SPATIAL DISTRIBUTION AND RESOURCE ACQUISITION IN *NEPHILA CLAVIPES*

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Abstract. Golden Orb Spiders (*Nephila clavipes*) form aggregations of hundreds of individuals. I hypothesized that aggregation would benefit individual spiders by increasing prey captures (if an insect dodges a web it is likely to land in another). I compared prey captures and spatial distribution of spiders in an aggregation to those of solitary individuals. Their spatial distribution was not random; larger spiders occupied positions on the edges of the aggregation, and larger solitary spiders were close to light sources. Contrary to expectations, solitary individuals had higher capture rates than individuals living in an aggregation. Resources at the station may not be limiting, and other factors may influence aggregation. (TCB)

INTRODUCTION (TCB)

Golden orb spiders (*Nephila clavipes*) can be found all over Costa Rica, aggregated by the hundreds in the eaves of buildings or under bridges (Lubin 1983). The spiders also occur solitarily near the aggregations and scattered throughout the rain forest. It is unknown whether the spiders aggregate because of available structural support, or if there is a benefit to association.

Over 200 orb spiders live in the eaves of the station building at Sirena Station, Corcovado National Park, Costa Rica. They occupy an area approximately 25m^3 (total web volume), open to the outside, with webs three and four layers deep in many cases. Others live solitarily near the lights and ceiling, and outside between porch beams.

I hypothesized that aggregation is more beneficial to individuals than living solitarily. In a dense web environment, when an insect evades a web it is likely to be caught in a neighboring web. Thus aggregation might act to increase prey captures per individual spider. I predicted that spiders living in aggregation in the station building would capture more prey than those living solitarily nearby.

Additionally, I hypothesized that web size and spider size would decrease with increased spider density. Because space in the middle of the aggregations is more limited, I expected that larger spiders would occupy sites at the edges of the aggregation, where potential prey may be encountered before reaching neighboring webs. Finally, I predicted that larger solitary spiders would occupy sites closer to the lights in the building.

These latter predictions are based on the expectation that either (i) larger spiders are dominant over smaller ones, and are able to obtain the preferred web sites, or (ii) spiders in the best sites grow larger because of high capture rates. Although capture rates were quantified for each position, I did not distinguish between these two possibilities.

METHODS (TCB)

This study was conducted at Station Sirena in Corcovado National Park, Costa Rica. To describe spatial distribution I mapped the locations of

Table 1. Results of spatial distribution analyses.

Relative spider postion	# individuals	Mean abdomen length (cm)	Mean # captures	Mean web density
		Aggregated		
outer	29	2.43±0.56	1.67±1.12	3.76±1.18
middle	26	2.01±0.74	1.46±1.45	5.0±1.19
inner	12	2.56±0.386	2.08±1.73	3.58±0.79
		Solitary		
near light	9	2.47±0.26	1.39±1.69	2.11±0.78
middle	11	2.16±0.45	1.91±1.87	1.5±0.52
far from light	19	2.46±0.31	1.78±1.18	1.36±0.50

68 aggregated and 40 solitary individuals. Each was assigned a position relative to the edge of the aggregation, or proximity to the lights, respectively. For aggregated individuals, the positions were outer, inner, or middle. Solitary spiders were either near (<1m), at intermediate distance from (between 1-2m), or far from (>2m) a light source. In addition to position, I assigned each web a density class. This was the number of webs, including the focal web, intersecting any part of an imaginary cylinder of the same diameter as the web, extending 20cm on either side of the web. I measured the abdomen length of each spider and the longest radius of its web (greatest distance from hub to edge).

