

Characteristics of a Roost.

As mentioned in a previous chapter, the Grey-Headed flying fox typically forms camps in mangroves, swamp, scrub, alongside rivers and occasionally in open forests. Hall and Richards (1979) state that these camps usually contain from 500 to 5000 individuals, and may be shared with other flying fox species. The colony at Gordon generally conforms in these aspects, although at times, the colony contained at least 12-14,000 animals. They roost by day in open forest, predominantly Eucalypts and Angophoras, and at the initiation of observations, shared their roost with P. scapulatus. The area covered by the roost varied between 1 and 2 Hectares, depending on the numbers present. According to reliable reports, the colony has been inhabited every summer since 1963. It was possibly inhabited spasmodically prior to that year, as one resident recalled having seen flying foxes there over 30 years ago. The colony was reported in the literature as a breeding colony of some 2000 animals in 1973 (Robinson, 1973). Mention was also made of a possible second colony in the Galston district, which no longer exists although during summer, animals still fly over 16 km. nightly to feed in the area. In the memory of local residents, 1981 was the first time the area was not deserted during winter.

To understand these considerable fluctuations in numbers of individuals and to establish the ecological context for following chapters, a relatively brief coverage of the generalized activities of flying foxes throughout the year, should be made.

Generalized Activities.

Nelson (1965a, 1965b) provides quite a good account of the yearly activity cycle for P. poliocephalus. An abbreviated version of his

findings is presented here followed by a discussion of how they relate to observations made at the Gordon colony in 1981.

Summer camps are formed in September when blossom is abundant, and large populations can be supported within restricted areas. Initially these camps consist of pregnant females. The young are born in October and during this month and November, adult males and females are segregated.

For the first 3 weeks after birth, the young depend on their mother continually for warmth, and are carried by their mother on feeding flights, after which they are left behind at the roost. By December and January blossom is abundant and the numbers within the summer camp are at a maximum. At this time, mates are selected and territories are marked by males and defended by both males and females. The camp is divided into recognizable groups; guard groups on the edge, with monogamous groups, polygamous groups and later, juvenile packs in the centre of the camp, where the concentration of individuals is greatest. In late January and February the 3 month old young, learn to fly and leave the camp at night to feed. In late March and early April the young leave the summer camp completely and form winter camps. Conception also occurs in late March to early April, after which the sexes segregate and the adults also begin to disperse and lead a nomadic existence. This exodus is complete in "April or June". Some adults will join the juveniles in the winter camps, with a greater proportion joining in the good blossom years.

Observations at the Gordon site were not begun until 27/12/80 when the camp was already established. From this time onwards the colony was always present, so corroboration of Nelson's (1965a, 1965b) observations in relation to the timing of establishment of summer camps is lacking. During 1981, however, the number of animals resident in the camp fell steadily during August, from around 8,500 to 6,000. The only count made in September, on the 15th and 17th showed an increase in numbers to approximately 7,500. This figure still falls far short of the early winter

record of around 13,000 made on the 3rd and 4th June. It is almost certain, however, that from September onwards numbers in the colony will increase.

Nelson (1965a, 1965b) states that the majority of animals within the summer camps initially will be pregnant females. On a brief visit to the colony on the 25th of October, a large proportion of adult females were seen to have young as Nelson (1965a) proposed. There were, however, some adult females without young and quite a few juvenile females present, also without young. At least some females give birth later than October, or alternatively carry their young for longer periods as evidenced by a female with a baby, shot feeding at Galston on the 22nd of December, roughly a month later than Nelson predicts the young should be carried. Another inconsistency is the fact that males and females should have been segregated during September and October, with males largely absent during September and progressively filtering in during October and November. In both cases the opposite was found to be true. In mid-September at my observation post there were very few females but many males. This pattern seemed to be true all over the colony, except along the creek where sexing of animals is very difficult due to their habit of roosting in the treetops. In any case, the majority of animals along the creek appeared to be juveniles. Returning on the 25/11/81, there did appear to be more females than males although no attempt was made to verify this. Females were also more noticeable due to the presence of young. At this time sexual segregation should have been evident but again males and females were in close association.

During December and January counts were made only of bats flying to the west as it was not realized at this time that two separate streams left the colony. The numbers of bats flying west showed a steady increase from the end of December to a peak in mid-January. This agrees with Nelson's

predictions, but may simply reflect the fact that they are changing their direction of feeding flights to utilize different food sources to the west. No absolute numbers were obtained at this time so a comparison of population size between summer and winter cannot be made. It is fair to say that the colony was larger during summer however, simply on the basis of the area the colony covered at these times. The density of animals appeared to remain relatively constant.

At Gordon some territories were already established and being defended at the outset of observations in December, 1980 with the first successful mating seen on the 22nd of February, the last was as late as the 19th of August. The majority of mating activity occurred in March to May, being most pronounced in April.

