Prey of *Micrathena gracilis* (Walckenaer) (Araneae:Araneidae) in comparison with artificial webs and other trapping devices

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Summary

Prey insects were collected from the orb-webs of *Micrathena gracilis* (Walckenaer) in a deciduous forest in southwestern Ohio, U.S.A. A comparison of collected prey with insects trapped by artificial webs shows *M. gracilis* to be size selective, since a larger proportion of its prey were greater in size (4-8 mm) than most of the insects (2-4 mm) trapped in artificial webs and other devices. Artificial webs were compared with window-pane traps, screen traps and sweep net samples, and provide a more accurate estimate of prey availability.

A comparison was made of prey caught by an individual *M. gracilis* on its web and an artificial web of identical size and mesh placed beside it. There were no significant differences in the size distribution of insects striking each web. A significant difference was found between the size of insects that hit each web and those which were restrained by the web (the latter being larger). The role of web mesh in the prey size selectivity of this species is discussed.

Introduction

Micrathena gracilis (Walckenaer) is an orb-weaving spider (family Araneidae) common to deciduous forests east of the Rocky Mountains (Kaston, 1948; Levi, 1978). It commonly inhabits the understorey layer in areas of lower light intensity (Weese, 1924). The web built by this species is a small orb (8-19 cm diameter) in a rectangular or triangular silk frame, which spans large open spaces between vegetation (90-250 cm). The species has been poorly studied (H. W. Levi, pers. comm.) with little information available regarding its feeding habits, reproduction (Montgomery, 1903), and general ecology.

As part of a study of web orientation in this species (J. M. Biere, unpubl. master's thesis) we collected some data on the insect prey captured by these spiders. In addition to prey collected from webs, we assessed insect abundance by a variety of insect trapping methods, including an artificial web of monofilament nylon, a window-pane trap/sticky trap combination, a nylon mesh sticky trap and a sweep net. Similar devices have been used in studies of prey abundance for other species of spiders (Roth, 1963; Cherrett, 1964; Kajak, 1965; Riechert & Tracy, 1975; Eberhard, 1977). The only device of similar design to the artificial web used in this study was developed by Eberhard (1977). He does not, however, present data on trapping efficiencies of his device compared with other trapping methods. The results of our studies provide a means of comparison of these methods, as well as some information on the prey of this species and its relation to the structure of the web (Uetz *et al.*, 1978).

Methods and Study Area

This study was conducted in a segment of Winton Woods County Park, Cincinnati, Hamilton Co., Ohio, USA, during the summer months (June-September 1977). The park is a recreational area, with a large acreage of mature secondary growth deciduous forest. Principal tree species include representatives of the genera *Quercus* (oaks), *Acer* (maples) and *Liriodendron* (tulip tree). The understorey consisted of saplings of the above, *Cornus* (dogwood) and *Carpinus* (hornbeam).

In our study of web orientation, we found that the direction which the spider (and web) faced was non-random, and was related to the microhabitat where webs are constructed. Web orientation appears to be a behavioural thermoregulatory mechanism, and is influenced by the amount of light in a microhabitat. A consideration of the lighting regime in this forest resulted in resolving three general microhabitats in which a web could be placed:

(1) Open – those sites in sunlit spaces with exposure to solar radiation most of the day.
(2) Closed – those sites where the canopy and understorey were well developed, reducing light penetration. Occasional sun flecks penetrated to the forest floor in these sites but none for long periods of time.
(3) Patchy – those sites which were intermediate between an open and closed site. Sites were

assessed in a qualitative manner during weekly surveys; patchy sites encompass a wide range of lighting regimes.

Prey were taken from webs of individual *M. gracilis*, preserved in 70% ethanol, and returned to the laboratory for identification and counting. Only prey which had been wrapped in silk were taken from these spiders. *M. gracilis* will bite potential victims before wrapping them in silk. By taking only wrapped prey it was assumed that these were victims that the spiders intended to feed upon. A number of spider species have been observed that discriminate between prey types (Robinson, 1976). Unpalatable prey are often attacked, then ignored or cut out of the web and dropped to the ground.

