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Macroderma

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EDITORIAL

The first two papers in this issue contain information on cave bats, including *Macroderma*, which inhabit the abandoned deep cut mine systems at Pine Creek in the Northern Territory. This information is seen to be a particularly valuable record in light of the endangered status of *Macroderma*, the rarity of several of the other species and the fact that open cut mining is now well under way in this area.

Transferral of *Pteropus* species to the protected fauna list in New South Wales has been implemented with notice in the NSW Government Gazette of February 28, 1986. Probably the main benefit of this legislation will be to protect camp sites from disturbance. As is the case with other species of protected fauna which cause economic losses there will be provision for orchardists to undertake control measures. The National Parks and Wildlife Service has issued a leaflet which advises the public of some of the positive aspects of flying foxes and the problems.

Despite some recent public statements to the contrary, there can be little doubt that flying foxes, from time to time, cause substantial crop damage. However, shooting does not seem to be very effective in preventing fruit losses, nor is it desirable. It is apparent that there is a real need for research into effective deterrents. Perhaps some fruitful leads will emerge from the Flying Fox Symposium to be held at the University of Queensland, August 30-31, 1986 (Notices p 26).

The Eighth International Bat Research Conference is to be held in Australia in 1989. It is being organized by Mike Augee, School of Zoology, University of NSW, under the auspices of the Royal Zoological Society of NSW. The venue is to be decided between Sydney and Cairns. Further information should be available in the next issue of this journal.

In the September issue of *Macroderma* we intend to publish a review of bat collecting techniques. This will be the first of a series of papers on techniques for bat researchers.

PAPERS

ROOST PREFERENCES OF CAVE-DWELLING BATS AT PINE CREEK, NORTHERN TERRITORY

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Abstract

Roosting sites of cave-dwelling bats from Pine Creek, Northern Territory are described. Six species were recorded: *Macroderma gigas*, *Hipposideros ater*, *H. stenotis*, *Rhinonicteris aurantius*, *Taphozous georgianus* and *Eptesicus pumilus*.

These differed in their roosting habits:

i. species which roosted in complete darkness (*M. gigas*, *R. aurantius*, *H. ater*);

ii. species which roosted close to mine entrances in conditions other than complete darkness (*H. stenotis*, *T. georgianus*, *E. pumilus*). A maternity colony of *M. gigas* was located and is described.

Introduction

There are few published observations on the roosting behaviour of northern Australian bats, including species regarded as rare and/or vulnerable. Three rare and vulnerable cave-dwelling bat species occur in the Northern Territory. These are the Ghost Bat (*Macroderma gigas*), Orange Horseshoe-bat (*Rhinonicteris aurantius*), and the Lesser Wart-nosed Horseshoe-bat (*Hipposideros stenotis*) (Strahan 1983).

The presence of *M. gigas* in the mine shafts of the Pine Creek area has long been recognized (eg. Parker 1973). *M. gigas* is listed in the IUCN Red Data Book of Endangered Species (Goodwin and Holloway 1978). With only several thousand individuals extant, it is considered endangered (Hamilton-Smith 1978) and on a nationwide scale is regarded as sparse to rare (Strahan 1983). *R. aurantius* belongs to an endemic, monotypic genus and is regarded as sparse in distribution (Strahan 1983) and vulnerable (Groves and Ride 1982). Its rarity is probably partly due to its specialized dry season roosting requirements. These are warm and humid deep caves or mine shafts (Strahan 1983) that confine it to a restricted habitat liable to human interference (Groves and Ride 1982). The nearest known colony of *R. aurantius* to Pine Creek is at Cutta Cutta Caves (Parker 1973). The size of this colony has drastically declined due to the development of the cave as a tourist attraction (Hamilton-Smith 1978). *H. stenotis* is a rare bat endemic to Australia (Hall and Richards 1979) and its presence at Pine Creek has previously been reported by Schulz and Menkhorst (1985).

This paper describes observations on the roost sites of six species of cave-dwelling bats, including the three regarded as rare, frequenting disused mines at Pine Creek, Northern Territory.

Study Area

The study area was located in the Brocks Creek Ridge land system immediately south of Pine Creek, Northern Territory (13°49'S 131°49'E). It is composed of north-south aligned ridges up to 250 m in height and contains the major hills of the area, including Gandy's Hill and the Kohinoor Anticline. The geology of the system is dominated by steeply folded metamorphics composed primarily of quartzite. On the stony ridge crests the vegetation consists of deciduous open woodlands with a sparse grass cover. On the lower slopes the vegetation consists of mixed woodland with a sparse ground cover. The area contains numerous mines which were excavated during a gold rush in the 1870s and 1880s. The mines vary from shallow (5 m in length) to deep horizontal drives (up to 250 m long). Vertical shafts connecting these horizontal tunnels are common.

Methods

A survey of the mines in the Pine Creek area was undertaken during a three week period in October 1983. All accessible mines were searched for bats during daylight hours. Most of the numerous vertical shafts present were not surveyed due to a lack of climbing equipment. When a bat or bat roost was located the distance from the shaft entrance was estimated by measured paces; light conditions were noted; and the bat species identified. When possible roosting bats were sexed and aged (eg. adult, flying young and non-flying dependent young). Light intensity was divided into two categories: i. 'total darkness' where the mine wall could not be seen at 2m, and ii. 'semi-darkness' where the wall could be seen with varying levels of clarity at 2 m when looking away from the mine shaft entrance. Disturbed bats were not included in the analysis.

Results

Fifty-four mines were investigated in a 120 ha area during the survey. The most extensive mine system was the Kohinoor Mine which consisted of a 212 m long adit, several complicated lateral drives and some vertical shafts.

Six species of bats were recorded roosting in the mines; *Macroderma gigas, Hipposideros ater, H. stenotis, Rhinonicteris aurantius, Taphozous georgianus* and *Eptesicus pumilus*.

These species could be divided into two groups on the basis of their roosting sites:

A. Species that roosted in complete darkness (*M. gigas, R. aurantius and H. ater*).

B. Species that roosted close to the shaft entrance in conditions other than complete darkness (*H. stenotis, T. georgianus* and *E. pumilus*).

The sites in which these two groups of bats roosted were mutually exclusive and members of the two groups were not found roosting together during the day. At night, however, *M. gigas* utilized the entrances of various mines as roost sites. Numerous fresh faecal and prey remains were found on the floor close to mine entrances but no day-roosting *M. gigas* were recorded at these sites during the survey. Eighteen *M. gigas* night roost sites were located and all were within 20 m of the mine entrance.

Group A

M. gigas was the most numerous of the three species in this group. The only substantial roost site was located in the Kohinoor Mine. A maximum count of 532 *M. gigas* was made on 9 October 1983 as they emerged after dusk. On investigation of the mine after this count, it was found that approximately 400 young remained. The young bats occupied a chamber at the junction of a complicated series of drives. They were clustered in groups of one to fifteen with each group separated by 0.5 to 2 m. The young bats were fully furred but noticeably smaller and less robust than the adults and were not observed to fly. The nursery colony remained at this site for two nights but on the third had moved down to a small chamber in the lower levels of a cross-drive, about 70 m from the first site. During the day most of the adults roosted with the young bats.

Approximately fifty adult *M. gigas* were observed roosting in a second cross-drive. All *M. gigas* at this roost site were females accompanied by suckling young. Females carrying young were noticeably slower and less manoeuvrable in flight. The accompanying young were at an earlier stage of development than the young bats in the nursery colony as they lacked any obvious fur and their eyes had not yet opened.

One individual *M. gigas* was located in another mine approximately 120 m west of Kohinoor Mine. It was disturbed in a complicated series of tunnels in total darkness. Due to the dangerous nature of several connecting passages not all tunnels in this complex were investigated and it is possible that other *M. gigas* were present. A dusk watch at the entrance of this complex revealed no *M. gigas* emerging although it is possible that there was an alternative exit.

R. aurantius occurred only at the base of a vertical shaft, opening into a central chamber at the rear of Jensen's Adit. This species was very flighty and once disturbed disappeared into inaccessible reaches of the shaft.

H. ater occurred in total darkness at the rear of Jensen's Adit in Kohinoor Mine (approximately 100 m from the *M. gigas* nursery colony) and a mine north-west of Pine Creek in the Gandy's Hill area. A total of 30 *H. ater* were located. Two colour phases were recorded - grey and orange. The proportions in the population of these two colour phases were 6:1 respectively.

Group B

The two common members of this group were *T. georgianus* and *E. pumilus*. Fifty-six *T. georgianus* were located in twenty-one mines. Of these 52.4% were roosting singly and 33.3% were roosting in pairs. These bats were usually found close to mine entrances, although two aggregations of *T. georgianus* in separate mines were in complete darkness. These aggregations consisted entirely of pregnant females.

