

BAT RESEARCH NEWS



VOLUME 22

NUMBER 1

FEBRUARY 1981

BAT RESEARCH NEWS

Volume 22: Numbers 1–4

1981

Original Issues Compiled by Drs. M. Brock Fenton and G. Roy Horst, Editors of *Bat Research News* (1981).

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Bat Research News is ISSN # 0005-6227.

BAT RESEARCH NEWS

Table of Contents for Volume 22, 1981

Volume 22: Number 1, February 1981

News	1
Recent Literature	2

Volume 22: Numbers 2/3, May/August 1981

Announcement: A New Editor	13
News	13
A Shrew Preying on a Free-tailed Bat, <i>Tadarida condylura</i> by Timothy O. Osborne and Laurel Y. Osborne	14
Book Reviews	
Animal Sonar Systems (edited by R-G. Busnel and J. F. Fish) reviewed by Robert M. R. Barclay	14
Proceedings of the Fifth International Bat Research Conference (edited by D. E. Wilson and A. L. Gardner) reviewed by Robert N. Herd	15
Recent Literature	19

Volume 22: Number 4, November 1981

Announcements	30
Abstracts Presented at the 12th Annual North American Symposium on Bat Research, held at Cornell University, Ithaca, New York	31

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Bat Research News is published four times per year, each year consisting of one volume of four numbers. Publication dates are February, May, August and November.

Subscriptions are \$5.00 per year (U.S. funds) mailed 3rd class to U.S. addresses, 1st class to Canada and Mexico. All other countries, bulk rates unless \$1.00 per issue air mail is prepaid.

Communication concerning dues, subscriptions, or back issues should be addressed to Horst. Communication concerning editorial content should be addressed to Fenton.

Bat Research News is printed by State University College Duplicating Service
Layout by Valerie Ingram, Cover by Margaret Langworthy

Printed and mailed at Potsdam, New York 13676

TABLE OF CONTENTS

<i>News</i>	1
<i>Recent Literature</i>	2
<i>Activity</i>	2
<i>Anatomy</i>	2
<i>Bats and Flowers</i>	3
<i>Behaviour</i>	3
<i>Conservation</i>	3
<i>Distribution</i>	4
<i>Echolocation</i>	5
<i>Ecology</i>	6
<i>Fossil Record</i>	6
<i>Karyotypes</i>	7
<i>Parasites</i>	7
<i>Physiology</i>	8
<i>Public Health</i>	8
<i>Reproduction</i>	9
<i>Systematics</i>	10
<i>Techniques</i>	10
<i>Variation</i>	10
<i>Miscellaneous</i>	11

NEWS

There is very little in this issue beyond a large number of citations to new literature. As usual I am indebted to a number of people for supplying some citations, notably Kunwar Bhatnager, Harlan Walley, Robert Barclay, Eleanor Fenton, and Tom Griffiths.

Please note that this begins the last Volume for me as editor. Roy has agreed to continue his services as managing editor for another year. Kunwar Bhatnagar has agreed to take over as editor beginning with Volume 23. Let us hope that he does not find it too lonely an undertaking. The three of us will hold an open discussion at the Ithaca Symposium on the future plans and goals of BRN. We sincerely hope you can be there to participate in that discussion. If you have any suggestions as to what you would like to see done with BRN please communicate your suggestions to us. Production difficulties have continued to plague us especially the duplicating and binding aspects, but even these finally appear to be resolved. You will receive the Vol. 22, # 2 issue in a few weeks and the August issue Vol. 22, # 3 in August!!

You will also find enclosed in this packet a title transmission page for the 12th North American Symposium on Bat Research which is scheduled for October 15, 16, 17 (Thursday through Saturday) 1981 at Cornell University, Ithaca, N.Y. Dr. William A. Wimsatt will chair the Host Committee and Roy Horst will again arrange the programme. We have arranged a special session on Echolocation for one afternoon consisting of four major papers by Drs. Griffin, Jen, Pollack and Suthers along with some shorter related papers. Dr. Fenton will lead the discussions of these presentations.

If any of you are interested in arranging a section of from four to eight papers on a common theme, please contact Roy at the earliest opportunity.

M.B.F.

RECENT LITERATURE

Activity

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**BAT
RESEARCH
NEWS**



VOLUME 22

NUMBER 2-3

**MAY
AUGUST 1981**

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Bat Research News is published four times per year, each year consisting of one volume of four numbers. Publication dates are February, May, August and November.

Subscriptions are \$5.00 per year (U.S. funds) mailed 3rd class to U.S. addresses, 1st class to Canada and Mexico. All other countries, bulk rates unless \$1.00 per issue air mail is prepaid.

Communication concerning dues, subscriptions, or back issues should be addressed to Horst. Communication concerning editorial content should be addressed to Fenton.

Bat Research News is printed by State University College Duplicating Service
Layout by Valerie Ingram, Cover by Margaret Langworthy

Printed and mailed at Potsdam, New York 13676

TABLE OF CONTENTS

<i>A new Editor</i>	13
<i>News</i>	13
<i>Article</i>	13
A Shrew preying on a free-tailed bat, <i>Tadarida condylura</i> , by Timothy O. Osborne and Laurel Y. Osborne.	14
Reviews	
"Animal Sonar Systems", edited by R-G. Busnel and J.F. Fish, by Robert M.R. Barclay.	14
"Proceedings of the Fifth International Bat Research Conference", edited by D.E. Wilson and A.L. Gardner, by Robert M. Herd.	15
Recent Literature	
<i>Anatomy</i>	19
<i>Bats and Flowers</i>	20
<i>Behavior</i>	20
<i>Distribution</i>	20
<i>Echolocation</i>	21
<i>Ecology</i>	22
<i>Fossil</i>	23
<i>Karyotypes and Cytogenetics</i>	24
<i>Parasites</i>	25
<i>Pesticides</i>	26
<i>Physiology</i>	26
<i>Public Health</i>	27
<i>Reproduction</i>	27
<i>Systematics</i>	28
<i>Technique</i>	29
<i>Mammalian Species</i>	29

Erratum

Volume 22 (1) page 7. The citation by Mogi, M. 1979 "Two species of barflies, *Penicilidia* . . ." should read "Two species of batflies, . . ." Sorry for this error and our apologies to the author, and to the now unmentioned barflies.

I am very pleased to announce that we have managed to find a new editor, someone to take up the torch with Volume 23. The volunteer is Kunwar P. Bhatnagar, and those of you who find this newsletter useful should be most grateful to him for such an altruistic act. He will work with Roy and me on the preparation of the next two (last two) issues of this volume and then work for one year with Roy who will continue as managing editor. His address is Department of Anatomy, University of Louisville, Kentucky 40292 (BRN returning to the Kentucky cradle).

NEWS

The latest issue of *Nyctalus* which I have seen (volume 1, number 3) includes the following papers: The Publication date is 1980.

STRATMANN, B. Untersuchungen über die historische und gegenwärtige Verbreitung der Fledermause im Bezirk Halle (Saale) nebst Angaben zur Ökologie.

HEISE, G. Ein Verfahren, um die Effektivität des Fledermauskasteneinsatzes zu erhöhen.

GRIMMBERGER, E. Nordlichster Fundort vom Mausorh, *Myotis myotis* (Borkhausen 1797) und Wochenstube der Groben Bartfledermaus *Myotis brandti* (Eversmann 1845) in Mecklenburg.

CERVENY, J. Abnormal coloration in bats (Chiroptera) of Czechoslovakia.

STRATMANN, B. und V. Kleinabendsegler, *Nyctalus leisleri* (Kuhl 1818) am nordlichen Harzrand bei Thale/Kr. Quedlinburg.

SCHMIDT, A. Zum Vorkommen der Fledermause im Süden des Bezirkes Frankfurt.

KLAWITTER, J. Spatsommerliche Einflüge und Überwinterungsbeginn der Wasserfledermaus (*Myotis daubentoni*) in der Spandauer Zitadelle.

HAENSEL, J. Wann werden Mausohren *Myotis myotis* (Borkhausen 1797) geschlechtsreif?

SCHMIDT, A. Unterarmlänge und Körpermasse von Abendseglern, *Nyctalus noctula* (Schreber 1774) aus dem Bezirk Frankfurt.

OHLEANDORF, B. Zur Verbreitung der Nordfledermaus, *Eptesicus nilssoni* (Keyserling u Blasius 1839) im Harz nebst Bemerkungen über Schutz, Überwinterungsverhalten und Vergleiche zu anderen Fledermausarten.

I recently received a letter from James D. Stewart, Staff Assistant and Coordinator, Agency of Environmental Conservation, State of Vermont, Montpelier, Vermont 05602, asking me to point out the following to people who collect bats in Vermont:

“Vermont law requires that anyone conducting research for scientific or educational purposes in caves known to be Indiana bat hibernaculums must hold a Vermont Scientific Collecting Permit. A person who takes or possesses an endangered species shall be fined not more than \$1,000.00. Each individual specimen of an endangered species so taken or possessed shall constitute a separate violation, V.S.A. Title 13, Chapter 79, “Protection of Endangered Species”. Vermont Fish and Game Department, Montpelier, Vermont.

Maria McCoy, P.O. Box 3, The Union, U.N.E. Armidale, NSW 2351, Australia is keen to correspond with anyone interested in the ecology and behaviour of Megachiroptera.

I have recently received the latest issue of Australian Bat Research News (editor G.C. Richards, Division of Wildlife Research CSIRO, P.O. Box 84, Lyneham, ACT 2602, Australia). It contains a few comments about the Chillagoe expedition to study echolocation in bats and birds, requests for photographs of Australian bats, some news and comments and the following articles:

A co-operative effort to study echolocation in the bats and swiftlets of northern Queensland, R.A. Suthers.

Bat ecology study in the A.C.T., W.R. Phillips and S.J. Inwards.

Lack of Provenance of *Tadarida norfolkensis*, R. Strahan Studies of batflies and batfleas in Queensland. F.R. Allison.

A SHREW PREYING ON A FREE-TAILED BAT *TADARIDA CONDYLURA*

Marlow (Proc. Zool. Soc. London, 124: 803-808, 1955) included mammals in the diet of *Crocidura* but Kingdon (East African Mammals. V. II, Pt. A, Academic Press, London, 1974.) presumed that mammals could only be accidentally scavenged in nature. This note reports that bats are occasional food items of *Crocidura* and that bat predation by shrews involves active pursuit and/or opportunistic feeding rather than accidental scavenging.

A small colony of 10 to 15 free-tailed bats *Tadarida condylura* occupied the attic of our bungalow at the headquarters of Lochinvar National Park, Zambia (15 degrees 59' S., 27 degrees 15' E.). They roosted on wooden beams which supported the roof above the crawl space between the roof and ceiling. We collected a specimen (T.O. Osborne 2112) on 9 May 1973 and after identification deposited it at the National Museums of Zambia, Livingstone.

At approximately 1400 h, on 11 July 1975, we heard a bat emitting loud squeaks and scuffling. Climbing into the crawl space with a flashlight, we saw that a shrew, *Crocidura hirta*, had firmly sunk its teeth into the back of a bat. The bat, its wings outstretched, attempted to leap into the air and fly, emitting audible squeaks and frequently turning its head backward in unsuccessful attempts to bite the shrew. The shrew kept its hold and dragged the bat 5m to a corner where it began eating the still struggling bat. The shrew was probably disturbed by the flashlight and retreated with the bat to a recess where continued observations were not possible.

Our sight identification of the shrew was based upon the senior author's familiarity with the species having previously collected 54 specimens and handled a further 24 live animals at Lochinvar National Park (Sheppe, J. Mamm., 53 (3): 445-460, 1972).

Timothy O. Osborne and Laurel Y. Osborne, National Parks and Wildlife Service, Private Bag 1, Chilanga, Zambia. Present address: Box 1081, Petersburg, AK 99833.

Animal Sonar Systems. R. - G. Busnel and J. F. Fish, eds. Plenum Press, New York, 1980. \$90. U.S.

This immense volume (1135 pages) contains the results of the second International Interdisciplinary Symposium on Animal Sonar Systems, held on the Isle of Jersey in 1979. As was the case with the proceedings of the first symposium, published in 1967, the chapters in this book will undoubtedly be cited for years to come and should serve as invaluable references, both for the student and expert alike.

The book is divided into six chapters of review papers followed by a seventh chapter containing the shorter poster papers presented at the conference. The chapters include those dealing with the performance of animal sonar systems, echolocation signals and echoes, the

adaptiveness of echolocation, auditory processing of echoes, theories and models of echolocation, and sensory designs. Each of the first five is further subdivided to include papers dealing with the two principle forms of echolocation: underwater as found among odontocetes and airborne as found mainly among microchiropterans.