This is slightly at variance with Nelson's observations, which state that mating occurs in late March to April - ceasing after the female has conceived. One readily distinguishable female was seen to mate repeatedly between 26/3/81 and 8/7/81. She was then seen after a considerable absence from the camp, with a young on the 25th October, only 16 weeks since her last mating, presumably when 3 months pregnant. This topic will be discussed in further detail in a later chapter.

Groups recognizable as monogamous and polygamous, and later juveniles were observed as predicted by Nelson (1965a, 1965b) and also will be discussed more fully later.

Females left young behind at Gordon at night presumably from mid-November onwards. Of 21 lactating females collected in orchards in the Galston district between 13/11/80 and 22/12/80, only two carried young. Oddly enough, they were shot on the 13th of November and 22nd of December - the first and last days on which bats were collected from farmers.

Young bats were observed in the roost at night on the 9th February. At this time they were capable of flying and early in the evening, up to about 8 p.m. (corrected from daylight saving) climbed together in the treetops and later dispersed gradually for places unknown - a search of the colony revealing only 5 or 6 young animals.

Throughout the year juveniles were always present. They were first noticed in daytime groups on the 6/3/80 but could easily have escaped attention before then. A large proportion, if not all the juveniles did not leave to form winter camps, but instead remained at Gordon concentrated in the trees along the creek, on the northern limits of the colony. As stated earlier, a large proportion of adults, apparently mostly males also remained at Gordon throughout the winter, almost certainly as a result of unseasonably good food supply in the form of flowering Eucalypts (as evidenced by stamens in faeces)<sup>and</sup> Moreton Bay Figs, Ficus macrophylla, seen fruiting almost constantly throughout the Autumn, Winter, Spring period.

From the preceding discussion it is readily seen that this work differs in many small ways from Nelson's (1965a, 1965b) findings, but largely follows the same pattern if we understand that the Gordon colony was acting in 1981 as both a summer and winter colony. The prolonged mild autumn conditions and presumed adequate food supply reduced the need for extensive migration or dispersal as was usual in preceding years. This fact largely accounts for many variations between our observations.

This pattern of atypical overwintering in summer camps was also noted with at least one other colony in northern New South Wales in 1981 and another reported by Nelson (1965a) in 1961/62.

#### The Roost - use of and effect on.

As is readily seen in Fig. 5 the area of the colony varies considerably, depending on the number of inhabitants. Density does not appear to vary

to the same extent, so colony area probably provides a reasonable index of numbers present. At all times a minimum individual distance is maintained, as seen in Fig. 8 .



Fig. 8. Roosting P. poliocephalus illustrating individual spacing. Furthermore, territories are typically maintained from January - February to March - April, with intruders being immediately expelled. The combination of these two systems results in pronounced spatial separation of animals. As well as expanding and contracting, the colony may also move vertically during non-territorial times of year in response to temperature and wind. High winds and low temperatures during August, 1981 caused the flying foxes to roost in the better foliated lower sections of the trees. At other times they climbed to more exposed sites to get the benefit of direct sun. During the hottest parts of summer days there is some movement, possibly attributable to animals seeking shade. Obviously then, the characteristics of a good roost vary with time of year. In summer a good roost would be shaded and elevated to benefit from any breeze. In winter the opposite would be generally true. During sunny weather and low

ambient temperatures an exposed roost would be highly desirable. During cold wind and/or rain a sheltered perch would again be favourable. Due to the animals' strong colonial instinct they seem to tolerate sites that are badly situated rather than roost outside the colony's limits.

The result of continual habitation is that in some instances the presence of the flying foxes does considerable damage to the trees at the roost site, as seen in Fig. 9