Seventy-three *E. pumilus* were recorded from ten mines. Thirty-one percent of observations were of single bats or pairs, while 69% of observations were of clusters of from three to sixteen individuals. The mean group size was 7.3 ± 1.8 (SE). Table 1 outlines the sex and age composition of clusters of *E. pumilus*. In most clusters lactating and non-lactating females, adult males, and young at various stages of development were present. In three of the six clusters volant young as well as those unable to fly were recorded. One young attached to the nipple of a female was completely unfurred and its eyes were closed. The other member of the group, *H. stenotis*, was only recorded as single females in eight mine shafts between 50 and 800 m apart.

None of the Group B species were found roosting in mines utilized as day roosts by *M. gigas* (Table 2). A small number of mines used as day roost sites by Group B species were utilized as night roost sites by *M. gigas.* No clusters of *E. pumilus* containing young bats were recorded from mines utilized by *M. gigas* as day or night roost sites. In contrast, all members of Group A were found to frequent the same mines (Table 2).

		COMPOSITION OF INDIVIDUAL CLUSTERS					
SEX AND AGE CATEGORIES		A	B	C	D	E	F
Lactating female		1	1	3	6	1	1
Non-lactating adult female		1	1	1	1	0	1
Adult Male		1	1	2	1	0	0
Young: able to fly well,	Male	2	2	2	3	0	1
developed coat of fur	Female	1	3	2	1	0	1
Young: unable to fly,	Male	1	0	1	3	1	0
fur starting to develop	Female	0	0	1	1	0	0
Young: attached to adult female		0	0	0	-	1	0
TOTAL IN EACH CULTURE		7	8	12	16	3	4

Table 1: Sex and age composition of *E. pumilus* clusters found roosting in mine shafts at Pine Creek.

	SPECIES				
	T. georgianus	*E. pumilus*	*H. stenotis*	*H. ater*	*R. aurantius*
Total found in day roost sites of *M. gigas*	0	0	0	10	0
Total found in night roost site of *M. gigas*	20	10	2	30	2
Total found in shafts not used by *M. gigas*	36	63	6	0	0
% found in *M. gigas* roost sites (day and night)	35.7	15.4	25.0	100.0	100.0
No. shafts shared by *M. gigas* (including night roosts)	5	3	2	3	1
Total number of shafts species located in	22	10	8	3	1
% shafts shared between species and *M. gigas* (including night roosts)	22.7	27.3	25.0	100.0	100.0

Table 2: Details outlining the occurrence of other bat species in shafts utilized by *M. gigas* as either day or night roost sites.

There was no significant difference between the distances at which the three Group B species roosted from mine entrances (Student's t-test), although they never occurred at exactly the same location. This spatial segregation occurred even in small mines where all three bat species were present.

Discussion

The colonies of three bat species observed during this survey are regarded as being significant on an Australia-wide basis.

The Kohinoor Mine supports the largest recorded colony of *M. gigas* in Australia. Other substantial colonies known in the Northern Territory are: approximately 300 individuals at Katherine Gorge, approximately 500 individuals at Kakadu National Park (in several roost sites), and approximately 100 individuals at Umbrawarra Gorge (L. S. Hall *pers. comm.*). In addition Douglas (1967) recorded a maximum of 287 individuals in the Klondyke Queen Mine in the Pilbara district of Western Australia. Prior to this study it was not known whether the species bred in the Pine Creek area. The presence of a nursery colony of four hundred bats and a further fifty young being carried by adult females also makes this the largest recorded maternity colony known in Australia. Of interest was the division of the *M. gigas* colony into adult females carrying young roosting apart from the main nursery colony and attendant females.

Eight *H. stenotis* were located in the mines of the Pine Creek area. This is the largest number of this species recorded since the discovery of this bat in the Northern Territory by Dahl in 1895 (Parker 1973). Little is known about the roosting requirements and breeding biology of this species. Schulz and Menkhorst (1985) found that the species roosted singly in semi-darkness and usually close to the shaft entrance.

Two *R. aurantius* were located during this survey. However, in May 1983 approximately one hundred *R. aurantius* were counted emerging from mines in the Pine Creek area. About two weeks later no *R. aurantius* were observed in this locality (Hall, *pers. comm.*). It is possible that they were disturbed by human interference or were in transit to other unknown sites. A quantity of guano representing an unoccupied roost site was located in a deep chamber associated with a mine near the Kohinoor Mine. Although no bats were seen, the chamber appeared to have a suitable microclimate for *R. aurantius*. The chamber was warm and humid with several pools of water on the cavern floor. It is possible that some of the vertical mine shafts not entered during this survey could also contain roosts of *R. aurantius*.

The roosting behaviour of *E. pumilus* in the mines at Pine Creek was similar to that reported by Maddock and McLeod (1976) from the Tennant Creek area. In both locations the species roosted in colonies, although no clusters of more than twenty individuals were found at Pine Creek. Mixed age and sex clusters were also reported by Maddock and McLeod (1976).

Group A bats on the whole frequented the same mines. This was seen even with *H. ater* occurring together with *M. gigas* (a predator of the former species) in the same mine complex. The restriction of Group A bats to a few mines is likely to be a function of the roosting requirements of these species. All require warm, humid conditions in total darkness (Strahan, 1983) and only a few mines appeared to be suitable.

By contrast Group B bats appeared less restricted by roosting requirements and utilized a large number of mines. The only member of this group to occur in sites of total darkness within shafts was *T. georgianus*. This species was found to roost either singly or in pairs in semi-darkness near the entrance of mine shafts or in groups in complete darkness deeper within mine shafts. The former were both of males and females while the latter aggregations consisted entirely of pregnant females. Since Kitchener (1973) found that young were born between October and February, it is likely that these aggregations represented maternity colonies.

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References

Goodwin, H.A. and Holloway, C.W. (1972). *Red data book*. Vol. 1. Mammalia. International Union for Conservation of Nature and Natural Resources.

Groves, R.H. and Ride, W.D.L. (1982). *Species at risk: research in Australia*. Aust. Acad. of Science.

Hall, L.S. and Richards, G.C. (1979). *Bats of eastern Australia*. Booklet No. 12. Qld. Mus., Brisbane.

Hamilton-Smith, E. (1978). Endangered and threatened Chiroptera of Australia and the Pacific region. In Tyler, M.J. (ed.). *The status of endangered Australasian wildlife*. Roy. Zool. Soc. S. Aust., Adelaide.

Kitchener, D.J. (1973) Reproduction in the Common Sheath-tailed Bat, *Taphozous georgianus* (Thomas) (Microchiroptera: Emballonuridae), in Western Australia. *Aust. J. Zool.* 21, 375-389.

Maddock, T.H. and McLeod, A.N. (1976) Observations on the Little Brown Bat, *Eptesicus pumilus caurinus* Thomas, in the Tennant Creek area of the Northern Territory. Part I: Introduction and breeding biology. *S. Aust. Nat.* 50, 42-50.

Parker, S.A. (1973) An annotated checklist of the native land mammals of the Northern Territory. *Rec. S. Aust. Mus.* 16: 1-57.

Schulz, M. and Menkhorst, K. (1985) Notes on the Lesser Warty-nosed Horseshoe Bat (*Hipposideros stenotis*). *Aust. Bat Res. News* 20: 14-16.

Strahan, R. (ed.) (1983) *Complete book of Australian mammals*. Angus and Robertson, Sydney.

THE AUSTRALIAN GHOST BAT, *MACRODERMA GIGAS*, AT PINE CREEK, NORTHERN TERRITORY.

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INTRODUCTION

The Australian ghost bat *Macroderma gigas*, is of special significance for a number of reasons. It has unusual carnivorous habits, (Douglas, 1967; Kulzer *et al.*, 1984) it is one of the largest Microchiropteran bats (exceeded in size only by *Vampyrum spectrum*, Vehrencamp *et al.*, 1977), its distribution within Australia appears to be shrinking (Molnar *et al.*, 1984), and its sensitivity to disturbance may make it very vulnerable to the intrusion of man. This bat is listed in the I.U.C.N. Red Data Book of Endangered Species (Hamilton-Smith, 1978). The present observations have been assembled to help fill some of the gaps in our knowledge of *Macroderma gigas* and to provide a stimulus for more detailed work. A starting point for this study was made by a multidisciplinary team of ecologists, ethologists, physiologists and biophysicists who worked on a large colony of *Macroderma gigas* located in a disused gold mine complex at Pine Creek, N.T. during the period 10-30 May 1983. The easy accessibility of the mine and the proximity to facilities simplified the logistical problems associated with the erection of three radio receiver towers. The major goal of the pilot study was the radio-tracking of

Macroderma to their night-time foraging sites where we could carry out more detailed studies of their hunting style and their use of both sonic and ultrasonic signals for communication. Of special interest was the possibility, raised by physiological studies (Pettigrew *et al.*, 1983) that this bat might use passive listening and/or vision for hunting. In addition we wanted to know more about the status of the colony and its distribution and numbers throughout the extensive system of shafts, adits and stopes within the mine, including the prevailing microclimates where the bats tended to congregate, especially at the maternity roost. Since the completion of the 1983 field trip, more data have come to hand from both captive bats and from subsequent visits to Pine Creek in 1983 and 1984. These data have been incorporated since they bear on the breeding biology and diet of *Macroderma gigas*.

