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Low Predation Rates in the Field by the Tropical Spider *Tengella radiata* (Araneae: Tengellidae)[1]

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ABSTRACT

Marked individual *Tengella radiata* spiders showed low and variable rates of weight gain in the field in old lowland forest in Costa Rica. Calibration studies of weight gained on controlled diets in captivity and rates of metabolism allow extrapolation of field results to probable rates of predation in the field. The prey capture rate for this species is apparently substantially lower than those of other similar sized spiders.

RESUMEN

Arañas de *Tengella radiata* en un bosque viejo en tierras bajas de Costa Rica mostraron tasas bajas y variables de aumento de peso. Estudios en cautiverio de la cantidad de presa necesaria para un aumento dado de peso, y de la tasa metabolica de la araña permitieron una extrapolación de los datos del campo a un estimativo de las tasas probables de captura de presas en el campo. Esta especie muestra una tasa de captura en el campo mas baja de las de otras arañas, auncuando se corrigen los datos por los efectos de tamaño.

PREDATION RATES ARE USUALLY DIFFICULT to measure precisely in the field due to problems associated with observing mobile predators closely over extended periods of time. Many web-building spiders are easier to study because they are relatively sedentary (*e.g.*, Riechert 1978, Janetos 1982). This study took advantage of the immobility of the spider *Tengella radiata* (Kulczynski) to study rates of weight gain of individuals in the field over periods of weeks and months. A calibration study of captive spiders permitted weight gains to be translated into rates of prey capture.

Tengella radiata is common in many parts of Costa Rica, ranging in elevation from 50 to 1500 m in habitats which vary from "virgin" forest to coffee fields (Wolff 1977, M. Santana and W. Eberhard, pers. obs.). Despite its wide distribution within Costa Rica, the species is unknown outside the country, and indeed the two other species in this monogeneric family are known from a total of only three specimens. The web of *T. radiata* is a large, horizontal sheet with a tangle of threads above that includes some adhesive cribellate lines. Webs are nearly always built under an overhang of some sort or against a large object such as the base of a tree. During the day the spider normally rests in a silk tube connected to the most protected side of the sheet, while at night it is usually at the mouth of the tube or out on the sheet. Spiders attack prey on the sheet both day and night.

[1] Received 18 November 1988, revision accepted 24 May 1989.

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METHODS

Field observations were made in undisturbed rain forest (tropical wet forest of Holdridge—Hartshorn *et al.* 1982) at Finca La Selva near Puerto Viejo, Sarapiqui, Costa Rica (elevation about 50 m) during the rainy season from 1 June to 9 December 1982. Both mature females and immature spiders were coaxed weekly from their tubular retreats and carried to an analytical balance in pieces of plastic tubing stoppered at both ends with cotton. Each spider was marked distinctively with spots of model airplane paint. The spiders were weighed to the nearest .1 mg, then returned to their webs. Usually spiders were away from their webs for less than seven hours. The spiders were remarkably undisturbed by this treatment, and some were collected and weighed weekly for up to 16 weeks before disappearing. Some spiders were followed through more than one instar; they were remarked when, after a period of lack of web repair, an exuvium was found on the web and the spider was larger and lighter in color than it had been before. One mature female laid eggs, and her weight change for that week was discarded.

Laboratory observations of feeding were made in San Jose (elevation 1000 m) between 30 April and 8 June 1984. Twenty spiders, whose sizes covered most of the range of sizes followed in the field, were housed at room temperature, which varied from approximately 18 to 25°C, in tubes made from the waxed cardboard of disposable beer cups. The tubes were stoppered at both ends with sponges which were moistened regularly. Live *Ceratitis capitata* flies (medflies) ($\bar{x}$ = 5.3 mg) were introduced at variable schedules into the tubes. Feeding rates were adjusted on the basis of spider body size to produce, on the assumption of 33 percent conversion of prey mass into spider mass (Turnbull 1962), rates of growth similar to those which preliminary estimates had suggested were occurring in the field (dotted line in Fig. 2). Once a week each spider was removed from its tube, weighed to the nearest .1 mg, and replaced after feces and the remains of its meals had been removed from the tube.

Metabolism measurements were obtained as follows. Eight large female spiders ($\bar{x}$ = .798 ± .148 gm, range .599–1.264 gm) were collected in Monteverde, Puntarenas Province, Costa Rica and were allowed to build small webs and then fed small orthopterans. After being transported to the University of Florida in Gainesville, they were acclimated to 25°C for 7 days. The animals did not feed during this time. Each spider was then placed in a 50 ml glass respirometer flask that also contained a bag of soda lime to absorb CO_2 and the flasks were attached to a Gilson Differential Respirometer. The acclimation period to a given observation temperature was three hours, followed by an experimental run of four hours with readings taken every 15 or 20 min. Mean resting rates of oxygen consumption were calculated for each individual, and these rates were used to calculate overall means.

