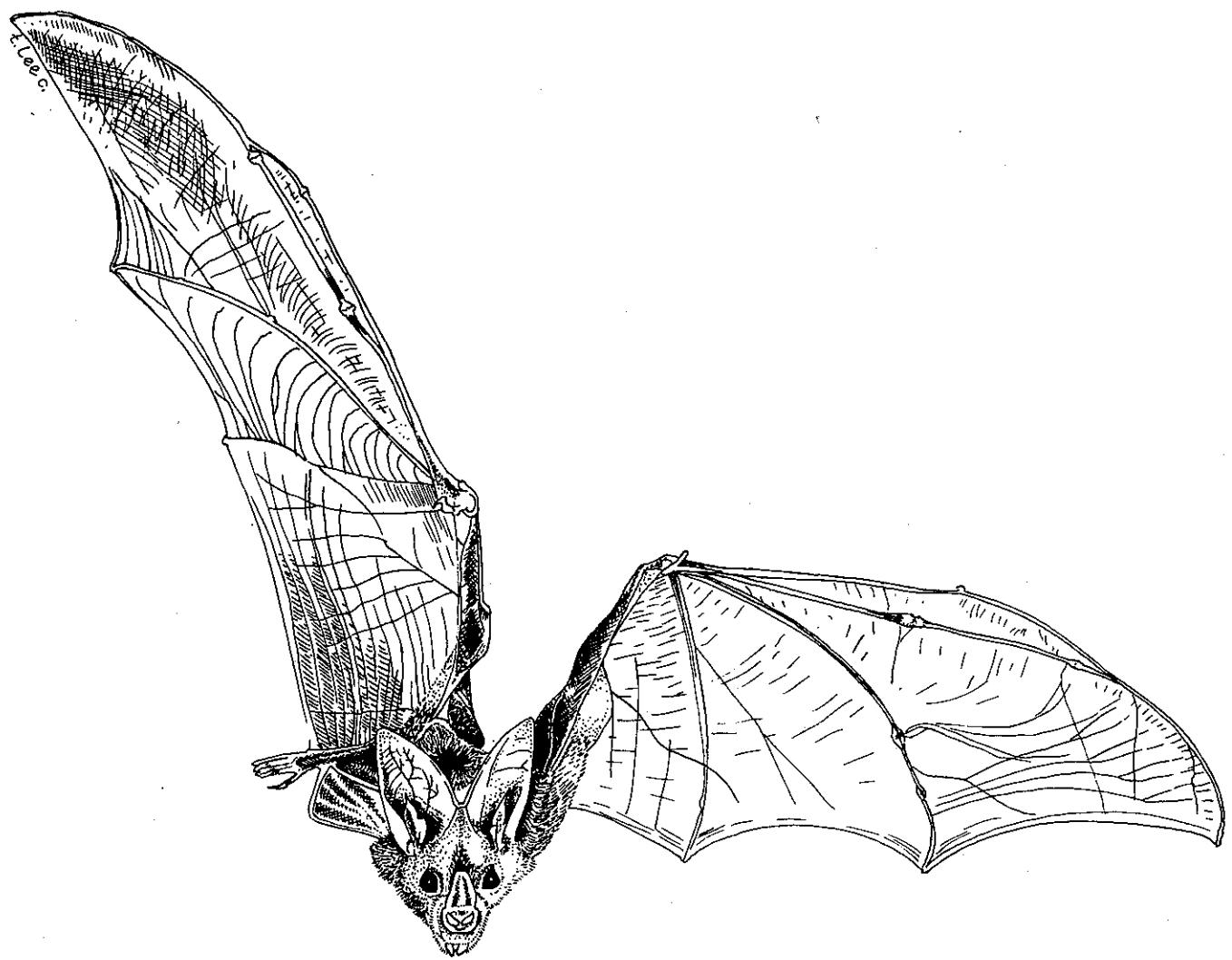


# Macroderma

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*Macroderma*

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## EDITORIAL

The response both in Australia and overseas to the first edition of *Macroderma* has been very encouraging, in particular the quantity of material received for publication. The system seems to be running relatively smoothly, but suggestions for improvements would be welcomed. Intending contributors are referred to guidelines on the inside back cover.

The supplement to this issue contains a bibliography of literature of relevance to Australasian bats from 1980 onwards and a directory of research workers and current interests. Both will be updated periodically.

In addition to *Macroderma* and *Rhinonycteris* Australia now has two new endemic genera, *Scoteanax* and *Scotorepens*. Kitchener and Caputi have revised the Australian Nycticeiini and have placed all forms into one or other of these two new genera, which were originally proposed by Troughton. People who have worked with *Scotorepens* on the south-eastern coast of Australia may not be convinced of the correctness of the apparent inclusion of "the bullet" within *S. orion*. Readers are referred to a review of the revision by Dan Walton on p. 42 of this issue.

The flying fox conference scheduled for October this year has sadly been postponed until 1986 (notice p. 74). There is, however, some good news on the flying fox front. We are informed by the NSW National Parks and Wildlife Service that *Pteropus* species in New South Wales will be placed on the protected fauna list. (Notice on the Sydney colony, p. 72).

Bat Conservation International, originally set up jointly from the US and Britain, has now split into two separate, parallel organizations. BC1 in Britain has taken the new title International Bat Project. Both organizations will continue to work closely together and both will produce quarterly bulletins. Details of these and other publications devoted to bats are provided on p. 74.

## PAPERS

### MAEDA'S MINIOPTERUS TAXONOMY

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There is no doubt that the genus *Miniopterus* presents us with one of those taxonomic problems that seem to go on forever. As Karl Koopman (1984) has pointed out, no two miniopterine taxonomies are congruent and so it seems that the definition of what constitutes a distinct species and the higher-level groupings of species remains in turmoil. I, too, have been examining the question of *Miniopterus* taxonomy for about 3 years and felt motivated to express my current views on Maeda's taxonomy, and thus the status of the Australian branch of the Miniopterinae, after reading Hamilton-Smith's (1984) note. In this article I will concentrate on the question of the validity of Maeda's results and the correctness of his methods. Many other aspects of Maeda's work have received criticism by Hill (1983), Koopman (1984) and myself (Wilson 1982), but space limitations preclude a more complete discussion here.

1. Problems with Maeda's results and methodology: From my point of view, Maeda has made several methodological errors. These include:
  - a. Reliance on a decision making process of incredible complexity. He has left us with a web of interwoven comparisons based in part on ratios and/or regressions and/or linear measurements. This makes it virtually impossible to duplicate and thus verify his conclusions. It leaves me with the distinct impression that his criterion for recognizing species differences is not constant throughout his study. I feel that it is this aspect of his methodology, more than any other, that has led to errors in his results. It seems to me that he must have been just as confused by his methods as I am. Why Maeda did not use multivariate statistical analyses is a profound mystery since their use would have avoided many of the apparent errors or shortcomings in his work.
  - b. Heavy reliance on ratios. If shape is an important factor in *Miniopterus* taxonomy (and I believe it is) then simple ratios and regressions are probably not appropriate as shape discriminators when the variation is subtle and not easily expressed in terms of ratios of linear measurements. So, although ratios are not without their uses as shape discriminators, they are crude and relatively insensitive measures. They also have very awkward statistical properties (Atchley *et al.* 1976; Corruccini 1977).

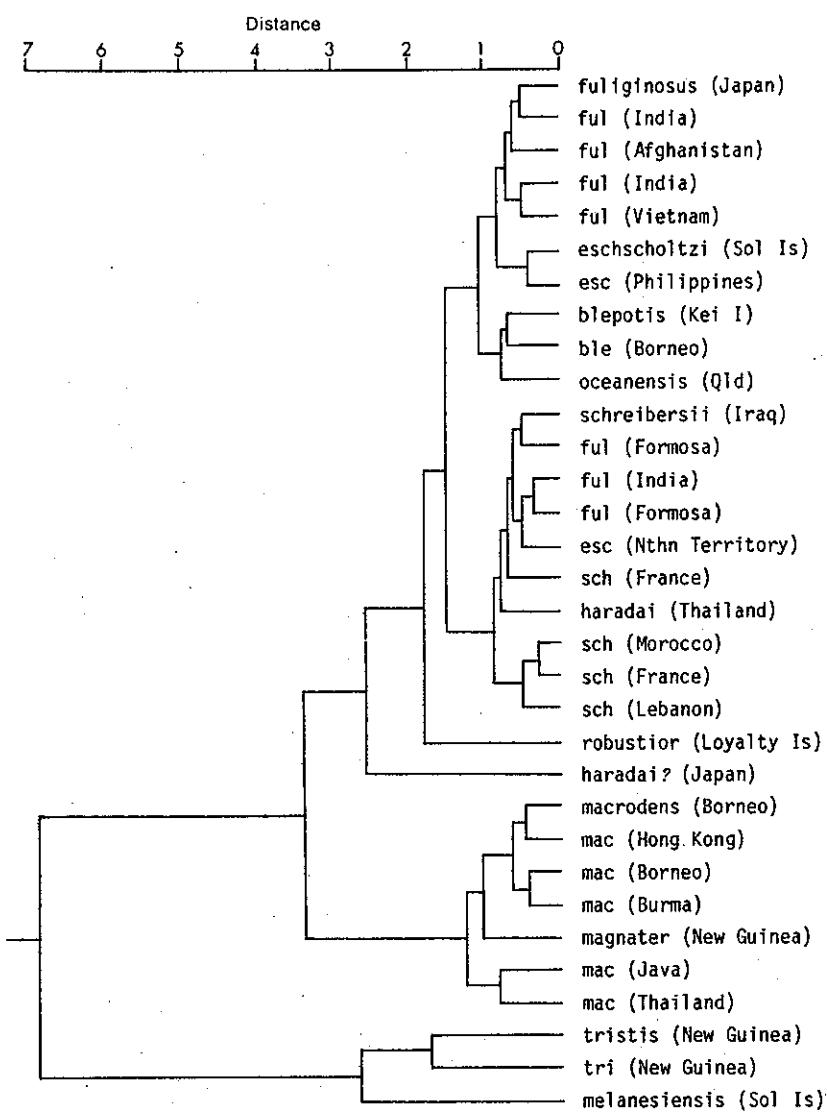


Figure 1. Dendrogram based on the Euclidean distance between centroids of selected OTUs. The centroids were taken to be represented by the tabulated mean values of each OTU published by Maeda (1982). Only skull characters were used in this study. Cophenetic correlation coefficient = 0.89.

c. Geographical variation was dismissed very lightly by Maeda (1982). Koopman (1984) raised the issue of geographical variation and Maeda's apparent disregard for it. Maeda has, however, considered the role of geographic variation in *Miniopterus* more than once (Maeda 1978, 1983, 1984). Koopman (1984) was apparently aware of the later 2 papers, but does not seem to have given them much weight in his review of the genus. My own work, some of which was presented at the recent Joint Meeting of the American and Australian Mammal Societies (Wilson 1984), showed that quite striking variation can exist between adjacent colonies of the larger Australian miniopterine. My results seem to be in conflict with the views of McKean (1966) who stated that there was no variation in skull morphology in what he called *Miniopterus schreibersii blepotis*.