As with any large, multi-author volume, there are good and poor papers included in this book. Particularly well done are the review papers by H. - U. Schnitzler and O. W. Henson Jr. on the performance of airborne animal sonar systems in the Microchiroptera and by J.D. Pye on echolocation signals and echoes in air. Although some of the Odontocete papers are much narrower in their scope, those by A. E. Murchison on detection range and range resolution and by P. E. Nachtigall on Odontocete echolocation performance on object size, shape and material, review the relevant literature including the extensive number of Russian publications. Also useful is the appendix provided at the end of F. G. Woods and W. E. Evans paper in which they review the ecological and echolocation data for each species of odontocete which has been investigated.

The 44 poster papers provided previously unpublished data on a variety of topics ranging from the defensive systems of insects versus bats to the physiology and neurobiology of odontocete and bat echolocation. E. R. Buchler and A. R. Mitz present some interesting observations on the similarities of call design among primitive echolocators which are further supported by J. Chase's paper on echolocation clicks made by rats. *Rhinolophus ferrumequinum*, fast becoming one the "the bats" for echolocation studies, is the subject of 8 papers presented by the large contingent of researchers from Germany.

The posters are followed by comprehensive bibliographies listing the papers published between 1965 and 1979 dealing with echolocation in the three main groups (Bats, odontocetes and others). Of special note is the inclusion of the Russian literature in the odontocete list, something unfortunately absent from the bat section. Three indices allow the reader to search the text by author, species and subject, something certainly necessary for such a diverse volume.

The book is dedicated to Donald Griffin and he starts it off in humorous style with numerous accounts of his experiences during the pioneering days of echolocation research. It is a fitting way to begin the volume and serves to point out the tremendous advances that have been made in such a relatively short period of time.

This is by no means a glossy text and unfortunately it suffers in places because of this. The papers are reproduced directly from the authors' own typed versions and the figures thus vary tremendously in style and format: some are almost totally unreadable. Luckily what it lacks in presentation, the book more than makes up for in its comprehensiveness. It will be indispensable for anyone involved in echolocation studies and considering the rapid advances already made since the Jersey meetings, one can only hope that it will not be another 13 years before the next symposium.

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PROCEEDINGS FIFTH INTERNATIONAL BAT RESEARCH CONFERENCE

Edited by D.E. Wilson and A.L. Gardner. Texas Tech Press, Lubbock, Texas. 434pp. \$16.00

This volume consists of 41 papers presented at the joint meeting of the Fifth International Bat Research Conference and the Ninth North American Bat Research Symposium held

at the University of New Mexico, 6-13 August 1978. It is loosely organized into four sections: "Phylogeny of the Chiroptera" (8) and "Physiological Ecology" (4). An index to authors, species and subjects is included. A third symposium, "Comparative Aspects of Reproduction in Chiroptera", has been published separately in *J. Reprod. Fert.* 56, (1979).

The preface includes a useful review of inconsistencies in the formation of several family and subfamily names. C.O. Handley, Jr. applies the rules of the International Code of Zoological Nomenclature, 1961 to validate the following names: Pteropodidae; Rhinopomatidae; Megadermatidae; Phyllostomidae; Stenodermatinae; Desmodontidae.

In his review of bat-detector techniques, the first of five contributed papers on echolocation, D. Pye discusses the implications of sensitivity, directionality, information yielded and engineering format, on the design of bat detectors, and the output from the various types of detectors (envelope or broadband; heterodyne or tuneable; squared wave form). Details of technical performance are given but little attention is paid to actual field performance, auxiliary equipment, future developments, or to published applications. A report (P.H.S. Jen *et al.*) on the echolocative skills of the little brown bat, *Myotis lucifugus*, shows that these bats avoid moving obstacles (vertical wires) with a significantly higher score than stationary ones, highlighting the biological importance of moving targets to bats, and suggests experience may enhance echolocative skill. In a preliminary report Y. Tupinier *et al.* present a detailed mathematical and geometric analysis of sonar signals recorded in the field of an unidentified Vespertilionid bat but fail to identify the specific advantages of this method of analysis and its biological significance. From a detailed histological study of the cochlea of five microchiropteran species A. Pye notes that they have much larger cochleas (in relation to body size) than other mammals and suggests a relationship between specialized cochlear structure and mode of echolocation, best exemplified in *Pteronotus parnellii*. Whilst there is homology of several structures in the central auditory system of echolocating bats with those in other mammals, J.M. Zook and J. H. Casseday observed that the intermediate nucleus of the lateral lemniscus, a component of the ascending auditory pathways, was unique to the bats studied. (*P. parnellii*, *Artibeus jamaicensis*) and is perhaps a feature shared by other echolocating mammals.

Associated with the high metabolic demands of flight bats require most of the fibres in their major down (power) stroke muscles to be highly oxidative in their metabolism. In a well presented study of the downstroke muscle histochemistry of two bats, T.L. Stickler found that larger bats (*Phyllostomus hastatus*) with more regular flight have lost the fast-twitch glycolytic fibres associated with phasic activity, whilst intermediate sized bats (*P. parnellii*) have maintained a diversity in muscle function with all fibre types being present. Previous studies have shown small bats (*M. Lucifugus*) have a high wing bent frequency and all muscle fibres to be fast-twitch (oxidative and glycolytic) with no slow oxidative fibres. Little ecological data are presented supporting the postulated flight behaviour of the bats discussed. Adaptations of the molossid wing for rapid flight (T.A. Vaughan and M.M. Bateman) include: flattening of the forearm; narrowing of the leading edge flaps; hair traits along the trailing edge of the forearm, and result in a flatter airfoil with features for boundary layer control and reduction of drag. Corrugations in the flight membranes are reported but not discussed and mathematical treatment of the changes in aerodynamic characteristics achieved by the adaptations cited is lacking. An introductory study (E.E. Okon) suggests brown adipose tissue may participate in the daily energy exchange mechanisms of *Eidolon helvum*.

The biological importance of vision to bats is highlighted in the comparative electroretinography study by G.M. Hope and K.P. Bhatnagar in which phyllostomatid and vespertilionid bats were ranked by the ability of their retinas to function when adapted to increasing levels of illumination (*Eptesicus fuscus*; *Desmodus rotundus*; *Carollia prespicillata*; *A. jamaicensis*), an order which reflected natural behaviour (choice of roosting site, time of departure for foraging). The retinas of various microchiropteran species do not function homogeneously, and whilst cones are absent from bat retinas evidence of a second class of photoreceptors in addition to rods is discussed.

The characteristics of circadian activity systems in some Neotropical bats may reflect rigid internal timing, other species may be very plastic, and some are transient. These conclusions (H.G. Erkert *et al.*) are based on data for 7 Colombian species in captivity and an apparent unawareness of several pertinent references. The adoption of an orphaned juvenile by a non-lactating female in which lactation is subsequently initiated and who continues to support the young with mouth-to-mouth blood feeding through its long development, provides an interesting example of the strong behaviour in vampire bats, *D. rotundus* (C. Schmidt *et al.*) Delayed implantation appears typical of the genus *Miniopterus*. In *M. schresbersii natalensis* the conceptus develops as far as the bilaminar blastocyst stage and the uterus undergoes conspicuous changes prior to implantation roughly 120 days after conception, resulting in a gestation period of about 8 months (M. Van der Merwe).

Several papers dealing with various aspects of bat ecology are included. In India *Rhinopoma kinneari* uses an artificial rock tunnel as a day roost, selected as it offers relatively stable environmental conditions and protection from predators. Pre-foraging activity begins 2 to 2½ hours before sunset and emergence closely follows sunset, with a few individual *R. kinneari* (scouts) initially flying out, circling and returning prior to the main flight exodus (B.S. Gaur). Long term banding studies of *M. lucifugus* in North America have shown that the annual survival rate of males (0.794) in southern Ontario is greater than that of females (0.755); further south the reverse occurs (females - 0.857, males - 0.771). H.B. Hitchcock and R. Keen suggest that in both regions females, due to demands of reproduction, have a more difficult time surviving than males and suffer greater mortality in Ontario than their southern counterparts through exposure to less favourable conditions. Assuming male mortality is little affected the relative survival rates change. The families of insects ectoparasitic upon bats in West Malaysia and the following aspects of their biology are discussed in a review by A.G. Marshall: morphological adaptations; life cycle patterns; sources of food; causes of mortality; behaviour of hosts; transference between hosts; population size and composition; host specificity. Unfortunately there is no table of bat species and associated ectoparasites and no recommended methods for the collection and examination of bats for parasites. Banding studies (W. Lopez-Forment) of *D. rotundus* have revealed a longevity of at least 9 years and suggest these bats remain faithful to a single roost in dry areas but many use several in wetter areas, possibly in response to humidity. Local migration out of the main roost area in search of food by the African fruit bat, *E. helvum*, and the possible establishment of maternity colonies with parturition in August is discussed by F.A. Mutere, apparently unaware of the comprehensive studies of the 1960's on Australian fruit bats by J. Nelson.

A taxonomic addition is recommended to the genus *Plecotus* with the description of a new subspecies, *P. austriacus kolombatovici*, from the Adriatic coast of Yugoslavia and adjacent islands (B. Bulic). Within the genus *Rhinolophus* J.D. Smith and C.S. Hood recommend the reduction of three species into one, viz, *R. maclaudi*, with two subspecies *R. m. maclaudi* and *R. m. ruwenzorii* (the latter formerly *R. ruwenzorii* and *R. hilli*). These rare horseshoe bats (19 specimens) appear to be diestrous or polyestrous and to consume macrolepidopteran moths.

In his outline of a global strategy for the conservation of bats R.E. Stebbings introduces the functions of the Chiropteran Specialist Group, Survival Service Commission, IUCN, and highlights the need for research with the status of only about 3% of the chiropteran fauna worldwide known. Widespread problems threatening bats include: loss of roosts, loss or reduction of food availability, pollution, deliberate killing, and disturbance. Some general solutions include conservation of critical habitat, new methods of control, legislation, education, control of trade and harvesting for food, captive propagation and artificial roosts. Papers are included on the status of bats in the Netherlands (S. Braaksma) and Australia (E. Hamilton-Smith), and of endangered species, including *M. dasycneme*, in Northwestern Europe (A.M. Voute), *M. myotis*, *Rhinophilus hipposideros* and *R. ferrumequinum* in the Federal Republic of Germany (H. Roer), *M. sodalis*, *M. grisescens* and *Plecotus townsendii ingens* in the Southern Ozards, U.S.A. (M.J. Harvey). Legislative actions in the United States pertinent to bat management is reviewed by T.M. Lera and S. Fortune but little data on its effectiveness are presented. The incidence of bat rabies and aspects of its management are summarized in a report on the Northeastern Symposium on Bat Rabies Management (C.V. Trimarchiand, J.G. Deb- bie), which recommends that bat rabies is best dealt with on a regional basis and policies

should include education of the public, biologists and medical personnel. The major area of concern remains house bats because of possible human/bat contact with the long-term solution being structural exclusion. Non-lethal chemical repellents offer an attractive alternative to poison for control of bats either prior to exclusion or where it is impractical but preliminary trials by R.T. Sterner *et al.* highlight the need for research into slow release aerosol formulations and baseline data on bat numbers prior to treatment.

In his introduction to the "Symposium on Chiropteran Phylogenetics", J.D. Smith reviews chiropteran phylogeny and questions the value of a single shared feature (wings) supporting a monophyletic origin. Following papers analyse primitive and derived characters of various organ and sensory systems in an attempt to determine natural relations both between the two chiropteran sub-orders and other mammalian groups, and between chiropteran families. Fetal membrane morphogenesis (W.P. Lockett) supports the concept of chiropteran monophyly but affinities among superfamilies remain unclear. Echolocation originated separately in two chiropteran suborders suggesting a diphyletic origin (J.A. Simmons). The analysis of echolocation calls of 25 species of microchiropterans provides a useful summary of the diversity of echolocation strategies whilst the cladogram derived from these calls only highlights possible directions of evolution rather than eluding to relationships between families. No evidence to reject a monophyletic origin is evident in chiropteran molar patterns (K.F. Koopman and G.T. MacIntyre). The W-shaped ectoloph of insectivorous microchiropterans has been independently acquired by many mammals groups, and is modified or lost in frugivorous and nectivorous microchiroptera. The Megachiroptera have a distinctive molar pattern showing no close resemblance to other mammal groups. The vomeronasal organ does not resolve the question of chiropteran phylogeny but may elucidate relationships between closely related species (K.P. Bhatnagar). Shared derived auditory characters and similarities in the visual systems of the two chiropteran sub-families are consistent with a monophyletic origin (M.J. Novacek; R.A. Suthers and M.R. Bradford, Jr.). Detailed histological examination of penial morphology suggests a closer relationship between Megachiroptera and Dermoptera and primates than was previously thought (J.D. Smith and G. Madkour). Most papers give general credence to a chiroptera monophyly but all authors recognized that analysis of no single character set will resolve the question. Audience discussion of these papers is not published.