This report is not meant to be a definitive or rigorous account of the biology of *Macroderma gigas*. It does represent a large number of observations of the current views of most Australian scientists who have worked with this unusual bat and, in the absence of alternative information could be a valuable stimulus to the formulation of policy guiding further research. Results and some discussion are therefore given together in each of the various sections.

Locality: Pine Creek is located on the Stuart Highway, approximately 200 km south east of Darwin, N.T., at 13°49'S 131°49'E.

Mean annual rainfall is 1200 mm, of which 1100 mm falls in the period December-March, the 'Wet'. At the time of the expedition, the 'Wet' season had been both drier and later than usual. Mean monthly temperature varies from 30°C in November to 24.5°C in July. The mean monthly temperature for May, when mine microclimate data were collected, is 26.8°C. Mean yearly temperature is estimated at 27.5°C.

The vegetation is both woodland and mixed open woodland dominated by *Eucalyptus alba, E. apodophylla* and *E. tectifica*. The dominant grass is *Themeda australis*.

The geology is Lower Proterozoic. There are steeply folded metamorphics composed mainly of quartzite with some phyllites and schists, the Brocks Creek Group (Christian and Stewart, 1953). Gentle slopes at around 190 m above sea level are capped by hillsides and outcrops providing up to 80 m of relief.

Daytime Roosts in the Mine Complex

Two major daytime roosts were found in adjacent adits, Jensen's and Kohinoor, of the Kohinoor mine complex which is located to the east of the new section of the Stuart Highway (grid reference N8 468 600 E 806 900 on sheet 45 of the Darwin-Katherine Railway, 1:10,000 series prepared by the Australian Survey Office). We could not rule out the possibility that these two adits were connected by a small passage negotiable by *Macroderma*.

The largest aggregation of bats was in Kohinoor, a 212 m long adit, 1.5 m high by 1.2 m wide in average cross-section. There is a series of stopes (side passages) 112 m from the entrance. In one part these stopes join up to form a large chamber which is approximately 30 m long, 10 m wide, and 10 m high at its highest point (called *main chamber*). A side passage leads out to the surface via a large narrow chamber (*exit chamber*) and a number of entrances. There is a low level section (*the trench*).

Daytime roost sites were in the main chamber (about 60% of the colony) and in the trench (about 40%). Small groups were occasionally found in the far end of the adit and its small side passage. Prior to evening emergence, small groups were found in the exit chamber and in the entrance section of the main adit.

Temperature in the main chamber and the trench was 26.4°C with 96% and 100% relative humidity, respectively. This microclimate formed a slight contrast to that found in other cavities of comparable size such as North Enterprise Mine (24.5°C, 88% R.H.) and Lady Alice Mine - Union Hill (25.8°C, 80% R.H.) which were less-favoured day roost sites but which were probable night roosts.

A second, smaller aggregation of *Macroderma* was found in Jensen's Adit which also had daytime roosts of *Hipposideros ater* and *Rhinonicteris aurantius* in side passages. Temperature and relative humidity were, respectively, 27.0°C and 100% at a point halfway along the adit at 56 m, 28.0°C and 100% in the side passage frequented by the two smaller Microchiropterans and 27.4°C, 94% at the far end of the adit where *Macroderma* roosted during the day.

These observations give some hints about the features of *Macroderma's* preferred daytime roosts and of the likely sites chosen for a maternity aggregation. It seems likely that the crucial features involve both a large cavern size, appropriate for the relatively low manoeuvrability of this bat, in combination with a high stable temperature and humidity, appropriate for a species which does not have the ability to enter torpor (Kulzer *et al.*, 1970; Leitner and Nelson, 1967). It would clearly be of great value to have more data on the seasonal fluctuation of microclimate in the preferred and non-preferred roosts to see whether it might be possible to predict which site *Macroderma* would choose. Present data are consistent with *Macroderma's* reduced preference for caverns of adequate size if these have lower temperature and/or humidity, such as the North Enterprise and Lady Alice mines, also in the area.

Status and Breeding of the Pine Creek Colony

On 19 May 1983 an estimate was made of the number of individuals in the Kohinoor-Jensen colony. The relatively large number of people on the expedition enabled us to monitor most of the possible exit sites from the Kohinoor mine complex. Dim lights were placed near each of 15 exit holes and the number of *Macroderma* leaving the mine between 1900 and 2100 h counted. The total count was 445 of which 360 left via the main entrance. This estimate must be regarded as conservative for the following reasons. Not all exit holes were covered or manned. The bats were disturbed by the presence of the dim lights and the observers which delayed their exodus; so that not all bats left the mine in the 1900- 2100 h period. Even if one ignores the upward correction which would be necessary because of these factors, our conservative estimate of 445 makes it the largest colony of *Macroderma* known (L.H., unpublished data).

Approximately equal numbers of males and females were observed at this time. In October 1983, the number of adults leaving the main entrance each evening appeared to have fallen somewhat, to approximately 300, all of which were females, but inside the main chamber there was a similar number of juveniles aged approximately two months. In June 1984 exit counts of 780 and 778 were made on two evenings. On 14 and 15 May 1985 exit counts were 1100 on both nights.

Observations of captive bats provided some further clues about breeding. Two males housed under constant conditions of temperature and lighting at St Lucia after capture at Pine Creek in June 1984 showed testicular hypertrophy in May 1985, becoming aggressive toward each other at that time. Two pregnant females captured in July 1981 gave birth on the same day, 31 July. Three females captured in June 1984 all had pregnancies at the same stage of development with embryos of a size consistent with conception around the second week of May.

If these data are put together, a picture of the breeding of *Macroderma gigas* emerges as follows:- Mating occurs in the second week of May, when there may also be an increase in the number of bats using the adit. A large proportion of males leave the adit after mating. Gestation appears to be around 11-12 weeks with births at the beginning of August. During the early wet season the numbers of *Macroderma gigas* in the adit increase again as a result of births but may fall again in the late wet season. More data are needed on this latter point. The number of breeding females may be fairly constant (at around 300) despite the marked fluctuations in the exit counts, in view of the rather constant number (445, 440 and 430) counted in three successive years in the post-mating period during the middle of the dry season.

Coordinated Radio Tracking

Radio transmitters operating in the 150 mHz range were fastened to 12 free-ranging *Macroderma*. These individuals were tracked over five successive nights from three simultaneously operated tracking stations. The observations totalled about 200 man hours and are reported in greater detail elsewhere (Tidemann *et al.*, 1985). Some additional points are made here.

a) Preferred nocturnal areas

Triangulation from the three stations enabled the position of a tagged bat to be plotted at any time. The data showed that individuals have preferred nocturnal areas. After leaving the mine in the evening, most bats flew 1-2 km (mean 1.9 km) directly to specific areas (mean = 60 ha) where they then spent most of the night. Each of the tagged bats had a different preferred area, to which it usually returned each night. The identification of these areas enabled observers equipped with night vision devices to make more detailed studies of foraging there (see below).

b) Mid-night inactivity

After the evening exodus (mean 1951 h ± 11 min. Range 1900 - 2100) from the mine each bat quickly flew to its preferred site, where there was an initial period of high activity lasting about 1-3 hours as judged by the rapidly fluctuating signal strength of the transmitter. This was usually followed by 1 hour of quiescence when the bat appeared to be stationary as judged by the steady signal from the transmitter. Around 0100 h most bats became active again and remained so until they re-entered the mine shortly before daybreak.

c) Sensitivity to disturbance

On one occasion we observed that nearby rifle fire (not associated with the expedition) caused two *Macroderma* to move several kilometres from their habitual foraging areas. Similarly, approach of a vehicle or a less-than-stealthy human on foot, towards a previously stationary bat usually led to the sudden movement of that bat out of the area.

d) Flexibility of day roost

After being tracked for several consecutive nights, one female *Macroderma* changed her day roost from the main mine to another abandoned mine (North Enterprise) about 2 km further to the north. Investigation of the mine revealed that this bat was accompanied by another 50 *Macroderma*. Since this mine had not been included in the initial survey we do not know whether all were recent arrivals or whether it was a previously established day roost. In view of the continued disturbance of the main colony, where a number of observations were being carried out on the behaviour of bats entering and leaving the mine, it seems possible that some bats may have sought a new day roost to avoid the activities of the expedition.

Audible Vocalisations of *Macroderma*

Sound recordings of *Macroderma's* vocalisations were made in and around the Kohinoor complex of mines at Pine Creek, N.T. The results have enabled a comprehensive range of vocalisations to be studied under natural conditions along with the associated behaviour of *Macroderma*. These were compared with recordings from captive bats.

