ethereal extracts of female abdomens indicated that each beetle contains between 0.5 and 1.0 μg of phenol, which corresponds to approximately 10 to 20 parts per million by weight. No phenol was detected in ethereal extracts of male abdomens.

Field tests were carried out to examine the attractiveness of phenol. Pure phenol mixed with water at concentrations varying from 500 to 10 ppm were attractive to the male beetle in particular. Two liters of the phenol-water mixtures was placed in open tins and tested at dusk when beetle flights occurred. On one such evening a total of 71 males and no females were caught in seven traps each containing approximately 100 ppm of the phenol-water mixture. On the following evening 222 males and 19 females were caught in the same traps. Control traps containing water and placed alongside each baited trap did not catch any beetles.

Reports on insect sex attractants have revealed structural characteristics that allow the attractants to be classified into three major groups: unsaturated alcohols and their esters, aliphatic acids, and terpene-like compounds (*3*). Phenol obviously does not fit into any of these groups. In fact, to our knowledge, while phenol occurs in plants (*4*), its presence has never been reported in insects.

R. F. HENZELL, M. D. LOWE
Ruakura Soil Research Centre,
Private Bag, Hamilton, New Zealand

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Social Organization in the Bat Myotis adversus

Abstract. *Studies in which the Australian bat* Myotis adversus *was marked and recaptured showed that mature males tend to be solitary, are strongly attached to a particular site, and apparently defend home sites. Harem formation concurrent with mating has been observed, and the bond between the mother and her young extends beyond nursing.*

A few megachiropteran bats are known to exhibit a range of vocal, olfactory, and tactile signals (*1*), and Australian flying foxes (*Pteropus*) show premating territorial behavior, mate selection, and polygamous groupings within large daytime camps (*2*). Microchiropteran bats, however, have been viewed as a socially conservative suborder of solitary and colonial species. In many of the latter species, nursing aggregates of mothers and young are recognized, but, beyond this, sociality is usually seen as a combination of passive aggregation with differing degrees of group stability and site attachment. Clustering behavior has been interpreted in terms of its physiological advantage (*3*). *Tadarida brasiliensis mexicana* appears to show an extreme of this mode of sociality, with aggregations of millions and with reduction of those interactions calling for recognition of one individual by another—even the bond between the mother and her young may be lost (*4*). In southeastern Australia, sociality in *Miniopterus schreibersii* differs from the above. Clustering appears to function as a social spacing mechanism; age classes (particularly of males) tend to be segregated at different roosts, especially at times of reproductive activity; and stable mating aggregates of adult males serve to fertilize large numbers of transient females (*5*). I report here a pattern of social organization in the Australian large-footed myotis *Myotis adversus* that does not conform to previously recognized social systems in microchiropteran bats.

I observed bats in an abandoned railway tunnel at Samford, about 21 km northwest from Brisbane (southeastern Queensland). The *M. adversus* are found in holes (approximately 10 cm in diameter and 30 to 45 cm deep) situated about 3.5 m above the floor and about 3 m apart along each wall of the tunnel. Holes on one wall lie directly opposite holes on the other wall, and a total of 26 pairs of holes are available to the bats. Between April 1968 and February 1969, 11 complete censuses of the tunnel were made. In early November 1968 an incomplete census was made to obtain data on growth of young. At each census I captured nearly all bats in the tunnel and could tell which bats (marked by banding) occupied which hole. A few bats may leave holes during a census and may sometimes enter (and be captured in) other holes. It is not always possible to be certain which bats have done this, but the error in ascribing hole occupancy to a particular bat is probably small.

