HOME RANGE, ROOST SWITCHING, AND FORAGING AREA IN A PHILIPPINE FRUIT BAT (Ptenochirus jahori)\n
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Abstract. We show that roost switching in the model fruit bat, Ptenochirus jahori, is probably determined by the spatially changing availability of fruit resources. We investigated the roosting behavior and foraging movements of this frugivorous bat species in a Philippine loessial rainforest with the help of radio-telemetry. Five male and five female P. jahori were radiotagged and followed up to four months. Single individuals moved around in primeval forest. Both sexes changed their day roosts at variable intervals (range 8 to 72 days). This data is in the line of our tropical primordial bat species and highly inhabiting tree cavities. Based on home ranges of individuals ranging from 6.1 to 35.7ha with no significant difference between the sexes. Ranges spawn home ranges varied from 63.3 to 659.9m. Each day typically moved several foraging areas every night and showed high fidelity to tree sites during the occupancy of a particular day. These core areas represented 38 to 55% of the home range, and contained at least one fruiting tree. The predictability of feeding movements in a nightlight, together with a preponderance of fruiting tree geometry, indicate some kind of "cape-hunting" behavior which reduces travel distance and energy costs. (Accepted 29 September 2001).

Key words: Core area, day roost, foraging, home range, roosting, fruit bat, Philippines, Bicol, roost switching, telemetry.

INTRODUCTION

The frugivorous mimic fruit bat, Ptenochirus jahori, belongs to the Old World bats (Pteropodidae). It is known only in two species and some in small groups in caves (McDowHana et al. 1992). P. jahori inhabits disturbed areas as well as primeval forest but is absent from sites more than a kilometer from forest or house patches (Heidenreich & Kenny 1989). P. jahori is the most abundant fruit bat species within our study site (Laff 1998, and below). The species' diet comprises fruit of at least 45 different plant species, nectar of two species, and flowers of seven species (Laff 1998). We carried out radio-telemetry studies of P. jahori in order to gain an insight into home range size and foraging area. Of particular interest was the roosting switching of this species since the reasons for such behavior are still unclear (Fenton et al. 1985).

STUDY AREA AND METHODS

The study was conducted around Sibulan (11°49‘ N, 12°58‘ E). Province of Aklan, Philippines. This area is located on the Northwest Peninsula of Panay Island at an average elevation of 450 m a.s.l. and is domi

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intervals (every five min.). For our data analysis, circumstances dictated a tracking period of roughly 11 days for each bear (11.5 ± 4.8 d). Day roost occupancy was checked weekly. We chose the nonparametric minimum-convex-polygon method to calculate home range and core-use area. Home range was defined as minimum area probability (MAP) = 0.95, and core-use area as MAP = 0.5 (Olson & Kulemeyer 1955; Wil-kinson & Bradshaw 1980). Centers of activity within the foraging areas were determined by calculating har-monic mean fixes (Spencer & Barrett 1984). The dis-tance between these centers of activity and the day roost was calculated. Data analysis was done using the software program RANGES VITE (Wareham, Dor-set, UK). Results are reported as ± SD. Means for the sexes were compared for statistical significance (P < 0.05) using Student’s t-test (50). Analysis of variance (ANOVA) was used when examining the distances between old and new roosts.

RESULTS

P. tridactylus readily occupied primary forest areas; only one of 16-18 sites was in a secondary forest patch; one bear roosted in a den and another one on a shelterset rock face. The pattern of day roost fidelity was diverse. Seven bears of both sexes changed their day roosts 1.07 times per month (range 8 to 72 days), the other three sites to their morning tree as long as we could pick up transmitter signal (range 99 to 127 days). Of these 30 four which changed their day roosts regularly, all the roosts could be located. The distances between old and new roosts were rather similar and showed no signifi-cant difference (ANCOVA: F = 0.16; 5.5 df; P > 0.05). For example, male 368 changed its roosts across dis-tances of 511, 444 and 528 m; it did so at a mean interval of 18 days. Female 548 switched roosts across distances of 536 and 537 m every 41.5 days, while in female 928 distances between old and new roosts were 136, 100, 674 and 113 m (with roost switching every 35 days).

Our observations indicate that one P. tridactylus switched day roosts in order to minimize travel distances to foraging areas. From the start of tracking (11 February 2000) female 349 occupied roost 1 (Fig. 1). It fed mainly on fruits of Ficus benjamina (for-aing in FA1 and 3), but included three other Ficus species (Moraceae) in its diet as well. Travel distances from day roost 1 to FA1 and FA3 were 475 and 686 m respectively. At the time the F. benjamina tree in FA1 no longer bore ripe fruits, he bear changed its

![FIG. 1. Home ranges (95% MAP) and foraging areas (arabic numerals in circles) of female 549 before and after roost switching. Foraging areas containing F. cese benjamina trees (see text) are highlighted by large circles. Note that the home range was calculated separately for each occupied roost.](image-url)
TABLE 1. Minimum area probabilities (MAP) and range spans of moulpy fruit bats in Papua, Philippines. 349-1 and 349-2 denote occupied routes 1 and 2 respectively.

