1961; Vehrecamp et al., 1977), there appear to be no published identifications of bats preyed upon by *V. spectrum* under natural conditions.

The efficiency with which *Chrotopterus* and *Vampyrum* consumed bat prey in captivity deserves mention. A male *Chrotopterus*, during four months of captivity, killed its bat prey, such as *Pteronotus parnellii, Glossohpaga soricina, Carollia brevicaude, C. perspicillata,* and small *Artibeus sp.*, by crushing the skull. It continued to mash the skull so as to derive the soft brain tissue, but without an apparent interest to consume the entire head. The result was a detached head with an intact muzzle, which dropped as the thoracic and abdominal portions of the body were methodically eaten. Satiated or not, this carnivore rarely consumed portions of the wing or leg appendages and associated patagia, which often resulted in an intact 'cut out' of these structures. In contrast, captive *V. spectrum* consumed their entire prey, unless inadvertently losing a portion of the meal that escaped the grip of its wrists and thumbs. Teeth were consumed except for larger bats such as *Carollia perspicillata* or *Artibeus jamaicensis*. When this carnivorous bat became satiated while eating, the bat held and did not consume the remainder of its prey until digestion allowed the meal to proceed.

The paucity of food habit data for carnivorous bats stems from the random chance of capturing these bats, let alone an individual that has eaten or one that is carrying prey, or locating roost sites where possible vertebrate food remains and feces could be obtained. If the above feeding observations apply under natural conditions, the different manner with which each of these species eats bats would further complicate the opportunity to obtain such data. The attempts of *Vampyrum* to eat the entire bat may explain why Goodwin and Greenhall (1961) and Vehrencamp et al. (1977) were unable to find more bat remains at tree roosts. Conversely, I would expect to find more evidence at a *Chrotopterus* roost if the prey are returned and eaten there, unless, of course, bats do not form a large portion of its diet.

Fieldwork in Belize and Guatemala was permitted, respectively, by the Department of Forestry, Belize, and the Instituto de Antropologia y Historia, Guatemala. Different versions of the manuscript were reviewed by A. M. Hutson, K. F. Koopman, and R. K. La Val.

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Some Quantitative Observations of the Retina in *Pipistrellus abramus*

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Wu, et al. (1981) showed that the general structure of the optic nerve in bats is similar to that of many other mammals (the elements of the optic nerves of these other species, can also be found in the optic nerve of bats). But from quantitative studies it appears that the optic nerve in bats is less highly developed than in other mammals.

The purpose of this study is to examine the structure of the retina in *Pipistrellus abramus*, with particular attention to the number of ganaglion cells.

Four bats were anaesthetized, perfused with saline, followed by perfusion with 10% formalin. The retinas were prepared as whole mounts and stained with 0.3% cresyl violet. Under light microscopy, the retinal whole mounts were divided into squares using an eye piece — micrometer grid. (The actual area of each square was 1470 μm2). The number of ganglion cells in each square was recorded and the total number of ganglion cells for each retina was determined. Two retinas were sectioned at 10 m thickness.

Results

The number of ganglion cells in 220 grid squares are shown in Fig. 1. The mean total area of six retinas is 1.8 mm2. The examination of ganglion cells of six retinas indicated a mean total count of 9615 +/- 484 ($p < 0.05$). The number of ganglion cells per unit area of the retina is far less in bats than in many species (Wu, et al., 1980; Binggeli, et al., 1969; Stone, 1965). Distribution of ganglion cell density appeared quite uneven. The number of ganglion cells in each grid square ranged from four to thirteen as calculated from 220 grid squares (Fig. 1). The iso-density map of ganglion cells could not be plotted because both the central and peripheral parts of the retina contained some high density squares as well as low density squares. A central area or "visual streak" where the denisty of ganglion cells is very high was not found, nor could a fovea be recognized. On the retinal whole mounts there are some remnants of pigment from the choroid which obfuscated the ganglion cells at these spots. Such spots (or artifacts) are represented by x in Fig. 1.

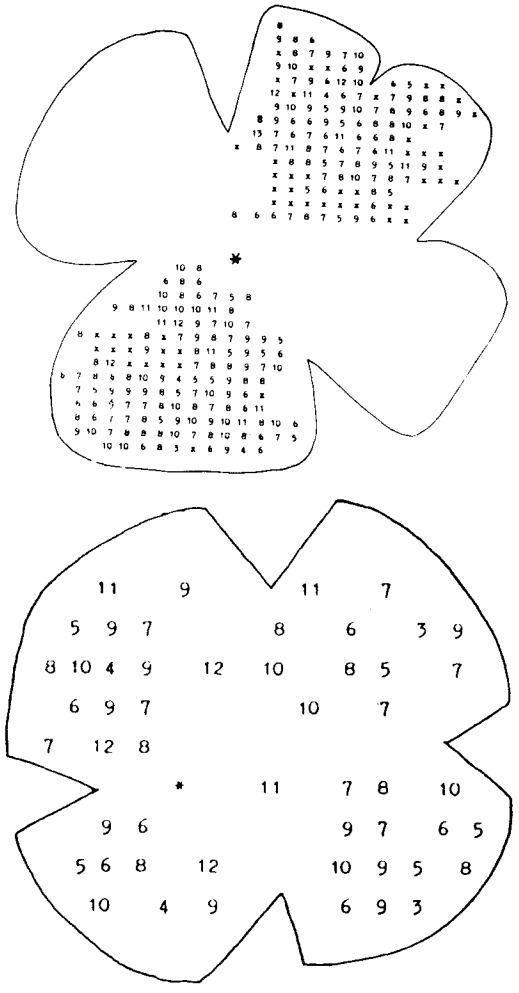

Fig. 1. The distribution of ganglion cells on two retinas. Each number represents the number of cells per 1470 um2. x means the number of cells in that square could not be measured. * optic disc.

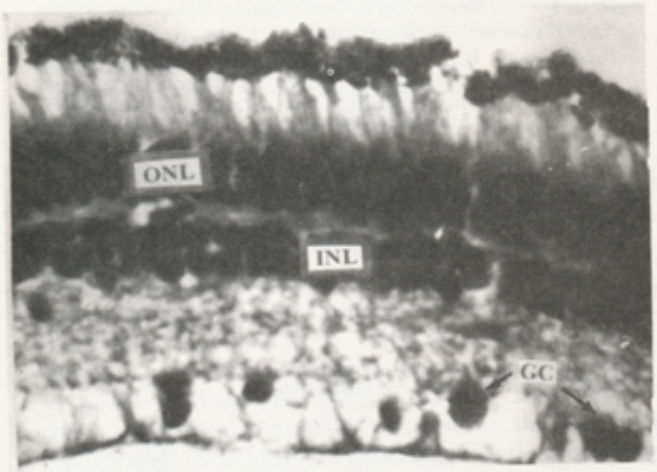

Fig. 2. A cross section of the retina of *P. abramus*. x530

ONL.	outer nuclear layer	GC.	ganglion cells
INL.	inner nuclear layer		

Table 1. Thickness of Each Layer in the Retina of *P. abramus*

Layer	Thickness (μm)
Pigment epithelium	8
Receptor layer	22
External limiting membrane	2
Outer nuclear layer	19
Outer plexiform layer	5
Inner nuclear layer	15
Inner plexiform layer	20
Ganglion cell layer	5
Optic nerve fiber layer	4
Internal limiting membrane	2

Upon examination of the sectioned retinas it appears that the outer nuclear layer is thicker than the inner nuclear layer (Fig. 2). The number of receptor cells and ganglion cells is in a ratio of 25:1, and the receptors consist almost entirely of rods. These results indicate that the retina of *Pipistrellus abramus* is similar to that of other nocturnal animals. The thickness of the retina in most mammals is 250-300 μm, however, in this study, it is found to be only 102 μm. This suggests that the number of retinal cells per given area of retina is less in *P. abramus*. This also suggests that this bat does not rely heavily on vision and employs echolocation more effectively. We concur with Suther's (1970) views on this matter.

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From the Managing Editor

This issue begins the tenure of a new Editor for *Bat Research News*. As many of you already know, Tom Griffiths of Illinois Wesleyan University has agreed to accept this thankless reponsibility for the next five-year period, succeeding Kunwar Bhatnagar. Kunwar served as Editor from 1982 through 1986 and was almost single handedly responsible for the great improvement in the style of *BRN* during that period. He initiated the News and Views section, which we will continue in almost unchanged format. Kunwar also initiated the concept of paying tribute to our accomplished senior colleagues while they are still among us to receive and enjoy our admiration and appreciation. Obituaries are fine and noble testimonials but the subject never gets to read them.

We do intend to make one significant change and that is to bend all our efforts at bringing *BRN* out in a more timely fashion. Fancy printing, elegant layouts (if they indeed were) and multiple reviews of the lead articles are fine for real journals with paid staff and adequate budgets. However, these features are also very time consuming and often frustrate our efforts at timeliness. We are a **newsletter** and we are determined to remain so, and not become a refereed journal. As a consequence on occasion we may substitute "quick and dirty" typesetting for more time-consuming high style and polish, which often delays things to the point that news becomes history. When Dr. Davis founded *BRN* it was done on an old purple-ink duplicating machine, but it was timely. We don't intend to go back to those methods in this day of electronic publishing, but we do intend to speed things up. This issue will be combined Spring-Summer, Vol. 28: 1-2. That brings us up to date and #3, Fall, will be out before the Bat Symposium in October. The Winter issue will include the abstracts of the Symposium.

After years of discussion with many of you Tom and I have agreed on the following editorial policies. We will continue to accept original articles and while we will attempt to edit for grammatical correctness, we will not routinely send such articles out for peer review. Authors will be fully responsible for the contents of their papers, and publication by *BRN* does not imply acceptance by the scientific community. We want to be Bat Research **News**, and hope that such articles will be, in reality, communications rather than original and final reports of your research. We will also maintain that publication of such "communications" does not constitute prior publication. This does not mean that you can't send us good, original material.

We are also determined to receive more "news" from you. It is of great interest to all of us to learn of your new grants, field projects, intended major collecting trips or extended field studies in far away places, awards, prizes, etc. If, for example, Tom Kunz wins an award for having produced the most attractive bat biologists, tell us about it so we can all share the good news. What is going on in your labs? We are interested. (We expect to be swamped with fascinating material.) We have also spread out our work just a bit. Pete August has agreed to be Editor for Book Reviews and will soon be tearing apart or lavishly praising your publishing efforts. We are in the process of engaging regular correspondents to report from Africa, Asia, Australia, Europe, and Latin America. Hopefully the next issue will have some of their contributions for your reading pleasure.

In closing, we all owe Kunwar a great debt of gratitude for his selfless and energetic service as Editor for the past five years. He now joins the ranks of distinguished past editors. Unfortunately his only material reward will be a lifetime subscription to the publication that he improved so much by his editorship. More important, he has the lasting gratitude of all of us, especially those who ever had a similar experience. Kunwar, we all thank you most sincerely.

Keep those cards and letters rolling in. Thank you all for your continued interest in and support of Bat Research News.

SLIDES OF BATS AVAILABLE AND SOUGHT

Colored slides of a world-wide selection of mammals are available from the Mammal Slide Library, a non-profit educational service of The American Society of Mammalogists. The 1986-1987 catalog lists over 900 slides of mammals depicting 605 species in 400 genera, 102 families and 19 orders. A variety of tropical and temperate bat species are represented by over 130 slides. The diversity of subjects unique and valuable resource for a wide variety of educational and research activities. Slide lists are available free of charge, and the complete catalog (with slide descriptions) costs $2.00 ($4.00 outside the USA, Canada, and Mexico). Slides of bats and other mammals, which are unrepresented, may be contributed. A want list is available from the library upon request. For more information or to order a catalog, write to: Dr. Dwight W. Moore, Division of Biological Sciences, Box 50, Emporia State University, Emporia, KS 66801 USA.

PEOPLE

The Zoological Society of India has conferred Fellowship in the Society to **Dr. K.B. Karim** of Nagpur India. Fellowship was conferred in recognition of the valuable scientific researches and services rendered to the cause of science, and zoology in particular, in India. The society believes and hopes that the recipient will continue to foster the interests of the Society and Zoological Science in general. The appointment to fellowship was made August 18, 1986. We join in offering our congratulations to Dr. Karim and extend our best wishes to her in her continuing efforts in research on the bats in India.

