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Effect of Habitat Disturbance on Colony Productivity of the Social Wasp *Mischocyttarus consimilis* Zikán (Hymenoptera, Vespidae)

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Abstract

Social wasps are important elements of the fauna in a variety of environments, including human-modified environments. Evidence indicates that habitat quality affects the growth of colonies of social wasps in urban environments. This study investigated whether the colony productivity of the social wasp *Mischocyttarus consimilis* Zikán is affected by loss of habitat quality in a human-occupied environment. Nests of *M. consimilis* were collected in forest and urban environments between January 2010 and June 2011. Only nests that reached the declining stage were sampled. As productivity parameters, we measured the total number of cells constructed, the total number of adults produced and dry mass of the nests. Productivity was significantly lower in urban than in forest environments for all parameters analyzed. Habitat quality is probably the principal factor that contributed to the lower productivity in the urban environments. In this type of environment, particularly where the study was conducted, the vegetation adjacent to the nesting sites was composed predominantly of grasses. Such habitats may have limited available resources, especially those used by wasps for feeding the larvae, such as immatures of other insects. This result suggests that human degradation of habitats negatively affects the final productivity of colonies of social wasps.

Introduction

Anthropogenic disturbance of natural habitats is one of the main factors that contribute to reduction of the biodiversity in tropical environments (reviewed in Samways, 2005; 2007). The effect of habitat on the colony dynamics of social insects has been examined in several studies (Santos & Gobbi, 1998; Inagawa et al., 2001; Gamboa et al., 2005). However, few studies have evaluated the effect of habitat modification by humans on the development of colonies in a tropical environment (Penna et al., 2007; Montagna et al., 2010). Evidence that human presence alters habitat quality has been reviewed recently by Raupp et al. (2010) and Schowalter (2012). The modification of natural habitats is due mainly to the progress of agriculture and livestock raising, as well as to urbanization (Abensperg-Traun & Smith, 2000; reviewed in New, 2005; reviewed in Raupp et al., 2010).

Social wasps are important elements of the fauna in many environments and important predators of other arthropods in tropical regions (Gould & Jeanne, 1984; Gobbi & Machado, 1986; Prezoto et al., 2005). In the tropics, many social wasps are facultatively synanthropic, occurring abundantly in both forest and urban environments (Fowler, 1983; Curtis & Stamp, 2006; De Oliveira et al., 2010). A recent approach suggests that nesting behavior in social insects is influenced by several ecological variables, including competition, foraging efficiency, microclimate, nest deterioration, nest quality, parasitism, predation, seasonality, and colony growth (reviewed in McGlynn, 2012). The wide range of nesting sites on human constructions and low interspecies competition may partly explain the facultative occurrence of some social wasp species in urban environments (Giannotti & Mansur, 1993; Prezoto et al., 2007; De Oliveira et al., 2010). However, synanthropic colonies of social wasps are directly exposed to the effects of human interference in the



habitat (Curtis & Stamp, 2006).

Habitat quality is one of the principal factors that influence the colony dynamics of social wasps (Inagawa et al., 2001; Gamboa et al., 2005; D'Adamo & Lozada, 2007). It has been suggested that habitat quality is reduced drastically with increased urbanization (reviewed in Raupp et al., 2010; reviewed in Schowalter, 2012). Therefore, it is expected that the low habitat quality in urban environments negatively affects the development of the social insect colonies. In the urban environment, as a direct consequence of the human-caused habitat degradation, the foraging areas surrounding the colony consist mainly of grasses, suggesting that this type of habitat offers less resources compared to sites where the original vegetation is preserved (Gould & Jeanne, 1984). For example, Naug and Wenzel (2006) demonstrated that the supply of resources in the surroundings of the nests was the main limiting factor on colony growth in *Ropalidia marginata* (Lepeletier). Similarly, Mead and Pratte (2002) demonstrated that differences in local resource availability among populations of the social wasp *Polistes dominula* (Christ) resulted in considerable differences in terms of nest growth and production of offspring.

Mischocyttarus consimilis Zikán is a Neotropical social wasp with a distribution restricted to Paraguay and the southern region of the state of Mato Grosso do Sul (Richards, 1978; Montagna et al., 2009). Colonies of *M. consimilis* are usually established by a single female, and the nests are composed of a single, uncovered comb that is attached to the substratum by a single, central petiole (Montagna et al., 2010). Colonies of this species found and abandon their colonies throughout the year (Torres et al., 2011). This species can be considered facultatively synanthropic, since it is abundant in locations affected by intense movement of people, as well as in forest environments (Montagna et al., 2010). This study investigated the effect of habitat disturbance on colony productivity of the social wasp *M. consimilis*.