Daily energy budgets (DEB) are known for few bats and in the first paper of the "Symposium on Physiological Ecology" T.H. Kunz brings together published data and his studies of *M. lucifugus* to derive a predictive equation: $\log \text{DEF (kcal/day)} = \log 184.5 + 0.7674 \log \text{body mass (g)}$. DEBs may be estimated from food consumption studies (ingesta and egesta methods) and from time budget studies, which for pregnant *M. lucifugus* give estimates within 6% of each other (mean 0.72 kcal/g/day). In what is perhaps the best presented paper of this volume, P. Thomas gives a comparative overview of some of the physiological adjustments made by bats associated with flight, pointing to the frequently overlooked limitations of present data and to areas for future research, notably small species and species which fly rapidly. For bats, their energetic cost of locomotion is less than that of terrestrial mammals and the difference increases as body mass decreases. They have, per unit body mass, a greater range in metabolic rate than terrestrial mammals, their minimum metabolic rate during flight being twice the maximum of exercising terrestrial mammals. 75% of metabolism during flight appears as heat which must be dissipated: about 20% lost via the respiratory tract (similar to birds, much less than terrestrial mammals); 80% via the skin and particularly the wing which vasodilate during flight. Appropriate pulmonary ventilation is maintained during flight by regulation of tidal volume as ventilation is synchronized with wing beat. The increase in cardiac output during flight cannot be accounted for by increase in heart rate alone (which is similar to birds and terrestrial mammals) and is likely due to an increase in stroke volume to about twice that of terrestrial mammals. In his review of renal form and function, K.N. Geluso discusses the use of renal indices in predicting renal function and suggests the ability of bats to concentrate urine can be related to various aspects of their ecology including: distribution, dietary habits, body size and flight related water loss.

Published studies on *M. lucifugus* and *M. thysanodes* form the basis of a review by E.H. Studier and M.J. O'Farrell in which they discuss discrepancies between laboratory data (often maximal performances) and field values, aspects of thermoregulation, daily energy budgets and water balance.

This volume is unnecessarily lengthy due largely to extensive reviews included in most papers but this is offset somewhat by the inclusion of many infrequently cited references. It is well edited (only eleven typographical/bibliographical errors observed) and provides a useful "state-of-the-art" coverage of many aspects of bat biology, reflecting its conference "origins". Those interested in bat biology will find their \$16.00 well spent. (Add \$2.00 for foreign delivery; from the Texas Tech Press, Sales Office, Texas Tech University Library, Lubbock, Texas. 79409, U.S.A.)

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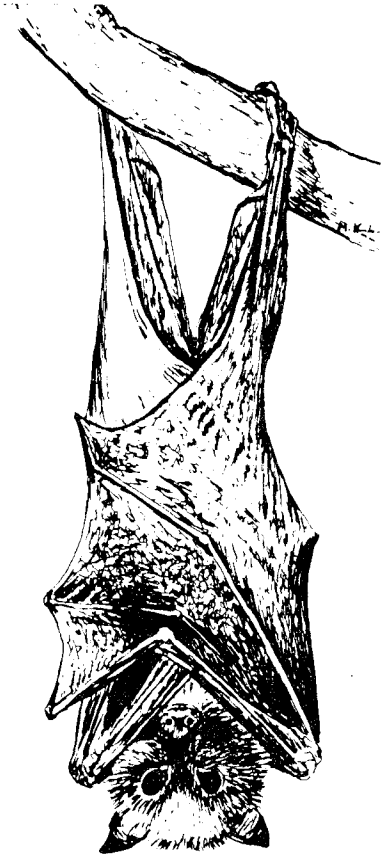
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BAT RESEARCH NEWS



VOLUME 22

NUMBER 4

NOVEMBER 1981

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Bat Research News is published four times per year, each year consisting of one volume of four numbers. Publication dates are February, May, August and November.

Subscriptions are \$5.00 per year (U.S. funds) mailed 3rd class to U.S. addresses, 1st class to Canada and Mexico. All other countries, bulk rates unless \$1.00 per issue air mail is prepaid.

Communication concerning dues, subscriptions, or back issues should be addressed to Horst. Communication concerning editorial content should be addressed to Fenton.

Bat Research News is printed by State University College Duplicating Service
Layout by Valerie Ingram, Cover by Margaret Langworthy

Printed and mailed at Potsdam, New York 13676

Table of Contents

Announcements..... 30

Programme of 12 Annual North American Symposium on Bat Research held at Cornell
University in Ithaca, New York, 15-17 October 1981..... 31

Announcements

The thirteenth annual North American Symposium on Bat Research will be held on October 15 and 16 in Louisville, Kentucky. Our host will be Kunwar Bhatnagar and our host institution will be the University of Louisville. The meetings and lodging will be at the Rodeway Inn in Louisville.

We are very interested in having special sessions again, much like the sessions on echolocation and behavior. Brock Fenton is planning a special session on bat management and conservation. We are especially interested in a session on functional morphology, reproductive biology, and/or hibernation. In general, these sessions entertain rather longer papers which not only offer new data, but also review the present status of that subject. If you are interested in organizing or participating in one of these sessions or would like to suggest another topic, please contact me at your earliest opportunity.

The formal call for papers for the 13th meeting as well as details concerning lodging, travel to Louisville, etc. will appear in the May issue of Bat Research News. You will also receive a direct mailing in May concerning details of the 13th symposium.

This issue is the last to emanate from the cluttered desk and fertile mind of Brock Fenton (from now on "color" and "behavior" will no longer sport a "u" in their spelling!). I personally want to thank Brock for his patience and fortitude with me during our assorted bureaucratic hassles and frustrations. All of us owe him a heartfelt round of applause for reviving BRN after it had, for all practical purposes, become defunct. Hopefully, we can continue his heroic efforts. With Kunwar as our new editor, we are in good hands indeed.

Please note that I will be on sabbatical leave from January to May, 1982 and during this period my address will be:

Dr. G. Roy Horst
% Charles Woods
Department of Natural Sciences
Florida State Museum
University of Florida
Gainesville, FL 32601

My phone number in Florida will be: (904) 392-1107.

Abstracts of papers presented arranged alphabetically by first authors

**ACTIVITY OF THE PRIMARY DOWNSTROKE MUSCULATURE DURING FLIGHT IN
PHYLLOSTOMATID, MOLOSSID, AND VESPERTILIONID BATS**

Scott Altenbach

Department of Biology, University of New Mexico, Albuquerque, NM 87106

The implantation of fine wire electrodes into different portions of *M. pectoralis* in bats and recording of myopotentials during flight reveals a temporal labor division in this muscle mass. Onset of activity precedes that of *M. serratus ventralis* and suggests that *M. pectoralis*, with its greater mechanical advantage, is the downstroke initiator and that the *M. serratus* contributes adductive power later in the stroke. Continuous or sporadic activity of *M. subscapularis* suggests the primary role of this muscle is as a rotational stabilizer of the humerus and that its role in adduction is secondary.

**A MORPHOMETRIC STUDY OF PITUITARY COLLOID IN THE LITTLE BROWN BAT,
MYOTIS LUCIFUGUS LUCIFUGUS, IN RELATION TO AGE, SEX, AND SEASON**

Edythe L. P. Anthony

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Extracellular colloid accumulations were examined in histological sections of the pituitary glands of 96 little brown bats. These periodic acid-Schiff-positive accumulations were scattered throughout the pars distalis, the pars intermedia, and the pars tuberalis; they were generally round or ovoid, and were surrounded by attenuated processes of agranular cells. Exceptionally large masses, which were occasionally observed in the pars distalis, were irregular in shape and were surrounded by a single layer of cuboidal cells.

The proportion of the volume of the pars distalis occupied by colloid was estimated for each bat using a standard point-counting technique. This proportion exhibited considerable individual variation, ranging from 0.00% to 3.18% in the total sample of 96 bats. Relationships between individual variations in colloid content and age, sex, and reproductive condition were examined using one-way analysis of variance. Pituitaries of juvenile males (N=4), yearling males (N=5), and non-parous females (N=11) contained significantly less colloid than those of parous females (N=22) and adult males (N=54). The means for each group suggest that colloid content increases progressively from the juvenile stage through sexual maturity. The relationship between colloid content and age could not be directly assessed following sexual maturity due to a lack of reliable age criteria. However, the frequency distribution of colloid content measurements made in parous females and adult males provides indirect evidence that colloid continues to accumulate throughout life. No sexual dimorphism in colloid content was observed before or after sexual maturity, and colloid content did not fluctuate in relation to the annual reproductive cycle of either males or females.

EMBALLONURID ECHOLOCATION AND (HOPEFULLY) THE DESIGN OF ECHOLOCATION CALLS

Robert M.R. Barclay

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Four species of emballonurids I recorded in Panama were distinguishable by differences in their calls and two, *Cormura brevirostris* and *Saccopteryx bilineata*, were identified by comparing field recordings to those made in a flight cage. All species' calls contained a short CF portion preceded by a sweep up in frequency and occasionally followed by a sweep down. *S. bilineata* and one unidentified species each produced two calls alternately, differing by 2-4 kHz in the CF frequency and the other unidentified species produced sets of three calls differing in frequency. Doppler shift compensation has been used to explain this phenomenon but the use of three frequencies clouds the picture and there may be other possibilities. In an as yet undetermined way I will try to work in a discussion of the forces acting on the evolution of echolocation call design.

CIRCANNUAL BODY WEIGHT RHYTHM IN *ANTROZOUS PALLIDUS*

Laura Beasley

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Pallid bats kept in captivity exhibit a circannual body weight cycle. There is a peak in body weight during the fall/winter and a subsequent decrease to a trough body weight in the spring/summer. The magnitude of the peak body weight is about one and one-half times the trough weight. The cycle repeats itself at about twelve month intervals (the period is measured peak-to-peak). The cycle continues under relatively constant laboratory conditions in most pallid bats examined including adults and juveniles, males and females, lab-born as well as field-caught animals. The circannual cycle persists under a variety of photoperiods (long days, 14 h light: 10 h dark; short days, 10 h light: 14 h dark; constant dim light or natural fluctuations), temperature regimens (25°C or natural fluctuations), housing conditions (individually-housed or group-housed in a small cage or a large flight cage) and feeding schedules (restricted or unlimited access to mealworms). None of these manipulations eliminates the circannual body weight cycle, but may influence such characteristics as its magnitude or period length.

THE SENSORY BASIS OF PREY LOCATION BY GLEANING INSECTIVOROUS BATS

Gary P. Bell

Department of Biology, Carleton University, Ottawa, Ontario, Canada K1S 5B6.

I used a combination of field observation and lab and field experimentation to determine the sensory modes used by *Antrozous pallidus* and *Macrotus californicus* in locating prey. *Antrozous* uses passive sound almost exclusively in finding prey on the ground. It appears to use echolocation only in navigation. *Macrotus* on the other hand uses vision as its primary sensory mode, but can locate prey in total darkness using echolocation of passive sound. *Macrotus* does not produce echolocation calls when light is sufficient for using vision however. This may be an adaptation for circumventing the defensive strategies of acoustically adapted insects.

KATYDID-EATING BATS: THEIR PROBABLE IMPACT ON CALLING ORTHOPTERA

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Four species of foliage gleaning bats in Panama respond to the calls of stridulating katydids, and can thus be caught in nets. In flight cages, two of these species were also attracted to speakers emitting katydid songs. Although they form a large portion of bat diets, these insects show no evasive responses to the calls of foraging bats.

Bat predation pressure has probably played an important role in the evolution of mating displays (i.e., calling) in neotropical Orthoptera. In habitats where foliage gleaning bats are rare, typical katydid songs are relatively long and loud; in habitats where the bats are common, the insects are conspicuously silent. It is likely that reduced sound production in katydids is an adaptation for avoidance of insectivorous bats that exploit their songs.

FILARIOID NEMATODES IN OLFACTORY MUCOSA, OLFACTORY BULB AND BRAIN VENTRICULAR SYSTEM OF BATS

Kunwar P. Bhatnagar, J.R. Lichtenfels, F.H. Whittaker and H.D. Frahm

Department of Anatomy, University of Louisville; U.S. Department of Agriculture, Animal Parasitology Institute, Beltsville, Maryland; Department of Biology, University of Louisville; and Max-Planck-Institut für Hirnforschung. Neurobiologische Abteilung, Frankfurt/M. 71, West Germany.

