A

BEHAVIOURAL STUDY OF THE

GREY HEADED FLYING FOX *Pteropus poliocephalus*

(Megachiroptera)

by

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INTRODUCTION.

Approximately 925 species of bats make up the order Chiroptera, the only order of mammals capable of true flight. The order is divided into two sub-orders, the Microchiroptera and Megachiroptera. The Microchiroptera are further subdivided into 16 families. As a group they are small to medium sized bats with small eyes, relatively short snouts and lack a claw on their first finger. The majority have flaps in front of their large ears which aid in utilizing echolocation for navigation and prey-detection (Matthews et.al., 1971). Their diet is quite varied, and listed by McNab (1969) as including fruit, nectar, vertebrates-including fish, blood and insects. This list is probably not exhaustive.

The Megachiroptera contains a single family, the Pteropodidae, composed of 35 genera with approximately 130 species (Ratcliffe, 1931, Matthews et.al., 1971). They are tropical and sub-tropical, have only rudimentary tails and normally have a claw on both the thumb and first finger. All genera,except Rousettus (Griffin et.al., 1958, Noll, 1979a) lack echolocation and navigate by sight. The majority roost in trees by day, and disperse to feed predominantly on fruit, blossoms and nectar at night. The 'patchiness' of distribution of this type of food, especially at higher latitudes where seasonality becomes more pronounced, requires either generalized feeding habits or high mobility. Australian Pteropus species utilize both.

The genus Pteropus is the largest with approximately 80 species, which cover a very wide geographical area. They extend from "Madagascar in the west to Samoa in the south-east, and Formosa and the South Liu-kiu Islands of Japan in the north-east, and includes India and Sri Lanka, the Malay Peninsular, Australia, and practically all the islands lying within these limits in the tropical belt." (Ratcliffe, 1931). They are

inexplicably absent from mainland Africa while occurring on an island only 40 miles from the coast of Tanzania. The Austro-Malayan region contains over half the known species. Furthermore, all groups not found within this region demonstrate close affinities to Austro-Malayan types. These two facts support the hypothesis that the group arose in this general area (with the probable exception of Australia) and dispersed to other areas (Ratcliffe, 1931). The Australian bat fauna is composed of 55 species. Four of these belong to the genus Pteropus and are the well known flying foxes or fruit bats.

Pteropus conspicillatus (Gould, 1850), the Spectacled fruit bat, inhabits coastal northern Queensland from Mackay to Cape York. It is usually found in densely timbered areas such as rain forest, or swamps. Body colouring is very dark, but the mantle (shoulders and back of neck) is pale yellow. There is also a distinct ring of pale yellow fur around each eye, giving this species its common name.

P. alecto (Temminck, 1837), the Black fruit bat, is the largest Australian species. It is predominantly coastal but ranges inland to a greater degree than the Spectacled fruit bat. The New South Wales-Queensland border marks the southern extent of its range, while it is found associated with the coast in Queensland, the Northern Territory and Western Australia. It usually forms camps in mangroves but has also been reported to roost on limestone rock faces (Hall, 1981). Overall body covering is blackish, sometimes with a reddish mantle.

P. scapulatus (Peters, 1862), the Little Red Fox is the smallest member of the group. It is widespread in all eastern states, excepting Tasmania, and travels extensively inland. It is also found in the northern half of the Northern Territory and Western Australia (Whitlock, 1949). The Little Red fruit bat is highly nomadic, undertaking irregular and

extensive migrations in response to the very uncertain flowering of hardwood trees (Nelson, 1965a) often following the blossoming of E. camaldulensis, the River Red Gum, along inland rivers. Camps are established in open forest, thick scrub and isolated trees, usually near water. Body colouring is reddish-brown with a lighter mantle. However, from personal observation some males are distinctly darker than other males and females. Captive specimens became noticeably lighter in colouring during the winter months. This also applied to the only captive dark male.