Within the mine under study (Kohinoor), *Macroderma* used a series of audible vocalisations of three broad types *viz.* the 'twitter', the 'chirp' and the 'squabble'. Detailed analysis of these vocalisations has been reported elsewhere (Guppy *et al.*, 1985).
(a) Twittering is the most frequent non-sonar vocalisation used in the day roost and occurs particularly towards the time of the night exodus. When bats are disturbed during the day, extensive bouts of twittering are used.

Twittering is highly reminiscent of types of bird song, and can be long and rambling. Three, possibly four, twitter components or syllables can be identified, including a musical, modulated form or trill-like sequence. In a previous report, the 'twitter' has been compared to the sound made when two coins are rubbed together (e.g. Douglas, 1967).
(b) The 'squabble' call, commonly recorded in captivity when individuals fight over food, was occasionally recorded in the day roost, and just inside the mine entrance. This vocalisation is used when two individuals roost very close together or touch accidentally during landing. All of the energy in this call is in the audible frequency range of humans (Guppy *et al.*, 1985).
(c) 'Chirping', which also has bird or cricket call qualities, was recorded extensively in the day roost and outside in the foraging area at night. A large fraction of the energy in this call is audible to humans (Guppy *et al.*, 1985). This fact, along with the high intensity of the call, make the 'chirp', once learned by an observer, a very useful means of monitoring the presence of *Macroderma* in the wild. A possible source of confusion to a novice in the field is the chirp of nocturnal grasshoppers, which were common in the Pine Creek area. These grasshopper calls could be readily distinguished from *Macroderma* 'chirps' by the difference in frequency content

and temporal structure. Experienced observers were able to use *Macroderma* 'chirps' to estimate their numbers at a habitual site (see below).

The 'chirp' was used deep in the mine, especially as individuals assembled prior to the evening exodus. Observations and recordings at the entrance of the Kohinoor adit, which carried the main bat traffic, indicated that chirping functioned as a contact call. Typically a few bats hung just inside the mine shaft entrance and chirped frequently. These 'chirps' seemed to be answered by individuals from both deeper in the mine and also from those hanging in trees close to the entrance. After several minutes, bats flew out of the mine, and others took their place just inside the entrance and commenced chirping. This behaviour was repeated in the reverse sequence when bats returned to the mine an hour or so before dawn. Some twittering was mixed with chirps near the mine entrance, but only chirping was heard outside the mine. The audible part of the chirp is very intense and, on a still night, can be easily heard 200 metres or more away. *Macroderma* has very sensitive hearing (Pettigrew *et al.*, 1983; Guppy *et al.*, 1985) particularly in the low frequency region where most of the energy of the chirp is concentrated. The chirp vocalisation contrasts sharply with the sonar signals (Guppy *et al.*, 1985) which are ultrasonic and relatively low in intensity and which may be useful over several metres only. No chirping was heard from flying *Macroderma*, although Vaughan (1976) reports a flight call used by *Cardioderma cor*, which he distinguished from the 'song' (which resembles the chirp of *Macroderma*).

An important conclusion to emerge from these studies concerned the limitations of data collection from captive subjects. Despite more than a year's observation and recording from a male and female *Macroderma* in a large flight cage, the 'twitter' was unknown to use until we observed *Macroderma* in the field.

Bio-Sonar

Detailed studies of the use of bio-sonar by captive *Macroderma* have been presented elsewhere (Guppy *et al.*, 1985). In the present study, these data were confirmed from ultrasonic recordings taken in the mine, where echolocation is compulsory for orientation during flight. Bio-sonar pulses emitted by *Macroderma* are very brief, around 1 msec in duration, with a repetition rate which varies widely according to the complexity of the navigation tasks. The carrier frequency of the pulses is modulated downwards, with most energy in the second and third harmonics (around 40 kHz and 60 kHz respectively).

Sonar signals were detected from bats flying out of, or into, the mine entrance and these appear similar to those already described for captive *Macroderma* (Guppy *et al.*, 1985). It was necessary to place the ultrasonic microphone immediately above the entrance of the mine shaft at ceiling level, in order to obtain good recordings of sonar signals. Microphones placed 5-7 m or so away from the entrance yielded very poor sonar recordings, if any, due to the low intensity of the signal. The difficulty in recording sonar pulses from *Macroderma* at any appreciable distance from the microphone emphasizes the relatively low intensity used by this species compared to other microchiropterans from which recordings can be made at distances of 30 m or more.

FIELD OBSERVATIONS AT PREFERRED SITES

The first preferred nocturnal site to be identified belonged to a tagged male *Macroderma* which returned there on three consecutive nights. A number of observers equipped with night vision devices and ultrasound recording equipment visited this site while the bat was present. This site, close to the Pine Creek Airstrip, was found to be occupied by about twenty *Macroderma*, whereas areas immediately adjacent in any direction were virtually devoid of *Macroderma*. The estimate of numbers present was based on visual observation and on the audible contact calls already described. Judgement of the number of individuals in these aggregations was also facilitated if the observer produced short noisy whistles or squeaks through pursed lips. Such stimuli proved to be very effective in attracting *Macroderma* which flew in close to the observer's head to investigate. During the early night watches it was found that *Macroderma* could be attracted by a highly pitched 'distress whistle'. The 'whistle' is similar to a rabbit squeal and is the same call used to attract foxes, *Vulpes vulpes*. Typically *Macroderma* would circle the person making the call, and then approach to within 1 or 2 m before flying away. The aggregation at the airstrip site was noted during six nights of observations over the course of the study.

The period of intense activity after the evening exodus which was observed by the radio trackers coincided with feeding bouts seen by the field observers. The bouts consisted of repeated forays from a perch in the upper canopy to which the bat returned to consume the prey item. The major source of prey at this time was insects, particularly the yellow-winged locust *Gastrimargus musicus*. Locusts were abundant throughout the area but were particularly numerous in recently burnt patches where they appeared to be feeding on the new green shoots.

At least some of the capture of large flying insects at 2-3 m above the ground appeared to be carried out in conventional Microchiropteran fashion, with ultrasound, based upon the presence of a 'terminal buzz' just before contact. Although *Macroderma's* pulses have most of their energy in the ultrasonic range they can be heard by an observer at short distances. On three occasions capture of a flying insect by *Macroderma* was heard to be preceded by the terminal buzz where the pulse repetition rate rose rapidly just before contact. This is very strong evidence that *Macroderma* does use ultrasound for prey capture and appears to eliminate the possibility that this species of bat hunts exclusively using vision or passive hearing. On the other hand, we also observed 'glide attacks', in addition to these 'tail chasing and stooping attacks' where the flying insect was taken in the air with the associated terminal buzz. In the former insects were taken from the ground after a silent glide and no terminal buzz could be detected by the observer from distances even closer than those aerial encounters associated with a terminal buzz. After a 'glide attack' the impact of the bat's claws in the burnt stubble was clearly audible.

As already mentioned, there were many clear instances of orientation to other sound sources by *Macroderma*. For example it was easy to attract them with acoustic stimuli, particularly short noisy whistles and squeaks. Bats which flew at the observer's head following such a sound appeared to do so without emitting any sound themselves.

Both before, and during the quiescent period after 2100 hrs (when relative immobility of the bats favoured observation) *Macroderma* were observed to hand from the branches of trees, *Eucalyptus alba* and *Eucalyptus tectifica*. The preferred perches appeared to be shallow sloping to near vertical thin branches in the mid to upper canopy. There, individual bats were observed to fly off and return to feed on unidentified small prey items, groom and/or survey the surrounding area by rotation of the head. Field observations confirmed the sensitivity to disturbance revealed by the radio-tracking study. *Macroderma* under observation with a night-vision device would take off if a slight noise or movement were made underneath the tree being used as a perch.

DIET

In that many expedition members hoped to get more information about *Macroderma's* capture of vertebrate prey, the present study was a disappointment since there was only one direct observation of vertebrate prey capture, and one observation of vertebrate prey pursuit. A *Macroderma* was seen to pursue a dusky horseshoe bat, *Hipposideros ater* in the beam of a spotlight. Capture was accompanied by a short squeal which one observer attributed to the *Macroderma* and the other observer attributed to the *Hipposideros*. That this was not an isolated event was suggested by the very cautious behaviour exhibited by the *Hipposideros* if *Macroderma* were in the vicinity as the former made their evening exodus. When *Macroderma* were in the vicinity, *Hipposideros* were seen to retreat back into the small entrance of a side passage where there was not enough room to *Macroderma* to manoeuvre.

On one occasion, a quail *Coturnix sp.*, flushed by an observer at a preferred site was observed in a spotlight to be pursued closely, but unsuccessfully, by a *Macroderma*.

Apart from the isolated incidents reported above, all the evidence pointed to invertebrates as the major source of prey of *Macroderma* at the time of the expedition. Collection of feeding debris at the bases of the identified night roost trees in the preferred sites, scats collected at both day and night roosts, and visual observations of prey capture were all overwhelmingly dominated by intervebrates such as scarabid coleopterans and the yellow-winged locust *Gastrimargus musicus*. At the base of one roost tree *Eucalyptus alba*, there were hundreds of wings and occasional legs of this locust associated with the sand tunnels of ants. Early morning observation at this roost tree revealed that ants were responsible for the very early disposal of scats and edible feeding debris. During the day, therefore, the preferred areas and night roosts were recognisable only by the numerous bright yellow wings of the *Gastrimargus* which the ants had left behind.