Some spiders were observed building webs. In these cases, the rates of oxygen consumption were observed during and after web-building activity. At the end of the run the webs were removed and weighed to estimate the cost of web material. Estimates of metabolic cost were obtained by subtracting the animal's resting oxygen consumption from its total oxygen consumption during the web-building period (Prestwich 1977).

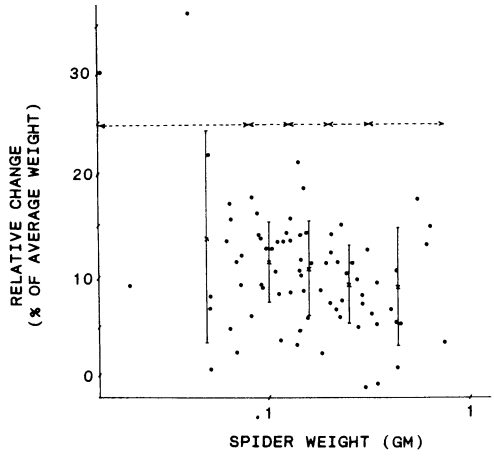

FIGURE 1. Relative weight gain during the entire time of observation (from 2 to 16 weeks; $\bar{x}$ = 5.4) and the log of body weight for each of 84 spiders. Although these data show a significant negative correlation (r = −.365, P = .00065), the correlation remaining after the effects of spider weight had been eliminated was not statistically significant. The x marks averages and the bars show standard deviations for spiders in the weight ranges indicated by the arrows above the graph.

RESULTS

The average weight change per week was calculated for each of 84 spiders (a total of 481 spider weeks) by dividing the difference between first and last weights measured for each spider by the number of weeks elapsed between the first and last weighing in order to partially eliminate short-term variations.

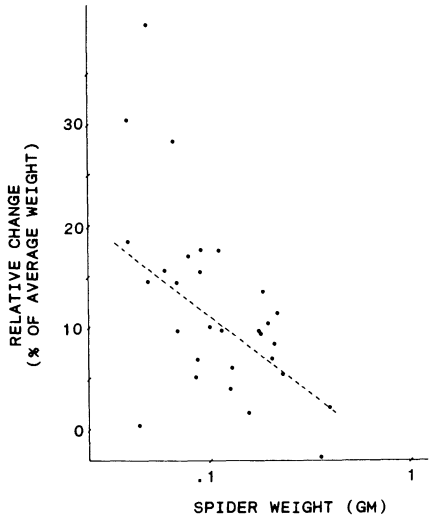

FIGURE 2. Weekly weight gains by 20 captive spiders of different weights. Each spider's weekly ration of food (*Ceratitis capitata* flies) was adjusted, on the assumption of 33 percent conversion of prey mass to spider mass, to produce the weight increments indicated by the dotted line.

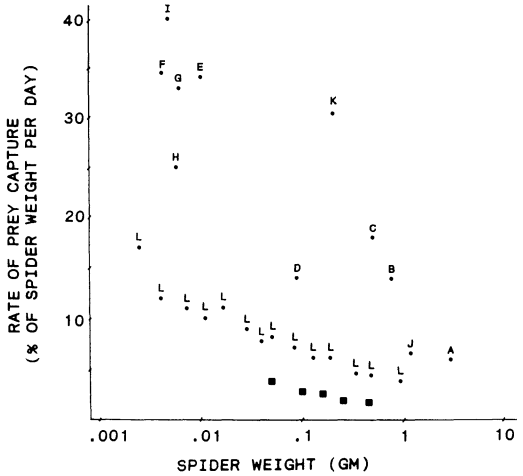

FIGURE 3. Estimated average relative rates of prey captured daily in the field (prey weight/spider weight × 100%) by *T. radiata* of different body weights assuming 33 percent conversion of prey mass to spider mass (squares), and published estimates of relative capture rates in the field of other spider species (A–J are Araneoidea): A—*Nephila maculata*; B—*Mastophora dizzydeani*; C—*Argiope argentata*; D—*Mecynogea lemniscata*; E—*Cyclosa caroli*; F—*Cyclosa* sp.; G—*Dolichognatha* sp. #1; H—*Dolichognatha* sp. #2; I—*Synotaxus turbinatus*; J—*Cyrtophora moluccensis*; K—*Agelenopsis aperta*; L—*Geolycosa godeffroyi*. References: A—Robinson and Robinson 1973; B—Eberhard 1977; C—Robinson and Robinson 1970; D to I—Eberhard 1979; J—Y. D. Lubin, pers. comm.; K—Riechert and Tracy 1975, Riechert 1978; L—Humphreys 1975. Methods of estimation: A to C—prey remains in or under web; D to J—rates of egg production by mature females; K—calculations based on overall acceptance rates for various prey and on captures by sticky traps in average sites, assuming prey are 75 percent water (sticky traps may not give reasonable estimates of prey available to spiders—see Castillo and Eberhard 1982 on traps that mimic orb webs). L—amount of guanine-like material in the feces of spiders during first 7 days after capture.