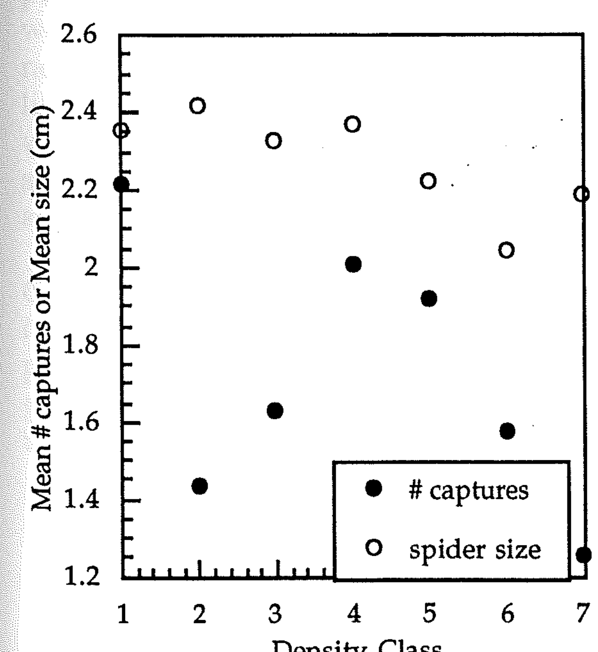

Figure1. Captures and spider size at differing web densities

For analysis of prey captures, I checked the webs once an hour, from 0700 to 1800 (day) and from 1830 to 2130 (for two nights), recording the number of captures, and which spiders were handling prey when observed.

RESULTS (TCB)

Spatial Distribution. Among the aggregated spiders, the largest occupied the inner and outer positions ($p<0.05$; Tables 1 and 2). Larger solitary spiders tended to be both near and far from a light source (Tables 1 and 2).

For all spiders, decreased web density was correlated with an increase in web size and spider size ($r^2=0.62$, 0.65, $p<0.05$; Figures 1 & 2). Pairwise comparisons of mean captures among the three positions for aggregated or solitary webs do not yield significant results (Table 2). Captures seem to be highest at a density of 1, and again near a density of 4 (Figure 1).

Group versus solitary resource acquisition. I analyzed captures per individ

Table 2. Results of students' t-test analyses of spatial distribution data.

aggregate positions	body size	captures	web density
outer vs.	t=2.41	t=0.61	t=3.87
middle	$p < 0.05$*	$p < 0.9$	$p < 0.001$*
outer vs.	t=0.81	t=0.907	t=0.49
inner	$p < 0.5$	$p < 0.4$	$p > 0.5$
inner vs.	t=2.43	t=0.761	t=3.77
middle	$p < 0.02$*	$p < 0.5$	$p < 0.001$*
solitary positions			
near vs.	t=1.83	t=0.05	t=2.09
middle	$p < 0.1$	$p > 0.9$	$p=0.05$*
near vs.	t=0.0838	t=0.199	t=3.07
far	$p > 0.9$	$p < 0.9$	$p < 0.01$*
far vs.	t=2.154	t=0.23	t=0.73
middle	$p < 0.05$*	$p < 0.9$	$p < 0.5$

*indicates a significant result

ual for aggregated versus solitary spiders during the day, at night, and overall (Table 3). Individuals living solitarily had more captures per spider in every case. Solitary spider capture rate was higher at night than in the day. Capture rate did not differ between night and day for aggregated spiders (Table 4).

Discussion (TCB)

Spatial Distribution. The distribution of spiders within the building followed definite patterns. Larger spiders with larger webs occupy the outer edges of an aggregation. Larger solitary spiders tend to be both near and far from a light source. These distributions may result from one of two things: (i) larger spiders may be dominant over smaller ones (able to obtain preferred web sites), or (ii) spiders in the best sites grow larger because of high capture rates. However, prey captures did not differ significantly between any positions (for either aggregated or solitary spiders).

A light source probably attracts insects from a considerable distance. To reach those solitary spiders nearest the light, the insects must pass by the far and middle webs. This may increase the chances for prey capture of the far and middle spiders, decreasing the importance of space near the light. The size distribution of solitary spiders may thus be due to other factors, or to chance alone.