P. poliocephalus is the subject of this study. As seen in Figure 1, it has a coastal distribution in all eastern states, ranging as far north as Townsville and visiting as far south as the islands of Bass Strait. Breeding colonies are known as far south as Nowra. The species appears to be extending its southern winter range in favourable years (Hall, 1973). During the day large camps are found in mangroves, Melaleuca swamps, thick scrub, in Weeping Willows, Salax babylonica and She-oaks, Casuarina spp. along river banks and occasionally in open forests (Nelson, 1965a, Hall and Richards, 1979). Mixed camps are sometimes formed by this species with either P. scapulatus or P. alecto.

The body colouring of this animal is dark grey with a mixture of lighter coloured hairs. There is also a distinctive yellow to reddish shoulder mantle which completely encircles the neck. The head is grey, but some males have a lighter coloured head, as seen by comparison of Figures 2 and 3. Beyond this inconsistent difference there are no readily distinguishable characteristics between the sexes except for the gonads. When the animal is wrapped up within its wings, sexual differentiation is not possible. The forearm length is usually between 138 - 152mm., but specimens up to 167mm. are known, with wingspans up to 1.2m. Body weight varies between 550 and 1,100 grams (Bartholomew et.al., 1964). (Unless stated otherwise, the majority of information on these four species was drawn from Hall and Richards, 1979).