Koopman (1984) presents a critique of Maeda's methodology as compared to his own. Briefly, Koopman suggests that Maeda lets the phenetics throw-up "natural" groups that are accepted as species groupings with little regard to geographical variation or the provenance of the samples. This is to some extent in line with Hamilton-Smith's (1984) point of view regarding the provenance of the South Australian samples used by Maeda. Koopman contrasts this with his own more circumspect approach. Without wishing to dwell on this point for too long, I believe that Maeda's approach can be *partly* reconciled to Koopman's if the appropriate methods of statistical analysis are used. As I have argued elsewhere in this article, Maeda's statistical methods are the cause of many of his problems.

- d. However grim the picture the above criticisms seem to paint, Maeda did get some things right. For example, he correctly identified a new species in the *tristis* group. Unfortunately, as acknowledged by Maeda (1982), *M. propithecus* Peterson (1981) has priority over his own *M. melanensis*. He also concluded independently of Peterson (1981) that *M. robustior* is a member of the *tristis* group. Finally, his east Australian form, *M. oceanensis* has been acknowledged by Randolph Peterson as a valid taxon (R. Peterson, pers. comm.).
2. An objective appraisal of Maeda's results. Although not yet completed, I have subjected Maeda's taxonomy to an objective review using multivariate techniques that should, at least in part, represent a multivariate implementation of Koopman's (1984) interpretation of Maeda's approach. This has been made possible by the fact that Maeda (1982) published extensive tables of summary statistics. The results discussed here are based only on skull characters for the larger miniopterine taxa - ie, *M. australis*

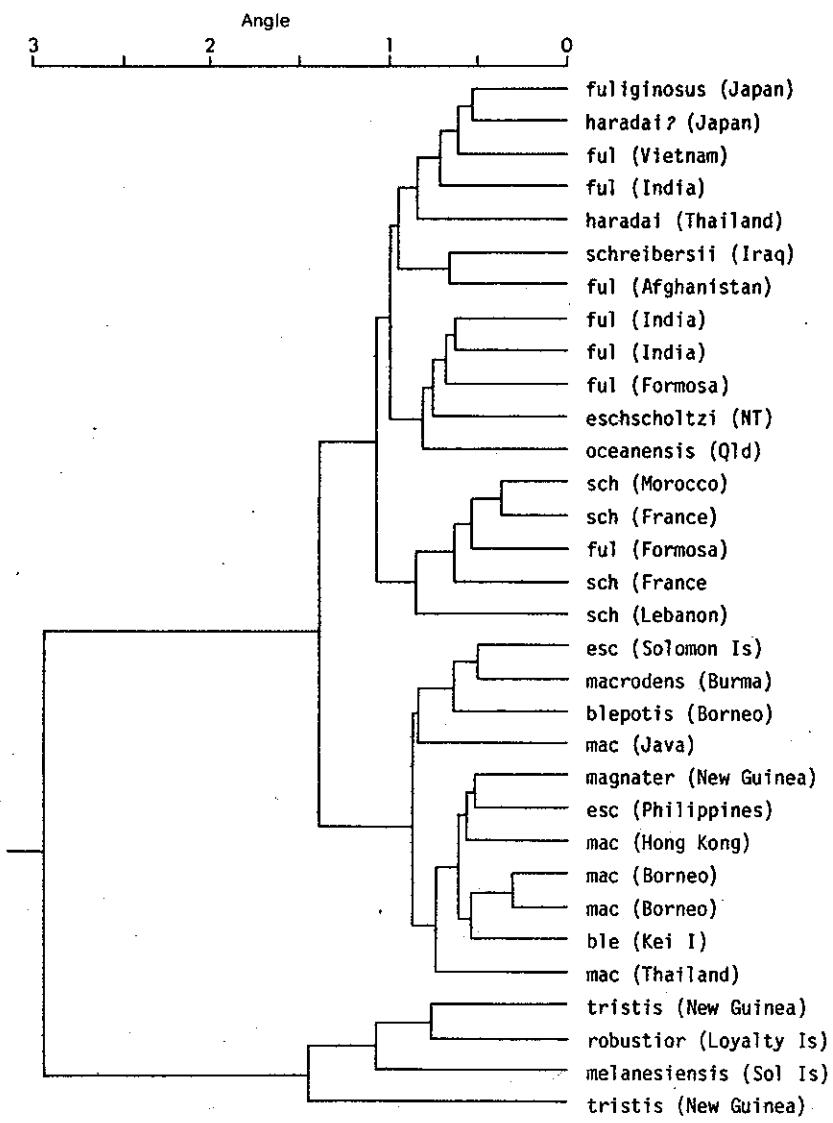


Figure 2. Dendrogram based on the angle between pairs of OTUs defined by the tabulated mean skull characters published by Maeda (1982). This angle is known to be a pure shape variable. Cophenetic correlation coefficient = 0.91.

and similarly sized and shaped taxa are omitted from this presentation, although they were included in the actual analysis.

There are two reasons why I pursued this study. First, I wished to examine in a general way the validity of Maeda's species groupings; and, second, I wanted to see if the data provided by Maeda supported the naming of a new species for the larger eastern Australian miniopterine, generally referred to as *Miniopterus schreibersii blepotis* following Tate (1941). My results to date are summarised in Figs. 1 and 2. Based on these results my conclusions are as follows:

- a. Differences exist between the dendrogram based on overall differences (Fig. 1), measured as Euclidean distance, and on shape differences (Fig. 2), measured as the angle between vectors pointing to each OTU (taxonomic unit) in the multidimensional space defined by the measurements used. I would place greater faith in the shape results for three reasons:
  - i. other unpublished analyses of my own have suggested that shape is the most important variable;
  - ii. The literature on *Miniopterus* taxonomy shows that qualitative shape comparisons have played an important role in taxonomic decision making (Hill 1983; Peterson 1981; Tate 1941) and,
  - iii. It is generally acknowledged in the literature on taxonomic theory and techniques that shape should be given greater weight.
- b. In general, Maeda's species groupings are not supported by these results. His groupings are depicted diagrammatically in Fig. 3.
- c. The *tristis* group is shown to be distinctly different from all other OTU's in both Fig. 1 and 2, with the exception that *M. robustior* is correctly grouped with the other *tristis*-like OTU's only in Fig. 2. The surprising observation is that the degree of difference within this group is as high as the differences within the "mega-group" formed by all other OTU's.
- d. There are many inconsistencies in Maeda's use of species names, suggesting that his methodology has not resulted in natural and consistent groups or species definitions. For example, in both Fig. 1 and 2, OTU's identified by Maeda as *M. fuliginosus* and *M. schreibersii* are distributed irregularly across several clusters. That is, all *fuliginosus* don't cluster with each other to the exclusion of other taxa, and the same is true of *schreibersii*.

Group	Subgroup	Species
<i>tristis</i>		<i>M. tristis</i> <i>M. propitristis</i> <i>M. bismarkensis</i> <i>M. robustior</i>
<i>fuliginosus</i>	<i>magnater</i>	<i>M. magnater</i> <i>M. macrodens</i> <i>M. oceanensis</i> <i>M. fuliginosus</i>
	<i>fuliginosus</i>	
<i>blepotis</i>		<i>M. blepotis</i> <i>M. eschscholtzii</i> <i>M. haradai</i>
<i>schreibersii</i>		<i>M. schreibersii</i>
<i>fuscus</i>		<i>M. fuscus</i> <i>M. mediuss</i> <i>M. macroneme</i>
<i>australis</i>	<i>pusillus</i>	<i>M. pusillus</i>
	<i>australis</i>	<i>M. australis</i> <i>M. solomonensis</i> <i>M. paululus</i>

Figure 3. Maeda's species and species groups as adapted from Maeda (1982:18). Note that the name *propitristis* has been substituted for *melanesiensis*, and that the smaller sized species have been listed here for the sake of completeness.

- e. With respect to Australia, these results suggest that the Northern Territory *oriolae* form and the eastern *oceanensis* form are closely related and part of a group apparently distributed from India to Queensland. A lack of samples from Sumatra and Java presents a problem for this hypothesis, and also a means of testing it. Interestingly enough, this particular result fits the concept held by Tate (1941), in that he felt there was a medium-sized species or species complex extending from Asia, through the Indonesian Archipelago to Australia and New Guinea.
- f. Several disclaimers should be made. First, these analyses are based only on Maeda's summary data. Second, there is an inadequate geographical range of samples. Third, the analyses to date are limited in extent and I will attempt to do a Principal Co-ordinate Analysis that will incorporate samples from Naracoorte in South Australia, east coast populations and Northern Territory forms. Finally, there is limited opportunity to study and control for geographical variation in shape in this kind of analysis.

The kind of analysis that I have presented above is no substitute for a properly conducted study based on raw data. It is possible though to use such results as a more objective means of testing the assumptions, methods and results of published taxonomic reviews, especially when the issues are as subtle, complex and bound-up with subjective responses as *Miniopterus* taxonomy seems to be. We must await the publication of Randolph Peterson's truly worldwide review of the genus before many, if not all, of the questions raised by Maeda's (1982) study can be answered.

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HABITAT REQUIREMENTS, SURVIVAL STRATEGIES AND ECOLOGY OF THE GHOST BAT  
*MACRODERMA GIGAS DOBSON*, (MICROCHIROPTERA, MEGADERMATIDAE) IN CENTRAL  
COASTAL QUEENSLAND

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Studies of the *Macroderma gigas* colony centered around the caves of Fitzroy Caves National Park and Mt Etna, Central Queensland, have identified the major habitat requirements and seasonal movements of the colony. The colony aggregates for a summer breeding season and disperses over a wide range during the cooler months. At the beginning of spring the pregnant females congregate in the warmest caves in the area, finally giving birth over a period of one month, commencing in mid-October. The last young are born by the end of November. There is no sexual segregation during parturition. Some males and immature females roost with the breeding females at all times. Birth caves at this time are initially rare as only a few caves have reached an acceptable temperature. As summer progresses and the caves become warmer, the young may be shifted into a number of suitable nursery caves in the area. Carried by their mothers initially, the young are later left to roost at night in colonies in the nursing cave. The young commence flying on average at seven weeks of age with all young capable of flight by the end of January. At this time the young accompany their mother during foraging and many "doubles" of female and young were caught in the mist nets during February.

From mid-summer the number of adult bats slowly increases as the remainder of the males and one year old females join the bats already present in the area. Weaning is completed during March and mating then occurs through April. During the wet season in late summer and early autumn, one cave in particular becomes critical to the bat colony because it alone seems to offer dry roost sites. After the wet season numerous caves, unsuitable during the wet, are used as roosting sites before the onset of winter. Sexual segregation can occur at the end of the mating season in May with predominantly males roosting in one cave and predominantly females in another.