On 31 July, artificial webs were tested against several other trapping methods in each of the three microhabitats described above. The trap comparison was supplemented by taking sweep net samples from the surrounding vegetation in trap areas as suggested by Kajak (1965). The following collection methods were compared:

1. Artificial webs. These devices consisted of monofilament nylon thread woven into a 3 mm by 3 mm mesh on a wood loom. This mesh was glued to a 40 x 40 cm frame made of 0.6 cm square plastic tubing. Tree Tanglefoot was painted on a 1000 cm^2 block of wood and the mesh was pressed against this sticky block. All traps received a uniform coating of Tanglefoot and had the same amount of surface area covered.
2. Black nylon netting of identical mesh size as the artificial webs (Roth, 1963) coated with Tree Tanglefoot in the same manner as artificial webs.
3. Window-pane traps of clear 3 mm thick plexiglass (perspex) coated with Tree Tanglefoot in the same manner as the artificial webs (Southwood, 1966).
4. Sweep net samples from each microhabitat as aerial traps (25 sweeps/sample, Kajak, 1965).
5. Prey picked from webs of *Micrathena gracilis* in the same microhabitats as aerial traps and sweep net samples.

The aerial traps (artificial webs, black nylon, and window-pane) were suspended side by side on lines of twine between trees approximately 1.5 m above the ground. Traps were set in place at 07.00 and taken down at 19.00. Sweep net samples were taken every two hours during the period of aerial trapping starting at 08.00. Prey were taken from spider webs as often as time allowed during the trapping period. Only prey items which had been wrapped by the spiders were taken. Aerial traps were removed from the lines and wrapped in wax paper, then returned to the laboratory, where each trap was carefully unwrapped. All prey picked from the traps were classified to taxon (order) and measured (body length to 2 mm classes). Sweep net samples were killed in jars of 70% ethanol in the field. All samples were placed in separate vials marked with the date, microhabitat type, and type of trap or time of sweep netting. Prey captured on artificial webs were compared with prey captured by *M. gracilis*.

On August 1, an artificial web was constructed with mesh size 1 x 3 mm. This was approximately the average mesh size of all webs surveyed. The artificial web frame was constructed of the same plastic tubing and the mesh made of the same nylon thread as that used to construct artificial webs used in weekly prey capture surveys. The 20 x 20 cm catching area was glued to a 25 x 25 cm plastic frame. This device was suspended within 6 cm of a natural web of the same mesh size and spiral area. A small metric rule was attached to the plastic frame for use as a reference in sizing insects.

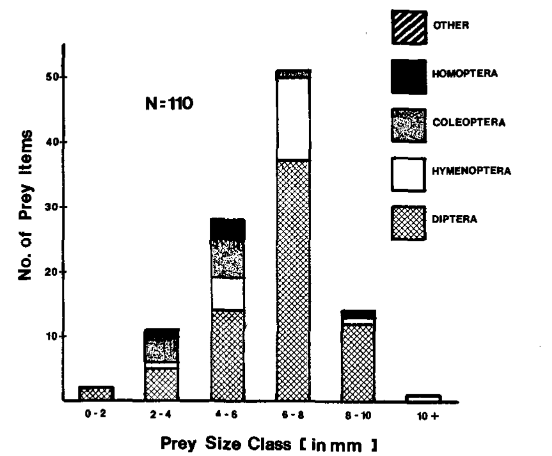

Fig. 1: Size distribution of prey collected from webs of *Micrathena gracilis*. Prey size classes are in mm. Prey abundance is expressed as the total number of individuals in each taxon (order), in each size class.

These side by side webs were observed throughout the day (07.00-19.00). Records were kept of the size and taxa of insects which hit and/or stuck to the webs, and insects captured by the spider as follows:

1. Hit – an insect that hit either web and stuck or escaped.
2. Stick – any insect that was unable to escape the artificial web or one that remained on the spider web for at least 10 seconds.
3. Fed – those insects that the spider attacked, wrapped, and transported back to the web hub to feed upon.

Results and Discussion

The prey of *Micrathena gracilis* (Fig. 1) consists of Diptera (66.4%), Hymenoptera (18.2%), Coleoptera (10.0%) and Homoptera (5.5%). Most insects caught by this species fell in the size range of 4-8 mm (72.7%). To determine whether a degree of specialization exists in the diet of this species, the prey it captures must be compared with what is available in the environment. Similar studies have been done for tropical (Robinson & Robinson, 1970, 1973) and temperate orb-weaving spiders (Cherrett, 1964; Kajak, 1965). A problem in all of these studies has been bias or relative efficiency of the trapping device in estimating prey caught by a spider's web. In this study, we used artificial webs of monofilament nylon (placed in various microhabitats in the study area where prey were collected from webs) to estimate prey available to *M. gracilis*. We supplemented these collections with other trapping methods, which were compared with the artificial webs.