Parasitic nematodes, of the superfamily Filarioidea, are reported for the first time in the olfactory mucosa of the vampire bat *Diaemus youngii*, the olfactory bulb of the nectarivorous bat *Lonchophylla thomasi*, and the brain ventricular system of the insectivorous bat *Molossus molossus*. What appears to be developing microfilariae are observed in the nematodes in *D. youngii* and *L. thomasi*. The adult nematode in *M. molossus* is similar in morphology and size to *Litomosoides molossi*, which is a filarioid parasite of the thoracic cavity of *M. molossus*. Since the life cycle of these worms is not known, future collectors are urged to examine cephalic tissues of bats for filarioid nematodes to clarify the host-parasite relationships.

FRUIT SELECTION AND HANDLING TIMES BY SIX SPECIES OF BATS IN COSTA RICA: EXPERIMENTAL IMPLICATIONS ON FORAGING STRATEGIES

Frank J. Bonaccorso and Thomas Gush

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A variety of mature fruits were offered to six species of bats housed in flight cages. Food preferences of caged bats were similar to foods showing up in fecal samples of mist-netted bats. Handling times per fruit and total time budgets devoted to feeding are compared in the six species of bats. *Carollia castanea* and *C. perspicillata* have very short handling times per fruit. *Artibeus toltecus* and *A. phaeotis* feed methodically and slowly and often take 10 to 20 times longer to eat

identical fruits than does similarly sized *C. castanea*. *Sturnira mordax* and *S. ludovici* handle fruits over time periods intermediate to *Artibeus* and *Carollia*. This study suggests that *C. castanea* and *C. perspicillata* have developed rapid efficient feeding behavior handling many fruits in succession in the first hours of dark in response to low density (dispersed), low abundance fruits. *Artibeus toltecus* and *A. phaeotis* have slow feeding rates that may reflect heavy dependence on moderately to very abundant clumped fruits such as *Ficus* and *Cecropia* spp. that are not all harvested within the early hours of the evening.

SUMMER STATUS OF THE INDIANA BAT IN IOWA

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The federally endangered Indiana bat, *Myotis sodalis*, reaches the northwestern limits of its summer range in Iowa. Sixty bats, including pregnant or lactating females and volant juveniles, were mist-netted in six south-central counties in summers of 1980 and 1981. All were netted over streams and clearings in upland forests. No maternity colonies were located.

RECOVERY PLAN FOR THE ENDANGERED INDIANA BAT (*MYOTIS SOCALIS*) AND GRAY BAT (*MYOTIS GRISESCENS*)

John T. Brady
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The Indiana bat and the gray bat are protected by the Endangered Species Act of 1973. Both species have experienced significant population declines in recent years primarily caused by human disturbance of Indiana bat hibernation caves and gray bat hibernation caves and nursery caves. Only a relatively few caves have the necessary microclimatic conditions that are acceptable to these two species.

Efforts have been made to protect these critical caves by the Recovery Team, the U.S. Fish and Wildlife Service, and numerous federal and state agencies. Management options include public acquisition of caves, posting of warning signs, and erection of fences and gates to exclude human entry.

Specifications for constructing fences and gates that will not interfere with bat use of caves are presented.

ECHOLOCATION AND FORAGING BEHAVIOR IN THE MEXICAN FISHING BAT, *PIZONYX VIVESI*

Patricia Brown and Robert Berry
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Pizonyx vivesi roost in vertical cliffs on small islands near San Carlos Bay, Sonora, Mexico. They emerge after dark to forage over the calm water in the lee of these islands and the adjacent bay. From a small boat we observed them dragging their hind feet in the water, often in the absence of any fish visibly breaking the water surface. While flying low over the water, they emitted FM-short CF echolocation signals, dropping the CF component while engaged in higher elevation maneuvers. Under similar circumstances, *Noctilio leporinus* and *albiventris* shorten or drop the CF portion of their CF-FM signal when not searching for prey over water.

**GEOGRAPHIC VARIATION IN MORPHOLOGICAL CHARACTERS
IN *EPTESICUS FUSCUS***

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Morphometric variation in 13 skeletal characters was studied in 97 geographic groups of *Eptesicus fuscus* throughout North America, Central America, and the Caribbean. Females average slightly larger than males, but no geographic trends in the degree of sexual dimorphism were found. Of the characters with significantly nonrandom spatial distributions, all but one exhibit a clear trend toward increased size at lower latitudes. Discrimination among subspecies, based on canonical variates analysis, shows considerable overlap among *fuscus*, *pallidus*, and *bernardinus*, and to a lesser degree, *miradorensis*. The Antillean subspecies, *dutertreus*, *hispanbiolae*, and *wetmorei*, are only misclassified as subspecies from adjacent islands or as *miradorensis*. The most well differentiated subspecies are *bahamensis* and *peninsulae*, both of which are essentially unique.

**A REASSESSMENT OF THE TAXONOMICAL STATUS OF *MINIOPTERUS* BASED ON
THE STUDY OF THE EMBRYOLOGY OF *MINIOPTERUS SCHREIBERSII FULIGINOSUS***

Gopal C. Chari and A. Gopalakrishna
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The developmental characters of *Miniopterus schreibersii fuliginosus* are different from all other vespertilionids studied so far. The blastocyst establishes contact with the uterine wall circumferentially on its entire surface so that the uterine lumen is obliterated at the level of nidation. The loss of the roof of the primitive amniotic cavity exposes the embryonic plate to the uterine lumen since there is no trophoblastic layer in this region. The abembryonic segment of the yolk sac is permanently bilaminar. The development and the ultimate structure of the chorio-allantoic placenta do not find a parallel among any mammal, let alone any bat. The embryological characters of *Miniopterus schreibersii fuliginosus* are so different from those of other vespertilionids that it suggests a reassessment of the taxonomical status of *Miniopterus*.

GRAY BATS AND POLLUTION IN MISSOURI AND NORTHERN ALABAMA

Donald R. Clark, Christine M. Bunck, Eugene Cromartie, Richard K. LaVal★
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Gray bats died with lethal brain concentrations of dieldrin and rising levels of heptachlor epoxide in 1976, 1977, and 1978 at Bat Caves No. 2-3, Franklin County, Missouri. The colony disappeared in 1979. Dieldrin was banned in 1974 and 1981 was the last year for heptachlor use in Missouri. The State is recommending three organophosphates (chlorpyrifos or Dursban, dyfonate or Fonophos,

and ethoprop or Mocap) as substitutes for heptachlor. All three compounds have excellent records in the environment.

Analyses of insects collected where bats of this colony fed showed beetles, particularly rove beetles (Staphylinidae), to be the most heavily contaminated part of the bat's diet. Lactation concentrated these residues so that levels in milk were approximately 30 times those in the insect diet.

Gray bats found dead in caves in northern Alabama showed DDD (a DDT derivative) contamination. Bats from the colony at Cave Springs Cave on the Wheeler National Wildlife Refuge contained up to 29 ppm DDD in their brains, but this is probably less than one-half the lethal level. Bats from other colonies contained less. The DDD contamination enters the Tennessee River just above the Wheeler Refuge and is seen in gray bat colonies as far as 60 miles downriver.

A COMPARISON OF GRAY BAT FOOD HABITS OVER AN ESTABLISHED AND A NEWLY CREATED RESERVOIR IN MISSOURI

R.L. Clawson, C.A. Gray, and P.N. Gray

The food habits of gray bats whose colonies were located near an established and a newly created reservoir in Missouri were studied during the summer of 1981. Bat feces and insects were collected at biweekly intervals at 2 caves from May until the colonies dispersed. Observations indicated that bats were foraging extensively over the established reservoir while very limited foraging occurred over the new reservoir. Data will be presented comparing insects found in the bat feces and collected in light traps and a Malaise trap over the reservoirs for the 2 populations.

SEX STEROID BINDING PROTEIN IN THE PLASMA OF MALE *MYOTIS LUCIFUGUS* LUCIFUGUS: IDENTIFICATION AND EVIDENCE FOR SEASONAL VARIATION

D.A. Damassa, A.W. Gustafson and J.C. King
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A specific sex steroid binding protein (SBP) was identified in the plasma of the male little brown bat, *Myotis lucifugus lucifugus*. Electrophoresis of plasma in 5% polyacrylamide gels yielded an active molecular species with a mobility distinctly different from albumin. This protein had high binding affinities for 5-dihydrotestosterone (DHT), estradiol and testosterone but low or negligible affinities for estrone, progesterone, androstenedione or cortisol. The association constant for binding with DHT was calculated by Scatchard analysis to be $5.77 \times 10^9 \text{M}^{-1}$. Using a DEAE-cellulose filter assay, the concentrations of SBP (mean \pm SE) measured in males collected during the summer spermatogenic period were 1) $3.07 \pm 0.43 \times 10^{-7} \text{M}$ (early July), 2) $1.64 \pm 0.21 \times 10^{-7} \text{M}$ (late July) and 3) $2.07 \pm 0.22 \times 10^{-7} \text{M}$ (mid August); in males collected in February (mid-hibernation) during the aspermatogenic period, but when secondary reproductive functions are maintained, the concentrations of SBP were less than $0.15 \times 10^{-7} \text{M}$ in all individuals ($n=7$). The presence of SBP in the plasma of *Myotis l. lucifugus*, a species which has a wide seasonal variation in plasma testosterone levels with an extremely high summer peak, could provide valuable information on the physiological role of SBP. Furthermore, SBP may play an important role in modulation of the unique asynchronous reproductive cycle in this and certain other species of bats which hibernate. Previously, SBP has not been demonstrated in Chiroptera.

ECTOPARASITES OF *MYOTIS LUCIFUGUS* IN MINNESOTA AND NORTH DAKOTA

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During May to September of 1979 a survey was undertaken to determine the distribution and abundance of ectoparasites in maternity colonies of the Little Brown Bat (*Myotis lucifugus*). A total of 341 hosts (187 adult ♀♀, 93 juvenile ♀♀, 61 juvenile ♂♂) were examined from 9 colonies in northwestern Minnesota (315 bats) and 3 in northeastern North Dakota (26 bats). Not all 9 species of ectoparasite recovered were found at each colony or on all hosts in an infested colony. The flea, *Myodopsylla insignis*, and the mite, *Macronyssus crosbyi*, were widely distributed and the most numerous ectoparasites taken. Rates of infestation by these species were found to vary by colony, date of collection, and host age. Other species found in lesser abundance or few colonies include *Cimex adjunctus*, *Spinturnix americanus*, *Cryptonyssus flexus*, *Notoedres* supp., and *Leptotrombidium* spp. Data gathered indicate that both adult female and juvenile bats in colonies are very susceptible but are not necessarily subjected to high rates of infestation by ectoparasites.

BONE CELL CHANGES IN THE BAT, *MYOTIS LUCIFUGUS*, AS A RESULT OF HIBERNATION

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We have found two mechanisms involved in the mobilization of calcium from the skeleton of bats. One mechanism involves the slow removal of calcium associated with the loss of bone around individual osteocytes (osteocytic osteolysis). The second mechanism is a rapid transient removal of calcium that is associated with the appearance of osteoclasts. During hibernation of the little brown bat, *Myotis lucifugus*, bone loss due to osteocytic osteolysis is found within diaphyseal bone. In hibernating animals there are no recognizable osteoblasts or osteoclasts lining bony surfaces and the cell population of the bone marrow is greatly depleted. As animals progress from hibernation to the arousal state, osteoclasts re-appear on bony surfaces and begin active bone resorption. These osteoclasts appear before the marrow cavities are re-populated and before osteoblasts can be found. Throughout the hibernating period there are round cells within the vascular spaces of marrow cavities that have the morphological characteristics of the monocytemacrophage cell type. It is postulated from these observations that blood borne cells give rise to the osteoclast population and that stem cells of the bone marrow give rise to the osteoblasts. The observation that osteoclasts are the first cells to reappear on the bone surface suggests that the demand for calcium and the hormonal regulation to meet this demand, is an early event in the ability of the bat to return from the hibernating to the active state.

SAMPLING ECHOLOCATING BATS: RESULTS FROM DIFFERENT LOCATIONS.

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By monitoring the echolocation calls of many species of bats, particularly those using high intensity vocalizations, it is possible to assess the relative abundances of species active in an area and to gather some data about habitat use. When bats are monitored in this way the results are often very revealing, indicating the presence of species not sampled by mist netting or trapping. The implications of this approach, as well as its limitations are discussed with reference to sites in Africa, Australia, and North America.