With the onset of winter the entire population again re-assembles briefly in the warmest caves finally dispersing during July. Some bats remain in the caves area during the winter, especially the pregnant females, and the warm caves used at this time are probably very important in relieving environmental stress on these females. Seventy-five per cent of the population disperses in small groups from the caves area to roost in caves, rock shelters, overhangs and mines

over a wide area. Animals from this colony have been caught during winter at distances of 20, 25, 35 and 50 km from the caves area and most probably the reports of single Ghost Bats further afield at Gladstone 90 km, Banana Range 130 km and the foothills of the Blackdown Tableland 150 km represent limits of the dispersal of this colony. During this study a similar sized Ghost Bat colony at Cape Hillsborough, 300 km to the north, has been kept under observation with at least 50% of its' population being tagged. No interchange of colony members with the caves area colony has been detected. In contrast to the 30-50 animals remaining in the caves area which invariably roost together, the dispersed groups are small with single paired animals most frequently observed. The largest grouping of dispersed bats was found in an abandoned mine and totalled 12 individuals. This dispersal from the caves area over a wider area is most probably in response to shortages in food supply during the cooler months.

The population starts to reassemble in the caves area at the beginning of spring and the population pattern cycles once again.

Microhabitat preference of the colony was initially difficult to determine. The Ghost Bat in the caves area prefers to roost in avens where warm air created by the bats can be trapped. Maximum-minimum thermometer readings at points below these roosts were invariably meaningless. To overcome this problem a remote infrared biological thermometer was purchased and two seasons data have now been obtained with this instrument. Ghost Bats in Central Queensland can warm an aven to 30°C to 40°C above ambient rock temperature with a very narrow preferred range from 23°C to 26°C. Above this range the colony will cease aven roosting while below this range the colony will disperse to another site. At the lower preferred temperature, shifts can be to a site of similar temperature but of higher relative humidity to offset any evaporative cooling.

Demographic studies were very successful with this colony because the entire population can be found at one site during the mating season and at the onset of winter. As a consequence the entire population over five years has been tagged and the breeding, nursing and mating season could be precisely determined. The population size of this colony fluctuates around 150 individuals with a 1:1 sex ratio, with 40-45 young being born each year. Both females and males commence breeding in their second year. Major mortality periods for the colony are at parturition for adult females, early nursing and weaning for young with older animals dropping from the population in winter.

Feeding studies have been carried out by identification of prey remains found in roost sites together with faecal analysis. In

the forested coastal environment of Central Queensland the prey chosen is predominantly arboreal. This is in keeping with the wing and sonar characteristics which suggest a gleaning bat. Identification of prey remains from roosts was usually to a species level whilst the small size of the remains from faecal pellets meant they could only be identified as of insect, mammal or bird origin. During the warmer months the predominant prey are insects with large species such as grasshoppers, *Valanga* sp., Rhinoceros beetles *Xylotrupes gideon*, Longicorn beetles *Agrionome spinicollis* and various species of Cicadas and Tettigoniid grasshoppers forming the bulk of the remains found in roosts.

Although the majority of the beetle prey do not stridulate there is strong evidence that insect sounds attract Ghost Bat attacks. The Rhinoceros beetle, *Xylotrupes gideon*, feeds in large noisy groups in introduced Poinciana trees at Olsens Caves and invariably numbers of Ghost Bats will be present hawking back and forth in the scrub feeding on these insects. Stridulating Cicadas are heavily preyed upon and indeed the single call of a foraging Ghost Bat can silence calling Cicadas over an area of about a hectare.

As the weather cools the percentage of insect fragments in the faeces decreases while the proportion of bird and mammal bones increases. Remains of feathers, rodent tails and bat wings from feeding roosts have identified 22 bird species, 3 rodent species and 3 bat species preyed upon by *M. gigas*. The Owlet nightjar *Aegotheles cristatus*, Little shrike thrush *Colluricinclla megarhyncha*, Lewin's Honeyeater *Lichenostomus lewinii*, House Mouse *Mus musculus* and Sheath Tailed Bat *Taphozous georgianus* being the most common species taken. The bulk of the bird remains are of scrub species; they and the bat remains are found in feeding roosts all through the caves area. Rodent remains on the other hand have only been collected in feeding roosts adjacent to cleared and preferably ploughed agricultural land where it is possible for the bat to hunt ground dwelling animals.

Bat remains under feeding roosts show a seasonal species diversity. The Little Bent Winged Bat *Miniopterus australis* is mostly taken for only two weeks in mid-January, when the young Bent Wing bats initially fly from the breeding cave Bat Cleft on Mt Etna. In contrast, the Sheath Tail Bat *Taphozous georgianus* is largely taken during the colder months when easier prey is scarce. The Horseshoe Bat *Rhinolophus megaphyllus* is very rarely taken with only three remains of kills having been found.

In contrast to desert colonies of Ghost Bats, ground dwelling prey is rarely taken. No reptile or ground dwelling frog kills have

been recorded at all, while ground dwelling arthropods are very scarce with scorpions and carabids being recorded on only two occasions. Tree frogs are only rarely preyed upon with 10 *Litoria caerulea* being collected under roosts surprisingly during the cooler months when prey is scarce. During the summer wet when these frogs are very common in the vine thickets they are not preferred by the Ghost Bats.

During the course of this work Ghost Bats were held for extended periods in captivity. A total of four pregnant females with four males have been held for the six months through parturition and nursing to obtain growth records of the young during the phase of development when they are left high in the avens of the nursing cave and are consequently unobtainable. The highlight of the captive animal studies was the close observation and recording of the birth of a Ghost Bat. The ease of handling and tameness of the animals allowed even the close use of video equipment without detriment to either the adult or the young. Of the four young raised in captivity, one died from a broken wing but three survived and were successfully released with their mothers back in to the cave colony from where all have been recaptured over a period of years. One of these, a female, has since successfully bred in the wild. In addition two females and two males were held for a period of nine months through the mating season, however, both females failed to become pregnant and undoubtedly greater numbers of bats would have to be held to have a successful breeding colony. Captive animals were held in a constant temperature room 8 m x 3 m with wire mesh on the ceiling for roosting. Adult females were found to require one baby rat per day to maintain weight and the bats rapidly adapted to eating segmented adult rats when rat breeding failed to keep pace with consumption. Because of the insistence in feeding on whole animals with roughage present (fur, elytra, feathers and bones etc) no difficulty with scouring was ever experienced with these captive animals. Probably because of the blood content of the food the captive bats were never observed to drink, although water was available at all times. The young, born blind and essentially naked, do not develop quickly. The ears prick after seven days and the eyes open at two weeks. At four weeks the mothers finally leave the young roosting by themselves and their weight at this time is around 50 grams. Pelage develops quickly and the young are capable of flight at the end of seven weeks when they weigh about 70 grams. Because of the intimidating size of the offered food, young did not successfully kill baby rats until 14 weeks of age, at around 90-100 grams. The young would accept and eat segmented rat at 12 weeks old. All young were released before weaning so that their close association with their mothers would enable them to develop hunting skills to survive in the wild.

Behaviour patterns, mother-young interactions, male young interactions and nursing female interactions with other young were recorded

at this time. Food preference tests revealed that baby rats and mice were preferred over any offered insect. The Ghost Bats were unable to capture birds (House Sparrow *Passer domesticus*) when the lights were on in the room, the birds proving capable of dodging all attack passes by the bats. Capture was immediate when the lights were extinguished however, paralleling the situation in the wild where birds are taken from sleeping roosts in the scrub at night. Capture of baby rats and mice was usually carried out by the bats hovering momentarily overhead and then dropping vertically on the prey. The wings enveloped the animal trapping it on a small area of floor, usually against a wall or in a corner where it was seized by the neck or head. Once seized the bat would fly back to the roost where the struggles of the prey would cease very quickly. The prey would then be consumed from the head with usually the hind legs and tail being discarded. During eating the bats invariably used their thumbs to hold the prey. One bat with one thumb missing always had difficulty holding baby rats.

Management strategies have been implemented at the caves to maximize the survival of the Ghost Bat colony in the area. Limited options exist during the winter months because the bulk of the population is dispersed over a wide area. However, protection can be given to the breeding aggregations during spring, summer and autumn. To this end the major cave utilized by the Ghost Bat colony for parturition, nursing, wet season roosts and mating has been closed to the public during the last two breeding seasons. The colony has reacted in a favourable manner to this strategy; young mortality over this period has been reduced by 50%, the colony has exhibited greatly reduced disturbance behaviour and the period of occupancy of this cave has increased dramatically. It is planned to increase the period of closure this coming year. Protection of the warm caves, utilized by some of the pregnant females during the winter is also desirable. Fortunately one such site is on Fitzroy Caves National Park and access is controlled. Unfortunately the most important warm cave is on private property and another potentially useful cave is located on Mt Etna.

## REVIEW

### A Review of Kitchener D.J. and Caputi N. (1985)

#### SYSTEMATIC REVISION OF AUSTRALIAN *SCOTLEANAX* AND *SCOTOREPENS* (CHIROPTERA : VESPERTILIONIDAE), WITH REMARKS ON RELATIONSHIPS TO OTHER NYCTICEIINI

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Proposed as the division Nycticeini by Tate (1942), Kitchener and Caputi trace the historic, taxonomic and nomenclatural transformations among the included genera and their variously associated species. Perhaps a few lines tracing the nomenclatural and taxonomic alteration of division Nycticeini to tribe Nycticeiini would have been appropriate.

As the authors note, *Scotleanax* and *Scotorepens* were proposed at generic rank by Troughton, but generally have been accorded subgeneric status. On the basis of those data presented, there is little doubt that the Australian bats studied fall into two groupings: *Scotleanax rueppellii* and *Scotorepens* in which the authors recognize four species. The comparison of these two Australian groups with representatives of the other groups included by Tate (1942) in his division Nycticeini is thorough and the conclusions appear sound. That the opportunity to organize this wealth of data into a matrix that could provide insight into the intergeneric relationships was missed is most unfortunate. Perhaps the authors intend doing this in a subsequent work. Such an analysis is carried out later in the work, but utilizing morphometric characters. Their conclusions here are very interesting, but perhaps too timidly presented.

The authors point out, with thanks to J.E. Hill, the heretofore overlooked existence of the genus-group *Oligotomus*, type species *Oligotomus australis*. Although the authors note that *Oligotomus* is preoccupied, and therefore unavailable, and that *Oligotomus australis* = *Scotleanax rueppellii*, the availability status of *australis* is unresolved and the name is not shown as a junior synonym of *rueppelli*. Is there anything which would qualify as a name-bearer for *australis*? The unavailability of *Oligotomus* in no way affects the availability of *australis*.

The case presented for *S. rueppellii* appears solid. For those species incorporated into *Scotorepens*, the cases seem less solid. Seven named forms are reduced to four recognised species.

