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NEWS

In 1977 EMC Corporation of St. Paul Minnesota published a book on bats for young readers. The author is George Shea, Scott W. Earle has done the illustrations, and the book is called 'Bats'. The Library of Congress number is JUV QL 737 C5 S49.

The National Speleological Society has formed a Bat Subcommittee, under the NSS Conservation Committee. The objectives of this subcommittee are (1) to promote the preservation of and public education of bats, and (2) to develop a membership which will work actively toward the first objective. Persons interesting in becoming a member should contact Thomas Lera, the Chairman of the bat subcommittee; 415 Aldine 16-D, Chicago Illinois 60657. (this from the NSS News, Dec. 1977).

R. V. Peterson, (Biosystematics Research Institute, Agriculture Canada Research Branch, K.W. Neatby Building, Ottawa, Canada K1A OC6) made the following request about some bat ectoparasites. 'In connection with current studies on the New World Nycteribiidae, Streblidae (Diptera) and Polyctenidae (Hemiptera) - ectoparasites of bats - I am anxious to receive specimens from as many localities as possible. Specimens from all of eastern North America, and especially from the southeastern States are urgently needed. If any readers of BRN have specimens they could donate or make available for study, I would be pleased to receive them.'

Several readers sent me copies of a ghastly advertisement which offers people a solution to problems with bats. The BATRAP KILLS YOUR BATS, you don't see them! you don't handle them! and, there's no odor! I hope that the people who designed, sold or used this ghoulish device are appropriately rewarded (as soon as possible). Bats do need friends.

MEETINGS

Fifth International Bat Research Conference, 6 - 11 August 1978 in Albuquerque, New Mexico. For further information contact James S. Findley, Museum of Southwestern Biology, University of New Mexico, Albuquerque, New Mexico 871-31, or Don E. Wilson, National Fish and Wildlife Laboratory, National Museum of Natural History, Washington, D.C. 20560

The Second "Congressus Theriologicus Internationalis" to be held at the Brno Exhibitions and Fairs, Brno, Czechoslovakia between 20 and 27 June 1978. For more information contact: The Secretary, II. Congressus Theriologicus Internationalis, Institute of Vertebrate Zoology, Czechoslovak Academy of Sciences, Kvetna 8, 603 65 Brno, Czechoslovalia.

RECENT LITERATURE

Anatomy

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Conservation, Pesticides, Disease

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Some Others (newly arrived)

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Robbins, L.W., M.D. Engstrom, R.B. Wilhelm, and J.R. Choate. 1977. Ecogeographic status of **Myotis leibii** in Kansas. Mammalia 41: 365-366.

Biology of Bats

Volume 3 of Biology of Bats, edited by W.A. Wimsatt was published in December 1977, and is available from Academic Press. If you are a subscriber to the series, the cost is $50.00 U.S., if you are not, the cost is $59.00 U.S. The book, which includes an introduction by Wimsatt, contains five chapters . . .

Bradbury, J.W. Social organization and communication. Chapter 1.

Novick, A. Acoustic communications. Chapter 2.

Kallen, F. Cardiovascular systems of bats: structure and function. Chapter 3.

Riedesel, M. Blood physiology. Chapter 4.

Rasweiler, J.J. IV. The care and management of bats as laboratory animals. Chapter 5.

IN PRESS (or accepted for publication)

Arata, A. and M. Thomas. in press. Reproduction and pupulation dynamics of Neotropical bats. Revue Suisse de Zoologie.

Koopman, K.F. in press. The genus **Nycticeius** (Vespertilionidae) with special reference to tropical Australia. Proc. East African Acad. Sci.

Koopman, K.F. in press. Zoogeography of Peruvian bats with special emphasis on the role of the Andes. American Museum Novitates **or** Bull. Am. Mus. Nat. Hist.

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I hope that some of our readers might take a few moments and send in some more material for this abbreviated section. Thank you!

QUICKIES

This month we have two . . . One, by C.V. Trimarchi was solicited by me, the other was submitted for consideration and accepted.

RABIES IN INSECTIVOROUS TEMPERATE-ZONE BATS

Charles V. Trimarchi

In recent years several cases of human rabies from the bite of insectivorous bats have been reported; the most recent was in 1976, when a woman died of rabies after being bitten by a rabid big brown bat. Although only 10 cases of human deaths from rabies transmitted by bats have been reported in the United States, the very nature of this disease attracks wide attention and elicits demands for the elimination of bat populations. However, there is no evidence that the destruction of bats and their habitat is effective in reducing the public health hazard of bat rabies. Better understanding of bat rabies would ensure that ecologically sound and effective measures are adopted for the management of this disease.

The first rabid bat reported in North America was found in Florida in 1953. Since that time the disease has been reported from all 48 contiguous United States and all provinces of Canada except the Martimes; a small number of cases have been reported in Europe and Asia. The total number of rabid bats reported each year in the United States has increased to an average of nearly 500 and now accounts for 10-20% of the number of all species. The geographic distribution of bat rabies is largely independent of that for rabies in terrestrial animals. Each year there are 10 to 15 states, generally in the northwest and eastern seaboard, which report rabies exclusively in bats. Most cases of rabies in nontropical bats have been reported during the summer months.

The virus has been isolated from most species of North Temperate Zone bats, including almost all that have been adequately sampled. Rabies in migratory species, including **Lasiurus borealis** and **L. cinereus** and **Lasionycterus noctivagans**, account for roughly 40% of reported cases. In these species the positivity rate in submitted specimens is much higher that in colonial bats. This is, at least in part, a reflection of the rarity of contact between humans and healthy migratory bats. In New York State during the last decade the infection rate in bats submitted for examination, which includes a large number of animals behaving abnormally, has remained remarkably constant at 3-5% each year.

Rabies is an acute, infectious disease of the central nervous system. It is caused by a bullet-shaped RNA virus of the rhabdovirus group, which is normally transmitted by the bite of an infected animal. After exposure there is an incubation period varying in length from two weeks to several months. With rare exceptions, the disease is fatal once clinical symptoms develop.

The course in Temperate Zone bats is similar. Naturally infected bats exhibit abnormal behavior, including aggressiveness, paralysis, and death after 3-5 days. Early reports of bats as asymptomatic carriers of rabies virus have not been substantiated for Temperate Zone insectivorous species. Modern virologic techniques have not demonstrated rabies virus in the salivary glands of bats unless it is also present in brain tissue. However, unusually long incubation periods of over one year have been reported in captive bats. In big brown

bats there have been extended periods of up to 10 days' clinical illness with virus being shed in the saliva during the entire period.

Aerosol transmission of rabies virus from bats to man and other terrestrial mammals, well documented in the Frio Cave population of Mexican freetails, is apparently dependent of unique conditions of animal density and extremely high bat infection rates, which have never been reported in North Temperate Zone bats. Although rabies virus can be demonstrated in the lungs, nasal mucosa, and urinary bladder epithelium of naturally infected bats, the low quantities of virus in these organs compared to salivary glands, along with the frequency of biting even among healthy bats, suggest the bits route as the most common route of transmission of the virus between bats.

Although one might expect that a virus transmitted by bite would move rapidly through a population of animals having as much physical contact as our colonial bats, this does not appear to be the case. Once virus has been confirmed in a population of bats, however, the likelihood of some additional infected individuals in subsequent years is quite high. For several years I have investigated colonies from which rabid bats have been confirmed. Every animal in the colony found dead, sick, or acting abnormally was examined for virus and, if alive, for antibody. In each colony the result has been identification of one or two rabid bats per year. In addition, on two occasions, extermination of an "infected" colony resulted in rapid recolonization of the roost and identification of one or more rabid individuals in the new population. On the other hand, examination of randomly selected colonies of bats rarely turns up evidence of rabies infection. These observations, along with the relatively small number of rabid bats identified each year among the animals referred to our laboratory for study, suggest a low incidence of infection in bats.

Studies designed to measure susceptibility of terrestrial animals to rabies from bat bites have produced varying results. Intamuscular inoculation of red bat rabies virus isolates caused infection in several species of animals, but numerous bites by rabid red bats failed to infect striped skunks. Bites by big brown, silver-haired, and **Myotis** bats were capable of infecting laboratory mice. The face that several states report bat rabies but have been free of terrestrial animal rabies for years also belies the significance of bats as a source of rabies virus for other mammals. Serial passage of rabies virus through mice or tissue culture results in the modification or attenuation of the virus and thus lessens its pathogenicity for other hosts. It is likely that bats are infected with rabies only through the bites of other bats. This bat-to-bat transmission of the virus for an enormous number of passages may have diminished its effect upon certain other species without necessarily reducing its virulence in bats.

Natural-occurring antirabies antibody has been demonstrated in 5 to 20% of big and little brown bats in infected colonies. A new microvolume serum neutralization test enables further studies of this phenomenon without the need to kill the bats examined. However, correlation of antibody levels with a recent incidence of rabies infection in a population has yet to be established. The appearance of antibody in "healthy" bats can be explained by recovery from rabies infection, by exposure to rabies virus without infection, or less likely, by

exposure to other viruses of the rhabdovirus group which cross-react serologically with rabies virus.

The role of stress in the susceptibility of bats to rabies infection cannot be adequately assessed at this time. However, the high incidence of rabies in bats in captivity, along with reports of virus reactivation by treatment of test animals with corticosteroids and by overcrowding, suggests some relationship. This factors may play a role in the seasonal distribution of bat rabies, especially in nonhibernating species.

Certainly the public must be informed of the real hazards of contact with bats, but they must also be made aware of the significant ecologic role bats play in our environment. Public health officials must be cognizant of the fact that use of toxicants such as DDT in a roost can compound the problem by dispersing the weakened and dying animals, thus increasing the chance of human exposure. Extermination is a temporary solution at best, for bats quickly recolonize a roost. Also, control (fumigation) measures against several colonies of bats in an area may produce artificially large populations in neighboring colonies as bats respond to the disturbance and move. This could create overcrowding and stress, a favorable environment for severe epizootics such as those found with other wildlife species.

In response to demands from individuals and government officials to eliminate bat populations, a comprehensive program to deal with the problem should be evolved. It must reduce the hazard of human exposure to rabid bats while protecting our bat populations. We must also continue to answer questions on the extent, distribution, and epidemiology of bat rabies. Bats should be collected for virologic and antibody studies from each colony where there has been a laboratory-confirmed case of rabies. Bat colonies in buildings such as schools, hospitals, and homes, where the hazard of human exposure is high but no recent history of rabies exists, should be displaced by structural modification of the buildings. This can include the closing of entrance holes, removal of soffits, repair of roofs and chimneys, and change in ventilation or lighting.

The public must be aware that if they are bitten by a bat, they should was the wound immediately, see immediate medical treatment, and see that the bat is examined for rabies. Physicians and emergency rooms must be informed of current procedures of treatment. Post-exposure immunization for rabies is undergoing major modifications at this time. For passive immunization antirabies serum of equine origin has now been generally replaced by hyper-

immune globulin of human origin.* This eliminates many adverse reactions. For active immunization a new vaccine using virus grown in cell culture and then inactivated is already available in Europe and in Canada and is expected to be licensed shortly in the United States. The higher potency and reduced risk of adverse reactions of these new vaccines should also encourage individuals studying bats to receive preexposure immunization.

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*Rabies Immune Globulin (human) "Hyper Rab," Cutter Laboratories, Inc., Berkeley, Calif. 94710

Although bat infection rates are low and human deaths from bat rabies rare, many people receive precautionary rabies immunization because of known or suspected bat bites. Because of this, bat rabies will continue to be a highly publicized public health issue. Research is necessary to define the extent and distribution of bat rabies and its relation to rabies cycles in other vertebrates. The results of these studies will hopefully lead to the management of this problem, which threatens what should be a harmonious coexistence of bats and man.

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From: The Division of Laboratories and Research, New York State Department of Health, Empire State Plaza, Albany, NY 12201.

NEW RECORDS OF DIPTERAN AND ACARINE ECTOPARASITES OF BATS FROM INDIA

B.D. Sharma and Tej Sharma

While investigating some Arthropoda ectoparasitic on bats in Jammu and Kashmire State, we found new records of infestation by flies and mites. In the Poonch and Srinagar regions, six specimens of **Myotis blythi** Tomes were examined and on four of them we found **Macronyssus** sp. (Dermanyssidae) and **Spinturnix myotis** (Kol.) (Spinturnicidae). In the Poonch Valley, of eight specimens of **Nyctalus noctual** Schreber collected from cellars and an old ruin, two were infested with the mites **Leptotrombidium fletcheri** Womersley and Haeslip, previously unrecorded from India. Six of ten other **N. noctula** from Poonch, Jammu and Srinagar Regions harboured the nycteribiids **Penicillida (Penicillida) dufouri** West-wood and **Stylidia** sp.

We thank Dr. R.G. Fennah, Director (CIE, London) and Dr. P.H.V. Grandjean, Hooper Foundation (USA) for identification of the ectoparasites. We are especially grateful to Robert Barclay of the Department of Biology at Carleton University for assistance with this manuscript.

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BOOK REVIEWS

Among the material forwarded to me by the former Editor of **Bat Research News** was some books submitted to him for review by BRN. I have asked some of the graduate students here at Carleton to write reviews of said books. In future other books that are submitted for review will also be distributed to Graduate Students (here or elsewhere) for review.

THE LIVES OF BATS by D.W. Yalden and P.A. Morris. New York Quadrangle Press, the New York Times Book Co., 247 pp, illustrated. 1975. $9.95.

This straight-forward, easy to read book covers many aspects of bat biology and will answer questions about bats from people who are not familiar with them. It has chapters on flight, feeding, hibernation, reproduction, population dynamics, echolocation, and the conservation of bats, and a who's who for bats at the end.

The style unfortunately is a mixture for technical and popular writing. The scientific sections include quoted references (most of the time) and this clashes with the rest of the book which is generally chatty and opinionated. Had the authors eliminated the vestigal scientific prose. gone into more detail in some areas, and made fewer assumptions about the biological background of their readers, this would have been a very good book for the general public. As it stands, it could make interesting reading for scientists who do not work with bats.

Although published in 1975, the book does not make much use of current literature. In particular the chapter on echolocation admittedly relies heavily on Griffin's **Listening in the dark** (1958). Although echolocation is an active area of bat research, the most recent reference to that literature is 1970.

The book has a strongly European flavour and much of the discussion of hibernation, reproduction and pupulation studies is based on work done in Europe, with only passing reference to extensive American work on the subject.

Many assumptions concerning the readers' knowledge of taxonomy would easily have been avoided had reference been made to the (out-of-date) section bats 'Who's Who'.

The use of sentences such as 'Biologically it is fascinating, but from all other viewpoints utterly revolting', leads me to think that the book was intended for people with a moderate scientific background and some curiosity about the 'Lives of Bats'.

Brian C. Hutchinson, Department of Biology, Carleton University, Ottawa Canada

BIBLIOGRAPHY OF BATS (MAMMALIA : CHIROPTERA) 1958-67 by Adam Krzanowski. Rheinische Frederich-Wilhelms—Universitat, Bonn, 599 pp. undated.

Although it is a far cry from the original stated goal of a 200 year bibliography of bats, this sizeable volume is thorough and useful. It provides accurate reference to more than 5000 titles spanning the years 1958 to 1967, and including systematics, anatomy, physiology, ecology, behaviour, management, and much more.

I made a random search of about 100 titles published in 1966 as documented in **Biological Abstracts** or **The Zoological Record**, and failed to find a single omission in this volume. I did find a few (three) errors in pagination or other referencing details. One minor but annoying inconsistency I found concerned the language of titling. Some German and Russian papers are listed with English titles, while others are not, and one title, a paper in Russian with an abstract in German, is listed in German.

The volume is cross-indexed under 88 different subject headings. It is a valuable contribution, exhaustive in its coverage, and easy to use. We can look forward to the second volume covering 1968 to 1973 and

promised in the near future.

Gary P. Bell, Department of Biology, Carleton University, Ottawa, Canada.

BIOLOGY OF BATS OF THE NEW WORLD FAMILY PHYLLOSTOMATIDAE, PART I. Edited by R. J. Baker, J.K. Jones Jr., and D.C. Carter. Texas Tech University, The Museum Special Publication no. 10, Texas Tech University Press. 218 pp. 1976. $6.00.

After reading the Editors' introduction which promised a treatise on the phyllostomatids made necessary by the 'wealth of information . . . which has been gathered', I was disappointed to find how little of the volume actually dealt with this family. The volume is a loosely arranged anthology dealing with bat research in general with heavy emphasis on the Phyllostomatidae.

The annotated checklist and keys to subfamilies and genera (Jones and Carter) is a valuable took containing information on species distribution and systematics, and providing key references for some controversial species. This would have been more useful had some synonyms been included.

The chapter on zoogeography (Koopman) is adequate. However, the lack of data about present distributions and especially about the situation in the past, makes speculations about colonization and centers of differentiation a bit tenuous. I think that some maps would have been useful in following the analysis of subregions.

The discussion of chiropteran evolution (Smith), through slanted towards the phyllostomatids, is general, and suffers from a general lack of data. This chapter is an adequate introduction to the 'state of the art' in phyllostomatid systematics.

The papers on collecting techniques (Tuttle) and care in captivity (Greenhall) are useful and applicable to bats in general, but short on details about phyllostomatids. The chapter on care in captivity in particular deals as much with Vespertilionidae and Molossidae as it does with Phyllostomatidae.

The brief discussion about economics and conservation (C. Jones) emphasizes bat-human conflict, while the importance of some phyllostomatids in plant pollination and dispersal and their relationships with insects are alluded to only briefly. The excellent discussion of brain anatomy (McDaniel) comes closest to fulfilling the Editors' promises, and this chapter appears to include much of the data arising from the author's Ph.D. thesis.

The volume is completed by a review of lactation and milk (Jenness and Studier) which, more than any other, suffers from a lack of information. The discussion of lactation in the Phyllostomatidae seems strained since it is based on analysis of 23 species of bats, seven of which are phyllostomatids.

On an individual basis most of the papers in this volume are interesting and useful. A sometimes lack of data on the Phyllostomatidae notwithstanding, workers in all fields of bat research will find this volume extremely useful.

Gary P. Bell, Department of Biology, Carleton University, Ottawa, Canada.

NEW SUBSCRIBERS

In one of the next numbers of this volume year we will include a complete list of subscribers based on the records in the computer.

GRADUATE STUDENT AWARD

Due to the present logistical support provided by both Carleton University and the State University College at Potsdam, we have been able to effect an unanticipated savings in our operational expenses. This amount appears to be about $150.00 U.S., the equivalent of approximately $.30 per BRN subscriber. Rather than adjust the subscription cost by such a token amount, we have decided to make this money available as an award for a Graduate Student working in Bat Biology. We hope that this money will stimulate student interest in bat research.

Specifically this award will be presented to that graduate student at the Albuquerque meetings whom we consider to have presented the most outstanding paper arising from his/her graduate research. By graduate student we mean someone registered in a graduate programme and working on an advanced degree in the 1977-78 academic year. We reserve the right to verify the academic standing of any applicants. While we intend this award for graduate students, we do not preclude senior undergraduates from the competition.

Pending the continued availability of these funds, we will present the money to the winner at the Albuquerque meetings. The winner will be selected by a panel of five people, including J.A. Simmons, K.F. Koopman, J.S. Findley, G.R. Horst and M.B. Fenton.

To be considered for this award, graduate students submitting their abstracts for the programme should draw attention to their eligibility in a covering letter to the programme chairman (G.R. Horst).

PROGRAM OF THE EIGHTH ANNUAL NORTH AMERICAN SYMPOSIUM ON BAT RESEARCH

October 14 - 15, 1977
Carleton University, Ottawa, Canada

Friday, October 14, 1977

8:00 Registration

8:45 Opening Announcements
Welcome by Dr. G. Paquet, Dean of Graduate Studies and Research, Carleton University

Session on Systematics, Karl Koopman, Chairman, American Museum of Natural History

9:15 Introductory Comments by Dr. Koopman

9:35 SIGNIFICANCE OF THE DISTAL PART OF THE HUMERUS IN THE IDENTIFICATION OF EGYPTIAN BATS. Gamal Madkour, Department of Zoology, Faculty of Science, Tanta University, Tanta, A. R. Egypt.

9:50 CHIROPTERAN ABUNDANCE IN TWO WORLDS: ARE BATS RARE IN AFRICA? James S. Findley, University of New Mexico, Albuquerque, N. M. and Don E. Wilson, National Fish and Wildlife Laboratory, Washington D. C.

10:05 Coffee Break

10:25 EMBALLONURID PHYLOGENY: THE REFUTATION OF AN HYPOTHESIS. James Dale Smith, California State University, Fullerton, CA.

10:40 VARIATION IN THE AFRICAN MOLOSSID **TADARIDA BIVITTATA**. Judith L. Eger and R. L. Peterson, Royal Ontario Museum, Toronto, Ontario.

10:55 ON THE STATUS OF SOME **MYOTIS** FROM WESTERN MEXICO, WITH COMMENTS ON VARIATION IN **M. NIGRICANS**. Michael A. Bogan, National Fish and Wildlife Laboratory, Washington D. C.

11:10 Coffee Break

Session on Reproduction, William A. Wimsatt, Chairman, Cornell University

11:20 MORPHOLOGY OF THE UTERUS, PLACENTA AND PARAPLACENTAL ORGANS IN THE DISC-WINGED BAT **THYROPTERA TRICOLOR** SPIX. William A. Wimsatt, Cornell University, Ithaca. N.Y. and Allen C. Enders, University of California, Davis, CA.

11:40 COMPARATIVE MORPHOLOGY OF THE YOLK SAC IN THREE SPECIES OF INDIAN CHIROPTERA. K. B. Karim, Institute of Science, Nagpur, India.

11:55 AGE DETERMINATION OF **MYOTIS LUCIFUGUS** BY EPIPHYSEAL CLOSURE. W. T. Rumage III, E. L. P. Anthony and T. H. Kunz, Boston University, Boston, MA.

12:10 Lunch

Session on Echolocation, James A. Simmons, Chairman, Washington University

2:00 THE VARIETIES OF ECHOLOCATION IN BATS. James A. Simmons, Washington University, St. Louis, MO.

2:20 INSECT FLIGHT SOUNDS DISCRIMINATION BY THE BIG BROWN BAT. Josef Hamr, University of Guelph, Guelph, Ontario.

2:35 MODIFICATION OF M. CRICOTHYROIDEUS AND THE LARYNX FOR THE AMPLIFICATION OF HIGH FREQUENCY PULSES IN THE MORMOOPIDAE. Thomas A. Griffiths, State University College, Plattsburg, N. Y.

2:50 MOTH EARS AND BAT CRIES: SOME RELATIONSHIPS. J. H. Fullard, Carleton University, Ottawa, Canada.

3:05 Coffee Break

3:20 PHOTOGRAPHIC EVIDENCE FOR ORAL EMISSION OF ECHOLOCATION SOUNDS IN CERTAIN PHYLLOSTOMATID BATS. J. Scott Altenbach, University of New Mexico, Albuquerque, N. M.

Session on Anatomy, Kunwar Bhatnagar, Chairman, University of Louisville

3:35 OLFACTORY RECEPTOR-GLOMERULAR RATION VERSUS OLFACTORY ACUITY IN **EPTESICUS**, **ARTIBEUS**, AND **DESMODUS**. Kunwar Bhatnagar, University of Louisville, Louisville, KY.

3:55 PENIAL MORPHOLOGY OF BATS. James Dale Smith, University of California, Fullerton, CA and Gamal Madkour, Department of Zoology, Faculty of Science, Tanta University, Tanta, A. R. Egypt.

4:10 ECO-ETHOLOGICAL SIGNIFICANCE OF THE ALLOMETRIC DEVELOPMENT OF THE TWO VISUAL SYSTEMS AMONG CHIROPTERA. Georg Baron, Universite de Montreal, Montreal, Canada.

4:25 Coffee Break

4:35 DENTAL HISTOLOGY OF ARTIBEUS JAMAICENSIS. John P. Farney, Kearney State College, Kearney, NB.

4:50 USE OF THE CHEEKS AS TEMPORARY FOOD STORAGE RESERVOIRS IN SOME MOLOSSID BATS. Timothy L. Strickler, Duke University, Durham, NC.

Saturday, October 15, 1977

Session on Ecology, T. H. Kunz, Chairman, Boston University

9:00 RESPONSES OF BATS TO INSECT PATCHINESS. T. H. Kunz, Boston University, Boston, MA, S. McCoy, Mount Holyoke College, South Hadley, MA and K. Kosciusko, Bates College, Lewiston, ME.

9:20 ANNUAL AND LOCAL VARIATION IN THE DIET OF **MYOTIS LUCIFUGUS** IN SOUTH-EASTERN ONTARIO. K. L. Strong, Brandon University, Brandon, Ontario.

9:35 THE FEEDING GROUNDS OF BATS AROUND A LAKE IN SOUTHEASTERN ONTARIO. T. M. Harrison, Carleton University, Ottawa, Canada.

9:50 SURVIVAL AND LIFE-EXPECTANCY CALCULATIONS FOR WINTER-BANDED BATS. Robert Keen, Michigan Technological University, Houghton, MI.

10:05 Coffee Break

10:25 THE STRUCTURE AND DYNAMICS OF ARTHROPOD COMMUNITIES OF BAT GUANO ECOSYSTEMS. E. Robin Franklin, Boston University, Boston, MA.

10:40 PARTITIONING OF FOOD RESOURCES BY INSECTIVOROUS BATS. M. B. Fenton, Address unknown.

Session on Behavior, Edwin Gould, Chairman, The Johns Hopkins University

10:55 FORAGING BEHAVIOR OF MALAYSIAN NECTAR FEEDING BATS. Edwin Gould, The Johns Hopkins University, Baltimore, MA.

11:15 A COMPARISON OF FLIGHT MECHANICS OF THE LESSER BULLDOG BAT AND THE MEXICAN FREE-TAILED BAT. Carl Brandon, Vermont Technical College, Randolph Center, VT.

11:30 Coffee Break

11:40 Business Meeting - Plans for 1978. James Findley

12:10 Lunch

2:00 DRY SEASON FORAGING BEHAVIOR OF TWO AFRICAN FRUIT BAT SPECIES. Donald W. Thomas, Carleton University, Ottawa, Canada.

2:15 VOCAL COMMUNICATION AND SOCIAL BEHAVIOR OF **MYOTIS LUCIFUGUS.** R. M. Barclay, Carleton University, Ottawa, Canada.

2:30 OBSERVATIONS ON FEEDING EFFICIENCY OF CAPTIVE **GLOSSOPHAGA SORICINA.** John R. Winkelmann, Gettysburg College, Gettysburg, PA.

2:45 THE IMPORTANCE OF ACOUSTIC AND OLFACTORY STIMULI IN THE LOCATION OF BATS, A POTENTIAL FOOD SOURCE, BY **PEROMYSCUS MANICULATUS**. Kathleen Martin and M. B. Fenton, Carleton University, Ottawa, Canada.

3:00 Coffee Break

Session on Conservation, Merlin Tuttle, Chairman, Milwaukee Museum

3:20 Introductory Comments by Dr. Tuttle

3:35 STATUS OF THE ENDANGERED BATS, **MYOTIS GRISESCENS** AND **M. SODALIS**, IN MISSOURI. Richard K. LaVal, Fish and Wildlife Research Center, Columbia, MO.

3:50 STATUS OF **PLECOTUS TOWNSENDII INGENS** AND THE KENTUCKY POPULATION OF P. T. **VIRGINIANUS**. Michael J. Harver, Memphis State University, Memphis, TN.

4:05 Coffee Break

4:15 MANAGEMENT PROGRAMS FOR VAMPIRE BAT POPULATIONS IN LATIN AMERICA - AN ASSESSMENT. G. Clay Mitchell, Denver Wildlife Research Center, Lakewood, CO.

4:30 RABIES AND THE BAT RESEARCHER: AN UPDATE ON PRE-EXPOSURE IMMUNIZATION AND THE NEW VACCINES. C. V. Timarchi, Division of Laboratories and Research, N.Y. State Department of Health, Albany NY.

4:45 VESPERTILLIONID TRANSMISSION OF RABIES TO CARNIVORES IN TEMPERATE NORTHERN REGIONS. David H. Johnston, Ontario Ministry of Natural Resources, Maple, Ontario.

5:00 Business Meeting

ABSTRACTS

In alphabetical order by first author
(late abstracts appear last)

VOCAL COMMUNICATION AND SOCIAL BEHAVIOR OF **MYOTIS LUCIFUGUS**

R.M. Barclay

Vocalizations used by little brown bat in a variety of social contexts were recorded in the field. Tape recording of vocalizations and behavioural observations were made throughout the year, at a nursery colony, night roosts, feeding areas, and during swarming and mating at a hibernaculum. Distinct call-types were identified by analyzing the tapes using a period meter/oscilloscope display and a sonagraph. The structure and associated behaviours of the calls will be discussed. The vocal repertoire of this species appears to be somewhat limited, although stereotyped vocalizations are used in maternal-infant interactions and mating. There is also a general class of highly variable, broad-band vocalizations which are used in intraspecific aggressive encounters, and appear to take the place of physical aggression.

ECO-ETHOLOGICAL SIGNIFICANCE OF THE ALLOMETRIC DEVELOPMENT OF THE TWO VISUAL SYSTEMS AMONG CHIROPTERA

Georg Baron

Volumes of the rostral colliculus and the nuclei of the geniculate body were examined in 19 species of Chiroptera belonging to 8 families characterized by different eco-ethological adaptations. These volumes were compared to those of Basal insectivores using the allometry formula. The data were expressed in terms of progression indices which estimate how many times a given brain center is greater than that of a Basal Insectivores of the same body weight. According to the progression indices of the rostral colliculus, Chiroptera separate into two groups: the Megachiroptera which have a mean index of 331 and the Microchiroptera with a mean index of 188. On the other hand, mean indices of the lateral geniculate body distinguish between three groups: the Megachiroptera (mean 869); the frugivorous and nectarivorous Microchiroptera (mean 293); the insect-eating, blood sucking, and fish eating Microchiroptera (mean 135). The results indicate that the two anatomically and structurally distinct elements belong to two functionally different visual systems which have evolved somewhat independently. The relation between allometric development of these visual centers and the eco-ethological adaptations of the species examined reveals, to a certain extent, the relative importance of the different functional aspects of vision.

OLFACTORY RECEPTOR-GLOMERULAR RATIO VERSUS OLFACTORY ACUITY IN **EPTESICUS**, **ARTIBEUS**, AND **DESMODUS**

Kunwar P. Bhatnagar

Cytoarchitecturally, the olfactory bulb appears strikingly uniform throughout the vertebrate series. Based upon sporadic quantitative studies on mammals it has been reported, for example, that the size of the olfactory glomerulus is directly proportional to the bulb size so that the total number of glomeruli remains more or

less constant, and that in species as divergent as **Loxodonta** and Homo, the numerical density of glomeruli per mm^2 bulb surface is almost identical. Nevertheless, a wide diversity exists in the acuity of the sense of smell in different animals. It might be suspected that these differences, since macrosmatic animals tend to have more extensive olfactory epithelial areas than microsmatic animals, could be expressed in terms of ratio of receptors to glomeruli. However, the only species for which the receptor-glomerular ratio has thus for been determined is the rabbit. To test this hypotheses then the present investigation has dealt with the quantitative estimation of the number of olfactory receptors projecting upon a glomerulus in three species of bats with differential olfactory acuity. Live bats were Bouin-perfused. The decalcified heads were serially sectioned at 10mm and stained with trichrome, Protargol S or cresyl violet. Every fifth section was examined. Measurements of olfactory epithelial surface areas (SA), in mm^2, were made using camera licida and projection techniques. Mean height (h) of the receptor neclear compartment within the olfactory epithelium, and the mean diameter (d) of a receptor nucleus, in millimeters, were carefully determined. Total number of receptors per nasal cavity was estimated from the formula: $SA \times h \quad d^3/6$, where the denominator represents the volume of one receptor nucleus, in mm^3. Glomeruli were counted directly under the microscipe. Their total number was estimated using Abercrombie's formula. The following results were obtained:

	receptors per nasal cavity	glomeruli per bulb	mean glomerular diameter (m)	receptor-glomerular ratio
Eptesicus fuscus	1.561×10^7 (5)	970 (6)	60	16,095 : 1
Artibeus jamaicensis	8.938×10^7 (2)	1,188 (1)	130	75,240 : 1
Desmodus rotundus	9.432×10^7 (1)	1,336 (1)	80	70,595 : 1

( ) = number of animals examined

Artibeus and **Desmodus**, the Jamaican fruit-bat and the vampire bat respectively, recognized for their far keener sense of smell and a well-developed olfactory apparatus, when compared with the less-well endowed insectivorous **Eptesicus**, do indicate a much higher receptor-glomerular ration. These data when compared with the one available for rabbit (5.0×10^7; 1,999; 185; 26,000 : 1) suggests that the receptor-glomeruli are not numerically constant amongst species. Data is being gathered from many other species to make a more objective analysis. It is hoped that these data will provide greater insight into the elements of olfactory acuity.