The Animal Behavior Society paid a singular honor to **Donald Griffin** at its 23rd annual meeting at Williams College in Williamstown, MA. The Society dedicated a day long session (June 25) on Animal Cognition to the honor of Dr. Griffin's seminal contributions to this field. A second session of invited papers was presented in honor of Dr. Griffin's Retirement. (Do any of us believe he really will retire?) Thursday evening (June 25) there was a banquet in Dr. Griffin's honor where former students, colleagues and friends spent a pleasant few hours telling stories about (and on) Don and his rich and colorful career. Bat people at the banquet included Jack Bradbury, Julia Chase, Dorothy Covalt-Dunning, Alvin Novick, Rod Suthers, Tim and Janet Williams, and myself. We congratulate Don on his retirement, but at the same time look forward to a continuing stream of contributions from a revered elder statesman of Chiroptology.

G. Roy Horst

FIRST ANNUAL *BAT RESEARCH NEWS* COVER CONTEST

BAT RESEARCH NEWS will change its front cover format slightly by adopting a single cover illustration for an entire volume (year). In the past, *BRN* has run photographs, drawings, and other bat-related illustrations, changing the cover on each issue. We herein announce a competition open to all subscribers of *BRN*. Individuals with original artwork on a bat-related theme may submit a copy of the work to the address below. Submissions will be judged by Roy Horst and Tom Griffiths, and the winner will receive the following: 1) the pleasure of seeing the illustration appear for one full year, with credit given; 2) a year's paid subscription to *BRN;* and 3) waiver of the registration fee at that year's annual North American Symposium on Bat Research. Please submit one copy (preferably not the original) of your artwork to: Dr. Thomas Griffiths, Editor —*Bat Research News*, Dept. of Biology, Illinois Wesleyan University, Bloomington, IL 61702.

MEETINGS

The **Animal Behavior Society** held its 23rd Annual Meeting at Williams College in Williamstown, Massachusetts on June 21-26, 1987. Careful examination of the titles on the program, and subsequent reading of many of the abstracts, (yes, I even went to some of the presentations) yielded some very interesting data about which groups of animals' behavior these animal behaviorists study. There are 279 papers listed, of these 43 did not list a taxon or taxa in the title, were purely theoretical discussions, or were concerned with methods, etc.

Those titles identifying the subject species are listed as follows:

	Titles
Invertebrates	25
Fish	12
Amphibians	5
Reptiles	13
Birds	46
Mammals	135

Mammals of the following groups were represented as follows:

	Titles
Rodents	47
Primates	41 (human 7, non-human 34)
Carnivores	21 (Fissipedia 16, Pinnepedia 5)
Ungulates	16
Cetaceans	7
Chiroptera	1
Marsupials	1

Clearly our colleagues in behavior are fond of mammals, but it is equally clear that they are not giving as much attention to bats as to many other groups. Many of the participants who presented papers on non-bat species, have in fact regularly presented papers on bats at the North American Symposium on Bat Research.

G. Roy Horst

CONFERENCE ANNOUNCEMENT

The deadline for submitting abstracts for papers for Endangered and Sensitive Species of the San Joaquin Valley: A Conference on Their Biology, Management and Conservation, a conference to be held December 10 and 11, 1987, at California State College, Bakersfield, has been changed from July 1, 1987 to September 1, 1987. Please submit abstracts (5 copies) to Daniel F. Williams, Department of Biological Sciences, California State University, Stanislaus, Turlock, California, 95380.

Richard L. Anderson
Wildlife Ecologist
California Energy Commission

ANNOUNCEMENT

THE SEVENTEENTH ANNUAL NORTH AMERICAN SYMPOSIUM ON BAT RESEARCH

The Seventeenth Annual North American Symposium on Bat Research will be held between 15 and 17 October 1987 in Toronto, Canada.

The local organizing committee includes Dr. J.L. Eger (Department of Mammalogy, Royal Ontario Museum, Toronto, Canada, M5S 2C6; 416-586-5767), Dr. M.B. Fenton (Department of Biology, York University, North York, Ontario M3J 1P3; 416-736-5243) and Dr. J.H. Fullard (Department of Zoology, Erindale College, University of Toronto, Mississauga, Ontario, L5L 1C6; 416-828-5364) who will be assisted cheerfully by an assortment of friends and colleagues.

Registration and technical sessions will be held in the Royal Ontario Museum (ROM—the corner of University Avenue and Bloor Street W.), and we have arranged for a block of rooms to be reserved in Venture Inn, which is two blocks north of the Museum. The Thursday evening registration at the ROM will be organized around a cash bar and the opportunity for registrants to view the Bat Cave exhibit.

The schedule for the meetings is as follows:
Thursday 15 October
Registration from 18:00-21:30 at ROM
Friday 16 October
Sessions from 09:00-17:00 at ROM
Banquet Sai Woo's Restaurant
Saturday 17 October
Sessions from 09:00-17:00 at ROM

On Friday morning we will devote one session to paapers entered in the student competition. Students who want to enter this competition should complete the attached form. As in the past, we hope to have a modest array of cash prizes for the best contribution from students.

Toronto is the capital of the province of Ontario and is relatively easily reached by air or by road. Visitors travelling by air usually arrive at the Pearson International Airport (Terminal 1 or Terminal 2). There is an excellent bus and subway service from the airport to within three blocks of the hotel (total cost $5.00 Canadian), as well as limosine and taxi service ($30.00-$40.00). People arriving at the airport can take a bus to the end of the subway line (Islington or The Royal York Hotel) and leave the subway at the Museum stop which is closest to the hotel.

In the middle of October, the weather in Toronto can be very pleasant (sunny and 10° C), or wet and cold. We suggest you plan for the latter and enjoy the former. Toronto is a city of approximately 2.5 million people which offers many attractions (other than the bat meetings in 1987). There is a very good Zoo (with colonies of Rousettus and Pteropus), a Science Center, art galleries and some local professional n'er do well baseball, football and hockey teams all of which could be in action in October.

The Royal Ontario Museum is also an important attraction. It is located at the northern edge of the St. George campus of the University of Toronto and close to many shops and restaurants. The "main drag" is Yonge Street about four blocks east of the museum.

The local currency is Canadian $$$. We suggest you consider buying them at a bank where you will undoubtedly do better than at the hotel, local shops or restaurants. In April 1987, one U.S.$$ = c. $1.40 Canadian).

Registration Fee is $20.00 Canadian, paid before 1 September 1987, and $30.00 Canadian if paid after 1 September 1987. Please make cheques or money orders payable to **The Seventeenth Annual Bat Conference.**

The Banquet will be held in Sai Woo's Restaurant on Friday evening. Tickets will be $20.00 Canadian each (cost includes two subway tokens for going to and coming from the banquet). Please make cheques or money orders payable to **The Seventeenth Annual Bat Conference** and note that by Tuesday 13 October we must tell the restaurant how many people will attend the banquet. This means that you should not count on being able to get a ticket at the last minute.

Hotel Room (Canadian $$$) 62.00 single; 67.00 double plus 5% tax.

An important feature of the ROM is its mammal collection in general and specifically, the bat collection. Those interested in working in the collection or touring the facilities of the Department of Mammalogy should contact Dr. Eger directly.

In the Toronto area there are three main foci of bat research. At the Royal Ontario Museum, R.L. Peterson and J.L. Eger are studying the systematics of bats, focussing particularly on molossids. At the Erindale campus of the University of Toronto, J.H. Fullard is continuing his research on the interactions between bats and their insect prey and paying special attention to the neurobiological implication of bat-sensitive moth ears. At York University, M.B. Fenton and several colleagues (Mark Brigham, Joe Cebek and Brian Hickey) are studying the behavioral ecology of bats, including foraging strategies and echolocation, and social behavior.

M.B. Fenton

WILLIAM A. WIMSATT MEMORIAL FELLOWSHIP

Dear Colleague:

The family and friends of the late William A. Wimsatt have proposed to the American Society of Mammalogists that a fellowship be established in his memory in perpetuity. The Trustees and Directors of the Society have agreed to establish such a memorial and the details of its establishment are now complete. The fellowship will be known as the William A. Wimsatt Memorial Fellowship of the American Society of Mammalogists. Funds donated to this fellowship will be invested by the trustees of the Society, the income being awarded annually to a full-time graduate student in an accredited university in Mexico, Canada or the United States, who is writing a thesis or dissertation on any aspect of the biology of bats. In the event no acceptable application is received in a given year, the income from the fund shall be added to the principal of that year.

The Society's Committee on Grants in Aid will issue a continuing announcement in the Journal of Mammalogy describing the application procedure, deadline dates and other pertinent information. This Committee will also receive all applications and select the student who will be designated the "William A. Wimsatt Fellow" for that year.

No segment of the scientific community was more dear to Bill Wimsatt than his students and the students of his colleagues. He gave to them gifts beyond price, and to each he gave a large measure of his intellect and his heart. To the last lingering days he continued to advise and guide and encourage his students, and does so still in their memories. What more appropriate monument can we erect than to offer our support of a deserving graduate student as a living memorial to Bill's spirit?

The trustees of the Society have recommended that the principal amount in such an endowment should be a minimum of $10,000. If one hundred of Bill's friends each contribute $100 we can easily surpass that figure. Contributions may be spread over more than one payment and additional gifts can be added at any time.

We invite you to join with us in establishing this fellowship. Donations should be to the William A. Wimsatt Fund and sent to Roy Horst (address below) who will receive your contributions in behalf of the Wimsatt family and the Society. Dr. Horst will send you an appropriate recognition from the Wimsatt family and record for your tax purposes, and he will forward the funds to the Treasurer and Trustees of the Society.

We are grateful to you for joining us in this act of love and gratitude.

Dr. Horst's address is: G.R. Horst
Department of Biology
State University of New York
Potsdam, New York 13676 U.S.A

RECENT LITERATURE

ANATOMY

Vigh, B., I. Vighteichmann, and B. Aros. 1986. Neurohemal areas bordering the internal cerebral veins in the pineal organ of the bat (Myotis blythi oxygnathus). Z. Mikroskopisch-Anatomische Forschung, 100:745-758.

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Noblet, J. P. 1986. Discovery of Myotis nattereri at the boundary Yugoslavia-Albania (in French). Mammalia, 50:266-268.

Pierson, E. D., W. E. Rainey, R. M. Warner, and C. C. White-Warner. 1986. First record of Monophyllus from Montserrat, West Indies. Mammalia, 50:269-271.

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Dinerstein, E. 1986. Reproductive ecology of fruit bats and the seasonality of fruit production in a Costa Rican cloud forest. Biotropica, 18:307-318. [National Zoological Park, Smithsonian Nepal Terai Ecology Project, Washington, D. C. 20008]

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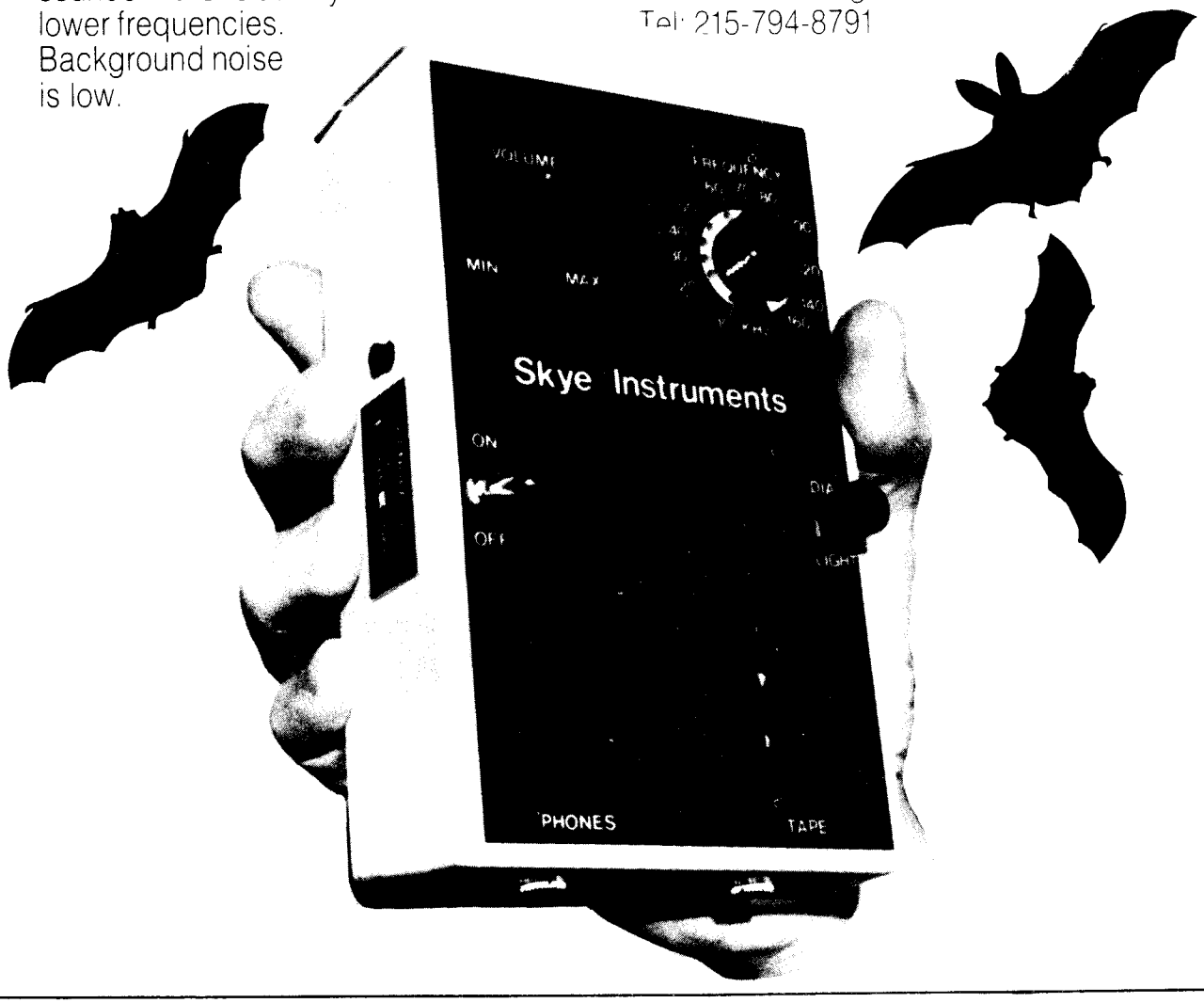