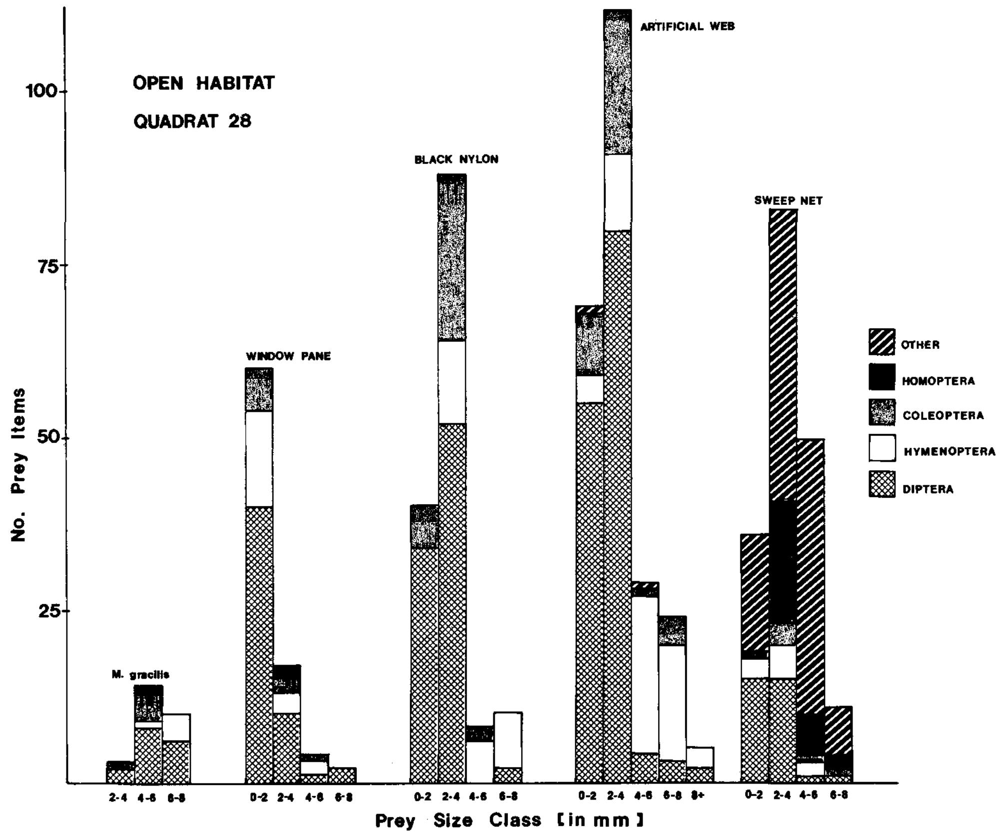

Fig. 2: Open habitat. Test of methods for trapping insect prey of orb weaving spiders. Abundance of prey in each size class and order is expressed as in Fig. 1. Each trapping method is represented by a separate set of columns. Three microhabitats are compared here and in Figs. 2 and 3: open, patchy, closed (based on degree of solar radiation).

There were no significant differences between aerial trapping methods with regard to prey composition by size (G-test, Sokal & Rohlf, 1964; $0.50 < p < 0.60$) or by taxonomic composition (G-test $0.40 < p < 0.50$). Differences between aerial trapping methods in total numbers of prey caught were significant. Window-pane traps caught less than the black nylon traps (G-test $p < 0.05$) or artificial webs (G-test $p < 0.005$). Artificial webs caught more prey than the black nylon traps (G-test $p < 0.05$). These differences were attained in all three microhabitats tested (Figs. 2, 3 and 4). The mesh of artificial webs did not intertwine like the mesh of black nylon traps and this may have been more responsible for their increased efficiency than was their invisibility. Insects trapped on artificial webs had nothing to push against in their struggle. The extensibility of the monofilament lines may act more like the spiral silk in natural webs. Denny (1976) suggests that the extensibility of spiral silk is an important factor in containing struggling prey in webs.