Quite obviously the authors examined the type specimens of the various names and a table of measurements of types is presented in their Appendix I. In the text, however, synonymies are established without references to examination of the types involved. Both *bairstoni* and *inflatus* were established by Thomas. In the description of *inflatus*, Thomas suggests that *inflatus* may be a large, eastern Australian representative of *bairstoni*. This point should be noted in establishing the synonymy and certainly in the section dealing with regional morphological variation. The geographic distributions of *bairstoni* and *greyi* cover an enormous array of habitats. One suspects that these two species warrant more extensive study. While latitude (as climate) may correlate well with observed morphological variation, climatic extremes may be more significant in delimiting species distribution.

A large number of morphometric characters were considered, and quite profitably, yet we have no idea as to which of them are independent variables. Such a determination may have reduced the number of morphometric characters needed to carry out the various analyses and opened the way for other analyses.

Kitchener and Caputi, for the phylogenetic analyses, used *Pipistrellus tenuis papuanus* as the outgroup. This choice may garner criticism and "a more appropriate choice" be preferred. Indeed, it would have been interesting to carry out the analyses using as the out group a representative of each of the divisions recognized by Tate. At any rate, what is done is done and we now have more information than we did.

There is always the temptation in a review to dwell on faults, omissions and errors while valuable aspects are either ignored or given a brief treatment. In this particular paper, Kitchener and Caputi have raised more questions than they have resolved, a contribution not to be scorned. It would appear from their data that the division Nycticeini of Tate is paraphyletic or possibly polyphyletic. *Scoteanax* and *Scotorepens* appear to have very interesting and very different zoogeographic affinities. Intraspecific variation is poorly understood among Australian Chiroptera and such studies do much to improve our understanding of the fauna. The relationship of climate to distribution of species of Australian Chiroptera is also poorly known. Bats have a lengthy fossil record in Australia and there is no reason to suppose that all our Chiropteran fauna arrived via the northern island route.

Fundamental to such studies is the existence in Australia of comprehensive collections, not only encompassing Australian material, but extra-limital comparative material also must be available. Frantic

dashes by Australian workers to Europe or North America to examine extra-limital comparative material, and in too many cases Australian material, exact a toll on the final product.

One may prefer a different organization of the data presented by Kitchener and Caputi, preferring perhaps to see various portions expanded or to see alternative approaches explored. Regardless of responses to the authors' style, organization, depth of analyses or conclusions, for those interested in chiropteran phylogeny and the origin of the chiropteran fauna of Australia, this is not a ho-hum paper.

## SHORT COMMUNICATIONS

### BAT-BANDING IN AUSTRALIA - 1957-1984

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The first bat (a Common Bent-wing Bat, *Miniopterus schreibersii*) was banded in Australia on 4 August 1957 by Dr George Dunnet of the CSIRO Wildlife Section (Dr Dunnet is now Professor of Zoology at the University of Aberdeen and the Wildlife Survey Section is now the CSIRO Division of Wildlife and Rangelands Research). Dr Dunnet left Australia shortly afterwards and his work was continued by the author.

On 1 July, 1960, following an increasing number of requests to the CSIRO from researchers who wanted supplies of bands for marking bats, bat-banding in Australia was placed on a national footing by the formation of the Australian Bat-Banding Scheme. This scheme was placed under the aegis of the Australian Bird-Banding Scheme which was administered by the CSIRO Wildlife Survey Section.

Between 1960 and 1969 a number of reports were published about bat-banding in Australia (Purchase 1962, 1969a, 1969b; Purchase and Hiscox 1960; Simpson and Hamilton-Smith 1965). These covered the activities of the Australian Bat-Banding Scheme up to June 1967. No detailed reports covering the activities of the Australian Bat-Banding Scheme since July 1967 have been published, although some notes and interim reports have appeared in Australian Bat Research News (Purchase 1971, 1980 and 1982).

On 1 July 1984, following a decision made by the CSIRO Executive, responsibility for the administration of the Australian Bat-Banding Scheme (and the Australian Bird-Banding Scheme) was transferred to the Australian National Parks and Wildlife Service.

This note lists the number of bats which have been banded and recovered during the 24 years that the Australian Bat-Banding Scheme was administered by the CSIRO (Table 1).

A detailed report of the activities of the Australian Bat-Banding Scheme is in preparation and will be published elsewhere.

Table 1. Numbers of each species banded and recovered in Australia and Papua New Guinea from August 1957 to June 1984.

Name	Banded	Recovered	
		New Bats	Total Times
<b>AUSTRALIA</b>			
<i>Pteropus conspicillatus</i>	1	-	-
<i>Macroderma gigas</i>	47	1	1
<i>Rhinolophus megaphyllus</i>	2340	217	391
<i>Hipposideros ater</i>	16	-	-
<i>Taphozous flaviventris</i>	4	-	-
<i>Taphozous hilli</i>	5	-	-
<i>Taphozous georgianus</i>	382	104	127
<i>Tadarida australis</i>	12	-	-
<i>Chaerophon jobensis</i>	48	-	-
<i>Mormopterus beccarii</i>	169	1	1
<i>Mormopterus loriae</i>	4	-	-
<i>Mormopterus planiceps</i>	270	119	257
<i>Chalinolobus dyweri</i>	50	27	54
<i>Chalinolobus gouldii</i>	1176	105	141
<i>Chalinolobus morio</i>	2917	593	844
<i>Chalinolobus nigrogriseus</i>	3	-	-
<i>Eptesicus pumilus</i>	1487	300	666
<i>Eptesicus regulus</i>	1236	224	308
<i>Eptesicus sagittula</i>	655	96	120
<i>Eptesicus vulturinus</i>	1360	292	491
<i>Eptesicus</i> sp.	38	4	4
<i>Miniopterus australis</i>	1595	260	341
<i>Miniopterus schreibersii</i>	67438	8251	10092
<i>Myotis adversus</i>	200	57	111
<i>Scotorepens balstoni</i>	49	33	67
<i>Scotorepens greyii</i>	72	-	-
<i>Scotorepens orion</i>	22	2	2
<i>Scotorepens</i> 'bullet'	5	-	-
<i>Scoteanax rueppellii</i>	101	1	1
<i>Nyctophilus arnhemensis</i>	1	-	-
<i>Nyctophilus bifax</i>	4	-	-
<i>Nyctophilus geoffroyi</i>	1094	82	99
<i>Nyctophilus gouldi</i>	1270	166	210
<i>Nyctophilus major</i>	19	-	-
<i>Pipistrellus tasmaniensis</i>	201	4	5
<b>Totals (Australia)</b>	<b>84291</b>	<b>10939</b>	<b>14333</b>

Table 1 (cont.)

Numbers of each species banded and recovered in Australia and Papua New Guinea from August 1957 to June 1984.

Name	Banded	Recovered	
		New Bats	Total Times
<b>PAPUA NEW GUINEA</b>			
<i>Rousettus stresmanni</i>	9	-	-
<i>Rousettus</i> sp.	15	-	-
<i>Dobsonia moluccensis</i>	4	-	-
<i>Paranyctimene raptor</i>	19	-	-
<i>Syconycteris crassa</i>	27	3	3
<i>Syconycteris</i> sp.	55	2	2
Totals (Papua New Guinea)	129	4	5
Grand Totals	84420	10944	14338

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## OBSERVATIONS ON BATS OF CAPE HILLSBOROUGH NATIONAL PARK, QUEENSLAND

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Cape Hillsborough National Park, situated on the coast 30 km north of Mackay, Queensland, was visited in September and October 1982. A prominent feature of the park are basalt cliffs surrounded by tropical rainforest and capped with dry sclerophyll forest. Small caves and overhangs at the base of these cliffs provide suitable roost sites for a number of cave dwelling bat species.

The north-eastern Sheathtail Bat, *Taphozous australis*, encountered in sea caves at the southern end of the park represents the most southerly record for this species. The caves occupied by *T. australis* had entrances at, or slightly above, the high-water mark. They were characteristically airy with numerous openings at roof level resulting in cave temperatures below external ambient temperature. The internal temperature of one of these caves at midday was 2°C below the external temperature of 24°C. Within the caves, *T. australis* could be seen in small groups of individuals separated by a distance of approximately ten cm, clinging to a near vertical face of the cave with head downwards and the body supported by the pad at the base of each thumb. The bats were seldom seen below a height of three metres from the cave floor.

The Common Sheathtail Bat, *Taphozous georgianus*, was not recorded from any of the sea caves but was relatively common in caves further inland. These caves were warmer than the caves utilized by *T. australis*, having fewer openings at roof level and hence a greater tendency to store heat. The temperature of one of these roost sites was 2.5°C above the external ambient temperature of 23°C when measured at midday on the day previous to the temperature measurements made of the sea cave. *T. georgianus* were encountered individually, most often in small cavities at roof level or, in the case of one large and very warm cave, on the wall.

Thus, although both *T. australis* and *T. georgianus* occur within the park this sympatry does not extend to choice of roost sites. In no cave did both species occur together, and their choice of roost sites and roosting behaviour differed markedly.

In the warm caves frequented by *T. georgianus*, the Eastern Horseshoe Bat *Rhinolophus megaphyllus* was commonly encountered.

Table 1: Measurements of *Taphozous australis*, *Taphozous georgianus* and *Pipistrellus tenuis* from Cape Hillsborough National Park.  
 (All measurements are in mm).

Species	Sex	Head	Head + Body	Tail	Ear	Forearm
<i>T. australis</i>	F	24.0	75.7	22.0	18.4	64.6
<i>T. australis</i>	M	24.0	81.0	25.0	17.3	65.4
<i>T. georgianus</i>	M	23.3	81.0	26.0	20.0	70.3
<i>T. georgianus</i>	M	23.7	81.0	28.0	19.0	69.9
<i>T. georgianus</i>	M	25.0	85.4	25.0	18.5	71.3
<i>P. tenuis</i>	M	14.0	46.3	33.0	8.2	33.8

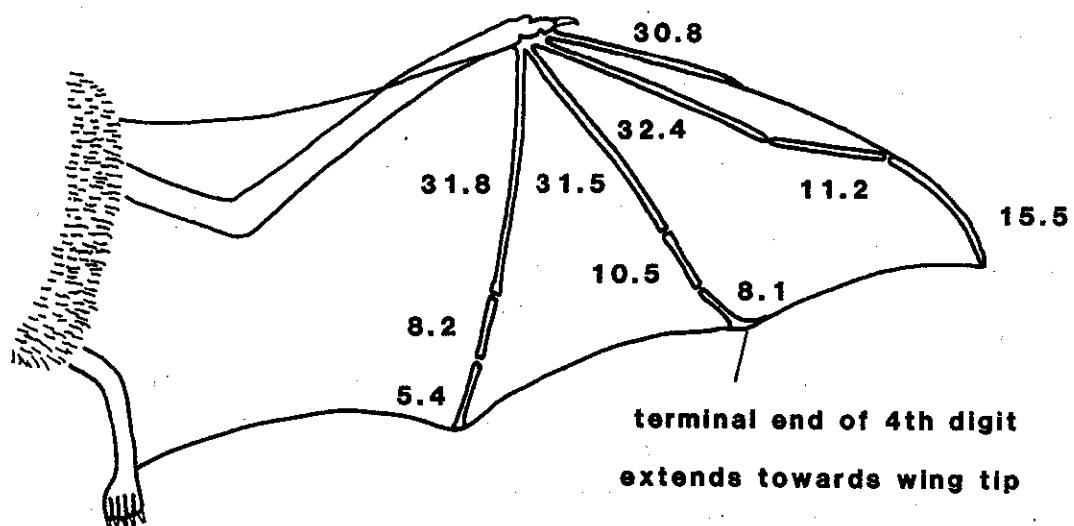


Fig. 1. Wing dimensions (mm) of *Pipistrellus tenuis* from Cape Hillsborough National Park.