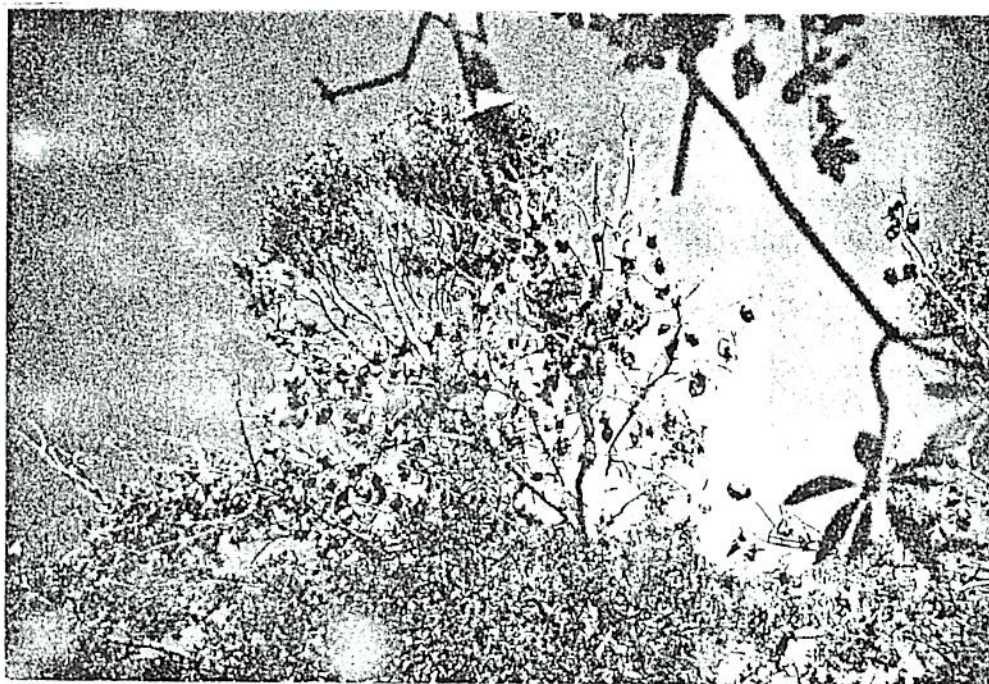


Fig. 9. Damage to trees resulting from roosting P. poliocephalus. The extent of this damage and alternative causes at Gordon have already been discussed. On consideration of the damage done to other areas, notably the effects of P. scapulatus on the poplar plantation at Kempsey already mentioned, their effect on a stand of Paper barks Melaleuca spp at Scott's Head, on cherry trees at Armidale and the damage done to riverside She-oaks, Casuarina spp. at Tenterfield by roosting P. poliocephalus, it is this author's opinion that a significant share of the blame for tree defoliation, damage and death at Gordon must belong to the flying foxes. Similarly, their detrimental effect to cultivated fruit is well known and has been previously discussed.

Having said this, consideration should be made of the beneficial effects of the flying foxes. Pteropids are instrumental in seed transport. From observations made in this study it was found that seeds are transported intact both in the digestive tract and in the mouth - presumably being carried in the cheek pouches. On return to the roost in the early morning the food is chewed and eventually spat out. Intact seeds found carried and dropped inside the colony in this manner include figs, Ficus macrophylla, small (19 mm x 14 mm) peach seeds and many seeds of an unidentified palm, probably of genus Archontophoenix. These seeds are covered by a very fibrous outer coating, the seed itself measuring some 22 mm x 14 mm. The only seeds positively identified in the faeces were fig seeds and the black mulberry, Morus nigra. Other small seeds were found but not identified. The seeds are transported considerable distances as the bats may fly at least 20 km. on feeding flights.

The role of the Grey Headed flying fox in plant pollination is unclear. All the flower-visiting chiropterans in Australia belong to the family Pteropodidae (Armstrong, 1979). The genus Pteropus and notably P. poliocephalus visit and feed on a wide variety of native flora. Their involvement in pollination is unknown but, according to Armstrong (1979), potentially important.

A final aspect of the effect of flying foxes on their roost is the addition of nutrients to the soil from dung. From an analysis of soil under the colony and soil from a similar site nearby, but not inhabited by flying foxes it was found that pH was largely unchanged (4.2 sample against 4.5 control), salinity was almost doubled (.20 against .11 ms/cm) and phosphorous was over 6 times higher (56 against 9 ppm.) The sample was not analysed for nitrogen. Little change would have been expected in any case, as the diet of flying foxes is low in nitrogen content, mostly being obtained from pollen (Armstrong, 1979).



Benefit of the Roost to Bats.

The concentration of a large number of animals into a very small space has many deleterious as well as beneficial effects. Predators are drawn to these large concentrations of potential food. The crowding in the trees and repetitive use of the same branch results in stripping of the foliage and subsequent full exposure to the effects of sun, wind and rain. The establishment and maintenance of territories requires considerable effort to continually repel intruders. Furthermore, the concentration of large numbers of animals in a small area means that they must disperse widely to obtain food. Once found all available food must be utilized with maximum efficiency.

The benefit(s) must be considerable to justify the considerable energetic costs this system incurs. The two major theories which seek to explain the formation of colonies relate to increased protection from predation and information exchange with regard to food. The observations of this study support the findings of Ward and Zahavi (1973) albeit with some modification. They maintain that, for birds, colonies have "evolved primarily for the efficient exploitation of unevenly distributed food sources by serving as information centres." Secondly, these colonies have then become shaped by predation-pressure to minimize vulnerability through joint defence, choice of 'safe' sites, optimal dispersal and mutual awareness of attack.