The rate of weight gain was positively correlated with the average weight of the spider ($r = .37$, $P = .0052$). When the weight changes were adjusted for spider size by dividing weight change by spider weight (thus giving "relative weight changes"), spiders of all sizes averaged increases of just over 6 percent of their body weight per week: averages (± standard deviations) for spiders weighing 15 to 80, 81 to 140, and 141 to 750 mg were 7.7 ± 13.4, 6.7 ± 11.6, and 5.1 ± 13.1 percent respectively. Relative weight changes correlated negatively with average weights ($r = -.365$, $P = .00065$) using the log average weight (Fig. 1). However, since analyses of ratios sometimes yield spurious correlations (Atchley *et al.* 1976), a stepwise regression analysis was performed using the equation $y = a + bx + cx^2$, in which y = average weight change and x = average weight. The term c, which tested for a decelerating rate of increase after the effects of weight had been removed, was not statistically significant. In sum, larger spiders made larger absolute weight gains, but approximately similar relative gains compared to smaller spiders.

The weight gains observed in the laboratory were evenly distributed around expected values (dotted line in Fig. 2), showing that, at least at these rates of feeding (slightly greater than those typical in the field), the spiders achieved conversions of approximately 33 percent. Figure 3 compares the estimated average weights of prey consumed per day by *T. radiata* of different sizes in the field (assuming 33% conversion) and compares them with data from other species of spider.

Metabolic rates are given in Table 1. The average value of Q10 between 20 to 30°C was 2.15. Four small webs were built in the respirometer flasks while oxygen consumption was being recorded. Rates of consumption when spiders were moving about were between two and four times resting values. The mean dried web weight was .4 ± .2 (SEM)

TABLE 1. *Metabolic rates of mature female* Tengella radiata *as a function of temperature. Results are expressed as means ± standard error of mean in* $\mu LO_2/(g)(h)$.

Temperature (°C)	N	VO_2
20	8	107 ± 4
25	8	148 ± 17
30	8	229 ± 29
35	6	417 ± 52

mg and the mean net (active–resting) VO_2 was 243 $\mu LO_2/g$.

DISCUSSION

Although the data on probable predation rates (Fig. 3) were obtained with a variety of methods, and probably vary in their precision (see caption to Fig. 3), it is striking that *T. radiata* rates are well below those of all other spiders. This difference is not a function of web design: similar sized *Agelenopsis aperta* (K in Fig. 3) may capture prey about 10 times faster than *T. radiata* even though they spin a similar sheet which is probably somewhat inferior as a trap since it lacks sticky lines and is only used part of each day (Reichert & Tracy 1975). Metabolic rates of *T. radiata* are not unusual compared to other spiders (Anderson & Prestwich 1982), and the relative cost per weight of web is similar to that of the sheet-web spider *Sossipus janus* (Lycosidae) (Prestwich 1977).

The *T. radiata* field data may somewhat underestimate true rates of weight gain since the spiders were away from their webs for several hours each week, and may have been less ready to capture prey for some time after returning due to the disturbance of being handled. Web damage produced during collection, though not substantial, probably also elicited some extra web repair. Captive spiders also probably had lower energy expenditures than those in the field since they did not build and maintain webs, and were kept at lower temperatures than those at the field study site. In addition, the percentage of a prey that is ingested probably varies with prey species (Turnbull 1962); the relatively soft-bodied medflies used in the lab study were probably more completely used than some prey captured in the field, giving underestimates of prey weights captured in the field. However, even if the *T. radiata* values in Figure 3 are increased under the conservative assumptions that an entire day of predation was lost each week and only 25 percent rather than 33 percent of the prey mass is converted into spider mass (Turnbull 1962 documented a 27% rate in the araneoid *Linyphia triangularis*; Reichert and Tracy 1975 found a 20% conversion in *Agelenopsis,* but must have underestimated the true rate since they counted food fed to subadults in their calculations), the *T. radiata* rates are nevertheless substantially below those of the other species (the estimated capture for a 200 mg *T. radiata* would be only 3.1% of its weight daily *vs.* about 17% for the araneoids [line for points A–J in Fig. 3], or 30% for the agelenid *Agelenopsis,* and 5.5% for the lycosid *Geolycosa*). In sum, prey capture rates of *T. radiata* are substantially less than those of spiders in other taxonomic groups which have been studied. The taxonomic affinities of Tengellidae are unclear, but it is generally placed closer to Agelenidae (represented in Fig. 3 by K–*Agelenopsis*) than Araneoidea (A–J in Fig. 3) (Lehtinen 1967, Wolff 1977).

This study supports the common contention that spiders in nature are often undernourished (*e.g.,* Anderson 1974, Wise 1975, Reichert & Tracy 1975, Spiller 1984). In fact a substantial fraction of *T. radiata* observed in the field (14% of 84) showed net *loss* of weight over periods ranging from 1–7 weeks (the length of time these spiders were followed averaged 3.2 ± 1.9 weeks; the average for the entire sample was 5.4 ± 3.3).

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