Individuals of bright orange, grey and brown colour phases were present. Like *T. georgianus*, *R. megaphyllus* was never found in conjunction with *T. australis*.

A small cave approximately 40 m from the sea showed evidence of use as a feeding site by Ghost Bats, *Macroderma gigas*. The remains of two *M. gigas* in addition to numerous insect fragments and the partial remains of at least three rodents were found on the wall and floor of the cave. The bats had presumably died from natural causes as both were found as intact skeletons. Another set of remains consisted of the lower vertebrae, pelvis, hind legs and tail of a moderate sized rodent. Although skeletal, these remains were still joined and the tail had a partial covering of skin. The other remains were three hind legs, a front foot, tail and mandible from at least two other rodents. The tail was almost completely covered with skin.

The nature of these remains is consistent with Guppy and Cole's (1983) description of captive Ghost Bats killing and eating house mice, *Mus musculus*. "After killing, the Ghost Bat flies back to a roost site with the prey tightly clamped between its jaws. The prey is eaten progressively from the head towards the tail and thoroughly masticated. The tail and sometimes the hindquarters are dropped."

Subsequent analysis of the rodent remains, based on tail sculation showed that the intact hindquarters belonged to an individual of the *Melomys* genus, a group of partly arboreal rodents. The second tail was also that of a *Melomys* as was the mandible. The other remains were suspected to also be from a member of this genus. The remains were probably those of *Melomys cervinipes* or *M. burtoni* given the size of the hindfoot (length 27 mm without claws) and the known distribution of these species. Watts and Aslin (1981) describe the habitat of *M. cervinipes* as closed forest and that of *M. burtoni* as grassland, although both species do inhabit sugar cane plantations. Although the cave was surrounded by tropical rainforest, grassland also occurs within the park and sugar cane plantations border the park. Although only *M. cervinipes* has been recorded from the park, both species probably occur there. The partly arboreal nature of both these species raises the question of whether the rodents were taken by *M. gigas* during arboreal sorties or while on the ground.

A male *Pipistrellus tenuis* was also found within a cave occupied by *Taphozous georgianus*, representing a sizeable range extension south for this species. Hall and Richards (1979) give Townsville as the most southerly record for this species, approximately 300 kilometres to the northwest of this new locality (148°58'22"E, 21°02'11"S).

Hall and Richards (1979) in their key to the genera of Australian bats state the following generic character for *Pipistrellus* "end of 4th digit extends along wing membrane edge towards tail". In fact, the end of the fourth digit extends along the wing membrane edge toward the wingtip (Fig. 1) and not the tail. An unlobed calcaneum and pronounced swelling of the muzzle aid in separating *P. tenuis* from the similarly sized *Eptesicus pumilus*.

Body measurements of *T. australis* and *T. georgianus* are given in Table 1 and wing dimensions of *P. tenuis* are shown in Figure 1.

#### Acknowledgements

I would like to thank Ranger Doug Shultz for sharing his intimate knowledge of the park during our stay and Jack Mahoney who generously offered to identify the rodent remains. I am indebted to Rae and Les Hall for their hospitality in Brisbane and additionally to Les for his comments on the manuscript.

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#### ECTOPARASITES FROM THE GREY-HEADED FLYING FOX, *PTEROPOUS POLIOCEPHALUS* AND RED FLYING FOX, *P. SCAPULATUS* (CHIROPTEA : PTEROPODIDAE) FROM SOUTHEASTERN QUEENSLAND, AUSTRALIA

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In June and July 1984 a collection of ectoparasites was made from 6 grey-headed flying foxes, *Pteropus poliocephalus* Temminck and 2 red flying foxes, *P. scapulatus* Peters collected from mangrove roosts near Brisbane, Queensland, Australia. After capture the bats were transported to laboratory facilities for general anaesthesia and visual ectoparasite searches. Ectoparasites from each bat species were pooled and stored in 70% ethanol prior to identification.

Two species of batflies (Nycteribiidae), 1 species of mite (Laelapidae), and 1 tick (Ixodidae) were found on the 2 species of bats. One female of *Cyclopodia australis* Theodor was removed from the 2 *P. scapulatus* while 1 male of *C. australis* and 4 males and 3 females of *Cyclopodia albertisii* Rondani were found on the 6 *P. poliocephalus*. One male, 23 females, and 1 nymph of *Neolaelaps spinosa* (Berlese) and 1 larva of *Amblyomma* sp. were also found on the *P. poliocephalus*. The *Amblyomma* is not one of the 5 Australian species for which the larva has been described (Roberts 1969). Some morphological variation evident in the *C. albertisii* was the presence of 2 pairs of notopleural setae on all specimens except for 1 male in which they were 2-3. Theodor (1959) and Maa (1971) indicated there were 3 pairs of setae or usually 3 pairs of setae, respectively. The latter author listed an example in which they were 2-3. Phoresy of *N. spinosa* on the flies was not noted although this has been reported previously in Australia (see Domrow 1969, 1963, 1967; Maa 1971).

*Cyclopodia australis* and *C. albertisii* are confined to fruit bats of the genus *Pteropus* but apparently exhibit different host species preferences (Maa 1971). In Australia, *C. australis* infests the bats (in order of decreasing preference) *P. scapulatus*, *P. alecto* Temminck (= *gouldi* Peters), *P. conspicillatus* Gould, and *P. poliocephalus*, whereas for *C. albertisii* the order is *P. conspicillatus*, *P. alecto*, *P. poliocephalus* and *P. scapulatus*, with both fly species occasionally occurring on the same host individual (Maa 1971). Present data do not appear to contradict these findings. Near Brisbane, *C. australis* has previously been collected from *Pteropus* sp. and *C. albertisii* from *P. poliocephalus* and *Pteropus* sp. (Maa 1971) so the present records are also of interest in this respect.

*Neolaelaps spinosa* has not previously been recorded from *P. poliocephalus* although it has been taken from flying foxes throughout the Australasian region including the Australian states of New South Wales, Queensland, and Northern Territory. The present record is the first for the genus *Amblyomma* from an Australian bat although the association must be considered fortuitous since no known species regularly occur on bats.

We are grateful to Drs J.H. Kass, M.F. Huerta and J.D. Pettigrew for collecting these ectoparasites during their research. Drs Kaas and Huerta were funded by a Vanderbilt University Research Council grant.

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## DOES DOBSONIA (CHIROPTERA : PTEROPODIDAE) HAVE A FLING?

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With very few exceptions bats, both megachiropterans and microchiropterans, have the main wing membrane (the plagiopatagium major) attached laterally to the sides of the body. Those few exceptions where the line of attachment of the main membranes is not lateral but is displaced dorsally to a significant degree include the genera *Dobsonia*, *Pteralopex*, and one species of *Rousettus* (Sub-order Megachiroptera : Family Pteropodidae) and members of the genus *Pteronotus* (Suborder Microchiroptera : Family Mormoopidae) (see Hill and Smith 1984). In *Dobsonia* and two species of *Pteronotus*, the attachment is to the mid-line of the back, and the unfurred wing-membranes covering the back give *Dobsonia* the common name of Naked or Bare-backed Fruit Bats.

The extreme form seen in *Dobsonia* and some species of *Pteronotus* may have important aerodynamic functions. Hall (1983) and Hill and Smith (1984) have suggested that the extension of the wing membranes to cover the back gives increased surface area for generating lift. Hill and Smith (1984) correctly note the significance of extending the lift generating area without altering wingspan or wing shape, for these changes would affect the overall aerodynamic performance of the animal. Hall (1983) has suggested that the increased surface area of *Dobsonia moluccensis* enables it to avoid stalling at low speed.

But there is, perhaps, another benefit from the form seen in *Dobsonia*. Because the wing membranes join at the midline of the back, it is highly likely that a significant portion of the dorsal surfaces of the wings come together at the top of the upstroke. They would then rapidly separate at the start of the downstroke, and this rapid separation of the dorsal wing surfaces is probably responsible for the distinctive sound *Dobsonia moluccensis* makes as it comes in to land or take-off. This has been aptly described by Smith and Hood (1981:91) as a ".... hollow 'pock-pock-pock' sound". (They suggest that the sound is made by the wings clapping together, but this seems unlikely given the flexibility of the membranes and the fact that they are furled at the top of the upstroke just prior to being 'flicked' open).

The technique of bringing the dorsal surfaces of the wings into contact at the top of the upstroke was first described by Weis-Fogh (1973) in a genus of insects. It is clear from the physical analyses conducted by Weis-Fogh and others, that this is a mechanism for producing high lift. When the wings begin to separate on the down-stroke, a rapid movement of air is established over the dorsal surfaces of the wings and this generates a high lift force (Alexander 1982; Ellington 1984). The lift produced in this way is higher than the lift available normally, and as the wings move down through the rest of the stroke, lift forces quickly drop to their normal levels as the pattern of air movements stabilizes (Ellington 1984). The so-called 'clap and fling' mechanism has been documented in a number of insects and in pigeons (Alexander 1982). In fact, the clapping of pigeon wings during strenuous take-off produces an audible signature that seems very similar to that produced by *Dobsonia moluccensis*. I therefore put forward the hypothesis that in *Dobsonia* a form of the 'clap and fling' mechanism has evolved.

The evidence presented here for *Dobsonia*, though purely circumstantial, strongly suggests a possible form-function relationship that is worthy of further investigation, both from a biomechanical point of view and from an ecological point of view. A mechanism that produces high lift at low speeds could have profound importance because it would allow heavy payloads to be lifted, and permit access to foraging and/or roosting areas unavailable to less fortunately endowed pteropodids of a similar body mass. Also, if it can be shown that *Dobsonia moluccensis* uses this mechanism of lift generation, then it will have been shown to occur in all the extant true fliers, for this mechanism has been found to exist in some insects and birds, leaving flying mammals (bats) as the only group in which it has not been shown to occur.

Let me conclude by stressing that this is no more than a working hypothesis based on circumstantial evidence and has not been evaluated against direct observations.