ON THE STATUS OF SOME **MYOTIS** FROM WESTERN MEXICO, WITH COMMENTS ON VARIATION IN **M. NIGRICANS**

Michael A. Bogan

The small **Myotis** from the Islas Tres Marias, Nayarit, Mexica, heretofore known as **M. californicus mexicanus**, in fact represent a previously undescribed species. The island form has it closest affinities with **M. nigricans carteri**, a form which also warrants specific status. An overview of variation **M. nigricans** supports the specific status of **M. carteri**, confirms the distinctness of **M. nigricans extremus**, and does not support the subspecific status of **M. n. punensis**.

A COMPARISON OF FLIGHT MECHANICS OF THE LESSER BULLDOG BAT AND THE MEXICAN FREE-TAILED BAT

Carl Brandon

Noctilio albiventris and **Tadarida brasiliensis** both share an efficient high aspect ratio wing planform. In other respects, these bats are very different. **Tadarida** has many advanced morphological adaptation which are lacking in **Noctilio**. The flight of both bats was analyzed with the aid of high speed strobe motion pictures of the bats flying in a wind tunnel over a range of airspeeds and of the landing maneuvers of both bats in a flight room. The results of these studies point out many differences in the flight mechanics of these two bats, such as the method of landing and the use of the tail membrane for pitch control.

VARIATION IN THE AFRICAN MOLOSSID **TADARIDA BIVITTATA**

Judith L. Eger and R. L. Peterson

Tadarida bivittata (T. ansorgei and **T. rhodesiae)** inhabits dry woodlands and savanna areas of central Africa. Discrimination of nine local populations using 27 morphometric characters indicated the presence of two major groupings. Apparent anomalies were present in the groupings provided by the discriminant functions analysis. Consideration is given to possible ecological and geographic explanations for the anomalies.

DENTAL HISTOLOGY OF ARTIBEUS JAMAICENSIS

Dr. John P. Farney

Fifty-five specimens of **A. jamaicensis** were used in the analysis. Descriptive microscopic and macroscopic features were divided into four components of dental structure, enamel, dentin, cementum, and periodontal ligaments. Ground sections and a scanning electron microscope were used. Ground sections were examined with phase-contrast and bright field microscopy.

PARTITIONING OF FOOD RESOURCES BY INSECTIVOROUS BATS

M. B. Fenton

A variety of studies has shown that insectivorous bats may be either very selective or very general in their food habits. Most species for which data are available show this mosaic of generalized/specialized feeding, a phenomenon sometimes interprested as evidence for differential use of some insects as food. A more parsimonious explanation of these data, and one compatible with reported variation and the high energy demands associated with flight by small bats, is opportunistic feeding. Data on habitat use, diet and patterns of activity for some communities of bats suggest high levels of overlap in all of these parameters and do not point to obvious patterns of food and habitat partitioning by sympatric insectivorous bats. These observations further imply that opportunistic feeding is a strategy common to many insectivorous bats.

CHIROPTERAN ABUNDANCE IN TWO WORLDS: ARE BATS RARE IN AFRICA?

James S. Findley and Don E. Wilson

Data are presented which suggest that fewer bats are captured per net-night in Africa than in the Neotropical or Nearactic region. Possible expanations of this phenomenon are discussed, and include the great abundance of easily captured phyllostomid bats in the Neotropics, the ease of capturing western Nearctic bats over water holes, and the possibility that chiropteran biomass is really less in the Ethiopian region.

THE STRUCTURE AND DYNAMICS OF ARTHROPOD COMMUNITIES OF BAT GUANO ECOSYSTEMS

E. Robin Franklin

Deposits of bat guano in buildings harbour unique isolated communities of arthropods. Guano in three summer roosts of **Myotis lucifugus** located in New Hampshire has been sampled monthly from February through April and twice a month from May through September, 1977. Arthropods are extracted from the guano in Berlese-Tullgren funnels. Preliminary community analysis shows small mites to outnumber other arthropods which include dermestid, tenebrionid, and histerid beetles, and bat flea, a booklouse, a pseudoscorpion, a cimicid, and the masked assassin bug. As nutrient input begins after bats return in May, and as temperature and relative humidity increase, data suggest an increase in numbers of arthropod individuals and species. Data also suggest preferences of some species for either the top or bottom layer of guano.

MOTH EARS AND BAT CRIES: SOME RELATIONSHIPS

J. H. Fullard

Arctiid moths possess paired tympanal organs which, like those of noctuids, alert the insects to the approach of echolocating bats. Using sound production as a behavioural threshold cue, specimens of **Cycnia tenera**, the Dogbane Tiger Moth, were exposed to artificial bat cries of differing frequencies to determine the auditory sensitivity of the ear. Compared with non-acoustic sclerites, the arctiid ear remains relatively constant in size throughout the different sizes of species in the family. This is believed to be a morphological response based on tuning characteristics of the tympanum to those frequencies most predominant in the echolocation cries of sympatric insectivorous bats.

FORAGING BEHAVIOR OF MALAYSIAN NECTAR FEEDING BATS

Edwin Gould

Feeding strategies of Malaysian, nectarivorous bats include trapline foraging and territoreal defence of resources. A high initial visit rate with a subsequent leveling off of activity by bat pollinators is related to a nectar parcelling mechanisms of **Oroxylum indicum** (Bignoniaceae) flowers. Differing temporal patterns of visitation to **Durio**, **Parkia** and **Musa** reflect different flowering strategies. Patterns of visitation to flowers may provide a useful comparative measure of pat pollination energetics in the New and Old World Tropics.

MODIFICATION OF M. CRICOTHYROIDEUS AND THE LARYNX FOR THE AMPLIFICATION OF HIGH FREQUENCY PULSES IN THE MORMOOPIDAE

Thomas A. Griffiths

Mormoopid bats have been shown to emit a constant frequency (CF) call composed of 3 to 5 frequencies. This call consists of a fundamental frequency of approximately 30kHz. and harmonics at approximately 60, 90, and sometimes 120 and 150 kHz. Most of the sound energy (amplitude) is contained in the second harmonic (60 kHz.) portion of the call. It is this amplified second harmonic that these bats employ in echolocation. Specimens of **Mormoops megallophylla** and **Pteronotus davyi** were dissected their hyoid, laryngeal, and pharyngeal regions were compared with those of **Macrotus waterhousii, Phyllostomus hastatus, Artibeus jamaicensis, Phyllops haitiensis, Glossophaga soricina,** and **Phyllonycteris poeyi.** Mormoopid bats possess two modifications of the larynx that were not observed in other species dissected. First, the anterior five to seven tracheal rings are enlarged, forming a large chamber immediately posterior to the laryngeal chamber. Secondly, M. cricothyroideus has split into two separate muscles. One runs anteriorly-posteriorly from the cricoid to the thyroid cartilages, as in non-mormoopid bats. The other runs medially from long, calcified, posterior thyroid cornua to insert on the soft cartilage walls of the laryngeal chamber. These modifications permit the mormoopid larynx to act as a tuneable resonating chamber, amplifying the second harmonic in a manner similar to the vaiable Helmholtz resonator. This tuneable resonator permits: 1) increase or decrease in amplitude during a CF pulse; or 2) maintenance of a constant amplitude over slight variations of frequency within a single pulse.

INSECT FLIGHT SOUNDS DISCRIMINATION BY THE BIG BROWN BAT

Josef Hamr

Big brown bats **(Eptesicus fuscus)** learned to associate insect flight sounds with food presented to them at platforms in two choice tests. The bats reacted positively to these sounds, regardless of the actual presence of food at the sources of sound. Eptesicus were able to discriminate between the flight sound of Jume beetle and a bee and between Jume beetle and pure frequency tones of 3kHz, 5kHz, and 14kHz. Discrimination was also made between the flight sounds of a house fly and a bee. The insect flight sounds presented to the bats ranged from 500-Hz to 5000-Hz in frequency and from 50-dB to 60-dB (A; re .0002 dynes/cm^2) in intensity. Eptesicus can apparently identify the flight sounds over a wide range of grequency composition. Observations made during the testing suggest that the bats relied more on passive listening than on echolocation when making their choices.

THE FEEDING GROUNDS OF BATS AROUND A LAKE IN SOUTHEASTERN ONTARIO

T. M. Harrison

I used 40 kHz ultrasonic detectors to monitor the activity of bats along a series of transects on and near Lake Opinicon in southeastern Ontario during July and August 1976 and 1977. The activity data indicate that bats use some areas more than others and that the pattern of use varies seasonally and temporally. Dispersal of light-tagged **Myotis lucifugus** from two nursery colonies in this area showed that the bats from the colonies used common feeding areas on and around the lake. Wind direction and wind speed appeared to influence the availability of insects and also affects patterns of bat activity. Bats were most active along shorelines, less over open water and least inland.

STATUS OF PLECOTUS TOWNSENDII INGENS AND THE KENTUCKY POPULATION OF P. T. VIRBINIANUS

Michael J. Harvey

The Ozark big-eared bat (**Plecotus townsendii ingens**) and the Virginia big-eared bat (**P. t. virginianus**) will soon be added to the United States list of endangered species. The Ozard big-eared bat has been reported in small numbers from only a few caves in northwestern Arkansas, southwestern Missouri, and eastern Oklahoma. The total surviving population may number no more than a few hundred individuals. In February 1975 a colony of 60 **P. t. ingens** was discovered hibernating in a cave in western Arkansas. None were found in the cave during the following winter. No critical habitat for the Ozark big-eared bat has been recommended. The Virginia big-eared bat is found in three separate populations centered in western Virginia, eastern West Virginia, and Eastern Kentucky. The total number surviving is estimated to be 2500-3000 individuals. The entire Kentucky population of **P. t. virginianus** is thought to hibernate in a single cave. Estimates of the hibernating colony size during the past 14 years range from 472 to 1000 bats. As many as 300 individuals, mostly females, have been reported to be present in the cave during the summer. The cave will be listed as critical habitat for **P. t. virginianus**.

COMPARATIVE MORPHOLOGY OF THE YOLK SAC IN THREE SPECIES OF INDIAN CHIROPTERA

K. B. Karim

In most bats at least (unlike many other mammals) the yolk sac persists throughout pregnancy as a functional entity, but the pattern of its differentiation and presumably its functions differ profoundly among the major groups. The development and the definitive structure of the yolk sac in three species of Indian bats representing three different families have been studies viz **Rousettus leschenaulti** (Pteropidae), **Hipposideros fulvus fulvus** (Hipposideridae) and **Pipistrellus mimus mimus** (**Vespertilionidae**). In **Rousettus leschenaulti** the yolk sac undergoes complete collapse, its lumen is totally obliterated and ultimately it becomes converted into a richly vascular, endocrine gland-like structure. The endodermal cells hypertrophy and form numerous ductless acinus-like groups embedded in a mesodermal matrix. The mesenchymal epithelium facing the exocoelom remains continuous and its cells show minimal hypertrophy. The yolk sac is progressively drawn towards the embryonic pole of the chorionic sac where in late stages it comes to rest abutting against the placental disc. In **Hipposideros fulvus fulvus** the vascularized yolk-sac splanchnopleure is separated from the somatopleure and undergoes collapse accompanied by further hypertrophy of the endodermal cells. The lumen of the yolk sac however persists in the form of an inter-communicating system of strak-like spaces. The yolk sac appears to be progressively displaced towards the placental disc; it has a collapsed shrivelled structure. Thus in **Rousettus** and **Hipposideros** the final location of the yolk sac is opposite to its earlier (abembryonic) position. In **Pipistrellus mimus mimus** the yolk sac retains its original position (abembryonic) until term. However, as the exocoelom explands the embryonic segment of the yolk sac, that is, the roof of the yolk sac, becomes invaginated towards the abembryonic trilaminar omphalopleure. Unlike the other two species, in **Pipistrellus** the mesodermal epithelium of the invaginated roof of the yolk sac becomes markedly hypertrophied. The exocoelomic surface is also thrown into numerous redundant folds, involving both the epithelium and underlying vascularized connective tissue; these project into the exocoelom. The endodermal surface however, remains unfolded and the lining epithelium persists as a layer of hypertrophied cubical to columnar cells. Possible functional implications of these transformations of the yolk sac will be briefly discussed.

SURVIVAL AND LIFE-EXPECTANCY CALCULATIONS FOR WINTER-BANDED BATS

Robert Keen

Conventional techniques of banding and recovery of winter-hibernating bats provide survival data which are not readily amenable to conventional population and life-table analysis, primarily because the bats' ages are not determined when they are banded. Current methods for calculating survivorship and life-expectancy will be critiqued, using published results principally for **Myotis lucifugus**. Corrected life-expectancy values will be presented, based on geometric mean Lx values, rather than arithmetic mean values.

RESPONSES OF BATS TO INSECT PATCHINESS

T. H. Kunz, S. McCoy and K. Kosciusko

Studies on feeding ecology of insectivorous bats have traditionally considered populations as single points in space and time. This study more broadly examines population responses of the bat, **Myotis lucifugus** to insect patchiness. Three general patches are considered: horizontal and vertical space, and time. Cylindrical sticky traps were positioned at the surface of the water of a small like (near shore and in the middle) to assess the horizontal distribution of insect patches. Vertical insect patches were monitored by positioning sticky traps at the water surface, and at 4 and 8 m above the water. Responses of bats to these patches were determined by recording bat passes and feeding buzzes, and directly observing feeding activity in different patches. Feeding activity was significantly greater at the pond edge in 85% of the observational periods. The numbers of insects, operationally important to the bats, caught at this location exceeded the mid-lake catch 80% of the time. Insect density was markedly stratified along the lake edge. Reflecting this vertical patchiness, bats consistently foraged over the lake within 0.5 m of the water surface. These data support existing theory of optimal patch use in that bats usually forage in the most predictable patches.

SIGNIFICANCE OF THE DISTAL PART OF THE HUMERUS IN THE IDENTIFICATION OF EGYPTIAN BATS

Gamal Madkour

This investigation deals with a comparative study of the distal part of the humeri of fourteen bats which are **Rousettus degyptiacus aegyptiacus** (Pteropidae) - Megachiroptera - **Rhinopoma hardwichei sennaaviense, R. microphyllum microphyllum** (Rhinopomatidae) - **Taphozous perforatus perforatus, T. nudiventris nudiventris** (Emballonuridae), **Nycteris thebaica thebaica** (Nycteridae), **Rhinolophus clivosus brachygnathus, Asellia tridens tridens** (Thinolophoidea), **Popistrellus kuhli marginatus, P. ruppelli ruppelli, Otonycteris hemprichi hemprichi, Plecotus austriacus christiei** (Vespertilionidae), **Tadavida aegyptiaca aegyptiaca, T. teniotis ruppelli** (Molossidae) - Microchiroptera. This distal part of the humerus shown no remarkable specialization in the Megachiroptera, while in the Microchiroptera the entocondyloid tuberosity is large. Other structures were also described in these bats.

THE IMPORTANCE OF ACOUSTIC AND OLFACTORY STIMULI IN THE LOCATION OF BATS, A POTENTIAL FOOD SOURCE, BY **PEROMYSCUS MANICULATUS**

Kathleen Martin and M. B. Fenton

Mice within the Renfrew mine (Renfrew County, Ontario) appear to use both olfactory, auditory cues and random searching to locate bats, which account for an important part of their winter diet. Experimental evidence suggests that the auditory stimuli may provide the mice with an indication of the physical condition of the bat. A healthy bat is able to produce a call which may serve to deter mice from approaching too near.

MANAGEMENT PROGRAMS FOR VAMPIRE BAT POPULATIONS IN LATIN AMERICA--AN ASSESSMENT

G. Clay Mitchell

Annual bovine losses resulting from vampire bat-transmitted rabies are estimated at approximately 1 million head in Latin America. Daily loss of blood, mortality of other livestock, and human predation further aggravate the problem. In 1968 the Agency for International Development (AID) funded the U.S. Fish and Wildlife Service to develop species-specific control methods to manage vampire bat populations and to reduce vampire-transmitted rabies. In the early 70's two control methods were developed--tropically treating vampire bats with the anticoagulant, Diphenadione, and systemically treating cattle with the same compound. Following development of control methodology, the research program, located in Mexico, was terminated. AID has continued to fund this program with two main objectives--for Denver Wildlife Research Center biologists to do adaptive research when necessary and to assist Latin American countries develop and initiate control campaigns through training and technical assistance. Benefits received form the control programs include elimination of vampire bat-transmitted rabies in Nicaragua, reduction of human predation in Nicaragua and Panama, reduction in rabies losses in the 10 Latin American countries with management programs, benefits to non-haematophagous bat species by vampire bat population management and increase of 16% in milk production after vampire predation was removed in Nicaragua and other countries.

AGE DETERMINATION OF **MYOTIS LUCIFUGUS** BY EPIPHYSEAL CLOSURE

W. T. Rumage III, E. L. P. Anthony and T. H. Kunz

During the summer of 1977, growth of newborn **Myotis lucifugus** was monitored at a nursery colony in Canaan, New Hampshire in an effort to devise a method for age determination in juveniles. The colony was sampled at weekly intervals. Between 19 June and 10 July, 110 known-age juvenile bats were banded, and the forearm was measured to the nearest 0.1 mm with dial calipers. Length of the cartilaginous gap in the proximal epiphysis of the fourth and fifth fingers was measured to the nearest 0.05 mm using a dissecting scope fitted with an ocular micrometer. The same measurements were made on recaptured individuals until 7 August. For juveniles whose forearm is less than 32.5 mm, age can be determined most easily and consistently by forearm size (Kunz and Hamill, in prep.). However, when the forearm reaches 32.5 mm (at an age of 13 days), and the epiphyses begin to fuse, linear measurement of cartilage can be used to accurately estimate age of the bats up to 36 dats (N=47 observations; 43 individuals). Although epiphyseal closure is a curvilinear function of time, the natural logarithm transformation yields a straight line: $y=2.065 - 0.062x$, where x=age in days and y=1n (length of the cartilaginous gap of the fourth proximal epiphysis in mm). Rate of closure was similar in both sexes.

THE VARIETIES OF ECHOLOCATION IN BATS

James A. Simmons

Bats use a variety of different types of echolocation systems for different environmental and perceptual situations. The kinds of signals used by a bat is a given task in the field or in the laboratory provide a clue to the bat's perceptual interests and intentions. Some species appear to be very flexible in adapting their sonar to different information-gathering problems while other species appear to be more rigid in echolocation. Free-tailed bats **(Tadarida)** feed in open spaces with no clutter or obstacles, using single-harmonic, constant-frequency (CF) signals to search for prey and single-harmonic, frequency-modulated signals for target localization and identification. In cluttered situations **Tadarida** used multiple-harmonic FM signals similar to the somar sounds of **Eptesicus**. Bats that pursue prey in the neighborhood of obstacles but with the target flying a short disdance away from clutter **(Eptesicus, Myotis)** use multiple-harmonic FM-plus-CF signals for searching and FM signals for target localization and identification. **Pterontus** uses CF-plus-FM signals in the same way. The presence of an FM component in all the signals seems to represent the animals's interest in observing obstacles to flight while also hunting. Bats that operate in denselycluttered environments **(Phyllostomus, Megaderma)** use many harmonics in Fm signals which are usually weak in intensity. They appear to resort to high-resolution imaging of all objects in a small area to pick out targets of interest. Some bats **(Rhinolophus, Hipposideros, Pteronotus parnellii)** use long CF signals for Doppler resolution of targets from clutter and FM signals for target identification and clutter imaging. **Plecotus phyllotis** can use both weak, multiple-harmonic FM signals in cluttered spaces and long CF-plus-FM signals for hunting prey. Compound signals to be sorted out with multiple neural sonar receivers are used by many species. Short CF signals are generally used for target detection if the target is not too intimately associated with clutter. Bats adapt to dense clutter either by extending the length of the CF signal to exploit velocity (Doppler) information or use very broadband, multiple-harmonic signals to obtain high-quality multidimensional acoustic images of targets in clutter. Some of these adaptations appear only in species differentiation while other appear also as adaptive changes in behavior within individuals.

EMBALLONURID PHYLOGENY: THE REFUTATION OF AN HYPOTHESIS

James Dale Smith

In a recent paper, Barghoorn (1977, Amer. Mus. Novit., 2618:1-29) described new material of **Vespertiliavus** Schlosser and proposed a phylogenetic hypothesis for the relationships among emballonurid bats. His description and stereophotographs of AMNH 55349 are well done, but his assessment of emballonurid kinship relationships leaves much to be desired. In his analysis of these relationships, he has employed cladistic procedures with which I have no argument. My concerns are that he has selected characteristics (some23) the majority of which, by his own admission, are of doubtful use in elucidating relationships among emballonurids or chiroptera as a whole. He cited extensive independent and convergent acquisition of character states as the obfuscating factors involved. On the contrary, I believe poor choice of characters, inaccurate coding, and a loose adherence to the homology principle more appropriately confound his phylogenetic analysis. Barghoorn rightly criticizes the traditional systematist's practice of not precisely defining plesiomorphic (primitive) and apomorphic (derived) character states and how these relate to the formulation of monophyletic clades. However, he also has neglected such careful and precise definition in his construction of transformation series which results in dubious polarities of these morphoclines. An independent analysis of his characters lends little support to his proposed phylogenetic hypothesis for emballonurid bats. Essentially two monophyletic clades are apparent; one involving **Taphozous, Saccolaimus,** and **Vespertiliavus,** on one hand, and on the other, the remaining emballonurids. Whereas these two monophyletic groups may be valid, the focus in the latter group is observed by a high degree of autapomorghy which delimits the group. The resolution of the relationships Emballonura and Diclidurines to other emballonurids is inadequate and largely paraphyletic. These matters will be discussed and an alternative hypothesis proposed.

PENIAL MORPHOLOGY OF BATS

James Dale Smith and Gamal Madkour

Very little is known concerning the comparative histomorphology of the penes of bats. For that matter, comparatively little information exists for mammalian penes in general; a great deal has been published on the isolated os penis of bats as well as other mammals. In the past year, we have transversed and serially sectioned (stained by Gomori's trichrome) penes of 80 bat species (14 of 17 families) and several other supposed mammalian sister-groups. The purpose of this research is to examine phylogenetic hypothese of chiropteran relationships especially that concerning the proposed monophyletic relationship between mega and microchiroptera. The general histomorphology of bat penes will be discussed as well as some preliminary observations concerning the question of mega and microchiropteran relationships.

USE OF THE CHEEKS AS TEMPORARY FOOD STORAGE RESERVOIRS IN SOME MOLOSSID BATS

Timothy L. Strickler

This paper discusses the use of the cheeks as temporary storage reservoirs in **Tadarida macrotis** and several other species of molossid bats. The molossid species **Tadarida, Otomops** and **Eumops** have moderately large to large expandable cheecks which are frequently filled with partially masticated food in captive animals. Smaller-lipped species such as **Molossus** do not appear to display this behavior. Such hoarding may be associated with mass foraging in **Tadarida brasiliensis**, and its presence in the other species reported here may be related to similar foraging patterns at some stage in their evolution. It is suggested that such behavior may be practiced by numerous other mammalian species which show no obvious external manifestations of a cheek pouch. Further elaboration of large cheeks such as those of the above molossids into definitive cheek pouches may be associated with the acquisition of food processing functions by these structures, or may simply reflect the need for larger storage spaces.

ANNUAL AND LOCAL VARIATION IN THE DIET OF **MYOTIS LUCIFUGUS** IN SOUTHEASTERN ONTARIO

K. L. Strong

By analysis of feces I compared the diets of **Myotis lucifugus** from two nursery colonies and a night roost within 2 km of one another. Between June 1976 and June 1977 one colony showed a marked increase in the number of caddisflies consumed, and in the summer of 1977 one colony relied heavily on caddisflies for their food while the other used mainly chironomids. Data from the night roost suggested that in the first feeding period the bats ate more chironomids, while during later feeding they fed more on caddisflies.

DRY SEASON FORAGING BEHAVIOUR OF TWO AFRICAN FRUIT BAT SPECIES

Donald W. Thomas

Species composition, habitat use, and foraging behaviour of the fruit bat community in Rhodesia was examined during the dry season by means of mist net captures and radio tracking. The two species present (**Epomophrus gambianus** and **Rousettus aegyptiacus**) were caught primarily in riverine habitat where **Diospyros**

senesis (Ebanaceae) was the only abundant fruit. Radio tracking of two **E. gambianus** indicated that thier ranges were restricted to one or several adjacent **D. senensis** trees and to nearby thick canopied roost trees. **Rousettus aegyptiacus** appeared to forage in groups. Competitive foraging strategies for the two species are discussed.

RABIES AND THE BAT RESEARCHER: AN UPDATE ON PRE-EXPOSURE IMMUNIZATION AND THE NEW VACCINES

C. V. Trimarchi

Rabies had been reported in bats in all 48 contiguos United States and all provinces of Canada except the maritimes. Because persons handling bats in field and laboratory are at a high risk of exposure to the virus, pre-exposure immunization is recommended. This currently requires three injections of Duck Embryo Vaccine (one each month for two months with the third given three months later) followed by a blood-serum test, and a booster each year for continued protection. New vaccines, including a hamster kidney cell culture vaccine available in Canada, and a human diploid cell culture vaccine, soon to be licensed in the United States, may reduce the number of injections necessary and increase antibody levels achieved through immunization. Trials show that the cell culture vaccines reduce the frequency of adverse reactions associated with the old nervous tissue and avian embryo material. Also, hyperimmune serum of human origin is now commercially available to replace horse serum for passive immunization in cases of severe exposure or post-exposure vaccination of unimmunized individuals.

MORPHOLOGY OF THE UTERUS, PLACENTA AND PARAPLACENTAL ORGANS IN THE DISC-WINGED BAT **THYROPTERA TRICOLOR** SPIX.

William A. Winsatt and Allen C. Enders

The study is based on a small series of pregnant and non-pregnant remales collected over a four year period from the same locality in southern Veracruz, Mexico. Pregnant animals were collected in January, March and May. These presented a development series progressing from recently implanted pre-somite embyros in January, limb-bud stage embryos in March, to term fetuses in late May; this suggests that gestation length in **Thyroptera** may exceed five months. The uterus was found to be bicornuate, although the horns are exceedingly short. The corpus uteri was unusually voluminous, thin-walled, and lacked the glandular density observed in the cornua. The cervical canal was long, thick walled and opened by a single opening at the apex of a prominent os projecting into the vagina. The cervical canal was heavily pleated in its longitudinal axis. The voiducts open into the apex of the uterine cornua directly; there is no oviductal papilla at the junction. The ovaries are completely surrounded by a this capsule, but the intracapsular space communicates with the peritoneal cavity via a small opening. Never more than a single embryo or fetus was present in the uterus and only a single corpus luteum was observed in one of the ovaries; this indicates that **Thyroptera**, like most bats, is monovular. Ovoimplantation occurs in one of the horns of the uterus and is interstitial, as indicated by the presence of a decidua capsularis. Early growth and expansion of the conceptus rapidly expands the walls of both cornua such that even in late pre-somite stages the uterus had assumed a symmetrical ovate shape in which its original becornuate conformation could no longer be discerned grossly. Amniogenesis is accomplished precociously, presumably by cavitation as in the human. The yolk sac is voluminous following implantation and is rapidly invested by mesoderm converting it into a tri-laminar structure. There was at least a transient chorio-vitelline placenta with both vascilar (embryonic side) and avascular (adembryonic side) segments.

In late stages the embryonic half of the sac is invaginated into the adembryonic half and the choriovitelline placenta is thereby obliterated. The development of the definitive allantoic placenta resembles that of other bats (e. g. **Myotis, Desmodus**). The maternal endothelium disappears soon after trophoblastic invasion of the endometrium so a hemochorial condition of the interhemal membrane is established relatively early. Electron microscopic examination revealed that the definitive barrier is hemodichorial, and otherwise resembles the conditions described by us in **Myotis.**

OBSERVATIONS ON FEEDING EFFICIENCY OF CAPTIVE GLOSSOPHAGA SORICINA

John R. Winkelmann

Feeding efficiency in glossophagine bats is virtually undocumented, despite abundant interest in the ecology and morphology of flower-feeding. The volume of nectar ingested during a flower visit depends not only on the amount available, but also on the capacity of the tongue and the number of tongue dips per visit. These and other feeding characteristics were studied in captive **Glossophaga soricina.** The bats were maintained in flight cages on a diet of 20% honey and water plus 5% (by weight) powdered nutritional supplement (Enfamil). Automatic monitoring of the feeding activity of 15 bats over four 24 h periods revealed no subcycles in their aggregate feeding activity. The fewest visits recorded in any ten minutes during the dark period was eleven and the highest was 85. Mean number of visits and mean food consumption per bat for the four 24 h periods were 224.4 and 14.02 ml, resulting in the removal of 0.063 ml of liquid per visit. Mean volume per tongue dip was found to be 0.038 ml by counting tongue dips (456) and measuring volume depletion in a modified pipette. Thus, even in familiar circumstances and with easy access to unlimited food, the number of tongue dips (1.64) and amount of food removed per visit is small. Visits seldom lasted as long as one second although bats feeding at barely accessible food supplies hovered as long as eight seconds. Such behavior is compatible with field observation of very rapid visits to flowers of two species of **Calliandra** (nectar volumes of 0.24 ml or less). Wild bats, with higher energy budgets and more dilute food (about 14% sugar in **Calliandra** nectar), must make many more flower visits and ingest much more liquid than captives. Therefore, aerodynamic considerations, as well as renal physiology would seem to require intermittent feeding.

LATE ARRIVALS:

PHOTOGRAPHIC EVIDENCE FOR ORAL EMISSION OF ECHOLOCATION SOUNDS IN CERTAIN PHYLLOSTOMATID BATS

Scott Altenbach

Phtographs of flying Phyllostomatid bats show that the mouths of several species are open to varying degrees, and suggest possible oral emission of echolocation sounds. **Carollia perspicillata, Carollia castanea,** and **Trachops cirrhosus** consistently have the mouth open slightly more than upper canine length. The blunt tongue is extended to lie in the lower aspect of the open mouth and protrudes slightly beyond the lower lip. In contrast, the mouths of **Ectophylla alba, Vampyressa nymphaea, Artibeus phaeotis,** and **Artibeus jamaicensis** are closed tightly and suggest nasal emission of the sounds.

STATUS AND PROTECTION OF THE ENDANGERED **MYOTIS GRISESCENS** AND **MYOTIS SODALIS** IN MISSOURI.