Vertebrate remains collected at the day roost included the feathers of Long-tailed finch, *Poephila acuticauda*, Owlet-nightjar, *Aegotheles cristatus*, Black-faced woodswallow, *Artamus cinereus*, Peaceful dove, *Geopelia striata*, Diamond dove, *G. cuneata*, Sacred or Red-backed kingfisher, *Halcyon sp.*, Red-backed wren, *Malurus melanocephalus*, Brown honeyeater, *Lichmera indistincta*, and Barn owl, *Tyto alba* as well as identifiable remains of one *Pseudomys delicatulus* and an agamid lizard. Also found in the day roost was the partially consumed remains of *Sminthopsis butleri* (M. Archer and S. Hand, *pers. comm.*). The presence of the barn owl feathers inside the mine is presumably related to the well-known cave-roosting propensities of this bird rather than to any connection with *Macroderma*, although no owls were observed in the Kohinoor mine complex by the expedition. A 300 g plus barn owl exceeds the largest prey species so far recorded for *Macroderma* (90-100 g, Red-plumed pigeon, *Lophophaps ferruginea*, (Frith, 1973) by such a considerable margin as to be inconceivable as prey. Further collections were made from the day roosts in October 1983 and July 1984. Avian remains were much more common at these times. Feathers and skeletal remains were recorded for the White-breasted woodswallow, *Artamus leucorhyncus* (from six different sites in the main chamber), White-winged triller, *Lalage sueurii* (two wings in different parts of the main chamber), Owlet nightjar *Aegotheles cristatus* (some bones and a large number of feathers at one site), Peaceful dove, *Geopelia striata*, Brown honeyeater, *Lichmera indistincta*, Hooded parrot, *Psephotus chrysopterygius*, Long-tailed finch, *Poephila acuticauda* and Masked finch, *P. personata*.

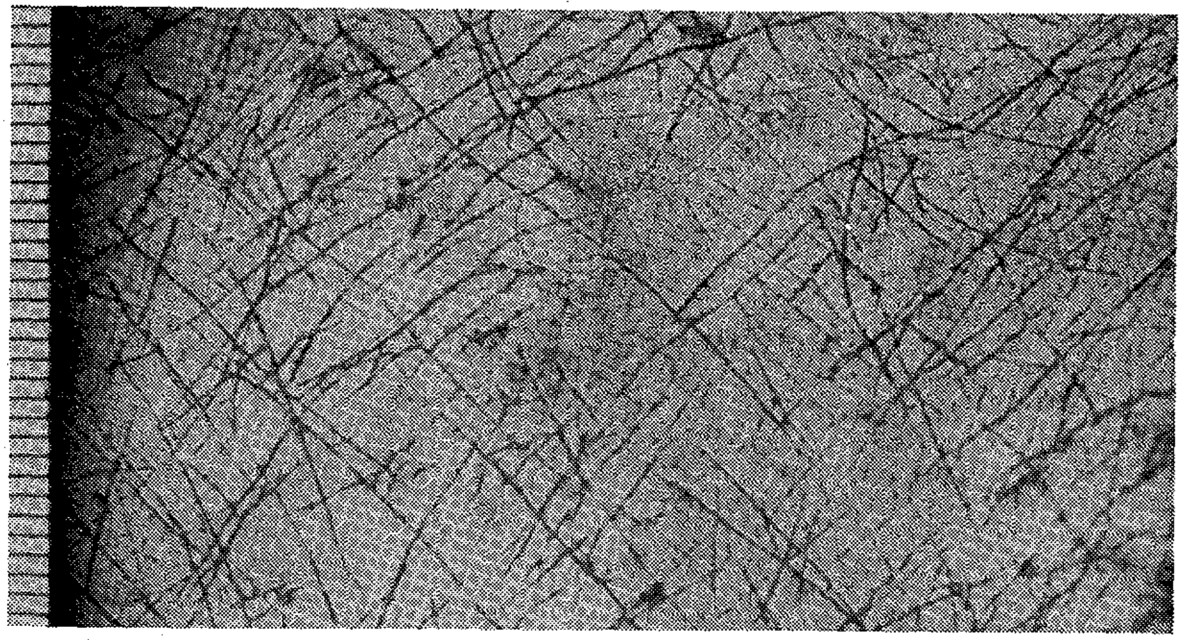

Fig. 1. Scratch marks on the bark of *Eucalyptus alba* at one of the nocturnal preferred areas of *Macroderma gigas* near the Pine Creek airstrip. The base of this tree was littered with the remains of *Gastrimargus musicus*, the predominant prey species for *Macroderma* at the time. The spacing of the scratches and the parallel grouping conform to that produced by captive *Macroderma* and do not conform to the arrangement produced by quolls, goannas or possums. Scale : mm.

SCRATCH MARKS ON *EUCALYPTUS ALBA*

The identification of preferred sites where the bats tended to spend the night led to another chance observation *viz*: scratch marks on the tree trunks of *Eucalyptus alba*. *In contrast to Eucalyptus tectifica*, which was also commonly used as a night roost, *Eucalyptus alba* has smooth white bark (turning to a salmon colour later in the dry season) upon which the fine scratch marks made by *Macroderma's* feet are readily visible. The characteristics of these scratch marks were carefully measured and compared with the scratches made by captive *Macroderma* and also with the easily distinguished scratch marks of goannas, possums and the northern quoll, *Dasyurus hallucatus*, which was common at Pine Creek and was even observed on several occasions deep in Kohinoor mine.

Scratch marks were very fine, no more than 0.2 mm into the surface of the bark and occurred in groups of two, three or four, the scratches parallel to one another. Within a group, the spacing between the scratches was around 2-4 mm, comparable to the spacing of the toes of *Macroderma* when it spreads its claws. The scratches varied in length from a few millimetres to several centimetres (Figure 1). A surprising feature of the scratch marks was their distribution on the multiple trunks of *Eucalyptus alba*. While some scratch marks were found 3 m from the ground toward the canopy where most bats had been observed to roost during the quiescent period, the greatest density of scratches was within 1 m of the ground. Scratches occurred all the way down to ground level but were scarce below 70 cm, the prevailing height of grass before burning.

Interpretation of these findings has been aided by the observation of captive *Macroderma*. The common occurrence of four scratch marks when *Macroderma* has five toes was verified in observations of the perching of captive *Macroderma* and appears to be a result of the very light pressure exerted by the first toe. Under ideal conditions, sometimes a fifth scratch mark can be observed parallel to, but much fainter than, the other four. The presence of scratch marks close to the ground may be related to *Macroderma's* technique for handling heavy prey. It is possible for a *Macroderma* to kill a 100 g rat (J.N., unpublished) or pigeon (Frith, 1973). Such large prey is held in the bat's jaws while the rear limbs reach out backwards to drag the prey. When the feet encounter a vertical surface the bat drags its prey up to a metre or so where it is consumed. While this behaviour has been observed a number of times in captivity (J.N. and J.P., unpublished observations) we never saw *Macroderma* on roost trees close to the ground during the course of the expedition.

There is a previous report of scratch marks just like those described here, on the walls of Cutta Cutta cave near Katherine where *Macroderma* have also been seen (Walsh, 1964). Walsh (1964) was sceptical about *Macroderma* being the agent because some marks were found horizontally across ceilings and because many were found close to the floor of the cave. Our present observations support the interpretation that *Macroderma* was responsible, since horizontal scratch marks can be produced on a ceiling during abortive landings and also by the reaching of one foot while the other is used to hang from (J.P. & J.N., unpublished observations). As for the marks low down, we have often observed captive *Macroderma* to climb from the ground up onto sidewalls and branches.

CONCLUSION

This pilot study has demonstrated the feasibility of a coordinated, multidisciplinary field study of a little-known and vulnerable native species. The important new findings on *Macroderma* which have emerged are the discovery of social grouping at habitual nocturnal foraging sites and the large role played in the bat's behaviour by sounds in the audible frequency range, including both the powerful attractive effect upon this bat of novel extraneous low-frequency sounds and the common use by this bat of low frequency calls for intra-specific communication.

Many questions remain which could be settled by further application of the same techniques for longer periods and at different times of the year. For example, radio-tracking during the latter part of the 'dry', when invertebrate prey abundance is lower and when many females are lactating, should greatly increase the chances of observing the circumstances surrounding the capture of vertebrate prey. Study at this time might also help to illuminate the puzzle surrounding *Macroderma's* apparent use of the lower portions of roost trees. More information is also clearly needed on the microclimate and the location of the maternity roost in the mine complex.

