Microclimate study

Microclimate preferences of the grey-headed flying fox (*Pteropus poliocephalus*) in the Sydney region

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This study aimed to determine the microclimate characteristics of grey-headed flying-fox camps. Temperature and humidity data were collected via data-loggers located in six camps and in the bushland immediately adjacent to each camp in the greater Sydney region. Significant differences were found between the microclimate within the camps and the surrounding bushland. In general, areas within the camps had a greater variance in temperature and humidity than the surrounding area. The authors hypothesise that camps may be specifically located in areas with high microclimate variance to accommodate a range of individual preferences that vary depending on demography.

The camps studied were: Gordon (Ku-ring-gai Flying Fox Reserve), Fairfield (Cabramatta Creek), Penrith (Emu Plains), Yarramundi, Kurnell and the Sydney Botanic Gardens. The six camps were surveyed between March 2007 and January 2008, encapsulating the breeding season of the species. At each location, the core of the roosting area in the camp was identified based on long-term observations of the distribution of roosting animals.

Funding
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Data collection
All data loggers were set to record at two-hourly intervals. Data were collected at intervals less than 170 days, which represented the memory limit of the loggers. In total, 136 loggers were deployed across the six locations. Complete temperature and humidity data were obtained from only 112 data loggers as a result of missing or faulty data loggers. The missing or faulty data loggers were evenly distributed across the sample camps.

Analysis
Daily mean, minimum, maximum and variance (maximum–minimum) values for temperature and humidity were calculated for each logger. Then the data was averaged across three seasons (Winter, Spring and Summer).

Temperature
No significant differences in mean daily temperatures were observed between the roost and the surrounding reserve. The camps had significantly higher maximum daily temperatures (~1^{0}C) than surrounding bushland. The minimum daily temperatures within the roosts (camps) were significantly lower (<1^{0}C) than in the surrounding bushland. This general pattern occurred throughout the three seasons although the magnitude of the difference varied slightly between seasons The roost had significantly greater variance in daily temperatures (~1.3^{0}C) than the surrounding reserve.

Humidity
In both Winter and Spring the mean humidity was higher in the roost than in the surrounding bushland whereas the opposite was true in the Summer. The roost tended to have a higher daily maximum relative humidity than the surrounding bushland, although not significantly so. The magnitude of this difference varied depending on the season, the difference being greatest in Winter and Spring. No significant differences were observed in daily minimum relative humidity between the roost and the surrounding reserve. The variance in humidity was significantly greater (~2.2%) in the roosts than in the surrounding reserve.

Permanent versus transient camps
In Winter and Spring permanently occupied camps had higher mean daily temperatures whereas no difference was observed in Summer. In all cases the difference was less than 1^0C. Maximum daily temperatures were significantly higher (~1.6^0C) in the core areas than in the surrounding bushland in the permanently occupied camps but no difference was observed in the transient camps.
In Winter and Spring permanently occupied camps had higher minimum daily temperatures (i.e. it was ~1^0C and 0.5^0C warmer respectively) than did transient camps whereas no difference was observed in Summer.
The permanently occupied camps had significantly greater variance in daily temperatures (~8.4^0C) than did transient camps. This general pattern varied slightly between seasons, with the greatest difference between permanent and transient camps being observed in the Spring and Summer.

The mean daily relative humidity was lower in the permanent roosts than in the transient. In Winter the permanently occupied camps had significantly lower daily maximum relative humidity (~1.5%), which was reduced somewhat in the Spring (~1%) and there was no difference in the Summer. Permanent camps had slightly lower daily minimum relative humidity than did transient camps (~2.5%). The difference was significant in both Winter and Spring but not in Summer. No significant differences were observed in daily relative humidity variance between the permanent and transient camps.

Discussion
Our results suggest that camp microclimate may have a significant effect on the GHFF, indicating that the thermal regime of their immediate roosting environment is likely an important factor influencing their energy Expenditure.
The current study shows that both temperature and humidity play a role in determining camp selection in the GHFF. In particular, the core areas of GHFF's camp locations have a higher variance in temperature and humidity relative to the surrounding peripheral areas. Similarly, permanently occupied camps have far greater variation in daily temperatures than transient camps.

The fact that the difference between the camp microclimate and the surrounding bushland held true for all of the camps with subtle variations between camps is somewhat remarkable given the vastly different geographic locations of the camps we sampled. In only one instance did we find significant interactions with camp identity (maximum daily temperature) and in that case only one location (Kurnell) did not follow the general trend.

During breeding and lactation periods, females may select warm microclimates within camps in order to reduce the energetic costs of maintaining a high body temperature and facilitate higher rates of juvenile development thereby increasing the fitness of both the mother and her offspring.

As the present study was conducted during GHFF breeding season, the colonies consisted of territorial males and females with and without young; therefore, having a large variance in temperature and humidity could potentially accommodate the needs of all group members in this highly social species.

There are, however, numerous possible explanations as to why the core area of the camp would be significantly more variable than the peripheral areas with respect to both temperature and humidity. [refers to behaviour of microbats in caves then discusses possibilities that large numbers of flying-foxes could affect temperature and humidity in the roost but then this hypothesis is discounted because data collected at night when flying-foxes absent while foraging] A far more likely alternative explanation for the differences between locations relates indirectly to the behaviour of the bats.

GHFFs cause a considerable amount of defoliation of the selected roosting trees therefore, data loggers within the core roosting areas may have been exposed to direct sunlight, which may increase the temperature recorded by the loggers. The data loggers housed within the periphery of the reserves, in contrast, were located in intact trees, which would limit temperature variation. This indirect effect of the bats on the temperature in the camp is further supported by the greater degree of temperature variation in permanently occupied camps in comparison with the transient camps. Defoliation of trees in core areas, however, cannot explain the observed pattern in the humidity data. Nevertheless, these differences in foliage coverage still reflect the roosting preferences of the bats, but there is some evidence that the core location of the colony can shift over time. This shift in key roost trees may be in direct response to the change in microclimate variables as the canopy continues to senesce.

...this study suggests that GHFFs may also select camps on the basis of humidity. Our data show that the variance in humidity within camps is over 2% higher than in the surrounding bushland. While this is a seemingly small difference, it is possible that humidity influences camp selection to a greater extent than reported here because our data were collected during an unusually wet year. The average mean relative humidity recorded in the camps during this study was 72.5%. Independent data collected from weather stations by the Bureau of Meteorology indicated that Sydney experienced above-average rainfall during the study period. Additionally, between 19 November and 10 December 2007, Sydney recorded the most humid three-week period for 20 years and higher-than-average humidity was recorded over the entire study period.

This unusual and consistently high humidity allowed for only minor distinctions in humidity throughout the Sydney region. Hence it is likely that the true differences within camps and between camps may have been masked. Consequently, additional long-term studies will be required to further understand the role humidity plays in camp selection by GHFFs.

Permanent versus semi-permanent camps

.... we suggest that food availability is the strongest factor determining how often a GHFF camp is occupied. If local food rewards are high around transient camp locations, it is likely that bats will be less choosey with respect to camp microhabitat variables in favour of higher food intake, particularly if their presence in the camp is ephemeral.

Management considerations

[paper refers to climate change predictions of high temperatures and decreased rainfall in the region. Effect on flying-foxes especially females and young – refers to a related unpublished study by Snoyman]