**THE FORAGING BEHAVIOR OF HAREM FEMALES IN *CAROLLIA PERSPICILLATA*
(PHYLLOSTOMIDAE)**

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Gregarious living can evolve for a number of reasons, including a limited number of roost sites, predator protection, physiological advantages (i.e. huddling), and exchange of information about good feeding locations. Like most bats, *Carollia perspicillata* is gregarious with most males clustered in their day roosts in bachelor groups and a few males and all females clustered in harems. Although females occasionally change harems, they generally are associated with the same harem mates for weeks or months. In this study we radiotracked 30 females in two field seasons to see whether or not they forage near each other away from the day roost. Overlap in the foraging areas of females from the same harem provides indirect evidence for the hypothesis that females are clustered, and hence are defendable by males, in order to exchange information about good feeding areas. Our data does not support this hypothesis. Although female feeding areas tend to be clustered away from the day roost, these clusters do not correspond to female spatial patterns within the roost. We conclude that it is unlikely that females are exchanging food information with their harem mates.

ASSESSING THE FEEDING CAPABILITIES OF LARGE ANIMALIVOROUS BATS

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Careful morphological measurements were taken on the jaws and teeth of the largest insectivorous and carnivorous microchiropterans. Comparisons are made with small animalivorous bats. Besides changes in the teeth that are normally associated with carnivorous bats, it was discovered that a few of the largest insectivorous bats have very wide skulls with the zygomatic width 80 % of skull length. These wide-faced bats also have increased masseter volume and relatively longer upper canines. Several of these bats are known to eat hard food items. Loose correlations are made with wide faces, ear shape and echolocating ability, and wild speculation is made about the evolution of these bats.

THE ONTOGENY OF HOMEOTHERMY IN *MYOTIS LUCIFUGUS*

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Juvenile *Myotis lucifugus* from a nursery colony in New Hampshire were studied to determine the age at which they were able to reach adult-like body temperatures. Young were obtained from the nursery colony during the mother's first foraging foray and taken to the laboratory where they were aged (using forearm and epiphyseal gap lengths), weighed and assigned to 10°, 20° and 30°C incubators. Initial deep rectal body temperature was measured followed by a measurement after 1 hour and a final temperature measurement after 2 hours of incubation. In addition to these measurements on individuals, body temperatures of juveniles incubated in groups were also determined. Results indicate that neonates are capable of maintaining body temperatures 6° to 8°C higher than ambient temperature as early as the first day after birth. Final body temperature steadily increased linearly with age until approximately 22 days of age, when final body temperature asymptotes. These asymptotic values approximate the average body temperature of adults incubated at the same ambient

temperatures. The determination of the age at which young are capable of thermoregulating efficiently can be used as one indicator of the age of independence (weaning) and is important to this species because of the time constraints imposed by a short growing season and the impending first and most critical hibernation period. Results from this study will be used in future comparisons of the ontogeny of homeothermy in populations of *Myotis lucifugus* in northern Alberta to assess the effects of more severe time constraints on the completion of growth and maturation.

ECHOLOCATION ASSEMBLAGES AND THEIR INFLUENCES ON MOTH AUDITORY SYSTEMS

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Moths have developed simplistic auditory structures with which they detect and monitor the echolocation calls of the insectivorous bats they are endeavoring to evade. Selection pressure, in the form of echolocation types (dominant frequencies, intensities, etc.) has acted on moth ears to tune them to be maximally sensitive to the greatest array of pertinent, echolocation bats with which they are sympatric. Moths from such depauperate areas as southern Ontario exhibit considerably less sensitivity in their ears to both very low and very high frequencies than do tropical moths sampled in Cote D'Ivoire, Zimbabwe, and Papua New Guinea. This is assumed to be a physiological response to the increased diversity of echolocation signals present in tropical locations.

The evidence also suggests that certain bats which emit unusually high frequency echolocation calls (over 150 kHz) may be exploiting the acoustic relationships of moths and bats and may, therefore, be increasing their foraging success on auditive moths. Examples of such potential counter-maneuvers in bats from south-central British Columbia, Africa, and Papua New Guinea will be discussed.

PRELIMINARY DATA ON THE REPRODUCTIVE PATTERN OF *PTERONOTUS PARNELLI MEXICANUS* MILLER

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We have visited a colony of about 4000 *Pteronotus parnelli mexicanus* since February 1981, near Chinameca, in the State of Morelos, Mexico. The area has a tropical deciduous forest type vegetation. We caught 10 males and 10 females every month, during two visits a month, finding pregnant females from February 29 to May 25. These had embryos of 7mm in February increasing to 28 mm in May, and one female with an 8 mm embryo on July 26. The embryos were implanted 88% of the time in the right-horn of the uterus. A maternal colony is suggested by the fact that all females left the tunnel around June 8; parturition may occur at the beginning of this month, and coupled with the beginning of the rainy season in late May. The gestation period lasts approximately three and a half months. A relationship between environmental and roost temperature and relative humidity, with parturition, hasn't been established yet. However, these parameters are equal inside and outside the tunnel from early June on. During the dry season, we observed that the colony occupied the wetter portion of the 100 m long tunnel. On the other hand, we were able to obtain males with well-developed epididymides every month. The testes are always inguinal in position (there is no scrotum), and vary from 2 to 4 millimeters in length. Epididymides with spermatozoa were found in 3 and 4 mm testes; those from 2 mm testes were void of spermatozoa. There are some scattered data in the literature which suggest a restricted and unique breeding season for this species from January or February, through May or June, but stronger evidence for this had not been furnished.

BEHAVIOURAL FLEXIBILITY IN THREE SPECIES OF VESPERTILIONID BATS

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Experimental work with captive *Myotis lucifugus*, *Antrozous pallidus* and *Eptesicus fuscus* challenges the notion of the bat as a specialist locked into a narrow range of foraging responses. Flexibility within and between species was assessed as the relative ability of each animal to respond to a changing series of tasks involving passive hearing, vision, echolocation, and short and long term memory. Other experiments indicated that individuals of each of the three species are capable of extending their foraging repertoire by learning specialized behaviours from conspecifics, or, in some cases from other species. Experiments with *E. fuscus* born and raised in captivity provides unique insights into the innate nature of flexibility.

HABITAT USE BY *EPTESICUS FUSCUS* IN URBAN AND RURAL AREAS

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From June to August 1981 I compared habitat use by *E. fuscus* in rural and urban areas around Ottawa. Patterns of activity by populations were monitored with QMC mini bat detectors along regular transects traversing a variety of different habitats. One gram radio transmitters were attached to individuals to gather data about short-range movements, and the exploitation of patches of insects around lights by big brown bats was also investigated.

HOUSE BAT MANAGEMENT

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The soundest long-term solution for the management of bats that enter buildings, and cause a nuisance problem or present a public health hazard, is by exclusion or batproofing the structure. The only acceptable way that the Fish and Wildlife Service (FWS) can deal with bats in buildings and carry out its responsibility for bat protection, conservation, and alleviate human-bat conflicts is exclusion by non-lethal means. Chemical toxicants do not solve house bat problems and may create worse ones. Since FWS policy prohibits the use of DDT and recommends against use of chemicals that may be a threat to human health and the environment, the major recommendation should be bat exclusion. The batproofing techniques described provide numerous acceptable alternatives to lethal poisons and chemicals for dealing with house bat problems and hazards. Recent declines in bat populations and greater appreciation of the ecological importance of bats have identified the need for sound management policies and strategies essential for bat conservation, while protecting human health and solving nuisance problems. The Internal Revenue Service has informed the FWS that one of the best deterrents against house bats is to improve the energy efficiency of the structure since bats may enter holes through which there is heat loss. Therefore any heat conservation methods use for batproofing will also be eligible for Federal residential energy tax credits. The manual should be useful to homeowners, public health officials, pest control operators, wildlife biologists, physicians, veterinarians, and others interested or concerned about bat interactions with humans.

INSECT HUNTING BY ECHOLOCATION AT HIGH ALTITUDES ABOVE THE GROUND.

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An Andersen-Miller "divide-by-ten" bat detector was combined with a lightweight FM transmitter to produce a radio microphone which could be carried aloft by a small helium-filled kite balloon. The use of such a radio microphone at Chillagoe, Queensland, Australia showed two species of molossid bats actively hunting for insects at altitudes as high as 300 m above the ground. This observation suggests that insect hunting by echolocating bats has an important "third dimension". Similar or improved radio microphones could probably be used effectively to monitor the presence of bats and their insect hunting at much higher altitudes. Tethered kite balloons, kites, or perhaps radio controlled model aircraft might be effective to explore bat activity at high altitudes. Such data might also tell us a great deal about local concentrations of insects; perhaps the bats can locate these better than entomologists have yet been able to do.

Insect hunting by echolocation at altitudes roughly above 100 m must occur in an environment entire free from the "clutter" of echoes from objects other than flying insects (or perhaps other foraging bats). This may facilitate insect detection and pursuit; and this in turn might have led to more high altitude insect hunting than would otherwise be the case.

SYSTEMATICS OF THE NEW WORLD NECTAR-FEEDING BATS (PHYLLOSTOMIDAE: GLOSSOPHAGINAE), BASED ON THE MORPHOLOGY OF THE HYOID AND LINGUAL REGIONS

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Dissection and histological examination of the hyoid and lingual regions of the New World nectar-feeding bats reveal marked modification of the tongue retractor musculature (*Mm. sternohyoideus*, *geniohyoideus*, *hyoglossus*, *styloglossus*, and *genioglossus*) and modifications of the internal and external tongue structure. Use of these derived characters in a cladistic analysis leads to the phylogenetic hypothesis that nectivory evolved twice in the family Phyllostomidae. One group of bats, consisting of the genera **Lonchophylla**, **Lionycteris**, and **Platalina** (all traditionally considered glossophagines), probably deserves separate subfamilial status, based on the markedly different adaptations for nectivory observed. The other group of bats, consisting of the remaining 10 glossophagine genera plus **Phyllonycteris**, **Erophylla**, and perhaps **Brachyphylla**, is clearly a monophyletic group. Within my newly restricted subfamily Glossophaginae there are two major clades. One is comprised of **Glossophage**, **Monophyllus**, and surprisingly, **Lichonycteris**. The other is comprised of the more derived nectar-feeding genera: **Leptonycteris**, **Anoura**, **Hylonycteris**, **Choeroniscus**, **Choeronycteris**, and probably **Scleronycteris** and **Musonycteris**. Interestingly, both karyotypic evidence, and evidence from dental and basicranial studies can be interpreted to support the phylogeny presented here.

ENDANGERED CHIROPTERA OF ARKANSAS: DISTRIBUTION, STATUS, AND MANAGEMENT

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A 3 year study of distribution, status, and ecology of *Myotis grisescens*, *M. sodalis*, and *Plecotus townsendii ingens* in the Ozark Mountains of northwestern and north central Arkansas was completed in September 1981. Fifty-five caves inhabited by, or recently inhabited by, hibernation or summer colonies of endangered bats were located. *M. grisescens* maternity, bachelor, and transient caves were found scattered throughout the region. A gray bat hibernaculum, housing ca. 250,000 individuals, has been gated to protect the colony. Colonies of *M. sodalis* hibernate in only a few Arkansas caves; the largest colony numbers ca. 5,000. The only known maternity colony, numbering ca. 170, and the largest known hibernating colony, numbering ca. 420, of *P. t. ingens* were discovered during the study. Several caves will be gated or fenced in the near future to protect endangered bat colonies.

RELATIONSHIPS BETWEEN *MYOTIS YUMANENSIS* AND *M. LUCIFUGUS* IN THE OKANAGAN VALLEY IN BRITISH COLUMBIA

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The extreme morphological similarity between *M. lucifugus* and *M. yumanensis* in some parts of their range, including the Okanagan Valley in British Columbia, and the existence of individuals apparently morphologically intermediate between the two species has important implications. The intermediate bats may represent simply morphological variation within the two species, or could be the result of hybridization of parental stocks. Preliminary results of an enzyme electrophoretic survey of a series of individuals from the Okanagan represents a range of phenotypes but does not support the hypothesis of hybridization. The taxonomic and evolutionary implications of the morphologically intermediate animals will be discussed.

PRELIMINARY RESULTS OF THE NEW YORK STATE BAT HIBERNACULA SURVEY

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The New York State Department of Environmental Conservation has been investigating potential Indiana bat (*Myotis sodalis*) hibernacula since 1976 as part of its endangered species program. These surveys have so far included the investigation of 37 caves and mines, of which only three contained Indiana bats.