Richard K. LaVal

Populations of hibernating Myotis **sodalis** in Missouri decreased 19% between 1960 and 1976, whereas hibernating **Myotis grisescens** may be down only about 10% over the same period. The **M. grisescens** hibernacula seem relatively safe at this time. All the larger **M. sodalis** hibernacula are either reasonably safe or, we hope, soon will be. Summer populations of **Myotis grisescens** may be down as much as 65% this century, due mainly to human disturbance of maternity colonies in caves. We hope to acquire and protect some of the larger colonies over the next few years, but protection of the multitude of smaller colonies would be very difficult, at best. **Myotis sodalis** seems to occur through much of the state in summer, but its status is poorly known at this time. Pesticide poisoning is a known threat to some **M. grisescens** maternity populations, and may effect M. sodalis as well.

VESPERTILIONID TRANSMISSION OF RABIES TO CARNIVORES IN TEMPERATE NORTH AMERICA

C. D. MacInnes and D. H. Johnston

There is a controversy surrounding the role of vespertilionid bats as transmitters of rabies to terrestrial mammals in the temperate zone of North America. Epidemiological evidence indicates that transmission probably occurs in some geographic regions where bat rabies is endemic but not in others. Observations on wild **Eptesicus fuscus** found flightless and dying of rabies suggest that their behavious made them highly attractive to being eaten by carnivores. Transmission of rabies could occur by two modes, direct virus inoculation through biting, or absorption through the gastriontestinal tract following ingestion. Transmission by these means could potentially be a significant route of infection for carnivores such as foxes, raccoons and skunks in temperate North America.

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NEWS

Dedee P. Woodside and Chris Tidemann (Department of Zoology, Australian National University, Box 4, G.P.O. Canberra, A.C.T. 2600, Australia) have developed a collapsible version of the Tuttle Bat Trap. The details of the trap are provided in a paper scheduled to appear soon in the **Australian Wildlife Research** (volume 5, number 3). I have had the opportunity of trying this trap in the field and can assure readers that it works and that it is very portable. The first night we used it up in this area we caught six species which represents a significant portion of our bat fauna of 8 species.

Stephen Cross (Southern Oregon State College, Ashland, Oregon 97520) and a group of his students have produced a spiral bound manuscript entitled 'A survey of bat populations and their habitat preferences in southern Oregon'. This useful publication has distribution maps, and a variety of other information (habitats, etc.) on bats of southern Oregon. He has indicated that there are a number of copies still available, and that interested parties should contact him directly.

Giancarlo Baldini P. (Centro de Estudios Cientificos 'Vincente Marcano' Apartado de Correos no. 14.191, Caracas 1010, Venezuela) has written to report that the Association Louis Pasteur of Science Students has been closed, and replaced by the Centro de Estudios Cientificos 'Vincente Marcano' (CENECI).

EDITORIAL

This issue of the **Bat Research News** contains a valuable contribution from three of our colleagues in Czechoslovakia. J. Gaisler, V. Hanak and I. Horacek have produced a summary of bat research in Czechoslovakia which could be of great value, particularly to Mammalogists planning to attend the International Congress in Brno this summer. I am very grateful to these gentlemen for taking the time to assemble this information and to sent it to me for **BRN**.

I would be very happy to receive similar submissions from other groups of bat biologists. If, in each issue, we could include this kind of a review by country, state or province, or even by laboratory, it would make this newsletter much more useful to its subscribers.

Please consider this an invitation to assemble that kind of a summary and having taken the trouble to do that, please send it along so that I can include it in the next issue of **BRN**.

Frankly, I will not hold my breath. The number of people actually contributing to this newsletter is **very small**, and miniscule relative to the number of subscribers. Several colleagues have promised manuscripts on techniques for studying different aspects of bat biology, but talk is cheap. Only one person, apart from this Editor, consistently sends in literature citations, but one is better than none.

I hope that this newsletter serves a valuable function. It could be very useful if we carried summaries of the work done on bats in different places. I think that the Literature section could be very valuable, but if a few more people each took a little time to send in citations, the coverage could be significantly broadened.

Roy Horst and I hope to include a complete list of subscribers in the next (August) issue. This will fatten up an otherwise lean Newsletter since I expect to be in the field for most of June and July and may not have as much time to devote to **BRN**.

I look forward to being overwhelmed by submissions.

RECENT LITERATURE

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Thomas, D.W. and M.B. Fenton. in press. Notes on the dry season roosting and foraging behaviour of **Epomophorus gambianus** and **Rousettus aegyptiacus** (Chiroptera : Pteropodidae). Journal Zoology (London).

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PRESENT STATUS OF BAT RESEARCH IN CZECHOSLOVAKIA

Jiri Gaisler, Vladimir Hanak and Ivan Horacek

To provide our colleagues in other parts of the world with some idea about the type of work being done with bats in Czechoslovakia, we have prepared the following summary about the status of bat research here. The summary is divided into several parts, including: 1. trends in former activity, 2. future work, 3. some suggestions for international cooperation, 4. a short list of some Czechoslovak chiroptologists, 5. selected references, 6. papers in press, 7. unpublished theses (in Czech), 8. list of Czechoslovak bat collections. We hope that this information will be of special value to colleagues planning to attend the mammal conference in Brno this summer.

1. Trends in former activity

a- In the last two decades, a major part of bat research activity was focused on completing the basic faunal-ecological surveys. Thus we now have reasonable data for species such as **Rhinolophus hipposideros, Myotis myotis, Plecotus austriacus** and **P. auritus**, species which live in caves or in buildings. Recently we have spent more time working on tree and fissure species such as members of the genera **Nyctalus, Pipistrellus, Eptesicus, Vespertilio**, and **Barbastella**. In these investigations, many zoologists, some of them from regional museums, participated, and some of the publications arising from this work include numbers 6, 8, 10, 11, 13, 14, 19, 20, 34, 35, 44, and 45.

b- The systematics, taxonomy and distribution of Palaearctic **Plecotus** spp., **Myotis mystacinus** and **Myotis brandti**, and **Rhinolophus bocharicus** have received special attention from Hanak, while he and Gaisler have studied some **Eptesicus** spp, **Pipistrellus nathusii** and **P. pipistrellus**. More general evaluations were made of other material collected abroad: the bats of Afghanistan and Egypt - Gaisler, Albania - Hanak, Bulgaria - Hanak, Horacek and Cerveny. Publications arising from some of these studies include: 7, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 28, 30, 66, and 67.

c- Research on palaeontology and palaeoecology has only recently been initiated, and to date is based on Holocene thanatocenoses, with some attention to Neocene and Pleistocene material. The main workers have been Rybar and Horacek, and publicatons arising from this work include 49, 50, 62, and 69.

d- Research on bat ecology arises out of a wide programme of bat banding to which most Czechoslovak chiroptologists contributed. Results from these studies have been analyzed on either a national (Gaisler and Hanak) or regional point of view (Hurka, Nevrly, and Cerveny), or incorporated into more detailed studies of the ecology and reproduction of certain species, including: **Rhinolophus hipposideros** (Gaisler), **Myotis Myotis** (Sklenar, Kratky, Solcova and Horacek), **Plecotus** spp. (Hanak, Hurka, Soucek, Horacek), **Pipistrellus pipistrellus** (Hurka), and **Myotis emarginatus** (Gaisler). A number of publications has been produced by this work, some of them concentrating on hibernation (4, 5, 6, 8, 10, 11, 12, 13, 20, 27, 29, 33, 34, 35, 41, 44, 45, 48, 59, 71, and 72).

e- Studies of bat morphology have included a variety of topics ranging from morphology and growth of pelage (Klima, Gaisler and Mazak), myology (Sterba, and Trnkova), brain morphology (Sigmund, Zajicova and Petrovicky), postcranial osteology (Zalman, Cerveny and Sigmund), morphology of bacula (Vlcek), and postnatal development (Gaisler, Sklenar, Rybar and Kratky). References include: 1, 3, 9, 38, 39, 40, 42, 46, 47, 51, 53, 54, 55, 56, and 58.

f- Several workers have been studying different aspects of bat parasites, including insects (Hurka), mites (Dusbabek), helminths (Hurkova, Rysavy, Tenora, and Barus), and protozoans (Kucera and Sebek). Papers arising from these studies include: 2, 31, 32, 36, 37, and 43.

g- There are several other studies which have been completed, including: population ecology of **Myotis myotis** (Horacek) and karyology of all central European species of bats (Zima). Bauerova investigated the feeding ecology of **Myotis myotis, Plecotus austriacus** and some other species, while the autecology of **Eptesicus serotinus** (Rumler), **Nyctalus noctula** (Gaisler, Hanak, and Dungel), and **Myotis daubentoni** (Hanak and Kratky) have also been examined. Publications based on these studies include: 57, 58, 65, 61, 68, 70, and 73.

2. Future Work

One of the priorities in bat research in Czechoslovakia is the use of quantitative approaches to assess population densities and structures of bat communities. One winter and two summer censuses are conducted using a limited banding-and-recapture programme which involves netting and visual observations of flying bats. We pay special attention to abundance and behaviour of bats in towns. A comprehensive and multidisciplinary study of **Myotis nattereri** is in progress. Some workers are using scanning electron microscopy to study hair morphology, electrophoresis for sperm proteins, and others using sectioning to examine age structure of populations. Apart from these innovations, former work on general ecology, palaeontology, morphology and parisitology is being continued.

3. Some suggestions for International Cooperation

We have provided this information to give bat biologists in other parts of the world a picture of the type of work we are conducting. We would be happy to see some specific studies, for example relationships between Palaearctic and Nearctic bats such as **Myotis nattereri** and **M. thysanodes**, and would be happy to collaborate in this context.

It is obvious from the recent literature that a number of ecological studies is underway, and we hope that a more general standardization of methods could be achieved to facilitate comparison of data from different sources.

We welcome opportunities to study bats and are anxious to increase the levels of international cooperation.

Appendix I: A short list of Czechoslovak chiroptologists.

Dr. Zdena Bauerova / Dept. of Animal Biology, J.E. Purkyne Univ. /, Kotlarska 2, 611 37 Brno
Ing. Jaroslav Cerveny / Inst. of Animal Breeding /, pricna 8, 110 00 Prahal
Dr. Frantisek Dusbabek / Inst. of Parasitology C.A.S. /, Flemingovo nam. 3, 160 00 Praha 6
Dr. Jiri Gaisler / Dept. of Animal Biology, J.E. Purkyne Univ. /, Kotlarska 2, 611 37 Brno
Dr. Vladimir Hanak / Inst. of Systematic Zoology, Charles Univ. /, Vinicna 7, 128 44 Praha 2
Dr. Ivan Horacek / Dept. of Quaternary Res., Inst. of Geology C.A.S. /, Sidl. Michelska 1182, 145 00 Praha 4
Assist. Prof. Dr. Karel Hurka / Inst. of Systematic Zoology, Charles Univ. /, Vinicna 7, 128 44 Praha 2
Dr. Ludek Hurka / West-Bohemian Museum /, Kopeckeho sady 2, 301 50 Plzen 1
Dr. Jiri Kratky / Museum of the Sumava Mts. /, 34192 Kasperske Hory
Dr. Miloslav Nevrly / North-Bohemian Museum /, 460 00 Liberec
Dr. Jozef Palasthy / Museum SRR /, 080 00 Presov
Dr. Petr Rybar / Regional centre of Nature Conservancy /, 531 16 Pardubice - zamek 4
Dr. Zdenek Rumler / The regional museum/, nam. Republiky, 771 73 Olomouc
Dr. Jan Sklenar, / East-Bohemian Museum /, 531 00 Pardubice - zamek 4
Dr. Jan Zima / Inst. of Vertbrate Zoology C.A.S. /, Kvetna 8, 603 65

Appendix II: Selected references

/a/ Published papers

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3 Gaisler, J., 1962: Postnatale Entwicklung der Kleinen Hufeisennase /Rhinolophus hipposideros Bechst./ unter naturlichen Bedingungen. Symposium theriologicum, Brno, 1960: 118-125. /in Germ./

4 --, 1963: The ecology of lesser horseshoe bat /Rhinolophus hipposideros hipposideros Bechstein, 1800/ in Czechoslovakia. Part I. Vest. Cs. spol. zool., 27: 211-233; Part II: Ecological demands, problem of synanthropy. ibid., 27: 322-327.

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10 --, 1975: A quantitative study of some populations of bats in Czechoslovakia /Mammalia, Chiroptera/. Acta sc. natn., Brno, 9/5/: 1-33.

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12 --, V. Hanak, 1969: Ergebnisser der zwanzigjahringen Beringung von Fledermause /Chiroptera/ in der Tschechoslowakei: 1948-1967. Acta Sc. nat., Brno, 3/5/: 1-33. /in Germ./

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19 --, 1967: Verzeichnis der Saugetiere der Tschechoslowakei. Saugetierk. Mitt., 15: 193-221. /in Germ./

20 --, 1969: Okologische Bemerkungen zur Verbreitung der Langohren /Gattung Plecotus Geoffroy, 1818/ in der Tschechoslowakei. Lynx, 10: 35-39. /in Germ./

21 --, 1969: Zur Kenntnis der Rhinolophus bocharicus Kastchenko et Akimov, 1917 /Mammalia: Chiroptera/. Vest. Cs. spol. zool., 35: 175-185. /G/

22 --, 1971: Myotis brandti /Eversmann, 1845/ /Vespertilionidae, Chiroptera/ in der Tschechoslowakei. Vest. Cs. spol. zool., 35:175-185. /G/

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38 Klima, M., J. Gaisler, 1967: Study on growth of juvenile pelage in bats. I. Vespertilionidae. Zool. listy, 16: 111-124,; II. Rhinolophidae. ibid., 343-354.

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Appendix III: List of Czechoslovak bat collections.

Over 7000 specimens belonging to 120 bat spp. are deposited in approx. 25 collections, 12 of which contain over 100 specimens:

/A/ Inst. of Systematic Zoology, Charles Univ., Praha - 3500 spec.
Dr. V. Hanak /se App. I/

/B/ Institute of Vertebrate Zoology C.A.S., Brno - 2150 spec.
Dr. J. Gaisler /see App. I/

/C/ Dept. of Animal Biology, J.E. Purkyne Univ., Brno - 300 spec.
Dr. J. Gaisler /see App. I/

/D/ East Slovakian Museum, 040 00 Kosice - 279 spec.
Ing. A. Mosansky

/E/ National Museum /Nat. Hist./, 115 79 Praha - 260 spec.
Dr. J. Hanzak

/F/ Silesian Museum, 746 46 Opava - 243 spec.
Dr. B. Benes

/G/ Slovak National Museum, 800 00 Bratislava - 220 spec.
Dr. B. Matousek

/H/ Regional Museum Bardejov, 085 01 Bardejov - 200 spec.
T. Weisz

/I/ West Bohemain Museum, Plzen - 190 spec.
Dr. L. Hurka /see App. I/

/J/ East Bohemian Museum, Pardubice - 150 spec.
Dr. J. Sklenar /see App. I/

/K/ Regional Museum, Olomouc - 120 spec.
Dr. Z. Rumler /see App. I/

/L/ Moravian Museum, 600 00 Brno - 100 spec.
Dr. M. Sebela

Other cited collections:

/M/ South Bohemian Museum, 370 00 Ceske Budejovice - 50 spec.
Dr. P. Burger

/N/ Regional Museum, 071 01 Michalovce - 50 spec.
Dr. S. Danko

In these collections, most of the bat material is preserved as /1/ prepared dry skins and skulls, /2/ skulls /prepared mostly by means of dermestid beetles /3/ cadavers in alcohol.

Species composition of a larger Czechoslovak collections of the Palaearctic and north-Oriental forms /obtained mostly through our own collecting activity/ is reviewed in a following table.

Besides this, also a series of Cuban bats occures in the collections A, B, C, F and I /in total 275 specimens/: Noctilio leporinus-4, Eptesicus fuscus-4, Natalus macer-8, Natalus lepidus-23, Tadarida minuta-10, T. macrotis-2, T. midas-10, T. brasiliensis-12, T. laticaudata-2, Molossus major-10, Eumops glaucinus-1, Chilonycteris parnelli-4, C. macleayi-10, C. fuliginosus-21, Mormoops blainvillei-21, Macrotus waterhousi-28, Monophyllus cubanus-1, Brachyphylla serehorni-10, Brachyphyllas nana-27, Artibeus jamaicensis-38, Phyllonycteris poeyi-29.

Of the other areas only a few specimens /obtained mostly through exchange/ are available /E,A,B,C, - a total of about 150 spec./: Cynopterus sphinx, Pteropus giganteus, P. hypomelanus, P. policephalus, Eidolon helvum, Hypsignathus monstrosus, Nyctinme spp., Hipposideros commersoni, Myotis lucifugus, M. nigricans, M. grisescens, Eptesicus fuscus, Pipistrellus subflavus, Scotophilus nigrita, Nycticeius humeralis, Cheiromeles parvidens, Tadarida cynocephala, Molossus obscurus, Glossophaga soricina, Carollia perspicillata, Phyllostomus hastatus, Desmodus rotundus, etc.

As concerns exchange of specimens, we always shall be aggreable, especially in cases concerning forms having relation to Palaearctic taxa /e.g. Kerivoula, south-Asiatic and African Mytois, Pipistrellus, Eptesicus, etc./.

For purpose of scientific study, of course, most of the material reviewed above will be available from the curators of individual collections.

	Czechoslovakia	SE Europe Bulgaria, Rumania Albania, Yugoslav., Turk.	other Europe France, Italy, Poland, Germany	USSR mainly central Asia + Transcaucasia	Afghanistan	N Africa /Egypt, Tunisia, Algeria	other areas of Palaearct. region	Total number	Collections /see above for expl. area of collecting
Rousettus aegyptiacus	-	-	-	-	-	21	-	21	B,C,A
Rhinopoma microphyllum	-	-	-	-	76	-	-	76	B,A,G
R. hardwickei	-	-	-	-	17	62	-	79	B,A,C
Taphozous nudiventris	-	-	-	-	21	23	-	44	B,A,C
T. perforatus	-	-	-	-	-	37	-	37	B
Nycteris thebaica	-	-	-	-	-	20	-	20	B
Megaderma Lyra	-	-	-	-	2	-	-	2	B
Hipposideros fulvus	-	-	-	-	1	-	-	1	B
Aeslia tridens	-	-	-	-	-	82	-	82	B,C,A
Rhinolophus hipposideros	680	20	-	-	5	-	-	705	B,A,C, etc.
R. ferrumequinum	90	222	5	24	1	1	1	344	A,B,C,G,D,E
R. clivosus	-	-	-	-	-	4	-	4	C,B
R. bocharicus	-	-	-	13	-	-	-	13	A
R. mehelyi	-	53	-	23	-	-	-	76	A,C
R. blasii	-	70	-	4	-	-	-	74	A,B
R. euryale	92	149	-	-	-	-	-	241	A,B,C,D,E,H
Myotis bechsteini	40	3	-	-	-	-	-	43	B,A,D,E, etc.
M. blythi	110	79	11	29	-	28	-	257	A,B,C,L, etc.
M. myotis	650	98	2	-	-	-	-	750	A,B,C,G, etc.
M. ~~Nnatterori~~	118	4	1	2	-	-	-	125	A,F,I,B, etc.
M. emarginatus	135	58	-	14	-	-	-	207	A,B,C,G, etc.
M. brandti	85	5	-	-	-	-	-	90	A,B,C,I, etc.
M. mystacinus	230	15	-	5	-	-	-	250	A,B,C,E, etc.
M. frater	-	-	-	4	-	-	1	5	A
M. daubentoni	185	1	-	-	-	-	-	186	A,E,F,B, etc.
M. dasycneme	13	-	-	-	-	-	-	13	A,B,C
M. capaccinii	-	~~71~~	-	-	-	-	1	73	A,B,C,E,J
M. longipes	-	-	-	-	314	-	-	314	B,A,G,K
Vespertilio murinus	55	76	-	-	-	-	-	131	A,B,f',C, etc.
V. superans	-	-	-	-	-	-	1	1	A
Eptesicus serotinus	150	19	1	24	34	-	-	228	A,B,F,I,etc.
E. ognevi	-	-	-	3	-	-	-	3	A
E. nasutus	-	-	-	-	24	-	-	24	B,A
E. nilssoni	92	-	-	3	-	-	-	95	A,I,D,F,etc.
Pipistrellus pipistrellus	143	54	12	29	96	1	-	335	A,B,C,I,etc.
P. natuhsii	35	-	-	-	-	-	-	35	A,B,C,H,D,E
P. savii	-	1	-	-	-	-	-	8	A,B
P. kuhli	-	3	3	5	2	19	-	32	A,B,J,C
P. deserti	-	-	-	-	-	16	-	16	B
P. coromandra	-	-	-	-	22	-	3	25	B,A
Otonycteris hemprichi	-	-	-	-	-	17	-	17	A,B
Scotophilus heathi	-	-	-	-	13	-	-	13	B,A
Nyctalusnoctula	140	33	1	1	-	-	-	175	A,E,C,B, etc.
N. aviator	-	-	-	-	-	-	1	1	C
N. lasiopterus	2	-	-	-	-	-	-	2	M,N
N. montanus	-	-	-	-	1	-	-	1	B
N. leisleri	29	-	-	-	-	-	-	29	C,A,B,I,L
Barbastella barastellus	180	1	-	-	-	-	-	181	A,B,I,C,etc.
B. darjelingensis	-	-	-	2	-	-	-	2	A
Plecotus auritus	170	3	-	14	-	-	-	187	A,B,I,C, etc.
P. austriacus	260	31	7	-	2	1	-	301	A,B,I,D, etc.
Miniopterus schreibersii	210	167	3	72	69	-	1	521	B,A,D,C,G,E
Tadarida teniotis	-	-	-	1	-	-	-	1	C
Total:	3898	1244	46	272	700	332	8	6500	in 15 colls.

BAT MONTH: PUBLIC EDUCATION AT THE TACKAPAUSHA MUSEUM

Kenneth H. Balcom

The largest number of compaints about bats to the Nassau County Health Department are received during the month of October, apparently corresponding to increased swarming and migratory activities among Long Island bats (Connor, 1971). In anticipation of increased bat and human interactions, a public education program called Bat Month was developed by the Tackapausha Museum a regional natural history museum operated by the Nassau County Department of Recreation and Parks. Each October for the past three years, the museum has presented this unique program designed to contradict common sterotypes about bats. To do this we feature demonstrations involving live bats, a weekly children's program, an "Animal-of-the-Week," and workshops for students, health department personnel and the general public. In addition, a formal, fifty-minute presentation entitled "The Untold Truth About Bats" is available to school groups at other times of the year. Bat Buttons and fact sheets about bats are sold at the sales desk. T-shirts with bat motifs are also available to the visitors during special T-shirt day promotions.

This program has attracted considerable publicity from television, radio and newspapers all of which have cooperated in presenting bats in a positive way. The subject of rabies is given careful attention in all of the presentations and the importance of minimizing disturbances to bats, especially hibernating colonies is also stressed. Preserved bats, skeletons, slide programs and a live silver-haired bat all prove effective means of informing people about bats.

Connor, P.F. 1971. The Mammals of Long Island, New York, N.Y. State Mus. and Sci. Svce., Bull. 416. 78 pp.

Tackapausha Museum and Preserve, Nassau County Department of Recreation and Parks, Washington Avenue, Seaford, New York 11783.

A Technique for Electromyographic Study of Unrestrained Locomotion in Small Mammals Using Radiotelemetry

Timothy L. Strickler
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Durham, North Carolina 27710

In recent years numerous commercially available radiotelemetry units designed for use in electromyography have appeared on the market. These units allow single and multi-channel EMG recording in unrestrained animals, and thus represent an important technological advance in the study of animal locomotion. However, most of this equipment is useful only with relatively large animals (< 1kg.), and is quite expensive. The purpose of this communication is to describe the use of a custom built, light weight and relatively inexpensive radio transmitter in the study of electromyographic activity in small mammals.

The transmitter was designed by O.W. Henson (Dept. of Anatomy, University of North Carolina, Chapel Hill, North Carolina) for use in auditory system recording in flying bats, and its construction and use in this application were recently described (Henson and Goldman, 1978). I have used the same transmitter in this laboratory, without modification, to record EMG's in the laboratory rat (**Rattus norvegicus**) and in the crab-eating macaque **(Macaca fasciculars)**. The electrical components were assembled on a 1x10x15 mm piece of balsa wood, and the completed unit weighs less than 1.0g. including the power source (1.34 V. battery). The transmitting frequency can be adjusted over the entire range of a standard FM receiver using a variable inductor, and the transmitting distance is approximately 8 meters. The total cost of the electrical components is in the vicinity of $35.00 U.S. O.W. Henson is presently preparing a description and schematic of the transmitter for publication.

For exteriorizing the EMG leads, I used a silicone plug similar to that described by Altenbach (1972). Several modifications were made to Altenbach's procedure to facilitate the casting of the plug. Specifically, I made a mold from a 2 cm square piece of 1 cm thick plexiglass by first boring a 5 mm diameter hole through the center of the block. Using a 7.5 mm diameter milling bit, the initial hole was enlarged to a depth of 6 mm. On the opposite side of the block a 9 mm diameter milling bit was used to enlarge the initial hole to a depth of 2 mm. The block was then bisected to produce a two piece mold (see figure). To prepare the plug I removed the insulation from the terminal 1 cm of each of two 15 cm lengths of .025 mm diamter teflon coated platinum-iridium electrode wire (Medwire Corp.). Each uninsulated tip was crimped into the base of a 10 mm long female amphenol connector, and the connectors plugged into a two-pronged jig. The plexiglass mold was lightly coated with glycerine before each half was filled with Sears Silicone Adhesive Sealant. The jig, connectors and electrode wires were positioned in one half of the mold and the two halves were fastened together. After curing for 24 hours the mold was opened and the finished plug removed and trimmed of excess silicone.

I used the following procedure to implant the electrode wires in the rat. The animal was anesthetized with methoxyflurane, and the hair on its dorsal surface removed with a depilatory (Surgex). Two incisions were then made; one over the muscle to be recorded, and one in the midline over the upper lumbar vertebrae. I passed a long, large gauge hypodermic needle subcutaneously from the first incision to the second, and fed the two electrode wires into the tip of the needle. When the needle was withdrawn the wires were left in its path, with the tips accessible through the first incision. The silicone plug was sutured to the thick lumbodorsal fascia in three separate locations, spaced 120° apart. I then perfused the second incision with penicillin G and drew the skin up tightly around the neck of the silicone plug with single sutures. The tips of the electrode wires were prepared before the operation by removing the insulation from a 1 mm portion of their length, 5 mm from the tips of the wires. The tips were pushed through the muscle as close together as possible, so that the bared portion of the wire remained enclosed within the muscle. The insulated tips were tied tightly together with suture thread to prevent the electrodes from being withdrawn during locomotion, the area flushed with penicillin G and the wound closed. The fact that the tips of the electrode wires were uninsulated did not affect the ability of the uninsulated intramuscular portion of the electrode to record electromyographic activity in the muscle to which it was attached. This method of electrode placement was superior to several others which were used in preliminary studies, especially with respect to its long-term ability to reamin in place postoperatively.

Prior to recording, I adjusted the broadcasting frequency of the transmitter to correspond to a frequency range which was silent on the receiver (that is, a range within which no FM radio stations could be detected). Two male amphenol connectors were attached to the transmitter inputs during construction and then glued to the balsa frame. To record electromyograms these connectors were inserted into the silicone plug and the animal released. The transmitted isgnals were detected by a Kenwood stereo receiver (KR-2600), and recorded on a Gould 260 chart recorder. The animals' movements and the chart recorder output were filmed on a single video tape using the split screen feature of a special effects generator.

The electromyograms which were recorded from the rat gluteus superficialis and the monkey masseter using the system described above were virtually indistinguishable in quality from published records on non-telemetered EMGs. When the electrodes are properly inserted, noise in the system is minimal, and I noted no artifacts due to electrode wire movement between the plug and muscle. Although I have not yet quantified the EMG recordings, simultaneous recordings of masseter electrical activity and mandibular bone strain in the macaque showed that qualitative differences in the recorded EMG were related to differences in the strength of muscular contractions. Increased amounts of bone strain in the macaque mandible corresponded to increased activity in the masseter (indicated by greater EMG aplitude), and even without quantitative analysis, qualitative assessments of the relative strengths of muscular contractions can be made.

I plan to use this transmitter to record activity patterns in several bat shoulder muscles during flight, and I anticipate no major problems with it in this application. During several of our initial operations on rats wer failed to attach one of the two electrode wires properly, and discovered that when the bared wires are lodged in the subcutaneous tissue, the system can be used to record electrocardiograms.

The research reported here was supported by two grants from the Duke University Medical Center Research Awards Committee (393-5033; 393-5037). I thank Dr. O.W. Henson for his willingness to share the details of construction and operation of his transmitter with me, and Dr. William L. Hylander, Duke University Anatomy Department, for his co-operation in the macaque experiment.

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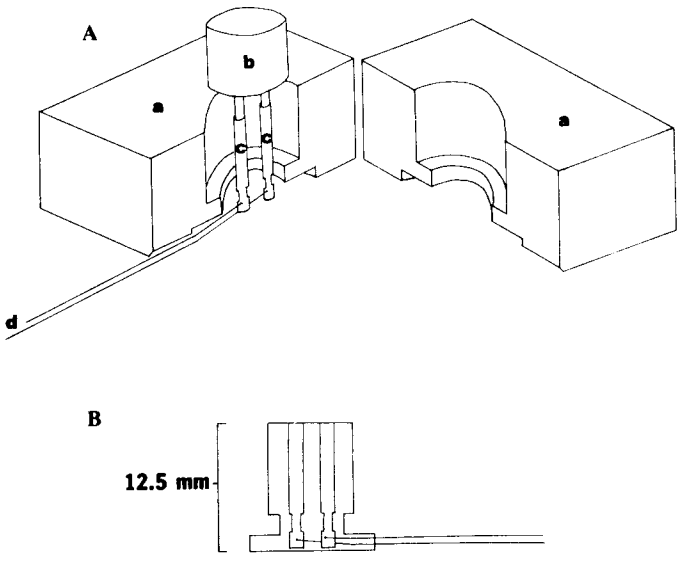

Details of Silicone plug construction. A. The two piece mold(a) with jig (b), amphenol connectors (c) and electrode wires (d) in place prior to filling the mold with silicone.

B. Lateral view of the completed plug.

BAT RESEARCH NEWS

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NEWS

In the most recent issue, I included a reference to a paper accepted for publication, specifically:

Potter, F.L. in press. Roosting patterns and social behavior in captive Carollia perspicillata. Journal of Mammalogy.

This was incorrect. The author is Fran PORTER, the mistake is mine.

QMC Instruments (229 Mile End Road London E1 4AA England) has sent me an advertisement for a new model of their bat detector. This is a QMC Mini Bat Detector which is pocket-sized and tuneable, and includes the following features: a sensitive microphone which covers all known animal ultrasound (10 to 160 kHz); a clip-on horn for direction finding and increased sensitivity; an automatic gain control for finding increased dynamic range; a built-in beat frequency oscillator for continuous or long signals; an output socket for an ear plug; and a self illuminated dial pointer. The machine is 130 by 70 by 40 mm, and runs on two AA cells. The cost, including packing and delivery charges, is 53.50 pounds sterling. They advertise 'special prices' for bulk orders.

Cavelights (523 Tomahawk Tr. no. 2309, Indianapolis, Indiana 46224) is selling lights which they call 'Midnight Sun'. I recently purchased a modified 'Midnight Sun' headlight (Model 1000) and have had occasion to use same in the field. The lamp features rechargable 'Gel/Cell' battery and a variety of bulbs to achieve different light brightness and life. I was very favourably impressed with the function of my light during a recent trip to Africa.

R.L. Peterson (Department of Mammalogy, Royal Ontario Museum, Toronto, Canada M5S 2C6) reported that although he found the recent article on Czechoslovakian bat research very interesting, he was unable to take advantage of the information on collections of bats during the recent conference at Brno. It turned out that when he arrived there he was informed that without prior permission it was not possible to view any of the collections. Persons counting on visiting the collections mentioned in the article should bear this in mind and make the necessary arrangements.