<table>
<thead>
<tr>
<th>Bat number</th>
<th>sex</th>
<th>age</th>
<th>n</th>
<th>95% MAP [ha]</th>
<th>95% MAP [ha]</th>
<th>Span [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>349</td>
<td>F</td>
<td>Adult</td>
<td>19</td>
<td>19.9</td>
<td>4.7</td>
<td>672</td>
</tr>
<tr>
<td>389</td>
<td>F</td>
<td>Adult</td>
<td>29</td>
<td>8.4</td>
<td>3.0</td>
<td>535</td>
</tr>
<tr>
<td>349-1</td>
<td>F</td>
<td>Adult</td>
<td>36</td>
<td>10.2</td>
<td>5.6</td>
<td>817</td>
</tr>
<tr>
<td>349-2</td>
<td>F</td>
<td>Adult</td>
<td>33</td>
<td>14.9</td>
<td>9.1</td>
<td>654</td>
</tr>
<tr>
<td>928</td>
<td>F</td>
<td>Adult</td>
<td>32</td>
<td>16.2</td>
<td>5.5</td>
<td>801</td>
</tr>
<tr>
<td>709</td>
<td>F</td>
<td>Adult</td>
<td>30</td>
<td>30.9</td>
<td>9.2</td>
<td>1367</td>
</tr>
<tr>
<td>168</td>
<td>M</td>
<td>Adult</td>
<td>21</td>
<td>20.0</td>
<td>4.8</td>
<td>1589</td>
</tr>
<tr>
<td>190</td>
<td>M</td>
<td>Adult</td>
<td>35</td>
<td>23.0</td>
<td>12.7</td>
<td>1314</td>
</tr>
<tr>
<td>131</td>
<td>M</td>
<td>Adult</td>
<td>33</td>
<td>24.6</td>
<td>10.4</td>
<td>865</td>
</tr>
<tr>
<td>747</td>
<td>M</td>
<td>Adult</td>
<td>27</td>
<td>10.1</td>
<td>3.5</td>
<td>557</td>
</tr>
<tr>
<td>848</td>
<td>M</td>
<td>Adult</td>
<td>39</td>
<td>13.1</td>
<td>2.3</td>
<td>591</td>
</tr>
</tbody>
</table>

Mean range size between the sexes (M: P < 0.5). The only pregnant individual we tagged, female 799, had the largest range of all tracked bats (Table 1). Male 349 (Table 1) showed larger mean range sizes than did females 349-1 and 349-2, (combined is 131 m). However, this difference was not significant (M: P > 0.05). The bats spent most of their time near to feeding sites with one or several feeding trees. The core use areas (Table 1: 95% MAP of all tagged) showed varied from 2.3 to 12.7 ha, representing 18-55% the of the movement's home ranges.

TABLE 2. Distance between day roost and center of foraging area (FA) of moulpy fruit bats in Papua, Philippines. AF and AM denote females and males respectively. AF349-1 and AF349-2 indicate occupied routes 1 and 2 respectively.

<table>
<thead>
<tr>
<th>Bat ID</th>
<th>FA1</th>
<th>FA2</th>
<th>FA3</th>
<th>FA4</th>
<th>FA5</th>
<th>FA6</th>
<th>FA7</th>
</tr>
</thead>
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<tr>
<td>AF149</td>
<td>202</td>
<td>318</td>
<td>452</td>
<td>633</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AF349</td>
<td>20</td>
<td>202</td>
<td>485</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AF349-2</td>
<td>47</td>
<td>497</td>
<td>636</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AF349-2</td>
<td>–</td>
<td>–</td>
<td>170</td>
<td>285</td>
<td>298</td>
<td>520</td>
<td>583</td>
</tr>
<tr>
<td>AF324</td>
<td>132</td>
<td>255</td>
<td>590</td>
<td>605</td>
<td>801</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AF709</td>
<td>430</td>
<td>594</td>
<td>1349</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AM168</td>
<td>41</td>
<td>377</td>
<td>798</td>
<td>1072</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AM190</td>
<td>385</td>
<td>417</td>
<td>645</td>
<td>710</td>
<td>999</td>
<td>1308</td>
<td>–</td>
</tr>
<tr>
<td>AM131</td>
<td>359</td>
<td>553</td>
<td>552</td>
<td>750</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AM747</td>
<td>72</td>
<td>170</td>
<td>233</td>
<td>247</td>
<td>277</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>AM848</td>
<td>57</td>
<td>196</td>
<td>282</td>
<td>345</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

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cative nights. The mean number of foraging areas vi-
sited per tracking period (see area study and methods) was 4.6 ± 0.9 for males and 3.8 ± 0.8 for females (Table 2). All bats had visited at least two different for-
aging areas every night.