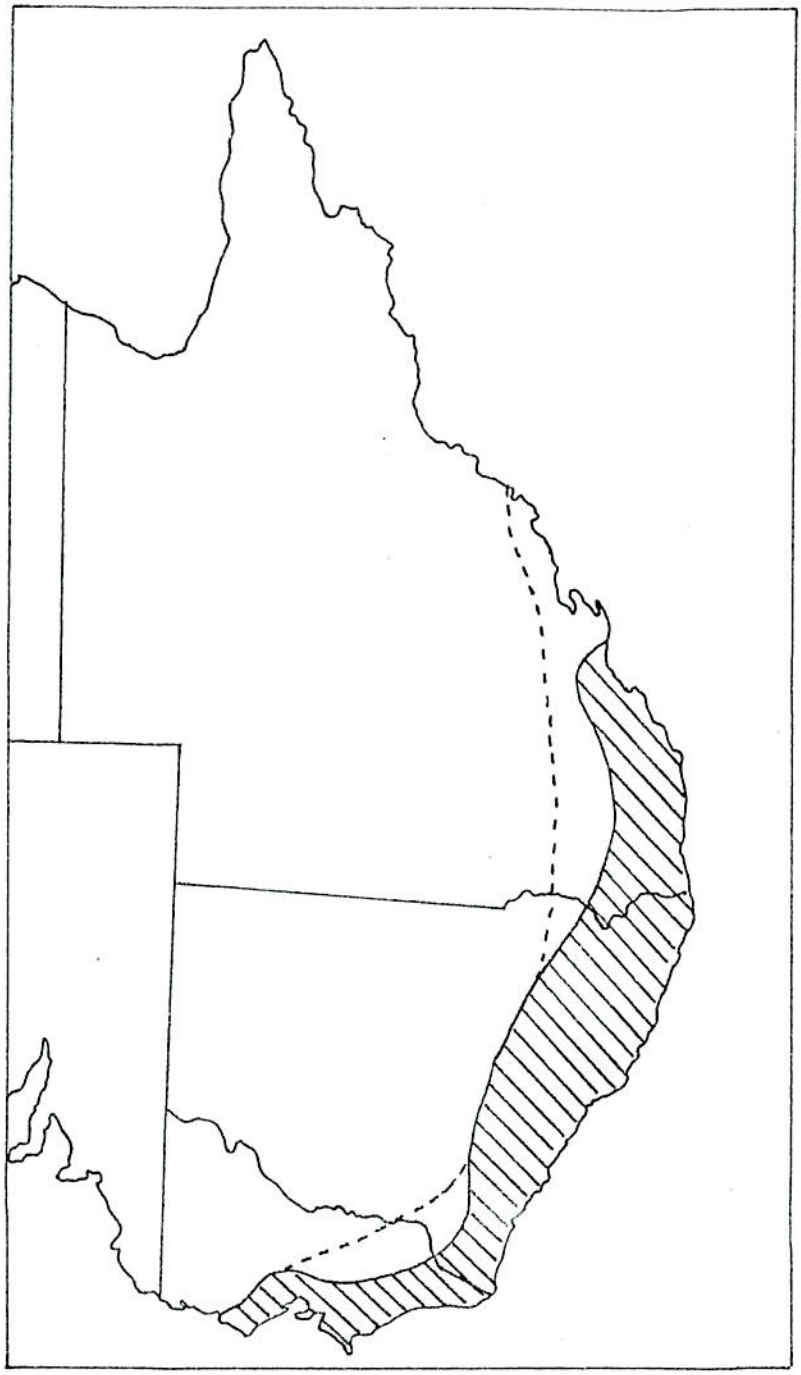

Fig. 1. Distribution of P. poliocephalus - after Nelson (1965a). Dotted lines represent distribution as outlined by Hall and Richards (1979).

Fig. 2 Female Pteropus poliocephalus.

Fig. 3 Male P.poliocephalus. Note lighter colouration of head and body.

All four species produce a single young (McKean and Hamilton-Smith, 1967). P.poliocephalus give birth during October and carry their young continually for approximately 4 weeks. The young is weaned completely at around 4 months of age.

P. poliocephalus and P. scapulatus are of some economic importance due to their roosting and feeding habits. In the Sydney area, notably in the fruit growing areas to the immediate north, the Grey Headed flying fox can be an important pest of summer fruit. This is especially so in years when hardwood trees fail to flower significantly and deprive them of an important food source. Further north both species can be a problem in bananas, pome fruits, stone-fruits, paw-paws and figs. For all fruits, the majority of damage usually seems to be greatest with overripe fruit. The commercial method of harvesting fruit before it is fully ripe acts to significantly reduce losses from flying foxes. A significant proportion of the damage done is through the animal's habit of testing fruit by biting it, as seen in Figure 4, and by knocking fruit to the ground when climbing in the tree.

Fig. 4. Plums damaged by P.poliocephalus. Note the characteristic pattern of four holes made by the animals teeth.

During the course of this study, damage attributable to P. poliocephalus was seen in summer fruit at Sydney and to apples at Tenterfield. Damage caused by P. scapulatus included the virtual stripping of a neglected cherry orchard at Armidale and significant damage to the growing points of approximately 8000 poplar trees by day-roosting scapulatus at Kempsey.

Control of these animals, mostly by shooting and gas scare guns, has been largely ineffective and/or expensive. The recent use of strobe lights in orchards has met with considerable success but costs at present are prohibitive. Development of this control measure towards simplicity, so that purchase costs and operating costs are reduced is highly desirable, as the animals are not destroyed as happens with so many other methods.

Beyond the economic consideration there is a need for work on these animals simply because many aspects of their biology and ecology need to be clarified. The major works on Australian flying foxes were contributed by Ratcliffe (1931,1932) and Nelson (1964, 1965a, 1965b). These authors dealt with general ecology, vocal communication, movements and behaviour. The only other major paper on this group dealt with physiology (Bartholomew et.al., 1964). The only work dealing specifically with behaviour (Nelson, 1965b) did not take a quantitative approach.

In all the papers mentioned above, several important questions are left unanswered and in a few areas, the results of this survey are at odds with published information.

Objectives of this study.

The major aims of this work therefore were:

1) to provide a descriptive account of the activity and behaviour patterns of P. poliocephalus, with substantiation provided by quantitative data.

2) to identify the major ecological factors affecting these activities.

3) to observe changes in behaviour with time.

4) to contribute to the existing knowledge on this species, especially in the areas of temperature regulation, reproduction and social organization.

5) to provide specific information on the Gordon camp, being of interest because of its southerly position and proximity to a major fruit-growing area.

CHAPTER 2. MATERIALS AND METHODS.

The Study Area.

All daytime observations of *P. poliocephalus* were made at a colony in the Sydney suburb of Gordon. The site lies some 13.5 kms. from the G.P.O. in a direct line to the NNW and 16 kms. to the SE of the fruit growing Hills district.