Material and Methods

Data collection and field procedures

To evaluate the effects of the human-caused habitat disturbance on colony development, we compared the final productivity of colonies of *M. consimilis* located in a forest environment (conserved habitat) and an urban environment (disturbed habitat), in the municipality of Dourados (22°13'16''S; 54°48'20''W) in the state of Mato Grosso do Sul. We collected 11 abandoned nests in each environment during January 2010 to June 2011. Colonies in the selected areas were monitored weekly to determine the end of the colony cycle. Only nests that reached the declining stage (widespread presence of empty cells in the comb and nest abandonment), as defined by Jeanne (1972), were used in the

sample. As productivity parameters we measured the number of constructed cells, number of adults produced, and dry mass of the nest. The number of adults produced was estimated by counting the number of layers of meconium in each cell of the comb. The meconium layer is formed on the floor of the productive cells as a result of the elimination of feces by the last-instar larva, just before pupation (Gobbi & Zucchi, 1985; Giannotti, 1999). The meconium layer was removed in the laboratory with the aid of tweezers, sectioning each cell of the comb. For analysis of the nest dry mass, the nest was placed in a separate Petri dish, and then dried in a vacuum chamber for 24 h and immediately weighed on a precision balance.

Study sites

The forest environment selected in this study belongs to an environmental preservation area known as the "Reserva do Coqueiro", located 10 Km from the urban perimeter of the city of Dourados. The Reserva do Coqueiro is composed predominantly by a preserved forest, traversed by a road that leads to approximately a dozen camp-houses adjacent to the forest. The camp-houses are used mainly for recreational events and remain closed most of the year. Human traffic in that area is sparse. All the nests collected in the reserve were located on the edges of the camp-houses.

The contrasting urban environment is in a residential area known as the "Cidade Universitária", near the campus of the Universidade Federal da Grande Dourados. This area is undergoing rapid development, with extensive new construction in progress. The areas adjacent to the buildings are predominantly grassed or covered by sidewalks or asphalt, and human traffic is intense year-round. All the nests collected in this environment were located on the edges of occupied houses and university buildings.

Statistical analysis

The t-test for two independent samples was used to evaluate possible differences in colony productivity parameters between the two wasp populations. We performed a correlation analysis between the number of individuals produced and the number of cells constructed, to evaluate possible differences in strategies of comb use between the two populations. For all analyses, the variable was considered when the resulting regression coefficient was significant at the 0.05 level.

Results

For nests in the forest environment, the mean values (\pm SE; $n=11$) were: number of adults produced, 250.6 ± 6.62 ; number of constructed cells, 215 ± 22.8 ; nest dry mass, 1.11 ± 5.66 g; proportion of productive cells, $67.4 \pm 39.6\%$; pro-

portion of reused cells, $37.3 \pm 6.85\%$; and number of adults produced per cell, 1.09 ± 0.13 (Table 1). In this environment we found a significant positive correlation between the number of cells constructed and the number of adults produced ($r=0.84$; $p<0.01$; $n=11$) (Fig. 1).

For nests in the urban environment, the mean values (\pm SE; $n=11$) were: number of adults produced, 131.9 ± 4.69 ; number of constructed cells, 142.2 ± 13.4 ; nest dry mass, 0.59 ± 5.70 g; proportion of productive cells, $56.2 \pm 20.2\%$; proportion of reused cells, $39.3 \pm 5.91\%$; and number of adults produced per cell, 0.98 ± 0.09 (Table 1). In this environment, the correlation analysis was significantly posi-

tive between the number of constructed cells and the number of adults produced ($r=0.64$; $p=0.03$; $n=11$) (Fig. 1).

Productivity in the urban environment was significantly lower than in the forest environment with respect to the number of adults produced ($t=-2.35$; $df=13.69$; $p<0.05$), number of cells constructed ($t=-3.08$; $df=17.80$; $p<0.01$), and dry mass of nests ($t=-3.51$; $df=15.16$; $p<0.01$) (Table 1). In contrast, the proportion of productive cells ($t=-1.59$; $df=19.73$; $p=0.12$), proportion of reused cells ($t=0.25$; $df=19.93$; $p=0.8$), and number of adults produced per cell ($t=-1.04$; $df=17.68$; $p=0.3$) did not show significant differences between the two environments (Table 1).

