ROOSTING BEHAVIOR OF THE EXPLODING BUTTERFLY, *MANATARIA MACULATA*

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Abstract: Although the structure of highly organized social insect societies, such as those of Hymenoptera and Isoptera, has been extensively studied, little is known about the structure of Lepidopteran social groups. In Lepidoptera, sociality is evident in clustered egg laying, larval foraging groups, and group roosting in adults. The daytime group roosting behavior of *Manataria maculata* at Monteverde, Costa Rica is acknowledged but not well understood. Our study attempted to determine whether this migratory butterfly exhibits site and group fidelity when roosting. Based on observations of group and nest fidelity in other insect families, we predicted that *M. maculata* would a) not mix between roosting groups and b) be found at the same roost sites on consecutive days. We performed a mark-recapture study over four days and determined that the social behavior of *M. maculata* is more fluid than predicted. Our results demonstrate that site fidelity is low and that individuals not only move between groups, but also can potentially travel large distances (over 300 m) in the course of one day.

Key Words: Monteverde, cloud forest, Costa Rica, social behavior, roosting, Lepidoptera, Nymphalidae, Satyrinae

INTRODUCTION

The advantages of sociality for insects include early warning against predators, reduced likelihood of predation per individual, social facilitation of foraging, kin-associated fitness benefits, thermoregulation, and improved mating opportunities. Disadvantages include increased conspicuousness, greater transmission of pathogens and parasites, and intraspecific competition for resources (Costa and Pierce 1997, Altringham 1996). Social behaviors, such as laying eggs in clusters and communal roosting, have been observed in some species of Lepidoptera. Social communication and cooperation in this order are generally simpler than in the more behaviorally complex eusocial societies of Hymenoptera and Isoptera. Nonetheless, Lepidopteran aggregations are not as well studied, perhaps because they are eclipsed by the more elaborate behavior of eusocial insects (Costa and Pierce 1997).

The tropical butterfly *Manataria maculata* (Nymphalidae: Satyrinae) is an altitudinal migrant that is frequently observed roosting in shaded embankments, tree holes, and other dark hiding places.

Manataria maculata roost in groups during the day, leaving the roost occasionally to forage. At night, they roost individually in the canopy. Daytime group size can range from only a few individuals to over four dozen. Although the larval life history of *M. maculata* is relatively well understood (DeVries 1987, Nadkarni and Wheelwright 2000), studies of the social behavior of adults are rare.

The aim of our study was to understand the structure of *M. maculata* social groups. Several insect families, including Lepidoptera, have been shown to exhibit fidelity to a roosting site over a variety of time periods (Adams 1999). Therefore, we hypothesized that *M. maculata* would have distinct daytime social groups which do not mingle and which exhibit site fidelity. We predicted that we would not find *M. maculata* from one roost site mixed with those from another, and that we would find butterflies returning to the same roost sites over several consecutive days.

METHODS

Field site.

We conducted our study on 19-22 January, 2007, between 0730 and 1630 each day, in the cloud forest immediately surrounding the Estación Biológica Monteverde (elevation 1560 m). We used a total of six roost sites located along various trails around the station (Table 1, Figure 1). A typical roost site of *M. maculata* is located underneath a small overhang in a damp earth bank, about 1.5 m above the ground, surrounded by roots and vegetation. The average dimensions of the six roost sites were 22 cm x 13 cm x 11 cm.

Table 1: Descriptions of six *Manataria maculata* roosting sites located in the sides of damp embankments and rotting trees at the Estación Biológica Monteverde.

Site #	Description
1	Under an overhang in a very damp earth bank, surrounded by vegetation (moss and ferns), on the uphill side of the trail directly above the bridge.
2	Under an overhang in a damp earth bank, a 5 minute walk down the first right fork above the bridge, on the uphill side of the Jilquero Trail.
3a	Inside a very moist hollow log on the left of the Principal Trail leading uphill from the bridge, a 15 minute walk up the first left fork above the bridge.
3b	Under a large root in an earth overhang in a bank on the uphill side of the Principal Trail, about 4 m beyond site 3a.
5	Beneath overhanging bromeliads and orchids at the top of a rotten upright tree stump, located along a trail in the forest behind the field station, near the zipline tower. Unlike the areas around the other sites, the area around this site did not appear to offer alternative roost sites (such as earth overhangs).
6	Under a moist earth overhang in the bank on the uphill side of the trail 30 m short of the waterfall pool.

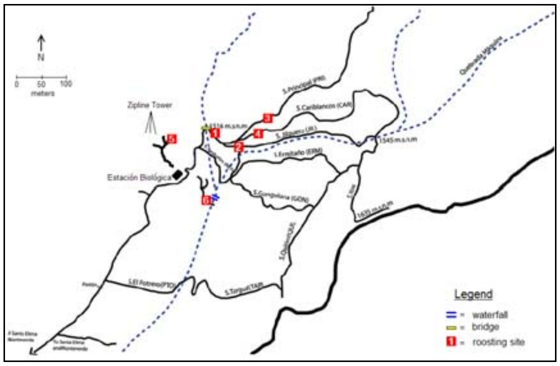

Figure 1: *Manataria maculata* roosting sites we studied were located along the trails around Estacion Biologica at Monteverde. Additional site descriptions are provided in Table 1.

Field methods.

When roosting *M. maculata* are disturbed, the entire group emerges simultaneously; our procedure took advantage of this behavior. After locating *M. maculata* in a roost, we netted the entire group as it flew out. We then removed each individual and processed it at the site of capture, either marking both hindwings with a permanent marker or noting the presence of previous markings. We used unique markings for each site. We recorded the total number of unmarked individuals, the number of previously marked individuals, and the site where each marked individual originated. If we failed to capture any individuals at a given site, or if no *M. maculata* were present, we allowed a minimum of two hours to pass before re-visiting the site.