The colony itself is situated on the Southern slope of a small valley + Southern ? although in summer the northern boundary was extended, with flying foxes roosting in several trees on the northern side of the creek. The valley represents a finger-like extension of Davidson Park, a large, mostly natural recreation area. See Figure 5. The section of the park in which the flying foxes are found is administered by the Ku-ring-gai Municipal Council, and is surrounded on both sides by residential dwellings, to within 50 metres of the colony's summer boundaries. Due to the topography of the area, however, these buildings are not visible from ground level, within the colony. The valley runs in an East-West direction and has a small creek - Stoney Creek - which flows intermittently to the east into Middle Harbour. It provides a stormwater channel for drainage from surrounding roads, houses and a nearby hospital.

Vegetation.

Vegetation in the area is Eucalypt-dominated open forest, following the classification of Specht (1973).

Along the creek the dominant tree species are Blueberry Ash, *Elaeocarpus reticulatus*, in association with Coachwood, *Ceratopetalum apetalum*. There is a large amount of privet, *Ligustrum lucidum* and *L. sinense*. Ground cover is predominantly Wandering Jew, *Tradescantia albiflora*, with some Crofton weed, *Eupatorium adenophorum*, and Ginger, *Hedychium gardnerianum*.

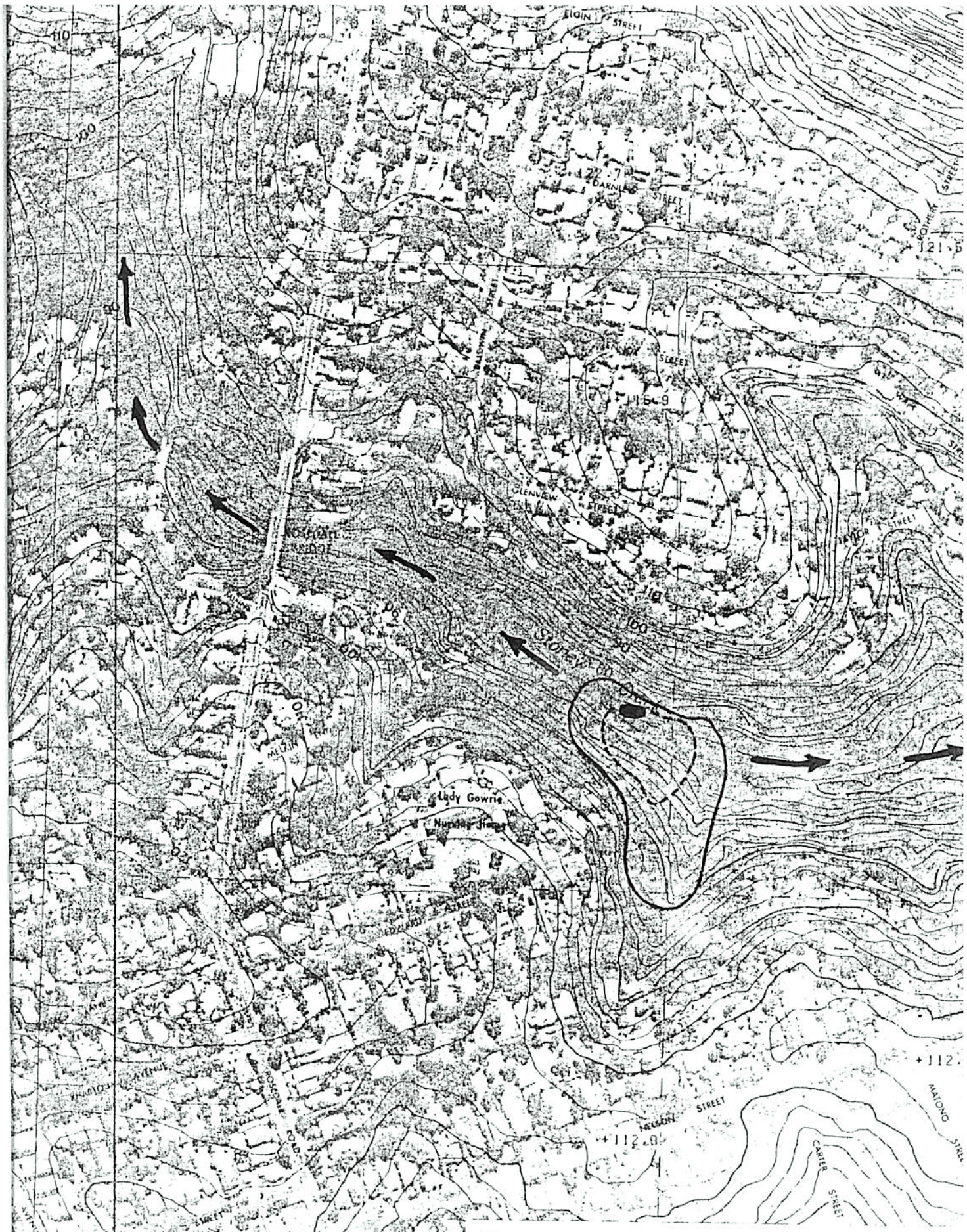

Fig. 5. Orthophotomap of study area Gordon, Sydney. (33°45' Lat. 151°09' Long.)
Scale: 100 m 200 m. 300 m.

Contour interval 2m.
Unbroken line - summer extent of colony
Dotted line - winter extent of colony.
Solid colour - area of Little Reds.
Arrows indicate direction of flight at dusk.

Higher up the sides of the valley the trees are taller and include two angophoras, the Smooth and Rough barked apple, A. costata and A. floribunda, three eucalypts,Blackbutt, E. pilularis, Sydney Blue Gum, E. saligna and Red Bloodwood, E. gummifera, the Turpentine, Syncarpia glomulife and occasional Camphor Laurels, Cinnamomum camphora. There are quite a few dead trees,mostly Angophoras, Blackbutts and Blue Gums. The flying foxes have been blamed for their death by residents but D. Costello (pers. comm.) of the Kuringai Council attributes a large portion of the blame to altered drainage and natural causes. On the slopes of the valley the predominant species making up the lower storey are Hakea spp, Grevillea spp, Leptospermum spp, Banksia spp, and Lantana camara. Again Wandering Jew, T. albiflora, provides the ground cover.

