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SHORT COMMUNICATION

Insect attraction by webs of *Nephila clavipes* (Araneae: Nephilidae)

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Abstract. Although well studied, the role of spider webs in attracting prey and the role of web ornaments remain open questions. We carried out a field study to determine whether webs of *Nephila clavipes* (Linnaeus 1767) attract insects. *Nephila* builds large orb-webs with debris-decoration that host kleptobiotic *Argyrodes* spiders. We studied the potential prey of *Nephila* with sticky traps placed in two similar linear plots. One plot contained 20 *Nephila* webs, and the other was cleared of *Nephila* webs. We measured the number and size of the insects caught in the traps. We compared the size of the trapped insects with prey caught by *Nephila* and gleaned by *Argyrodes*. In the plot with *Nephila* webs we collected 314 individuals versus 105 individuals in the plot without *Nephila*. Species of Diptera and Coleoptera were captured most frequently. Four saprophagous families, Phoridae and Sciaridae (both Diptera), Staphylinidae and Elateridae (both Coleoptera), were more abundant in the plot with *Nephila* webs. We show for the first time under natural conditions that prey attraction is most efficient for saprophagous insects, suggesting that the debris-decoration in *Nephila* webs attracts this guild. We also found that the size of some insects captured does not correspond to the range of prey consumed by *Nephila*, but to that of kleptobiotic *Argyrodes* spiders. We hypothesize that the debris-decoration may be used by *Nephila* as a strategy to limit food competition with *Argyrodes*.

Keywords: Prey attraction, debris-decoration, kleptobiosis, food competition

Among theories proposed to explain the existence of ornamentation on spider webs, the prey attraction hypothesis has been most extensively tested and discussed (Blackledge & Wenzell 1999; Herberstein et al. 2000). However, Gonzaga & Vasconcellos-Neto (2005) and Chou et al. (2005) showed that the linear detritus stabilimenta built by *Cyclosa* species (Araneidae) do not increase prey capture, but rather have an anti-predator function. Another function of stabilimenta, described for *Gasteracantha cancriformis* (Linnaeus 1758) (Araneidae), is a warning to large animals that could destroy webs (Jaffé et al. 2006). Champion de Crespigny et al. (2001) showed that *Nephila edulis* (Labillardière 1799) (Nephilidae), a species with a relatively permanent web, incorporates a prey cache on which it feeds during periods of food shortage. Most studies, however, describe stabilimenta as a strategy to attract prey. For example, the experimental study of Bjorkman-Chiswell et al. (2004) showed that a band of decaying carcasses and plant matter built by *N. edulis* attracts sheep blowflies.

In *Nephila clavipes* (Linnaeus 1767) (Nephilidae) adults build stabilimenta made of decaying matter (Fig. 1), generally insect carcasses (Hénaut et al. 2005). These authors observed that numerous insects captured by the web are too small to be consumed by *Nephila* but are gleaned by kleptobiotic *Argyrodes* spiders (Theridiidae). Our field study tested the role of *N. clavipes* webs in attracting insects and looked at the possibility that *Nephila* has a strategy to provide a supply of food to the kleptobiotic spiders. To approach these questions we identified the trophic characteristics (at family level) and size of the potential prey in the environment to determine which guilds of prey are attracted, and also, if they fall within the range of prey sizes consumed by *Nephila* or *Argyrodes* spiders.

The work was conducted at the edge of a coffee plantation in Southern Mexico. The study area was established along big trees and barbed wire fences. For further details on the study area, see Hénaut et al. (2005). The *Nephila* webs were distributed regularly in a row along the fence, built on the fences or between the fences and trees. The area was a 200-m long, homogeneous linear transect with 40 *Nephila* webs. We divided the area into two consecutive plots of 100 m each (20 *Nephila* webs in each plot). The first plot was called "with *Nephila*" (*Nephila* spiders and their webs were left in this plot), the other was called "without *Nephila*" (20 *Nephila* webs with their spiders were removed). Identification of experimental spiders was based on voucher specimens deposited in the collection of the Laboratorio de Ecoetología de Artrópodos in Ecosur, Tapachula, Mexico.

The study was carried out at the end of the rainy season (November 2003), when *N. clavipes* and their prey were numerous. At this time *Nephila* spiders are adult, and their webs are not destroyed by heavy rain.

To determine the capture rate of potential prey, eight sticky traps per plot were set up. The traps, similar to those used by Hénaut et al. (2006), were hung one meter above the ground, less than one meter from one side of each *Nephila* web on the plot with *Nephila*, and every 10 meters in the plot without *Nephila*. The sticky traps were made of a transparent plastic board (30 × 20 cm) coated with Tangle Foot © (The Tanglefoot Company, Grand Rapids MI 49504 USA). Captures were repeated over two 24-h periods using different traps and renewed webs.