Window-pane traps are barely visible, but strong flying insects may be able to avoid them if they detect the trap (Southwood, 1966). Many insects can detect minute differences in air currents such as might occur around a solid pane of glass (Chapman, 1971). The detection of a solid surface may trigger an avoidance response by the insects or provide a cue for landing. The low number of insects found on window-pane traps suggests that the former may occur.

Sweep net samples took an entirely different insect fauna than all other trapping methods. There were significant differences between sweep net samples and aerial traps with regard to prey composition by size (G-test $p < 0.01$) and by taxonomic composition (G-test $p < 0.01$).

These data suggest that the artificial webs were the most effective method of capturing flying insects of all methods compared. The question then, is how well they estimate prey available to orb-web building spiders. To find this, we examined the insect prey

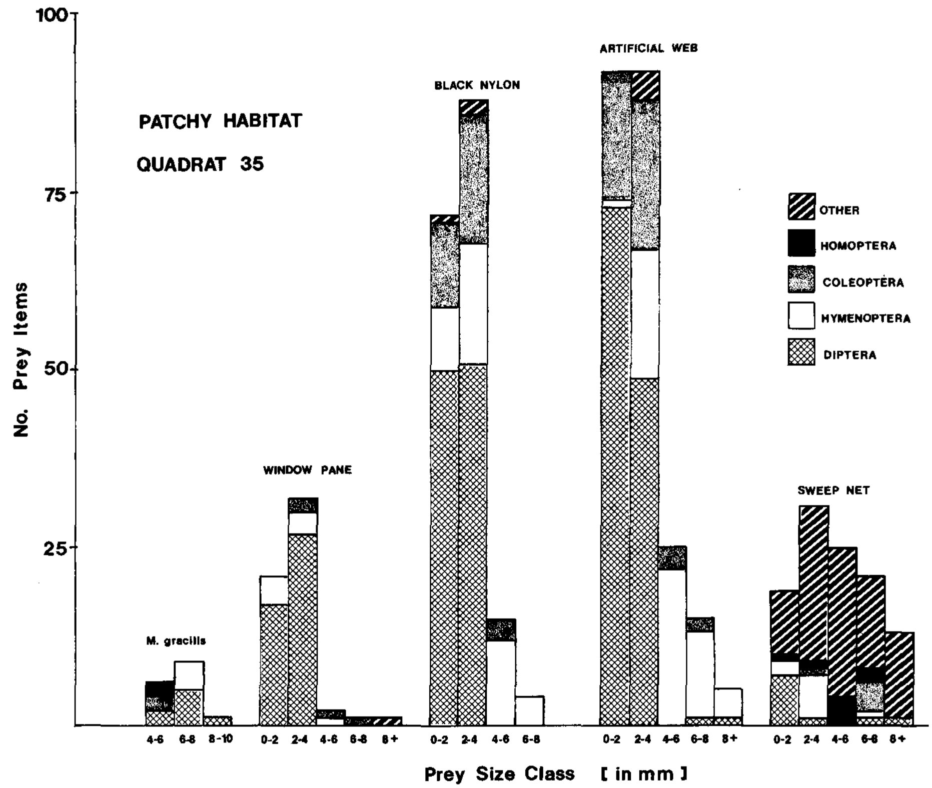

Fig. 3: Patchy habitat. For explanation see Fig. 2.

captured by a *Micrathena gracilis* web and an artificial web of the same mesh and area suspended beside it. The number of insects that hit and stuck on the artificial web was greater than for the *M. gracilis* web of the same dimensions (Fig. 5). Capture efficiency (no. insects stuck/no. striking the web) was 29.7% for *M. gracilis* and 59.4% for the artificial web; a two-fold difference. The density of sticky threads in the artificial web is actually twice that of the *M. gracilis* web, since in the spider web only the spiral threads are sticky (not the radii or cross threads). Also, insects may fly through spider webs, breaking silk threads as they go. Since monofilament nylon is many times stronger than silk, most of these insects would be stopped by an artificial web. This is a reasonable explanation for the twofold difference in capture efficiency, but not the difference in total number of insects striking the webs. Perhaps the presence of the spider makes a web more visible, triggering avoidance and reducing catch.