In view of the prominence of social interactions in the behaviour of *Macroderma*, much more needs to be learned about the significance of large aggregations like the one described here and those at Kakadu, Katherine Gorge and Umbrawarra Gorge (P.H., S.C. and L.H., unpublished).

Do these large colonies play some special part in the life history and dispersal of this species which could not be adequately fulfilled by the apparently abundant, but scattered, smaller groups?

If the answer to this question should be affirmative, then the present apparent abundance of small groups of *Macroderma* in the Northern Territory could give a false sense of security about the status of this species. The small number of known large aggregations and the apparent sensitivity of these to disturbance argue strongly that the question of their role should be settled before rational decisions can be made about conservation strategy. In the event that large colonial aggregations should prove to be an essential feature of *Macroderma's* ecology, further investigation of the particular microclimate requirements of the colony could help in the provision of suitable conditions in alternate cavities should the original area be threatened by renewed mining activity, such as that occurring at Pine Creek.

ACKNOWLEDGEMENTS

We would like to thank the many individuals who helped make the field study a success, particularly the hospitable townspeople of Pine Creek. We also thank the staff of the Conservation Commission of N.T., in particular Cliff Ellis, Paul Dahl and Mark Stevens, for their cooperation and Russell Dann of Goldfields Exploration Enterprises for information about the location of mine shafts. Ian Mason and Richard Schodde identified the bird feathers. Purchase of telemetry equipment was supported by grants from the Australian Research Grants Scheme to J.D.P. and from the Conservations Fund of the S.A. Department of Environment and Planning to C.R.T. We thank the N.S.W. National Parks and Wildlife Service for the loan of telemetry equipment to the expedition. CSIRO Division of Applied Physics loaned the Racal Store 4D high speed tape recorder to R.B.C. and A.G. for sonar and ultrasound recordings and N.S.W. National Parks and Wildlife Service loaned a nightscope to R.B.C. and A.G. for the study of foraging.

REFERENCES

Christian, C.S. and Stewart, G.A. (1953) *General report on survey of the Katherine-Darwin region, 1946*. Land Research Series No. 1. C.S.I.R.O. Melbourne.

Douglas, A.M. (1967) The natural history of the ghost bat, *Macroderma gigas* (Microchiroptera, Megadermatidae), in Western Australia. *West. Aust. Nat.* 10, 125-138.

Frith, H.J. (1973) *Wildlife Conservation*. Angus & Robertson, Sydney.

Guppy, A. and Coles, R.B. (1983) Feeding behaviour of the Australian ghost bat, *Macroderma gigas* (Chiroptera: Megadermatidae) in captivity. *Aust. Mammal.* 6, 97-99.

Guppy, A., Coles, R.B. and Pettigrew, J.D. (1985) Echolocation and acoustic communication signals in the Australian ghost bat *Macroderma gigas* (Microchiroptera: Megadermatidae). *Aust. Mammal.* 8, 299-308.

Hamilton-Smith, E. (1978) Endangered and threatened chiroptera of Australia and the Pacific Region. Chapter 8 in Tyler, J.M. (Ed.) *The Status of Endangered Australian Wildlife.* Roy. Zool. Soc. S.A., Adelaide.

Hall, L.S. and Richards, G. (1979) *Bats of Eastern Australia.* Queensland Museum Booklet No. 12.

Kulzer, E., Nelson, J.E., McKean, J.L. and Mohres, F.P. (1970) Untersuchungen uber die Temperaturregulation australischer Fledermause (*Microchiroptera*). *Z. vergl. Physiologie* 69, 426-451.

Kulzer, E., Nelson, J.E., McKean, J.L. and Mohres, F.P. (1984) Prey catching behaviour and echolocation in the Australian Ghost Bat, *Macroderma gigas* (Microchiroptera: Megadermatidae). *Aust. Mammal.* 7, 37-50.

Leitner, P. and Nelson, J.E. (1967) Body temperature, oxygen consumption and heart rate in the Australian false vampire bat, *Macroderma gigas. Comp. Biochem. Physiol.* 21, 65-74.

Molnar, R.E., Hall, L.S. and Mahoney, J.A. (1984) New fossil localities for *Macroderma* Miller, 1906 (Chiroptera: Megadermatidae) in New South Wales and its past and present distribution in Australia. *Aust. Mammal.* 7, 63-73.

Pettigrew, J.D., Coles, R.B., Guppy, A., Brown, M. and Nelson, J. (1983) Sensory abilities of the Australian ghost bat, *Macroderma gigas. Neurosci. Letts.* Suppl. 11, 568.

Tidemann, C.R., Priddel, D.M., Nelson, J.E. and Pettigrew, J.D. (1985) Foraging behaviour of the Australian ghost bat, *Macroderma gigas* (Microchiroptera: Megadermatidae). *Aust. J. Zool.* 33, 705-713.

Vaughan, T.A. (1976) Nocturnal behaviour of the African false vampire bat (*Cardioderma cor*). J. Mammal. 57, 227-248.

Vehrencamp, S.L., Stiles, F.G. and Bradbury, J.W. (1977) Observations on the foraging behaviour and avian prey of the Neotropical carnivorous bat, *Vampyrum spectrum. J. Mammal.* 58, 469-478.

Walsh, W.P. (1964) Unexplained markings in Kintore and Cutta Cutta Caves, Northern Territory, Australia. *Helictite* 2, 83-91.

SHORT COMMUNICATIONS

DOBSONIA FLIGHT AND ECOLOGY: MORE ON LIFT AT LOW SPEED

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I read with much interest the hypothesis proposed by Wilson (1985) that *Dobsonia* has evolved a form of the 'clap and fling' flight mechanism which, in conjunction with its huge wing area, would 'permit access to foraging and/or roost areas unavailable to less fortunately endowed pteropodids of a similar body mass'. I would like to lend support to these suggestions with a few field observations.

The only colony that I have observed resided in a huge boulder pile on the beach just north of the mouth of the Pascoe River, on the eastern coast of the Cape York Peninsula at 12°30'S, 143°17'E. The boulder pile was about 50 m high, and made up of massive boulders heaped in such a way that huge cavernicolous spaces formed between them. Light levels ranged from sunlit to complete darkness, and the colony of 30 or so *D. moluccensis* resided (typically) in the twilight zones.

Observer presence caused some nervousness and disturbance to the residents, resulting in frequent flying around in the cavern. I was able to watch many landings which showed me the amazing manouverability of this species. They could not only fly forward extremely slowly, and hover, but could also fly backwards!. As each bat approached the group of roosting conspecifics it would hover, presumbly to investigate the situation. In this short search for a place to land they could move around the site by hovering, reversing and moving forward slowly - repeatedly - and then, once a site was selected, land by swinging the feet upwards to grab onto the rock.

I can therefore support part of Wilson's (1985) hypothesis. Some evidence is accumulating to lend weight to his suggestion that *Dobsonia* can access foraging areas that are unavailable to *Pteropus*. It appears that *Dobsonia* can forage below the canopy in rainforests, a stratum inaccessible to *Pteropus* in most situations, but, at present, my data on this are inconclusive. However, *Dobsonia* has been observed foraging below the canopy over several consecutive nights on Cape York, where it was able to access fruiting figs (G.B. Baker and W.R. Phillips, *pers. comm.*).

Dobsonia's abilities would certainly reduce interspecific competition for food resources that, even in rainforest, can be, at times, quite limited.

The ability to manouvre in the manner described above, would certainly give *Dobsonia* access to fruit on the periphery of tree crowns and I feel that the combination of (a) an ability to hover and (b) large cheek pouches, points strongly to this specialist foraging mode.

Reference:

Wilson, P. (1985) Does *Dobsonia* (Chiroptera: Pteropodidae) have a fling? *Macroderma* 1, 53-55.

BAT REMAINS IN A TASMANIAN CAVE

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The remains of a number of bats have been located in Judd's Cavern, a large efflux cave approximately 26 kilometres west of Geeveston in Southern Tasmania. There are no previous records of the presence of bats in Tasmanian caves. The species also do not utilize caves on the mainland of Australia, except where suitable tree roosts are unavailable (e.g. Strahan, 1983).

The remains of seventeen individuals were found. These consisted largely of intact skeletons on the cave floor. However, a number of specimens, still attached to the cave wall, retained some fur and skin. Identifications were based on size, skull features and baculum shape. Two specimens were *Chalinolobus morio* and the rest were *Eptesicus* spp. In the interests of minimising disturbance not all the *Eptesicus* specimens were identified to species level. Of the four individuals examined in detail, three were *E. regulus* and one was *E. sagittula*.

The bats were all located in a small extension (subsequently named Bat Passage), approximately 800 m horizontally in from the cave entrance and about 20 m above the stream level. The extension consists of a breakdown chamber of several avens of varying heights and connects with the main cave via a short passage. There is some suggestion of a direct connection from the bat passage to the surface, through the presence of cave crickets and a Tasmanian cave spider and charcoal fragments in close proximity to the bats. There is also some draught present in a vertical extension leading up from the bat passage.