Trapped insects were preserved in 70% ethanol before being counted, identified, and measured in the laboratory under a binocular microscope. We determined the number of individuals per order for each plot (with or without *Nephila*). Individuals were identified to the family level only for the orders in which the number of individuals was significantly different between the two plots. Some prey individuals (49 insects in the plots with *Nephila* and 30 insects in the plots without *Nephila*) could not be identified. We measured the length of each prey item from the extreme anterior point of the head to the hindmost part of the abdomen. The mean body length of insect families (mean ± SE) was also calculated for the most frequent families.

Figure 1.—A web of *Nephila clavipes*. A general view and a focus on debris-decoration: a = plant remains, b = prey remains.

The total number of insects per trap, the number of insects of the most abundant orders, the number of saprophagous insect families, and the number of insects of the two most abundant saprophagous families were compared between the two experimental plots using one-way ANOVA after square root transformation of the response variables.

We collected three times more insects in the plot with *Nephila* (363 individuals: 10 orders and 42 families) than in the plot without *Nephila* (135 individuals: 9 orders and 28 families). The mean number of insects per trap was significantly greater in the plot with *Nephila* than in the plot without *Nephila* (22.7 ± 1.9 *vs.* 8.1 ± 1.0 respectively; $F_{1,30} = 38.89$, $P < 0.001$). The number of individuals per order was also always higher in the plot with *Nephila* (Table 1). For five orders with more than 10 individuals captured, the difference was statistically significant (Table 1).

For orders that presented a significant difference between plots, we analyzed the number of individuals per family. Few families presented significantly more individuals in the plot with *Nephila* (Diptera: Phoridae, Sciaridae, Dolichopodidae; Hymenoptera: Formicidae; Homoptera: Cicadellidae) and only one family of Diptera (Chironomidae) presented significantly more individuals in the plot without *Nephila* (Table 2).

From the five families that differed in abundance between plots, three were saprophagous (Phoridae, Sciaridae, and Dolichopodidae) according to Borror & DeLong (1981). Four other saprophagous families (Otitidae, Drosophilidae, Sphaeroceridae, Mycetophelidae)

Table 1.—Comparison of the total number of invertebrates of 11 orders captured in traps on two plots. Comparisons by means of ANOVA were made only for orders represented by more than 10 individuals.

Order	*Nephila* present	*Nephila* absent	ANOVA
Diptera	213	62	$F_{1,30}$ = 41.63, $P < 0.001$
Coleoptera	68	44	$F_{1,30}$ = 1.87, P = 0.181
Hymenoptera	32	8	$F_{1,30}$ = 12.04, P = 0.002
Homoptera	22	12	$F_{1,30}$ = 2.28, P = 0.141
Hemiptera	13	2	$F_{1,30}$ = 10.58, P = 0.003
Orthoptera	2	0	-
Lepidoptera	2	1	-
Psocoptera	7	3	-
Zoraptera	1	0	-
Strepsiptera	0	1	-
Araneae	3	2	-

were trapped, but at very low abundance. When pooled together, the mean number of individuals from saprophagous families per trap was significantly higher in the plot with *Nephila* (n = 175) than in the plot without *Nephila* ($F_{1,30}$ = 67.76, $P < 0.001$). This difference was due mostly to two families: Phoridae and Sciaridae (Table 2).

The mean body length of insects trapped in the plot with *Nephila* (2.02 ± 0.05 mm; range: 0.8–11 mm) was significantly smaller ($F_{1,416}$ = 10.3, P = 0.001) than in the plot without *Nephila* (2.36 ± 0.09 mm; range: 0.8–5 mm). The sizes of trapped individuals belonging to the three saprophagous families that presented a significant difference between both plots were Phoridae (1.4 ± 0.04 mm, n = 106); Sciaridae (1.7 ± 0.06 mm, n = 74) and Dolichopodidae (2.5 ± 0.2 mm, n = 7). None of these insects fit in the range of prey sizes caught by *Nephila*, but they do fit in the range of prey sizes exploited by *Argyrodes* spiders (Hénaut et al. 2005).

Our study provides the first evidence under natural conditions that webs of *Nephila clavipes* attract a larger number and higher diversity of insects than control sites. Both plots were in a similar environment (architecture, floral composition, orientation, climate), so the greater number of insects in the plot with *Nephila* webs could not reflect environmental variation. Furthermore, traps were placed at the height of *Nephila* webs sufficiently far from webs so that prey were unlikely to steer away from the webs onto the traps, all the more so since the prey of *Nephila* webs tumble to escape from the web (Zschokke et al. 2006). Therefore, we conclude that the presence of *Nephila* webs increased the number of insects that stuck to the traps.

