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SHORT COMMUNICATION

Feeding Activity of the Flatid Planthopper *Metcalfa pruinosa* (Hemiptera: Fulgoroidea)

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Temporal partitioning of daily activities has been posited as a means of decreasing interspecific competition or avoiding predation. The ecological significance of temporal partitioning, particularly in mammals, was recently summarized by Kronfeld-Schor and Dayan (2003). Behavioral studies of daily activity times can be critical for understanding migration, feeding, and reproduction. Studies on insect daily temporal differences in activity include dung colonizing beetles (Cavency *et al.*, 1995), territorial defense in male *Epitheca* dragonflies (Paulson, 1973), calling regimes of cicadas (Gogala and Riede, 1995; Reide and Kroker, 1995), and overlap in daily activity of two aphid predator guilds (Losey and Denno, 1999). The daily changes in light intensity that occur at dawn and dusk can serve as cues that trigger activities ranging from local movements to long-distance migrations. Factors influencing these migrations in some delphacid planthoppers, may include light intensity, temperature, lack of wind, and the lunar cycle (Jeffrey and Dyck, 1983; Kisimoto and Rosenberg, 1994).

The North American flatid planthopper *Metcalfa pruinosa* (Say) (Hemiptera: Flatidae), which has spread throughout much of southern Europe since its introduction some thirty years ago, has been the focus of a number of morphological, ecological, and behavioral studies (Alma, 2000; Wilson and Lucchi, 2000, 2001; Lucchi and Mazzoni, 2004). In Europe, this insect can reach high densities on a variety of economically important woody plants. These planthoppers feed by sucking phloem sap and produce copious amounts of honeydew because they lack a filter chamber and have a midgut cellular membrane which prevents the efficient uptake of sugars (Lucchi *et al.*, 1999). Honeybees (*Apis mellifera* L.) (Hymenoptera: Apidae) collect honeydew produced by *M. pruinosa* and utilize it to manufacture honey (Lucchi, 1997). This honey is harvested by apiarists in Italy and southern France and marketed as "Meile di Melata di *Metcalfa*" (=*Metcalfa* honey) (Lucchi, 2000). Field observations indicate that honeybees collect most of the honeydew in the early morning and at sunset (Barbattini *et al.*, 1997). This restriction of honeybee activity to these times is likely due to the relative availability of honeydew and the fact that honeydew dries quickly during the heat of the day.

In the present study we detailed the feeding activity schedules of fifth instar nymphs and adults of *M. pruinosa* by measuring honeydew production.

Materials and Methods

Experiments were conducted under ambient conditions on Japanese pittosporum shrubs (*Pittosporum tobira* (Thunb.) W. T. Aiton) (Pittosporaceae) in Marina di Carrara, Italy. Ten *Metcalfa pruinosa* fifth instar nymphs or ten adults, collected from pittosporum plants in the vicinity, were placed in 10 cylindrical cages each running through a twig of pittosporum (Fig. 1). The experiment was conducted over 5 consecutive days, from 7 to 11 July 2001, for nymphs in their 10 cages and 6 consecutive days, from 13 to 18 August 2001, for adults in their ten cages. Each cage was constructed of a plastic cylinder (80 mm. high, 60 mm. diam.) with a plastic screw cap on the bottom and a 155 mm. cylinder of fine netting glued to the top of the cage. The netting was slipped over a ca. 100 mm. length of pittosporum twig, from which the leaves had been removed, and tied tightly around the twig at ca. 100 mm. from the top of the plastic portion of the cage. A 60 mm. diam. construction paper disc was placed in the bottom of each cage and left for 8 hours. At the end of 8 hours the disc was removed and the number of ca. 1 mm. diam. honeydew droplets was counted (Fig. 2). The aggregate of the honeydew droplet counts was calculated for each filter

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Fig. 1. Honeydew collection cage in a pittosporum shrub.

disc and served as an index of relative feeding activity. For comparative purposes, the 24 hour day was divided into three 8 hour periods (+1 GMT): day (08:00–16:00 h), evening (16:00–24:00 h), and night (00:00–08:00 h). The index of the amount of honeydew for each of the three daily periods among nymphs and among adults was analyzed via one-way analysis of variance (Roscoe 1975).