Nelson (1965b) supports the alternative view that flying fox colonies exist primarily for protection from predators such as Wedge-tailed eagles, Aquila audax, White-breasted Sea eagles, Haliaeetus leucogaster, goannas, Varanus spp. and pythons, family Boidae.

The food of the Grey Headed flying fox (and other species) is very patchily distributed in both time and space. Without help, an isolated individual could spend a great amount of time and energy seeking food when its existing supplies ceased, as demonstrated by Morrison (1978a)

and Fleming et.al. (1977). Under Ward and Zahavi's (1973) system an individual whose food supply has been cut off can immediately follow 'successful' individuals to an alternative food source. One way these authors suggest this may be accomplished is for the unsuccessful animals to leave first and then land after a short distance. As other animals fly over, the unsuccessful animal then follows. This has often been seen at Gordon where the bats fly around 500 m, land in treetops and then join other animals flying out. Further substantiation comes from groups of bats flying over Galston in a distinct line, some 16 km. from the camp. Obviously any unsuccessful bat joining such a group would be led to food. Finally, observations of the bats as they stream out at dusk readily show 'follow the leader' behaviour - any bat getting off course of the main stream, being rapidly followed by several others.

One point where flying foxes do not conform to Ward and Zahavi's (1973) hypothesis is in the times when these colonies should be established. As Nelson (1965a, 1965b) states, the large summer colonies are at their peak capacity when food is at a maximum. Ward and Zahavi (1973) believe that group size should be greatest when food is scarce. The larger numbers, they reason cover more area, and provide the greatest information when it is most needed. Obviously there must be a limitation to this idea. The distance an animal can economically travel, to and from even assured food, in one night is limited. This means that if food is scarce, the useable area around the colony simply may not be able to support the large numbers. The result of this should be dispersion of individuals, as seen for the majority of flying foxes in winter. This aspect aside, many facets of Ward and Zahavi's (1973) system neatly apply to flying foxes. Their hypothesis therefore is probably a very adequate explanation for the existence of flying fox camps.

### Exodus.

According to Ward and Zahavi's (1973) system just discussed, we would expect considerable co-ordination of animals leaving the colony on feeding flights but we would not expect this degree of co-ordination amongst animals returning to the camp from the feeding areas.

The timing of exodus of the animals was found to be related to three factors; sunset, season and the presence or absence of cloud cover. From Fig. 11 it is readily seen that the time of nightly exit from the camp has a relatively stable correlation to sunset. However, as seen from Fig. 10 and 11 this correlation is significantly affected by season. In mid-summer when nights are shortest (and supposedly food most abundant) the flying foxes leave the camp very soon after sunset (5.3 mins. average with standard deviation of 8.5 mins.), when there is still considerable ambient light. In mid-winter to early spring (when nights are longest and food supposedly short) the exodus times are considerably later in relation to sunset (32 mins. average with standard deviation of 3.7 mins.) and ambient light is greatly reduced. The differences in seasonal exodus times were highly significant at the .001 level.

The third factor affecting exodus time (and duration) is the degree of cloud cover. Referring to Fig. 12 it is seen that animals leave earlier when cloud cover is greatest and leave latest on clear nights. This relationship was tested by linear regression and found to be significant at the .001 level. The effect of heavy cloud cover is to reduce ambient light. This reduced light stimulates the majority of bats to leave earlier in relation to sunset. The same relationship was found by Funakoshi et. al. (1978) for Pipistrellus abramus. Not all individuals respond in this way however, as many stay behind and leave later on overcast nights. This is seen on Fig. 11 through comparison of overcast and clear nights. The sign-

Key.

B = Counted at bridge flying west

a = Weather records lost. Bureau of Meteorology records only 2.7 sunshine hours with some light showers