The understorey is quite dense, limiting access to large parts of the colony. Access is however provided by two intersecting paths, one following the creek, the other running from the end of Edward St. on the southern side of the valley, down to the creek.

Animal species present.

The following vertebrate species were seen in and around the camp site at Gordon.

Birds.

Yellow-Tailed Black-cockatoo,	Calyptorhynchus funereus.
White Cockatoo,	Cacatua galerita.
Galah,	Eolophus roseicapillus.
Rainbow Lorikeet	Trichoglossus haematodus.
Eastern Rosella,	Platycercus eximius.
* Kookaburra,	Dacelo gigas.
Pied Currawong,	Strepera graculina.
* Australian Raven,	Corvus coronoides.
Black-backed Magpie,	Gymnorhina tibicen.

Tawny Frogmouth,	Podargus strigoides.
Dollar Bird,	Eurystomus orientalis.
Eastern Whip-bird,	Psophodes olivaceus.
Noisy Miner,	Manorina melanocephala.
Silvereye,	Zosterops lateralis.
Small unidentified hawk.	

Mammals.

Ring-Tailed Possum,	Pseudocheirus lanuginosus.
Rat,	Rattus sp.
Fox,	Vulpes vulpes.
Cat,	Felis catus.
Dog,	Canis familiaris.

Reptiles.

Eastern Water Dragon,	Physignathus lesueurii.
Blue Tongue Lizard,	Tiliqua scincoides.
Water Skink,	Sphenomorphus quoyii.
Small unidentified skinks,	Family Scincidae.
Gecko,	Phyllurus sp.

* denotes species seen feeding on young P. poliocephalus.

Soil and Topography.

Soil in the Kuringai area generally is yellow podzolic soil on a sandstone base. At the colony, the soil was classified by a 1959 Department of Agriculture soil survey as being skeletal soil on sandstone and part of an 'Awatea-rowland' association with considerable areas of shallow soil with a profile depth of 30 cms. or less. The texture is sandy to sandy clay loam.

The effect of the flying foxes on the soil was ascertained by

analysis of soil under the colony and soil from a similar position outside the colony limits to provide a contrast. Soil was collected randomly at 30 sites with a 3 inch soil corer and sent to the Department of Agriculture for analysis.

Topographically, the area is quite steeply graded on either side of the creek with a slope of around 30^{o} or less on the southern side and 35^{o} or more on the northern side.

Period of Study and Observation Methods.