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**Abstracts of Papers Presented at the Bat Biology Symposium held at the University of Queensland, 8 May 1985.**

**POPULATION DYNAMICS AND DISPERSAL PATTERNS OF *RHINOLOPHUS MEGAPHYLLUS* IN THE BRISBANE FOREST PARK, SOUTH-EAST QUEENSLAND**

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Between November 1984 and April 1985 the populations of *R. megaphyllus* resident in seven abandoned mines in the Brisbane area were monitored. Males were present throughout this period, but females did not arrive until March 1985. A maximum of approximately 30 individuals was found in any one colony, and a mark recapture study found females to be highly site specific. This work is part of an on-going project.

**THE USE OF DOPPLER INFORMATION BY FREQUENCY MODULATING BATS**

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When a bat locates a target (eg. a flying insect) that is moving with respect to it, the returned echo will be Doppler shifted in frequency. Constant frequency emitting bats make use of the Doppler shifts from the beating wings of their prey, in order to isolate them from an acoustically cluttering environment, for example foliage. The use of Doppler (target velocity) information by frequency modulating bats has been the source of controversy. It is considered that frequency modulating bats, similar to *Myotis advereus*, do not extract Doppler information without ambiguity.

## THE EFFECT OF RAINFOREST FRAGMENTATION ON A TROPICAL INSECTIVOROUS BAT COMMUNITY

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Studies in progress indicate that the fragmentation of large tracts of tropical rainforest may considerably alter the composition and structure of the insectivorous bat community resident in such eco-systems.

By using an electronic method to identify free-flying echo-locating bats, replicated transects were conducted to establish bat species composition in (a) parts of rainforest that were either still intact, recently logged, or regenerating for periods up to 10 years; and (b) areas of eucalypt savannah contiguous with the rainforest tract, sampled at intervals up to 10 km from the ecotone. Data were collected from 14 detectable species, each of which was later characterised according to wing morphology, flight pattern and foraging modes.

Six species were only ever detected within intact rainforest, being rarely recorded from snig tracks, and never from logging ramps, roadways, nor eucalypt savannah. A further six species were only ever detected in eucalypt savannah or at logging ramps, roadways or snig tracks within rainforest. The remaining two detectable species showed an affinity for all habitats and disturbance levels.

The eucalypt savannah community contained a majority of fast flying species that relied upon aerial intercept or *fast* aerial pursuit of insect prey. Such foraging patterns are impossible in dense rainforest where the community primarily forages by ambushing passing prey, by gleaning it from foliage, or by *slow* aerial pursuit.

These results suggest that if rainforest is fragmented by roads or contains large gaps, the rainforest specialists lose foraging zones and eucalypt savannah opportunists invade the vacant sites, occupying these open areas that accommodate their flight and foraging patterns.

**THERMOREGULATORY AND CLUSTERING BEHAVIOUR OF *MINIOPTERUS* BATS  
DURING WINTER IN EASTERN AUSTRALIA**

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A census of the thermoregulatory and clustering behaviour of *Miniopterus s. blepotis* and *M. australis* was carried out in eastern Australia during the three coldest months of the year. Factors found to be significant to winter behaviour included roost ambient temperature, latitude, altitude, distance from the coast, climate, weather and roost morphology. Saturation deficit was found to be of no significance in choice of roost by torpid bats. Cluster types were detailed and appeared to operate on an antagonistic relationship between buffering and exposure to environmental changes and the degree of receptiveness to environmental change afforded by each of these strategies. Evidence was presented to suggest bats migrated away from warmer roosts to cooler ones in order to undergo torpor as a behavioural mechanism to avoid the absence of prey organisms in areas of northern Australia where the dry season is most severe.

**OVARIAN FUNCTION IN THE GREY HEADED FLYING FOX *PTEROPOUS POLIOCEPHALUS***

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The grey headed flying fox is a seasonal breeder producing one young per annum after a gestation of about 6 months. The mechanisms that regulate ovulation and sexual receptivity in the female are unknown. It has been asserted that the Indian flying fox (*P. giganteus*), similar in size and appearance to *P. poliocephalus*, is a reflex ovulator alternating between ovaries in successive seasons, but there is no real evidence for this.

We have collected blood and reproductive tracts from females shot in the wild throughout the year and have measured plasma progesterone and oestradiol- $17\beta$  concentrations by radioimmunoassay, and examined the tracts histologically.

Around Brisbane, mating occurs mainly in March/April, but sometimes much later than this. No females collected in January to February had sperm in the tract whereas 11 of 14 collected in March did. From January to March increasing numbers of large antral follicles were seen in both ovaries, but peripheral plasma levels of oestradiol- $17\beta$  and progesterone did not increase significantly, and none of the adjacent uteri showed signs of oestrogenic stimulation. Thus female sex hormones do not appear to be important in generating female sexual receptivity. In the wild, males attempt copulation throughout the year with penetration as late as June. Mating can occur up to  $2\frac{1}{2}$  to 3 months after conception, and in this series we found abundant sperm in both uterine horns of one female bearing a corpus luteum and an apparently healthy advanced post-implantation embryo. Perhaps, like humans, female *poliocephalus* are always receptive, with frequency of copulation largely determined by male drive and persistence.

None of the March females with sperm, had preovulatory follicles or *corpora lutea*, while the single animal found with a preovulatory follicle (in July), had no sperm in the tract. Clearly mechanisms controlling ovulation are more complex than a mere reflex response to copulation. Observations that pairs copulate several times a day throughout March/April support this view. The time course of follicular development up to ovulation also remains unknown, but may be affected by the time and frequency of copulation.

#### REPRODUCTIVE SEASONALITY IN MALE FRUIT BATS, GENUS *PTEROPOUS*

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Members of the genus *Pteropus* show marked seasonality with periods of mating occurring at roughly the same time each year. *P. poliocephalus* and *P. alecto* mate during March and April (short-day breeders) whereas *P. scapulatus* mate during October and November (long-day breeders).

In *P. poliocephalus* peak testis weight occurs during March and maximal regression is evident from June to September. After the breeding season there is an increase in testicular germ cell loss and an obvious regression of the Leydig cells. Epididymal weight in *P. poliocephalus* peaks during April, and after the breeding season the epididymal epithelium undergoes regressive changes even though some spermatozoa are found within the epididymis throughout the period of

testicular regression. The major accessory glands of the fruit bat, the seminal vesicles, show a marked increase in weight during the breeding season (peak in April) when the epithelium is secreting globular material found in the semen.

Radioimmunoassay for testosterone shows that marked seasonal changes occur in peripheral plasma levels. During March very high levels are present ( $43.8 \pm 9.3$  ng/ml) though these decrease soon after the breeding season to be lowest in June ( $1.4 \pm 0.7$  ng/ml). There is also some evidence for a change in body weight with season (peak in February) which may or may not be linked to reproductive changes.

Initial photoperiod manipulation experiments indicate that the reproductive status of *P. poliocephalus* can be altered by changing the photoperiod. Testis size appears to be affected by both the duration of the photoperiod and whether it is increasing or decreasing. If light is the governing factor in *Pteropus* reproductive seasonality then the discrepancy between breeding seasons of species of the same genus often found cohabitating provides an interesting neuroendocrine dilemma.

#### TEMPERATURE REGULATION IN THE LITTLE RED FLYING FOX, *PTEROPOUS SCAPULATUS*

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Air temperature influences physiological and behavioural thermoregulation in the little red flying fox. Thermoregulatory and metabolic options used by the species at unfavourably low air temperatures were described. The species was found to be more thermolabile than was previously supposed and was described as a facultative homeotherm. Thermolability results from a change in the set-point body temperature and not from a loss of precision in body temperature maintenance.

Posture of the wings about the body permitted thermolability and increased the thermoregulatory options for the species. Posture affected the endogenous and exogenous thermal gradients through changes in insulation of the body shell. Thermoregulatory behaviour affected body temperature maintenance; for example, wing fanning contributed to a reduction in the rate of body temperature rise at unfavourably high air temperatures.

## BLOOD PHYSIOLOGY OF THE GREY HEADED FRUIT BAT (*PTEROPOUS POLIOCEPHALUS*)

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The biological diversity found in various bat species provides the opportunity to compare many physiological and biochemical systems. Although several aspects of bat physiology have been studied, comparative haematological data in general and red cell metabolic studies in particular are limited. In view of this and our continuing interest in erythrocyte chemistry, genetics and physiology, we are examining the blood physiology of the Grey Headed Fruit Bat (*Pteropus poliocephalus*).

Five bats are maintained in the University Animal House, four kindly provided by the Currumbin Sanctuary and one captured at Bellingen, NSW.

Blood is obtained from a leg vein and collected into heparinised syringes. The following measurements are made: haemoglobin concentration, haematocrit, erythrocyte count, plasma glucose and lactate, red cell adenosine triphosphate, 2,3-diphosphoglycerate (DPG) and reduced glutathione. Activities of eleven erythrocyte enzymes and erythrocyte glucose utilization and lactate production are also estimated.

Our preliminary data suggest that there are some very interesting differences between bat erythrocytes and those of other mammalian species. Some of the more interesting characteristics of bat erythrocytes are:

- i. a significantly higher rate of glucose metabolism;
- ii. elevated levels of pyruvate kinase - one of the enzymes regulating glucose metabolism;
- iii. high levels of DPG;
- iv. a higher activity of 6-phosphogluconate-dehydrogenase than that of glucose-6-phosphate-dehydrogenase, a situation contrary to that found in most other mammalian species.

## FLYING FOXES: FAST FOOD SPECIALISTS

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Megachiropterans are known to have remarkably short transit times for food through their digestive systems (0.5 hr or less), but information on the morphology of their gastrointestinal tract is available for only a few species.

We have been looking at the morphology of the gastrointestinal tract of *Pteropus poliocephalus* and *P. alecto* using both light and electron microscopy. We have also measured food transit times for a number of cultivated fruits fed to these species.

The minimum food transit time varies between 12 to 34 minutes with little variation between species. In both species the stomach features marked cardiac and fundic regions, and an extended terminal portion containing the pylorus. The stomach has a very high proportion of parietal cells and zymogen cells confined to a small area at the base of the gastric glands. Brunner's glands are present in the pylorus and in the anterior part of the duodenum. There is considerable variation in intestinal length (1.3 to 2.6 m), and the large intestine is short and indistinguishable externally from the small intestine. There is no caecum or appendix. The tall, broad, triangular villi provide mucosal surface area to serosal surface area ratios which are larger than those reported for most other mammals. A high density ( $<79 \mu\text{m}^2$ ) of very tall/microvilli produces an enormous increase in absorptive surface area of intestinal epithelial cells.

These observations indicate that flying foxes have the mechanisms to quickly absorb nutrients from their food. This would reduce the quantity of food carried in the digestive tract if slower absorption occurred, thus enabling a reduction of energy expenditure while foraging.

## DO BAT WORMS MAKE PEOPLE SICK?

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The suggestion that *Toxocara pteropodis*, a worm found in the intestines of suckling fruit bats, may have been the cause of the

Palm Island "mystery disease" prompted further work on this parasite which has led to an understanding of the life-cycle, its distribution in bat populations and its potential to infect humans. It has been found in all Australian *Pteropus* species, and develops to maturity in the intestines of suckling young, which then pass eggs in their faeces. Eggs become infective after 10 days, and adult bats probably acquire infection by eating or licking contaminated leaves and fruit. The larvae from these eggs hatch out in the intestine and accumulate in the bat's liver. In females, these larvae migrate to the mammary glands at the end of pregnancy and reach the baby's intestine in the milk.