Nos. - Refers to percentage overcast at commencement of streaming

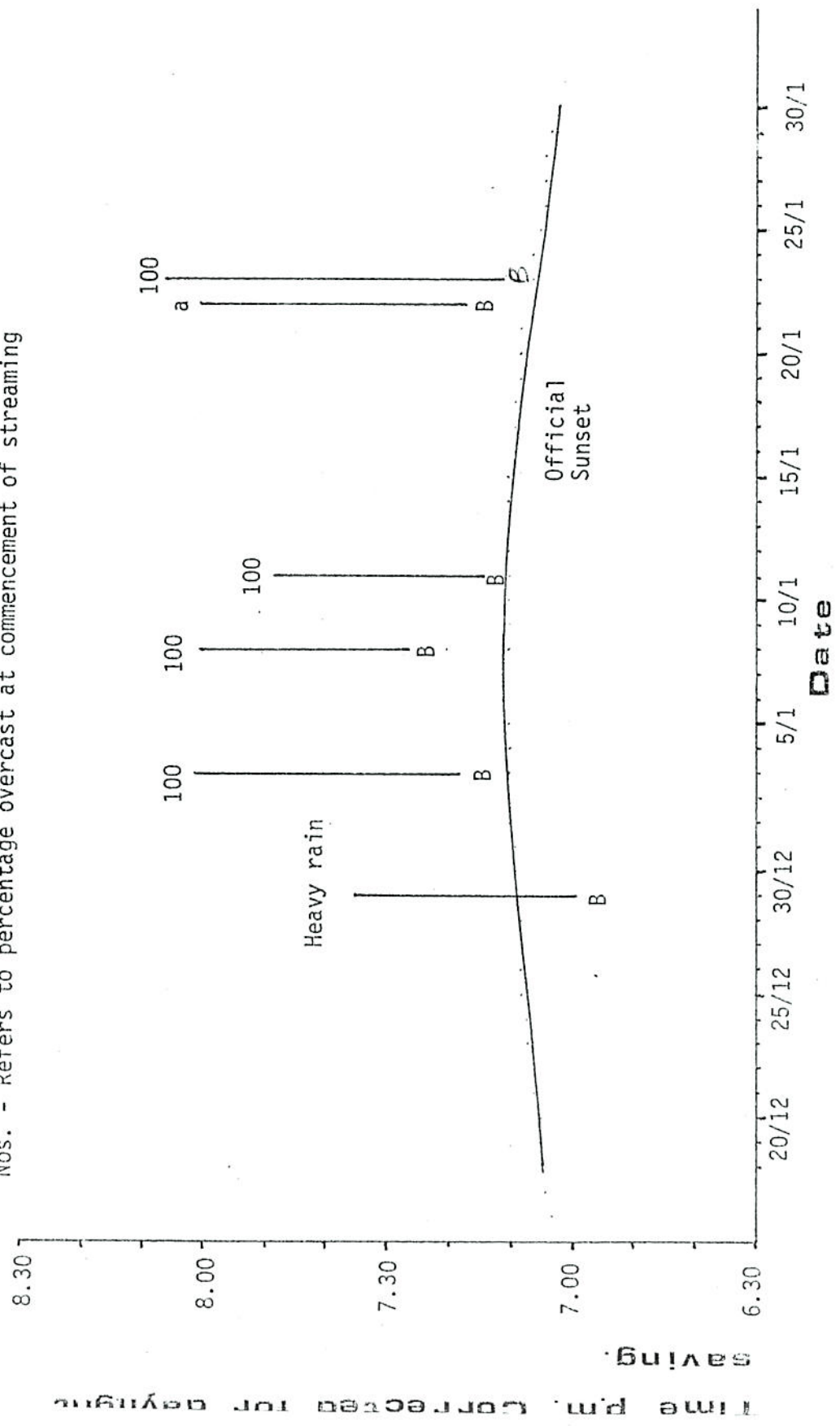


Fig. 10 - Time and duration of exodus between 29/12/80 and 23/1/81 for bats flying west only.

Key.

- B- Counted at bridge flying West
- M- Counted at Maytone Ave. flying South/South East
- No- Refers to percentage of overcast at commencement of streaming