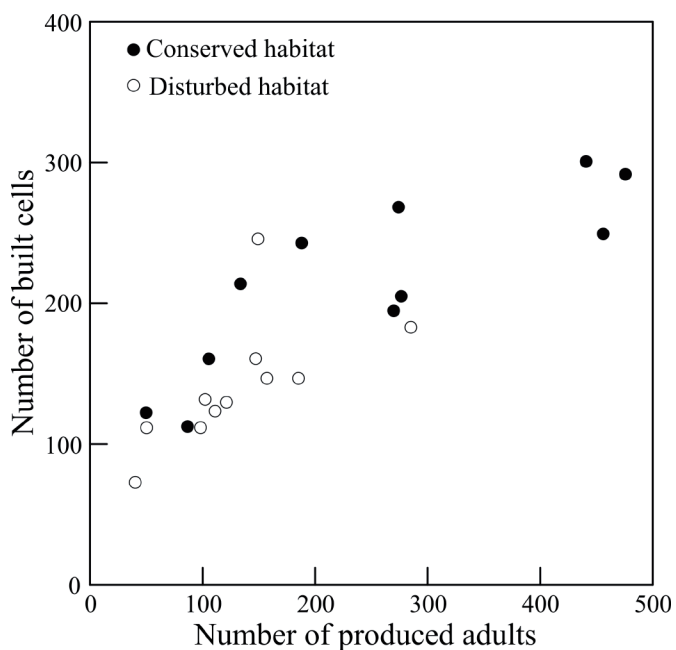


Figure 1. Correlation between the number of cells constructed and adults produced per colony of the social wasp *Mischocyttarus consimilis* nesting in conserved and disturbed habitat.

Discussion

Colony productivity for *M. consimilis* was determined by the size of the nest in both environments, with larger nests being more productive. However, nests collected in the urban environment were less productive than nests collected in the forest environment, as estimated by the number of cells constructed, number of adults produced, and dry mass of nests. Montagna et al. (2010), studying colonies of *M. consimilis* in an urban environment, found a mean productivity of 72.9 ± 10.5 and 40.7 ± 14.0 , for the number of cells constructed and adults produced, respectively. The productivity found by Montagna and coworkers is lower than in our study; however, the authors evaluated only colonies in the post-emergence stage. Our results and those of Montagna and coworkers suggest that colony productivity in tropical social wasps is affected by the habitat quality, and an increase in urbanization negatively influences the development of the colonies. Particularly in the study locale, the vegetation adjacent to the nesting sites was composed predominantly of grasses. Studies demonstrate that habitats with those characteristics have low availability of resources, especially prey used by

Table 1. Comparison of the colony productivity of the social wasp *Mischocyttarus consimilis* nesting in conserved and disturbed habitat.

Parameter	Conserved habitat			Disturbed habitat			T	P
	N	Mean	SE	N	Mean	SE		
Built cells	11	215	22.8	11	142.2	13.4	-3.08	0.006
Produced adults	11	250.6	6.62	11	131.9	4.69	-2.35	0.03
Nests dry mass (g)	11	1.11	5.66	11	0.59	5.7	-3.51	0.003
Productive cells (%)	11	67.4	39.6	11	56.2	20.2	-1.59	0.12
Reused cells (%)	11	37.3	6.85	11	39.3	5.91	0.25	0.8
Adults produced/cell	11	1.09	0.13	11	0.98	0.09	-1.04	0.3

n = nest number; SE = standard error.

social wasps to feed the larvae (Gould & Jeanne, 1984; Raw, 1998; Nadeau & Stamp, 2003). Mead and Pratte (2002) suggested that the low availability of prey in a disturbed habitat negatively affects the food allocation rates for the colony, leading to deficient feeding of the larvae. Poorly fed larvae have longer development periods, thus reducing the capacity to reuse the comb to produce more adults.

A reduction of the colony cycle in wasp nesting in an urban environment is another factor that may have contributed to the lower productivity in this environment. Although it was not possible to quantify this parameter, field observations during the study period indicated that colonies in the urban environment generally had shorter cycles than colonies in forest environments. Torres et al. (2011) noted that the colony cycle of *M. consimilis* in a urban environment lasts approximately eight months, but can exceed one year in forest environments. The various human effects on the habitat can cause disturbances that could, on average, shorten the colony cycle. This appears to be a likely reason for the shortening of the colony cycle in *M. consimilis*, since in tropical regions, wasp colonies can ordinarily remain active year-round because climatic variables do not impose restrictions on the colony's activities (Gobbi & Zucchi, 1980; Giannotti, 1997; Torres et al., 2011).

There was no evidence that the different wasp populations use different strategies with respect to the use of the comb. The number of adults produced per cell as well as the proportions of reused and productive cells did not differ between the two populations. This result eliminates a possible strategy of a difference in use of the comb between the two wasp populations. Montagna et al. (2010), studying this same species, demonstrated that old cells in the comb were more often used to produce adults. Similarly, Inagawa et al. (2001) observed an association between the proportion of productive cells and adult production, and did not find evidence for differentiated use of the comb among different populations of the social wasp *Polistes snelleni* (Saussure).

Despite the considerable reduction in the colony productivity, the social wasp *M. consimilis* usually nested in urban environments. The availability of nesting sites on human constructions, especially edges of houses and building may help to explain the optional occurrence of this species in this type of environment (Clapperton, 2000; Mead & Pratte, 2002). In the same way, synanthropic nesting would be selected if the predation rate by vertebrates and interspecific competition are lower in environments occupied by humans compared to forest environments (Judd, 1998; reviewed in McGlynn, 2012).

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