On average females tended to travel about as far
foraging areas as did males (480 ± 203 m vs. 454 ± 243 m. S. P = 0.5). Interestingly, day roosts of all but two bats were positioned in one corner of their home range. Moreover, the home ranges often had a conspicuously elongate shape.

DISCUSSION AND CONCLUSIONS

To account for roost switching behavior one could assume a change in the distribution of ripe fruits, predator avoidance, competition over tree cavities, and changes in the nature of the host through, e.g., parasitism (Moomet 1980, Kama 1982, Fenton 1983, Fenton et al. 1985). Many frugivorous bat species studied so far failed to move their roost to minimize commuting costs during foraging (Bradbury 1977, Morrison 1978a, 1980, Fenton et al. 1985). Hall (1983) stated that individuals of the prosopod bat species Nyctinema secundatum is a solitary foraging
species, mostly in primary forest, with a body mass of ca. 50 g. Therefore this animal is not only abundant at a food resource but is isolated. Thus individuals are likely to change their roosting position and often find sites opportu-
nistically as availability of food in an area changes (Hall 1983). In their study, Spencer & Flecking (1989) found that N. secundatum is not site specific. From the study, Hall (1983) state-
tment. A high density of fruiting trees during their two
months tracking period probably accounted for the sedentary behavior. The same authors indicated that some bats changed their day roost locations more fre-
quently, but left open why they did so.

Our observations suggest that roost switching might be influenced by spatial changes in the avail-
ability of food resources and, by implication, the tendency to minimize travel costs. In the case of female 349, most switching and the ripening of E. denisonia trees (the fruits of which is obviously pre-
ferred to other figs) in a new foraging area coincided. We did not monitor the ripening time of E. denis-
onia trees in FAP before female 349 visited this foraging area. However, we know that the fruit had newly opened since overripe fruits fall on the forest floor in large numbers. This was not the case when we checked the trees after the roost switch.

Furthermore, the abundance of trees with cavities in our study site makes it unreasonable to assume that a lack of available roosting trees determined the di-
rection of the roost switch.

To our knowledge data on the most switching fre-
quency of prosopod bat species living in tree cavities is not available. Individuals of P. jagori moved to new roosts at variable intervals. This indicates that the roost switch is probably determined by change in the distribution of ripe fruits.

In P. jagori there is no significant difference in the
home range size between the two sexes. As reported for other frugivorous bat species (Moomet 1979a, August 1981, McCracken & Beasley 1988). Hemsley 1986, Handly & Moomet 1991) individuals leave their day roosts after sunset in order to fly to for-
aging areas where they find for varying periods. In-
dividuals of P. jagori showed a high fidelity to foraging
sites, even female 709 visited in first foraging area imme-
diately after sunset for at least seven days. More-
ever, some bats moved between their other foraging
areas in quick succession, probably to increase dietary diversity since most foraging areas differ in offering different food resources. The predictability of foraging movements (as in Streckeria anulata, Winklermann et al. 2000) together with the constancy of resource availability (usually all of the bats inclu-
ding a particular Ficus species (Moraceae) in their diet, the individuals of which were frugivorous continuously throughout the year), indicates some kind of "trap-
lining" behavior in P. jagori in the short term. The small sizes of foraging areas and a preferential direc-
tion of the home range strengthen this indication. "Trap-
lining" minimizes travel distances and energy cost (Kean 1982).

Heckert & Huntley (1989) prediction that small species in rainforest should display relatively short foraging distances of the order of 0.1 to 1.5 km in any one night (In contrast to small bats forager
over much longer distances in, e.g., dry forest, Morrison 1978a) agrees largely with our results. Rain-
forest and late successional stages are believed to pro-
vide a higher diversity of food resources than do other habitat types (Winklermann et al. 2000).

The present study has come up with a number of differences between the sexes falling short of statisti-
cal significance. Published conclusions of "no dif-
fERENCE" without an inclusion of a statistical power
analysis are contested (e.g., Winklermann et al. 2000). We are aware of our small sample size. However, the observed differences in the variables between the
two sexes are so small that they are not expected to be of great importance, in biological terms, even if the sample size were increased enormously. Cohen (1969) provides help in calculating the power of statistical tests. In our case, power = 0.65 or P = 0.05 trilogy to effective size d = 0.13. Note that if we assume that the differences between the two sexes reported above are negligible, we would need sample sizes that are so large that the associated "power" of the null hypothesis is probably quite often impossible (Milliken 1997). Using Cohen's (1965) desired power criterion of 0.80, our sample size needed would be n = 932 as P = 0.05 for each simple.

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