BOOKS ABOUT BATS

FOR ADULTS

Bats of America
A great bat book; life history and identification ofbats all over the U.S. Many illustrations in B&W and color. By Roger W. Barbour and Wayne H. Davis, 286pp. 1969, hb. **$35.00**

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Reprinted from the memoirs of the National Academy of Sciences, Vol. 4, Part 1, 1888. For those interested in the history of cave biology. By A.S. Packard, 155pp. hb. **$16.00**

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This book will appeal to amateur naturalist and conservationalist, as well as scientists and professional zoologists. By John E. Hill and James D. Smith, 248pp. 1984, hb. **$25.00**

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10 chapters, each by a different well-known author. Includes Reproduction, Roosting Ecology, Growth and Survival, Plant-visiting Bats, Bat Parasites, and more. Edited by Thomas Kunz, 425pp. 1982, hb. **$49.50**

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A wide-range book including breeding, feeding, physiology, aerodynamics, and more. By Wilfred Schober, 212pp. 175 illus., 1984, hb. **$25.00**

What About Bats?
A great introduction to bats for both children and adults. By James K. Baker, 60pp. 1979, pb. **$1.50**

Bats and Public Health
This book is valuable for its bibliography as well as its general health information. By Merlin Tuttle and Stephen J. Kern, 11pp. 1981, pb. **$1.00**

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The leaf-nosed bat from south India *Hipposideros speosis*. Photo by Mr. P. Kumarasumy, courtesy of Dr. G. Marimuthu, Madurai Kamaraj University, Madurai, Tamil Nadu 625 021 India.

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BAT RESEARCH NEWS

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Records of *Tonatia carrikeri* (Chiroptera: Phyllostomidae) from the Brazilian Amazon and *Tonatia schulzi* in Guyana.

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There are few locality records that document the distribution of *Tonatia carrikeri*. Seven specimens of this white-fronted *Tonatia* from Bolivar, Venezuela, provided the basis for the description of the species. These were collected (6 December 1909) by M. A. Carriker, Jr., in riparian forest along the Río Mocho of the Río Caura drainage. Linares (1986) reported that this type locality was in error. He stated (in litt.) that he has not been able to locate "Río Mocho" on any Venezuelan maps, and found that people in the Caura region were unfamiliar with this name. He suspected that the true identity of this locality is in the Rio Hacha region of Bolivar. We do not agree with this, although we have been unable to locate the name "Río Mocho." All evidence (Allen, 1910; 1911) leads us to associate this locality with the Río Caura. Allen (1910) described *carrikeri* as a species of *Chrotopterus*, but Goodwin (1942) correctly placed this bat in the genus *Tonatia*. We summarize the distribution of *T. carrikeri* in South America and report its occurrence in the Brazilian Amazon. First, it is necessary to review those records that have been reported as *T. carrikeri* but actually represent *T. schulzi*.

Tonatia schulzi closely resembles *T. carrikeri*, and went undetected from the forests associated with the Guianan Shield until it was recognized and described by Genoways and Williams (1980). Over 50 years lapsed after Carriker's collection before another *Tonatia* specimen was reported as *carrikeri* (Husson, 1962). This male bat was collected in Suriname and has been preserved in fluid for over one hundred years. Husson (1962) commented on the poor condition of this specimen, which is stored in the Zoological Museum of Humboldt University of Berlin. Although Husson did not see the type series for comparison, the measurements that he recorded were smaller than those given for the Venezuelan specimens by Allen (1910). Husson (1962) reported the length of the forearm and the greatest length of skull (excluding incisors), among other measurements, as 44.6 mm and 23.2 mm, respectively, which compare favorably with *T. schulzi* (42.0-44.0 mm; 23.0-23.8 mm, including incisors) rather than *T. carrikeri* (45.8, 46.7 mm; 25.0, 26.0 mm, including incisors) (Genoways and Williams, 1984). We were unable to obtain a reevaluation of this questionable specimen, but it would appear to be *T. schulzi*. During

TABLE 1. Selected cranial measurements of South American *Tonatia carrikeri*.

		GLS	ZB	MB	POB
COLOMBIA					
(15 FMNH; 1 ICN)	M (7)	24.2	11.2	11.9	3.9
		(23.7-24.4)	(10.8-12.1)	(11.4-12.8)	(3.6-4.1)
	F (8)	23.4	10.8	11.4	3.7
		(22.8-24.0)	(10.5-11.2)	(11.1-12.1)	(3.6-3.9)
VENEZUELA					
(7 AMNH; 1 USNM; 1 EBRG)	M (3)	24.5	12.0	12.7 (2)	4.0
		(23.7-25.1)	(11.5-12.2)	(12.5,12.8)	(3.9-4.2)
	F (5)	24.0	11.3 (4)	11.4 (2)	3.7
		(23.2-24.5)	(10.8-11.5)	(11.4,11.4)	(3.5-4.0)
SURINAME					
(3 CM)	F (2)	24.3,25.0	11.3,11.6	12.0,12.3	3.7-3.9
BRAZIL					
(4 USNM)	M (1)	24.6	11.5	12.8	3.6
	F (2)	13.2,13.3	10.8,11.1	11.4,11.6	3.6,3.9
PERU					
(2 LSUMZ)	F (2)	22.6,23.5	10.3,10.9	10.9,12.0	3.3,3.6
BOLIVIA					
(1 AMNH)	F (1)	23.9	11.2	11.5	3.7

All measurements to nearest 0.1 mm: greatest length of skull (GLS); zygomatic breadth (ZB); mastoid breadth (MB) is greatest width of skull across mastoids; postorbital breadth (POB); braincase breadth (BB); braincase depth (BD); canine breadth (CB) is alveolar between outside bases of canines; postpalatal length (PPL); breadth across molars (M-M); maxillary toothrow (MXT); mandibular length (MNL) is from the furthest point of the ramus to the furthest point of the condyle. The acronyms in Table 1 refer to the following collections where the specimens are located: AMNH = American Museum of Natural History; CM = Carnegie Museum of Natural History; EBRG = Museo de la Estacion Biologica de Rancho Grande, Marcay, Venezuela; FMNH = Field Museum of Natural History; ICN = Instituto de Ciencias Naturales, Museo de Historia Natural, Bogota, Colombia; LSUMZ = Louisiana State University; USNM = National Museum of Natural History)

endoparasite studies in Suriname, Chabaud and Bain (1974) reported a male bat they identified as *T. carrikeri*. Genoways and Williams (1984) examined this specimen (RMNH 26111) in the collections of the Leiden Natural History Museum, and identified it as *T. schulzi*. In a third example of mistaken identity, Swanepoel and Genoways (1979) reported a male specimen from Guyana as *T. carrikeri*, but the overall size reflected in their measurements was small. We examined this specimen (ROM 6746 8), which is in the Guyanan collections of the Royal Ontario Museum, and found it to be *T. schulzi*. This bat was collected (13 November 1972) by S. E. Brock at 3 mi south of Linden, West Demerara District, and is the first recognized specimen of this species from Guyana.

We examined the known specimens of *T. carrikeri*. The resulting localities suggest a lowland distribution in forest habitats of both the Atlantic versant of Colombia, Venezuela and the Guyanas as well as the Amazon basin drainage. Handley (1976) reported two additional localities from the southern forests of the Orinoco drainage which increased the number of known Venezuelan specimens to nine. Sixteen specimens were reported from riparian forest along the western edge of the llanos of Colombia (McCarthy et al., 1983). Specimens from the three localities in Suriname were collected in both undisturbed rainforest and secondary forest (Williams and Genoways, 1980; Genoways et al., 1981; Genoways and Williams, 1984). Gardner (1976) reported two specimens from the western Amazonian drainage along the Rio Curanja in Loreto, eastern Peru. The only Bolivian specimen was collected along the

BB	*BD*	*CB*	*PPL*	*M-M*	*MXT*	*MNL*
9.7-10.1	4.4	7.8	7.4	8.0	14.8	
(9.3-10.2)	(9.3-11.0)	(4.0-4.7)	(7.1-8.6)	(7.1-7.7)	(7.8-8.3)	(14.5-15.2)
9.5 (7)	9.4 (7)	4.1	7.7 (6)	7.2 (6)	7.7	14.3
(9.2-9.7)	(8.5-10.2)	(4.0-4.5)	(7.4-8.0)	(6.8-7.8)	(7.3-8.1)	(14.0-14.6)
10.1	10.6	4.6	8.4 (2)	7.9 (2)	8.0	15.3
(9.9-10.4)	(9.6-11.8)	(4.5-4.7)	(8.3,8.4)	(7.8,8.0)	(7.8-8.2)	(14.8-15.6)
9.8 (4)	10.1 (3)	4.1	7.9 (3)	7.6	7.9	14.7 (4)
(9.6-10.0)	(9.9-10.2)	(4.1.4.2)	(7.7-8..2)	(7.4-7.8)	(7.4-8.3)	(14.6-14.9)
9.8,9.8	10.3,11.1	4.4,4.4	8.2,8.2	7.6,8.1	7.7,8.0	14.9,15.3
10.0	10.9	4.6	8.0	7.4	8.2	15.2
9.7,9.8	9.7,10.4	4.1,4.1	7.9,7.9	7.2,7.5	7.6,7.7	14.2,14.4
9.2,9.5	9.3,9.8	4.1,4.1	7.8,7.9	7.2,7.4	7.1,7.5	14.3,14.3
9.6	9.9	4.2	8.0	7.8	7.8	14.8

Rio Itenez, Beni, bordering Brazil, in the southern Amazon basin (Koopman, 1976). An obvious common denominator is the association of *T. carrikeri* with mesic habitats. The majority of the collecting localities were directly associated with rivers.

Mok et al. (1982) summarized the known bat fauna of the Amazon basin of Brazil and *T. carrikeri* was not reported, but four specimens of this medium-sized *Tonatia* are in the collections of the U.S. National Museum of Natural History (USNM) and document the first Brazilian records. The data for these are as follows:

USNM 360803 M (fluid specimen). Para: Belem; Utinga. 14 January 1965. R. E. Shope 14700.

USNM 393005 F (skin and skeleton). Para: Belem; Mocambo. 6 March 1968. C. O. Handley, Jr., 13673.

USNM 460095 M (skin and skeleton). Para: Belem; IPEAN (Northern Brazil Agricultural Research Station). 3 February 1969. C. O. Handley, Jr ., 13729.

USNM (uncatalogued) F (skin and skeleton). Para: Rio Iriri (east bank), 85 km SW Altamira. 18 October 1986. L. K. Gordon, 990.

All four of these bats were mist-netted in forest habitat. Specific details concerning the Utinga specimen are lacking. The Mocambo bat was captured at 2245 h near ground level in freshwater swamp forest (Igapo). The IPEAN site was situated in low tidal swamp forest (Varzea), where the *T. carrikeri* was captured at 2115 h in an aerial mist net set below the dense canopy of a tall stand of trees. The recent specimen from Rio Iriri was obtained in riparian forest at ground level. The Mocambo female appeared to be reproductively inactive; the Iriri female was lactating.

Table 1 provides comparative cranial measurements for *T. carrikeri* from Para, Brazil, and the other South American localities. Measurements taken follow Handley (1959) unless otherwise stated. Measurements for each sex are given separately because McCarthy et al. (1983) demonstrated sexual dimorphism in *T. carrikeri*.