The presence of many individuals of three different species located within the one extension of the cave suggests circumstances other than individuals accidently entering the cave mouth and becoming lost.

We would like to thank Arthur Clarke and other members of the Southern Caving Society for informing us of the discovery and allowing access to the specimens.

References

Strahan, R. (ed) (1983) '*Complete book of Australian mammals*'. Angus and Robertson, Sydney.

IDENTITY OF *NYCTOPHILUS* IN TASMANIA.

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There has been some confusion regarding the identity of the larger species of *Nyctophilus* in Tasmania. Hall and Richards (1979) refer to it as *N. gouldi*, whereas Koopman (1984) considers it to be *N. timoriensis*. Recent electrophoretic work carried out at the Evolutionary Biology Unit of the South Australian Museum indicates that Tasmanian specimens are more closely related to *N. timoriensis* than to *N. gouldi* (T. Reardon *pers. comm.*).

References
Hall, L.S. and Richards, G.C. (1979) *Bats of Eastern Australia.* Queensland Museum Booklet No. 12. Queensland Museum, Brisbane.
Koopman, K.F. (1984) Taxonomic and distributional notes on tropical Australian bats. *Amer. Mus. Novit.* 2778, 1-48.

Abstracts of papers presented at the Bat Biology Symposium held at the University of Queensland, 8 May 1985.

The following abstracts were inadvertently omitted from *Macroderma* Volume 1, Number 2.

SEASONAL CHANGE IN THE DIET OF THE QUEENSLAND BLOSSOM BAT (*SYCONYCTERIS AUSTRALIS*) IN COASTAL VEGETATION ON BRIBIE ISLAND.

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Little is known of the feeding behaviour of the nectivore, *Syconycteris australis*. The objective of this study is to monitor dietary changes in relation to local flowering patterns of potential food sources.

Animals are caught in as many as ten mist nets set within a sampling area of approximately 50 ha. Local plant associations include wallum, *Melaleuca* swamp, and dense, dune vegetation. To improve the probability of capture, nets are set adjacent to plants in bloom. Prior to release, animals are individually marked by ear notching. Faecal samples are collected from the floor of small cages where the animals are held in captivity for a maximum of two hours. The faeces are later inspected for the presence and abundance of different species of pollen.

Seasonal flowering intensities of plants considered as possible food sources are monitored by quantitative transect techniques in the sampling area. The relative abundance of different species of flower are being compared with the relative abundance of different pollen in faecal samples.

Initially, netting was conducted throughout the night until it was found that most captures occurred between dusk and midnight. So far, significant amounts of pollen from *Banksia serratifolia, B. integrifolia, B. asplenifolia* and *Melaleuca quinquenervia* have been found in faecal samples.

BEHAVIOURAL CHANGES BETWEEN MATED GREY-HEADED FLYING FOXES, *PTEROPUS POLIOCEPHALUS*

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Interactions between mated flying foxes were observed on Indooroopilly Island, on the Brisbane River, from February til May, 1984. A survey of the diurnal pattern was made after which observations were conducted between 0630 and 0930 h, thrice weekly. Observations began at a time, presumably after mate selection had occurred and ceased when the camp broke up and dispersed. Data collected was (a) contextual, (b) social interactions: the frequency of interactions between females and males, males, and females and their infants was used to examine the interdependency between social relationships, (c) timed sequence and (d) event sequence: the sequence of behaviours within the female-male interactions were recorded to examine the changes in the relationship between mates. The relative frequencies of female-male, male-male and female-infant interactions suggest no interdependence. Frequencies of male-male and female-infant interactions remained low and constant: a dramatic peak in the female-male interaction frequency occurred during the mating phase. Lag sequential techniques were used to analyse the event sequence data. Each week, criterion behaviours were selected and successive behaviours at each lag, from 1 to 6, were determined. In this way probable common sequences of behaviour were identified. Courtship sequences were identified during the first few weeks of observations. These sequences involved appeasement and aggressive behaviours by the male and rejection of the male by the female. After several more weeks the male's aggressive behaviour began to elicit sexual responsiveness in the female, she would allow him to sniff and lick around her vaginal opening and eventually they would copulate. A peak in copulations and relatively open interactions ensued and presumably reflects the strengthened and intimate individual mate pair bond. Toward the end of the breeding season mates were aggressive toward each other, and the amount of copulation and social interaction between them decreased presumably indicating the termination of their relationship.

PRELIMINARY STUDIES OF THE NASAL ANATOMY OF THREE MEGACHIROPTERAN SPECIES: *Pteropus poliocephalus*, *Pteropus scapulatus* and *Nyctimene robinsoni*.

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University of Queensland
St Lucia, Qld 4067

In all three species, but particularly in *N. robinsoni*, the Queensland tube-nosed bat, left and right external nares are well separated, a feature which may help to locate odours. The tube nose of *Nyctimene* has musculature to change the direction and width of the nares. The nasolachrymal duct opens to a partially-separate medioventral section of the tubular nostril.

In all three species there is a wide patent incisive duct between nasal and oral cavities. In the red and grey-headed flying foxes but not in the tube-nosed bat, groups of taste buds occur in the palate at the oral opening of the duct.

The histology of the nasal cavity resembles that of most land mammals. Ciliated pseudostratified epithelium with numerous goblet cells line the respiratory areas of the cavity, and olfactory epithelium the more dorsal parts; ciliated olfactory receptors and their supporting and basal cells do not differ significantly from those in other mammals.

There is no vomeronasal organ in any of the three species investigated. This is in agreement with published reports for other *Megachiroptera*.

ANTIBODIES TO ARBOVIRUSES IN FLYING FOX SERUM

Daisy H. Cybinski
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Private Mail Bag Number 3
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Serum samples were obtained from 7 flying foxes (*Pteropus spp.*) collected around Brisbane and tested for neutralizing antibodies to 36 Australian arboviruses by a micro technique using Vero tissue culture. These included 4 viruses of the family Togaviridae: - Murray Valley Encephalitis, Ross River, Sindbis and Barmah Forest viruses; 8 viruses of the family Rhabdoviridae:- Bovine ephemeral fever, Kimberley, Adelaide River, Oak Vale, Kununurra, Parry Creek, Tibrogargan and Coastal Plains viruses; 6 viruses of the family Bunyaviridae:- Akabane, Peaton, Tinaroo, Thimiri, Belmont and Precarious Point viruses; 12 viruses of the family Reoviridae:- D'Anguilar, CSIRO Village, CSIRO 157, CSIRO 439, CSIRO 753, CSIRO 775, DPP 59, Bluetongue types 1, 15, 20, 21 and Nugget viruses; and 6 unassigned viruses:- CSIRO 264, Leanyer, CSIRO 1056, CSIRO 1568, CSIRO 1499 and Johnston Atoll viruses.

One serum was found to contain neutralizing antibody to Murray Valley Encephalitis virus while all other tests gave negative results.

AUSTRALASIAN BAT WORKERS - RESEARCH INTERESTS.
UPDATE TO DIRECTORY IN *MACRODERMA* VOLUME 1, SUPPLEMENT.

Stan C. Flavel, Murray Road, INGLEWOOD SA 5133 (08) 3805404.
Echolocation, reproduction, taxonomy, ectoparasites, roost ecology diet.

Leslie S. Hall, Department of Anatomy, University of Queensland, ST LUCIA QLD 4067 (07) 3773933.
General; ecological morphometrics.

Tony M. Hutson, Bat Conservation Officer, Fauna and Flora Preservation Society c/o Zoological Society of London, Regent's Park, LONDON NW14RY UK (01) 5860872.
Conservation of bats in UK and worldwide, including FFPS's International Bat Project.

Dan Lunney, National Parks and Wildlife Service, PO Box N189, Grosvenor Street, SYDNEY NSW 2000. (02) 2376828
Ecology of Australian bats.

Maria McCoy, Zoology Department, Australian National University, G.P.O. Box 4, CANBERRA ACT 2600. (062) 493070
Physiology and ecology of *Pteropus scapulatus*. Thermoregulation, heat exchange mechanisms. Population dynamics, migration, breeding bat pollination and dispersal of Australian plants. Conservation problems.

Andrew McWilliam, Department of Zoology, University of Aberdeen, Tillydrone Avenue ABERDEEN AB92TN SCOTLAND UK.
Feeding ecology, socio-biology, reproduction and conservation of Microchiroptera (particularly African) and Megachiroptera (especially *Pteropus*).

Ulla M. Norberg, Department of Zoology, University of Goteborg, Box 25059, S-400 31 GOTEBORG SWEDEN 31-853644, 31-285597 (ah).
Bat flight; bat wing morphology related to flight and foraging behaviour.

Terry Reardon, Evolutionary Biology Unit, South Australian Museum, Blacks Road, GILLES PLAINS SA 5086 (08) 2611033.
Taxonomy of Australasian bats using biochemical techniques. Reproductive studies in the sibling species of *Eptesicus* and *Mormopterus*.