The major features of the Palm Island epidemic were hepatitis and diarrhoea, affecting children almost exclusively. All these children had eaten mangoes which had been contaminated with flying fox faeces containing *Toxocara* eggs. Mice fed a single dose of these eggs develop liver infection (hepatitis), and such eggs given daily will produce diarrhoea in mice after five days. Guinea pigs infected with these eggs also develop hepatitis, but rats and pigs are resistant to infection. This varying susceptibility of different experimental hosts made it impossible to predict whether or not humans could be infected. For this reason, eggs were fed to the Asian crab-eating monkey, *Macaca fascicularis*, which was subsequently shown to develop liver infection. Although this finding indicates that humans, too, are susceptible to infection, the high doses of eggs required to produce illness makes this an unlikely explanation for the Palm Island epidemic.

Further work is being undertaken in conjunction with the Malaysian Institute of Medical Research to develop a specific blood test which will diagnose infections in humans.

#### THE INS AND OUTS OF FLYING FOX PARASITES

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Fruit bats (genus *Pteropus*), possess many parasites (various Protozoa, Rickettsiales, Ticks, Mites, Insects, Cestodes and Nematodes). I am particularly interested in two protozoan parasites which infect the blood of local bats. *Hepatocystis pteropi* is a malaria type parasite which has been found in the species of bats included in my study, ie. the grey headed fruit bat, the black fruit bat and the small red fruit bat. This parasite develops, as with malaria, female and male gametes, the macrogametocytes and microgametocytes, within the

erythrocytes. The liver is also infected, but with a different form of the parasite: the asexually reproducing schizont. This is large enough to be visible as a white spot. The vector of this parasite has not yet been discovered. It is almost certainly not the mosquitoes which transmit malaria, but *Culicoides*, which are similar insects which often infest bat colonies.

Trypanosomes have been found in some *Pteropus* species including the black fruit bat. Little is known about the natural vector. However, several developmental stages of *Trypanosoma* sp. have been found locally in bat flies.

I have been surveying fruit bats for infection with *Hepatocystis* and *Trypanosoma*, amongst three species of *Pteropus*, taking into consideration age, sex, season, length of time in captivity and other variables. I have also been keeping note of the types of ectoparasites found on the bats, to determine any relationship between them and the protozoan parasites.

The survey has been in progress for only four months and eighteen bats have been examined. *Hepatocystis* has been found in three bats and *Trypanosoma* in no bats.

The development of gametocytes of *Hepatocystis* has been studied and confirmed in previously published observations. No schizonts were seen in any of the bats, either in the liver or in other organs that were examined microscopically. Some bats were infested with ticks, mites and flies. However, most of the bats I have been studying have been kept in captivity for substantial periods, resulting in the loss of ectoparasites. Therefore I have not been able to make a detailed study of any relationship between the ectoparasites and the protozoan parasites.

In future work I shall attempt the experimental transmission of *Trypanosoma* sp. and will make a detailed study of the two parasites with the electron microscope.

#### LEAD POISONING IN FRUIT BATS

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Clinical evidence of lead (Pb) poisoning in domestic mammals includes abdominal pain, diarrhoea, constipation and nervous signs such

as circling, head pressing, muscle tremors, incoordination and excitement with convulsions. Of 39 fruit bats submitted to the Department of Veterinary Pathology and Public Health for post-mortem examination, 5 showed some of the above signs prior to death. Kidney Pb levels in these 5 bats ranged from 20.5 to 44.6 ppm and liver levels were 12.1 to 47.4 ppm. In domestic mammals levels of 25 ppm in kidney and 10 ppm in liver are considered to be of diagnostic significance.

Many other bats, found dead or with no clinical evidence of Pb poisoning prior to death have also had high Pb levels in their tissues; some of these bats had been in captivity for many months prior to death. Tissues in normal bats have also been shown to have considerable levels of Pb; up to 8 ppm in kidney and 11 ppm in liver.

Knowledge is lacking on the level of Pb intake and by association, the level of Pb in the tissues required to induce Pb poisoning in fruit bats. The source of the Pb is speculative, but the specialised diet of the bat, suggests that environmental, particularly atmospheric, contamination may be a possible source.

Lead-containing insecticide fruit sprays are now illegal: their continued illicit use would of course put fruit bats at risk.

#### COMPLEMENTARY ROLES OF VISION AND ECHOLOCATION IN NEW WORLD MICROCHIROPTERA

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Comparative study of 30 species of New World Microchiroptera reveals that nocturnal insectivorous and piscivorous bats tend to have tiny eyes relative to body size and poor visual acuity but produce intense sonar cries. Frugivorous, nectivorous, and sanguivorous bats on the other hand have much larger eyes up to 100 times the relative weight and much better visual acuity as measured by optomotor tests, but they produce relatively faint sonar sounds. In short, there seems to be a reciprocity between the development of vision and echolocation with vision being favoured when the food sought is large and echolocation when the diet is comprised of small, fast-moving prey.

The emballonurids fall into a somewhat different category; they are diurnally active and hunt insects at night. They have relatively large eyes, modified for daytime vision, and intense sonar

for the pursuit of insects at night. Gleaning bats comprise a fourth category with large nocturnally adapted eyes and acute sonar. Behaviourally they appear to hunt acoustically at low light levels and visually in brighter light (Bell *et al.* 1984).

Experimentation suggests that it is the behavioural context that determines which sense bats use at a particular time. During escape, visual cues appear to be of greater importance than acoustic cues in many species, while echolocation is essential for avoidance of small obstacles in flight. Similarly, while echolocation is sufficient for short-distance homing, vision is necessary for homing from long distances. In short, while vision and echolocation gather somewhat redundant information, they seem for the most part to play complementary roles in the orientation of New World Microchiroptera.

#### FREQUENCY ORGANISATION OF AUDITORY CORTICAL FIELDS IN THE FLYING FOX

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We mapped the frequency organisation of the auditory fields of ketamine anaesthetised grey-headed flying foxes (*Pteropus poliocephalus*) as part of a study of sensory representation in the cerebral cortex of the flying fox, which has a smooth cortex with a single shallow sulcus in the temporal region. We used tungsten-in-glass microelectrodes to record multiunit activity in approximately 86 surface-normal penetrations per animal. Acoustic stimuli were 300 ms pure tone-bursts from 100 Hz to 50 Hz presented at a rate of 1 Hz, and were delivered via a speaker in the free field. Auditory evoked activity was limited to a 3 mm x 3 mm area straddling the sulcus; this area was bordered by the second somatosensory field (SII) anteriorly and by visual fields posteriorly and medially. A primary auditory field (AI) was identified centrally within the auditory area on the basis of sharp frequency tuning and low thresholds to pure tones. The frequency at which threshold was lowest varied between 2 and 32 kHz, and was tonotopically-organised such that low frequencies occurred rostrally and high frequencies occurred caudally. Evoked activity in the surrounding belt of auditory cortex was generally broadly-tuned and had higher thresholds than observed in AI. However, a distinct dorso-medial field was identified, in which thresholds were exceptionally low (-20 to +10 dB SPL) to acoustic stimuli in the range 9 to 15 kHz. Qualitative differences in habituation and tuning properties within the broadly tuned areas are probably indicative of several distinct auditory fields which may be identified by further investigation.

**TOPOGRAPHIC ORGANISATION OF CORTICAL SENSORY FIELDS  
IN THE GREY-HEADED FLYING FOX (*PTEROPOUS POLIOCEPHALUS*)**

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We chose to study cortical organisation in the flying fox because, unlike many other mammals, it has a relatively unconvoluted cortex. This is a major advantage for studies involving mapping of cortical sensory representations because it avoids the problems which inevitably arise when "unfolding" cortical maps of fields which extend into sulci. Initially we concentrated upon the tactile representation of the body surface (somatosensation). At least two topographical maps (somatotopic) have been described in all mammals so far studied. Apart from minor variations in the placement of the body parts, the somatotopy is remarkably consistent across species. However, we found that in the somatotopic map of the grey-headed flying fox, the position of the distal forelimb was displaced from its usual mammalian position. The forelimb and the wing are located caudally in the map whereas the corresponding limbs and digits of walking mammals are located rostrally. Also, the orientation of these limb representations are reversed, with the digits of the bat's wing pointing caudally. This variant somatotopy appears to reflect postural differences, supporting the notion that topographical maps may have functional significance apart from their point-to-point connections with the sensory periphery.

**FUNCTIONAL ORGANIZATION OF THE RETINA OF MEGACHIROPTERA**

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In Megachiroptera the retinal morphology is characterised by regularly spaced choroidal papillae extending into the nervous layers of the retina which, as a consequence, appear undulated. Each choroidal papilla contains a capillary loop which reaches the level of the inner plexiform layer.

There are two possible interpretations for this unique retinal morphology. (a) The papillation may be necessary for the capillary loops to reach inner layers of the retina and to supply them with

oxygen (the nutritional interpretation); (b) the visual interpretation of the papillation suggests a unique internal arrangement of retinal cells and of their connectivity. This would provide these animals with a neural circuitry organized around the axis of each papilla. These two views are not mutually incompatible.

We are exploring the two above functional interpretations in the retinae of a number of *Pteropus* species by applying the following methods: regional distribution of retinal ganglion cells (RGC) viewed in retinal wholemounts, local distribution of RGCs around the axis of a choroidal papilla, ultrastructural characteristics of the capillary loop and characterization of RGCs according to their central connections (after intracerebral injection of horseradish peroxidase).

#### MOTHER-YOUNG RELATIONSHIPS IN THE GREY-HEADED FLYING FOX *PTEROPOUS POLIOCEPHALUS*

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I have studied mother-young relationships in grey-headed flying foxes (*Pteropus poliocephalus*) conducted at the colony at Indooroopilly Is. in the Brisbane River. Behaviour patterns indicative of the mother-young relationship were described and recorded over time revealing how the relationship changes as the infant grows older. Information about the frequency and duration of particular behaviour patterns was obtained using a multi-channel event recorder. This was accompanied by written notes.

Of the many different behaviour patterns which were recorded, I have selected three important changing aspects of the mother-young relationship.

- (a) the development of a distance between mother and infant in the colony
- (b) the proportion of time the infant spends off the nipple
- (c) the amount of self-grooming with the age of the infant.

For the first four or five weeks of its life the infant flying fox clasps onto the body of its mother, grasping her fur with the claws of its toes. By four or five weeks of age, the infant supports itself on the front of her body where it may be enfolded by her wings. The proportion of time spent out of contact with its mother's body increases over the next nine weeks.