We wish to thank J. L. Eger, (ROM), L. K. Gordon (USNM), R. J. Izor (FMNH), S. McLaren (CM), and N. Moncrief (LSUMZ) for their kind assistance. M. D. Carleton permitted the inclusion of the Rio Iriri specimen.

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Deciduous Teeth of *Thyroptera tricolor*

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In general, the deciduous dentitions of bats have not been well studied; that of the family Thyropteridae appears to be unknown. The lack of information in the literature warrants recording a preliminary description here. Four specimens of *Thyroptera tricolor albiventer* (three from Costa Rica, one from Mexico) were examined. Two are advanced embryos, including a male with external forearm length 14.5 mm and an individual of unknown sex with forearm length 15.1 mm. The other two specimens are neonates with forearms measuring 16.4 and 17.0 mm. The whole specimens were cleared in potassium hydroxide solution and the bony tissues stained with alizarin red. Two were double-stained, with alizarin for bone and with alcian blue which selectively stains cartilage (Wassersug, 1976; Dingerkus and Uhler, 1977). The skin was carefully removed from the facial region. The anterior portions of the skull were drawn using a camera lucida (Fig. 1).

Neonatal bats were pre-volant but probably were capable of terrestrial locomotion. Suction disks on thumbs and feet were well-developed. The greatest diameter of thumb disks was 3.6 mm; that of foot disks was 2.5 mm. These are equivalent in size to the disks of adults (Wimsatt and Villa-R., 1970). However, the wings were not so well formed. External forearm lengths (given above) contrast with those of adults, which range from 33.5 to 37.5 mm (Wilson and Findley, 1977). The ossified portion of the ulna in one neonate

measured 10.8 mm and in all specimens cartilaginous epiphyses of digital bones were large and obvious. Permanent teeth were not yet erupted through the gums but were just beneath the gum line.

The deciduous dental formula for *Thyroptera tricolor* appears to be dI 2/2, dC 1/1, dP 2/2 = 20. All deciduous teeth except the lower-incisors have a sharply pointed main cusp. Although they are sharply pointed, the extreme tips of these cusps in certain teeth in the double-stained specimens (advanced embryos) are stained blue, indicating their cartilaginous nature. Cartilage-tipped teeth include dP^{1-2}, dC_1, and dP_{1-2}. The main cusp is curved posterolingually in every tooth except dP^2, in which it is erect. The deciduous dentition is strongly heterodont. The upper first and second incisors each bear a low rounded knob posteriorly in addition to the main pointed cusp. Lower first and second incisors each bear three rounded, posterolingually recurved cusps, with the central cusp being most prominent. One of the neonates has previously shed its right dI_1, and its left appears near to shedding because the tip of the root is barely inserted in the bone of the dentary anterior to the developing permanent first lower incisor. Upper deciduous canines have a flattened, expanded flange at the gum line posterior to the main cusp. The main cusp of the lower deciduous canine curves first slightly anteriorly, then posteriorly, and the tooth is slightly constricted just below the crown. The upper first premolar is expanded below its main cusp. The upper second premolar also is expanded below the main cusp but it has an additional low rounded posterior knob that does not appear to penetrate the gum line. One of the advanced embryos had only one pair of deciduous upper premolars still in place. The root of the deciduous lower first premolar is inclined anteriorly from base toward crown and the emergent cusp angles sharply backwards at the gum line. The lower second premolar is expanded below its main cusp. All lacteal teeth have fairly long roots; these are particularly deep and tapering in dI^2, dC^1, dC_1, and dP^2.

The deciduous dental formula for *T. tricolor* is the same as that given for the phyllostomid subfamilies Stenoderminae and Desmodontinae (Phillips et. al., 1977; Birney and Timme, 1975), and for the phyllostomine *Macrotus waterhousii* (although a specimen of *Tonatia* examined by Dorst [1957] had a third upper premolar) and the mormoopid *Pteronotus suapurensis* (Nelson, 1966), but it indicates one fewer lower incisor per side than is found in most vespertilionid bats (Vaughan, 1970; Orr, 1970; Friant, 1963). It is possible that a third lower deciduous incisor occurs in *T. tricolor* but had already been shed in utero due to incipient eruption of the permanent third lower incisors. However, none of the specimens examined in this study possessed a dI_3.

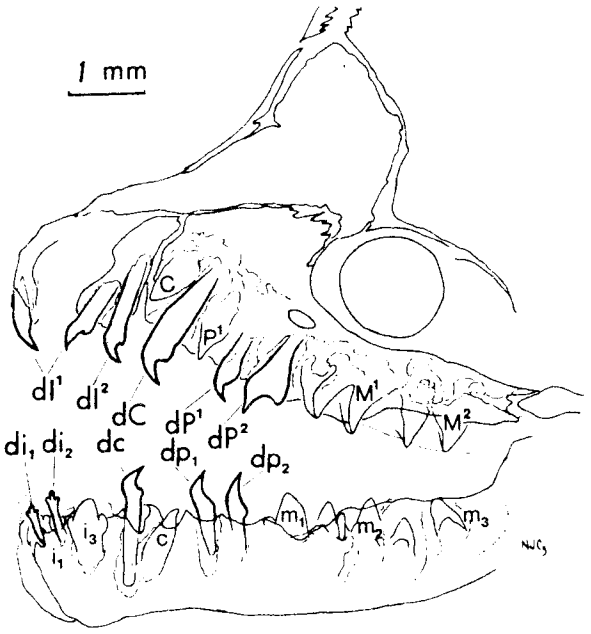

Figure 1. Facial portion of the skull of a neonatal *Thyroptera tricolor albiventer* from Sontecomapan, Campeche, Mexico, showing the deciduous dentition (bold outlines) and developing permanent dentition. Teeth are simply numbered consecutively, with no regard for their possible phylogenetic origin or position (cf. Miller, 1907).

The family Thyropteridae has usually been allied with the Natalidae and Furipteridae in the superfamily Vespertilionides (Hood and Smith, 1982; Koopman, 1983). The deciduous teeth of Natalidae and Furipteridae has not been described. If the deciduous dental formula for *T. tricolor* presented here is correct, its similarity to the deciduous dental formulae of Phyllostomoidea rather than to those of Vespertilionids is interesting in light of the similar features of the female reproductive tracts between Thyropteridae and Phyllostomoidea (Hood and Smith, 1982). However, more information is necessary before the deciduous teeth can provide useful data for systematic studies of bats.

Like the deciduous teeth of bats of many other families, those of *Thyroptera tricolor* are well suited for clinging to teats of the mother. Robinson and Lyon

(1901, cited by Wilson, 1978) stated that young *Thyroptera discifera* (which, unlike *T. tricolor*, roosts in more open situations beneath leaves) cling to the neck and breasts of the mother with teeth and reduced claws, even while she flies about. The mammae of *T. discifera* are broad and straplike, 2 mm long and 3 mm wide, providing a convenient means for the young to hold on by their teeth alone. One young *T. discifera* managed to cling to a nipple for 20 minutes without once using its claws (Wilson, 1978). Findley and Wilson (1974) noted that in older females of *T. tricolor* the nipples were invariably enlarged from previous use.

Early development of the adhesive disks probably enables young bats to attach themselves or move about within rolled leaves of *Heliconia* or *Calathea* (Findley and Wilson, 1974; Strickler, 1978) while separated from their mothers. Because the rolled leaves in which *T. tricolor* roosts are suitable for roosting only for about 24-hour periods before they grow too large (Findley and Wilson, 1974), young bats probably must be transported by the mother on a daily basis to a new roost site. The ability of the young to hang on during transport is of obvious importance. The milk teeth are morphologically well adapted for this purpose.

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Sighting of a Colony of the Indian False Vampire Bat *Megaderma lyra*

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We had occasion to observe a colony of *Megaderma lyra* in March and April 1987 inside a temple not far from the town of Tirunelveli (8°44' lat., 77°42' long.) situated at the southern tip of peninsular India. We report this sighting because one seldom gets an opportunity to watch these shy and retiring animals in their natural setting. In and around Madurai (9°58' lat., 78°10' long.) the bats dwell in caves which become inaccessible to humans after some distance. Individuals of both sexes do roost fairly close to the cave mouths but promptly disappear into the interior at the slightest disturbance.

In the temple we visited (Krishnapuram temple), the bats roosted during day time in a corridor surrounding the sanctum sanctorum on four sides. The bats, numbering roughly 350-400 animals, fluttered about and nervously flew away from the corridor we just then entered and went to the next, around the corner. Upon further disturbance, all of them flew into the red brick temple spire/turret. Most bats carried young which seemed to be much like sub-adults in size. We wondered, considering their relatively large size, why the young still had to be carried by the mother. Possibly the panic caused by the intrusion of our party of three men could have forced the young to cling to the mothers. Brosset (1962) states "No case of sexual segregation is recorded for *Megaderma lyra*. Males and females are found together." We suspect there are all-female nursing colonies which form only during the breeding months of March-April-May in Madurai. Interestingly, it is the males that appear to quit during these months, literally allowing the females to "rule the roost." In Tirunelveli we did not capture any bats to sex them but infer that the colony comprised only pregnant females and females still carrying their young. Further confirmation that nursing colonies of pregnant females and new mothers are formed in March-April-May comes from the fact that since 1983, we have succeeded in capturing only females from a cave in the Keela Kuyil Kudi and in the Pannian hill complex (Marimuthu, unpublished) during these months. From our recordings of temperature, light intensity and humidity profiles of various caves we confirm Brosset's (1962) observation that "elements of biotope, as origin, size, shape of the cavity, degree of humidity, structure of the wall and ceilings, do not interfere in the ecology of this bat." We may add: nor temperature variations and lighting conditions. In the Tirunelveli temple many individuals were seen to be hanging from the ledges of the ceiling wall in broad daylight, and even direct sunlight. This seemed strange, because this shy bat ventures out to forage in pitch darkness well over an hour after sunset and returns to the daytime roost before sunrise in Madurai. In that sense it is the most nocturnal of bats. One of us (G.M.; see also Marimuthu and Neuweiler, 1987) is now working out the details of how *Megaderma lyra* catches prey, using live frogs in a fish pond in an outdoor 'bat enclosure' (7.5 x 3.4 x 3.5 m). It is well known that the fare of *Megaderma* is rich and varied and often consists of frogs, mice, birds, lizards, spiders, insects and other smaller bats.

Another observation we made during our *Megaderma* sighting was that when they all assembled within the interior of the spire which tapered, they were densely huddled together within a limited space, *Megaderma* is normally not a huddler even though they do huddle in twos and threes for the first 2-3 days in captivity.

We thank Mr. J. Balasingh for leading us to the temple, the bats, and Mr. P. Kumarasamy for photography.This study was supported by a grant from DST, Government of India to MKC and by a Research Associateship of CSIR to GM.

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

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Eighteenth North American Bat Research Symposium

13-15 October 1988
University of Calgary
Calgary, Alberta, Canada

Organizing Committee:

Dr. Robert M.R. Barclay (403-220-3564)
Dr. Anthony P. Russell (403-220-5198)
Biological Sciences, University of Calgary
Calgary, Alberta, Canada T2N 1N4

Registration technical sessions and social gatherings will be held on the campus of the University of Calgary. Accommodation has been arranged at extremely reasonable rates in the new facilities constructed for the athletes of the Winter Olympics.

Registration will be held on Thursday 13 October from 1800-2200 h in the residence complex and prior to the technical sessions the following morning. Technical sessions will tentatively run from 0900-2300 h on Thursday and a banquet on Friday night.

As usual, the Friday morning session will be devoted to student presentations entered in the Student Paper Competition. There will likely be a few cash prizes for the best contributions.

A workshop, tentatively dealing with techniques for teaching about echolocation, is being planned by Brock Fenton.

Calgary (population 650,000) is located in south central Alberta, approximately 45 minutes from the Rocky Mountains and one hour from Banff National Park. The city is served by various airlines with direct flights from Los Angeles, San Francisco, Denver, Salt Lake City, Chicago and numerous Canadian cities. We will be happy to transport people from the airport to the campus during "normal" hours on Thursday. Please let us know your flight number and arrival time. For those arriving at abnormal hours, taxi service to the campus will be approximately $15-20 Canadian. Alternatively, a bus ride connecting the light rail transit (LRT) train will get you to the University Station for $1.25.

If you watched the Olympics you know that Calgary weather is rarely predictable. In mid-October you can expect dry conditions with daytime temperatures of 5-10 degrees C and nighttime temperatures just below 0 degrees C. It could of course be 10 degrees C on either side of those! Sunshine tends to be the order of the day, however.