Kunwar Bhatnagar has written to say that he will be on sabbatical leave between 1 September 1978 and 31 July 1979. During this time his address will be: until 31 December c/o Dr. H. Stephan, Max-Planck Institut fur Hirnforschung, Neurobiologisches Abteilung, Deutschordenstrasse 46, Postfach 710 409, D-6000 Frankfurt/M 71 Niederrad, Federal Republic of Germany; and from 1 January to 31 July, c/o Prof. Dr. med. Winrich Breipohl, Institut für Anatomie, Universitätsklinikum Essen, Hufelandstrasse 55, D-4300 Essen1, Federal Republic of Germany.

The New York State Department of Health, Division of Laboratories and Research, recently held a Symposium on the Management of Bat Rabies as a Public Health Problem. The symposium was organized by John Debbie and Chuck Trimarchi on 6 and 7 June 1978 in Albany, New York. The programme included presentations from various State and Provincial Officials, as well as presentations from people working with bats. I found the Symposium very interesting and was particularly encouraged to find out that so many government officials were reluctant to authorize the use of pesticides in bat control. In my opinion, the Symposium represented an important effort to put the Public Health officials in contact with some bat researchers, and perhaps gave both groups a better idea of the views and problems that each faces. The organizers ofthe symposium are to be

heartily congratulated for their efforts. The following comment, overheard in the hallway, indicates that not all public health people are encouraging people not to use pesticides:

> 'You might as well kill them with DDT because if you just chase 'em away they'll die in the freezing weather anyway. The biologists should know this, they've studied their behavior' . . .

Fortunately, this remark, and similar broad-minded comments from some bat workers, does not reflect the prevailing attitudes of the Symposium.

Don Mairs of the Pesticides Control Board for the State of Maine recently contacted me about controlling bats in buildings. They have been swamped with requests for bat control this summer but have kept the number of applications of pesticides to an absolute minimum. They recommend exclusion of bats as the only effective means of control but find that slate roofs are a difficult problem. The Director of the Public Health Laboratory, Dr. Howard Lind, has supported the Pesticides Control Board in minimizing the application of pesticides as a means of controlling bats in buildings.

Jay P. Kennedy (Box 183 Myersville, Maryland 21773) has sent me the most recent issue of Frederick Underground (Volume IV, no. 4) which contains a number of articles about bats. Frederick Underground is a monthly publication of the Frederick Grotto of the National Speleological Society.

Carol Conroy, one of our subscribers, has moved, her new address is: 6400 Macarthur Blvd., Washington, D.C. 20016.

K. Usman (c/o Dr. M.K. Chandrashekaran, Unit of Animal Behaviour, School of Biological Sciences, Madurai University, Madurai 625821, India) is a teacher and is currently working towards his Ph.D. He is interested in Ecological and Ethological studies of insectivorous bats, and specifically the effect of light and seasonal variation on the activity of bats. He would be glad to correspond with others who are working in this area.

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* I am particularly grateful to the following people who assisted with the preparation of this section by sending me references:

Robert Barclay, Jackie Belwood, Kunwar Bhatnagar, Emmett Easton, Eleanor Fenton, Jon Swenson, and Harlan Walley.

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BAT RESEARCH NEWS

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NEWS

Kunwar BHATNAGAR, who is enjoying the tranquility of a sabbatical leave, has sent me a copy of a stamp recently issued by West Germany, that shows a fossil bat. The bat, **Palaeochiropteryx tupaiodon**, was recovered from the mine Messel near Darmstadt, which is near Frankfurt/M, is about 50 million years old, and is excellently preserved, showing impressions of some soft tissues in the abdominal region. The stamp was issued on 13 July 1978, it is 25.5 by 43 mm, and costs 80 Pf. Kunwar, and his colleague Dr. Heiko FRAHM of the Max-Planck-Institut fur Hirnforschung are to be thanked for drawing the stamp to my attention.

In April 1978, the Canada Diseases Weekly Report carried information about a suspected case of Human Rabies reported from Nova Scotia. The report was picked up by the Bureau of Epidemiology and Veterinary Public Health Coordinator, CDC (Center for Disease Control) Veterinary Public Health Notes. The victim, a 63-year-old man from Parrsboro, Nova Sootia, was admitted to a hospital in Halifax on 9 August 1977 with an undiagnosed acute neurologic condition, and he died on 11 August 1977. During the last 12 hours before his death the patient had to be moved to a private room because of his violent behaviour which was uncontrolled by sedatives. The postmortem findings revealed no definite cause of death, but the pathological evidence was consistent with the diagnosis of rabies, even though the symptomatology was not that of classical rabies. Investigation showed that the man had been bitten by a bat about a year before the onset of his illness, that he had not travelled outside of the province in the previous year and that the family dog did not have rabies. The time lapse between possible exposure in 1976 and the onset of illness in 1977 is within the outer limits of the incubation period for rabies. The connection between the possible bat bite and the disease seems somewhat tenuous. Editor.

F.A. MUTERE, the Dean of the Faculty of Science at Kenyatta University College (P.O. Box 43844, Nairobi, Kenya) has written concerning the official prices of the proceedings of the Nairobi Fourth International Bat Research Conference. In his letter of 23 August 1978, he indicated that the prices were as follows:

KShs	90.00
U.S.$	16.95
UK	6.80

Copies may be ordered from:

Sales and Distribution
Kenya Literature Bureau
P.O. Box 30022
Nairobi, Kenya

People who attended the bat conference in Albuquerque (abstracts enclosed in this volume), and who paid for copies of the Nairobi proceedings at a higher rate, will be repaid the difference between this lower price and the price they were mistakenly charged in August.

Denny G. CONSTANTINE (Veterinary Public Health Unit, California Department of Health, 2151 Berkeley Way, Berkeley, California 94704) sent the following bit of information from The British American of August 1978, page 34: "An anonymous conservationist has paid 24,000 pounds sterling for a derelict mansion which will preserve a rare kind of bat. The 25-bedroom house, in Woodchester Park, Strand, Glos., is overrun by Greater Horseshoe bats. When the building was put up for sale earlier this year by a forestry company, conservationists had feared a developer would buy it and scare the colony away. Now the bats will be allowed to stay".

Denny also sent copies of an exchange of letters between him and Dr. K.F. Girard of the Massachusetts Department of Health, concerning 'Bats, Rabies and DDT'. I am loathe to present the exchange in its entirety, but readers may avail themselves of the information in the letters by consulting The New England Journal of Medicine, of 20 April 1978, pages 915-916. The gist of the exchange is that Dr. Constantine and Dr. Girard have different opinions about the use of DDT in controlling bats in buildings.

The National Speleological Society Bat Subcommittee is producing a newsletter NIGHT FLYER (editor Thomas Lera, 5350 Amesbury Drive, no. 616, Dallas, Texas 75206) and I have recently received Volume,1, number 4. If you are interested in being included on their mailing list you should contact Thomas Lera.

There is relatively little in the way of news this time, in part because of the recently 'settled' postal strike in Canada.

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BIOLOGY OF BATS. Volume III. Edited by W.A. Wimsatt. New York, Academic Press. 651 pp. 1977. $59.00

This long awaited third volume of W.A. Wimsatt's series, published after a considerable delay, contains but five chapters in over 600 pages. It includes sections on social organization, acoustic orientation, the cardiovascular system, blood physiology and bats as laboratory animals.

J.W. Bradbury's chapter on Social Organization and Communication is perhaps the most readable and well organized section in this volume. Unfortunately, however, it suffers the most from the long delay prior to publishing and the references include only those as recent as 1974. This is disappointing considering the wealth of information on chiropteran behaviour which has been published in the last several years. None-the-less, the author stimulates the reader with some interesting hypotheses and relates the social organizations of bats to those typical of other mammals.

The chapter on Acoustic Orientation by A. Novick suffers primarily from its length (200+ pages), which is due, at least in part, to the continual repetition of the same examples in various sections of the chapter. The review is certainly very thorough and has an extensive reference list, as do all the chapters in the volume, but the language in places is rather technical and often requires several readings before becoming clear. The lack of any figures is unfortunate and sonagraphic representations of echolocation types might have been very useful. The author does pose some intriguing suggestions concerning the structure, function and evolution of various aspects of echolocation in bats.

F.C. Kallen's chapter on the Cardiovascular System, although also some 200 pages long, suffers less from this than the previous chapter because the author refers back and forth to various sections rather than needlessly repeating information. Again the content is highly technical in places but is accompanied by some truly excellent diagrams which do help clarify some points and add greatly to the work. Throughout the chapter, Kallen stresses the underlying typically mammalian structure of the bat's cardiovascular system while concentrating on the unique adaptations that these animals have evolved.

The shortest chapter is that by M.L. Riedesel on Blood Physiology. This brevity, as the author states, is due in part to the lack of information on the subject but also to the use of tables in summarizing the data presented. Again, the unique characteristics of bat blood are stressed and Riedesel demonstrates how the animals cope with the special problems they encounter in an interesting fashion.

For those comtemplating or already maintaining bats in the laboratory, J.J. Rasweiler's chapter on the subject will undoubtedly serve as a valuable compilation of information. Again, however, although there is an extensive reference list, only a few post-1973 citations are given. The chapter does include a long review of what is known about the natural feeding habits of bats and artificial diet recipies are given prominent coverage. As well a source list of products is given and should prove useful.

Undoubtedly one of the major criticisms of this volume has to lie with the numerous obvious typographical errors. In some places complete lines are missing and the number of misplaced or incorrect letters leads one to wonder about the spelling of unfamiliar words. This is inexcusable for a book costing nearly $60.

On the whole, this volume contains a wealth of information on the five subjects covered and should be very useful especially for new students of chiropteran biology. It is thus unfortunate that many will have to pass over the book because of its high price.

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**ABSTRACTS OF THE
NINTH NORTH AMERICAN and
FIFTH INTERNATIONAL SYMPOSIUM
on BAT RESEARCH**

**August 6-11, 1978
University of New Mexico
Albuquerque, New Mexico**

ROUSSETUS AEGYTIAGUS, E. GEOFFROY (CHIROPTERA) – A POTENTIAL RESERVOIR, HOST, AMPLIFIER AND DISSEMINATOR OF JAPANESE B ENCEPHALITIS VIRUS IN EAST AFRICA.

BY

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This study was designed, on the one hand, to complement previous bat serological findings by Addy et. al., (1975) and to determine the possible role **Roussetus aegypticaus** bats may play in the maintenance, amplification and dissemination of Japanese B encephalitis virus, on the other hand. For this purpose, 355 blood samples from **Roussetus aegypticaus** bats were collected and serologically examined for haemagglutination inhibiting (HAI) antibodies of five group B arboviruses, namely, West Nile (WN), Japanese B encephalitis (JBE), Entebbe Bat Salivary Gland (ENT), Bukalasa Bat (BB), and Dakar Bat (DB) viruses, and the results obtained revealed that the rate of JBE HAI antibody incidence was quite high, so that JBE virus could be considered to be in circulation among **Roussetus aegytiacus** bats in Uganda.

A further 20 **Roussetus aegyptiacus** bats were examined serologically for antibodies, this time to WN and JBE viruses only. Bats whose sera were found to contain no antibodies to both WN and JBE viruses, were infected subcutaneously with 0.1 ml of 3.5 $\log_{10}$ of JBE virus antigen suspension. Thus, blood samples collected for 15 consecutive days, from 15 sero-negative bats 24 hours after infection with JBE virus, revealed through Virus reisolation attempts that viraemia occurred 3 days (72 hours) after infection and persisted for a period of 7 days. Results of Serological tests on sera from the 15 JBE virus-infected bats, revealed that haemagglutination inhibiting and protective (neutralizing) antibodies made their respective appearances, 9 and 10 days after infection, i.e. at a time when viraemia had just begun to disappear.

From these findings, it was concluded that the bat species, **Roussetus aegyptiacus**, may be considered a potential reservoir host, amplifier and disseminator of JBE virus.

Epidemiological implications of these findings were discussed.

AGING BATS (MYOTIS DAUBENTONI) LEAVING HIBERNACULUM

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Earlier studies of epiphyseal fusion in hand bones have shown tht special X-ray techniques can be used to separate young from old bats for a longer time than when classical methods are applied (Baagoe 1977a + b).

X-ray studies of live Danish **Myotis daubentonii** showed that a large number of young can be distinguished when they leave their winter quarters in March-April, 8-9 months old. Further studies of museum specimens indicated that the

X-ray method can not be used much beyond this age.

The X-ray method has now been used in a study of the departure of **M. daubentonii** from the winter quarters in Monsted Limestone Pit, in Northern Jutland, Denmark. (Baagoe, Degn, and Nielsen in prep.).

Twice a week from late March to late April 1977 the only entrance to the mine was covered with a Tuttle trap and all bats leaving the mine that night were caught, counted, sexed, an marked temporarily by toe claw cutting. Approximately 2000 animals were handled. Samples from each night were X-rayed, and all bats were released shortly after, about 1000 bats were X-rayed.

By weighting the percentage of young obtained in each sample against the curve of departure based on the tuttle trap catches it is possible to calculate the percentage of young in the winter population (males 23.9%, females 18.2%). Also an attempt was made to estimate bat activity around the entrance by registrating the number of interruptions of laser beams.

Results from these investigations will be presented and comparisons will be made of departure curves for males and females, and young and old.

THE NATURE OF THE CHROMOSOMAL CONTACT ZONE IN **URODERMA BILOBATUM**

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The interaction at the zone of contact between two chromosomal races of the Peters' tent-making bat, **Uroderma bilobatum**, have been extensively examined. One parental stock is characterized by a 2n=38. G-banding analysis reveals that three chromosomal events (a centric fusion or fission, a translocation of a small acrocentric to the distal end of a large acrocentric, and a translocation of a medium sized acrocentric to a small biarmed element) explain the variation. Extensive hybridization occurs between the two cytotypes and $F_1$and backcross individuals are fertile. These data suggest that the magnitude of negative meiotic heterosis is not as great as expected in an individual heterozygous for one, two or three chromosomal changes. These data are interpreted as implying that rapid phyletic change can occur in the karyotype of a population without small deme size as a requisite. The canalization model (Bickham and Baker) of chromosomal evolution is discussed in light of these data.

ON THE EVOLUTIONARY ORIGIN OF VAMPIRE BATS

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G-banded chromosomal homologies of **Desmodus rotundus, Diaemus youngii, Diphylla ecaudata, Glossophaga soricina, Monophyllus redmani, Phyllonycteris aphylla, Erophylla sezekorni,** and **Brachyphylla nana** were analyzed using modified Hennigian cladistical methods in an effort to elucidate the evolutionary origin of vampire bats. Phylogenetic relationships within the Desmodontinae and a primitive karyotype of 2N=34; FN=60 are proposed for the subfamily. G-ganded patterns of Diaemus and Glossophaga are examined in relation to the karyotype previously proposed as primitive for the family Phyllostomatidae. Evolutionary implications are discussed and a cladogram incorporating chromosomal rearrangements is presented.

URINE CONCENTRATION IN THE POSTPRANDIAL INSECTIVOROUS BAT: A PROPOSED MECHANISM OF KIDNEY FUNCTION

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Insectivorous bats produce maximum urine concentrations after feeding. Previous investigators have reported maximum urine concentrations achieved by postprandial bats but have not studied the dynamics of the urine concentrating process. In this investigation, urine flow rate, urine concentration, and plasma concentration were determined before and after feeding in the little brown bat (Myotis **lucifugus lucifugus)** while exposed to an environmental dehydration stress. Renal osmotic clearnace was used to describe the dynamics of the urine concentrating process in the postprandial bat.

Urine flow rate tripled with feeding and remained elevated for 9.5 hours posprandially. At that time urine flow rate returned to the prefeeding level. Urine concentration doubled with feeding and remained elevated for at least 14.5 hours posprandially. Plasma concentration increased markedly within 2 hours of feeding and then increased more slowly over the remaining 12.5 hours of the stress exposure. The renal osmotic clearance of the bat, the product of urine flow rate and the ratio of urine to plasma osmolality, quadrupled with feeding. Osmotic clearance remained elevated until 9.5 hours posprandially when it returned to the prefeeding level. Changes in osmotic clearance paralleled changes in urine flow rate.

The postprandial bat varied the rate of production of a maximally concentrated urine. The direct relationship of somotic clearance and urine flow rate in the bat, when compared with theoretical considerations and actual data from other periodically feeding carnivores, suggests an increase in glomerular filtration rate (GFR) with food con-

The postprandial bat varied the rate of production of a maximally concentrated urine. The direct relationship of somotic clearance and urine flow rate in the bat, when compared with theoretical considerations and actual data from other periodically feeding carnivores, suggests an increase in glomerular filtration rate (GFR) with food con-sumption. The observed urine concentrating behavior of the postprandial bat kidney results from variation of GFR at urine flows below those which saturate the kidney's water reabsorption mechanism. The increased GFR with food intake provides for rapid and efficient removal of urea and solutes, and the decreased GFR after solutes and urea have been removed results in water conservation during intervals between feedings.

HABITAT USE BY SYMPATRIC SPECIES OF INSECTIVOROUS BATS

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I used the echolocation calls of insectivorous bats to assess patterns of habitat use in three discrete habitats in southeastern Arizona: desert grassland, oak-juniper scrub, and deciduous riparian woodland. The calls were picked up by a broad-band solid dielectric capacitance microphone and analyzed by a zero-crossing transient signal analyzer ('period meter'). An oscilloscope display of this analysis permitted identification of the bats and localization of habitats used for hunting. The effect of concentrations of insects on these patterns of habitat use were assessed by attracting insects to a portable ultra-violet light.

FINE STRUCTURAL OBSERVATIONS ON THE ADRENAL CORTEX OF ACTIVE AND HIBERNATING LITTLE BROWN BATS, MYOTIS LUCIFUGUS LUCIFUGUS

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Adrenal cortical fine structure was studied in bats collected in January and in mid-July. To provide functional correlates, cortisol levels were determined by radioimmunoassay from plasma of animals collected at the same periods of the year. The cells of the zona glomerulosa were generally similar in both time periods. They contained numerous fine lipid droplets, abundant mitochondria with tubular and plate-like cristae, a well-developed Golgi apparatus, a moderate amount of agranular endoplasmic reticulum, little granular endoplasmic reticulum and abundant free ribosomes. The cells of the remainder of the cortex had some features which were relatively constant. The small Golgi apparatus and the abundant mitochondria with predominantly tubular cristae changed little. Some of the other organelles changed dramatically. In January, the agranular endoplasmic reticulum was extensive, filling most of the cytoplasm between mitochondria, the Golgi apparatus and a few large lipid droplets. Some free ribosomes were present. In mid-July, large lipid droplets and ribosomes were more abundant;

July, large lipid droplets and ribosomes were more abundant; agranular endoplasmic reticulum was drastically reduced. Plasma cortisol levels (mean + SE) were 0.56 + 0.04 ug/ml in July and rose to 1.14 + 0.06 ug/ml in January (human range = 0.02-0.25 ug/ml). No speculation can be made concerning the unusual levels of cortisol, but the observed changes suggest that hibernation represents a stress and that the large quantity of agranular endoplasmic reticulum is a mechanism for synthesis of cholesterol not provided by diet as a hormone precursor while during the summer, dietary cholesterol is available. The abundance of ribosomes in summer could be in anticipation of synthesis of the membrane proteins for the agranular reticulum needed in the subsequent hibernal period.

FEEDING ECOLOGY OF A BAT COMMUNITY IN INDIANA WITH EMPHASIS ON THE INDIANA BAT, MYOTIS SODALIS

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Insect remains in feces were compared with the aerial, nocturnal insect community monitored simultaneously in three habitats used by seven species of bats for foraging from early summer through early autumn. The effect of seasonal and habitat differences in the insects available to bats as prey are discussed with respect to bat foraging behavior and prey selection. Changes in foraging are examined as adaptations of species to their respective niches, and as seasonal adjustments to changing food supply and to the varying energetic demands of life history phases such as lactation and migration. Various aspects of bat jaw morphology that accompany feeding strategies for different types of insects are also discussed.

PRELIMINARY INVESTIGATIONS AND MANAGEMENT OF THE INDIANA BAT (**MYOTIS SODALIS**) IN NEW YORK STATE

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Under a cooperative endangered species agreement with the federal government New York's Department of Environmental Conservation Endangered Species Unit has begun investigations into the status of the Indiana bat **Myotis sodalis** within New York and has instituted preliminary management plans for known **M. sodalis** hibernaculae. A continuing search of literature pertinent to **M. sodalis** in general with particular reference to New York is under way. Bat researchers and cavers throughout North America have been and are being contacted in an attempt to establish the history of bat research and banding in New York and to gather locations and information on known or possible **M. sodalis** hibernaculae in the state. Potential hibernaculae are being investigated and known hibernaculae are being monitored to determine bat numbers, cause of mortality of dead bats found and cause of any threat to the bat populations. Cooperative agreements between the Department and certain landowners are being formulated to provide enforcement of laws protecting **M. sodalis**, to restrict access to the hibernacula cave areas in winter, and to formulate a permit system for regulation of access to the caves throughout the rest of the year. Plans are also being developed for a research project to study the summer range of **M. sodalis** in northern New York.

ECHOLOCATION BEHAVIOR DURING HUNTING AND OBSTACLE AVOIDANCE IN THE BATS **MEGADERMA LYRA** AND **MYOTIS MYOTIS**: A COMPUTER ANALYSIS OF ECHOLOCATION SOUNDS RECORDED UNDER CONTROLLED BEHAVIORAL SITUATIONS

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In laboratory experiments bats had to perform prescribed tasks. The flight phases were photographed and simultaneously echolocation sounds were recorded to find out structural regularities. Sound analyses with power spectra, time-frequency spectrograms and ambiguity functions were performed on a PDP-11 computer. The data were interpreted using the theory of technical echolocation systems to explain the structure of the sounds.

The bat **Megaderma lyra** located living prey and acoustically simulated prey by passive listening but used active echolocation for detecting dead prey. During active orientation this bat characteristically used short groups of ultrasonic pulses. Three distinct groups could be identified and correlated with different orientation phases. The sounds differed in frequency spectra, pulse durations and repetition rates.

In the bat **Myotis myotis** the duration, harmonic structure, bandwidth and repetition rate of echolocation sounds changed in a predictable way during goal directed flights toward mealworms. The terminal buzz could be expanded by pulling the target away along the flight path.

In a systems theoretical analysis it could be shown that the observed sounds potentially would give nearly constant distance resolution and signal strength at the output of an optimum receiver independent of the hunting phase. This invariance of important echolocation properties is achieved by adapting the signal energy and the bandwidth-time product of the emitted sounds to the hunting phase. The data presented suggest that these bats obtain optimum results by providing their acoustic processor with cues best suited to the situation. This is accomplished through the choice of either passive or various forms of active orientation.

THE CHIROPTERAN VOMERONASAL ORGAN: ITS RELEVANCE TO THE PHYLOGENY OF BATS

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Situated bilaterally in the anteroventral nasal septum, a well-developed vomeronasal (Jacobson's) organ has been described in most mammals. Its widespread occurrence in the order Chiroptera has been recognized only recently. Classical anatomists, noting a striking constancy in its morphology and relations, considered that the vomeronasal organ might prove valuable in determining the phylogenetic affinities of animal groups; perhaps of greater value than either dentition of placentation. This investigation was undertaken to test the above hypothesis by character analysis of the vomeronasal organ with reference to the phylogeny of the Chiroptera. The degree of development of the adult vomeronasal organ complex has been taken for purposes of this discussion only as a primitive characteristic; the more developed the organ, the more primitive the group.

This study encompassed 37 species representing all of the chiropteran superfamilies and 13 of the 17 families, as well as 13 subfamilies of the 5 families. Specimens from families Crasconycteridae, Furipteridae, Myzopodidae, and Mystacinidae were unavailable. Snouts of adult bats were variously fixed, decaldified, embedded in Paraplast, and serially sectioned at 10 μm. Sections were stained with Gomori's one-step trichrome, periodic acid-Schiff (PAS) technique, or the Protargol silver method of Bodian.

The vomeronasal organ complex was found to be well developed in the families Phyllostomatidae (with the exception of **Brachyphylla**) and Mormoopidae. It is rudimentary in the families Rhinopomatidae, Megadermatidae, Rhinolophidae, and Thyropteridae. The organ complex is lacking in the investigated species of the families Pteropodidae, Emballonuridae, Noctilionidae, Nycteridae, Natalidae, Molossidae, and Vespertilionidae (with the exception of **Miniopterus**). The comparative morphology of the vomeronasal organ and its related cartilages are described and some functional implications discussed.

In general the vomeronasal organ complex tends to be represented in one form or another in the suborder Microchiroptera, but is lacking in the investigated species of the suborder Megachiroptera. Based on this finding and the fact that the organ is well represented in groups known to be closely related to bats (e.g. insectivores and primates), it would seem that the Microchiroptera share a closer affinity with other mammalian groups than they do with the Megachiroptera. The two chiropteran suborders thus would appear polyphyletic in origin.

The available data on the chiropteran vomeronasal organ complex supports the additional conclusions that (1) the phyllostomatid bats are most primitive, with **Brachyphylla** occupying a position much higher in the group. Vespertilionids are at the other extreme, with **Miniopterus** holding a basal primitive position. Rhinolophids and emballonurids appear between the other two microchiropteran superfamilies; (2) the well developed condition of the organ in frugivorous, nectarivorous, and sanguivorous microchiroptera strongly indicates an olfactory role in feeding, thus suggesting the order Chiroptera as an ideal group in which to study the still debated question of vomeronasal organ function; (3) functional anatomy of the organ does not support the speculation that bats perform the facial grimace called Flehmen; (4) the primitive ancestral bat may have had a fully developed vomeronasal organ; (5) in itself it may not appear to be a significant criterion but along with other characters the organ could provide a reliable index for determination of affinities within a group; (6) before any definitive conclusions are drawn, the organ needs to be studied in a much broader spectrum of species; and (7) considering primates and bats together, the organ is fully developed in the New World species, whereas it is either rudimentary or lacking in the Old World species.

REPRODUCTIVE STRATEGIES OF AN AFRICAN INSECTIVOROUS BAT COMMUNITY IN RELATION TO FOOD SUPPLY

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Periods of reproduction in several species of cave dwelling insectivorous bats in Central Africa were found to be seasonal. Pregnancy, lactation and weaning occurred during the wet season when insect abundance was at a yearly maximum; however, these activities were not highly synchronized between species suggesting a temporal partitioning of cave space. Food supply is hypothesized to be a limiting factor to polyestry.

FORAGING BEHAVIOR OF THREE SPECIES OF CARNIVOROUS GLEANING BATS (**PHYLLOSTOMIDAE**) IN PANAMA

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Three species of phyllostomid bats, **Trachops cirrhosus**, **Tonatia sylvicola**, and **Tonatia bidens**, all similar in body size, are reupted as being "Gleaning Carnivores". All three species were studied in Tropical Moist Forest on Barro Colorado Island, Panama. Differences in habitat selection, vertical stratification, and prey selection in these three species prevent

Tonatia bidens and perhaps the other two species feed considerably on insects that produce sound. The primary means of prey capture may be auditory signals produced by the prey and not echolocation.

BEHAVIORAL ASPECTS OF REPRODUCTION IN CHIROPTERA

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While reproductive cycles in the Chiroptera are grossly adjusted to ambient environmental cycles, one tends to forget the fact that there is a great degree of fine tuning and hence diversity in these cycles both within habitats and within species. Behavioral interactions, differential use of a common habitat, and variations in demographic strategies all combine to modulate the baseline seasonalities and thus generate these diversities. As an example of this process, I shall discuss several examples of species in which reproductive timing is modulated by behavioral and ecological factors. Within habitat diversity in timing can be shown in a suite of 4 emballonurid bats which we have studied in western Costa Rica. While roosting sympatrically these bats partition up the suitable foraging areas and thus experience different degrees of seasonal variation in food. The species with low seasonal variations have higher adult survivals and time reproduction to favor the parent at the expense of the offspring; those with more seasonal variations in food have lower adult survival and show timing which favors the offspring at the expense of the adults. Within species diversity will be demonstrated by comparing the differences in timing of the 2 sexes in epomophorine bats and within a single sex through dominance interactions in emballonurids. In the latter cases, the behavioral data suggest some interesting ties between access to resources and reproductive physiologies which deserve future study.

FLIGHT MECHANICS AND FUNCTIONAL MORPHOLOGY OF TWO BATS (NOCTILIO ALBIVENTRIA AND TADARIDA BRASILIENSIS)

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Tadaria brasiliensis has many musculo-skeltel specializations for efficient flight, characteristic of the family Molossidae. The greatly expended greater tuberosity of the humerus allows for a strong humero-scapular lock which enables the serratus anterior to partake in the initiation of the downstroke. The medial position of the coracoid process allows for an expended coracoid head of the biceps brachii for a powerful downstroke. The high aspect ratio wing results in less induced drag during flight. **Noctilio albiventris** was compared to **Tadarida brasiliensis,** because while it has a high aspect ratio wing, it lacks the many internal specializations of **Tadarida.** The differences in flight, as predicted by Vaughan (1959), due to the musculo-skeletal differences revealed through dissection, were confirmed with the aid of high speed strobe cinematography and still photographs taken in a flight room and a wind tunnel. **Tadarida** requires much less change in flight speed. Many other differences in the level flight and landing maneuvers were observed.

A COMPARISON OF NEONATAL VOCALIZATIONS AND HEARING IN FM AND CF BATS

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The adult moustache bat, **Pteronotus parnellii** uses long constant frequency (CF) pulses with a terminal frequency modulated (FM) component for echolocation. The auditory system is sharply tuned to the CF portion of the pulse. Newborn **Pteronotus parnellii** emit long (50 msec) audible (below 20 kHz) isolation cries often with FM components at the beginning and/or end. In addition shorter (about 15 msec) pulses are recorded. Auditory evoked potentials and single units recorded from the posterior colliculus show the infants to be most sensitive to frequencies around 20 kHz, but to be responsive up to 75 kHz, with a relative peak around 60-65 kHz, the range of the adult CF component.

Adult **Pteronotus suapurensis** emit short CF/FM pulses, and exhibit maximal sensitivity, but with less sharp tuning, in the range of the CF component (55 kHz). Newborn **P. suapurensis** emit pulses with both FM and CF components. While their absolute sensitivity is much less than that of the adults, they too have the lowest threshold for sounds around 50 kHz, with responses up to 100 kHz.

Adult pallid bats (**Antrozous pallidus**) and cave myotis (**Myotis velifer**) use short FM sounds in echolocation. Their auditory systems are broadly tuned to analyze these vocalizations. Infant pallid bats are born deaf, with evoked auditory potentials first recorded on day six to low frequency sounds. They emit only long FM isolation calls, with ultrasounds appearing at day 9. In contrast, the more precocial cave myotis can hear loud low frequency sounds at birth. Newborn **Myotis** emit audible isolation calls, but within a few days these become ultrasonic and a short orientation-type pulse appears.

ALLOMETRIC SCALING OF RESPIRATORY VARIABLES IN BATS

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The metabolic expenditures of bats inflight are twice as high as the maximum sustained metabolic levels of terrestrial mammals of comparable size (Carpenter, 1975. pp. 883 - 890 in "Swimming and flying in nature", vol. 2, T. Y. T. -Wu **et al.** editors, Plenum, N.Y.; and Thomas, S. P. 1975. **J. Exp. Biol.,** 63: 273-293.) These requirements are met aerobically, indicating that there must be a combination of adjustments in the oxygen delivery systems of bats to assure such high rates of oxygen supply. Scattered literature references present data that may reflect adaptations for increased oxygen delivery, but there has been no survey of any obvious avenues of increased oxygen supply for a wide array of bat species. This paper combines appropriate literature values and many new data in a systematic description of the various mechanisms for enhanced oxygen delivery in bats, including a consideration of the effect on such parameters of a wide range of body sizes.