Table 1 summarizes data relating to the frequencies of recapture, group size, and hole usage. Sexes were treated separately and bats less than 12 weeks old were excluded. The frequency of recapture differed significantly from that expected from random recapture for both sexes (*6*). For males and females more bats were recaptured zero to one time, and, for males, more were recaptured seven or more times than would be expected. For some males, therefore, site attachment to the tunnel is more strongly expressed than for others; but there is no suggestion that this is true for females. Many bats (male and female) recaptured zero or one time were less than 1 year old at both capture and recapture. Mortality of, or dispersal by, this age class could explain why more bats were recaptured zero or one time than would be expected. Males are more often found alone than would be expected; females are more often found in groups; females are not attached to specific holes and in fact may use the same hole less often than would be expected; and males captured five or more times tend to use certain holes repetitively and other holes less often than would be expected. This last arises because specific males tend to be associated with specific holes. Thus, for all but 1 of the 14 males captured five or more times a "favored" hole was evident, and 40 of the 91 captures of these bats were made in favored holes. For six bats half or more of their captures were in the favored hole. With one exception the favored hole of one male was not the same as that of another male; in this case one individual occupied the hole in question only after the other had disappeared from the tunnel.

The holes used by any resident male (male taken five or more times) are, on average, closer together than the holes used by females captured the same number of times. Thus for 14 resident males the average displacement per recapture, measured from the hole of first capture, was 3.03 ± 1.74

Table 1. Frequency of recapture, size of groups, and frequency of hole usage for *Myotis adversus* captured at Samford. The observed frequency distributions $O(x)$ are compared with estimated Poisson distributions $E(x)$. Expected values for distributions truncated at zero were determined by the method outlined by Craig (*13*). Braces show grouping for χ^2.

No.	Recaptures				Individuals per hole				Number of holes used x times					
	Male		Female		Male		Female		Males (total)		Males (taken ≥ 5 times)		Females (total)	
	$O(x)$	$E(x)$	$O(x)$	$E(x)$	$O(x)$	$E(x)$	$O(x)$	$E(x)$	$O(x)$	$E(x)$	$O(x)$	$E(x)$	$O(x)$	$E(x)$
0	12	1.51	8	1.88	(308)		(182)		(15)		(19)		(34)	
1	7	4.96	7	5.96	82	52.0	8	0.07	7	7.46	14	8.55	13	8.96
2	2	8.12	8	9.47	12	34.4	2	1.90	11	10.37	7	9.80	4	6.35
3	5	8.86	11	10.03	4	15.1	2	3.41	8	9.61	4	7.48	1	3.00
4	6	7.26	7	7.97	3	5.0	3	4.60	5	6.67	4	4.29	1	1.06
5	2	4.75	2	6.52	1	1.3	0	4.96	6	3.71	4	1.96	0	0.30
6	1	2.59	2	3.45	0	0.3	3	4.46	0	1.72	0	0.75		
7	4	1.21	0	1.57	0	0.06	1	3.43	0	0.68				
8	0	0.50	0	0.62	1	0.01	0	2.26						
9	1	0.18	0	0.22			1	1.35						
10							3	0.73						
11							3	0.36						
12							2	0.16						
χ^2	32.36		11.29		40.47		15.91		1.10		8.04		3.97	
P	< .001		< .01		< .001		< .001		<.7		< .02		< .05	

(the unit of displacement is the distance between holes); for females captured five or more times the average displacement was 6.75 ± 2.92 ($P < .01$). These figures do not take account of displacements across the tunnel. For males there were only 16 movements across the tunnel (10 individuals) out of a total of 86 movements (27 individuals), and most of these were to holes more or less opposite each other. Females displaced across the tunnel more frequently than males (36 of 94 movements; 28 of 36 individuals).

The data demonstrate that certain male *M. adversus* are strongly attached to the Samford tunnel. Each of these males may be found in a number of holes, usually in close proximity, and is likely to use one hole more often than the others. While individual males tend to be found singly at any given census, the cluster of holes used by one male may overlap considerably with the clusters of holes used by other males. However, the favored hole of any resident male is unlikely to be occupied by another resident male and will certainly not be occupied simultaneously. For females the data demonstrate a strong tendency toward grouping but there is no suggestion that any given female is more strongly attached than any other to either the tunnel, a cluster of holes, or a specific hole.

