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Web Construction in Spiders

The orb web of a spider (Fig. 34.1) is the outcome of highly complex and stereotyped behavioral patterns, and has a key role in the survival of the organism. It constitutes a trap in which flying prey is caught, it extends the perceptual range of a nearly blind organism, and the threads provide the substrate on which hooked legs can move at high speed. The purpose of this exercise is to demonstrate some of the factors that determine web location, the sequence of events that results in web construction, and the extent to which web construction may be modified.

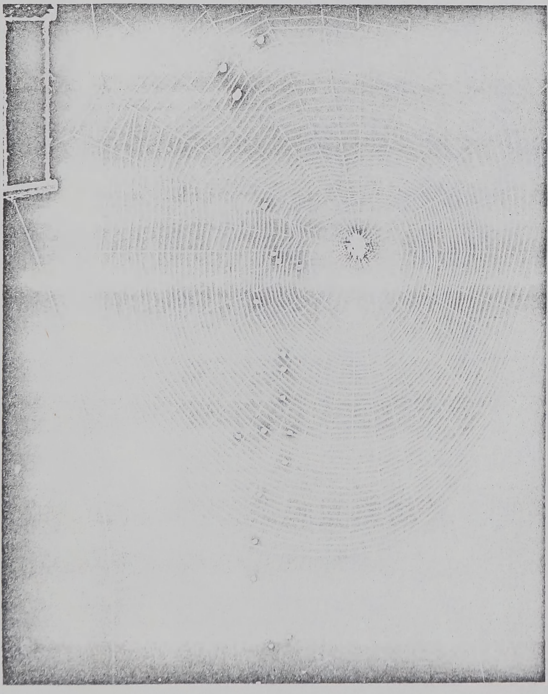

Figure 34-1. Web of adult female *Araneus diadematus* Cl. built in an aluminum frame in the laboratory, and photographed against a black box with lights shining from four sides. Note spider as white figure in center of web, and scale of two vertical white lines, 20 mm apart, in upper left corner.

METHODS

Subjects and Materials

For indoor observation you will need a frame to house the spider and provide an anchor for its web, a room in which light and temperature can be manipulated, a good light, and a dark background for observation and possibly photography. A simple frame can be made of four rectangular pieces of cardboard, 10 × 50 cm, taped together to form a square; transparent wrap can be used to close front and back. Figure 34.2 shows a more permanent frame that can be constructed from wood or metal. The screens on the narrow sides of the frame facilitate anchoring for frame threads, and the glass doors prevent escape and permit a clear view of the web; glass should be removed for photography. Web-building indoors is more likely under conditions of (*a*) high humidity, achieved by placing open vessels filled with water around the frame, (*b*) short (8-hour) nights, produced in winter by turning on electric lights in the evening and morning, and (*c*) a temperature difference of at least 5°C between night and day, obtained by changing the thermostat setting or opening windows. More details are given in Witt (1971) and Witt et al. (1968).

Procedure

A. Time and Place of Web Building Since most spiders in the field build their webs every morning at sunrise, observations on the beginning and ending of web-building can be most profitably made at this time. If the exercise takes place in the late summer, you will find many webs built close together, and you can gain some knowledge of a species' site preferences by determining the height of the web from the ground and the direction that it faces as well as by recording the supporting plants. The effect of wind on web site selection can be tested by constructing wind shields or placing plastic cylinders outdoors and watching the consequent web locations, or releasing animals indoors in a space that contains rapidly moving as well as quiet air spaces (Enders, 1972). Additional observations on web height can be made by releasing spiders of different species in a room with a high ceiling. Certain species may build their webs closer to the ceiling than others. (Data on web height can be statistically analyzed for species differences.) For further reading on timing and frequency of web building and on web location see Witt (1963) and Turnbull (1973).