Heart size, stroke volume and total lung volume increase with approximate linearity as body size increases, but all values are above those predicted by scaling equations (Stahl, W. R., 1967. **J. Appl. Physio.,** 22: 453-460) for mammals of similar size. Resting heart reates and ventilation frequencies decline allometrically with increased body size. However, standard metabolic rates are similar to those of other mammals; therefore the resting heart and ventilation rates are lower than predicted by Stahl's equations for mammals in general, and approach the values for birds (Calder, W. A., 1968. **Condor,** 70: 358-365). Blood capacity are independent of body weight but have mean values higher than those of other groups of mammals, except for marine species.

LEAD CONCENTRATIONS: BATS VERSUS TERRESTRIAL SMALL MAMMALS COLLECTED NEAR A MAJOR HIGHWAY

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Lead concentrations had never been investigatedin bats living near a major highway. Meadow voles, white-footed mice, and short-tailed shrews were trapped adjacent to the Baltimore-Washington Parkway and also near Monpelier Barn located 0.61 km NNW of the Parkway. Big brown and little brown bats were captured at their roosts in Montpelier Barn. Stomach contents and whole mammals were analyzed for lead by either furnace or flame atomic absorption. Average lead concentrations in bats exceeded those in terrestrial mammals except that Parkway shrews and little brown bats contained

statistically similar levels. Concentrations in Parkway shrews and white-footed mice exceeded those published previously for these two species. Estimated dosages of lead ingested by little brown bats, Parkway shrews, and Parkway voles equalled or exceeded dosages that have caused mortality or reproductive impairment in domestic mammals. Average lead concentrations in the bats and Parkway shrews equalled or exceeded those in field voles and/or field mice that showed lead-induced renal inclusions and/or renal edema and were collected at abandoned mine sites in Wales.

THE NEW ZEALAND SHORT-TAILED BAT (MYSTACINA TUBERCULATA GRAY, 1843; FAMILY MYSTACINIDAE): A REVIEW OF PRESENT KNOWLEDGE

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Research on the New Zealand short-tailed bat is reviewed from published and unpublished studies. The monotypic family Mystacinidae, presently aligned with the Vespertilionidae and Molossidae, is considered to be best re-associated with the Emballonuridae and Noctilionidae. The two subspecies of **M. tuberculata** are retained pending elevation to specific status. The dichotomy of **Mystacina** stock probably occurred in the Pliocene with the lesser short-tailed bat (M.t. **tuberculata)** and the greater short-tailed bat **(M. t. robusta)** evolving north and south respectively of the Pliocene Manawatu Strait at the onset of Pleistocene cooling. **Mystacina** has no fossil record and its origin and phylogeny are uncertain. The possibilities of an early to mid-Tertiary origin in Antarctica, Australia or South America and an earlier Cretaceous origin in Gondwanaland are discussed.

Several adaptations of **Mystacina** for terrestrial behaviour, such as the manner of folding and protecting the wings and the basal talons on the claws of the robust feet, are unique among the Chiroptera. These assist the bat while feeding on fruit, nectar, pollen and flightless arthropods as well as for roosting. Colonies are usually in hollow trees or caves, but may also be in other terrestrial sites, such as abandoned seabird burrows, holes in cliffs of volcanic pumice, or bat-excavated tunnels in the decayed floors and sides of fallen hollow kauri trees. The short, erect, velvet-like fur of this bat and the unique talons on the claws of the toes and thumbs are probably adaptations for this crevice-dwelling and tunnel-digging behaviour. The absence of mammalian predators and the lack of competition from other mammals throughout the Tertiary are thought to have significantly influenced the evolution of the terrestrial and arboreal adaptations of this bat.

Mystacina is a relatively small bat. Adult male and female lesser short-tailed bats weigh about 12-15 g and have forearm lengths of 40-43 mm. A female bat with full-term foetus weighed 20 g and a young bat soon after birth weighed 3.2 g. Greater short-tailed bats have not been weighed, but probably weigh 25-35 g, with forearm lengths of 44-49 mm.

Lesser short-tailed bats at latitude 35 S are monoestrous and monotocous. Copulation probably occurs in autumn and parturition in summer (December-January). Reproductive data for greater short-tailed bats at latitude 47 S suggest that these bats may be polyoestrous and monotocous with parturition occurring from spring to autumn.

Mystacina feeds seasonally on forest fruits, pollen and nectar, and probably the year round on flying and flightless arthropods. The family Mystacinidae thus joins the two tropical families Phyllostomatidae and Pteropodidae as the only families, of the 19 presently recognised in the Chiroptera, to feed wholly or partially on plant food. The partially extensile tongue of **Mystacina** has a brush of fine papillae on the tip suggesting modification and specilisation for a nectar, pollen and fruit diet.

Parasites and associated fauna of **Mystacina** include the recently described family, genus and species of bat-fly **(Mystacinobia zelandica)** which, unlike all other bat-flies, feeds on the fruity guano in the roosts and not on bat blood. **Mystacina** also has an undescribed tick **(Argas (Carios)** sp.), about 6 undescribed species of fur mites, and a recently described subfamily, genus and species of sarcoptic wing mite **(Chirophagoides mystacops).** This bat appears to have no streblids, nycteribiids, fleas or parasitic bugs, nor have any demodicid hair follicle mites, cestodes, nematodes, or blood parasites been found.

FIELD ACTIVITY OF A COLONY OF **EPTESICUS SEROTINUS**

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A colony of 15 to 20 female **Eptesicus serotinus** has been studied in the field 1976 to 1978 by vision and by the ultrasonic detector described in J. Mamm. 58: 226-229. Observations have been made on foot, only in one place an automatic registration unit has been constructed, using a modified detector.

The bats leave the roost a quarter to half an hour after sunset, and often follow a rather fixed route 400 m northeast and then spread out. Animals from the roost are recorded up to 1 km away, but as the roost is in the southern part of the home range, this only covers 2 km^2. It consists of open farmland with scattered trees and hedges, forest edges and closed beechwood, which is all utilized.

The home range of the colony is not divided in individual territories. Sometimes even the whole colony is found in one small area. More often they are a few together or even alone. They never fly in the same small area for more than half an hour at a time, and they do not use the same area regularly through the whole season.

Also during the night bats rest in the roost. They may take up to three rounds in the field per night, but if the weather is unfavourable they omit the last one or two. Activity stops more than an hour before sunrise.

Some of these results do not agree with those of Nyholm (Ann. Zool. Fenn. 2: 77-123). He found for example that **Myotis mystacinus** and **M. daubentonii** had individual territories in woodland until the beginning of August, then hunting together in open areas.

SYSTEMATIC AND EVOLUTIONARY IMPLICATIONS OF GENIC VARIATION IN THE MASTIFF BAT, EUMOPS (CHIROPTERA: MOLOSSIDAE)

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Starch-gel electrophoresis was used to characterize the levels of genic divergence associated with morphologically derived species groupings. A total of 24 loci encoding for 14 proteins were identified and scored in the following species: **Eumops glaucinus, E. auripendulus, E. underwoodi, E. bonariensis, E. hansae,** and **E. dabbenei.**

A phenogram of genetic relationships is remarkably like the phenetic classification proposed by Eger (1977), but with two noteable exceptions. Electrophoretic data indicate that **E. auripendulus** and **E. glaucinus** are genetically less closely allied than morphological evidence would suggest. Also, **E. dabbenei** shares a 95% Rogers' similarity coefficient with E. underwoodi. We suggest that the markedly larger size of **E. dabbenei** reflects an independent rate of change in morphology that was made possible through the geographic isolation of this race and which proceeded without concomitant genic evolution. Low levels of heterozygoisty and low numbers of polymorphic loci point to the fact that **Eumops** is apparently conservative in its genetic make-up; as such, high similarity values between even widely separated geographic localities is expected.

E. hansae appears as divergent genically as it is morphologically. Its degree of differentiation is sufficient to make its inclusion within the genus **Eumops** suspect and worthy of additional study.

MORPHOLOGICAL CHARACTERISTICS AND DISTRIBUTION OF PLECOTUS AURITUS AND PLECOTUS AUSTRIACUS IN SOME REGIONS OF YUGOSLAVIA

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The cranial and body dimensions of **Plecotus auritus** and **P. austriacus** from Yugoslavia, and cranial dimensions of specimens from other European countries were investigated. For the first time the partial distribution of **P. auritus** in Yugoslavia was established, and a delimitation between different populations of **P. austriacus** in western and southern parts is given. The dimensions of **P. auritus** are somewhat larger than in other European specimens, but this difference is not significant. This species occurs in lowlands of Northern Yugoslavia, and highlands of Western and Central Yugoslavia. Its range toward the most eastern parts of the country has to be established. In some regions the area of distribution of **P. auritus** is sympatric with those of **P. austriacus**. Looking at the dimensions of **P. austriacus** it was found that population with large dimensions occurs in northern and southeastern regions of Yugoslavia, in Central Croatia and Bosna an intermediary population between those with large and small dimensions, and on coastal mainland and the islands of the Adriatic the population with small dimensions only. This later population with small dimensions is described as a new subspecies **P. austriacus kilombatovici**. For better discrimination of **P. auritus** and **P. austriacus** as well the subspecies of the later named species, scatter diagram the length of interorbital constriction plotted against the length of tympanic bulla is given. The baccula of Yugoslav specimens of both species are described, and also the chromosomes of insular population are analysed. Karyotypically the insular specimens do not differ from **P. austriacus** from Poland and Tunisia except that the fourteenth pair represents possibly the small biarmed chromosomes.

CHARACTERISTICS OF CIRCADIAN ACTIVITY SYSTEMS IN NEOTROPICAL BATS

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Comparative studies on different neotropical bat species such as **Molossus ater** (M.a.), **Molossus major** (M.m.) belonging to the family Molossidae, **Phyllostomus discolor** (P.d.), **Glossophaga soricina** (G.s.), **Sturnira lilium** (S.l.), **Artibeus lituratus** (A.l.) and **Artibeus jamaicensis** (A.j.) belonging to the Phyllostomidae have shown that circadian systems even for exclusively tropical Chiroptera can be distinct from one another. The period lenth of the free-running circadian rhythm depends in each case on the light intensity and follows Aschoff's rule. Within the light intensity interval from 10^{-7} lx (physiological darkness) to about 10 lx, changes remarkably for both insectivorous Molossidae, M.a. and M.m. (22,2 - 24,6 hrs for P.d. and G.s.).

Corresponding to a larger plasticity of the circadian systems, the range of entrainment of the biological oscillation above 20-30 hrs in a LD-cycle of 10^{1}: 10^{-4} lx is also very large for both Molossus species. For P.d. the average lies between 23,5 and 27 hrs, for S.l. between 22,5 and 27, and for G.s. only between 24 and 25 hrs. By reducing the intensity of the Zeitgeber-LD to 10^{-2}:10^{-4} lx the range of entrainment decreases to 22-26 hrs for M.m. and 23-25 hrs for a M.a.. On the contrary, P.d. and G.s. under the same conditions can only synchronize by 24 hrs light-dark cycles.

After a phase shift of a synchronizing LD-cycle 12:12 hrs (10^{1}:10^{-4} lx) of =+ resp. -8 hrs species with wide variation range of the period lenth and range of entrainment resynchronize very fast. bats with a small variation range of the period lenth need in contrast a larger number of transient-cycles in order to resynchronize (G.s. up to 22!). Thereby strong asymmetry effects occur. Reduction of the intensity of the Zeitgeber by decreasing the light

intensity in the light phase to 10^{-2} lx leads to a remarkable elongation of the period of resynchronisation for all species.

Besides the range of entrainment and the speed of resynchronisation, also the phase position of the entrained circadian rhythm and the overt activity pattern depends on the light intensity during the light and dark phase of the LD-cycle. In this case the light intensity does not only function as a controlling exogenous factor over the circadian system, but also directly modifies the respective circadian activity level. The various bat species differ strongly from one another in regard to the extent of this masking direct effect of light intensity. Whereas the course of gross locomotary activity by P.d. doesn't change essentially through changes of the light intensity in the D-time, the activity pattern of A.I. can be varied optionally by this means. Under natural lighting conditions this strong direct photosensitivity of the activity pattern of A.I. leads to strong lunarperiodical changes of the activity pattern and to corresponding periodical masking of the phase position of onset and end of activity.

NEURONS WHICH DETECT SONAR ECHOES AND CODE ECHO TIME DELAYS IN THE AUDITORY SYSTEM OF THE BAT EPTESICUS FUSCUS

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We have recorded from single neurons in the inferior colliculus, auditory cortex, and nucleus intercollicularis of the echolocating bat, **Eptesicus fuscus.** Previous research by Nobuo Suga and by George Pollak and his colleagues has shown the existence of neurons in the inferior colliculus that mark the time of occurrence of outgoing sonar sounds or returning sonar echoes. We have found neurons in the nucleus intercollicularis which respond only to echoes within a small span of echo time delays. They have characteristics that might be expected from knowledge of target-range perception by echolocating bats, and they may code target range in a spatial map in the brain. These neurons may provide information about distances to objects to the multimodal spatial system in the superior colliculus. These observations, together with the extensive research by Suga and his colleagues, indicate that the bat's brain contains maps of the spatial positions of sonar targets in the bat's environment.

THE INFLUENCE OF MOTH HEARING ON PREY CAPTURE BY INSECTIVOROUS BATS

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A large variety of moths in several families has ears which are sensitive to the ultrasonic cries of bats. Physical characteristics of the moths' ears influence the hearing ranges of the moths. For example, a typical North American arctiid, geometrid, or noctuid moth has an ear which is broadly tuned from 30 to 60 kHz, and with this the moth could detect an echolocating **Myotis lucifugus** or **Eptesicus fuscus** at approximately 30 m. The same moth could not detect a bat using a high intensity 100 kHz CF echolocation call beyond 1 m. In this paper we report the results of a study which assessed the incidence of bats using different echolocation strategies and the tuning of moths' ears from a study site in west Africa.

COMPARATIVE MORPHOMETRY OF THE ACCESSORY OLFACTORY BULB IN BATS

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Serial sections of bat-brains of 66 species belonging to nine different families were investigated for the presence of an accessory olfactory bulb (which receives its sensory afferences from the vomeronasal organ).

The occurrence of this brain structure is widespread among the south american bat family of Phyllostomatidae, where it could be observed in 23 out of 26 species. It is also present in vampire bats (Desmodus rotundus and Diphylla ecaudata) and in the vespertilionid bat Miniopterus schreibersi.

The size of the accessory olfactory bulb varies between 0,022 mm in Sphaeronycteris toxophyllum and 0,616 mm in Phyllostomus discolor. A comparison of the volumes of accessory olfactory bulb versus body-weight in a double logarithmic scale (allometric method) shows that this structure is best developed in the phyllostomatid subfamily of Glossophaginae, followed by Phyllostomatinae, Carolliinae, Stenoderminae and Desmodontidae, whereas it is of minute size in Chilonycteris rubiginosa and Miniopterus schreibersi. Within the Phyllostomatidae, a positive correlation between presence of this brain component and feeding habit on fruits, pollen or nectar becomes obvious, supported by the fact that the insectivorous Chilonycteriinae Mormoops megalophylla and Chilonycteris personata have no accessory olfactory bulb. Its absence seems also to be the rule in strictly insect-eating families, e.g. Emballonuridae, Molossidae and, with exception of Miniopterus schreibersi, the Vespertilionidae.

ECOLOGY OF THE STRAW-COLOURED FRUIT BAT (EIDOLON HELVUM KEER, 1792) IN SOUTHERN NIGERIA

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The distribution and the feeding and roosting activities of the straw-coloured fruit bat **(Eidolon helvum** Kerr) were determined from visual observations. Studies on population structure and reproduction were made on bats collected periodically with gun-shots.

The straw-coloured fruit bat was found living gregariously in isolated colonies comprising of thousands of individuals in several parts of Nigeria. The distribution is not static, migrations related to persistent disturbance to the population, food shortage and other less understood causes being frequently observed. Roosts are very noisy and are usually situated in groves and thickets close to human habitation in places like churches, parks, markets, local shrines and marshy areas which offer sanctuary to the bats. The roosting period is 6.00 a.m. to 7.00 p.m. local time and the trees most favoured for roosting are those that project above the surrounding vegetation.

Feeding takes place mainly between 7.00 p.m. to 6.00 a.m. when the bats are widely dispersed from around the roost to distant places to obtain suitable plant food. The diet consists exclusively of a variety of ripe succulent fruits, floral parts and leaves.

Mating and fertilization occur mainly in May to July with about 57 - 91% of females being pregnant. The oviduct of the freshly-pregnated female weighs, on average, about 0.3 g and retains this weight until about the end of November. The average weight of the oviduct increases from about 2 g in early December to about 40 g in February. Babies are born in March to May at 30 - 60 g body weight. Each mother continuously carries about her single baby until June or July when the babies are weaned at 120 - 150 g body weight.

E. helvum is of tremendous importance in the local economy. Firstly, by its roosting activities these bats cause mechanical damage, and often death to some economically important trees like oil palm **(Elaeis guineensis),** Iroko **(Chlorophoro excelsa)** and teak **(Tectona grandis).** Feeding on fruits like mango, pawpaw, guava, pea, plantain and banana cause yield losses and a qualitative devaluation of fruits. Faeces from thousands of bats cause much filth and stench in the environment of roosts and the clamour of bats in roosts or while feeding near human habitation is very exasperating. Bats are however an important item of the diet in all localities where they occur. They also serve as pollinating agents for a number of economically important trees in the families Moraceae and Bombacear.

THE HIBERNATION BEHAVIOUS OR RHINOLOPHUS FERRUMEQUINUM IN RELATION TO AGE, SEX, AND EVOLUTIONARY HISTORY

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In termperate latitudes the winter behaviour of the Rhinolophidae differs considerably from that of the more typically hiberanting Vespertilionidae. For example in England, where both families are represented, torpid rhinolophids roost almost exclusively in caves, while many vespertilionids do not. Here, relative to vespertilionids, they select higher and more constant temperatures, assume a different type of posture, and show different patterns of clustering behaviour.

During several winters in southern England, a number of behavioural adaptations to torpor have been measured in a small banded population of **Rhinolophus ferrumequinum.** These include (1) temperature selection, (2) posture, (3) 'physiological clustering' (contact), (4) 'social clustering' (proximity), and (5) geographic distribution. In addition homeothermic activity patterns (e.g. arousal and feeding) have been recorded and inferred.

It is found that significant individual differences in these traits are functions of sex and fat reserve weight. An attempt is then made to interpret **Rhinolophus** hibernation behaviour in terms of (1) optimisation of foraging efficiency and fat reserve conservation, (2) the different reproductive roles of immatures, males, and females, and (3) morphological and perhaps physiological constraints resulting from the origin and expansion of the Rhinolophidae in the tropics.

ROOSTING ECOLOGY OF INDIAN DESERT RAT-TAILED BAT, RHINOPOMA KINNEARI, WROUGHTON

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The roosting ecology of the Indian Desert rat-tailed bat, Rhinopoma kinneari Wroughton (Syn. R. microphyllum Brunnich) Rhinopomidae, an insectivorous bat was studied in the Mandore Garden, 10 km North of Jodhpur. This place harbours a large population of bats from March to mid-October of each year. During September and early October, they migrate to their winter roosting sites.

These bats have a great affinity ot their niche and do not leave it even when disturbed. They roost individually on the ceiling, in groups (20-or more), in the corner of the compartments (rooms) and at the junction of the ceiling with the walls of the compartment. Temperature and relative humidity was recorded outside and inside the tunnel during the course of the present study (1973-1975) which revealed that bats by virtue of their nocturnal habit do not face the problem of extreme diurnal variation of temperature and relative humidity.

During most of the day the bats remain inactive, but respond immediately to any external stimuli as light, sound etc. Their activity starts 2-2½ hours before the sunset (when it is hottest inside the tunnel) and they start moving from the eastern end to the western end of the tunnel. Their circadian rhythm has been correlated with the environmental conditions.

RENAL FORM AND FUNCTION IN BATS: AN ECOPHYSIOLOGICAL POINT OF VIEW

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In the last ten years, an ecophysiological approach has prevailed in chiropteran literature dealing with renal form and function. Studies have been concerned primarily with relationships between the ecological distribution and habits of bats and their ability to conserve urinary water. Based on these studies, three factors can be shown to be correlated with renal performance: 1. dietary intake of protein, 2. body size, and 3. ecological distribution. Further explanation of variation in renal concentrating ability in bats will be accomplished most readily by determining when these maximal capacities are employed under natural conditions. Ways to interpret concentration values of field-collected urine will be discussed.

FOETAL MEMBRANES AND PLACENTATION IN THE CHIROPTERA

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The foetal membranes and placentation in one or more representatives of the families Pteropidae, Rhinopomatidae, Emballonuridae, Megadermatidae, Rhinolophidae, Hipposideridae, Vespertilionidae and Molossidae are described. Amniogenesis occurs exclusively by cavitation in **Scotophilus temmincki**, primitive amnion by cavitation but the definitive amnion by fold formation in most other species and by the development of two cavities - a primary and a secondary amniotic cavities - in **Cynopterus sphinx gangeticus.**

Three main trends are noticed in the development of the yolk sac - (i) the abembryonic segment of the yolk sac persists until term in **Megaderma lyra lyra** and all vespertilionids, (ii) the splanchnopleure, which gets completely separated from the chorion, ultimately occurs as a collapsed bag with highly folded walls composed of hypertrophied cellular elements in **Rhinopoma kinneari, Taphozous longimanus, Rhinolophus rouxi** and all hipposiderids, and (iii) the free yolk-sac splanchnopleur gets converted into a solic, vascular gland-like structure in which the endodermal cells become hypertrophied and occur in the form of acinus-like groups without lumina in all pteropids and **Tadarida aegyptiaca**.

The allantoic vesicle, which is large until about mid-pregnancy in all the species, becomes progressively reduced until it is either totally lost or is reduced to a narrow duct or a solid cord within the umbilical cord.

The definitive allantoic placenta is located mesometrially in Pteropidae, Rhinopomatidae, Megadermatidae, Rhinolophidae, Hipposideridae and Molossidae, laterally with the mesometrial moiety being converted into a haematoma in Emballonuridae and antimesometrially in all Vespertilionidae. The placenta becomes double discoidal during the last quarter of pregnancy in Rhinolophidae, Hipposideridae and **Miniopterus schreibersii** among Vespertilionidae. A discoidal, labyrinthine haematoma-like structure develops within each placental disc in **Miniopterus schreibersii.**

The placenta is vasochorial in all the bats except Rousettus leschenaulti among Pteropidae, all vespertilionids and Tadarida aegyptiaca in which it is haemochorial. The nature of the trophoblast, which forms a part of the placental barrier, differs in different species.

EVOLUTIONARY GENETICS AND SPECIATION IN HYBRIDIZING CYTOTYPES OF THE TENT-MAKING BAT, URODERMA BILOBATUM

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Genetic variation at 22 loci was examined for 407 individuals of **Uroderma** representing two species and three chromosomal forms. **Uroderma magnirostrum** (2n=36) is specifically distinct from other **Uroderma.** The genic data support specific status of U. **magnirostrum** revealing maintenance of genetic integrity in this species when sympatric with other **Uroderma.**

Uroderma bilobatum davisi (2n=44) and **U. b. convexum** (2n=38) are parapatrically distributed and form a 200 km hybrid zone along the western versant of Middle America from central El Salvadore to northwestern Nicaragua. Distribution of marker alleles at 11 polymorphic loci indicates that these two cytotypes are maintained as distinct genetic units (species) despite the absence of an effective premating isolation mechanism. In no case was a marker allel for either cytotype detected in a population of the other cytotype outside of the chromosomally defined hybrid zone. Genic similarity for the two cytotypes is unusually high, S = .972, and is interpreted as suggesting sympatric speciation via a chromosomal mechanism for **U. b. davisi** and **U. b. convexum.**

The genic and chromosomal data for the **U. b. davisi-U. b. convexum** complex do not indicate biological parameters consistent with currently accepted hypotheses for chromosomal speciation. Electrophoretic data reveal that functional vagility is high in **Uroderma.** Additionally, there is sufficient gene flow between populations of each cyto-

type to suggest that populations of **Uroderma** are not subdivided into small demes or adapted to high levels of inbreeding and therefore evolution of these bats is unlikely to be dependent upon the effects of genetic drift. The presence within the hybrid zone of at least two successful generations of backcrosses and of reconstituted parental karyotypes is evidence that individuals heterozygous for several chromosomal rearrangements do not of necessity experience significantly reduced fecundity.

A model of chromosomal rearrangement incorporation and subsequent speciation based on the assumption that chromosomal rearrangements provide increased fitness is presented. According to this model, incorporation of a chromosomal rearrangement is the result of the fitness conferred to heterozygous individuals by the new arrangement overbalancing the negative meiotic effect of chromosomal rearrangement heterozygosity. Subsequent selection for the rearranged homozygote which possesses the adaptively superior karyotype but does not experience the gametic loss resulting from chromosomal heterozygosity drives the rearrangement to fixation. This model is applicable to organisms without regard to biological characteristics of initial deme size, population locality, inbreeding, drift or bagility.

LONG LATENCY, "SUBTHRESHOLD" RESPONSES OF SINGLE UNITS TO THE CF COMPONENT EMITTED BY THE SHORT CF-FM BAT, PTERONOTUS SUAPURENSIS

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Neural adaptations for the use of the constant frequency (CF) component of orientation sounds are much less conspicuous in bats emitting short CF components (short CF-FM bats) than in ones using long (10 msec) CF components. However, we report here a previously undescribed auditory response pattern that appears to be related to the short CF component in the neotropical bat, **Pteronotus suapurensis**. In the posterior colliculi of this species, many single units that were tuned to, or slightly above, the frequency of the emitted CF components (about 52 kHz and 78 kHz, the dominant harmonics) showed the following behavior: At moderate intensities, these units, like all others in the colliculus, responded to tone pips within a given frequency range with a short burst of spikes at a latency of 3-10 msec. As a tone pip was reduced in intensity, the response area narrowed and the unit eventually ceased firing even at its best frequency. As intensity was further decreased below this threshold value, however, the unit began responding again, at a greater latency (12-20 msec). This was often a very vigorous response, associated with a negative slow wave also not seen at higher intensities. The threshold of the late response was as much as 35 db (average 14.4) lower than that of the short latency response. The long latency response, which was seen only in units responding around the frequency of the CF component, was often most vigorous and of lowest threshold at CF durations of 1.5 - 3 msec, approximately the duration of the bats' CF emission. The late responses sometimes showed different directionality than the short latency responses of the same units. Recovery cycles of the late responses were very long. Long latency responses of this type were not found in other species studied, including **P. parnelli**.

Although the circuitry leading to these late responses is not known, it seems likely that they are involved in analysis of the CF component of echoes, perhaps in initial target detection.

MALE REPRODUCTIVE CYCLES IN HIBERNATING BATS

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The seasonal reproductive cycles of certain male bats that hibernate represent unusual and unique reproductive strategies. They are characterized annually by a total temporal separation of primary and secondary sexual functions: primary spermatogenic acitvity of the testis occurs only during the summer or sometimes into early fall; in contrast, secondary sexual activity related to maximally-stimulated accessory organs, libido and associated mating behavior occurs later during a breeding period which in most species overlaps the hibernation period. Undoubtedly, the asynchronous nature of circannual reproductive periodicity, observed only in bats of the families Vespertilionidae and Rhinolophidae, is largely a physiological response to hibernation. When the cycles of the seminiferous epithelium, the interstitial cells of Leydig, and the accessory reproductive organs are examined together and in relation to the associated conspecific female strategies of either delayed ovulation or delayed implantation, interspecific differences in the response to hibernation are apparent. For example, Leydig cell activity may occur only during spermatogenesis in some species, whereas it seems to be maintained throughout the hibernal interval in others. In addition, accessory organs may experience involution either before or after the hibernation period. Nevertheless, all species exhibit temporal separations of spermatogenesis and accessory reproductive function. Thus, the peculiar asynchronies or reproductive cyclicity observed in bats that hibernate are not only unusual strategies among bats overall, but also are apparently unique relationships in mammalian reproduction in general.

VOCAL COMMUNICATION BY **RHINOLOPHUS FERRUMEQUINUM**

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Over a period of two seasons a high-frequency microphone has been placed in the summer roost of a colony of Greater Horseshoe bats and recordings were made of their vocalisations. This paper describes some of the types of call produced and compares their structures with the echolocation cries used by the same bats in and around the roost. Comparisons are drawn between these calls and those of other species of **Rhinolophus** in captive, hand-held situations.

ONTOGENY OF THERMOREGULATION CORRELATED WITH OXYGEN CONSUMPTION IN THE PALLID BAT (ANTROZOUS PALLIDUS) AND THE CAVE MYOTIS (MYOTIS VELIFER).

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The body temperature and oxygen consumption of 19 infant pallid bats were recorded over a wide range of ambient temperatures, from 24 C to 4 C. Very young bats less than 10 days old are essentially poikilothermic, unable to maintain a high body temperature as the ambient temperature drops. Ordinarily, such infants would remain close to the mother in a roost or in flight. After several weeks the infants are able to maintain a high body temperature at

increasingly low ambient temperatures. The onset of thermoregulatory ability is correlated with increasing insulation, i.e., fur, and shivering. Recorded oxygen consumptions reveal that in the early developmental stages of thermoregulation high body temperature is maintaingd at a very high metabolic cost with oxygen consumption per gram body weight under cold stress increasing drastically at about age 23 days. More mature infants are capable of maintaining a high body temperature at lower ambient temperatures approaching freezing, but this is still achieved very inefficiently. Oxygen consumption per gram body weight at room temperature (24 C) increased from birth to age 18 days, peaked between 18 and 26 days, then decreased until it reached and remained at the adult level by age 32 days. Adult pallid bats can maintain their body temperature over a broad range of ambient temperatures without a great metabolic expenditure. Body temperature and oxygen consumption of seven infant cave myotis were recorded. These showed a sharp increase in oxygen consumption per gram body weight under cold stress at age 15-20 days. Oxygen consumption of several adults of each species was also studied.

STATUS OF THE ENDANGERED BATS, MYOTIS SODALIS, M. GRISESCENS, AND PLECOTUS TOWNSENDII INGENS, IN THE SOUTHERN OZARKS

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Three bat taxa (**Myotis sodalis**, Indiana myotis; **M. grisescens**, gray myotis; **Plecotus townsendii ingens**, Ozark big-eared bat) considered to be endangered occur in the southern Ozark Mountains. Small colonies of **M. sodalis** hibernate in several caves throughout the region. The largest known Indiana Myotis colony in the southern Ozarks numbers less than 2000 individuals and has decreased in size during recent years. In summer, small numbers of male **M. sodalis** inhabit a few caves. **M. grisescens** maternity colonies occur in several caves scattered throughout the southern Ozarks. During winter, most gray myotis of the region hibernate in a Baxter County, Arkansas, cave. The hibernating colony in the cave has been estimated to number from 175,000 to 250,000 individuals. The cave was recently gated to protect the colony from disturbance. The total surviving population of **Plecotus townsendii ingens** may number only a few hundred individuals. Hibernating groups of 60 and 45 Ozark big-eared bats have recently been discovered in Washington County, Arkansas, caves. A few additional southern Ozark caves serve as hibernacula for small numbers of **P. t. ingens**. Nothing is known about the summer habitat of this bat.