Ideally, we would have visited each site at the same time each day. However, the inclusion of new sites over the course of the study, the realization that *M. maculata* take several hours to return to their roost after being disturbed, and our academic schedule at the field site all combined to prevent us from visiting the roosts at the same time each day. On the afternoon of Day 1 (19 January) we visited sites 1 through 5. On Day 2, we visited the sites in the morning and the afternoon, discarding Site 4 due to an absence of *M. maculata*, and adding Site 6. On Day 2 we released 53 unmarked individuals, but afterwards switched to marking all captured individuals because we realized that we would not have enough replicates unless we continued marking over the remaining days of the study. On Days 3 and 4, we only visited the sites in the morning and split Site 3 into Site 3a and Site 3b. We attempted to control for time of day by beginning our sampling at approximately 0730. *Statistical analysis:* We used our mark-recapture data to obtain an estimate of the population size of *M. maculata* within the study area (about 40,000 m^2, Fig 1) using the Lincoln Index.

RESULTS

We observed a total of 302 *M. maculata* at all the roosts over four days. Of those, 97 individuals escaped, 205 individuals were captured, and we marked 152 individuals. Eighteen of the butterflies we marked were subsequently recaptured. Of those 18 butterflies, 15 butterflies were found at the sites at which they had been marked; the remaining three butterflies were found at other sites. One individual was marked at Site 5 and recaptured at a later date at Site 3, approximately 300 m away (Figure 1). Over the four days of the study, we also observed a general decrease in the number of *M. maculata* roosting in each site (Figure 2).

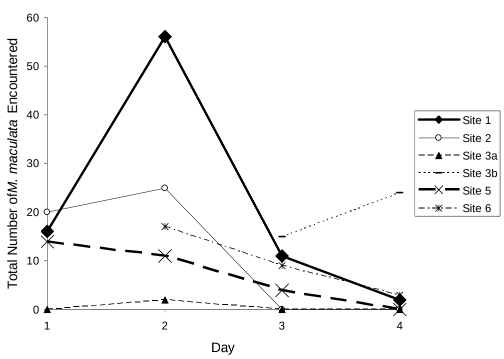

Figure 2. We observed a general decrease in the number of *Manataria maculata* per site over the four days of our study (day 1 = 19 January, 2007). Here, we exclude data collected in the afternoon of days 1 and 2 because afternoon data were not consistently collected across all four days of the study period.

On Day 4 we captured 25 butterflies, three of them marked. Given that we marked a total of 152 individuals, we calculated the population in our 40,000 m^2 (0.04 km^2) study area to be 1267 individuals.

DISCUSSION

Our data refute our hypotheses that *M. maculata* have distinct daytime social groups and exhibit site fidelity. Instead, our results show that site and group fidelity was not steadfast. Rather, the roosting groups intermingled, and the population of *M. maculata* that used a roost was larger than the number of butterflies found there at any given time. Although we observed many small overhangs in the banks along the trails in the study area, only a few appeared to be consistently used by *M. maculata*. Therefore, we believe there are specific features of these roosting sites, such as nutrient concentrations or pheromone markers, which encourage *M. maculata* to return. This hypothesis warrants further investigation.

Based on our observation that the number of butterflies roosting in the morning tended to decline over the four days of study, we suggest that *M. maculata* could 1) periodically change roosting location, or 2) abandon roosts if frequently disturbed. These possibilities are not mutually exclusive. Despite our efforts to minimize disturbance to the roosts, we may have discouraged *M. maculata* from returning to our study sites each day. Trauma or injury from being handled, a large source population, and the release of 53 unmarked individuals on Day 2 could also explain our low recapture rate.

Our estimate of population size may violate several of the assumptions of mark-recapture population size estimates, including random mixing and equal survival of marked and unmarked animals. These factors could result in either an underestimate or an overestimate of population size, respectively. We consider our estimate of population size to be surprisingly high, especially since rarity is common in the tropics.

A number of questions concerning the social behavior of *M. maculata* remain unresolved. Studies on the foraging behavior of this species could examine how *M. maculata* sociality varies throughout the day. Further, a genetic analysis of roosting groups would reveal whether or not kinship determines group composition. Finally, it is unknown whether the roosting behavior exhibited at Monteverde persists at the lower elevations of *M. maculata*'s range. More detailed knowledge of the group roosting behavior of *M. maculata* could contribute to the sparse literature on Lepidopteran sociality in the adult insects (Costa and Pierce 1997, Murillo and Nishida 2003).

LITERATURE CITED

Adams, A. Y. 1999. "Communal roosting in insects." Retrieved 22 January 2007 from the World Wide Web: http://www.colostate.edu/Depts/Entomology/courses/en507/papers_1999/yackel.htm.

Altringham, J. D. 1996. Bats: Biology and Behaviour. Oxford University Press. Oxford, NY.

Costa, J. T. and N. E. Pierce. 1997. "Social Evolution in the Lepidoptera: Ecological context and communication in larval societies." Pages 407-442 in J. C. Choe and B. J. Crespi, editors. Social Behavior in Insects and Arachnids. Cambridge University Press: Cambridge ,UK.

DeVries, P. J. 1987. The butterflies of Costa Rica and their natural history: Papilonidae, Pieridae, Nymphalidae. Princeton University Press. Princeton NJ.

Murillo, L. R. and K. Nishida. 2003. Life history of *Manataria maculate* (Lepidoptera: Satyrinae) from Costa Rica. Rev. Biol. Trop. 51:2.

Nadkarni, N. M. and N. T. Wheelwright, editors. Monteverde: Ecology and conservation of a tropical cloud rainforest. 2000. Pages 119-120. Oxford University Press, Oxford NY.