Results and Discussion

Metcalfa pruinosa fifth instar nymphs and adults produced significantly more honeydew during daylight hours (08:00–16:00 h) than either evening (16:00–24:00 h) or night (00:00–08:00 h) (F_{nymphs} = 9.83; d.f. = 2, 139; $P < 0.001$; F_{adults} = 15.141; d.f. = 2, 179; $P < 0.001$; Table 1). During the course of the study, daily temperatures ranged from 17.4 to 28.2 C for nymphs and 15.0 to 35.4 C for adults (Weather Archive, Pisa/S. Giusto (Italy); Russia's Weather Server 2006). Lower night time temperatures may have had some effect

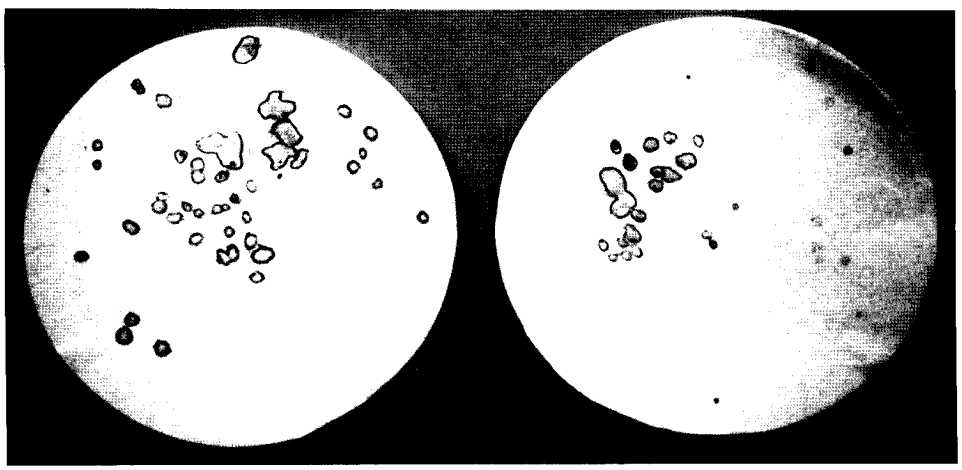

Fig. 2. Paper discs laden with honeydew droplets outlined by black lines.

Table 1. Indices of the mean (X ± SD) and total amount of honeydew produced by *Metcalfa pruinosa* nymphs and adults during night (00:00–08:00), day (08:00–16:00), and evening (16:00–24:00) as measured across the widest point of each droplet (in mm) (Nymphs: $N_{day, evening} = 50$, $N_{night} = 40$; Adults: N = 60).

Time	Nymph X ± SD	Adult X ± SD	Nymph Total	Adult Total
Night	2.2 ± 4.28	4.6 ± 4.23	89.0	279.0
Day	10.8 ± 13.84	11.2 ± 10.09	541.0	671.5
Evening	4.1 ± 8.19	5.5 ± 5.58	203.0	328.5

on honeydew output; however, the lower range of temperatures was still relatively warm and studies on mating activity indicate that adults are particularly active at night (Zezlina and Virant-Doberlet, in press). Feeding activity schedules inferred from the honeydew production data suggest that nymphs and adults spend most of the daylight hours feeding and that local movement of nymphs and dispersal and mating of adults occurs at night.

Metcalfa pruinosa nymphs are found in dense conspecific assemblages in Europe and in small, widely scattered mixed-species assemblages, consisting of *M. pruinosa*, *Anormenis chloris* (Melichar), *Ormenoides venusta* (Melichar) (Flatidae), and *Acanalonia conica* (Say) (Acanaloniidae) in North America (Wilson and McPherson, 1980; Wilson and Lucchi, 2000, 2001). The means by which nymphs aggregate is unknown but likely involves attraction to plant volatiles and/or signals produced by nymphs. Although adults call via substrate vibrations, nymphs apparently do not (Virant-Doberlet, pers. comm.). Nymphs do have large numbers of exoskeletal pits (Lucchi and Santini, 1993), which suggests the possibility of aggregation pheromones; however, pheromones have not been definitively recorded for any Auchenorrhyncha. The feeding activity data indicate that nymphs form feeding site aggregations at night and spend the daylight hours in these aggregations, which are covered with white wax produced by the nymphs. These groups of wax covered nymphs somewhat resemble bird droppings and may serve as visual camouflage and/or be chemically distasteful to predators (Wilson and McPherson, 1981).

Metcalfa pruinosa adults disperse soon after eclosion and begin mating about one month thereafter (Santini and Lucchi, 1994, 2000). Calling behavior via substrate vibrations on their host plants mainly occurs between midnight and 04:00, as does copulation (Santini and Lucchi, 1994; Zezlina and Virant-Doberlet, in press). Adults are particularly sensitive to light and significantly reduce calling activities under lighted conditions (Zezlina and Virant-Doberlet, in press). Adult feeding activity supports the contention that feeding occurs during daylight hours, whereas dispersal, mating, and oviposition occur at night. As suggested by Zezlina and Virant-Doberlet (in press), three selective agents may limit non-feeding activities to night time hours: 1) visual predators, such as spiders and birds, 2) thermoregulation, limiting activity to the coolest part of the summer day, and/or 3) temporal partitioning of the acoustic environment by the members of the planthopper mixed-species feeding assemblages.

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