FORELIMB MORPHOLOGY OF THE PALLID BAT (ANTROZOUS PALLIDUS)

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A morphological analysis of the forelimb of the pallid bat, **Antrozous pallidus,** is presented which provides descriptive information regarding aspects of the osteology and myology of the limb. Earlier investigators have elucidated a series of adaptations for flight which are unique to chiropterans. These include osteological specializations to constrain humeral excursion and a myological division of labor in the primary downstroke musculature. In this study, a mechanism is proposed which incorporates the involvement of clavicular movements in a transverse plane with humeral movements during the wing stroke. It is hypothesized that this arrangement serves to maximize the mechanical advantage of select downstroke muscles and to minimize the bending forces effected on the clavicle as it prevents medial collapse of the shoulder. Interpretations are based upon anatomical analysis of fresh and dissected specimens and upon x-ray analysis of the shoulder region.

POSSIBLE GEOGRAPHICAL INFLUENCE ON SURVIVAL BY SEX IN MYOTIS LUCIFUGUS

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Statistical analysis of survival of unaged, winter-banded Myotis **lucifugus** in an Ontario hibernaculum 1947-48 through 1974-75 show that males outlive females. Similar studies in southern Indiana and northern Kentucky by Humphrey and Cope (1976) show the opposite - that females outlive males. Environmental factors that may influence the success of survival of the two sexes are discussed.

BIOCHEMICAL VARIATION AND GENIC SIMILARITY IN THE THREE SPECIES OF VAMPIRE BATS, DESMODUS ROTUNDUS, DIAEMUS YOUNGII, AND DIPHYLLA ECAUDATA

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The genetic structure of 12 populations representing three genera of vampire bats **(Desmodus, Diaemus,** and **Diphylla)** was examined using isozyme electrophoresis. Of the 21 loci coding for enzymes and proteins, six were considered monomorphic, with the same allel fixed in the three genera. The mean proportion of polymorphic loci per population for the three genera ranged from 0.00 to 0.24, whereas the mean proportion of loci heterozygous per individual was 0.000 to 0.036. The estimates of heterozygosity indicate a trend toward low values for phyllostomatid bats. Similarity values between paired combinations of the three genera are within the range of those reported between other genera of phyllostomatid bats representing the same subfamily. Rogers' coefficient of similarity values between **Desmodus** and **Diaemus** (S=0.613) and between **Desmodus** and **Diphylla** (S=0.524) indicate that **Diaemus** and **Diphylla** are equidistant from **Desmodua.** Similarity values between **Diaemus** and **Diphylla** (S=0.398) suggest that these bats were independent derivatives and did not share a common ancestor once the divergence from the desmodontine progenitor occurred.

Similarity values among seven populations of **Desmodus rotundus** ranging from southern Mexico to southern Costa Rica are similar to values found among other populations of conspecific bats.

ELECTRORETINOGRAPHIC ESTIMATES OF THE SPECTRAL CAPACITY AND DYNAMIC RANGE OF THE RETINAS OF FOUR SPECIES OF VESPERTILIONID ADN PHYLLOSTOMATID BATS

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Available evidence indicates that the visual systems of the Chiroptera are structurally adequate and can support behaviorally evinced vision. Little is known of the physiology of the visual systems of this order however. This report communicates preliminary results of electrophysiological experiments designed to estimate limitations imposed on vision by the ability of these retinas to function in response to spectral stimulation and under light adapted conditions. **Eptesicus fucus** were collected locally and **Desmodus rotundus, Carollia perspicillata** and **Artibeus**

jamaicesis were collected near Tlapacoyan, Puebla, Mexico. The bats were anesthesized by interperitoneal injections of sodium pentobarbital and their pupils dilated with atropine sulfate. Electroretinograms (ERGs) were recorded from the cornea with the animal restrained in a head-holder. Signals were differentially amplified (1000X, 0.1-300 Hertz) computor averaged and permanently recorded onan X-Y plotter. A dual channel optical system, providing control of intensity, spectral content and timing of each beampath, delivered a corneal irradiance of 4.0 log microwatts/cm ei-ther as stimulation or adaptation.

The functions describing the responses to equal energy stimuli at 20 nanometer (nm) intervals from 440 to 680nm were very similar for the four species studied and could be adequately matched by pigment absorption curves with peaks at about 500 nm. The dynamic range of the retina of **Eptesicus** was very narrow while that of **Artibeus was the broadest of the four species.** ERGs were unrecordable from **Eptesicus** prior to several hours of dark-adaptation, while those from **Artibeus** could be recorded at up to about -1.0 log microwatts per cm . **Carollia** and **Desmodus** fell between these levels. These results suggest that these retinas are suited only for nocturanl function, although **Artibeus,** at least, probably could function visually at a relatively low light level. These retinas did not appear to function in a manner suggesting cone presence. If more than one class of photoreceptors is present, their numbers are too small to be detected under these conditions. In all probability, visual function in these species is subserved by only rhodopsin bearing photoreceptors.

ECONOMICS OF NECTAR FEEDING: PHYSIOLOGICAL AND ENVIRONMENTAL VARIABLES AND A COMPARISON WITH OTHER NECTARIVORES

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Some economic factors in nectarivory are: What and how much to eat from a cafeteria choice, when to eat it, to forage singly or jointly, when to abandon a patch of depleted resource and move to another patch. Such decisions are influenced by plant parameters (spacing, phenology, caloric rewards) and biotic factors (competition, predation).

These points are discussed for nectar-feeding bats; comparisons with insects and birds are made. Areas for fruitful research are suggested.

Flight metabolism for nectar-feeding bats may be 14X SMR. The bats expend 63% of their 24 hr. energy budget in the 3 hours spent foraging. This is more than birds, but within the general cost range. In summer **Leptoncyteris** forage in flocks which search more efficiently and exploit patches more thoroughly than would individuals. Group feeding allows intermittent communal roosting which affords more efficient digestion.

The efficiency of an individual in a flock depends on his own physiology, on the floral rewards and on properties of the flock. A model is given of these interacting factors which may influence flock size.

Although optimal foraging is a theoretician's dream, there is little supporting data from real organisms. Indeed, unless the resource involved is a limiting resource, there is no compelling reason to expect foraging to be optimal. Small volant endotherms (including insects) are ideal organisms for investigation of optimal foraging since they are likely energy-limited. In switching from a "worked" patch, **Leptonycteris** adopt a strategy which maximizes return on investment. Safety factors arising from their sociality and the shape of the foraging/plant depletion curve allow individual bats to be somewhat sloppy in their decisions without sacrificing feeding efficiency. Sunbird foraging may also fit optimization paradigms.

OBSTACLE AVOIDANCE BY ECHOLOCATING BATS

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Echolocating bats emit ultrasonic signals and listen to returning echoes. The ability of echolocating bats to avoid obstables was measured by making them fly through an array of vertical metal wires or monofilament nylon lines. The numbers of misses and hits were recorded relative to wires or lines that were stationary or were moving at an average speed of 7 cm/sec. Four different sizes of wires or lines ranging from 0.23 to 1.53 mm were used for the tests. The inter-wire or inter-line intervals were always kept at 30 cm. The results showed that echolocating bats could fly successfully between obstacles, even those with diameter of 0.23 mm, 75% of the time. The bats could dodge these obstacles with a significantly higher number of misses when the obstacles were moved horizontally than when kept stationary (p 0.05). Thus, in terms of the avoidance of obstacles, echolocating bats appear to perform better when confronted with an array of moving obstacles than with stationary ones. These data suggest that the auditory system of a bat may contain neurons which are highly sensitive to moving objects (Supported by NSF Grant BNS 77-23834).

FEMALE REPRODUCTION IN NON-HIBERNATING BATS

D. P. Jerrett

The major female reproductive events in the estrus cycle(s) of both non-hibernating mega and microchriopteran species is reviewed. However, special attention is given to the reproductive biology of the temperate North American species **Tadarida brasiliensis mexicana** (Molossidae), the Mexican free-tailed bat, which expresses dextral uterine and ovarian dominance. Only the larger right ovary is capable of producing an ovulatory follicle and the left has long been considered atrophic. In order to elucidate the normal estrous cycle and define the structural and functional characteristics of the ovaries of this non-hibernating bat several analytical techniques were utilized. These included light microscopic analysis, histochemical localization of ^{5}, 38 hydroxysteroid dehydrogenase (HSD) activity, transmission electromicroscopy and competitive binding radioimmunoassay of seasonal plasma progesterone levels.

Interstitial tissue is found in both ovaries but the left is almost entirely an interstitial organ. Enzyme histochemical analysis demonstrates that the gonads have seasonal varying amounts of ^{5}, 38 HSD localized either in the thecal cells of the Graafian follicle or in the ovarian interstitium. Transmission electron microscopic observations of interstitial cells disclose the presence of cytoplasmic organelles typical of those characteristic for steroidogenesis.

The corpus luteum persists throughout gestation reaching its maximum development just prior to partuition. Circulating plasma progesterone values correlate directly with luteal gland size and peak at 106 ng/ml when the corpus luteum was largest.

DETERMINATION OF THE PRIMITIVE KARYOTYPE FOR THE STENODERMINE BATS

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The subfamily Stenoderminae has diploid numbers ranging from 14 to 44 and fundamental numbers of 20 to 62. Gardner (1977) proposed that the primitive karyotype for the subfamily had a 2n=40 or more with a low FN, with the present array of karyotypes attained through centric fissions and possible additions of heterochromatin. G-and C-banding analyses were performed on the following stenodermine genera: **Artibeus, Centurio, Chiroderma,**

Enchistenes, Sturnira, Uroderma, Vampyressa, and Vampyrops. Reciprocal translocations, pericentric inversions, and fusions, rather than fissions, appear to have been the major modes of chromosomal rearrangements. Most heterochromatin was centromeric, or occasionally, interstitial. No whole arms were found to be heterochromatic. The banding data from these bat genera indicate an ancestral karyotype with 2n=30-32 and FN=56-60, a totally biarmed karyotype. The **Sturnira-Artibeus-Vampyrops** lineage is believed to approximate the primitive subfamilial karyotype (2n=30-31, FN=56). All three genera appear to have almost identical G-banding patterns. **Enchistenes** differs from these genera by a reciprocal translocation. All other genera examined differ from the proposed ancestral karyotype by several rearrangements.

FEEDING AND BREEDING HABITS OF SOME CENTRAL INDIAN MICROCHIROPTERA

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Feeding and breeding habits of nine Central Indian Microchiroptera were studied in captivity and as far as possible in the wild also. The species studies are: Scotophilus h. heathi Horsfield, S. temmincki wroughtoni Thomas, Scotozous d. domeri Dobson, Pipistrellus m. mimus Wroughton, P.C. cormandra Gray (Family Vespertilionidae); Hipposideros f. fulvus Gray, H. cineraceus durgadasi Khajuria, Rhinolophys l. lepidus Blyth (family Rhinolophidae) and Megaderma l. lyra Geoffroy (family Megadermatidae).

The nocturnal habits of bats and through mastication of food make the study of feeding habits difficult. A new method was developed to study the feeding habits in captivity. Common nocturnal insects were collected with light traps in hot season particularly during rains when the feeding activity is maximum. They were tried as food of captive bats. It was found that food taken is selective and thus appears natural.

Considerable unrecorded data has been collected on mating habits, gestation period, parturition, care of young, etc. The observations were spread over a period of over six years.

EXTERNAL GENITALIA AND BACULA OF SOME CENTRAL INDIAN MICROCHIROPTERA

H. Khajuria

External genitalia of nine and bacula of ten species/subspecies belonging to seven genera and three families of Central Indian Microchiroptera have been described and illustrated wherever necessary. The forms studied are: **Megaderma l.lyra, Hipposideros fulvus fulvus, H. cineraceus durgadasi, Rhinolophus l. lepidus, Myotis peshwa, Pipistrellus c. coromandra, P. m. mimus, P. ceylonicus indicus, Scotozous d. dormeri, Scotophilus temminicki wroughtoni** and **Scotophilus h. heathi.** External male genitalia may possibly provide distinguishing characters upto specific and generic levels but the material available did not permit a more detailed study. Although there is a considerable variation in shape and size of bacula, genera and in many cases species can usually be distinguished by bacular characters. An attempt has been made to define bacular characters of some Indian genera on the basis of available information.

PHYLOGENETIC ANALYSIS OF CHIROPTERAN DENTITION

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The dentition of the most primitive Microchiroptera shows few differences from that of primitive placental mammals. Assuming that the condition of having the paracone and metacone near the labial margin of the molar tooth is primitive, then the condition of having these two cusps near the center of the molar is derived. With this latter condition goes a W-shaped ectoloph and a shift of the hypoconulid to a lingual position near the entoconid. This presumeably derived condition is found in most Microchiroptera, Scandentia (tree shrews), Dermoptera, and some Insectivora (shrews, moles, **Nesophontes**), but not in Primates or hedgehogs. If the Archonta (sensu McKenna) are a

monophyletic group, then, on the basis of molar pattern, the Scandentia, Dermoptera, and (Micro) chiroptera, could be considered a derived monophyletic subgroup within the Archonta. The Scandentia also share the same derived dental formula with the most primitive Microchiroptera, but since this involves only incisor and anterior premolar reduction, it is probably not particularly significant. Fruit and nectar feeding Phyllostomidae show progressive modifications of the primitive microchiropteran molar pattern, which, in extreme cases, could probably not be clearly homologized with it if intermediate conditions were lacking. Megachiropteran molars are also highly modified in connection with frugivory, and while they show some vague general resemblances to some frugivorous Michrochiroptera and Primates, there is no firm basis for postulating homology, let alone synapomorphy. The ability to homologize primitive microchiropteran molar patterns, and the failure to do this for Megachiroptera, has a sound functional basis.

MALE REPRODUCTIVE CYCLE IN NONHIBERNATING BATS

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Most knowledge relative to bat reproduction has been gained on temperate North American and European bats that have evolved unique specializations to deal with prolonged hibernation. Students of bat reproduction have neglected the less bizarre reproductive processes of the more typically mammalian cycles of the tropical bats. The male reproductive events in the nonhibernating chiropteran species are discussed with special attention directed toward the wide variety in morphological organization of the reproductive organs.

Attention is also directed at the relative structural stability of the male sex accessory organs in certain families (i.e. Molossidae and Pteropodidae) as compared to the wide ranging variation in others (i.e. Vespertilionidae).

The male reproductive cycles of representative genera from several primarily nonhibernating families of chiroptera are reviewed. Seasonal and aseasonal breeding patterns are discussed.

DAILY ENERGY BUDGETS OF FREE-LIVING BATS

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This review examines the assumptions, methods, limitations, and results of estimating energy budgets for free-living bats. Daily energy budgets (DEB) derived from two independent methods are summarized for a temperate zone insectivorous bat (**Myotis lucifugus**), These independent estimates of energy utilization, based on food consumption and time-budget studies, produce comparable values. A comparison of DEB reported for this and other species yields a first-order, general predictive equation for estimating energy budgets of free-living bats from body weight.

A COMPARATIVE FOOD HABIT STUDY OF TWO FOLIAGE-GLEANING BATS, NYCTERIS THEBIACA (AFRICA) AND MICRONYCTERIS MEGALOTIS (CENTRAL AMERICA)

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Prey selection by two foliage-gleaning bats, Nycteris thebiaca (Africa) and Micronycteris megalotis (Neotropical America) is compared and contrasted based on remains of prey deposited under roosts. Orthopterans comprised 54% of the diet of N. thebiaca within the study period, whereas the second most commonly encountered order, Lepidoptera, only accounted for 20%. In contrast, the diet of M. megalotis consisted of only 23% Orthoptera and 5% Lepidoptera. The prey of M. megalotis seemed to be largely Coleoptera (57%), which had only accounted for 13% of the N. thebiaca diet.

Nycteris thebiace, a large-winged (FA=47), medium-sized (wt=11.5) foliage-gleaner, seemed to employ the strategy of catching a maximum number of large insects, especially orthopterans such as katydids and cockroaches. Micronycteris megalotis, a small-winged (FA=34), small-sized (wt=6.7) foliage-gleaner, depended on its apparent ability to capture large numbers of small insects, such as small beetles, but also captured orthopterans and other large insects when the opportunity presented itself.

BAT MANAGEMENT IN THE UNITED STATES: A SURVEY OF LEGISLATIVE ACTIONS, COURT DECISIONS AND AGENCY INTERPRETATIONS

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In 1966, Congress enacted legislation which afforded native animals legal protection. Since that time, this legislation has been twice revised. The current Endangered Species Act of 1973, provides not only animals but also plants with what appears to be a reasonable degree of protection and survival. Recent court decisions support the concept and validity of the Endangered Species Act of 1973.

This paper is the result of a survey conducted throughout fourteen Federal departments and agencies in order to obtain their interpretation of this legislation, and more specifically, how bats are protected by this interpretation. The survey included four questions:

1. What Federal laws, regulations and guidelines govern your agency's actions regarding both the protection and/or eradication of bats?
2. How has your agency interpreted these laws, regulations and guidelines in the formation of its internal policies?
3. What do your protection policies include?
4. If eradication is necessary, what methods and recommendations are followed and what chemicals and in what dosages are allowed?

DEVELOPMENT OF ECHOLOCATION IN THE GREATER HORSESHOE BAT' RHINOLOPHUS FERRUMEQUINUM

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The developmentof echolocation in the Greater Horseshoe Bat, **Rhinolophus ferrumequinum,** was studied under natural conditions. A microphone was placed in the attic of an empty mansion which is consistently used as a nursery colony by **Rhinolophus ferrumequinum.** Recording could thus be obtained at any time of the day without disturbing the bats. The attic was also entered when the adult bats left for their evening feeds and recordings were ob-

tained from bats of known age with minimal disturbance to the colony.

Constant frequency pulses were emmitted on the first day and after the fourth day (upward sweeping frequency modulated pulses were emmitted on the 2nd and 3rd and subsequent days). The fundamental frequency of these pulses showed a logarithmic increase in frequency until the 15 day when the bats started flying. The frequency at this age was about 2 kHz below that of adult bats in the same colony. Sounds emmitted before the 10th day had strong harmonic structure, this is reduced after the tenth day with the suppression of the fundamental.

LONGEVITY OF WILD DESMODUS ROTUNDUS IN MEXICO

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A series of **Desmodus rotundus murinus** were banded in three caves in the Mexican State of Guerrero in 1969. One of these caves, with the largest population of these vampires was visited twice in 1975, and once in 1978, when all unbanded bats were sexed and banded, and their reproductive state was noted. Only one bat, banded in one of the other two caves, changed roost, after three months. Thus, a series of data were obtained, giving us information on the longevity of these animals in a wild state, the population turnover and an idea of the number of years that these animals are fertile. These visits will proceed into the future, hopefully giving us an idea of the maximum longevity of **Desmodus rotundus** in the wild, which at this date is of nine years, minus one week.

THE USE OF FETAL MEMBRANE DATA IN ASSESSING CHIROPTERAN PHYLOGENY

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The mammalian fetal membranes develop from all three germ layers and comprise a complex and interrelated organ system which is essential for normal embryonic development. Differences in fetal membrane development are rare within mammalian families, and this evolutionary conservatism aids in morphotype reconstruction of fetal membrane patterns within each family. Using sound principles of character analysis and phylogenetic reconstruction, developmental features of the fetal membranes can be utilized to test hypotheses of relationships among the families and superfamilies of Chiroptera. Of particular interest is Smith's (1976, 1977) hypothesis concerning the possible diphyletic origin of megachiropteran and microchiropteran bats, based in part on observed differences in wing morphology and dentition. In addition, fetal membrane data may be used to test hypotheses of phylogenetic relationships between Chiroptera and other eutherians, in particular, the postulated superordinal relationship among Chiroptera, Dermoptera, Tupaiidae, and Primates as the Archonta.

Comparison and analysis of developmental features of chiropteran fetal membranes with those of Dermpotera, Tupaiidae, Primates, Lipotphyla, Macroscelidea, and all other orders of Eutheria corroborate the hypothesis of a monophyletic origin for the Chiroptera. Mossman's (1937) suggestion of the possible diphyletic origin of bats was based primarily on striking fetal membrane differences between pteropodids and vespertilionids; data for most microchiropteran families were lacking at the time. However, developmental patterns of the fetal membranes are quite similar in pteropodids, megadermatids, rhinopomatids, hipposiderids, and rhinolophids, and the morphotype reconstructed for these families may closely approximate the ancestral chiropteran condition. Available fetal membrane data support the monophyletic relationship of the Phyllostomatoidea, including the Phyllostomatidae, Desmodontidae, and probably the Noctilionidae. Shared, derived character states of the fetal membranes strongly support the hypothesis (Smith, 1972) that Noctilionidae is closely related cladistically to other phyllostomatoids. Fetal membranes of vespertilionids are quite different from those of most other chiropteran families; incomplete data suggest that thyropterids and

natalids resemble the vespertilionid pattern. Relationships among vespertilionids, emballonurids, and molossids are unclear from analysis of their fetal membranes; they possess few shared, derived character states in common which do not occur in other microchiropterans.

Phyletic relationships among "archontans" are not clarified by character analyses of their fetal membranes. Among archontans, the morphotype of chiropteran fetal membranes most closely resembles that of Primates; however, the primate morphotype approximates the postulated eutherian morphotype. The hypothesis that Chiroptera and Dermoptera are sister groups is not supported by analysis of the fetal membranes. Fetal membranes of the monofamilial Dermoptera are relatively derived when compared to the chiropteran morphotype. Although character analysis of fetal membrane data provides additional tests for hypotheses of chiropteran phylogeny, it is emphasized here that multiple phylogenetic analyses of both "soft" and "hard" anatomical features, as well as a consideration of the available molecular data, are the best methods for phylogenetic reconstruction of Chiroptera and other Eutheria.

ON THE ECOLOGY OF INSECTS ECTOPARASITIC UPON MALAYSIAN BATS

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In West Malaysia (Malaya) 86 species of bats belonging to 7 families occur, and they are parasitised by 83 species of insect from 6 families and 4 orders: 2 species Arixeniidae (Dermaptera), 3 species Cimicidae and 3 species Polyctenidae (Hemiptera), 42 species Nycteribiidae and 29 species Streblidae (Diptera), 4 species Ischnopsyllidae (Siphonaptera). The majority of these insects are highly host-specific permanent ectoparasites and they show a number of adaptations for this mode of life such as a blood diet, viviparity, winglessness and the possession of combs. The majority of bat species are parasitised by at least one species of insect, but infestations vary greatly in size and diversity, being generally small and not diverse. The major cause of mortality is predation by the host, and this accounts for any imbalance in the sex ratio.

MOTHER-INFANT COMMUNICATION IN THE GREATER HORSESHOE BAT

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A Japanese Constant Frequency bat, **Rhinolophus ferrumequinum nippon**, has a close mother-infant relationship. Infant vocalization and its development probably serving as a basis of mother-infant communication were analyzed by tracing their vocalization and behaviour. The baby can emit oral and nasal calls. Development consists in a shift from orals to nasals, low to higher frequency and noisy to pure tones. The shift occurs even within a syllable. Morphological perfection of the laryngo-nasal junction underlies vocalization development.

The pattern of mother-infant acoustic communication was then analyzed. Communication between an experimentally separated mother and 3-week old infant couple starts with noisy oral calls of the infant. The mother answers by emitting a train of long "lead signals". Then the infant turns to emit pure nasal signals. The mother soon begins to actively synchronize her signals with the infants. Then, the infant also tries to synchronize its signals to the mother's. This results in a quite regular antiphonation in two-to-two or two-to-three syllable relationship. After establishment of such pattern of antiphonation, communication shifts into partial duetting. Gradual rise of the frequency of the infant signals and eventual coincidence of it with that of mother's become to be frequently observed. When the frequency coincidence is still incomplete, interference between mother's and infant's signals produces characteristic banded patterns on sonagrams. Because CF bats emit long and constant-frequency signals, the mother's lead signals play a

role of frequency-guide. In the final stage of communication just prior to the reunion of separated mother-infant couple, series of synchronized antiphonation and duetting is repeated in temporally much compressed and extremely high-pitched trains.

The most important part of the communication for the completion of mother-infant reunion seems to be the high-pitched duetting with frequency coincidence. Some acoustic signals used in the communication, such as the "lead signals" of the mother and "contact calls" of the both after the reunion, appear to be exclusively communicative. Although antiphonation of mother and infant has been observed and referred to as characteristic to mother-infant communication in FM bats as well as in macrochiropterans, the high-pitched and frequency-coincided duetting may be essential in the CF bats.

SOCIAL ORGANIZATION AND GENETIC PATERNITY STUDIES IN THE POLYGYNOUS BAT, PHYLLOSTOMUS HASTATUS

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In Trinidad, W.I., the bat **Phyllostomus hastatus** has a highly polygynous social organization. Adult females roost in large (mean average size, 18 females/harem) harems tended by a single adult male. Residual adult males roost in bachelor clusters. The composition of harems is very stable and the same females may roost together for life. The same adult male may retain a harem for three or more years. Genetic-paternity studies show that the harem male has preferred reproductive access to the females in his harem and that strong polygyny results in marked changes in gene frequencies between generations. However, dispersal of offspring prevents the development of significant genetic heterogeneity among social units. New harems are formed by aggregations of yearling females from different harems and caves, and kin selection cannot explain the social cohesiveness of these groups. Radio-telemetry studies on foraging behavior show that harem mates have individual foraging areas close to one another, and suggest that individuals in a harem may help one another locate food.

INTERACTIONS BETWEEN BATS AND GREEN LACEWINGS IN FREE FLIGHT

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Green lacewings can hear and respond to pulsed ultrasound. This capability presumably provides a defense mechanism against marauding bats. The avoidance behavior of free flying green lacewings was studied in the presence of hunting bats and artificial bat cries. Several bats of two species (**Pipistrellus pipistrellus** and **Myotis brandtii**) were trained to catch mealworms. Interactions between bats and green lacewings, mostly **Chrysopa carnea, Neuroptera**, were photographed using stroboscopic flashes. Continuous recordings of the bats' orientation cries were made using two ultrasonic detectors. Artificial bat cries were synthesized in the standard manner, with each pulse having a constant frequency of 50 kHz. Free flying green lacewings respond to hunting bats mostly by folding the wings and falling in a nose dive, in what can be considered as an early warning response. This response tends to take the insect out of the bat's acoustic field. However, should a bat detect and attempt to catch a falling green lacewing, the insect can switch to a last chance maneuver. This maneuver consists of a momentary extension of the wings provoked by the bat's high cry repetition rate

during the buzz, which is always associated with an attempted catch. The last chance response is verified by experiments using artificial bat cries. The green lacewing's behavioral repertoire is not limited to early warning and last chance responses. Insects can change their flight pattern or fall with the wings extended. The probability of avoidance behavior occuring is a function of stimulus intensity and repetition rate. Responses can vary on the individual and the population level for the same stimulus repeated successively. The selection pressure, as defined by the number of catches divided yb the number of insects flying in the catch area that could have been caught, is about 0.04. The insect's ears can be destroyed without otherwise interfering with its flight. In this case the selection pressure for non-reacting green lacewings is 0.40. The selective advantage for responding to bat cries about 0.36, which is similar to that for moths reacting to hunting bats contra non-reacting moths in the field. In addition, the responses of free flying green lacewings provide a behavioral substrate for interpreting neurobiological studies of avoidance behavior.

LOCALIZATION OF ADENOSINE TRIPHOSPHATASE AND ULTRASTRUCTURE OF THE MUCOSAE OF THE STOMACH OF THE COMMON VAMPIRE BAT (**DESMODUS ROTUNDUS**) DURING FLUID TRANSPORT

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As the vampire feeds, the fundic caecum expands to accomodate the bulk of the ingested blood. Within minutes fluid is transported across the mucosae thus concentrating the meal. One group of five bats were allowed to feed on CDP diluted bovine blood for a half hour. Another group of five bats were starved for twenty-four hours. After etherization, pieces of the middle segment of the caeca were excised and either fixed in 5% glutaraldehyde in 0.067M cocadylate buffer (pH 7.2) for two hours, or frozen. Both ten micron frozen sections affixed to glass slides and loose forty micron frozen sections were fixed in 0.5% glutaraldehyde for five minutes and subsequently placed in Wachstein-Meisel medium for the demonstration of magnesium dependent adenosine triphosphatase. Both pieces and loose sections were embedded in either glycol methacrylate or Spurr resin for light and electron microscopy, respectively. During fluid transport active adenosine triphosphatase is present along the lateral plasma membranes of the mucosal epithelial cells. This reaction is inhibited by 0.1M sodium fluoride. The intercellular spaces in the mucosal epithelium, the underlying connective tissue and resident blood vessels are distended by the increased hydrostatic pressure. It is probable that the active transport of sodium into the intercellular spaces between mucosal epithelial cells produces hyperosmotic conditions which drive passive water transport.

THE STATUS OF THE CHIROPTERAN FAUNA OF THE KINGDOM OF SAUDI ARABIA

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The chiropteran fauna of the Kingdom of Saudi Arabia consists at the present time of eighteen species belonging to eight families. Three species of bats are reported here for the first time from Saudi Arabia. These are the Sundevall's Leaf-nosed bat **Hipposideros caffer,** the Egyptian Free-tailed bat **Tadarida aegyptiaca,** and the Schreiber's bat **Miniopterus schreibersi.** Also the presence of an undescribed subspecies of the Slit-faced bat **Nycteris thebaica** is reported. The known distribution of the eighteen bats in the Kingdom are discussed with some notes on their biology. More intensive collecting may reveal the presence of four additional species of bats in the Kingdom.

PHYLOGENETIC ANALYSIS OF THE CHIROPTERAN AUDITORY REGION

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Bats show marked variation in auditory morphology, but the phylogenetic implications of such patterns are not adequately understood. A survey of chiropteran ear regions and comparisons with other mammalian orders suggest that bats typically retain several primitive eutherian features. These include: a horizontally inclined, annular ectotympanic, retention of the major branches of the internal carotid arteries, ventral exposure of the fenestra rotundum, the absence of bony tubes for vessels coursing through the middle ear cavity, and a small tympanohyal process. Primitively, the chiropteran auditory bulla is a small element formed primarily by the rostral entotympanic. In more derived states the bulla is variously expanded and inflated, and may include contributions from the ectotympanic. Microchiropterans are generally more derived than megachiropterans in showing modifications of the bulla, more vertical orientation of the tympanic ring, pronounced enlargement of the promontorium, opening of the pyriform fenestra and several other features. However, the distribution of apomorphic characters in these suborders and in other eutherian orders does not support a diphyletic origin for bats; the morphotypical plan for chiropteran ear regions is merely difficult to define because of the abundance of primitive eutherian characters. Some interesting similarities between megachiropteran and dermopteran ear regions are observed but these are generally plesiomorphous. Moreover, the tympanic chamber of Dermoptera shows a number of uniquely derived features, including the anomolous pattern of the petrosquamous drainage, which are not shared by any chiropterans considered in this survey.

SOCIAL ORGANIZATION AND THE ANNUAL CYCLE IN A KENYA POPULATION OF **PIPISTRELLUS NANUS**

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A field study of social organization, behavior and ecology of the 3.5 gram bat **Pipistrellus nanus** was conducted near Kibwezi, Kenya from June 1973 through July 1974. The bats roosted only in dead overlapping palm fronds or in roofing material made of bundles of palm fronds. Daily censusing of marked bats roosting in roofs showed that males were territorial at roosts and that females gathered at favored male roosts in small groups. Females were attracted to roost at these sites by audible male vocalizations. These territorial calls are described physically, and individual, seasonal and contextual variability in their usage is documented. Group size and composition, site fidelity and variability in social organization are summarized quantitatively and descriptions of temporal patterning of activity and behavior are provided. Heterothermy and foraging behavior are also documented. Reproduction was annual and synchronous with the flush of community productivity during the November rains, but the social system did not change qualitatively over most of the year. Deviations from typical mammalian sex ratios and patterns of size dimorphism are discussed, as is the influence of the strongly seasonal environment on quantitative aspects of social organization.