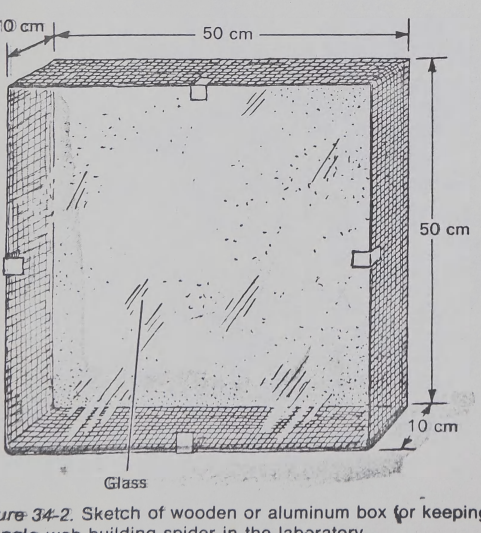

Figure 34-2. Sketch of wooden or aluminum box for keeping a single web-building spider in the laboratory.

B. Web-Building Behavior Since the timing of web building indoors is often unpredictable, the observer may be well rewarded for staying up one night with 3–5 spiders. Best results are obtained by using young females of a species that builds a web daily, e.g., *Araneus diadematus* Cl. (See also Witt, 1971.) Observe the web-building process from beginning to end.

1. How many phases can you recognize during construction of one web?
2. What characteristic pattern of movements is repeated over and over in a phase?
3. Which principal role do the front legs play in web building? Which do the hind-legs play?
4. What is the last movement of the spider when it finishes a web?
5. How much does a spider use its weight in web construction, and how do you think weightlessness would interfere with web building?

Once you have learned the normal sequence of events in web construction try some experimental manipulations as new webs are being built. For example, what is the effect of repeatedly cutting a radius just after it is laid? How many times will the spider rebuild a radius in the same place? Does the spider's response to this experimental manipulation depend on the stage of web construction at the time? What is the consequence of transferring spiders in the middle of construction from their own to another structure?

Through these observations you can learn a great deal about the plasticity of web-building behavior, the way it is "coded" in the animal, and how it serves the survival of the species. (See also Peters, 1970; Reed, 1969.)

C. The Physical Web and Its Behavioral Correlates Only after we have established objective, quantitative measures of behavior can we begin to identify factors that influence the physical structure of the web itself. Simple web measures can be obtained by measuring the vertical and horizontal diameter of the catching area with a ruler and by counting the number of radii and spiral turns; size of catching area divided by number of radii plus number of spiral turns provides a figure for mean mesh size.

For exact measurements, webs should be photographed. You can use pictures taken in the field, but for analysis of pattern, you generally get better photographs if the web is built in a laboratory frame. For further information on web photography see Witt (1971).

A planimeter can be used to measure central, catching, and frame zones of the web separately (Fig. 34.3). These measurements may show some relation to other parameters of importance to the survival of spiders (e.g., abundance of food, size and species of spider). Regularity measures have been shown to be most affected by age and drugs; measures of regularity can be obtained from radial angles as well as spiral distances. If you lay a ruler and protractor over a photograph of a web, centering the protractor on the web center, the central angles of radii can easily be recorded. By subtracting neighboring angles from each other (e.g., 18° − 16° = 2°; 16° − 17° = 1°, . . .) and calculating the mean of all such differences, you obtain a single figure for the angular regularity of a web. Another group of interesting measures identifies the shape (i.e., length over width of catching area). For more explanations of web measures, how they are taken and when they deviate from normal, consult Witt et al. (1968). After obtaining measures for several webs of a single spider, you may want to investigate the role which the absence of a leg plays in the achievement of web geometry. It would be surprising to find that an occurrence as common as the loss of a single leg made spiders incapable of weaving a trap for prey. Legs can substitute in function for each other, and only a multiple loss will result in abnormal web construction. Each pair of legs has a different function (e.g., first pair, probing; last pair, thread laying) and the removal of a pair will show disturbances in web geometry related to that pair's task. New observations may contribute to the analysis of the role which each leg or leg combination plays in thread positioning (see Reed et al., 1965).