Several studies have shown that the presence of debris-decoration made of silk on the webs of orb-web spiders attracts prey. For instance, *Argiope* spider web ornaments increased prey capture rate (Herberstein 2000; Bruce et al. 2001). In a field study, Tso (1998) showed that the stabilimentum-ornamented webs of *Cyclosa conica* (Pallas 1772) (Araneidae) trapped significantly more insects (150%) than undecorated webs. However, few field studies have been carried out to study the effect of debris-decoration containing detritus (animal and/or plant). Among these studies, Gonzaga & Vasconcellos-Neto (2005) and Chou et al. (2005) argued against the prey attraction hypothesis in research carried out both in the field and laboratory with *Cyclosa morretes* Levi 1999 and *C. fililineata* Hingston 1932 (Araneidae). These two spiders build debris-decorations that include linear and spiral silk structures and detritus. On the other hand, Bjorkman-Chiswell et al. (2004) observed that decaying matter in *N. edulis* webs do indeed attract saprophagous insects. Among all the insects we observed, particularly small saprophagous insects belonging to two families of dipterans were more abundant in both the traps and webs. Therefore, we suggest that the presence of decaying organic material in the *N. clavipes* webs is the possible

Table 2.—Total number of individuals (sum for all traps excluding non-identified individuals) for each family of Diptera, Hemiptera, Hymenoptera, and Homoptera in both plots. Comparison was done using ANOVA only for families with more than 10 individuals.

Order / Family	*Nephila* present	*Nephila* absent	ANOVA
Diptera			
Ceratopogonidae	0	1	-
Chamaemyiidae	11	9	$F_{1,30}$ = 0.002, P = 0.96
Chironomidae	2	14	$F_{1,30}$ = 5.54, P = 0.025
Clusidae	2	1	-
Dolichopodidae	6	1	$F_{1,30}$ = 5, P = 0.033
Drosophilidae	3	1	-
Empididae	0	3	-
Lauxaniidae	1	1	-
Muscidae	1	0	-
Mycetophilidae	1	0	-
Otitidae	1	1	-
Phoridae	96	10	$F_{1,30}$ = 34.02, $P < 0.001$
Sciaridae	62	12	$F_{1,30}$ = 13.53, P = 0.001
Simulidae	3	2	-
Sphaeroceridae	3	0	-
Tephritidae	0	1	-
Tipulidae	1	1	-
Trixoscelididae	1	0	-
Hemiptera			
Anthocoridae	4	0	-
Miridae	4	2	-
Pentatomidae	1	0	-
Hymenoptera			
Bethylidae	4	0	-
Braconidae	2	1	-
Ceraphronidae	2	0	-
Chalcididae	1	0	-
Encyrtidae	4	0	-
Eucharitidae	2	0	-
Eulophidae	1	0	-
Eupelmidae	0	1	-
Formicidae	15	6	$F_{1,30}$ = 5.25, P = 0.029

explanation for the high abundance of saprophagous catches. Less numerous hymenopterans and homopterans were also attracted to the web, probably by the bright yellow color of the silk and the spider, as described by Craig (1994) and Tso et al. (2004).

In our field study, the *N. clavipes* webs mainly attracted small prey (smaller than 3 mm) that are not within the range of prey sizes captured by the spider (Hénaut et al. 2005). Moreover, this spider builds permanent webs, so it can hardly take advantage of eating small insects during web consumption as observed in other orb-weaving species (Hénaut et al. 2001). However, the small insects attracted by the web fit perfectly in the range of prey gleaned by kleptobiotic *Argyrodes* spiders that live on *Nephila* webs (Hénaut et al. 2005). Numerous small insects may prevent direct competition for food between *Nephila* and *Argyrodes*, which happens when kleptobiotic spiders steal prey from the host's reserves or eat at the same time (Hénaut et al. 2005). The attraction of numerous small saprophagous prey by *N. clavipes* webs may be a side-effect of the use of decaying matter in the debris-decoration to attract larger insects that are prey of *Nephila*. Alternatively, the construction of these decorations is a strategy of *Nephila* to provide abundant food to the kleptoparasitic spiders living on its web, hence avoiding direct competition with them.

This field study suggests that debris-decoration does attract saprophagous insects, but also offers a new perspective about the function of these decorations in spiders. Further steps in this work would be to determine whether the presence of *Argyrodes* spiders actually induces the construction of the debris-decoration by *N. clavipes*.

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