TONOTOPICAL ORGANIZATION OF THE AUDITORY CORTEX IN THE CF–FM BAT **RHINOLOPHYS FERRUMEQUINUM**

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For echolocation, the Greater Horseshoebat, **Rhinolophus ferrumequinum**, uses pulses of about 50 msec duration, consisting of a long, constant frequency (cf) component (ca. 80-85 kHz) followed by a short, downward frequency modulated (fm) component. During flight they lower their emission-frequency in order to compensate for the frequency shifts caused by Doppler effects. Each individual receives its echoes at a characteristic frequency. This acts as a constant carrier frequency for fast frequency modulations caused by the movement of targets, for instance the wingbeats of flying insects. In behavioral experiments, the animals were shown to be able to detect such frequency modulations. They might be an important parameter for classification or even identification of targets.

According to the results obtained from the somatosensoric and visual cortex of other mammals and the auditory cortex in **Pteronutus**, one might expect that the important echo frequencies would be overrepresented in the **Rhinolophus** cortex. In order to detect small changes in frequency, neurons with best frequencies (BF's) around the resting frequency should have a higher frequency selectivity than those in other frequency ranges.

"Multi unit" recordings were made to investigate the tonotopical organization of the auditory cortex in **Rhinolophus**. Pure-tone-pulses of 50 msed duration were used as stimuli. Each measured frequency was normalized to the resting frequency of the individual bat to conform to the biological situation.

The population of neurons concerned with the processing of frequencies around the resting frequency and the fm component occupy a large area of the auditory cortex. The tonotopical organization of neurons concerned with frequencies lower than the echo frequencies is very similar to that of other mammals. Neurons with identical BF's in the fm part of the sound are organized in the same dorso-ventral structrue but with a stretched frequency-axis. The area ventral of the fm area is occupied by neurons having their BF's at and up to several kHz above the resting frequency. Areas of equal BF's are widely spread and form semicircles around each other with the resting frequency at the outside.

As in other mammals, the auditory cortex of **Rhinolophus** is organized in columns perpendicular to the cortex surface. Units found in perpendicular penetrations show very similar behavior, especially with respect to their BF's.

The Q-1o-dB value was used to measure the frequency-selectivity of the neurons. Only neurons with BF's between +11 and -5 kHz in relation to resting frequency showed very high Q-1oddB values of more than 3o and up to 417. For frequencies not occuring in the echolocation sounds, the Q-1o dB values were much lower.

Single cells in the auditory cortex are able to detect frequency modulations in the stimulus down to 0.5% modulation range. At higher ranges phase-locked firing occurs.

The behaviorally relevant echo frequencies are overrepresented in the auditory cortex of **Rhinolophus**, neurons in this frequency-range show a very high frequency-selectivity, and single neurons can code even very small frequency-modulations. All three properties are very well adapted for processing the frequency modulations on the echo carrier frequency.

FEMALE REPRODUCTIVE CYCLES IN HIBERNATING BATS

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Hibernation exerts a profound influence on the physiology of reproduction in two families of bats, Vespertilionidae and Rhinolophidae. The imposition of a period of hibernation on the female reproductive cycle appears to arrest the progress of reproductive events begun in the autumn and postpone their completion until spring. The basic sequence of reproductive events is similar in all hibernating bats except the vespertilionid genus, **Miniopterus**, Estrus and copulations are initiated in late summer and early autumn and the bats typically enter hibernation soon thereafter. Intermittent arousal and additional copulations may occur throughout the hibernation period. Spermatozoa are then

stored in the female reproductive tract until after permanent arousal in the spring when ovulation, fertilization and gestation take place. In **Miniopterus**, copulation in autumn is followed immediately by ovulation, fertilization and initial embryogenesis, and the females enter hibernation in a pregnant condition. During hibernation embryonic development is arrested and does not resume until after permanent arousal in the spring. The significant features that are of special interest in the reproductive processes of hibernating bats are the delay of ovulation and storage of sperm following copulation or in the case of **Miniopterus** the delay of embryogenesis. Morphological, physiological and experimental analysis of gamete and steroid production by the ovary, and pituitary control of these processes with respect to hibernation is reviewed in this paper. This evidence indicates that the phenomenon of hibernation and external factors regulating it supress endocrine activity of the pituitary and ovary resulting in the protraction of certain reproductive stages. However, while there is considerable evidence to support this thesis particularly with respect to

MORPHOLOGIC VARIATION AND HYBRIDIZATION IN MYOTIS YUMANENSIS SOCIABILIS AND MYOTIS LUCIFUGUS CARISSIMA

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Morphologic variation was examined in 240 **Myotis yumanensis sociabilis** and 169 **Myotis lucifugus carissima** from northeastern California dn southcentral Oregon to determine whether extreme similarity is due to intraspecific variation or hybridization. Seven external and eight cranial variables were analyzed using multivariate discriminant analyses. Intraspecific variation is partially responsible for morphologic overlap so that forearm length and greatest length of skull do not differentiate large **M. yumanensis** from small **M. lucifugus.** Pelage color and shape of skull profile also fail to distinguish some individuals. Intermediate individuals were found in roosts with both species. A character index using forearm length, greatest length of skull, and skull profile was calculated to assign specimens to a **yumanensis** group, a **lucifugus** group, or an intermediate group. Discriminant analyses of these groups assigned 100% of the **M. lucifugus** group and 98% of the **M. yumanensis** group to those species. Ninety-four percent of 225 M. **yumanesis** as identified by forearm length were assigned to that species by the discriminant analysis and 93% of the 72 **M. lucifugus** identified by the same variable. Using greatest length of skull, the percentages were 94% of 211 **M. yumanensis** and 96% of 45 **M. lucifugus.** Using skull profile, the percentages were 91% of 196 **M. yumanensis** and 76% of 76 **M. lucifugus.** Two discriminant analyses using all variables showed condylobasal length of skull to be the best discriminating character although separation of the two species based on this character alone was poor. Eleven animals were classified as probable hybrids based on computer-generated probabilities. The reason for hybridization is suggested to be the relatively recent establishment of sympatry between these two species due to Pleistocene climatic events. The extent of hybridization is greater than that reported by Harris (1974) for **M.l.carissima** and **M.y.yumanensis.** Because intraspecific variation complicates identification of hybrids, it is impossible to determine whether or not introgression is occurring. The current status of the two species in other areas of sympatry suggests that it is not.

NOTES ON BATS FROM THE STATE OF RIO DE JANEIRO, BRAZIL

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Intensive field work carried out during the past 10 years in the State of Rio de Janeiro, Brazil, permitted a survey of the bats occuring in that region. Forty-five species were recorded and many biological observations were obtained.

FREQUENCY ENCODING CHARACTERISTICS OF ECHO-RANGING NEURONS IN THE INFERIOR COLLICULUS OF MEXICAN FREE-TAILED BATS

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Phasic constant latency responders (pCLRs) are inferior collicular neurons characterized by a highly stable latency to repetitive acoustic signals. These neurons can accurately encode the time interval between two frequency modulated (FM) signals (i.e., simulated pulse and echo) and are of value for echo-ranging. The consistent firing latency results, in large part, from the excitation produced by one frequency component in a downward sweeping FM pulse and, thus, the neurons are responding to instantaneous frequency. This feature of the pCLRs was studied by presenting FM pulses having various durations where the frequency of each signal swept downward from 50 to 25 kHz. In each neuron the firing latency increased as the signal duration was lengthened. In other words, the firing latency followed, in a precise fashion, the temporal position of the excitatory frequency in the FM signal. The excitatory frequency was determined by noting the amount of latency shift associated with each change in signal duration. In pCLRs which also responded to pure tone bursts the putative excitatory frequency, determined from latency shifts, agreed closely with the unit's best frequency. The pCLRs, together with the most sharply tuned units in the long CF/FM bats, appear to have the greatest frequency sleectivity of any units so far observed in the mammalian auditory system.

BEHAVIOR AND ACOUSTIC COMMUNICATION IN **CAROLLIA PERSPICILLATA**

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Quantitative and descriptive data regarding social organization, acoustic communication and reproductive, agonistic and mother-infant behaviors were collected on a captive colony of up to 46 **Carollia perspicillata** over a period of 2½ years. Behavioral observations were made on a random basis during the 12 hour reversed dark cycle of the enclosure and represent approximately 1200 hours of observation. For each bat, roosting pattern data were also collected permitting analysis of group composition, group stability, spatial and temporal relationships among individuals and preferred roost sites. A condensor microphone which was positioned in the center of the enclosure and could be remotely rotated 360 from outside the enclosure was used to record sounds emitted in behavioral contexts. A variety of signal types revealed by sound spectrograms were recorded from adult bats under these naturalistic conditions. Additional acoustic recordings were made with experimental techniques. Mother-infant pairs were captured and acoustic signals were recorded while the infant was on the mother, during its removal, isolation and replacement. Sound spectrograms of infant signals were compared to determine the effect of maturity on signal characteristics and to determine if there were characteristics which distinguished one infant's signals from another. Playback techniques were utilized to determine responses of adult bats to previously recorded infant signals while the infants were removed from the enclosure. The responsiveness of mothers to their isolated infants was investigated using retrieval experiments. Behavioral and acoustic repertoires associated with recruitment of females, harem defense, herding of females, mating, infant isolation and mother-infant interactions are described and some of their possible communicative functions are discussed. Observations and experimental results revealed rich behavioral and acoustic repertoires used in social contexts by **Carollia perspicillata**.

A REVIEW OF BAT-DETECTOR TECHNIQUES

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The first description of a detector for ultrasound in air was published by Noyes and Pierce in 1938; that same year it was used by Pierce and Griffin to discover the echolocation signals of flying bats. Since then several useful instruments have been developed as basic tools for real-time detection and analysis either in the laboratory or in the field. They fall into three major functional classes: heterodyne instruments, envelope detectors and devices which operate upon a squared version of the waveform. The general principles of each are outlined and their relative merits and limitations discussed. Two new heterodyne machines - one tuned or broad-band and th other a miniature tuned-only instrument - will be described and demonstrated. Both are now commercially available.

THE STRUCTURE OF THE COCHLEA IN SOME NEW WORLD BATS

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The structure of the cochlea has been studied in nine species of bats from the families Emballonuridae, Mormoopidae and Phyllostomatidea, which were collected and intra-vitally perfused in Panama/Canal Zone. The heads were then double-embedded and serially sectioned in the horizontal plane. The greatest height of the cochlea was measured in modiolar sections and the number of half-turns was counted. Other parameters measured at every half-turn of the cochlea in themodiolar plane were: the width of the cochlea and the radial position of the arch of Corti, the width andthickness of the basilar membrane, the height of the cells of Claudius and the length and width of the spiral ligament. Other interesting features were noted and discussed here.

In five species the cochlea had hitherto not been studies; new specimens of the other four species are compared with their counterparts collected on earlier trips to Trinidad. The mode of life and the nature of the echolocation signals in these species will be considered briefly in relation to the structure of their cochleae.

FECAL ANALYSIS AND ITS LACK OF VALIDITY IN DETERMINING GRAY BAT PREY PREFERENCES

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Studies of gray bat (Myotis grisescens) foraging behavior over Norris Reservoir in eastern Tennessee have demonstrated strong selectivity for certain restricted locations where mayflies are exceptionally abundant. Numerous direct observations have confirmed that gray bats prey heavily upon these insects. Other areas, highly productive of beetles but with few mayflies, were ignored.

Despite these observations an analysis of feces, collected from gray bats returning from foraging as well as from beneath their roosts, indicated the following order of dietary preference: Coleoptera (43.4%), Diptera (34.3%), Lepidoptera (17.5%), Ephemeroptera (1.6%), Hemiptera (1.65), Homoptera (0.8%), Trichoptera (0.8%). Based upon this analysis alone, these bats might have been classified as beetle strategists, with mayflies ranking very low in order of preference. Nevertheless, an opposite conclusion is more likely correct. Clearly, ingestion of soft-bodied prey or a wide variety of differentially digestible prey types may lead to false conclusions regarding bat prey preferences based upon fecal analysis.

SPERM STORAGE & SURVIVAL IN CHIROPTERA

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The occurrence and duration of sperm storage among temperate and tropical Chiroptera will be reviewed together with the results of those experiments designed to test the fertilising capacity of stored sperm. The sites of sperm storage will be considered, including evidence that vaginal plugs store sperm. Both the morphological and physiological relationships between sperm and their storage organs will be reviewed together with evidence for the secretion of nutrients by the uterine, oviducal and epididymal epithelium. Immunological problems of sperm storage will be mentioned and speculations made about the origin and adaptive value of sperm storage in Chiroptera.

THE CONSERVATION OF BATS IN THE WESTERN INDIAN OCEAN

P.A. Racey

Pteropus seychellensis and **Coleura seychellensis** are the only endemic mammals of the granitic Seychelles. The fruit bats on Praslin and neighbouring Seychelles islands were counted by three methods — when roosting, when disturbed and when dispersing to feed. As a result of these counts the population has been estimated at 2,000 individuals. Because of the extent of predation on this species by Man, particularly to provide food for restaurants, legislation to prohibit trading in bats has been recommended. Felling of trees within roosts should also be prohibited. After extensive searching, only six individuals of **C. seychellensis** were discovered. These results will be discussed with reference to the status of bats on other islands in the Western Indian Ocean.

SPATIAL DISTRIBUTION OF DIFFERENT AGE AND SEX GROUPS IN POPULATIONS OF RHINOLOPHUS FERRUMEQUINUM (SHREBER)

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Estimates of survival rates of bats require an understanding of the way in which the deme distributes itself throughout its natural range. The tendency to disperse widely to sites away from sampling areas is one obvious problem, if it in fact occurs. Investigation of detailed distribution patterns is therefore an essential preliminary to survival rate calculation.

A population of the greater horseshoe bat, Rhinolophus ferrumequinum, was intensively studied near Nailsworth, Gloucestershire from 1956 to the present time. Data was collected in summer and winter sites in all months. In addition a nearby population in the Mendip Hills was studied at the same intensity, but only in winter sites. Captures and ringing of juveniles or first year bats in both areas allowed almost all individuals to be aged accurately by 1970. The winters of 1971/2 to 1975/6 form the major part of the data presented. In each winter four visits were made to most of the seventeen sites studied. In addition summer breeding site population counts were made without disturbance during this time.

Populations present in winter caves can be broadly classified into three types:

a) First year sites with about 50% of the captures being of this age. Both sexes occur together.

b) Second to seventh year sites with few juveniles and a predominance of these ages. Older males may add to these sites, especially in severe weather.
c) Adult male territories occupied by a single resident male aged from four to 21 years. Severe cold weather may force individuals out of small sites in some years. Small groups of mature females from three up to twenty two years visit individual males especially in October and April.

Movements of first year bats to new sites as second years commonly involve distances of up to 16 km. The eventual breeding site controlled by the male may be 60 km from the first year site of capture. Adult females, although they may hibernate up to 40 km from the first year site, appear to adhere strongly to the breeding cluster they were born in, and often are caught in or close to the first year site. Captures of mature females at the breeding site gives a valuable cross check against cave data. No similar check on the adult male cave survival data has been obtained.

In the summer months the mature females appear to regulate the return of immature bats of both sexes to the breeding site. Adult males cluster separately in caves, or retain their territories. One adult male was found regularly in the same site over a period of twelve consecutive years, and another two were found for nine years each.

EARLY DEVELOPMENT AND IMPLANTATION IN BATS

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Previous work with representatives of the families Phyllostomatidae and Noctilionidae established that embryonic development proceeds to blastocyst formation and shedding of the zona pellucida (ZP) in the oviduct. This is associated with prolonged retention of the embryo in the oviduct (11 days in **Glossophaga soricina**, 13 days in **Carollia sp.**, 16 days in **Desmodus rotundus**). In contrast embryos of the emballonurid bat **Pteropteryx kappleri** most frequently enter the uterus as zona-encased blastocysts, although a uterine morula has been observed in one animal. Blastocysts have also been found by other investigators in the oviducts of Rousettus sp., but embryos of the vespertilionids and rhinolophids generally enter the uterus at early cleavage stages.

The ovum transport process in **G. soricina** and **Noctilio albiventris** distinguishes between living embryos and dead ova from previous non-fertile cycles, with only the former being passed into the uterus. A high incidence of retained ova have also been observed in the oviducts of **P. kappleri**, suggesting that the differential transport mechanism may not depend upon shedding of the ZP by the embryo.

The blastocysts of **G. soricina** and **Carollia sp.** do not enter the main cavity of the simplex uterus, but attach circumferentially and implant within what initially appears to be the uterine end of the oviduct. This site (the "intramural uterine cornu") appears to be homologous to the cranial end of a horn in a bicornuate uterus. This assessment is supported by observations that implantation in the noctilionids and emballonurids occurs at the cranial end of one of the uterine horns. Initial trophoblastic attachment in **N. albiventris** "bipolar" (i.e., close to being circumferential), but decidual necrosis subsequently frees the abembryonic pole of the blastocyst. Although implantation is ultimately interstitial in **G. soricina** and **Carollia sp.** and partially interstitial in **N. albiventris**, the process in these species nevertheless bears similarities to the central form of implantation exhibited by most other bats.

THE INFLUENCE OF THE BIG BROWN BAT (EPTESICUS FUSCUS) ON THE FORAGING ACTIVITY OF THE SILVER-HAIRED BAT (LASIONYCTERIS NOCTIVAGANS) EVIDENCE FOR INTERSPECIFIC COMPETITION

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Abstract

Lasionycteris noctivagans was captured in mist nets at 29 different bodies of water in Southern Oregon. Mist netting was conducted on 37 nights over a 70 day period in midsummer of 1976. This paper is an analysis of changes in the distribution of capture times of Lasionycteris at sites where different relative numbers of Eptesicus fuscus were captured. Capture frequency curves for Lasionycteris were accumulated from (1) sites where Eptesicus fuscus was not mist netted, (2) sites where Eptesicus was also netted, and (3) sites where Eptesicus was netted, but in numbers between 24 percent and 76 percent of the total number of individuals of both species captured. The first curve showed a steep mode of captures in the first two hours past sunset, with very limited activity during the third and fourth hours following sunset. The third curve was significantly different, with captures beginning around one hour past sunset and continuing steadily over the subsequent four hours. The second curve showed captures in a pattern intermediate between the other two.

The average capture time of Lasionycteris at a site was correlated to the relative abundance of Eptesicus at that site. Results show large overlap in the spatial and temporal distribution of the two species, therefore competition was postulated as a likely explanation for the apparent effect of Eptesicus in delaying and prolonging the time during which Lasionycteris is active and can be netted. Other factors known to influence bat activity such as roost proximity and topography had little influence on changes in capture times for Lasionycteris.

THE ANTERIOR PITUITARY AND REPRODUCTION IN BATS

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With the diverse array of reproductive specializations found in bats it is surprising that relatively little work has been done on the role of the endocrine system in the reproductive biology of bats. This paucity of endocrine research is especially evident concerning the anterior pituitary and its involvement with the reproductive biology of bats. Most of the research that has been conducted on the bat anterior pituitary has dealt with the seasonal alterations in the cytology of hibernating temperate species at the light microscopic level. These data have been utilized to deduce on an analogical basis the underlying endocrine mechanisms controlling reproduction. This presentation will review the available information on the pars distalis of the bat and its relationship to the reproductive biology of both males and females in hibernating and non-hibernating species. Recent structural-functional studies by the author on the anterior pituitary of **Macrotus californicus** and its possible role in the process of delayed development will be discussed.

THE PHENOMENON OF "SILENT HEAT" IN MINIOPTERUS (VESPERTILIONIDAE)

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Reproduction inMiniopterus **schreibersii** and **M. australis** was studied in detail at latitude 27 50'S to 28 50'S in eastern Australia, and comparative data collected from 18 50'S to 37 S. The study aimed to elucidate the chronology and biology of the reproductive cycle with a view to substantiating current theories that extrapolate from one species to the other on circumstantial evidence to provide a thesis for the evolution of reproductive patterns in the genus and their adaptive significance.

Both species are monoestrous and monotocous. The left ovary provides gametes while implantation occurs in the right uterine cornu. Birth is in summer. In **M. schreibersii** conception occurs in autumn, about one month after the release of sperm to the epididymides. Implantation is deayed during the winter torpor but embryonic growth is not completely arrested.

Data from other latitudes lend further support to theories that a latitudinal cline exists in the timing of reproductive events in this species. However, it appears that even in tropical latitudes, **M. schreibersii** mates during winter and not in spring as previously suggested; delayed implantation of varying length may well be a consistent feature of this species.

M. australis conceives in late winter after an extended period of spermatogenesis. Epididymal sperm are present some 2½ months prior to insemination. I plantation does not appear to be delayed. No latitudinal variation in the chronology of events is noted from 23 50'S to 31 S (southern limit of the species), and gestation remains the same length as the (presumed) species specific minimum (New Hebrides, 15 15'S).

The study has refuted theories that hold that tropical members of both species have a similar reproductive cycle and that adaptive changes have occurred in **M. australis** in temperate latitudes towards the pattern shown by **M. schreibersii.** However, it is proposed that a silent ovulation, a phenomenon found to exist tinboth species at 28 50'S several months prior to behavioural oestrus may be a mechanism by which such evolutionary shifts could be effected.

POPULATION DEVELOPMENT OF BATS IN THE FEDERAL REPUBLIC OF GERMANY

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Regular stock of bats have become absolutely essential in view of the threat to many species. Developments in regard to various species were numerically recorded and commented on. A nursery colony of mouse-eared bats (**Myotis myotis**) consisting of three quarters which, in 1961, comprised 393 members, dropped by 26.7% within a period of 15 years. In a large winter quarter in the Frankenalb/North Bavaria, where in March 1962 4500 **Myotis myotis** were counted, the number had reduced to 400-500 by the winter of 1975/76 (i.e. a drop of 8.8-11.1%). The decline in the population of the lesser horseshoe bat (**Rhinolophus hipposideros**) in Central Europe is also catastrophic. Of the total of 32 of this species in 5 quarters in the Rhineland in 1966, for example, there were only 2 in 1977. In the most parts of the Federal Republic of Germany **Rhinolophus hipposideros** died out. In the neighbouring country Belgium the last **hipposideros** were ascertained 1977. As further investigations have proved, however, not all Central European species are directly threatened.

OBSERVATIONS ON THE SOCIAL BEHAVIOR OF THE COMMON VAMPIRE BAT, **DESMODUS ROTUNDUS**, IN CAPTIVITY

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A number of observations, both in the field and in the laboratory, have shown that the common vampire bat, **Desmodus rotundus**, has a complicated social structure. It is very likely that a number of individuals keep together for a longer period of time and establish a stable group. Especially the behavior related to infancy is highly specialised. As young vampire bats rely to their mothers up to an age of 9 months, strong bonds have to be established that the juveniles are not lost. Not only the mother takes care of the young one, but other group members as well groom and feed it. When the mother dies, another female of the group adopts the juvenile. After some days the lacteal glands develop and the foster-mother is able to suckle the young one.

VISUAL PATTERN DISCRIMINATION IN THE COMMON VAMPIRE BAT, **DESMODUS ROTUNDUS**

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In a two-choice apparatus, 2 common vampire bats, **Desmodus rotundus**, were trained to discriminate between a vertical bar (2X12 cm, positive) and a circle (r=2.76 cm, negative). These "standart patterns" were white on a black background and had the same area. The decision point, where the animals had to make their choice, was 50 cm away from the signs; the light intensity was 250 lx.

In the critical experiments the pattern was altered in different respects, but the standart signs were,always offered every three or four trials, so that the original training performance was maintained. Changing the background (black signs on a white background) did not diminish the level of the performance, equally when drawing the patterns as contours or broken outlines. Altering the position of the positive bar showed that only the vertical bar was selected, at an angle of 45 it was no longer preferred and a horizontal bar was significantly rejected. If the area of the signs differed very much, usually the most extensive pattern was selected (a circle was only selected when it was at least three times bigger than the bar)l In complex patterns the bats used for their discrimination, besides the vertical extent of the signs, the "vertical impression" of the pattern arrangement.

DETECTION OF TARGET MOVEMENTS BY ECHOLOCATING BATS

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Different species of bats live in various ecological situations and as a result they have to solve different echolocation tasks. During evolution, in each species the emitter and receiver of the echolocation system - that means the sound emission apparatus and the receiving auditory system - have been adapted for the evaluation of relevant information. Echolocation sounds with a long constant frequency (cf) and a short frequency modulated (fm) part are very effective for the detection of Doppler frequency shifts caused by the relative movement between bat and target.

Some bats with long cf-fm sounds lower the frequency of the emitted cf-parts of their orientation sounds in order to compensate for Doppler shifts caused by the relative movement between bat and target. The echofrequency is therefore maintained at a constant characteristic reference frequency. The properties of theis feedback system for Doppler shift compensation can be investigated with electronically simulated Doppler shifts.

The auditory system of bats with long cf-fm sounds and Doppler shift compensation is specialized for the analysis of echoes within the range of the reference frequency. At this frequency the auditory threshold shows a sharply tuned minimum. In single unit studies many extremely narrow-band neurons with a best frequency near the reference frequency have been found.

These results led to the hypothesis that the constant echofrequency adjusted by the Doppler shift compensation is used as a carrier for amplitude and frequency modulations caused by the moving wings of insects. The evaluation of these echo features would give the bat information bout the nature of the fluttering target.

Behavioral discrimination experiments have shown that **Rhinolophus ferrumequinum** is able to detect even very small frequency modulations in the echoes caused by oszillating target movements and to use this information to discriminate a fluttering from a non moving target. The real-time-spectrum-analysis of such echoes reveals assysmetrical bandwidth changes in succeeding spectra in rhythm with the wingbeat. This suggest that, owing to their specialized auditory system, these bats are able to detect at least the wingbeat frequency of a flying insect. It may even be possible, that they can gain additional information on the size, form, agular direction and nature of a fluttering insect.

CODING OF SMALL SINUSOIDAL FREQUENCY AND AMPLITUDE MODULATIONS IN THE INFERIOR COLLICULUS OF RHINOLOPHUS FERRUMEQUINUM - POSSIBLE MECHANISM FOR CODING OF WING BEAT REFLECTIONS FROM INSECTS

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Single nuurons in the inferior colliculus of the Greater Horseshoe bat, **Rhinolophus ferrumequinum,** showed two braod categories of response patterns to sinusoidally frequency (SFM) or amplitude (SAM) modulated stimuli. Tonic responding cells (best excitatory frequency (BEF) between 10 and 90 kHz) showed a rough sinusoidal modulation of the discharge pattern to SFM. Transient responding neurons, generally showing on- or off-responses to pure tones (BEF between 65 and 88 kHz), displayed highly synchronized discharge patterns to SFM-cycles. Modulation rates between 20 and 100 Hz were most effective and some neurons encoded modulation rates up to 350 Hz. The SFM responses were best synchronized to the modulation envelope for carrier frequencies in the upper portion of the tuning curve. Sharply tuned neurons with BEF around 80 kHz had the lowest threshold for modulation depth (+ 10 Hz or 0.025%). In general SAMs evoked the same type of response patterns and were encoded down to modulation index of 3%. The fine frequency and amplitude discriminations for periodical modulations by collicular neurons is discussed as related to the detection and discrimination performance of bats, when preying on flying insects in clustered surroundings.

SINGLE NEURON ACTIVITY IN THE INFERIOR COLLICULUS ELICITED BY ARTIFICIAL ECHOES IN VOCALIZING RHINOLOPHUS FERRUMEQUINUM

Gerd Schuller

During active echolocation in bats the emission of intense echolocation sounds leads to a strong self-stimulation of the ear. The echo intensities commonly lie far below that of the emitted pulse and the echoes are delayed in time and modulated in both frequency and amplitude depending on the distance and state of motion of the target. In bats with long CF-components the echoes always overlap with the emitted sounds and this overlap has been proved

to be essential for the functionaing of the Dopplershift compensation system in **Rhinolophus ferrumequinum.** It is argued, therefore, that the stimulation by the emitted sound plays an important role in echolocation performance and has not only masking effec. Consequently, the self-stimulation by the emitted sound was used as one important stimulus during single neuron recording experiments in the inferior colliculus of Rhinolophus **ferrumequinum.**

Besides neurons that exhibited the response features known from usual 2-tone experiments neurons were found whose responses to acoustical stimuli were specifically influenced by vocalization in the following way:

a) When the emitted vocalizations were frewuency shifted and played back to the bat's ear (simulation of Dopplershifts due to the bat's flight speed) some neurons encoded the frequency shifts by changes in the response patterns or the latency of the onset of the spike activity evoked by the played back echoes.

b) Some neurons encoded sinusoidally frequency modulated (SFM) signals (simulation of wing beat reflections of insects) by synchronized discharges much better or only when the vocalizations overlapped completely or partially with the SFM-stimulus. Vocalizations seem to influence the responses to an acoustical stimulus in a different way than does an artificial tone in the 2-tone stimulation experiments.

HETEROSCADASTICITY IN STATISTICAL ESTIMATES OF SPECIES PACKING IN BAT COMMUNITIES

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Thirty one faunas of insectivorous bats occuriing on the North American continent were studied with multivariate morphometric methods to test the hypothesis that communities of bats do not become more tightly packed in character attribute space, and by inference ecological resource space, as these communities increase in number of species along a temperate-tropic latitudinal gradient. Measures of species packing based on Euclidean distance coefficients may be biased if the character space is not orthogonal or if the distributions of nearest neighbor distances do not have equal variances. This bias has been removed from a previous linear regression predictive model of species packing by rotation of the character space to principal components, recalculation of the nearest neighbor distances and the use of the geometric mean distance to nearest neighbor in each fauna as a measure of species packing. Species packing increases with number of species in temperate zone faunas. However, in tropical faunas species packing remains nearly constant with increasing number of species.

PHYLOGENETIC ADAPTATIONS OF ECHOLOCATION IN BATS

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The orientation sounds of echolocating bats vary from species to species and within species from one situation to another. The same factors in the acoustic environment seem to influence both phylogenetic and behavioral adaptations of echolocation and echolocation sounds. Some bats (for example, **Tadarida**) are highly flexible in their use of a variety of echolocation sounds corresponding to the whole range of sounds used by several different and less flexible bats (for example, **Myotis, Eptesicus, Macrotus, Pteronotus**). Other bats are apparently highly specialized and may be less flexible on account of their specialization (for example, **Rhinolophus**).

The sonar sounds of bats can be organized by species, genera, and families into "phylogenetic trees" on the basis of different assumptions about which characteristics of the sounds are primitive and which are derived. These patterns, which can be interpreted as models of the evolution of bats and echolocation, are similar for several different kinds of assumptions about the features of primitive bats. If one assumes (1) that primitive echolocating bats were

insectivorous and used sonar to hunt for prey in or near vegetation, (2) that primitive bat larynxes produced short, multiple-harmonic orientation sounds with relatively little vocal-tract filtering, (3) that primitive bats exhibited relatively little flexibility in echolocation and that flexibility in echolocation evolved to satisfy increasingly adaptable habits (excepting species with obviously advantageous but restricting specializations), or (4) that primitive bats possessed some feature not directly related to echolocation (such as "primitive" shoulder articulations), the resulting hypothetical evolutionary trees for orientation sounds are surprisingly similar. Furthermore, this phylogenetic progression of orientation sounds is much like the pattern of adaptive changes present in the orientation sounds of individual species, indicating the likelihood that the same acoustic and environmental factors converge on both phylogenetic and behavioral adaptations of echolocation. A phylogenetic interpretation of the orientation sounds of bats, supported by observations of adaptive behavior in individual species, may be useful in clarifying evolutionary relationships among bats.

PHYLOGENETIC INFERENCE AND CHIROPTERAN PHYLOGENETICS

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"The resemblance of the bats to one another and their differences from all other animals are so obvious that the group has been intuitively recognized from the dawn of mankind....the essentially independent nature of the order has not been questioned for about a century (Simpson, 1945)." In view of their rather poor fossil record and their supposed morphologic uniqueness (possession of wings), the genealogical relationships of bats still remain largely unquestioned.