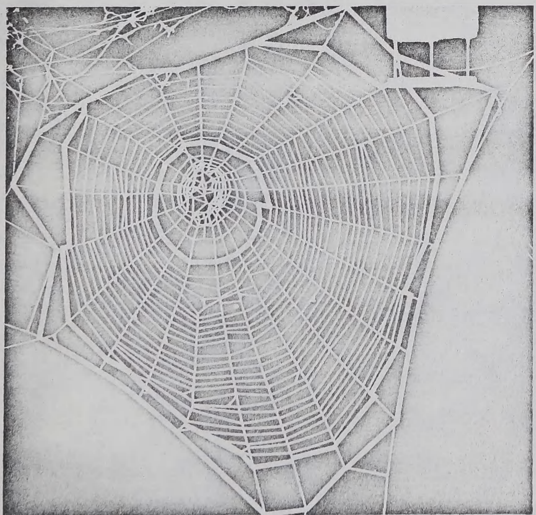

Figure 34-3. Thick white lines outline (from the center) the spiral turn enclosing the center area; the utermost spiral turn, enclosing the spiral or catching area; and the frame of the web of an adult female spider. The three areas, which can be measured with a planimeter, show sizes and ratios to each other that are characteristic of the species, age, and state of the builder.

QUESTIONS

1. Is there a species or age difference for: (*a*) mean distance between hub and ground in orb webs? (*b*) vegetation on which webs are attached? (*c*) mean mesh width and size of center area?
2. Is frequency of web renewal dependent on: (*a*) destruction of old web? (*b*) amount of prey eaten? (*c*) species of spider? (*d*) time of removal of old web?
3. List separately parts of web-building behavior or web use which can or cannot be modified by changes in the environment.
4. What factors (biochemical, behavioral) might cause a spider to build a smaller web than normally expected? Design an experiment to determine whether a relatively small web was the result of a lack of silk supply at web-building time.

ADDITIONAL STUDIES

You may want to explore a little further the "world of touch" in which a spider lives. With a vibrating tuning fork held to a radius, questions can be explored like range of perception, threshold intensity, and type of habituation which occurs to repeated stimulation of one or several radii. In prey catching, there is a chain of stimulus-reaction sequences to be observed, from the first impact of the fly against the web to the final sucking out of prey (Robinson and Olazarri, 1971). What stimulus releases what reaction? Are there alternate pathways? Do the spider's age and/or body weight as well as hunger play a role in the hunter-prey interaction? There are many such problems open to the interested investigator with access to a small colony of web-building spiders.

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Use them for helping move birds in and out of the observation pens.

If the birds in the adjacent pen appear to be unduly influencing the behavior of the birds under observation, they should be removed and placed temporarily in a poultry crate or similar container out of sight and preferably hearing.

This exercise may be run purely qualitatively to demonstrate the various behavior patterns and calls of chickens and their association with dominance and subordinance; and to demonstrate the phenomenon of social hierarchy. The exercise can also be conducted more rigorously in an attempt to quantify the frequency and sequences of behavior components in relation to dominance and subordinance, and to the sex of the birds. If the latter procedure is followed, the first period should be used to allow the students to identify and describe the behavior components; the second period to quantify them.

Coturnix quail may be substituted for chickens in this exercise (see Exercise 22).

EXERCISE 34. WEB CONSTRUCTION IN SPIDERS

You may want to make sure in advance that the necessary spiders for the exercise are available. From late spring to late autumn orb-webs can be found outdoors, frequently a great number in the same area. In the early morning and at sunset spiders sit in the hub of the web, and the low sun and dew make threads relatively well recognizable, while it is difficult to see a web or find a spider in the middle of the day.

One source of web-building spiders (available at all times except late winter and early spring) is Mr. Leonard Pankhurst, 204 Stroud Street, Canastota, New York. If time permits, one can search for or order a cocoon, and watch the hatching spiderlings, which will start building about two weeks after leaving the egg shell.

As long as spiders are given water (sprayed on the webs or through a drop placed on the mouth parts), they survive in the laboratory for several weeks.

A web photograph can be made in advance, duplicated, and given to students in the laboratory for evaluation. Several small groups can compare size, shape, and regularity measures obtained from the same web. The task of measuring a web proves to be a special opportunity to become familiar with details of the web pattern.

EXERCISE 35. TERRITORIAL BEHAVIOR IN DRAGONFLIES

Before taking the class into the field, the instructor should discuss with students territoriality and the criteria for determining whether an animal is displaying territorial behavior. The instructor should also briefly discuss the natural history of dragonflies so that students may be alert for observing all aspects of their life cycle.

After mating (described in the exercise), eggs of dragonflies are deposited either by the female repeatedly dipping her abdomen as she hovers low over water or, in some species, by inserting eggs into aquatic vegetation by means of a special ovipositor as