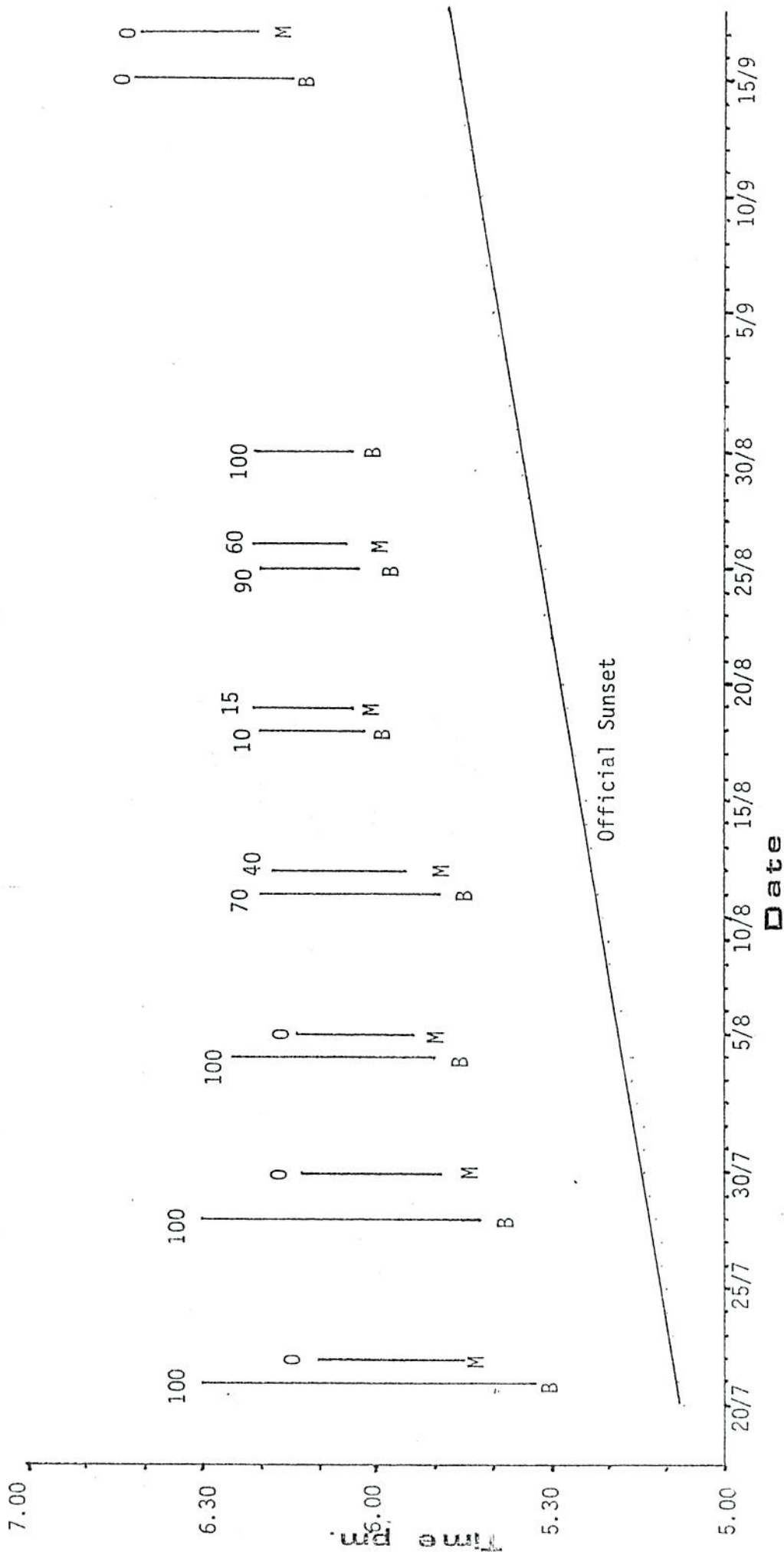


Fig.11- Time and duration of exodus between 21/7 - 17/9/81 for bats flying W. and S.