Calgary has numerous attractions including a first-rate zoo, (unfortunately the pandas will have gone by October), the Glenbow Museum, a planetarium, assorted professional sports teams, etc. In addition, the Tyrell Museum of Paleontology in Drumheller (1.5 hours' drive) is superb.

The University itself is in the northwest quadrant of the city and an easy LRT ride from downtown and the zoo. For those who wish to exert themselves, arrangements can be made to use racquet courts, a 200 m indoor track, an indoor speed skating track, pool, etc. Meals will be available on campus at various student-style eateries and there are a number of restaurants within walking distance. Hot breakfasts are included as part of the accommodation on campus.

We will be dealing in Canadian dollars which makes things all that more inexpensive for those of you coming from the U.S. At present, one U.S. dollar buys you approximately 1.35 Canadian dollars. We suggest you purchase Canadian dollars at a bank before your arrival.

Registration is $20 Can. if paid by 1 September 1988 and $30.00 if received after that date. Banquet tickets are $20.00 each and you should not expect to be able to get tickets at the last minute since we have to set numbers days in advance.

Abstracts of Papers and Posters Presented at the Seventeeth Annual North American Symposium on Bat Research at the Royal Ontario Museum, Toronto, Ontario, Canada October 15-17, 1987

Prenatal Developmental Morphology of the Forelimb of Some Bats in the Family Vespertilionidae

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

Embryos, juveniles, and adults of several species of bats from the family Vespertilionidae were examined. All bats used were double stained with alizarin red (bone) and alcian blue (cartilage) and then cleared in a trypsin bath. Developmental staging sequences were obtained from the analysis of percent ossification of the long-bones, adults exhibiting 100%. Results indicate that the prenatal development associated with the forelimb morphology in bats began with the typical mammalian pattern but quickly and dramatically produced differences. Osteogenesis associated with the radial/ulnar development underwent differential growth resulting in almost complete overtaking of the humeral/radial joint articulation by the proximal end of the radius. The olecranon process became vestigial and fused to the radius. Distally, radial/ulnar fusion took place through the growth and eventual ossification of a cartilagenous bridge which was forelimb bones. Furthermore, the ulna retained the structural integrity of its shaft which may remain functional during flight.

Foraging Behaviour and Habitat Use of *Myotis myotis* (Vespertilionidae)

D. Audet, Zoologisches Institut, Universitat Minchen

From their morphology and echolocation calls (Findley 1972, Neuweiler 1984), *M. myotis* were expected to coillect preys from the ground in relatively open areas. Studies on the diet of *M. myotis* (eg. Bauerova 1978) supported these hypotheses and suggested that this species should forage in the forest. I used radio-telemetry to study the foraging behaviour and habitat use of *M. myotis* from a nursery colony (ca 700 adults) in southern Bavaria, West Germany, between May and September 1987. Data from 20 individuals (17 females and 3 males) indicate that *M. myotis* forages in forested valleys and hills slopes, mostly using continuous flight. The bats normally spent 306 to 460 minutes away from the roost and flew for up to 363 minutes. They night roosted in trees at the foraging sites between 8 and 104 minutes nightly. Individuals returned to the same areas every night. The location of those areas varied from less than 1km to up to 8km from the nursery colony. Commuting costs were reduced, for the bats started hunting on their way to the foraging site and on cold nights did not return to the nursery colony but used a second building roost less than 100 m away from their foraging site. *M. myotis* shows an interesting solution to the problem of competitive interactions.

Mother-pup Vocal Communication in the Mexican Free-tailed Bat, *Tadarida brasiliensis mexicana*.

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

The main object of this study, begun June 1987, was to observe the behaviour of mothers and pups of *T. b. mexicana* during nursing reunions and to record and describe their vocal repertoire in the mother-pup communication context. Nursing bat pairs were removed from David Cave (near Austin, Texas) after mothers returned from feeding, and placed in an arena (1.2 x 0.9 x 0.1m) where the behaviour and calls of individuals could be recorded. Pup calls were lower (20 kHz) and about four times more intense than mothers' calls (25-45 kHz). Pups began calling only when an adult called. I observed no antiphonal calling between mothers and pups, but sometimes pups changed their temporal call pattern in the presence of one of more other pups. When a mother made physical contact with her pup, pup calls increased in frequency and decreased in intensity. Pup crawling activity increased with age. Continued research will include playback choice experiments to determine the capacity for individual recognition by mothers and pups.

Foraging Strategies of Lactating and Juvenile Hoary Bats (*Lasiurus cinereus*).

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

The reproductive condition of female bats should influence their foraging behaviour due to changes in such things as their energy demand and the thermoregulatory ability of the young. This was investigated in hoary bats at Delta Marsh, Manitoba, using radiotelemetry. Female hoary bats forage for long periods of time (mean 5 h/night) and cover large areas. As predicted, mean foraging times increase significantly as lactation progresses and decline after the young are foraging for themselves. Females with one young forage for shorter times than those with two. Early and late lactating females had significantly different habitat-use patterns although there was considerable individual variation. Preliminary results suggest that juveniles gradually increase their foraging range and eventually travel long distances (15× km) from the roost. There appears to be no maternal involvement in the development of juvenile foraging.

Arctiid Moths: Startling Bad Taste

D. Bates, Department of Biology, York University

To test the hypothesis that the clicks of arctiid moths are startle displays and not aposematic signals, four adult and three laboratory-born *Eptesicus fuscus* were trained to fly to a

platform to obtain a food reward. Criterion was reached when the bats flew directly to the platform and landed there without hesitation. The bats performed this task 39 to 51 times a day for at least eight days and twice a day they were presented with an acoustic stimulus when they were 1 m from the platform. The stimuli included recorded clicks of the arctiid *Cycnia tenera*, white noise clicks, or tape noise. Both experienced (field-caught) and naive (laboratory born and raised) animals quickly (2-6 presentations) learned to ignore all of the stimuli. I conclude that the clicks of arctiid moths startle bats. Further tests associating any of the sounds with a bad tasting food reward (as perceived by the bats) suggests that an initial startle reaction can be modified with experience.

Gastric Glands in Some Indian Bats

S.A. Bhide, Department of Zoology, Institute of Science

The cytology and cytochemistry of a frugivorous and three insectivorous bats are described. The pepsinogen cells of the gastric glands of *Pteropus giganteus giganteus* are unique in that they form a distinct layer of cells which contain neutral mucins only and whose thickness gradually decreases from the proximal to the distal end. The parietal cells are interspersed with interstitial mucus cells, and the surface mucous cells occupy the distal part of the gastric glands in this species. The three insectivorous species, namely *Hipposideros speoris*, *Scotophilus heathi* and *Pipistrellus mimus mimus* show distinct differences in the distribution of the different cell types in the cardiac, fundic, transitional and pyloric regions of the stomach as compared to *Pteropus*. The morphology of the stomach and the staining affinities of the different cell types, however, are different among the different species.

Environmental Temperatures at Diurnal Roosts and the Metabolic Responses of Neotropical Insectivorous Bats

F. Bonaccorso, M. Genoud, and A. Arends, Department of Zoology, University of Florida; Institut de Zoologie et d'Ecologie Animale, University of Lausanne; Universidad Nacional Experimental de Francisco Miranda

The basal metabolic rates (BMR), thermal conductances (H), and body temperatures (Tb), in response to experimental ambient temperature are presented for two small bat species from Venezuela, *Natalus tumidorostris* and *Peropteryx macrotis*. The two species respond as homiotherms when exposed to temperatures between 25 nd 38 C, however, BMR and H show highly significant differences between species. *N. tumidorostris* has a mass-specific BMR that is 67% of that expected from body size, and a slightly low H, 90% of expected. *P. macrotis* exhibits slightly elevated BMR and H, 106% and 116% respectively. Air temperature in the cave day-roost of *N. tumidorostris* is 28-32 C, whereas *P. macrotis* selects cave roosts with diurnal temperatures of 26-27 C. Literature review reveals that insectivorous tropical bats that select roost sites with warm ambient temperatures (above 30 C) have low BMR; and that those species that select cool roost sites (below 28 C) have normal or elevated BMR.

Social Interactions in Captive *Brachyphylla cavernarum*

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Several aspects of the social behaviour of captive *Brachyphylla cavernarum* were studied from May to July 1987. The animals were kept, at Fond St.-Jacques, Martinique, in an outdoor enclosure comprising a roosting-box and an aviary. Seventeen types of social behavior patterns were described and most of them were classified according to increasing aggressiveness by means of transition matrix which relates the action of the initiator to the reaction of the target-individual. Foot apposition did not provoke any reaction by the target-animals. Wing shaking and blow were the most frequent high level aggressive behavior patterns. Bites and allo-grooming occured rarely during the observation period. Most of the social interactions involved physical contact.

Behavioural Flexibility by an Insectivorous Bat (*Eptesicus fuscus*) in Different Habitats

R.M. Brigham, Department of Biology, York University

Using radio-telemetry I found the roosting and foraging behaviour of female *E. fuscus* from maternity colonies near Manotick, Ontario and Penticton, British Columbia, Canada differed significantly. In Ontario, bats were highly loyal to building roosts with maternity colonies averaging 38 individuals. Bats travelled a mean distance of 1 km to feeding areas that varied nightly. In B.C. individuals showed a low degree of loyalty to dead *P. ponderosa* tree roosts with colonies averaging 97 individuals. Single individuals roosted in rock crevices with an intermediate level of fidelity. Western bats consistently foraged above a 200 m stretch of the Okanagan River, travelling a mean distance of 2 km from day roosts. Bats at both study sites foraged for about 100 minutes nightly, with a 60 minute bout at dusk and 0-4 subsequent bouts. I propose that the observed differences in the distribution and density of insect prey at the two sites.

Monitoring Arousal from Torpor in Captive Bats and the Effects of Opioid Agonists and Antagonists

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Opioid peptides have been shown to play a role in maintenance of torpor in hibernating rodents. Both the hypothalamus and cortex of *Myotis lucifugus* contain opioid receptors and preliminary experiments suggested that injection of opioid antagonists elicited partial or complete arousal; however, activity was monitored by direct visual observation which may have affected responses. We have now devised a technique employing a small conical cage suspended from a force displacement transducer which permits remote measurement of activity, including small head movements, shivering, and postural shifts. Torpid male bats given a single intraperitoneal injection of the opioid antagonist, Naltrexone, underwent full arousal 30-50 minutes later, while the antagonist, Naloxone, failed to elicit arousal, presumably owing to its short biological half-life. As expected, arousal was not produced by injections of either δ - or κ -agonists, but morphine, which is also a μ -agonist, caused by full arousal approximately one hour after injection. In summary, the present data support the notion that opioid peptides modulate hibernation in *M. lucifugus*.

Voiceprints and Dialects in *Eptesicus fuscus*

J.E. Cebek, Department of Biology, York University

Although echolocation calls serve as components of the acoustic orientation mechanism of bats, they may also provide clues to the identity of individuals. I analyzed features of the echolocation calls (eg. minimum, maximum and peak frequencies) of 25 big brown bats from 4 separate colonies to test two related hypotheses. First, the variation between echoloca-

tion calls could be sufficient to distinguish individuals (ie. individuals have unique voiceprints). Second, that bats from one colony would have calls distinguishable from those of members of another colony (ie. colony cohorts have unique dialects). I am further employing these analyses of call variation in conjunction with allozyme investigations to challenge the hypothesis that colonies of big brown bats represent more than simple random aggregations of individuals.

Evaporative Water Loss in Hibernating Bats

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For temperate zone mammals such as bats, hibernation is the primary adaptation to long term reductions in food availability during the winter months. Hibernation is not energetically demanding and even small fat reserves can permit extended torpor. However, all hibernators arouse periodically. Water balance is one factor that may potentially be of primary importance in determining arousal frequency of these animals. We designed a laboratory experiment to measure evaporative water loss in hibernating *Myotis lucifugus*. Twenty-five bats were placed in sealed boxes provided with different dry air flows. During 24 hours tests at 2°C and 4°C bats (x=6.1 ± 0.4g) lost a minimum of 0.0007 and a maximum of 0.0464 gH_2O · g body weight day for air flows between 2 and 100 ml/ min. Since Kallen (1964) indicated that *M. lucifugus* could lose approximately 0.3 gH_2O before needing to arouse, we can calculate the duration of torpor. With these levels of H_2O loss, bats could remain torpid for one day up to the entire winter period.