The behavior of males with respect to holes could arise through passive avoidance or could stem from defense of holes. A number of older males have been found with their ears damaged; small notches may be present along the ear margin or portions of the pinna may have lost pigmentation and become anemic, or both. In both cases the damage is usually found on the distal third of the pinna. No young males (< 1 year old) and no females with equivalent damage have been observed. In *M. adversus* the ears are prominent, and it is suggested here that encounters involving ear biting occur between males and that these encounters relate to defense of holes. The five males noted as showing the most extensive ear damage were all resident in the tunnel.

In southeastern Queensland, females of *M. adversus* are polyestrus, producing litters in October and January (*7*). Males show two peaks of testicular and epididymal activity—April to June and September to November. These latter periods are almost certainly mating periods. Concurrent with these periods groups of females are found in association with a single mature male. Between April 1968 and February 1969, 16 such groups were found; these included from 1 to 12 females ($\bar{x} = 7.6$). Females associated with a given male in a particular month have been found distributed among other males a month later. Eleven males accounted for all 16 mating groups. Seven of these were individuals captured five or more times; they accounted for 12 of the mating groups and, in every case, the females were in the favored hole of the male concerned. Two other males were captured four times but both vanished during the study period; each accounted for one mating group and again the bats were in the favored hole of the male concerned. The remaining two males found with mating groups were captured twice only; one vanished early in the study period, the other arrived during October. These mating groups qualify as harems. These harems differ from those of red deer (*8*) in that the female bats orient around a male at a fixed point in space; however, they may be similar (though smaller) to harems of California fur seals (*9*) where the female chooses a harem independent of the specific identity of the male and where the harems vary with time in size and composition. No two male bats held harems in the same hole, and at no time was a harem hole used by another male concurrent with a mating group. On one occasion a harem hole was occupied by a different male at a time when the harem male was absent from the tunnel; and on another occasion a harem hole was occupied jointly by the harem male and two juvenile males. Eleven other instances of males, other than the harem male, being found in a harem hole occurred either after the harem male disappeared from the tunnel or before it had been captured in the tunnel. Although my data imply that in any one year a limited number of males will mate with the greater proportion of females [elephant seals, (*10*)], this has not yet been proven.

For five young born in October it was possible to identify the mothers (litter size is one). At all censuses, from birth of the young to 20 January, the mother and young were either together in the same hole or were both missing from the tunnel. This occurred despite changes in the composition of groups of adult females. On 3 February, one of the young was present in the tunnel but its mother was absent; none of the other mothers or young was captured. Other young were found apart from adult females on 3 February but not before this date. In *M. adversus* lactation lasts about 8 weeks. Young born in late October would therefore be suckling until about late December. The records above demonstrate that the bond between the mother and her young may persist for about 3 to 4 weeks after lactation. Extension of this bond beyond lactation has not been recognized in any other species of bat.

In Australia *M. adversus* is found near water. Group foraging over water has been observed, and coordinated following behavior may occur when bats forage from the water surface (*11*). The social system of *M. adversus* therefore involves at least three components: elaboration of the pair bond to give male territoriality and harem formation, extension of the mother-young bond beyond nursing, and the development of group foraging. In showing these features, *M. adversus* differs from the usual interpretation of sociality in microchiropteran bats. With the exception of this study and studies of *T. b. mexicana* and *Miniopterus schreibersii*, no serious attempt has been made to seek possible social patterns in this group of mammals (*12*). These studies do not support the view that microchiropteran bats are socially conservative.

P. D. DWYER
Zoology Department, University of Queensland, Brisbane, Australia, 4067

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14. I thank Dr. J. Kikkawa for his comments on the manuscript, Dr. G. Caughley for discussion regarding analysis of data, and the many people who assisted me in the field. Supported by grants from the University of Queensland and the Australian Research Grants Committee (grant No. 236,980).