Observations for this study were made between 27/12/80 and 16/9/81. Initially, up until 21/4/81, general observation methods were employed to gather sequential data. This system allowed familiarization with the area, the animals and their behaviour.

During this initial period aspects of major interest were; the timing and co-ordination of the nightly exodus from and return to the camp from the feeding areas to the North-East, behaviour at the colony in preparation for the departure, mother-young relationship, the behaviour of male and female animals prior to, and during the breeding season, night-time feeding at Camperdown and Manly, and behaviour in Moreton Bay Figs, Ficus macrophylla, and night time behaviour at the camp. Some notes were also made on the behaviour of approximately 1200 Little Red Foxes, P. scapulatus, which were resident at the roost from before the 27/12/80 up until around 4/2/81.

During this initial period, forty-four trips were made to the Gordon colony, or its immediate vicinity to observe general activity at the camp and the exodus and return of the animals to and from feeding areas. Included in these observations were four complete 24 hour watches at the Gordon colony, (made up of 6x4 hour watches for the first 24 hour cycle, then 3x8 hour watches for the remaining 3) for the period 4/2/81 to 8/4/81. Total observation time for 27/12/80 - 20/4/81 was 137 hours. These four, 24 hour watches were all made from one observation site and attempted to

use the same animals on each occasion, as individuals became recognizeable.

During daylight hours attention was focused on one particular female and her male baby, readily recognizeable due to their abnormal all-over gold colouring. All activities of these two bats were recorded and when time permitted, observations were made of nearby bats and the colony as a whole. Due to the very sedentary nature of the animals at this time of the year, several animals became readily recognizeable, firstly through position in tree, then variations in colouration and finally through behavioural differences. Night time observations recorded general activities within the colony. Recognizeable animals were usually absent at this time or generally impossible to identify positively, even with the aid of a 12 volt-powered spotlight. Visibility with the spotlight was further reduced due to the inclusion of a red cellophane cover over the lens in a largely unsuccessful attempt to reduce the animals reaction to the light. (Later a Startron* light intensifier was used with improved results for night observation).

Due to the sloping nature of the terrain, observations could be made on the animals with binoculars, some 15-20 m. distant on an equivalent level, as demonstrated in Fig. 6

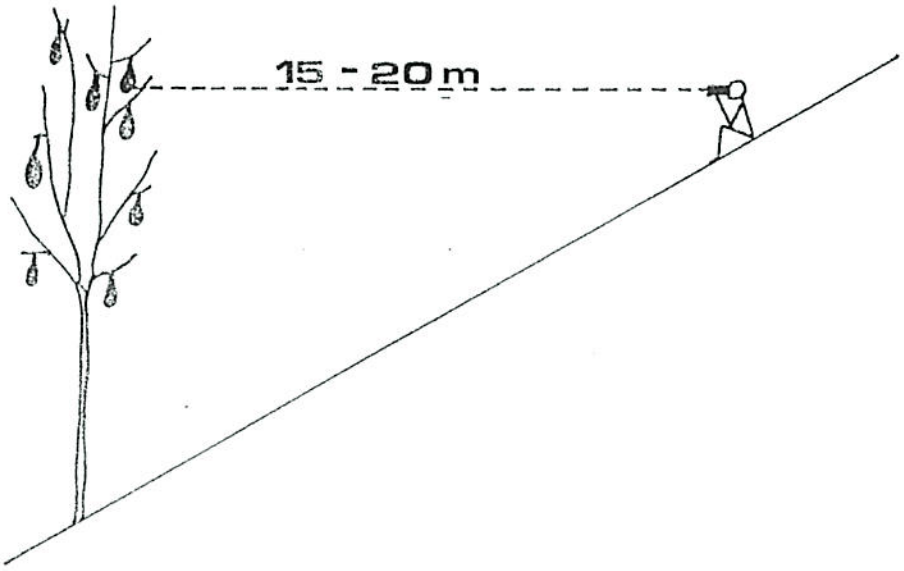

Fig. 6. Diagramatic representation of observation site.

The bats were totally undisturbed by this as surrounding vegetation formed a natural hide. See Fig. 7

Fig. 7. - Observation animals largely screened from observer by vegetation.