A Lek Mating System in New Zealand's Short-tailed bat, *Mystacina tuberculata*

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Behavior of *Mystacina tuberculata* at a small island breeding site suggests a lek mating system. Lekking is documented in two pteropodid species, but has not been reported for any michrochiropteran. In the autumn (March), males occupy and defend clustered tree hollows in a densely forested central valley. In 1,415 meters of transect, we have identified 4 clusters, with 4-8 male trees per cluster. At dusk, single males take up station at the mouths of small hollows, making an intense, warbling call. Although occupied trees are vigorously defended against other males, and calling can be heard throughout the night, certain trees are preferred, and individual occupancy appears unstable. Females make brief visits to the areas of male tree clusters, enter hollows of copulation, but forage on peripheral cliffs where seabird colonies likely provide a rich insect source.

Indentification and Distribution of Bats of the Genus Molossus

J.L. Eger, Department of Mammalogy, Royal Ontario Museum

This genus of seven species ranges from northern Mexico south to Uruguay and northern Argentina, including the islands of the Caribbean. Species are divided into three groups based on length and colour of pelage: *Molossus molossus* and *M. sinaloae* have long bicoloured fur; *M. bondae, M. pretiosus* and *M. rufus* have short, unicoloured fur while *M. coibensis* and *M. aztecus* have short, indistinctly bicoloured fur. *Molossus molossus* is widely distributed from Mexico to Argentina, including the Caribbean; *M. rufus* has a similar distribution excluding the Caribbean; *M. aztecus* appears confined to Mexico and Central America; *M. bondae* occurs in northern South America; *M. coibensis* and *M. pretiosus* occurs in northern South America; and *M. sinaloae* occurs in Mexico south to northern South America. An identification key to species and distribution maps of each species will be presented.

Roost Selection by Migrating Silver-haired Bats

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

Roost selection, roost characteristics, and the functions of roosts for migrating silver-haired bats (*Lasiovcteris noctivagans*) were studied at Delta Marsh, Manitoba. Roosting bats were located during the day and roost selection was assessed by comparing roost trees to a random sample of trees. Experiments were conducted to test the influence of previous roost roost use on roost selection. Only three species of trees were used by migrating bats. Tree height did not influence roost selection. However, bats selected trees with large circumferences. A typical roost was a crevice formed by either the exfoliated bark of a Peach-leaved Willow or a split in the trunk of a Green Ash or Manitoba Maple. Experiments using artificial roosts showed that roost choice was not influenced by previous roost use. Body temperatures of roosting bats showed that transient roosts provide little thermal protection and were likely used only as sheltered sites during the migration.

The Foraging Strategies of Insectivorous Bats

M. Brock Fenton, Department of Biology, York University

Using data from radio-tracking and observation of bats foraging in the field I propose a classification of bat foraging strategies that can be tested because it makes specific predictions about measurable components of foraging behaviour. Most animal-eating bats use one of two basic strategies: A) forage from continuous flight or B) forage from a perch. Continuous fliers can be subdivided according to whether they take airborne prey or non-airborne prey and two further subcategories are defined by the time the bats spend feeding each night (c. 120 min. vs. at least 300 min.) and the distance at which they react to prey (long range vs. short range). Species that forage from perches can be divided into two groups on the basis of prey size, those taking prey smaller than 5% of their mass and those taking prey up to 40% of their mass. The classification is discussed in the context of available data on bat foraging behaviour.

Variations on a Theme by Tuttle — Modifications of the Harp Trap

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Standing mist nets and standard Tuttle traps were used to capture bats in the understorey of tall dipterocarp rain forest in Malaysia. The Tuttle traps were more than 20 times as effective as mist nets at catching bats, at least when nets were inspected only a few times per night. However, limited direct observations of the traps suggested that less than one-third of bats hitting the traps were caught. Thus I developed two new traps with 4 banks (rows) of fishing line (0.20 mm) instead of the standard 2 banks. In 7 nights of trials the 4-bank traps caught a mean of 8 bats oer trap night compared to only 1.4 bats per night for a 2-bank trap strung at similar tension. The bats were predominantly small to medium-sized species of *Hipposideros* and *Rhinolophus* but several vespertilionids and a few small pteropodids were also caught. Two species were caught in the 4-bank traps that had never previously been caught in 2-bank traps, but further trials are required to determine whether there are consistent differences among species in their

susceptibility to the two trap types, and to examine the effect of varying the weight and tension of fishing line on the relative effectiveness of the traps.

Chlorophacinone, DDT and Other Pesticides for Bat Control: Efforts to Prohibit Use in New York State

S.C. Frantz, Wadsworth Center for Laboratories and Research, New York State Department of Health

In the course of investigating complaints regarding bat infestations of human structures, numerous cases of pesticide application have been revealed. Frustrated homeowners as well as professional pest control technicians have applied various products in attempts to repel or to kill bats. Chlorophacinone tracking powder used by pest control firms has been of particular concern. This product's use may exacerbate bat rabies risks and may be hazardous to people or other non-target animals living in the treated structure. My field investigations reveal that chlorophacinone tracking powder applied in an attic can migrate to other floors of a structure and remains detectable for several years. Further, this product may not be applied legally in New York State. Case histories, investigative techniques, analytical results, legal issues and other pertinent details are presented. The recently accomplished, final de-registration of DDT for bat control in the United States is also discussed.

Frugivorous and Animalivorous Bats (Michrochiroptera): Dental and Cranial Adaptations

P.W. Freeman, University of Nebraska State Museum

The most derived fruit eating bats have small canines, wide palates, and molars with a distinctive labial rim. Paracone and metacone have moved from a dilambdodent position in the middle of the tooth to the labial side of the tooth where they form the labial cutting edge. Along with the well-developed and close fitting labial cutting edges of the premolars an canines, this cutting edge skirts nearly the entire perimeter of the palate. The labial rim of the lower teeth fits inside the labial rim of the upper teeth like two cookie cutters facing and nesting one inside the other. Frugivores have a greater allocation of tooth area at the anterior end of the toothrow. The area occupied by canines of predators of struggling prey is treater than that for bats that eat non-struggling prey like fruit. In addition, frugivores have wider palates than long while many carnivores have longer palates than wide. Omnivores appear to have a more equal allocation of space to more kinds of teeth, particularly the incisors and non-molariform premolars, on the toothrow than do frugivores or animalivores. The mechanical nature of different food items is discussed and the suggestion made that describing foods in terms of their texture may be better than by taxon.

Foraging Range and Habitat Utilization of Male *Myotis sodalis* in Illinois Determined by Radio Telemetry and Computer Analysis Techniques

J.E. Gardner, J.E. Hofmann, J.D. Garner, and E.A. Cook, Illinois Natural History Survey and Illinois Department Conservation

Radio telemetry techniques were used to study foraging ranges and habitat utilization of two adult male *Myotis sodalis* in west-central Illinois. The bats were captured in mist nets positioned within a riparian corridor and monitored during May, June, and July, 1987. Azimuthal bearings (approximately 700) were recorded at regular intervals during peak foraging hours from two or more field stations. The microcomputer software package TELEM-PC was used to triangulate approximately 280 fix locations from these bearings and calculate home range size by various standardized methods described in the literature. Habitats were mapped from aerial photography, type classified, and digitized into the geographic information system (GIS) software ARC/INFO files for overlay analysis. This paper will present comparative results of range size and habitat use of the two radio-tracked males with emphasis on the computer techniques used to analyze the data.

Comparative Anatomy and Histology of the Tongues of Vampire Bats (*Desmodus rotundus*) and Robust Flower Bats (*Lonchophylla robusta*)

T.A. Griffiths and B.B. Criley, Department of Biology, Illinois Wesleyan University

Vampire bats and lonchophylline bats have grooved tongues that facilitate gathering the liquid blood and nectar consumed. Grooved tongues are unknown in other bat taxa, including those that consume a liquid diet. If the grooves are homologous structures, lonchophyllines andd desmodontines may be more closely related than previously suspected. Tongues of *Desmodus rotundus* were dissected and histologically sectioned for comparison with other chiropteran tongues. Externally, the vampire tongue resembles the lonchophylline tongue in that only fleshy and pointed monofid papillae and a few bifid papillae are present, though vampires lack a specialized hair-like papilla that lines the lingual groove of lonchophyllines. Internally, the vampire tongue has a branching single midline lingual artery, unlike lonchophyllines. Lingual veins and internal musculature are minimally modified. The vampire lingual grooves are shallower and extend less far posteriorly than in lonchophyllines. Most importantly, the vampire grooves are located ventral to the large lingual nerve, while in lonchophyllines they are dorsal to the nerve. We conclude the grooves are not homologous structures and are not evidence for a close relationship between the taxa.

Mitochondrial DNA Variation in the Bat *Tadarida brasiliensis mexicana*

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Mitochondrial genotypes reflect an animal's female lineage; therefore, the distribution of different genotypes across the species range may be used to elucidate population structure. In *Tadarida brasiliensis mexicana*, the mexican free-tailed bat, mitochondrial genotypes were used to address the questions of whether the species range is divided into two separate migratory flyways, and whether bats from a single lineage show loyalty to particular breeding and/or maternity caves. Polymorphisms of the mitochondrial genome from 35 mexican free-tailed bats were examined in this study. This included animals from four winter roost sites in Mexico and three summer caves in the southwestern U.S. Composite mitochondrial genotypes were constructed using DNA fragment patterns resulting from restriction enzyme digests. A total of 11 enzymes were used, six of which yielded polymorphic fragment patterns. Results show that although several genotypes were present in each cave, one main genotype was prevalent across the entire species range. These results support previous studies by McCracken and co-workers which found no significant difference in allele frequencies between caves across the species range.

Systematics of South American *Artibeus*

C.O. Handley, Smithsonian Institution

Studies of *Artibeus* of the Smithsonian Venezuelan Project and a review of the *Artibeus* of Gray (1838) have led to a clarification of relationships of this complex genus in South America. The six large species can be arranged in two groups. One is represented only by *A. lituratus*, but the other includes *A. fimbriatus* of Brazil and Paraguay, an undescribed species in Venezuela and Colombia, *A. fraterculus* on the Pacific Coast, and two widespread and geographically variable species, *A. obscurus* (*A. fuliginosus*) of the Amazon Basin and southern Brazil, and the ubiquitous *A. jamaicensis* (including *A. planirostris*). Eight smaller species are arranged in five groups. Diversity is greatest in eastern South America, where all of the groups occur and where three of them are endemic. The species *A. concolor, A. cinereus, A. anderseni*, and an undescribed dwarf species are found only in or near the Amazon Basin; *A. glaucus* is Andean and northern South American; and *A. phaeotis, A. hartii*, and *A. watsoni* range through Central America and into northern and western South America.

The Supraglottal Filter Function and the Acoustic Role of the Nasal Cavities in *Rhinolophus hilderbrandti*

D.J. Hartley and R.A. Suthers, School of Medicine, Indiana University

The Rhinolophidae emit constant-frequency echolocation pulses which are predominantly second harmonic (f2) with the fundamental (f1) and third harmonic (f3) attenuated by some 25 to 35 dB relative to this component. Crude light gas experiments have shown that the supraglottal vocal tract probably filters the source to give this pulse structure. We present the results of a more sophisticated use of helium which allowed us to derive the supraglottal filter function for *R. hilderbrandti*. By obtaining the filter function before and after filling the inflated nasal cavities, we have shown that these structures are not involved in f1 or f3 suppression but rather play a role in impedance matching the vocal tract to the atmosphere at f2. (Supported by NSF BNS 82-17099).

Recent Population Declines and Recovery Efforts for the Endangered Indiana Bat, *Myotis sodalis*, in Arkansas and Tennessee

Michael J. Harvey, Department of Biology, Tennessee Technological University

Only eight Arkansas caves and 13 Tennessee caves are currently known to serve as hibernacula for colonies of Indiana bats. Numerous caves formerly occupied by this species have been abandoned, many quite likely because of excessive human disturbance and/or vandalism. The Arkansas population currently numbers less than 2,900 and has declined over 50% during the past 5 years. The Tennessee population numbers ca. 22,200, having also declined during recent years. Several caves have been gated, fenced, or posted to protect Indiana bat colonies. There has not yet been adequate time to determine if protective measures taken will result in stable or increased Indiana bat populations at these protected sites. Indiana bat populations continue to decline throughout their range.

Feeding Behavior and Use of Space by the Red bat (*Lasiurus borealis*) at Pinery Provincial Park, Ontario

M.B.C. Hickey, Department of Biology, York University

for a total of 111 bat-nights between 14 June and 4 August, allow me to reject the hypothesis that red bats defend feeding territories. Even when insect densities are low red bats tolerate conspecifics at their feeding sites. Each of these bats were present at the feeding site every night from when they were banded until they began to leave their summer feeding site (4 Aug). Twenty-three of the 28 bats that I caught at the same feeding site left the area and presumablly established feeding sites elsewhere. I followed 4 bats with radio-transmitters for a total of 22 bat-nights and found that these bats did all of their feeding at the site where they were caught. One other bat left the area and was never found. One of the four bats fed at the site for four nights and then left the area. Three of the four bats used day roosts within 1 km of their feeding site. The other bat roosted out of transmitter range of the feeding site (1 km). All bats used night roosts within 50-200 m of the feeding site.