The purpose of this symposium is to revitalize critical examination of the phylogenetic relationships of bats. As such, two major questions will be approached. The first, and perhaps most important, concerns the assessment of the overall relationships of bats to other groups of eutherian mammals; specifically the Insectivora and Archonta. The focus of this question will be on the sister-group relationships of the two suborders Megachiroptera and Microchiroptera. Most chiroptologists have recognized the marked distinctness of the Megachiroptera and most post-Linnean classifications reflect this with their assignment to some higher taxonomic category. However, few studies have sought the shared similarities (other than the possession of wings) that these bats possess with Microchiroptera or other non-volant mammals. Such relationships must exist, even among exant mammals, if we are to interpret evolutionary relationships (i.e., descent with modification).

ADDITIONAL MATERIAL OF RHINOLOPHUS RUWENZORII HILL, 1942, WITH COMMENTS ON ITS NATURAL HISTORY AND TAXONOMIC STATUS

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Eleven specimens (LACM 51747-51 and 57772-77) of this rare and distinctive horseshoe bat will be reported from the east slope of M. Ruwenzori and two locations in the Impenetrable Forest, Kigezi Highlands, Uganda. The latter constitute an extension of the known distribution. The species apparently occupies an altitudianl range between 1000-3000 m with the majority of specimens reported from above 2000 m. The reproductive status of the March-taken specimens from the Impenetrable Forest will be reported. Examination of stomach contents suggests that, in March at least, the species appears to prey, exclusively, upon macrolepidopterans presumably of the families Noctuidae,

Geometridae, or Arctiidae. Judging from the size of fragmented pieces of exoskeleton, prey size ranges from 8-12 mm in length and 25-35 mm wing span. The taxonomic status of **R. ruwenzorii, R. maclaudi,** and **R. hilli** will be discussed. We will propose that among several possible solutions, and in the interest of systematic stability and simplicity, these three species constitute but a songle species **Rhinolophus maclaudi** (by priority). In addition, we suggest recognition of two subspecies **R. m. maclaudi** and **R. m. ruwenzorii** (new combination, by priority) for the West and East African populations, respectively. The recent distribution of **R. maclaudi** is suggestive of a formerly broader Trans-sudenese distribution. If **R. maclaudi** is indeed phylogenetically related to the **R. philippinensis** superspecies group, as has been supposed, it represents a generalized track linking Ethiopian Africa with Southeast Asia and associated Indo Australian Islands.

PENIAL HISTOMORPHOLOGY AND THE QUESTION OF CHIROPTERAN PHYLOGENY

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Relatively little is known concerning the histomorphology of the penis of bats; and for that matter, the internal anatomy of mammalian penes in general. In contrast, there is a rather extensive literature regarding the variation of the isolated os penis (baculum) of bats as well as other mammalian groups; especially of rodents and carnivores. The penis seems to be an ideal form/function complex for studying chiropteran phylogenetics because, unlike many such complexes, it should not be expected to be involved in either feeding or flight adaptations and therefore allow direct comparison among all possible mammalian sister-groups. The problems that we have encountered in this study have been in acquiring sufficient, well-preserved material, and general confusion, in the literature, relative to anatomical orientation and terminology. In addition, absolutely no assessment of primitive vs. derived characters or of homology has been proposed.

We have serially sectioned (x-sec.) and stained (Gomori Trichrome – specific for connective, muscular, and vascular tissues) penes of approximately 100 bat species representing all extant families (except Myzapodidae). In addition, we have prepared sections of some insectivores, **Tupaia, Cynocephalus**, and several primates.

The penis of bats is pendant (judged to be primitive among eutherian mammals) and of the vascular type (i.e., erection by blood engorgement of spongeous cisterns). Externally, the penis is comprised of the glans (distal knob-like structure in most cases), prepuce (flap of skin that variously covers the glans), penial shaft, and the proximal root. Internally, the structure of the penis varies considerably. In Primates and pteropodids, the glans consists entirely of a distal expansion of the corpus spongiosum; an os penis may or may not be present. In Microchiroptera, shrews and moles, and **Tupaia** the glans is not so constructed and consists of an os penis (in most cases); distal extensions of the corpora cavernosa; and extra spongeous tissue here referred to as accessory cavernous tissue. In these mammals the corpus spongiosum does not appear to extend into the glans or if it does, it is not expanded. This latter condition is judged to be primitive (by communality), whereas that described for Primates and pteropodids is here considered derived. Dermoptera appear to possess an intermediate glans construction with apparent shared, derived similarities with Primates and pteropodids. There is little variation, other than bacular size and shape, within the Pteropodidae.

The phylogenetic relationships among microchiropteran families is less clear, and confused by a great deal of variation. Winge's superfamilial groups seem to be corroborated. Vespertilionids possess the most internally complicated and externally ornamented penes of all microchiropterans. The glans of these bats is characterized by a marked augmentation of accessory spongeous masses in both the glans and prepuce. On the other hand, phyllostomatids possess the least complicated penes.

DIET PREFERENCES OF **CAROLLIA PERSPICILLATA**

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The diet preferences of **Carollia perspicillata** were studied in Costa Rica in 1977-1978. The bats were captured using mist nets and released into a large nylon flight cage. After acclimating to the cage for one night the bats were individually presented with ten fruits of two different types. The order of consumption, rate of consumption, method of consumption, and time of passage through the gut were observed with the aid of a night vision scope. In this manner, a variety of fruits were offered to the bats during both wet and dry seasons with special regard for the transition periods between seasons.

The bats preferred to eat fruits from the latest species to become ripe over fruits from species that had been fruiting for some time. The results of the feeding experiments will be compared with diet information obtained from the feces of the free population of bats.

BAT CONSERVATION WORLDWIDE AND THE WORK OF THE CHIROPTERA GROUP, SURVIVAL SERVICE COMMISSION, IUCN

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Historic attitudes to bats and conservation measures already taken will be reviewed. The major current problem is the very large number of bat species whose systematics and ecology are poorly known. A clearly differentiated species like **Pteropus rodricensis** whose world population is known to be less than 200 is obviously in need of conservation. But can we regard **Miniopterus schreibersi** in Europe as the same species as in Africa, Asia, or Australia? Are there local ecological races which ought to be protected? What criteria ought we to use to decide whether a species needs help? Overall threats to bats include loss of habitat and food, loss of roosts and pollution. The solutions to problems involve protecting critical habitat, education, legislation and as a last resort captive propagation. The S.S.C. Chiroptera Group aims to identify conservation problems, formulate projects and seek funding and personnel to carry them out.

PRIMARY ASSESSMENTS OF SELECT CHEMICALS AS NONLETHAL BAT REPELLENTS

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The relative aversive or repellent effects of select chemicals were compared in standardized laboratory tests with two species of insectivorous bats **(Eptesicus fuscus** and **Myotis lucifugus).** Behavioral responses of individual, captive bats were quantified before and during 10-minute indirect sprayings of allyl isothiocyanate, formalin, paradichlorobenzine, ortho-chlorobenzalmalonitrile, and several media (e.g., water, ethanol, Carbopol 941) within an airtight chamber. Relative to pretreatment, allyl isothiocyanate produced increased crawling and flight responses in exposed bats, with movement distance positively related to concentration (0.5%, 1.0%, and 5.0%). Subsequently, a field trial to assess the effectiveness of spraying bat roosts with allyl isothiocyanate aerosol was conducted at several sites in southern Massachusetts. Although results of this trial were equivocal, data suggest that the efficacy of chemical repellents is dependent on the aversive properties of compounds, the method of application used, and the nature of roost sites.

NIGHTLY DISPERSAL AND ACTIVITY PATTERNS OF THE GRAY BAT (MYOTIS GRISESCENS) OVER AN EAST TENNESSEE RESERVOIR

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Nightly dispersal an activity patterns of a maternity colony of 8,000 gray bats were studied from April through July of 1976 and 1977. Seasonally variable but highly predictable patterns of activity were found at the maternity cave entrance. Except for brief periods of extreme weather, these bats dispersed nightly along approximately 362 km of reservoir shoreline. Bats traveled several regular routes to foraging areas, often in loosely-formed groups. Most routes were over water, but one crossed a forested peninsula for a distance of 5.7 km. The most distant documented foraging site was 20.3 river-km from the cave.

Bats used the early evening period of maximum insect abundance for travel and group foraging along flyaways. Rates of travel were fastest over forest, where average flight speeds varied from 28 to 38 km/hr. Traveling groups decreased rapidly in size after the first half-hour, as individuals and small groups reached their territories.

All foraging territories observed were over water, within 20 m of shore, oval in shape, and at least partly protected from wind. The reservoir bottom at foraging sites was rocky, usually slab-rock. Different areas had strikingly different nightly and seasonal use patterns which were repeated annually. No territories were found over flooded farmlands, and areas of red clay bottom were invariably low-use areas. Inundation by the reservoir appears to have greatly decreased the amount of habitat suitable for gray bat foraging, and foraging sites are in limited supply.

CONTRACTILE PROPERTIES AND FIBER TYPE COMPOSITION OF SOME FORELIMB MUSCLES IN EPTESICUS FUSCUS

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In this study the three major downstroke muscles (posterior division of pectoralis profundus, posterior division of serratus anterior, and subscapularis) were studied histochemically in **Pteronotus parnellii** and **Phyllostomus hastatus.** Relative contraction speeds, oxidation and glycolytic potentials of the fibers of these muscles were estimated by using techniques for the determination of myosin ATPase, mitochondrial NADH - diaphorase and mitochondrial X-GPD activities respectively. Unlike the **Myotis lucifugus** pectoralis in which only fast oxidative fibers have been described, the pectoralis in both studied species contains both fast oxidative-glycolytic (FOG) and slow oxidative (SO) fibers, with SO fibers being more numerous in **Phyllostomus.** The serratus and subscapularis muscles contain fast glycolytic (FG) fibers in **Pteronotus,** in addition to FOG and SO, while FG fibers are absent in **Phyllostomus.** Histochemically, the serratus is more similar to the pectoralis in **Phyllostomus** than it is in **Pteronotus.** This fact may be related to the greater degree of development of the humero-scapular lock in **Phyllostomus,** because this lock allows the serratus to assist the pectoralis in moving the wings.

PHYSIOLOGICAL ECOLOGY OF **MYOTIS**

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Evidence continues to accumulate which indicates that studies of physiological ecology of captive bats and other small mammals frequently reflect maximum physiological capabilities while providing little useful data for estimating actual energy, water and mineral budgets of free-living individuals. It is important, therefore, to place

greater validity on studies done on bats in their natural setting or immediately after capture from studies performed on individuals maintained even briefly (a few days) in captivity.

Bats of the genus **Myotis** seem to be capable of regulating their body temperature (Tb) throughout most or all of the year. This ability, however, is not regularly evidenced in free-living bats. Naturally roosting females appear most often to uniformly regulate Tb (at or slightly above 30 C) in lower ambient temperatures (Ta) only during middle pregnancy and early post lactation. Although some females regulate Tb at other times of the year, it is never again a uniform characteristic of the population. In addition, appropriate maternity roost selection coupled with daily behavioral thermoregulation provide minimal Ta stress and serve to minimize required metabolic energy expenditure for daily routine maintenance. We feel that it is tenable to hypothesize that energy budgets in free-living **Myotis** may not be dependent on ingested energy level but that to a great extent, these bats maintain energy economy through behavioral and physiological adjustment of roosting energy use.

Water turnover in **Myotis** is also highly variable with roosting metabolic rate, behavioral thermoregulation and outside environmental conditions playing significant roles in modifying rates of evaporative water loss (EWL). Under most conditions, EWL is the major route of daily water loss in bats and is the route which is most readily controlled. Species capable of flying at reduced Tb may have reduced water vapor pressure deficits. They may conserve significant amounts of water by dissipating the heat generated by flying through radiative or conductive heat loss rather than evaporative heat loss. Daily fecal water loss is relatively constant and minimal. Daily urinary water loss may be variable due to differences in nitrogen load from feeding and differences in roosting EWL.

Relatively little data are available concerning mineral cycling in bats. Such limited information shows large daily fluctuations in blood ion composition which appear to relate directly to the extent of roosting EWL.

VISUAL SYSTEMS AND THE EVOLUTIONARY RELATIONSHIPS OF THE CHIROPTERA

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Megachiroptera depend heavily on vision and have well developed, nocturnal eyes. Except for certain rousettine species they lack an ability to echolocate. The visual development of the echolocating Microchiroptera varies with feeding habits and ecology. The megachiropteran eye is characterized by the presence of a regular array of microscopic choroidal papillae which protrude into the retina and impose their undulations on the adjacent receptor cell layer. These papillae are not present in Microchiroptera or in other vertebrates. A capillary loop from the choriocapillaries penetrates into the otherwise avascular retina from the tip of each papilla. The avascular retina of Microchiroptera is nourished by diffusion from the choroidal circulation. Avascular retinas are found in some insectivores. In primates the retina is perfused via a retinal artery. There is evidence for the existence of a few cone-like receptors in the predominately rod retinas of both the Mega- and Microchiroptera. Both groups lack an identifiable area or fovea. A tapetum lucidum is present in Megachiroptera, but not in Microchiroptera.

The importance of vision in the lifestyles of various bats is reflected in the relative development of visual centers in their brains. Two important visual centers are the dorsal lateral geniculate nucleus (LGNd), which relays information to the visual cortex, and the superior colliculus. Baron (1978) has compared the relative size (volume) of these structures in a number of species of bats to the size of the same structures in the "basal insectivores" – defined by Stephan (1967) as consisting of ten species belonging to the families Tenrecidae, Erinaceidae, and Soricidae.

LGNd is relatively larger in all bats studied (except **Noctilio**) than it is in basal insectivores of the same body size. In the insectivorous bats studied LGNd averages 1.4 times larger. In **Desmodus** it is twice as large and in the Phyllostomatidae it averages over three times as large. LGNd is greatly hypertrophied in the Megachiroptera, averaging ten times as large as in the basal insectivores. Not only is the LGNd of the Megachiroptera very large but it is organized into cellular laminae. In **Pteropus** (Crowle, 1974) and **Rousettus** at least three laminae are present. Lamination of LGNd is also found in **Tupaia** and all primates but is absent in the insectivores and the Microchiroptera. The retinal input to LGNd is bilateral in **Pteropus** (Crowle, 1974) and the fibers from one eye selectively innervate different portions of the nucleus on each side of the brain. Similar patterns of retino-geniculate connectivity are seen in **Tupaia** and primates.

Among the Microchiroptera a small ipsilateral projection to LGNd is present in **Anoura** (overlapping a part of the contralateral input), but none have been reported in **Myotis** or **Carollia** (Pentney and Cotter, 1976; Kirtland and campbell, 1969).

The superior colliculus is larger in all bats studied by Baron than it is in the basal insectivores. It averages 1.8 times as large in the insectivorous bats and 1.4 times as large in **Desmodus**. In the Phyllostomatidae it averages nearly twice as large and in **Noctilio** it is more than twice as large. In the Megachiroptera studied the superior colliculus averages 3.3 times as large as that of the basal insectivores. Retinal projections to the superior colliculus are bilateral in **Pteropus** (Crowle, 1974), but appear to be exclusively ipsilateral in the Microchiroptera studied to date – **Anoura**, **Carollia**, and **Myotis** (Kirtland and Campbell, 1969; Pentney and Cotter, 1976). The absence of ipsilateral retinal innervation of the superior colliculus has not been reported for any insectivore (except the mole, **Talpa**, which appears to have no retino-collicular fibers at all; Lund and Lund, 1965) or primate.

We are examining the retinal projections in two additional species of bats – an echolocating megachiropteran, **Rousettus aegypticus**, and a relatively visual microchiropteran, **Phyllostomus hastatus**.

THE PHYSIOLOGY AND ENERGETICS OF BAT FLIGHT

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The capacity for true flight places a number of special physical and biological demands on bats, but provides these unique mammals with several distinct advantages over their non-flying terrestrial counterparts. Among the physiological demands are the high energetic requirements of bat flight which can exceed by a factor of three the highest metabolic rates of which similar-size non-flying mammals appear capable during heavy exercise. Associated with this high metabolic requirement during flight is the need for bats to dissipate the large quantities of excess metabolic heat produced during flight. Bats appear to be well endowed in this regard, and can regulate their body temperature rather precisely during steady flight at a level which is several degrees above that at rest. The high energetic requirements of bat flight also place special demands on the respiratory and cardiovascular systems of these mammals. Whereas few studies have been made in these areas of bat flight physiology, at least certain species of bats maintain a rigid 1:1 synchronization between their ventilatory and wing-beat cycles, and echolocating bats appear to time their ultrasonic orientation pulse emissions during flight in a manner which is minimally disruptive to their pulmonary ventilation process. Limited data from bats indicate that these mammals may require somewhat higher ventilation volumes per unit of oxygen consumed during flight than do birds flying at comparable conditions. The high rates of oxygen transport by the cardiovascular systems of flying bats appear to be achieved by their capabilities for high cardiac outputs in combination with their blood properties which, at least in certain species of bats, have been shown to have significantly higher hemoglobin concentrations than those of a typical non-flying mammal. Among the many advantages which the capacity for flight confers on bats is the speed and economy of this mode of locomotion which enables flying bats to travel considerably greater distances per unit of energy consumed than their non-flying terrestrial counterparts.

A REPORT ON THE NORTHEASTERN SYMPOSIUM ON BAT RABIES MANAGEMENT

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On June 6th and 7th, 1978, a symposium on the management of bat rabies as a public health problem was held at the New York State Department of Health, Albany, N.Y. The program included presentations by representatives of the states of Delaware, Massachusetts, New Jersey, New York, Pennsylvania, Vermont, and the City of New York, and

the Province of Ontario, Canada. They reported on the extent and distribution of bat rabies, frequency of human exposure to bat rabies, and programs for management of bat bites in their respective areas. The program also included presentations by federal and state health officials and bat biologists on topics including concepts of bat rabies management, research programs on house bat control, methods of chemical control, efficacy of the use of toxicants in house bat removal, and responses of bat populations to management procedures. An open discussion followed the formal program.

Bat rabies was most frequently reported in the big brown bat, **Eptesicus fuscus**, with percentages of infection in examined specimens ranging from 3 to 10%. This figure represents bats which are examined because of aberrant behavior or human contact, and is therefore much higher than the incidence of rabies in the general bat population. Rabies is less frequently identified in the **Myotis** species of this region. In New York City and Delaware, migratory bats, especially the red bat, are most frequently found rabid. The number of actual cases of rabid bats biting humans is reportedly very low in each area. The major public health significance of bat rabies is the number of persons requiring rabies post-exposure prophylactic treatment because of exposure to bats which escape or are unsatisfactory for examination.

Management programs that were presented involved various combinations of the following activities: education of the public and medical personnel, prompt rabies diagnosis and rabies prophylaxis when indicated, exclusion of bats from buildings presenting high human-bat contact potentials such as schools and hospitals, collection of colonies associated with laboratory confirmed rabid bats, and research programs defining transmission capabilities of bats to man, pets, and terrestrial wildlife. Some areas including Massachusetts, New Hampshire, and Ontario, are currently using DDT within the guidelines set by the Center for Disease Control in Atlanta, Georgia, for the extermination of house colonies of big brown bats.

The open discussion included consideration of non-DDT chemical control substances, efficacy and safety of DDT as a method of controlling bats, and effectiveness of eliminating house bat colonies as a means of reducing the public health hazard of bat rabies.

ANALYSIS OF VESPERTILIONID SONAR SIGNALS DURING CRUISES, PURSUITS AND CATCHES

Yves Tupinier, Yvon Biraud, Monique Chiollaz et Bernard Escudie

Since ten years very few studies have been made on fine analyses on bat signals emitted during pursuits and catches.

Such experiments need being performed on naive animals under natural conditions in free space. That is what we have done during the summer 1977 on **Eptesicus serotinus** and **Pipistrellus** sp.

We have plotted for each click the amplitude and frequency modulation laws. It is interesting to follow the variations of these two quantities during the pursuit. We have noticed that the bat matches its emission to the situation: movement of the target and environment constrains. These constrains were quite severe: presence of echoes, reverberation and multipaths.

We have followed the ideas of J.A. SIMMONS who proved that many bats perform a coherent detection. We have calculated the instantaneous frequency laws. They are almost hyperbolic. The overall bandwith and the frequency nodulation ratio provides to these signals both a very important Doppler tolerance and good angular resolution when a binaurel interferometric type reception is performed.

Further investigation of the results of this experiment will allow an interesting comparison with the theorical approach trying to synthetize signals optimum in the presence of flucturations and reverberation.

FORAGING SITE SELECTION AND TERRITORIALITY OF THE GRAY BAT (MYOTIS GRISESCENS)

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Members of a gray bat maternity colony were highly selective in their choice of foraging territories. Many traveled to sites more than 10 km from their roosting cave, despite the existence of large areas of unused reservoir shoreline within less than 5 km. Following emergence, groups of gray bats exploited insect patches in otherwise marginal habitat while traveling to territorial sites. Arrival times at territories were positively correlated with early evening insect biomass.

Insect samples, collected simultaneously at both foraging and nonforaging sites in June and July of 1977, revealed no significant differences in total insect biomass but showed nightly biomass distribution to be much less patchy at foraging sites. Taxonomic comparison revealed significantly more Ephemeroptera and fewer Coleoptera at foraging sites. Both of the mayfly genera (Choroterpes and Stenacron) that occur at gray bat foraging sites prefer similar habitat, have extended annual periods of emergence, and often continue to emerge late at night when most other insects are relatively inactive. Therefore, though patchily distributed, once mayfly emergence sites were found by the bats, they provided relatively dependable food sources, both nightly and seasonally.

Territories were vigorously defended and occupied by from one to 10 or more individuals. At a closely studied territory a marked, adult female clearly dominated a group which averaged four to six members. Aggressive behavior was inversely proportional to edible insect biomass, and the dominant female excluded varying numbers of group members, proportional to declines in insect biomass.

A marked yearling female was permitted to share the territory only during brief periods of high insect biomass, and it is believed that both yearling and adult males were similarly excluded. At least some territorial sites were occupied for more than one year by the same bats, while other bats appeared unable to establish territories.

DELAYED IMPLANTATION IN THE NATAL CLINGING BAT MINIOPTERUS SCHREIBERSI NATALENSIS (A SMITH 1834)

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M. s. natalensis gives birth to a single progeny per annum, although less than one per cent twins can be expected. The first ovulations occur during the beginning of March, peaking during the first half of April. Ninety percent of the ova are shed from the left ovary but the conceptus alsays implants in the right uterine cornu. Implantation occurs four months after conception.

Gestation in this species last eight months and can be divided into two equal periods: the retarded gestation period (+ 4 months) from fertilization until implantation and the active gestation period, also + 4 months, from implantation until birth. During the retarded gestation period development is slowed, with the conceptus developing only as far as the free-lying bilaminar blastocyst. The only significant development during this stage is the formation of the entodermic vesicle and the primitive amniotic cavity within the inner cell mass.

The embryonic pole of the blastocyst is always orientated towards the antimesometrial side of the right uterus cornu at the implantation site, where a shallow cavity develops within the uterine wall, slightly enclosing the blastocyst.

As the time of implantation draws near the lining epithelium of the uterine cornu becomes progressively more fringed or scalloped, thus gradually enclosing the trophoblast in a "pocket". During implantation breakdown of the uterine epithelium is not restricted to the area surrounding the blastocyst, but occurs over the entire uterine lumen, although much accelerated directly around the blastocyst.

RESPONSE CHARACTERISTICS OF SINGLE NEURONS IN THE INFERIOR COLLICULUS OF ECHOLOCATING BATS, MOLOSSUS ATER AND MOLOSSUS MOLOSSUS (MOLOSSIDAE) TO TONAL AND FREQUENCY MODULATED SIGNALS UNDER MASKED AND UNMASKED STIMULUS CONDITIONS

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The echolocation calls of M.ater and M.molossus are similarly structured: they consist of a short constant frequency (CF) component of 2 to 3 ms duration at 43 and 55 kHz respectively, followed by a frequency modulation sweeping downward approx. one octave in 2 ms. There is a strong 2nd harmonic.

Single unit recordings were made in the inferior colliculus of awake Molossids using CF-tone pulses and different FM-signals usually centered at unit's best frequency (upward, downward sweeps, different sweep rates).

1. With CF-stimuli, tuning curves, Q -values and spike count functions were measured. Except for the different frequency ranges of maximal auditory sensitivity, there is no neurophysiologically detectable difference between the two Molossid species. Q-values commonly ranged between 3 and 20, the most sharply tuned neurons having Q-values between 50 and 60. Spike count functions were nonmonotonic in most neurons. Units with phasic-on responses formed the dominant response pattern class.

2. Thresholds, response patterns and spike count functions could differ markedly depending on the signal form. A large population of neurons possessed lower thresholds to downward sweeping FM-pulses with sweeprates comparable to those occuring in the echolocation call than to CF-pulses of equal duration or to FM-pulses with slower sweeprates (pulse duration 20 ms) elicited a more vigorous firing ("burst") than any other stimulus configuration tested.

3. A comparison was made between the masked thresholds of single units to CF- and FM-signals using pseudorandom noise as interference signal. Masked thresholds to FM-pulses are lower than to CF-signals of equal duration, e.e. more noise intensity is needed to mask the FM-response. Threshold Signal to Noise ratios are samller for the long FM-pulses (20 ms) than for the short FM-pulses (2 ms).

THE LEADING EDGE: A KEY TO RAPID FLIGHT IN BATS

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Molossids are the most peripheral family of bats with regard to wing structure and style of foraging. They are able to remain on the wing for long periods and to cover large distances at relatively high speeds. However, severe aerodynamic and energetic problems are associated with rapid and enduring flight. The major problem is the increase in drag at high speeds. The molossid wing has undergone several changes from the basic chiropteran wing plan which act in conjunction to alleviate this problem.

Several morphological features of the molossid wing appear to be of particular importance. The flattening of the forearm reduces the frontal area that this obstruction presents to the airstream and smooths the upper and lower surfaces of the airfoil, consequently reducing drag. The narrowing of the leading edge flap reduces both the camber and the area of the wing which also decreases drag. The high aspect ratios of molossid wings further serve to decrease the surface area. Hair tracts are located on the wing in such a say as to further smooth the contour of the airfoil. These tracts also tend to induce turbulence in the boundary layer at points where adverse pressure gradients might otherwise cause separation of airflow from the wing.

In our judgement, this composite of modifications of the mollosid wing has been critically important in allowing for high-speed flight.

THE POND BAT (**MYOTIS DASYCNEME**), AN ENDANGERED BAT SPECIES IN NORTHWESTERN EUROPE

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The studies by Hanak and Gaisler (1965) and Sluiter, van Heerdt and Voute (1971) concerning the distribution and ecology of **Myotis dasycneme**, show that the pond bat is not evenly distributed throughout Europe. During the summer this bat species appears to be concentrated in a limited number of summer roosts, to be found exclusively in human dwellings. The pond bat hibernates in caves, which are distributed considerably more evenly over the entire central European area. Although all European nursing colonies of the pond bat seem to be located in the northern European lowlands, they can easily be divided into two sub populations: that of the Soviet Union and the one of Northwestern Europe.

As far as we are informed at this moment, the latter group of nursing colonies is completely concentrated in a small area in the northern part of the Netherlands. This means, that during the summer the entire adult female and juvenile part of the Northwest-european sub population is housed in less than ten buildings occurring in an area 60 by 60 kilometers. Clearly a very dangerous situation as is demonstrated by the appalling decline of this population caused by the government encouraged and subsidised wave of building renovation sweeping across the country; a program which aims to slow down the continuing rise in unemployment in some parts of the Netherlands.

OBSERVATIONS OF FRUIT CONSUMPTION IN SOME STENODERMINE BATS

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Abstract

Fruit consumption and food passage time were investigated in five species of Stenodermine bats (Artibeus, lituratus, Artibeus watsoni, Vampyrodes caraccioli, Vampyrops helleri and Uroderma bilobatum) on Barro Colorado Island, Panama.

Mist netted bats that had been held overnight in 40 x 40 x 30 cm cages were offered figs (Ficus insipida and Ficus yopenensis) that had been carried into mist nets by bats the previous enening. The fruits were injected with ordinary food dye, weighed, and offered to the bats, one after another, from the end of a long stiff wire.

The bats almost always immediately accepted the proferred fruit, grabbing out for it with opened mouth and forearms. They then systematically worked their way through each fruit, biting, chewing, expressing fluids and edible portions which were then swallowed before spitting out small oval pellets of rind which were dropped as they ate. Time of defecation was easily pinpointed as the bats first paused in their eating and partially spread their wings.

The average size of the discarded pieces of fruit pulp (pellets) ranged from 0.02g (Artibeus watsoni, Uroderma bilobatum and Vampyrops helleri) to percentage of each fruit ingested ranged from 43.5% (A. watsoni) to 61.1% (V. caraccioli). The time of food passage ranged from a minimum of 10 min. (A. lituratus) to a maximum of 76 min. (U. bilobatum), averaging 19.5 min., 21 min., 35 min., 27. and 35 min in A. watsoni, V. helleri, U. bilobatum, A. lituratus and V. caraccioli respectively.

REPRODUCTIVE ASYMMETRY AND UNILATERAL PREGNANCY IN CHIROPTERA

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In most carinate birds, and in representatives of several groups of lower vertebrates, the female reproductive organs are profoundly asymmetric. By contrast, in mammals it has generally been supposed that the female reproductive organs are bilaterally symmetrical in form and function. In recent years, however, varying degrees of anatomical and/or functional asymmetry have been documented in monotremes, in some marsupials and ungulates, and in Chiroptera. Bats are especially noteworthy in that they display a far greater incidence of reproductive asymmetries, and carry them farther than observed in any other comparable group of mammals. Since the patterns observed vary widely among, and even within families, it seems unlikely that they have a common evolutionary basis or a unified controlling mechanism. The possible selective advantage gained from an asymmetric reproductive functioning — assuming there is one, can scarcely be guessed at presently, but it is perplexing as to why in this ancient order of mammals reproductive asymmetry is so much more commonplace than in any other order of mammals. Asymmetry is usually expressed as a unilateral dominance (structural and/or functional) of an ovary, the uterus, or both. In bats, as opposed to birds, the dominant side is usually dextral, but in a few instances the left side is dominant. The patterns of female reproductive asymmetry observed thus far in Chiroptera will be reviewed together with some regulative factors possibly involved in specific cases.

AUDITORY PATHWAYS TO THE TECTUM IN PTERONOTUS PARNELLII PARNELLII AND ARTIBEUS JAMAICENSIS

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The inferior colliculus is thought to play an important role in processing auditory information for echolocation. In order to identify neurons which project ot this nucleus, injections of the retrograde tracer, horseradish peroxidase, were made in the right inferior colliculus in 8 **Pteronotus** and 6 **Artibeus.** The results showed that most types of cells in the anteroventral and posteroventral cochlear nucleus project to the central nucleus of the inferior colliculus but that only cells from fusiform and deep layers of the dorsal cochlear nucleus project to the central nucleus. Thes These projections are all contralateral. The pattern of labeled cells in the superior olivary complex revealed a distinction between lateral and medial superior olives in **Pteronotus,** but this distinction was not clear in **Artibeus.** Cells in lateral superior olives project bilaterally, while those in medial superior olive project ipsilaterally to the central nucleus of the inferior colliculus. A striking difference between these bats and other mammalian species was seen in the lateral lemniscus. In addition to dorsal and ventral nuclei of the lateral lemniscus, these bats have a large intermediate nucleus which contributes input to the central nucleus of the inferior colliculus. In both species, injections which included the pericentral nucleus of the inferior colliculus revealed a projection from pyramidal cells in layer V of auditory cortex. These findings suggest that the inferior colliculus processes information from as many as eight separate nuclei in the lower brain stem as well as from auditory cortex. (Research supported by NSF grant BNS 77-0696)