Information so far collected has shed light on the status of all six bat species that hibernate in New York. Of the 37 locations visited so far, 21 contained fewer than 100 bats and only seven mines or caves harbored more than 1000 individuals.

The most abundant species found was *Myotis lucifugus* both in terms of the number of individuals observed and the number of sites inhabited.

The species with the fewest individuals recorded to date was *Myotis leibii*, while *Myotis sodalis* was found in the fewest number of sites.

As a result of the survey work completed so far, *Myotis leibii* could well be a candidate for New York State's endangered or threatened species list. In addition, one of the three sites containing

Myotis sodalis is now protected by a cooperative agreement with the landowner.

Similar protective efforts are underway at the remaining two locations and prospects for their protection in the near future are excellent. Future plans for the completion of New York's bat hibernacula are discussed.

SOME PARAMETERS OF DECISION-MAKING IN *LEPTONYCTERIS NIVALIS*

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The ordering of resource cues used in foraging decisions is discussed with regard to residence time in a patch and giving-up-time (time between last prey capture and exit from patch). The following parameters were manipulated in the laboratory using natural and artificial inflorescences:

Within patch: floral number and position, nectar level and concentration, richness of initial encounters and continual renewal and depletion by experimenter.

Between patch: floral number and richness.

Foragers: number and motivation.

The relation between these cues and the behavior and distribution of **Agave havardiana** is considered. Results are analyzed in view of the marginal value theorem, economic efficiency and the behavior of other species.

GROWTH RATES AND AGE ESTIMATION FOR *PIPISTRELLUS SUBFLAVUS*: A COMPARISON WITH *MYOTIS LUCIFUGUS* AND *EPTESICUS FUSCUS*

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Forearm, body weight and epiphyseal gap lengths of known aged **Pipistrellus subflavus** were used to develop an age estimation equation for this species based on recaptures of marked newborn at Harvard, Massachusetts. Forearm provided the most reliable age prediction from 1 to 21 days of age with 95% confidence intervals ranging from ± 0.17 to ± 0.41 days. The epiphyseal gap, as measured from the fourth metacarpal, extended the length of reliable age prediction to 44 days with 95% confidence intervals ranging from ± 0.5 to ± 1.34 days (days 10 to 44). There appears to be no difference in growth rates between sexes. A species comparison reveals that the growth rate of **P. subflavus** and **E. fuscus** are similar while that of **M. lucifugus** is significantly higher. Possible factors influencing these growth rates are discussed.

SIGNAL PROCESSING IN THE CEREBELLUM OF FREQUENCY-MODULATED BATS

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Responses to acoustic stimuli of single units in the cerebellum of bats were studied with free field and closed system stimulation. Two types of units were isolated. Units of the first type possessed substantial spontaneous discharges (0.5 - 5 millivolts) and generally did not respond to acoustic stimuli. The second type of unit generally lacked spontaneous activity and discharged (300-500 microvolt) either phasically or tonically to acoustic stimuli. They were conveniently called cerebellar

auditory units. These units could be isolated from a rather large area of cerebellar vermis and hemispheres but do not appear to be tonotopically organized. Units from cerebellar hemispheres generally had longer latency and lower best frequency than those from cerebellar vermis. Latencies of these units were between 4 and 34 msec with best frequencies ranging between 22 and 92.5 kHz. Their minimum thresholds were between 12 and 94 dB SPL. Impulse-count function of these units were either monotonic or non-monotonic, similar to other auditory units. In the closed system study, most units could be activated by stimulation from either ear but the neural mechanism of binaural interaction is not a simple summation or facilitation.

OBSTACLE AVOIDANCE IN THE BAT, *PTERONOTUS PARNELLII PARNELLII* AND *EPTESICUS FUSCUS*

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The sensitivity of echolocation in 42 CF-FM bats, *Pteronotus parnellii parnellii*, and 23 FM bats, *Eptesicus fuscus*, was studied by measuring their ability in negotiating a barrier of stationary and moving obstacles. The obstacles consisted of an array of six nylon monofilament lines (diameter 1.0 mm) vertically strung to an aluminum frame which was placed at the center of a flight room (12.12 m long, 2.26 m wide and 1.96 m high). By means of an electric motor, the aluminum frame could be oscillated with an amplitude of 31 cm at an average speed of 10.33 cm/sec in the horizontal direction parallel to the alignment of the obstacles. The distance between two obstacles was 25 cm.

While the mustache bats generally flew in a figure-eight pattern in the flight room, the big brown bats flew in a rather straight path. When agile bats of both species were confronted with stationary lines, they negotiated them without hesitation. However, when the barrier was moved, the bats generally hovered or circled at one side of the flight room before flying through the barrier. In terms of percent misses, both bats avoid moving lines more successfully than stationary ones, but the mustache bats had higher percent misses than the big brown bats did. Possible explanation for such a difference will be discussed. Similar to the big brown bats, the mustache bats increased the repetition rate and decreased the duration of their emitted signals as they approached the obstacles.

REPRODUCTION IN THE WRINKLE LIPPED BAT *TADARIDA AEGYPTIACA* BREEDING HABITS IN COLONIES OF EAST-NIMAR

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Data gathered on the examination of reproductive tract of more than three hundreds of *T. aegyptiaca* (Geoffroy 1818) collected at frequent intervals from East-Nimar in India. This bat has a synchronous breeding season. The Females are monoestrous and breed in June. Copulation occurred in late May and lasted up to June, when male Accessory sex glands were exhibiting peak activity. Ovulation and fertilization were between second and third week of June. Parturition were noticed from first week of September and lasted up to the third week.

One litter was produced annually. The gestation period was approximately 77 to 90 days. The period of sexual quiescence is from the month of July to March.

Young-ones gained weight rapidly and approached adult size by late December. The testes of young-ones is constant in weight and by March increased in weight and size. All young-ones, males and females, reached sexual maturity in their first breeding season. The mortality of bats is noticed only 10%, but mortality rates of males is greater than females during early period of life.

**BAT COMMUNITIES OF NIMAR (M.P.) INDIA
ECOLOGICAL DISTRIBUTION WITH RELATIVE ABUNDANCE AND MOVEMENT
PATTERNS**

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The bat fauna of East Nimar, Madhya Pradesh, are poorly known. Three bat communities were studied for one year, at three localities in the Asirgarh and one locality in Burhanpur. Removal sampling and banding techniques using Japanese mist nets were applied to document community structure, relative abundance and movement patterns.

Species diversity as measured by H' was highest in Asirgarh community, each community containing some common and many uncommon ones. The study indicated that 29 to 31 species occur at or near groundlevel in each locality. In Jan. 1977 and 1978 a total of 2753 bats were netted. *Tadarida aegyptiaca*, *Tadarida Plicata plicata*, *Scotophilus Heathi*, *Megaderma lyra lyra* and *Rhinolophus rouxi* were the uncommon species, while *Taphozous melanopogon*, *Taphozous longimanus*, *Taphozous Kachhensis*, *Heposideros speoris*, *Pipistrellus ceylonicus indicus*, *Pipistrellus mimus*, *Pteropus giganteus*, and *Cynopterus sphinx sphinx* were the most abundant species. *Pipistrellus coromendra*, *Rhinopoma hardwickei* and *Taphozous Saccolaimus* were more common than anticipated. The catch rate of August was only slightly below that of June, but catch rates of individual species varied substantially between the different months. Recapture patterns of several species suggest that home-range size may be positively co-related with body size. Rain tended to suppress bat activity, although time of the rain made a difference. Bright moon-light suppressed bat activity and altered the foraging patterns.

A RE-EVALUATION OF SOCIAL ORGANIZATION IN *ARTIBEUS JAMAICENSIS*

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Social organization was examined in a cave dwelling population of *Artibeus jamaicensis* in Puerto Rico. By sampling roosting clusters of bats occupying solution cavities during the spring breeding season. Complete clusters consisted of pregnant or lactating females (and their young) ranging up to 14 individuals and invariably a single scrotal male. Two types of bachelor groups included non-reproductive females or sexually mature males. Harem males had slightly larger testes than those occurring in bachelor groups and, judging from tooth wear, they were slightly older than bachelor males. Our results also indicate that larger and older harem males had larger harems than younger or smaller harem males. (Personal experience, senior author)

Available data on roost abundance, group composition, and predation risks for *A. jamaicensis* in Puerto Rico appear inconsistent with a resource defence polygyny hypothesis but insufficient to implicate female defense polygyny. Suggestions are made for further study to clarify factors that may have led to the evolution of harem groups.

VISUAL ACCOMMODATION IN THE FLYING FOX
PTEROPUS GIGANTEUS

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The Megachiroptera possess relatively large eyes and differ from microchiroptera in being more dependent on vision and, with few exceptions, lack echolocation abilities. The eye of the megachiroptera is unique among vertebrates in possessing choroidal papillae whose internal contours provide an undulating surface over which are arranged the photoreceptors. Various functions have been attributed to the papillae among which has been the provision multiple focal planes. Previous investigators have described the ciliary musculature of the bats as being degenerate or virtually absent, thus the generally held view has been that megachiropterans lack an active accommodative mechanism. The accommodative abilities of *Pteropus giganteus* were investigated in a caged colony using the recently developed technique of dynamic photorefraction. The resting refractive state was also determined by retinoscopy on manually restrained animals. Light and transmission electron microscopy were performed on a specimen perfused with Karnovsky's fixative. We report that the megachiropteran, *Pteropus giganteus*, possess a ciliary muscle that is as well developed as the majority of non-primate mammals and we present positive evidence that they have an active accommodative mechanism.

HABITAT USE, FORAGING BEHAVIOUR, AND ECHOLOCATION BY THE SPOTTED BAT, *EUDERMA MACULATUM*, IN SOUTHCENTRAL BRITISH COLUMBIA

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Between 6 May and 21 August 1981 I studied habitat use, foraging behaviour and response to the calls of conspecifics by spotted bats in the Okanagan Valley of British Columbia. Habitat use was monitored by listening to the audible (to me) echolocation calls. Spotted bats forage mainly in clearings in Ponderosa Pine forests and over open fields. During feeding the bats usually fly about 10 m above the ground, but will dive to within 1 m of the ground in pursuit of prey. All captures observed in the field involved flying prey, there is no evidence of gleaning behaviour. Spotted bats appear to maintain exclusive foraging areas with individuals separated by at least 50 m when feeding. I used a series of playback experiments to assess the role of echolocation calls in maintaining this pattern of spacing.

BATS OF THE COAST OF SOUTHERN GUERRERO, MEXICO

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In the narrow strip of coastal flatlands along the southern coast of Guerrero, Mexico, with a vegetation consisting mostly of coconut plantations and tropical deciduous medium forest, with an average altitude of 10 meters above sea level and average rain fall and temperature values of 1270 mm, and 27.5 °C, we have captured bats for 9 years, from June, 1972 to last month, with mistnets, firearms, in culverts and hollow trees.

From a total of 44 species expected in the area, we have collected 25 (57 %), pertaining to 6 families. Among them, *Promops centralis* is the first record for that state, *Pteropteryx macrotis* and

Chiroderma salvini had been reported solely from the sierra, the first from 2000 and the latter from 1500 meters above sea level; **Noctilio leporinus**, the fishing bat, had only been collected once in 1957. We have now four specimens. **Rhogeessa parvula** had been once previously captured in Agua de Obispo in the Sierra, at 2000 meters above sea level; now we have taken a series of 12 individuals at sea level.

NOTES ON THE BIOLOGY OF *MICRONYCTERIS BRACHYOTIS* IN SOUTHERN VERACRUZ

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The biology of **M. brachyotis** is up to now known only fragmentarily and from isolated specimens.

The authors found a cave in the coast of southern Veracruz which a numerous colony of this species use as a roost. This cave was visited on: August 1979; August 1980; May and July 1981; and 20, 6, one and none bats of this species were collected respectively. These years coincided with the gradual destruction of the evergreen tropical rain forest in the area around the cave.

The study techniques included analysis of stomach contents, recovering of the food remains adhered to the hair and membranes by means of gel-safranine technique, and dissection and histological analyses of reproductive tracts.

Our specimens represent the first record of the species for the state of Veracruz, extending its range some 220 km north from Mazahuito, Oaxaca. From our observations on the feeding habits, we can say that **M. brachyotis** preys upon arthropods - including spiders. No plant material was found in any case. In the stomach of a juvenile a whitish material that looked like milk was found.

Our data on reproduction, resulting from both dissection and histological analysis of the reproductive tract of some of the specimens, together with those on bibliography, seems to indicate that **M. brachyotis** is a seasonal monoestrous species, with the mating season in the beginning of the rainy season. Probably **Micronycteris brachyotis** is a species which heavily depends on the tropical rain forest, and when it has been cut, this bat will not be inhabiting the zone in large numbers as we found the colony on the first occasion, and eventually not even in small colonies.