Directional Sensitivity of Inferior Collicular Neurons of Echolocating Bats Emitting FM Orientation Signals

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The direction sensitivity of 94 inferior collicular (IC) neurons of *Eptesicus fuscus* and *Myotis lucifugus* were studied under free field stimulation conditions. The variation in discharge rate of each neuron was measured with a BF sound broadcast from a moving loudspeaker at different angles along the horizontal, vertical or diagonal plane of the frontal auditory space. A wide range of stimulus intensity above the MT of the neuron was used. Neurons were classified into three classes: (a) omnidirectional neurons (15%) were broadly tuned to sound delivered in the frontal auditory space and their responses did not show any correlation with sound direction; (b) stimulus intensity-dependent direction neurons (28%) varied their discharge rates with sound direction and intensity so that the peak of their directional sensitivity curves also varied with stimulus intensity; (c) stimulus intensity-independent directional neurons (57%) varied their discharge rates only with sound direction over a wide range of stimulus intensity so that their peak discharge always appeared at the same or a small range of angle. In most cases, the medial limbs of the directional sensitivity curves of these neurons were extremely sharp and congruent. Neural mechanisms underlying the directional sensitivity of these three classes of neurons and their role of echolocation will be discussed.

Ecology of Tent-Making Bats

T.K. Kunz and G.F. McCracken, Department of Biology, Boston University and Department of Zoology, University of Tennessee

This report summarizes our observations on tent-making bats in Trinidad, West Indies. Four species of bats (*Uroderma bilobatum, Artibeus jamaicensis, Artibeus cinereus*, and *Mesophylla macconnelli*, were observed and captured in tents. Thirteen species of plants were used by bats for tent construction including six species of palms (family Palmaceae), four species of *Philodendron*, one herbaceous epiphyte, and wild tannia (family Araceae), one species of *Heliconia* (family Mus-

ceae), and a deciduous, understory tree (family Polygonaceae). Typically, one to three leaves (or fronds) of a given plant were modified into tents. Tents were most commonly found at heights of two to three meters above the ground. Roosting groups ranged from two to five individuals, consisting either of one adult male and up to four pregnant females, lactating females and their young, bachelor males, or bachelor females (immature and non-reproductive). Solitary bats were usually males. Factors affecting roost selection are discussed.

The Potential for Vocal Signatures in the Calls of Young Hoary Bats (*Lasiurus cinereus*)

C.F. Koehler, Department of Biological Sciences, University of Calgary

I examined calls produced by the solitary bat *Lasiurus cinereus* during mother-young interactions and considered the potential for vocal signatures in the calls of young bats. Families of bats were observed in the field at Delta Marsh, Manitoba, and vocalizations were recorded using highspeed ultrasonic recording equipment. Adult female bats and young vocalize primarily during reunions. Calls were classified by pattern of frequency change with time and by situation and the variation in duration, maximum and minimum frequency was calculated. The degree of call variation within *L. cinereus* family units did not differ from that between family units and calls produced by different young could not be differentiated. This suggests that a vocal signature, which is present in some colonial bat species and allows auditory discrimination between calling young, is absent in *L. cinereus*.

Energetics of Pregnancy and Lactation in Free-Ranging Little Brown Bats (*Myotis lucifugus*)

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Our analysis is based on doubly-labeled water data obtained from 12 pregnant, 14 lactating, and 24 suckling *Myotis lucifugus* in New Hampshire. Isotope turnover rates of non-torpid individuals indicated mean field metabolic rates of 1.22 liter CO_2 day during pregnancy and 1.04 liter CO_2 day during lactation. Based on estimates of the composition and energy density of an insect diet, mean daily energy expenditure (DEE) was 29.9 KJ day for pregnant bats and 25.3 kJ day during lactation. Energy contained in the fetus and associated reproductive structures would raise DEE to 30.6 kJ/day in the last half of pregnancy. Energy exported as milk would raise mean DEE for lactatin M. lucifugus to 38.5 kJ/day. DEE at peak lactation may be as high as 55.9 kJ day. The gross efficiency of lactation is approximately 31%.

Zoogeography of Large Artibeus in Colombia

Burton K. Lim, Department of Mammalogy, Royal Ontario Museum

The ROM has a representative collection of Large *Artibeus* from the Rio Magdalena (eastern valley of the Andes) and adjacent regions in central Colombia. The Andes in Colombia is composed of three mountain ranges separated by two river valleys which combine to play a major role in the distribution of bats. Four taxa are recognized based on external and cranial features and measurements, and habitat. *A. lituratus* is a large district species, ubiquitous throughout most of Colombia, and sympatric with the other taxa. *A. jamaicensis trinitatus* is small and light coloured, common along the Rio Magdalena to northern Colombia, and associated with a tropical dry forest of the Amazon basin east of the Andes and allopatric with *A. j. trinitatus*. *A. fuliginosus* is small and dark coloured, and *A. planirostris hercules* is large and light coloured, and similar to *A. j. trinitatus*.

Detection and Catching Prey by the Indian False Vampire Bat *Megaderma lyra*

G. Marimuthu, Department of Animal Behaviour, Madurai Kamaraj University

The Indian false vampire bats Megaderma lyra are able to detect and capture a variety of prey (insects, spiders, crabs, fishes, geckos, frogs and mice) only when the prey move or jump. They also detect motion of the prey when freshly killed frogs are jerkily pulled on the sandy floor, but not able to detect when the latter are pulled on a wet glass plate (here possibly the noise is excluded). Clearly movement of the prey is the key factor. The bats avoid the non-palatable prey (toads and scorpions) only after touching them.

Mother-Pup Reunions and Spatial Memory in Mexican Free-Tailed Bat Maternity Colonies

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

Genetic studies have demonstrated that nursing in Mexican free-tailed bat maternity colonies is non-random and selective. However, direct observation of reunions by marked mother-pup pairs in natural roosts is accompanied by several logistical difficulties. These difficulties include documenting events that are brief and unpredictable in their schedule, and that occur in darkness and in extremely crowded conditions. Use of infrared-sensitive video to observe individuals marked with light reflecting tags has proved effective in documenting reunions and selective nursing within large colonies of these bats. Experiments in which marked pups were removed from creches prior to the return of adults also demonstrate that females return to within one meter of where they can expect to locate their pup. These experiments suggest that females employ spatial memory when relocating pups within creches.

Visually Guided Escape Responses in *Tadirida brasilienis mexicana*: Cue Preferences and Differences in Response of Adults and Young

S Mistry, Department of Zoology, University of Tennessee

Wild adult mexican free-tailed bats were tested in a Y-Maze for escape responses under six different combinations of acoustic (open or closed arm) and visual (light or dark) cues. Presented a choice of visual cues with acoustic cues held constant, the bats showed a significant orientation towards light. With visual cues held constant and different acoustic cues presented, they chose the open arm. When choosing between conflicting visual and acoustic stimuli (light/closed vs dark/open) they exhibited a marked preference for the open arm, suggesting that the primary mode of orientation in the escape response may be acoustic. Contrary to the behavior of adults, pups orienting visually showed significant tendency to go to the dark side. Such behavior could possibly aid a young bat in finding deep recesses away from the mouth of the cave, thus staying closer to a thermoneutral environment. Tests on adult bats using infrared light in place of white light resulted in a random response, indicating possible absence of infrared sensitivity and that use of such lighting in cave observations may not alter normal behavior.

Comparative Skeletogenesis in the Vespertilionidae

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I examined the skeletal morphogenesis in seven species in three Vespertilionid genera, based on embryos cleared and differentially stained for bone and cartilage. Particular attention was paid to ossification in the appendicular skeleton and to cranial features of taxonomic or developmental interest (e.g., dentition, fontanelles, sutures, and crests). Genera differed in ossification timing and embryonic morphology of several structures. Long-bone articulations, surface features, and the extent of mineralization are genera specific and correlate with ecology and functional morphology. Standard taxonomic characters (e.g., dentition, cranial crests) are manifest early in development, allowing identification of even early embryos. Supported in part by NIH grant 1 R23 DE07190 to James Hanken.

Notes on Systematic Variation in the Nanus Group of African *Pipistrellus*

R.L. Peterson, Department of Mammalogy, Royal Ontario Museum

The nanus group shares the following characters; a distinctive "hatchet" shaped tragus; a more-or-less elevated frontal; I1 usually weakly bifid; I2 relatively long; anterior upper premolar moderate in size; C and P4 usually separated by a space. mensural data have been subjected to various multivariate statistical analysis programs in an attempt to clarify the taxonomic status of the taxa that are allied in this group. *Pipistrellus nanus* (Peters, 1852) is widespread across central Africa. *P. minusculus* (Miller, 1900) includes *P. fouriei* (Thomas, 1926) and *P. culex* (Thomas, 1911). *P. helios* (Heller, 1912) is widespread. *P. musiculus* (Thomas, 1913) appears valid but is known only by the type series from Cameroun. *P. n. australis* (Roberts, 1913) is an invalid name but is a valid taxon which we propose to rename as a distinct species that is occasionally sympatric with *P. nanus*.

Mitochondrial DNA Analysis Reveals Dispersal Patterns, Gene Flow, and Origin of Some Antillean Island Population of *Artibeus jamaicensis*

Carleton J. Phillips, D.E. Pummo, H.H. Genoways and P. Ray, Department of Biology, Hofstra University

Restriciton endonuclease analysis of mitochondrial DNA (mtDNA) and mapping of the mitochondrial genome provides gentypic data that can be used to trace dispersal patterns and estimate gene flow between and among island and mainland populations. We have applied this technology to an investigation of *Artibeus jamaicensis* which occurs throughout much of the Neotropics. The extant Antillean populations were derived from three diverse genetic (maternal) sources; pariwise comparisons of restriction site data for the three revealed nucleotide sequence differences ranging from 8 to 17%, which exceeds that reported for any other species of mammals. One of the three genotypic groups (J) can be traced from the Yucatan Peninsula to the Greater and Lesser Antilles. Analysis of mtDNA revealed that bats from Mexico to Grenada (including Jamaica, Puerto Rico, St. Lucia, St. Vincent, and Barbados) carry an mtDNA genome derived from a common maternal ancestory. The small amount of mtDNA sequence variation within this group suggest that female bats carrying the genome dispersed recently and rapidly over this geographic area. We postulate that this was a post-Pleistocene event that correlated with the replacement of xeric habitats by mesic ones in the Caribbean. (Supported by NSF BBS-8609231 to DEP, CJP).

Energetics of Foraging in Three Species of Microchiropteran Bats

S.K. Robson and T.H. Kunz, Department of Biology, Boston University

Radiotelemetry and doubly labeled water methods were used to simultaneously estimate the engery expenditure associated with foraging in *Phyllostomus hastatus*, *Eptesicus fuscus*, and *Tadarida brasilliensis*. Radiotelemetry was used to determine the length of foraging bouts and the total time spent foraging each night. Knowledge of total daily energy expenditure, time spent foraging and energy expenditure of a resting individual makes it possible to predict the energy expended while foraging in free-ranging bats. The relationships between foraging costs, wing morphology, and foraging habitat are discussed.

Bovine Paralytic Rabies Control: Immunization of Vampirel Bats With an Inactivated Oral Rabies Vaccine

Charles Rupprecht, R. Lord, S. Papo, B. Dietzschold and A. M. Greenhall, The Wistar Institute

With recent advances in the area of wildlife rabies immunization via oral vaccines, we designed a feasibility studey to test the immunogenicity of an experimental inactivated rabies vaccine in vampires. In an area of Venezuela with no known rabies activity, vampire bats were caught, bled for rabies virus-neutralizing antibody (VNA) and maintained in captivity on a diet of difibrinated bovine blood. The inactiviated vaccine preparation consisted of the ERA fixed rabies straine grown to a titer of 10 7.2 pfu in BHK-21 Cells, inactivated by betapropiolactone treatment, purified by differential sucrose-gradient centrifugation, and was adjusted to a concentration of 1.0 mg/ml of protein in PBS/50% sucrose/distilled water: 100 mg of inactiviated ERA and 10 mg of Saponin (Quillaia sp., RavqxR) reconstituted according to manufacturer directions; sucrose and saponin; or sucrose alone. By day 14 only bats receiving inactivated vaccine had demonstrated serconversion as compared to contols. This system may represent a reasonable approach to the control of bovine rabies.