It would appear that despite a tendency to overestimate numbers of prey actually available to an orb-weaving spider (what strikes the web), artificial nylon webs are useful in studies of orb-weaving spiders and their prey. They would seem to be very useful in determining abundance of prey insects in different habitats, and in sampling the array of flying insects potentially striking a spider's web. Differences between a passive trap and a web containing a living spider are obvious, and require that data be interpreted carefully. Spiders captured significantly different sized prey than all trapping methods (including artificial webs of mesh size identical to their webs). The preferred size range of the spiders' prey was 4-8 mm, and the most abundant prey caught in the artificial webs were 2-4 mm.

However, there were no significant differences between habitats in the size of prey preferred by spiders (G-test $0.50 < p < 0.60$). This suggests that individual *M. gracilis* were taking prey in the 4-8 mm

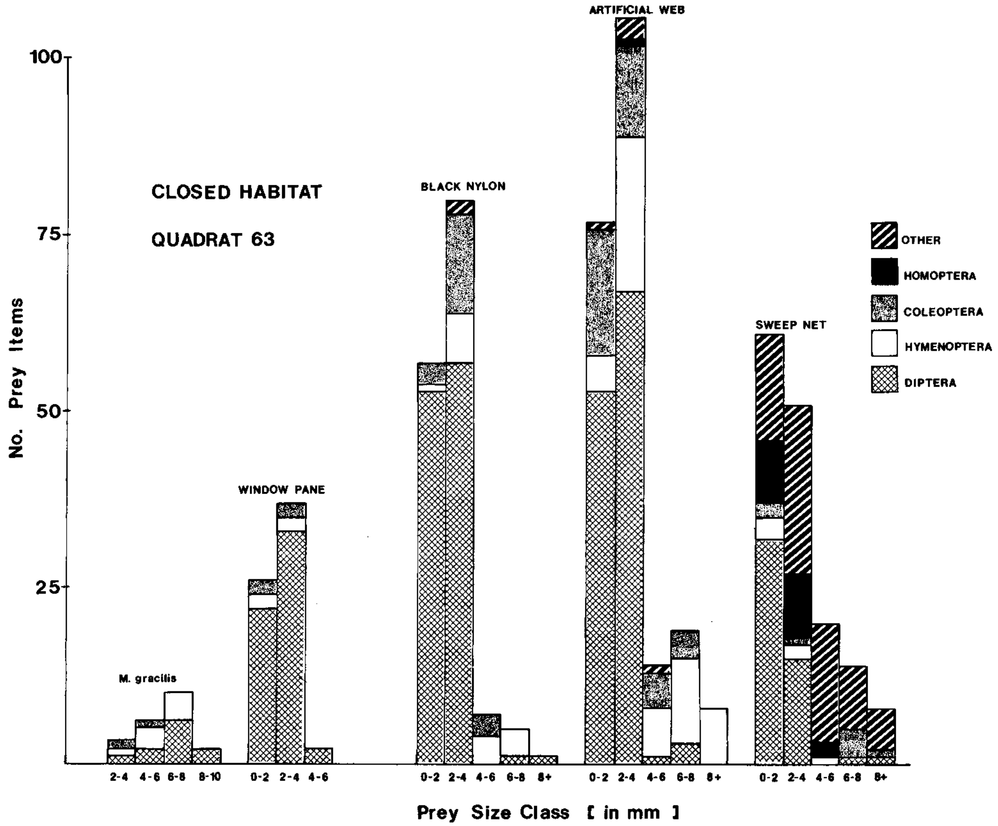

Fig. 4: Closed habitat. For explanation see Fig. 2.

size range in a size selective manner and were accepting all prey items in this size range regardless of taxa or habitat, despite a small-meshed web.

An argument has been made that mesh size of webs determines prey size (Witt, 1975; Risch, 1977). In an earlier study (Uetz *et al.*, 1978), a positive correlation was found between the mean mesh size of web's and the mean prey size taken by a variety of spider species. Despite the linear nature of the relationship for those species examined, it would not be difficult to find species whose mesh size and prey size make them exceptions (Chacón & Eberhard, 1980).

Of particular interest is the finding that there were no significant differences in the size distribution of insects striking the web of *Micrathena gracilis* and an artificial web of the same mesh size (G-test; $0.40 < p < 0.50$). However, there was a significant difference between the size distributions of insects that hit the webs and those that were retained by the webs, the latter being larger (G-test; $p < 0.05$). This suggests that the mesh of orb webs has two functions relative to prey size: (1) to filter "planktonic" insects from the air in the same manner as the nets of hydropsychid caddisflies filter suspended particles from water (Wallace & Malas, 1976); if this were the sole function of webs, then prey size would be an invariably linear function of mesh size; (2) the mesh serves to restrain insects until the spider can capture them (suggested by W. G. Eberhard, pers. comm.). The disparity shown here between sizes of prey captured by *Micrathena gracilis* and artificial webs may serve to illustrate the second function of mesh size.