ORAL AND HYOID MOVEMENT PATTERNS RELATED TO MASTICATION IN GIANT INDIAN FRUIT BATS, *PTEROPUS GIGANTEUS*

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Movements of tongue, mandible and hyoid apparatus are being examined by means of cine, videotape, and videoradiographic records of adult specimens of **Pteropus giganteus** (some with inlaid amalgams) masticating apple, banana, melon, and orange.

Compared to a previously examined microchiropteran, **Myotis lucifugus**, these pteropids rely much more heavily upon cheeks and tongue during mastication. Food is stored temporarily within large muscular cheek pouches, which also assist in shifting unmasticated food over toothrows. Tongue redistributes and seemingly reduces food by vertical/propalinal movements that compress and abrade it against palatal rugae. Regardless of food type, mandibular movement is predominately vertical, although lateral deviations suggest one working side may predominate during a given chewing cycle; reversals in directions of orbits regularly occur.

Other striking differences include: (1) lack of distinct transition from fast to slow closing, (2) extended dwell at minimum gape, (3) prolongation of slow opening stroke, which begins and ends with mandibular protrusion. This last kinematic factor reinforces the suggestion, made earlier on

anatomical grounds (Czarnecki and Kallen, 1981) that slow opening may be important in food reduction.

The upward and forward movement of hyoid during slow opening is reminiscent of that reported by Crompton et al. (1972) for opossum. Swallowing process is rapid and typically occurs during each masticatory cycle. The speed and frequency of swallowing and marked cervical flexion during feeding suggest that reduction of proximal portion of stylohyoid chain in pteropids (Sprague, 1943) may be associated with a need for increased mobility of the hyoid apparatus. Possible effects of these factors on type of vocalization will be discussed.

MOVEMENT PATTERNS OF *TADARIDA BRASILIENSIS* IN A SUMMER ROOST

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The movement and demographic patterns of a large summer colony of *Tadarida brasiliensis* within the roost at Carlsbad Caverns, New Mexico, were studied by observation of individuals color-marked by sex and age categories. From late May through mid-August, 1981, the colony size fluctuated from 750,000 (late May) to 60,000 as estimated by area of ceiling occupied. The colony numbered approximately 100,000 for most of the summer. These bats were considered residents. Bats were sampled by sweep-netting the evening outflight. Although this method does not present an accurate estimate of sex and age composition of the colony, it provides a view of changing behavior of the population throughout the season. Marked individuals moved throughout the colony as a whole, rather than within smaller groups of stable composition. The Carlsbad colony is usually considered to be primarily a maternity roost, although high proportions of males have been reported. In 1981, the percentage of females captured by sweep-netting declined from late May to mid-July, and then began to increase through mid-August. The increase coincided with the young of the year becoming volant. Marked males were observed roosting among pregnant and lactating females. Utilization of different areas of the cave ceiling changed between late May, when the population of bats was at its summer peak, and mid-June, when the population was at its lowest. Two mining shafts which had been open since 1903, were sealed in March, 1981. This may have increased the suitability of that part of the cave as a roost site.

THE SYSTEMATIC STATUS OF *MINIOPTERUS AUSTRALIS* AND RELATED FORMS

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The holotype of *M. australis* supposedly from the Loyalty Islands proves to differ from populations samples from both the Loyalty Islands and New Caledonia, but is indistinguishable from the holotype of *M. tibialis* of Amboina. The name *M. australis* was proposed by Tomes in 1858 as he originally thought that it came from Australia, but the type locality was later assumed to be Loyalty Islands. It is proposed that the type locality for *M. australis* be fixed as eastern Australia.

The *M. australis* complex, as here restricted, includes the following named forms: *M. tibialis* Tomes 1858 from Amboina, *M. minor* Peters 1867 from eastern Africa, *M. neatoni* Bocage 1889 from western Africa, and *M. witkampii* Sody 1930 from Borneo.

Within the complex of the remaining smaller taxa, the following names are available: *M. manavi* Thomas 1906 from Madagascar, *M. paululus* Hollister 1913 from the Philippines, and *M. shortridgei* Hill 1954 from Java.

Based on multivariate analyses, the phenetic relationships of these two groups are discussed.

THE NEURAL BASIS OF ECHOLOCATION

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The mechanisms by which bats are able to create neural images of targets in their environment from the echoes that reach their ears has recently attracted considerable attention from the neurobiology community. In this talk I shall describe the processes employed by the chiropteran auditory system for extracting information from echoes. Beginning in the inner ear, the auditory system performs a frequency to place transformation whereby the frequencies contained in the sounds reflected from objects in the environment are converted to a place of maximal vibration along the basilar membrane of the cochlea. The stream of neural discharges originating from each place along the basilar membrane is then projected, via the auditory nerve, into the brain, where these impulses are further processed and modified. Within the brain, there occurs a parcellation of pathways, with neurons in each pathway having discharge properties which encode such attributes as target range, location in space, and other features important for target recognition. These parallel pathways are ultimately mapped upon higher neural centers in some orderly fashion. Recent studies of the mustache bat, *Pteronotus p. parnellii*, will be presented to illustrate these properties of the bat's auditory system, and will demonstrate why bats are of great value for studies designed to learn about the mammalian auditory system in general.

THE BAT FAUNA OF JEBEL AL AKHDAR, N.E. LIBYA

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During one month of field work, 59 specimens representing eight species of bats were collected from the region of Jebel Al Akhdar. *Pipistrellus pipistrellus*, *Nyctalus lasiopterus*, *Miniopterus schreibersi* and *Tadarida teniotis* are new additions to the fauna of Libya. *Rhinolophus clivosus*, *Rhinolophus mehelyi*, *Pipistrellus kuhli* and *Plecotus austriacus* represent new distributional records and all species are discussed taxonomically. The status of the genus *Nyctalus* in Africa is discussed. The fauna of Jebel Al Akhdar, although distinctive, is tentatively considered more closely related to that of South Eastern Europe rather than with that of North West Africa or the Eastern Mediterranean region.

FORAGING BEHAVIOUR OF *PIPISTRELLUS PIPISTRELLUS*

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Individual *P. pipistrellus* marked with "Scotchlite" covered bat rings and with "cyalume" chemiluminescent tags foraged in riparian vegetation and in parkland within 100 m of water. In a lowland agricultural area where the habitat suitable for foraging was extensive, the average distance between the roost and foraging sites during pregnancy was 1.8 km and the maximum recorded distance was 5.1 km. These distances were reduced to 1.3 km and 3.7 km respectively during lactation. In an upland moorland area, bats foraged in all habitats where insects were abundant both before and after parturition. The average distance between the roost and foraging sites was 1.0 km and the maximum distance 2.5 km during both pregnancy and lactation. Pipistrelles moved between

foraging sites on a regular, "trap-lining" route, and fed opportunistically on available insects.

P. pipistrellus left the roost and travelled between foraging sites in groups of between two and six individuals, and "following" behaviour involving two bats was frequently observed. Bats foraged on beats which were seldom defended. Intraspecific aggression was evident only at low insect densities, and at high insect densities large numbers of bats were seen foraging in small areas without displaying any overt aggression. The rate at which *P. pipistrellus* attacked insects was proportional to insect density until a maximum rate of 10 "feeding buzzes" per minute was reached, and bats did not remain in an area or attempt to forage if the insect density was very low. Juvenile *P. pipistrellus* moved progressively further from the roost over a three week period after they first began to fly, and the recorded rate of attempted feeding also increased progressively during this period.

THE EVOLUTION OF FEMALE REPRODUCTIVE FUNCTION IN BATS

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The emballonurids, noctilionids, phyllostomatids and pteropodids exhibit a number of similarities in reproductive function, the biological significance of which is frequently unclear. Most of these bats possess reproductive tracts in which both sides are capable of functioning, yet they are monovular and often alternate successive ovulations between the ovaries. They also generally exhibit preferential stimulation of the oviduct and/or uterine horn ipsilateral to the corpus luteum. Many can ovulate and successfully conceive again soon after giving birth. Finally, embryonic development within the oviduct often advances to the blastocyst stage.

In the case of the emballonurids and pteropodids (which possess bicornuate or duplex uteri) the ability to alternate ovulations and to control the reproductive ducts via local pathways probably serves to decrease the interval required to recycle the reproductive tract after either a reproductive failure or a previous pregnancy. Since endometrial development on the non-pregnant side of the uterus is minimal in *Pteropteryx kappleri* during early pregnancy, it seems likely that this horn could be prepared to accommodate a conceptus with minimal delay in the event of a reproductive failure. Similarly, following parturition the previously non-pregnant horn can be prepared for a conceptus while the post-partum horn is involuting. In species with a low reproductive potential and possible restricted breeding seasons the ability to quickly reestablish a pregnancy in either situation would be of obvious value.

Instead of alternately utilizing two uterine horns, many of the phyllostomatids possess simplex uteri and at least some have evolved another means of recycling the uterus following non-pregnant (pseudopregnant) cycles. They simply eliminate much of the ageing endometrium at the prospective implantation site by menstruating and regenerate a new one. Although these species also tend to alternate ovulations and exhibit unilateral oviductal reactions, these traits may be primitive retentions which are of minimal biological significance.

THE BEHAVIORAL RESPONSE OF A FROG-EATING BAT, *TRACHOPS CIRRHOSUS*, TO LOW FREQUENCY SOUNDS

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Many bats are sensitive to high frequency sounds. This is not due to greater hearing sensitivity, relative to other mammals, but it is due to a number of adaptations, such as the reduced mass of the middle ear bones, which allow the bats to perceive ultrasonics. There have been few studies that have investigated the hearing abilities of bats to sounds in the human audible range, that is sounds less than 20 kHz. These studies, whether based on behavioral or neurophysiological responses, share a

common trend: as frequencies decrease below 20 kHz so does that bat's sensitivity.

For the past two years we have been investigating the frog-eating behavior of the bat *Trachops cirrhosus*. We have previously shown that these bats regularly eat frogs and use the frogs' vocalizations for locational cues. This suggests that *Trachops* should be able to perceive the relatively low frequency sounds characteristic of frog calls.

We constructed behavioral frequency audiograms for four bats by determining the intensity of a pure tone stimulus needed to elicit a behavioral response from the bat. These frequency audiograms show, as with other bat species, sensitivity decreases from 15-7 kHz. However, below 5 kHz sensitivity increases. An examination of a Fast Fourier Transform (frequency-intensity distribution) for 18 species of frogs on Barro Colorado Island, Panama suggests that the hearing sensitivities of *Trachops* is appropriate for a bat that uses frog calls for locational cues. We suggest that other species of bats may be sensitive to these relatively low frequency sounds and also utilize sounds in this frequency range during foraging.

A COMPARISON OF OVARIAN FOLLICULAR TYPES AND THEIR ENZYMOLOGICAL CHARACTERISTIC IN A NULLIPAROUS AND PREGNANT *TAPHOZOUS MELANOPOGON MELANOPOGON* TEMMNICK (MICROCHIROPTERA: MAMMALIA)

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Taphozous melanopogon melanopogon represents a unique example of cent per cent dextral dominance of the female genitalia. The ovary of non-pregnant bats begin to show signs of recrudescence in late October, when active folliculogenesis was discerned. Small non-growing follicles were observed in large numbers at the periphery of the ovary, primordial, secondary, pre-antral and antral follicles were also seen in varying numbers. These developing follicles have been classified into 7 types; on the basis of their diameter, number of associated cells, meiotic stage, and total population. A single healthy Graafian follicle with the ejected polar bodies was seen only in the right ovary. Granulosa cells occupied a considerable portion of the Graafian follicles and exhibited mitosis. Follicular atresia was extensive and prominent in the left ovary, but also occurred in the right. Many follicles after reaching a certain stage in development failed to develop any further and began to exhibit pronounced degenerative changes, manifested by pycnotic nuclei, sloughed granulosa cells, chromatolysis, and finally cytolysis. The mass of interstitial tissue was highly vascularized.

In parous bats, the dextral and sinistral ovary manifested profound differences. A single and initially extroverted corpus luteum was seen in the right ovary. Lutein cells with prominent nuclei and spherical nucleolus were seen. The mass of ovocytes near the periphery displayed arrested meiotic figures.

The left ovary lacked a functional corpus luteum. Its substance was filled with degenerating follicles, blood filled sinuses, mass of interstitial cells, and ovocytes with arrested meiotic figures. Follicular atresia was very extensive.