During the first five weeks of its life, the infant spends a large proportion of time attached to the nipple. At around five to six weeks of age there is a considerable increase in the proportion of time it spends off the nipple. As the infant grows older, its nutritional requirements increase but it spends less time on the nipple. It is difficult to know at what age it begins to forage for itself, but by eight weeks of age it joins the dusk flight out of the colony independently. It is possible that only part of the time spent attached to the nipple involves nutritional suckling, especially in very young infants. Non-nutritional suckling could be interpreted as a bond maintaining behaviour. It would be very informative to know exactly when the mother stops lactating.

There is no significant change in the amount of grooming the infant receives from the mother. It seems that grooming is such an important bond maintaining behaviour that it continues after the functional need for it disappears. Throughout the study mothers and infants engaged in mutual grooming.

This study only examines behaviour in the day time roosts. Perhaps the most revealing interactions between mother and young occur at night.

#### **RESULTS OF A QUESTIONNAIRE SURVEY OF AUSTRALIAN BATS USING BUILDINGS AS ROOSTS**

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In 1980 a questionnaire designed to survey the extent to which bats use buildings as roosts was widely circulated throughout Australia via 40 different government-funded bodies (eg. museums, fisheries and wildlife, public health departments, CSIRO), commercial pest control associations in 5 States, Bat Research News, and the 24th Australian Mammal Society Meeting in Sydney. A total of 77 questionnaires was distributed, but the actual number in circulation was unknown, because copies were often made by the original recipient for further distribution.

There was an excellent response to the questionnaire, with 36 replies (27 questionnaires and 9 letters) received from all States and the Northern Territory over a 3 year period. Six questionnaires reported single bats flying or resting in buildings and are not considered

further in this summary. The letters reported that bats were "not a problem in buildings" or that they were "encountered singly or sporadically".

Twelve species in 3 families (Emballonuridae, Molossidae, and Vespertilionidae) were identified as forming 22 colonies in buildings. An additional 3 colonies were reported, but the species were not identified and a respondent from near Taree, NSW reported a *Nycticeius* species (*rueppellii* or *greyi*?) and a Tadarida (or *Mormopterus* species sharing a building with *Chalinolobus gouldii*.) The species identified and the number of colonies reported were: *Taphozous georgianus* (1), *Mormopterus planiceps* (3), *M. becarii* (1), *Nyctophilus geoffroyi* (2), *Chalinolobus gouldii* (3), *C. morio* (2), *Nycticeius baletoni* (2), *Pipistrellus tasmaniensis* (3), *Eptesicus pumilus* (2), *E. vulturinus* (1), *E. sagittula* (1), and *E. regulus* (1).

The size of colonies varied from less than 10 to over 300, with 88.8% (n = 18) being less than 50. About 50% of colonies were located in vacant buildings and only 6 respondents said that bats were a nuisance. The majority of colonies (47%) were present only in the autumn and 4 buildings were used as summer maternity sites.

The results of this survey indicate that bats are not a pest problem in buildings in Australia and that questionnaires are a cost effective way of collecting information from many sources over a wide area.

#### AN ULTRASTRUCTURAL STUDY OF MEGACHIROPTERAN (MAMMALIA : CHIROPTERA) SPERMATOZOA: IMPLICATIONS FOR CHIROPTERAN PHYLOGENY.

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The fine structure of epididymal or electro-ejaculated spermatozoa of *Pteropus poliocephalus*, *P. scapulatus*, *P. conspicillatus*, *P. alecto* and *Syconycteris australis* is described. The sperm of all species were found to be very similar. The head is extremely flattened and spatulate; the nucleus is capped by a long acrosome that comprises the proximal half of the head and covers two-thirds of the nucleus area, and a prominent sub-acrosomal space possesses a unique 'anvil'-like shape. Redundant nuclear envelope forms a 'scroll' in a restricted region of the neck, next to the base of the proximal centriole and the most proximal of the mitochondria. The axoneme is atypical for mammals, the central singlets arising distal to the outer

doublets. Coarse fibres 1, 5, 6 and 9 are larger than the remainder, a feature shared with the Microchiroptera, most insectivores and the Primates. The large sub-acrosomal space of the megachiropteran sperm is significantly different from that of the Microchiroptera.

We consider that the difference in sperm ultrastructure between the chiropteran sub-orders is not inconsistent with theories of a di-phyletic origin for this group. The use of sperm ultrastructure as a phylogenetic tool is discussed and comparisons with the spermatozoa of other closely related Eutheria are made.

## NOTICES

### Preservation of the Sydney Flying-Fox Colony

In a small bush reserve in Gordon, a northern residential suburb of Sydney, is a breeding colony of grey-headed flying-foxes, *Pteropus poliocephalus*. The colony has used this site for over 20 years, although flying-foxes have been known to camp elsewhere in the area since white settlement.

The bats arrive at the Gordon camp each year in October prior to the birth of young. The population peaks at 20,000-23,000 in summer, but most bats leave the camp with the approach of cold weather in autumn; very few remain over winter.

The Gordon site contains the largest breeding colony in the southern half of the state. Ratcliffe (1931) estimated that flying fox colonies occurred about every 65 km along the NSW coast; today there are about 10 known breeding colonies. *P. poliocephalus* is not protected in NSW and recently has been removed from the protected fauna list in Queensland. The Gordon colony has come under considerable threat in recent years because its steadily increasing size has resulted in conflict with some local residents.

In 1983 private land bordering the site was sub-divided and in January 1985 the Heritage Council of NSW and the Ku-Ring-Gai Municipal Council decided to jointly finance the purchase of two of the blocks. This land provides the only relatively easy access to the valley and forms a buffer zone between bats and residents in Edwards Street.

The colony and reserve will be managed by the Ku-Ring-Gai Council in conjunction with the NSW National Parks and Wildlife Service. The Ku-Ring-Gai Bat Colony Committee (KBCC) was formed from community conservation groups and individuals in February 1985 at the invitation of the Council.

The aims of the Committee have been threefold: fund raising to assist the Council in the purchase of the land; increasing public awareness of the need for legal protection of flying-foxes; development of a long term management plan which will consider both the bats and the residents close to the colony.

In view of the overall decline in flying fox numbers since Ratcliffe (1931) made his survey, there is an urgent need for protection of these animals by law. McWilliam (1984) stated "Clearly in order to halt the continuing loss of colonies that threatens the long term survival of these native mammals in NSW, extant colonies need

protection. Therefore, it is recommended that all fruit bats and their remaining colony roost sites should be protected as a matter of urgency".

The Committee has been informed that the NSW National Parks and Wildlife Service hopes to have the *Pteropus* spp. added to the protected fauna list by the end of the year. However, resistance to this move is expected from certain sections of the fruit-growing industry, although commercial fruit-growing is declining in the Sydney region due to the spread of suburbia. Research into the problem of bat strike on fruit crops is being carried out by the NSW Department of Agriculture at the Glen Innes Research Station and acceptable means of protecting crops now appear to exist.

Two further areas of concern relate specifically to the Gordon colony: the understorey vegetation at the site has a heavy weed infestation, which together with increased run-off from nearby built-up areas, is inhibiting regeneration of roost trees; the Council has become ambivalent in its support of the colony following criticism from some residents.

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CSIRO Bull. 53, 1-80.

KBCC is financing its activities from donations, sale of stickers (\$1.00 post included), T-shirts and a booklet, "A bat came to stay" by Catherine Pallin - aged 10 years (\$3.00 post included). A brochure has been produced and speakers are visiting schools and other community groups in the district. Tax deductible donations to assist the Council in the purchase of the land may be sent to the Australian Conservation Foundation, 672B Glenferrie Road, Hawthorn, VIC 3122, stating a preference for the donation to be directed to the Ku-Ring-Gai Council Bat Colony Fund. Application has been made to the Bicentenary Environment Program for funding for vegetation regeneration.

The Committee would like to make contact with scientists whose research may be relevant to the bats or to the vegetation of the valley in order to develop a sound management plan. Letters of commendation to Council and to the Hon. R. Carr, Minister for Planning and Environment relating respectively to the Gordon colony and legislative protection of flying foxes would be of considerable benefit.

If you are able to help in any way our efforts to preserve the

Gordon colony or to have the animals protected contact: The Secretary, K.B.C.C 45 Highfield Road, Lindfield, NSW 2070 or phone (02) 4981663.

#### CHANGE OF DATE - FLYING FOX SYMPOSIUM

The symposium on flying foxes being organised by the Australian Mammal Society is now to be held in September 1986 (not 28/29 September 1985, as notified in the first issue of *Macroderma*).

Anyone wishing to contribute, attend, or be kept informed of developments, please contact:

Leslie S. Hall  
Department of Anatomy  
University of Queensland  
ST LUCIA QLD 4067

#### BAT ORGANIZATIONS AND JOURNALS

**Bat Research News** Editor Dr Kunwar Bhatnagar, Department of Anatomy, Health Sciences Centre, University of Louisville, Louisville, Kentucky 40292, USA.

**Myotis** Editor Dr Hubert Roer, Zool. Forschungsinstitut und Museum Alexander Koenig, Adenauerallee 150-164, D-5300 Bonn 1, Germany.

**Bat Conservation International** Secretary Heidi R. Zogg, c/o Milwaukee Public Museum, Milwaukee, Wisconsin 53233 USA produces newsletter *Bats*.

**International Bat Project** Conservation Office Tony Hutson, Flora and Fauna Preservation Society, c/o Zoological Society of London, Regents Park, London NW1 4RY UK produces newsletter *Bat News*.

#### FOR SALE

Slide Lecture on bats of the world. "Bats: Myth and Reality", is an exceptionally interesting introductory program, covering 11 families, 29 genera and 36 species. From giant flying foxes to the world's smallest mammal, bats of virtually every imaginable description - pouched, crested, epauletted, yellow-winged and more - are



## INSTRUCTIONS TO AUTHORS

Manuscripts plus two copies, complete with illustrations and tables, should be submitted to the Editor, Christopher Tidemann, Zoology Department, Australian National University, GPO Box 4, Canberra, ACT 2601.

MS should be in clear concise English and typed with double spacing on A4 paper.

Papers should consist of: title; names and addresses of authors; abstract of not more than 200 words; introduction; materials and methods; results; discussion or the latter two combined. References should conform to the World List of Scientific Periodicals, 4th Edition and references in the text should conform to the format used in this issue.

All pages, figures and tables should be consecutively numbered and the correct orientation shown on figures. Metric units should be used throughout. Camera ready copy is desirable for diagrams, but they should, at least, be submitted in black on a white background. Black and white photographs may be used. Tables should be in a format suitable for reproduction on a single page of the journal.

Common names, where used, should conform with the recommendations of the Australian Mammal Society (Bull. Aust. Mammal Soc. 6: 13-23).

Short communications should meet the requirements for papers, except that subheadings other than title, names and addresses of authors and references should not be used. Short communications should not exceed 5 double spaced typed A4 pages.

Manuscripts are not being routinely refereed at this stage, although editorial amendments may be suggested. Specialist opinion may be sought in some cases.

Notices may be in any format, but clear and concise English should be used.