The explanation for the lack of difference between prey captures among the three aggregated positions is less simple. This study may have been too short to adequately sample the captures per spider in the aggregation. A linear correlation between density and mean captures was not significant; however, there appears to be a curvilinear relationship. Most

Table 3. Mean total captures per individual, and t-test results.

	solitary	vs. aggregate	t	p<
day			2.10	0.05
mean	0.0325	0.01645		
s. d.	0.0592	0.01558		
night			3.83	0.001
mean	0.0271	0.01037		
s. d.	0.0227	0.02106		
total			2.21	0.05
mean	0.07174	0.03273		
s. d.	0.1099	0.07180		

Table 4. Capture rates and t-test results for day versus night.

	day	vs. night (captures/indiv/hr)	t	p<
solitary spiders				
mean	0.00174	0.00451	4.03	0.001
s. d.	0.00197	0.00381		
aggregate spiders				
mean	0.00148	0.00331	1.20	0.4
s. d.	0.00141	0.001239		

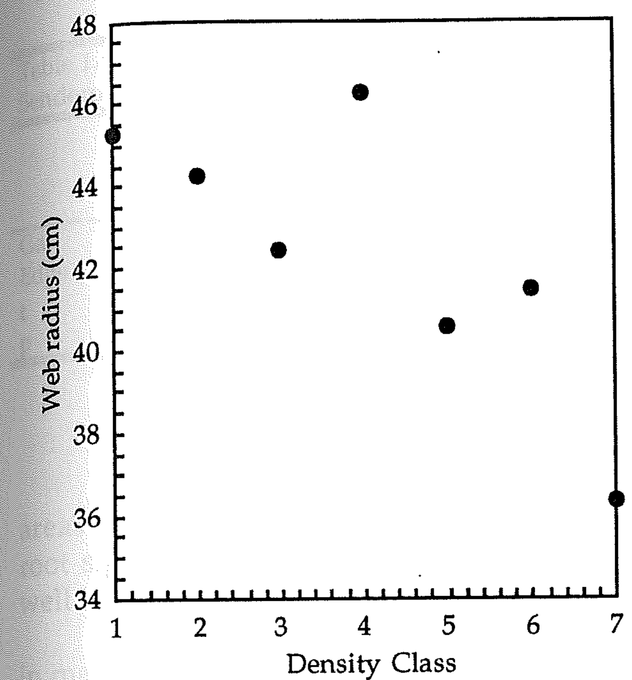

Figure 2. Web size as a function of density class.

prey were caught by spiders at a density of one, and by those at a density near 4 (Figure 1). Densities of 3 and 4 were typical of webs in the outer and inner positions of an aggregation, where webs were also the largest. Although not shown in this study, it seems likely that larger spiders, with larger webs, would catch more prey than smaller spiders in the middle of the aggregation.

Group versus solitary resource acquisition. Solitary spiders caught more prey per individual than did aggregated spiders, whether overall, during the day, or at night. This implies that there is no benefit to living in an aggregation. Why then are the spiders at the station (or elsewhere) aggregated? It may be that the food base at the station is large enough to support a very large spider population. The spiders may settle wherever there is space and support, and only when food is sufficient. This hypothesis is supported by the lack of substantial movement of spiders with established webs. In the two days of this study, only three individuals changed their location. If the spiders choose locations strategically and aggregation is not beneficial, preferred spots should be filled; yet there were available open spaces.

It appears that large spiders are large because they happened upon a site of high food availability, and thus experienced a high growth rate. This could be examined in a study of orb spider habitat choice. Do they have preferences? Do they move when prey is limited? Do larger individuals displace smaller ones? It is possible that in an area where food is more limited than at Sirena Station, aggregation is beneficial: this could be tested in an area with lower resource availability.

Literature Cited.

Lubin, Y. D. 1983. *Nephila clavipes.* In *Costa Rican Natural History,* ed. D. H. Janzen, 745-7. Chicago: University of Chicago Press.