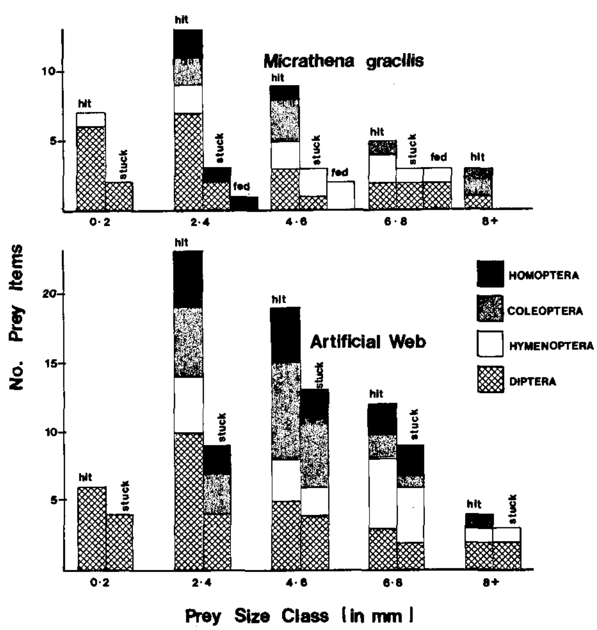

Fig. 5: Comparison of prey striking webs and prey retained by *Micrathena gracilis* and an artificial web of identical mesh size and spiral area. Prey abundance in each size class is expressed as in previous figures.

Micrathena gracilis employs a method of attack which has been described as the more primitive method among orb-weavers (Robinson, 1976), which he calls the "bite-wrap" attack. The spider first bites its victim and wraps it in silk only for transport back to the web hub. The more "advanced" attack method is initially to wrap the victim in silk before biting. This effectively reduces the activity of struggling prey and allows the spider to come into close contact with less danger than if the prey were able to defend itself. *M. gracilis'* attack method suggests that it should accept a larger number of small prey (2-4 mm) than the data here indicate. Observations of *M. gracilis* during this experiment and on other occasions indicated that 5 seconds was adequate time for an individual spider to attack a potential victim. Insects in the 2-4 mm size range were trapped for at least 5 seconds during most entanglements, yet were ignored by the spider. Many of these escaped from the web. A greater proportion of those insects that stuck on the web were in the 4-8 mm size range (G-test $p < 0.05$). The data suggest that *M. gracilis* either ignores smaller prey items or that this species has a threshold of vibration (amplitude) from struggling prey necessary to elicit an attack response. A possible explanation is that the sluggishness of this species makes it difficult for it to capture a victim rapidly (personal observation). If the spider was to attempt an attack on all prey items that struck the web, then it would risk a miss on a prey item 2-4 mm in body length more often than larger prey (Fig. 5). The energetic cost of including an item of the 2-4 mm size may be greater than the cost to the spider of ignoring the insect (Schoener, 1969). The restraining function of the web allows *M. gracilis* to compensate for a loss in agility due to morphology (which may be adaptive for some other reason) by capturing larger prey than would be predicted by its mesh size. The large prey size/mesh size ratio of this species (6-8 mm/1 mm) means that, in effect, 6 to 8 sticky threads will contact the insect. This is sufficient to restrain the insect long enough (and perhaps create enough vibration stimuli) for the spider to capture it. Smaller insects would be contacted by 1 or 2 threads, and escape more easily.

In conclusion, it must be said that the relationship between web structure and prey capture in orb-weavers is more complex than we, or anyone else, had previously suggested. Comparison of prey of *Micrathena gracilis* and other species (Robinson & Robinson, 1970, 1973; Kajak, 1965) with that collected by artificial webs and other trapping devices clearly indicates that these spiders exhibit selectivity (particularly with respect to size), in that they take prey in a ratio which is much different from the ratio available in the environment. The role of web structure in the prey selectivity of orb-weavers requires further clarification by future studies.

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