Resource Partitioning Between Little Brown (*Myotis lucifugus*) and Long-Legged (*M. volans*) Bats in Southern Alberta

Matthew B. Saunders, Department of Biological Sciences, University of Calgary

Little brown and long-legged bats are morphologically very similar and may be expected to compete for food resources when in sympatry. This study examines the possibility of behavioural and morphological partitioning of resources between these two species. Information obtained during the summer of 1987 on the diets of, and habitat use by these bats will be discussed. Diets were determined using fecal analysis, while habitat use was determined using both mist-netting and ultrasonic monitoring. Data collected on wing structure and the types of echolocation calls used by the bats will supplement the discussion. Preliminary evidence indicates that there may be no temporal or spatial variation in habitat use by these bats.

Ultrastructural Variation in Chiropteran Salivary Glands

Bernard Tandler, C.J. Phillips, T. Nagato, and K. Toyshima, Department of Oral Biology, Case Western Reserve University, School of Dentistry

Mammalian salivary glands produce and secrete products that play roles in digestion, behavior, basic physiology and maintenance of epithelium and nerves. Thes complex glands can be highly plastic in structure and in their product. because of their diverse feeding habits and correlative data on systematics and evolutionary history, bats provide us with an outstanding model for the comparative study of the structure of regulated, polarized secretory cells. Data from studies of bats can be used to recognize and delineate variation in the secretory processes. Comparisons of mature acinar cell secretory granules reveal some general patterns that may related in a broad sense to diet (e.g., insectivorous versus carnivorous versus frugivorous and nectarivorous). Extremes in secretory cell structure have been reported in Megaderma and Trachops where the presence of unique cells correlates with feeding on frogs. Another type of unique gland occurs in the flower bat Erophyla where a "green gland" is well developed in males. (supported by NIH RO1 DE 07648-01A1 to BT, CJP).

Features of Day Roosts Used by *Euderma maculaum* in British Columbia

John Taylor and V. Wai-Ping, Department of Biology, York University

To locate the day roosts used by *Euderma maculatum* in the Okanagan Valley of British Columbia we followed individuals carrying radio-transmitters and listened for the echolocation calls of bats leaving roosts. Along a 30 km stretch of valley, *E. maculatum* roosted only in cliff faces, using 5 of 13 available sites. We examined various features of used and unused sites, comparing height, slope, compass orientation and exposure to sunlight to determine which correlated best with patterns of bat use.

Seed Rains Generated By Pteropodid and Phyllostomid Fruit Bats

Don Thomas, Biologie Université de Sherbrooke

The paleotropical Pteropodidae and neotropical Phyllostomidae disperse the seeds of a large number of plants in tropical savanna and forest biomes. Due to their morphological, dietary and behavioral convergence, these two groups are often views as "ecological analogues"; however, this may not always be accurate. Here I compare and contrast the pattern of seed rain generated by the phyllostomid community in Costa Rica with that generated by the pteropodid community in Ivory Coast. In both Africa and Central America, bats generate dense nocturnal seed rains that dominate th total measureable input of animal dispersed seeds. This seed rain has a low species diversity (5-10 species) and is dominated by small-seeded successional species. In Ivory Coast, the bat generated seed rain is entirely restricted to savanna and edge habitats and no measurable rain occurs under canopy. In Costa Rica, the seed rain is almost entirely limited to forest patches. Given that savanna has a long uniterrupted history in Africa, but is a recent man-induced phenomenon in Central America, the differences in seed dispersal patterns may reflect fundamental differences in habitat us by neotropical and paleotropical fruit bats.

Rabies Transmission From Bats to Terrestrial Mammals: Evidence of Frequency and Significance

C.V. Trimarchi, New York State Department of Health, Division of Labatories and Research

Whether bat rabies is a source of infection for terrestrial mammals has been a subject of controversy, but several investigators have cited epizootiologic evidence that bats can be a continuing source of infection for land mammals. The geographic distribution of rabies virus activity in bats and terrestrial mammals does not support this conclusion. Data from experiments designed to infect terrestrial mammals with isolated bat rabies virus provide conflicting results. Seven cases of rabies in terrestrial mammals in New York State since 1981 provide epidemiologic evidence of bats as the source of infection. However, since 1981 there have been 371 cases of rabies from 57 counties in New York State and the frequency of contact of bats with predators such as cats (2675 cat contacts among 6554 submitted since 1981) suggest that bat-terrestrial mammal transmissions are not frequent events. The data suggest that biologists must consider the possibility of rabies in mammals with neurologic disorders even in areas where rabies has been reported only from bats. The data also indicate that pets, especially cats, should be vaccinated against rabies.

The Use of Echolocation and Passive Audition in Foraging by the Surface-Gleaning Bat, *Megaderma spasma*

K. Tyrell, Department of Ecology, University of Illinois

My studies have revealed that passive audition is critical for the capture of prey by sulace-gleaning *M. spasma*. Passive auditory cues were used both to detect prey and to determine its angular (horizontal and azimuthal) location. In the absence of passive auditory cues, echolocation was not used to capture prey. However, bats emitted echolocation pulses after the prey had been located using passive audition, as well as when approaching the source of prey sounds when prey was not present. What might then be the function of echolocation in surface gleaning? Echologication may be used in orientation, to give the bat information about general environmental features. My results suggest that echolocation is not used to give the bat information about the location of a specific target (prey item) per se, but rather to determine the range(distance) to the substrate surface. In this context, the bat need not detect the prey using echolocation, only the larger surface upon which the prey rests.

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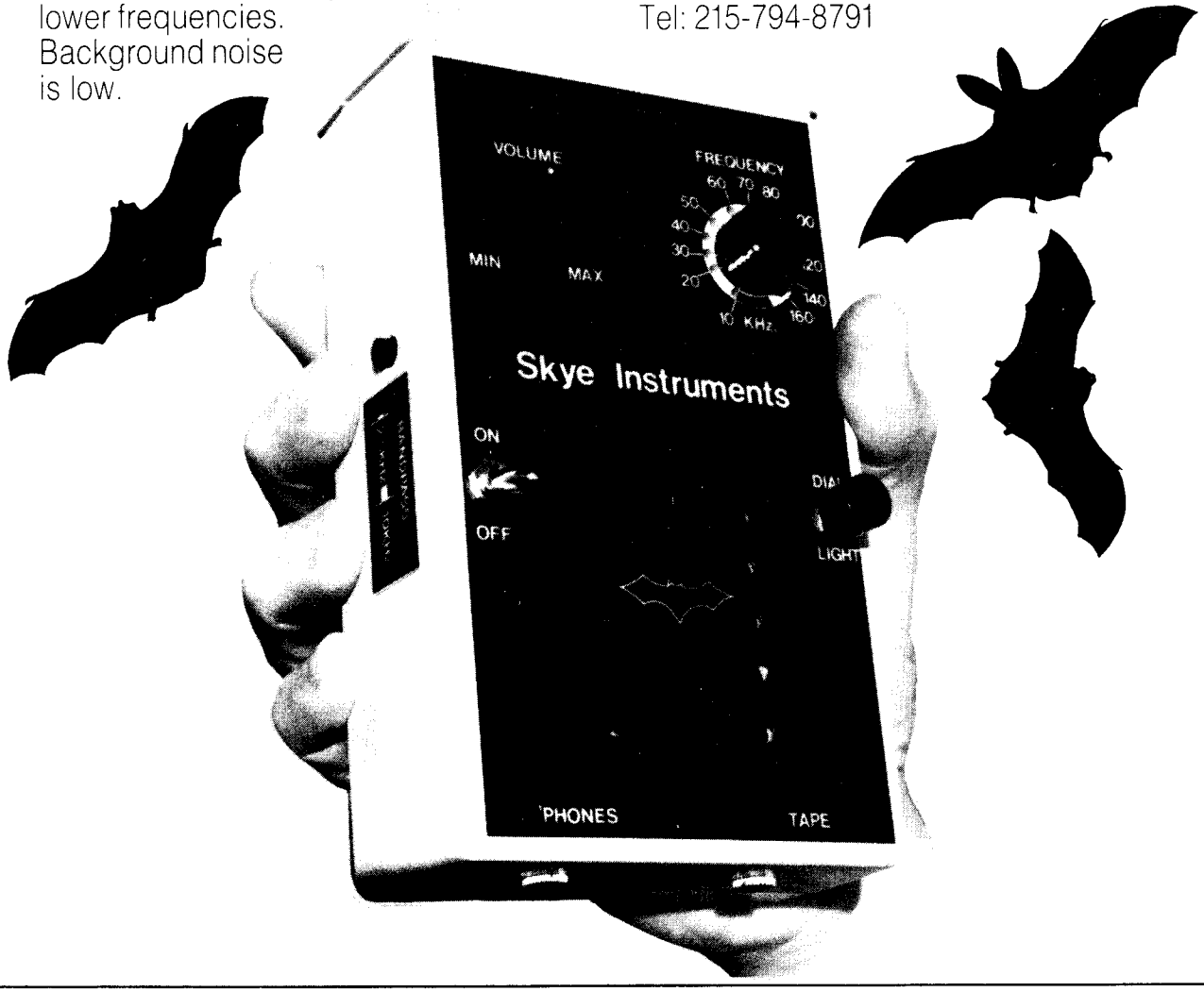

BOOKS ABOUT BATS

FOR ADULTS

Bats of America
A great bat book; life history and identification ofbats all over the U.S. Many illustrations in B&W and color. By Roger W. Barbour and Wayne H. Davis, 286pp. 1969, hb. **$35.00**

Cave Fauna of North America
Reprinted from the memoirs of the National Academy of Sciences, Vol. 4, Part 1, 1888. For those interested in the history of cave biology. By A.S. Packard, 155pp. hb. **$16.00**

Bats: A Natural History
This book will appeal to amateur naturalist and conservationalist, as well as scientists and professional zoologists. By John E. Hill and James D. Smith, 248pp. 1984, hb. **$25.00**

Ecology of Bats
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The Lives of Bats
A wide-range book including breeding, feeding, physiology, aerodynamics, and more. By Wilfred Schober, 212pp. 175 illus., 1984, hb. **$25.00**

What About Bats?
A great introduction to bats for both children and adults. By James K. Baker, 60pp. 1979, pb. **$1.50**

Bats and Public Health
This book is valuable for its bibliography as well as its general health information. By Merlin Tuttle and Stephen J. Kern, 11pp. 1981, pb. **$1.00**

Just Bats
An illustrated view of bats for a general audience. By M. Brock Fenton, 165pp. 1983, pb. **$10.00**

The Vampire Bat
The first comprehensive study of the interaction between vampire bats and their principal prey, the cow, at one location. By Dennis C. Turner, 145pp. 1975, hb, no/dj. **$10.00**

Cave Life of Oklahoma
Special issue of the Oklahoma Underground. A complete study which could serve as a guide for speleologists working on similar projects. By Jeffrey Black, 59pp. 1971, pb. **$5.00**

The Bat
A great B&W picture book of bats. The text is mostly identification of the species shown. By Nina Leen, 78pp. 1976, hb. **$7.50**

The Greater Horseshoe Bat
43 pages of great photos and simple but interesting text. A good conservation message at the end. By Roger Ransome, 1980, hb. **$5.00**

House Bat Management
Hints on how to "de-bat" and "bat-proof" a house. By Arthur Greenhall, 33pp., 30 illus. 1982, pb. **$6.00**

Cave Life: Evolution and Ecology
A technical study of cave populations including mathematical models of genetic and ecological communities. Deals very little with bats. By David Culver, 189pp. 1982, hb. **$25.00**

Photographing Bats: At Carlsbad Caverns National Park
A full-color flyer by Ronald C. Kerbo. 2pp. 1985. **$.50**

Communication in the Chiroptera
Reviews the available information on communication in bats including apparatus for sending and receiving signals. By M. Brock Fenton, 161pp. 1985, hb. **$35.00**

Bats
A British general information book that "sets the record straight about bats." This includes information on what the British have done to protect bats. By Phil Richardson, illustrated with drawings by Gary Troughton, 128pp. 1985, hb. **$10.00**

Vertebrate Flight — A Bibiolography
Over 2500 references on all aspects of flight in vertebrates. The most detailed coverage is given to flight in birds and bats. By J.M.V. Rayner, 200pp. 1985, pb. **$14.00**

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A simple view of bats with quite a bit of information. By Elizabeth Warren, 42pp. 1975, pb. **$1.50**

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Bats, The Night Fliers
A scientific book for kids 8 to 10. Mostly text with a few sketches. By Anabel Dean, 56pp. 1974, hb. **$6.00**

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FRONT COVER

The leaf-nosed bat of the front cover was produced by artist Bill Frampton for the Royal Ontario Museum. It served as the logo for the Seventeetn Annual North American Symposium on Bat Research, held last October at the ROM. It is now the logo for the new ROM exhibit called *The Bat Cave*.