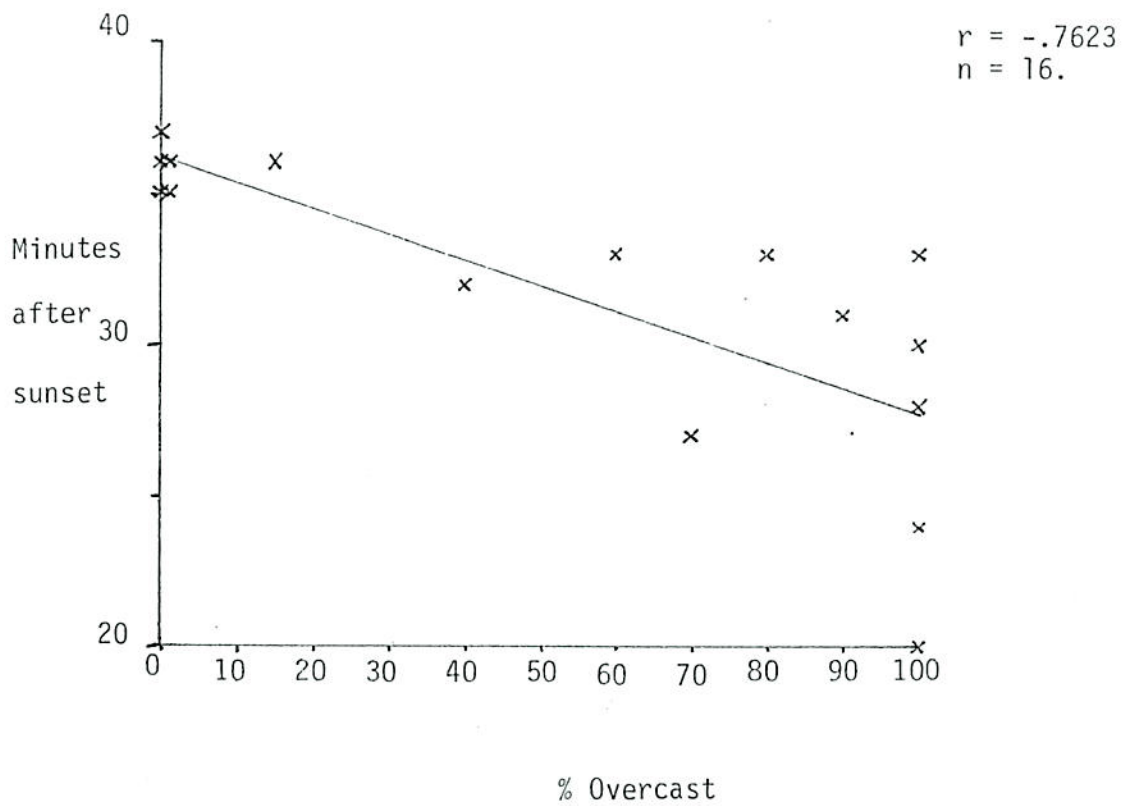


Fig. 12 - Colony exodus time, expressed in minutes since sunset, plotted against percentage overcast of sky at onset of streaming.

ificance of this/<sup>is</sup>not fully understood and is complicated by the fact that the majority of overcast counts were made of bats flying west, while most clear nights coincided with counts of bats flying south and south-east. Partial regression analysis applied to more records of these night flights would clarify the situation.

The flying foxes are far less co-ordinated in the timing and direction of their return to the roost. Animals were seen to return after only a couple of hours foraging, although the majority usually return immediately prior to dawn as seen in Fig. 13. An exception to this occurs on light moonlight nights. There are several reports in the literature on lunar phobia, where the bats return to the roost early, as if to minimise flying in bright moonlight. By doing so they reduce their vulnerability to visually orienting predators/ (Erkert, 1974, 1976; Morrison, 1978b, 1980). This behaviour was observed with P. poliocephalus on the night of 24/3/81. At 8.20 p.m. after less than two hours of foraging, the animals began returning to the colony. By 9.30 p.m. there was a terrific amount of activity and it was estimated that over half of the bats had returned. At this time my field notes read "moon has risen and is shining brightly... visibility improving". The bats ceased returning by around 11.40 p.m. The moon at this time of the month was not quite full (3/4) with very thin cloud cover present.

The flying foxes fly at least up to 20 km. from the camp to feed. This is established by night time observations of flying bats early in the evening. By retracing the direction of this flight, their point of origin appears almost invariably to be the Gordon colony. This gives the animals a minimum foraging area of 1257 sq. km. ( $a = \pi r^2$ ) or a density of around 11 bats per square kilometer when population size is 14,000.

By counting animals flying out to the west separately from those flying to the south and south-east, it is possible to closely observe the changing

Fig. 13 - Bats returning to roost from South, pre-dawn 8/4/81





proportion of bats flying to the feeding sites in those directions, presumably in response to fluctuating food availability. Those flying to the west were almost always in the majority, varying between 75.8 and 46.5% (averaging 64.3%) of the total counted between 29/12/80 and 17/9/81. The proportion can change relatively rapidly as exemplified by the two extremes mentioned above. Within four weeks, the proportion flying to the west fell from 75.8 to 46.5% of the population.

### Feeding.

The native foods which P. poliocephalus is listed as eating includes, the blossoms of Blackbutt, Eucalyptus pilularis; Bloodwood, E. intermedia; Flooded gum, E. grandis; Grey box, E. hemiphloia; Gum-topped box, E. moluccana; Spotted gum, E. maculata; Tallow-wood, E. microcorys; a messmate, E. cloeziana; Narrow-leaved ironbark, E. crebra; Dusky or Broad-leaved ironbark, E. fibrosa; Red Mahogany E. resinifera; E. drepanophylla; Northern Grey ironbark, E. siderophloia. The apple, Angophora intermedia, Turpentine, Syncarpia spp., paper bark trees, Melaleuca spp., the Moreton Bay chestnut, Castanospermum australe, Banksia spp., and Mistletoe, Loranthus spp. Native fruits eaten include Moreton Bay figs, Ficus macrophylla, and Lillipillies, Eugenia spp. They are also reported to eat the fruits and berries of a wide variety of introduced and cultivated plants, (Ratcliffe, 1931, Nelson, 1965a, Armstrong, 1979, Hall and Richards, 1979). Two previously unrecorded species of introduced plants which were observed being fed upon by P. poliocephalus, were the palm fruit, family Palmae, mentioned earlier and Privet berries, Ligustrum sp.

Captive animals ate virtually any succulent fruit given to them, including peaches, plums, bananas, watermelon, rockmelon, grapes, pears, apple, pineapple, persimmon, oranges and mandarins, although distinct preferences were shown. Grapes, apples and citrus were only eaten in the absence of an

alternative.

Faeces beneath the colony varied tremendously in colour, contents and consistency. From these facts emerge the picture of an opportunistic feeder capable of utilizing a wide range of foods as they become available. Coupled with the high mobility of this species, it is easy to appreciate the reasons for this species' success.