Differential acid phosphatase (AcPase) activity was observed in the primary, secondary, pre-antral, antral and mature Graafian follicles, corpus luteum, interstitial tissues, degenerating and atretic follicles of non-pregnant and pregnant bats. Pronounced differences were also seen in the left and right ovarian follicles of the bats during pregnancy. Alkaline phosphatase (AlkPase) activity in the ovary of bats during nulliparous state exhibited intense reaction in the granulosa cells of the developing follicles as well as in the atretic follicles. Mild enzyme reaction was discerned in the ovocytes and interstitial cells. The enzyme activity was particularly intense at the sites where pronounced blood vascularity was present. Several primary follicles with strong enzyme reaction in the granulosa cells and in the degenerating follicles were seen in the ovarian cortex. In the left ovary, degenerating and atretic follicles exhibited intense AlkPase reaction. High enzyme activity was also observed in the interstitial cells.

The present study demonstrates clearly the occurrence of enzymological asymmetry in the contralateral ovary which becomes significantly pronounced during pregnancy. Since ovarian phosphatases are linked with hormonal tides, their high and low activity can be taken as a "marker" for estrogen/progesterone surge/ebb. Further, there also seems to be some correlation between ovarian histoarchitecture and the concomitant phosphatases profiles - both showing characteristic asymmetry.

PRELIMINARY ANALYSIS OF VARIATION OF NEW ENGLAND *MYOTIS*

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Given the difficulty of identifying *Myotis sodalis* in New England, an examination of four species of *Myotis* (*keenii*, *leibii*, *lucifugus*, and *sodalis*) based on some cranial and external measurements was initiated to increase our knowledge of the morphological relationships of these species in New England. Results of Preliminary analyses indicate that both *M. leibii* and *M. keenii* are relatively distinct morphologically from the other species. As expected, there was also considerable overlap between *M. sodalis* and *M. lucifugus*. These results are compared with the original description of *M. sodalis* (Miller and Allen, 1928) which presently seems inadequate for the positive identification of this species in New England.

COMMUNITY STRUCTURE OF BATS IN A RAINFOREST IN BELIZE, CENTRAL AMERICA

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Data from mist-netting in a rainforest in southern Belize suggest that species diversity indices change seasonally. Generally, it is found that bat communities in tropical forests consist of a few common and several uncommon species. In Belize, the highest diversity occurred at the end of the dry season (May) and no single species dominated the samples. Following onset of the rainy season the diversity indices were much lower with *Carollia* and *Pteronotus* predominating. The reduced number of these two species in the dry season samples is the primary cause of the lowering of species diversity indices calculated. The relative scarcity of fruits and insects during the dry season may be causing *Carollia* and *Pteronotus* to increase their foraging ranges, thus lowering the probability of capturing these species late in the dry season.

BODY COMPOSITION AND ENERGY ALLOCATION DURING REPRODUCTION IN ADULT FEMALE AND JUVENILE *EPTESICUS FUSCUS*

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The big brown bat, *Eptesicus fuscus*, produces two offspring per litter which together at parturition may weigh up to 40% of their mother's mass, an unusually high value for mammals, making *Eptesicus* an interesting subject in which to investigate energy allocation in reproduction. In this study, we examined changes in body composition (water, fat, lean dry mass) during pregnancy, lactation, and post-lactation in 107 reproductive females and 56 juveniles. The body tissues examined included skin, brown fat, mammary glands, reproductive tissues and carcass. Early in pregnancy, females stored energy as fat at a time when it was not required by developing embryos. In middle and late pregnancy, females (excluding reproductive tissues) lost mass while embryos and associated tissues were growing exponentially. Lactating females had the least amount of fat, and over the course of lactation lost lean dry mass because of the great energy demands of nursing juveniles weighing up to 10 g each, and which were growing at the rate of 0.3 - 0.4 g per day. Post-lactating females showed a rapid increase in fat deposition; total wet mass increased 18% (3 g) in one week shortly after weaning in late July. Weaned juveniles were slower depositing fat prior to hibernation and showed no significant increase in mass through August.

RESOURCE UTILIZATION AND MOVEMENT PATTERNS OF CAROLLIA PERSPICILLATA

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The foraging biology of *Carollia perspicillata* was studied at Santa Rosa National Park, Costa Rica. Diet selection and foraging site selection were studied through feed in experiments with captive bats and an extensive mist-netting program. Bats were netted at sites where fruit resources were mapped and censused regularly.

Potential competitive interactions between species of frugivorous bats were reduced by minimizing diet overlap. Competitive interactions between roost populations of *C. perspicillata* were reduced by minimizing foraging site overlap.

Within the roost population of *C. perspicillata* differences in diet and site choice were exhibited between males and females, adults and juveniles, and reproductively active and non-active females. These differences resulted, in part, from differences between groups in energetic requirements and foraging experience. The population subgroups also differed in their response to seasonal variation in resource distribution. In general, diet and site selection were based on resource predictability and locatability.

PHYSIOLOGY OF PHONATION BY ECHOLOCATING BATS

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There is considerable evidence that the properties of the emitted sonar signal such as frequency, bandwidth, harmonic content, duration, etc.--are precisely controlled by the animal which can vary them in order to optimize them for the changing demands of acoustic orientation. Experiments on the laryngeal mechanisms of echolocation in *Eptesicus fuscus* provide some insight into the means by which the sonar signal is regulated. The high intensity of the echolocative pulse is primarily due to the bat's ability to develop unusually high subglottic pressures thus increasing the subglottic power during phonation. The maximum SPL is approximately linearly proportional to the subglottic pressure. Bilateral inferior laryngeal neurotomy caused no change in the repetition rate, duration, initial frequency or bandwidth of downward sweeping FM pulses, but after this treatment the mean subglottic pressure at pulse onset was lowered 8 to 16 cm of water and the peak SPL was reduced 4 to 5 dB. Section of the inferior laryngeal nerves also caused the bat to produce atypical rising FM pulses which began at about 20 kHz and swept upward almost one octave. Total bilateral superior laryngeal neurotomy eliminated most of the FM and reduced the fundamental frequency to 7.9 kHz with multiple harmonics. Pulse duration became highly variable and the peak-sound pressure level dropped 7 to 13 dB. Paralysis of the tongue by bilateral section of the hypoglossal nerves distal to the thyrohyoid twigs had no effect on downward sweeping FM pulses, but caused bats to also emit long duration pulses whose frequency rose and fell in a sinusoidal fashion. The aberrant rising FM and sinusoidal pulses can be understood as the result of timing errors in the opening and/or closing of the glottis relative to the contraction-relaxation cycle of the cricothyroid muscles.

MECHANISM FOR THE PRODUCTION OF ECHOLOCATIVE CLICKS BY SWIFTLETS

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The swiftlet, *Collocalia spodiopygia*, nests in dark caves where it produces echolocating clicks for navigation. Clicks are typically emitted in pairs with about 25 msec between the members of each pair and at repetition rates of up to 15 or more pairs/second. Most of the acoustic energy lies between 4 and 9 kHz. We have monitored pressure and airflow in the respiratory system and the electrical activity of muscles acting on the syrinx during click production. Clicks are generated in the syrinx. Immobilizing the tongue or sealing the glottis does not affect click production, providing a tracheal cannula permits airflow through the syrinx. Just prior to sound emission, expiratory effort causes sternal air sac pressure to rise and airflow through the syrinx to increase. The first member of the click pair is produced when the sternotrachealis muscles contract drawing the syrinx caudad. This relaxes the external and internal tympaniform membranes which begin to vibrate as they fold into the syringeal lumen before making contact with each other and obstructing the airway. Immediately after the first click, tracheal airflow and pressure go to zero. The tracheolateralis muscles then become active, pulling the syrinx cranial and abducting the syringeal membranes which are again set into vibration, producing the second member of the click pair.

ANTIPREDATOR BEHAVIOR OF PUG-NOSED TREE FROGS IN APPARENT RESPONSE TO FROG-EATING BATS

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Male pug-nosed tree frogs (*Smilisca silla*) visually detect hunting frog-eating bats (*Trachops cirrhosus*) and reduce call complexity and repetition rates in response. They synchronize calls, prefer to call near waterfalls, and also vary perch choice and call complexity and repetition rates according to light level. Conspicuous perches and complex calls are used only on moonlit nights or parts of nights, and calling ceases altogether on dark, moonless nights.

Frog-eating bats, tested in a large out-door cage, were shown to prefer complex calls and increased repetition rates. They also were more likely to respond to asynchronous versus synchronous calls, required more time to locate sources of synchronous calls, and preferred calls most distant from recorded waterfall sounds.

Light-limited periods of calling, reduced use of more easily locatable complex calls, synchronized calling, and choice of calling locations where background noise from waterfalls is high, all likely reduce a male frog's ability to attract mates. However, these behaviors also reduce probability of being eaten by a frog-eating bat. Frog calling behavior is an apparent compromise between these opposing selective forces.

PREDATION ON *MYOTIS VIVESI*, THE BAJA CALIFORNIA FISHING BAT, BY THE BARN OWL, *TYTO ALBA*

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A barn Owl (*Tyto alba*) roost was found on a cliff on Isla Rasa, a 50 ha. island in the Gulf of California, 60 Km SE from Bahía de los Angeles. 40 owl pellets were recovered from beneath the roost where the barn owl was seen in May 1981. The pellets were analysed in the lab and bony re-

mains (mainly skulls) separated. These were identified as follows (in numbers of individuals): 27 **Rattus norvegicus**, 19 **Myotis vivesi**, 2 **Mus musculus**, one **Larus heermanni** chick (1-2 weeks old), one **Halocyptena microsoma**, and a small unidentified larid. This is as far as we know, the first record of **M. vivesi** being predated upon by **T. alba**. The bat, and **H. microsoma**, the least petrel, inhabit Isla Partida, 15 Km NW from Isla Rasa, where they occur in large numbers sharing the roosting sites.

The 19 **M. vivesi**, weighing 522.69 g. represent 37.65% of the number of prey found in the 40 pellets (%N) and 9.84% of the total weight of the prey (%W); (All weights were calculated from the average weight of the specimens of each species found in the Mammal and Avian collections in the Instituto de Biología, UNAM; 27 **Rattus** weighing 4,641.3 g. represent the 52.94 %N and 87.4 %W thus being the main food resource of the owl. Miscellaneous identified animals represent the 9.41 %N and 2.77 %W of the prey remains found in the owl pellets.

We believe that only one, or at the most two owls inhabit Isla Rasa, since pellets were found only in one place, and cliffs, like the one where the roost was found, are scarce along the coast line and absent elsewhere in the island. However, barn owls may well be inhabiting other islands, including Isla Partida.

The total population of the Fishing bat and the barn owl in the area are unknown. However, we believe that the owl may represent in this area, as it does in others, a control for the population of rats and mice, especially since these are introduced species which probably lack natural predators in these islands. The influence of the owl on the bat's population is as yet unknown, and we can only speculate whether the owl was already there before the introduction of the rat or the owl followed the rats to the islands, and the corresponding effect on the bat's population.

A BEHAVIORAL AUDIOGRAM FOR THE BAT, *NOCTILIO LEPORINUS*

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We are currently studying the sonar system of the fish-catching bat, **Noctilio leporinus**, in relation to the bat's ability to discriminate target velocities. The possibility that **Noctilio leporinus** uses Doppler-shift information to perform this task has interested us in the auditory sensitivity of this bat. We report here the preliminary results of a behavioral audiogram in one bat, using a two-choice procedure in which the bat indicated that it perceived a tone burst by making one response and that it did not perceive a tone burst by making a different response. We tested the animal's sensitivity to frequencies ranging from 500 Hz to 112 kHz. Sensitivity was greatest to frequencies corresponding to the bat's echolocation signals (0 to 10 dB SPL between 32 and 56 kHz) and declined sharply outside of this range. Our preliminary results do not indicate a sharp increase in sensitivity at the frequency corresponding to the constant-frequency component of the bat's echolocation pulse.

RENAL STRUCTURE AND FUNCTION IN *ARTIBEUS JAMAICENSIS*

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When feeding on figs (**Ficus insipida**), the bat **Artibeus jamaicensis** increases dietary sodium density while decreasing potassium density by primarily extracting and ingesting pulp juices rather than other parts of the fruit. Based on urine osmotic pressure, these bats are uniformly dehydrated when they leave day roosts and become rapidly rehydrated ($\frac{1}{2}$ - 1 hr) after initiation of feeding. Throughout the night, after 2000 hrs, there is no difference in urine concentration of free-flying bats compared to bats held in the laboratory without food or water for the same time interval. The ratio of medullary to cortical thickness of the kidneys of **A. jamaicensis** is 2.37. Mean uniform maximum urine concentrations in this species is 972 mosmols/kg.