Simon Robson, Department of Oral Biology and Oral Surgery, University of Queensland, ST LUCIA QLD 4068 (07) 3773074.
All aspects of chiropteran ecology. Currently investigating roost selection and social organization in *Rhinolophus megaphyllus*.
James Dale Smith, Department of Biological Sciences, California State University, FULLERTON CALIFORNIA 92634 USA
General; biogeography of Australian and New Guinea bats.

Ray Williams, 10 King Street, MT KURING-GAI NSW 2080 (02) 4561637, (02) 4579830 (ah).
Bat ecology, especially breeding biology and habitat usage.

NOTICES

BAT ORGANIZATIONS AND JOURNALS

Adam Krzanowski has drawn to our attention the following addition to the list published in the last issue of *Macroderma* (1: 74):

***Nyctalus*.** Editor Dr. Joachim Haensel, Tierpark Berlin, DDR-1136, Berlin, AM Tierpark 125, German Democratic Republic

FLYING FOX SYMPOSIUM

The symposium is being organized by the Australian Mammal Society and will be held at the University of Queensland, Brisbane, 30-31 August, 1986.
The symposium will commence at 10.00am on Saturday 30 August to allow for early morning arrivals. A limited amount of accommodation will be available for the Friday, Saturday and Sunday nights at Crommwell College at a cost of $30.00 for dinner, bed and breakfast (lunch will be provided at the symposium).

A number of fruit-grower's co-operatives have been contacted and have indicated that a representative will attend the symposium.

An open forum on flying fox management and control methods will be held on Sunday 31 August and will allow a free exchange of ideas between fruit-growers and researchers - something that appears to have never previously occurred.

A number of interesting titles have already been offered and include -Flying foxes are flying primates, Jack Pettigrew; Ecology of Christmas Island flying foxes, Chris Tidemann; Flying foxes of Guam, Gary Wiles.

For further information, plese fill in the enclosed form and return to Les Hall, Department of Anatomy, University of Queensland, St Lucia Qld 4067.

CURRENT LITERATURE

Anon. 1985
Golden-tipped Bat - a rare and precious find
Aust. Zool. 22:13

Breed, W.G. and Inns, R.W. 1985
Variation in sperm morphology of Australian Vespertilionidae and its possible phylogenetic significance
Mammalia 49:105-108

Brown, P.E. and Berry, R.D. 1983
Echolocation behavior in a 'flycatcher' bat, *Hipposideros diadema.*
J. Acoust. Soc. Am. Suppl. 1, 74:S32

Buchanan, R. 1985
Site assessment of the Gordon bat colony. Weed control and restoration of native vegetation.
Unpublished report to Kuring-gai Bat Colony Committee

Calford, M.B. Wise, L.Z. and Pettigrew, J.D. 1985
Audiogram of the Grey-headed Flying-fox, *Pteropus poliocephalus* (Megachiroptera: Pteropodidae).
Aust. Mammal. 8:309-312

Conole, L. and Baverstock, G. 1982
Mammals of the Inverleigh Common. An annotated list.
Geelong Nat. 19:39-41

Constantine, D.G. 1985
Disease exchange between bats and researchers: problems and precautions.
Aust. Mammal. 8:325-329

Dell, J. and How, R.A. 1985
Vertebrate fauna pp 39-66 in The biological survey of the Eastern Goldfields of Western Australia Part 3. Jackson - Kalgoorlie Study Area.
Rec. W. Aust. Mus. Suppl. 23

Dixon, J.M. and Huxley, L. 1985
Donald Thomson's mammals and fishes of Northern Australia
Nelson:Melbourne

Domrow, R. and Lester, L.N. 1985
Chiggers of Australia (Acari : Trombiculidae): an annotated checklist, keys and bibliography
Aust. J. Zool. Suppl. Series No. 114:1-111

Ellis, W.A.H. 1985
The effect of a temperature-determined food supply on the annual activity cycle of the Lesser Long-eared Bat: *Nyctophilus geoffroyi* Leach 1821 (Microchiroptera : Vespertilionidae).
BSc Hons. Thesis, Aust. Nat. Univ., Zoology Dept, Canberra

Estbergs, J.A. and Braithwaite, R.W. 1985
The diet of the Rufous Owl *Ninox rufa* near Cooinda in the Northern Territory
Emu 85:202-205

Fenton, M.B. 1985
Echolocation : a window on the activities of some bats
Tower Karst 5:23-26

Griffin, D.R. and Thompson, D. 1982
High altitude echolocation of insects by bats
Behav. Ecol. Sociobiol. 10:303-306.

Guppy, A. Coles, R.B. and Pettigrew, J.D. 1985
Echolocation and acoustic communication in the Australian Ghost Bat, *Macroderma gigas* (Microchiroptera: Megadermatidae)
Aust. Mammal. 8:299-308

Jen, P.H.-S. and Suthers, R.A. 1982
Responses of inferior collicular neurones to acoustic stimuli in certain FM and CF-FM Paleotropical bats
J. Comp. Physiol. 146:423-434

Johnswood, L. 1985
Beautiful Bats - that bite
People 02/85:24-26

Kitchener, D.J. and Foley, S 1985
Notes on a collection of bats (Mammalia : Chiroptera) from Bali I. Indonesia
Rec. W. Aust. Mus. 12:223-232

Lunney, D. Barker, J. and Priddel, D. 1985
Movements and day roosts of the Chocolate Wattled Bat *Chalinolobus morio* (Gray) (Microchiroptera: Vespertilionidae) in a logged forest.
Aust. Mammal. 8:313-317

Lumsden, L.F. and Schulz, M. 1985
The mammals of Gellions Run, South Gippsland
Victorian Nat. 102:4-16

Marsh, S. 1985
Drive 'em batty
People 23/09/85: 32

McCoy, M. 1984
Body temperature and oxygen consumption of *Pteropus scapulatus* Peters, 1862 (Megachiroptera) and the reaction to radiant heat - a biotelemetric study
BSc Hons. Thesis, Univ. of New England, Armidale

Novacek, M.J. 1984
Evidence for echolocation in the oldest known bats
Nature 315:140-141

O'Neill, M.G. 1984
Structure and composition of Tasmanian bat communities
BSc Hons. Thesis, Univ. of Tasmania, Zoology Dept.

Parry-Jones, K. 1985
Winter flying-fox colonies in southern NSW
Aust. Zool. 22:5-6

Phillips, W.R. and Inwards, S.J. 1985
The annual activity and breeding cycles of Gould's Long-Eared Bat, *Nyctophilus gouldi* (Microchiroptera:Vespertilionidae)
Aust. J. Zool. 33:111-126

Richards, G.C. 1984
The conservation status of the rainforest bat fauna of North Queensland.pp 292-299 in, G.L. Warren & A.P. Kershaw (Eds.). Australian National Rainforest Study report to the World Wildlife Fund Vol. 1, Proceedings of a Workshop on the past, present and future of Australian Rainforests, Griffith University, Dec. 1983. Geography Dept., Monash University, for the Australian Conservation Foundation

Robinson, N.H. 1985
Bats of the Illawarra Region
Aust. Zool. 22:1-4

Strong, M. and Cuffe, E. 1985
Drongos pursue Microchiroptera
Sunbird 15:42-43

Suthers, R.A. 1981
Echolocation research in the outback
Trends in Neurosciences 4(11):IV-VI

Tedman, R.A. and Hall, L.S. 1985
The absorptive surface area of the small intestine of *Pteropus poliocephalus* (Megachiroptera: Pteropodidae): an important factor in rapid food transit?
Aust. Mammal. 8:271-278

Tedman, R.A. and Hall, L.S. 1985
The morphology of the gastrointestinal tract and food transit time in the fruit bats *Pteropus alecto* and *P. poliocephalus* (Megachiroptera)
Aust. J. Zool. 33:625-640.

Tidemann, C.R. Priddel, D.M. Nelson, J.E. and Pettigrew, J.D. 1985
Foraging behaviour of the Australian Ghost Bat, *Macroderma gigas* (Microchiroptera : Megadermatidae)
Aust. J. Zool. 33:705-713

Towers, P.A. and Martin, L. 1985
Some aspects of female reproduction in the Grey-headed Flying-fox, *Pteropus poliocephalus* (Megachiroptera:Pteropodidae)
Aust. Mammal. 8:257-263

Tunbridge, D. 1985
Mammals of the Flinders Ranges and their significance to the Adnyamathanha. A linguistically and ethnographically based study of past and present Flinders Ranges mammals
Unpublished report to Aust. National Parks and Wildlife Service

Winderlich, S. 1982
The reproductive biology of five Vespertilionid bats
BSc (Hons) Thesis, Zool. Dept. Aust. Nat. Univ.

Woodside, D.P. and Taylor, K.J. 1985
Echolocation calls of fourteen bats from eastern New South Wales
Aust. Mammal. 8:279-297.

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 adresses of authors and references should not be used. Short communications should not exceed 5 double spaced types 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.