#### Feeding Style.

Relatively little time was spent in this study on the feeding of flying foxes. However, on several occasions P. poliocephalus was observed feeding in peach and plum orchards, in Moreton Bay Figs, Ficus macrophylla, in Eucalypts and finally in Privet bushes, Ligustrum spp. Some points emerged which are worthy of comment.

Ratcliffe (1931) states that flying foxes locate their food solely by olfaction rather than visually. This conclusion lacks evidence as their sight is extremely well adapted for night vision (Nelson, 1965b) and may play a significant part, at least in locating food once the animal is near or in a food tree. For example, the white blossoms of some eucalypts are visible at night even to the unspecialized human eye. Once in a tree, the animal apparently sometimes tastes the fruit to sample its ripeness. The typical pattern of teeth marks seen in Fig. 4 being quite common on fruit in 'bad flying fox years'.

Feeding strategy, once in the trees appears to vary considerably. In some fruit orchards at Galston, the flying foxes removed fruit from the tree and flew between 50 and 300 m. away to tall surrounding eucalypts to eat it. This is evidenced by the discarded seeds below these trees. Only rarely would a flying fox be found feeding in the fruit tree itself. Similar behaviour was sometimes observed in Moreton Bay fig trees but mostly the flying foxes were quite territorial and regularly chased away 'intruders' by 'running' along the branch towards the intruder so that it almost

invariably flew off. Alternatively, the 'resident' would fly over to the intruder and in several cases land on top of it to make it leave. Occasionally fighting would occur which always resulted in one or the other leaving. (Nelson, 1965b) stated that feeding territories were established and defended, within a limit of 3 m. or so in all directions. He also stated that seasonal behaviour and mother-young behaviour occurred in these territories, suggesting that groups in daytime camps may extend into the feeding areas. Beyond the age of three weeks, there is some doubt as to whether mother and young would feed in the same tree. If this was so, they would need to leave the colony together. Several observations of mother-young pairs leaving at dusk never showed the two to leave together, the minimum observed time difference in their departure being 20 seconds. Such pairs also routinely returned to their daytime perch separately, placing further doubt on Nelson's (1965b) theory. The irregularity of the records for this phenomenon however, leave room for some speculation.

Detailed records of feeding were obtained on only one occasion when adult P. poliocephalus were observed eating privet berries in daytime at the colony at 7.30 a.m. on 24/6/81, for a period of around 20 mins. There were 3 flying foxes in the bush, none of which displayed territorial feeding behaviour. The animals climbed about the bush silently and pulled bunches of the small black berries toward themselves using their wing claws. Once a mouthful of food was obtained (taking an average of 34 seconds) the animal chewed for a further 31 seconds on average, either with their wings by their sides or while enclosed in a 'wing tent' similar to that used by masturbating males. The bolus of food was then spat out and the animals typically looked around and then moved to the next bunch of berries - usually taking only 5-10 seconds (av 6 seconds).

Observations of captive animals showed that both P. scapulatus and P. poliocephalus routinely used their feet to hold larger pieces of fruit,

and occasionally adjusted the position of the fruit with their wrists.

A point of considerable interest concerns the sex ratio and reproductive states of flying foxes shot in cultivated orchards. During the 1980/81 fruit season, the flying fox problem at Galston was considerable until around the 2nd of December. At this time many Angophoras began flowering and the flying fox numbers visiting orchards decreased considerably.

Up until, and including the 2nd of December, 29 flying foxes were obtained from farmers. The sex ratio was 11 males to 18 females (with 12 lactating females, 4 non-lactating females and 2 unclassified females). After this time only 11 animals were obtained, 9 of which were lactating females, one was a non-lactating female (classified on nipple development and milk expression) and the remaining animal was a male. The probability, by chance of this second group having the observed sex ratio is less than 2%, through chi-squared analysis. This perhaps suggests that females needing larger supplies of food and moisture to feed young were turning to the relatively abundant crops of cultivated fruit. Substantiation of this theory shall be sought through the sex and reproductive status of animals shot in the 1981/82 season.

#### Drinking.

Flying foxes were never observed drinking on the wing as reported by Ratcliffe (1931) and many others. Apparently they fly low over the water and either lap it up as they fly or allow their body fur to be wet and later lick this moisture off. After rain in the colony, flying foxes were often observed to lick their body and wings (and in one case another adult bat), to remove water and also lick surrounding foliage to obtain water.

Animals in captivity were fed succulent food but not given water for some months with no obvious ill-effects, although the animals appeared

cleaner when water was supplied. It may be that free drinking water is necessary for urine bathing but not for bodily homeostasis, which can be supplied by metabolic water or free water in the food. However, it is almost certain that as temperatures increase in summer, the need for water also increases, necessitating drinking from standing water or rain water. In the cooler temperatures of winter, the need is not as great and enough water may be obtained from food.