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Thermoresponsiveness of the Preoptic Region of the Brain in House Sparrows

Abstract. *Heating the preoptic region of the house sparrow caused the bird to decrease its metabolism and to decrease its body temperature, whereas cooling that region caused an increase in metabolism and an increase in body temperature. These responses indicate that the preoptic region of birds, like that of other vertebrates, is an important center for thermoregulation.*

Localized thermosensitivity is centered in the preoptic area of mammals (*1*), fish (*2*), and reptiles (*3*). Temperature changes in this area elicit thermoregulatory responses. Similar sensitivity has not been clearly demonstrated in birds. Von Saalfeld (*4*) showed that heating the anterior dorsal midbrain in pigeons increases the respiratory rate to the point where panting is simulated. Localized thermostimulation of the spinal cord elicits thermoregulatory responses in birds (*5*). There is some evidence that the hypothalamus is required for maintenance of uniform body temperature in birds (*6*). In the study reported here we found that heating the preoptic region of the house sparrow caused the bird to decrease its metabolism and to decrease its body temperature, whereas cooling that region caused an increase in metabolism and an increase in body temperature. These responses indicate that the preoptic region of birds, like that of other vertebrates, is an important center for thermoregulation.

Adult male house sparrows (*Passer domesticus*) in winter plumage caught locally in September and October have a mean weight of 25.5 ± 3.2 g ($N = 25$). An ultrasmall thermode (0.75 mm in outside diameter) modeled after that of Williams and Heath (*7*) was stereotaxically implanted at various angles in the anterior forebrain directed toward the preoptic area. Birds were allowed to recover for 2 to 3 days after surgery before cooling or heating of the thermode was initiated. The thermode was cooled by the passage through it of a continuous flow of water (18° to 21°C) and heated by a flow of 44°C water. We controlled the temperature of the tissue immediately adjacent to the thermode by adjusting the temperature of the thermode efflux. The body temperature of the birds was recorded continuously by means of thermocouples in the cloaca. A small number of these birds were tested for metabolic response to thermode heating and cooling. The oxygen consumption of the birds was used to estimate changes in the intensity of shivering, which is the only form of thermoregulatory heat production in birds (*8*).

We were able to measure the oxygen consumption and cloacal temperature of birds with an implanted thermode by restraining them in a dark chamber (22° to 23°C). By means of a Beckman paramagnetic oxygen analyzer we monitored a continuous flow of air (1000 ml/min) through the chamber for a change in the percentage of oxygen. When testing was completed, the brain of the bird was removed, embedded in celloidin, sagittally sectioned at 40 μm, and stained with cresyl violet.

A restraining device used to hold the birds during the experiments caused continuous stimulation which resulted

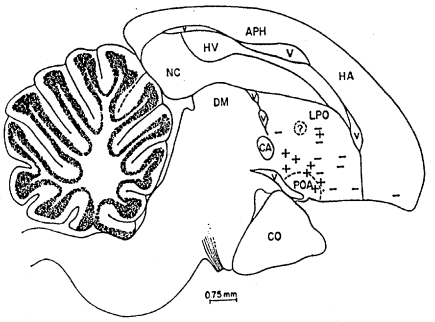

Fig. 1. Drawing of a sagittal section of the brain of the house sparrow approximately 0.5 mm from the midline. The symbols represent the location of the thermode tip in the brain of a bird responsive (+) or nonresponsive (−) to thermal stimulation. One preparation that gave variable results is labeled with a question mark. *APH*, Area parahippocampalis: *CA*, commissura anterior; *CO*, chiasma opticum; *LPO*, lobus parolfactorius; *HA*, hyperstriatum accessorium; *HV*, hyperstriatum ventrale; *NC*, neostriatum caudale; *POA*, nucleus preopticus anterior; *DM*, nucleus dorsomedialis thalami; *V*, *ventriculus* (*11*).