This observation site was used for all subsequent observations up until 16/9/81, although as mentioned the method of observation changed considerably from 21/4/81 onwards. The new method employed consisted of three sets of 5 min. observations made in 15 minute cycles. The first five minutes were used to record every action of 5 bats on a record sheet as shown in Appendix 1. The second five minutes was used to record the activity of each of 10 bats at a precise point in time in sequential 30 second periods. The third 5 minutes was used to make general observations,notes and photographs. Ambient temperature was taken at my observation post initially at 30 minute intervals and later at 15 minute intervals with a mercury thermomete accurate to $\pm$ .05^{o}C. General observations were also made with respect to rain, wind and the presence or absence of cloud cover.

The activity, state or behaviour categories listed in Appendix 1 require some explanation. Rather than introduce unnecessary repetition,

a full explanation of each category is provided in Chapters 4 and 5. It is sufficient here to realize that each category refers to a specific state or behaviour, except where otherwise stated.

Due to practical limitations, this method could only be applied successfully during daylight hours. A routine was established so that all observations were usually done on Tuesday and Wednesday of each week. The Tuesday observations ran from noon to 'nightfall' (not sunset) and Wednesday observations from dawn (not sunrise) to noon. Thus the weekly observations were completed within a 24 hour period,reducing variation in weather conditions within a particular week's records.

Again, where possible, the same animals were used repetitively for observation. This was initially very easy, but after approximately mid-July, territorial structure became less defined and eventually only one animal was always present which could be readily recognized.

Using this observation system, 38 trips were made to the Gordon colony between 12/4/81 and 16/9/81. Total observation time was 229 hours 45 minutes or 6 hours 2 minutes average per observation period.

At irregular intervals, attempts were made to estimate the number of animals as they flew out to feed. The bats followed the valley to East and West only, as they left the camp. Counts were made as they flew West over Rosedale Bridge and at Maytone Avenue as they flew to the East and South. An ENM counter was used with 1 unit signifying 10 bats. Accuracy was affected most by ambient light, darker nights and later leaving times with respect to sunset, making counting more difficult. Clear nights also made counting more difficult than overcast nights. Cohesion of the 'stream' of animals also affected accuracy, a more compact stream being far easier to count

Travels, Captive Animals and Specimens.

In addition to the observations at Gordon, several trips were made to country areas to observe existing and recently vacated camps of flying foxes - mostly P. scapulatus at Tamworth, Kootingal, Kempsey and Scotts Head, and P.poliocephalus at Tenterfield. Resulting from these excursions several wounded animals were obtained, as a result of local attempts at control or for sport. They were subsequently given veterinary treatment and kept to observe their general behaviour and feeding habits. Over 400 dead animals were obtained as a result of these trips. More than 76% of these were P. scapulatus and the remainder were P. poliocephalus. Depending on their state of decay, they were either frozen or allowed to decompose to provide skeletons for later morphometric work, and are not included in this discussion except to mention the sex ratios of flying foxes shot while feeding in orchards in the Galston district.

Comments on Methodology.

One area of study design that should be explained concerns the repetitive use of the same animals in the observations. It was originally intended to observe a different group of animals each week, to remove bias in results due to variations in individual behaviour. However, a major aim of this study was to observe changes in behaviour over time. Due to the basic similarity between male and female morphology, the animals are difficult to sex unless their reproductive organs are visible. Furthermore, unless hanging side by side it is also difficult to distinguish adult and sub-adult animals readily.

It would be impossible each week to select a group of animals of a particular sex or age without at least several hours observation prior to study, thus rendering early morning recording an impossibility. On the other hand, to randomly select a group of animals of unknown sex or age is

equally poor experimental method as unknown bias would be introduced into results of behaviours that are specifically male, female or juvenile oriented. Typical activities affected in this way would include interactions between male and female animals, mother-young interactions such as suckling and weaning, male scent marking and territory defence.

Under the circumstances it was more practical to repetitively observe a small known group of animals and follow the change in their behaviour with time. This method gave excellent sequential, but admittedly biased, results due to individual behaviour differences. The alternative would have led to a discontinuous and inconclusive view of many different groups of animals, varying widely in both age and sex structure.