Several factors influencing web-spinning activity in the common house spider *Achaeearanea tepidariorum* Koch

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Web-spinning activity of *Achaeearanea tepidariorum* (Koch) was observed in relation to amount of prior feeding, hours of food deprivation, and the number of flies (*Drosophila melanogaster*) available in the animal's environment. Web spinning was positively related to the number of flies consumed in a 24-h period prior to testing, but did not vary significantly between 24 and 72 h of food deprivation. The amount of available food in the environment was positively related to web-spinning activity during a 48-h test period.

A spider's web may be regarded as a record of its movements during a short period of time (Witt et al, 1968) and hence utilized as a readily available measure of the animal's activity. Emission rate of this activity has typically been discussed as controlled by endogenous mechanisms (Comstock, 1948; Savory, 1964; Witt et al, 1968; and others), although other investigations of exogenous control of this behavior are reported (Spronk, 1935; Wolff & Hempel, 1951; Szlep, 1958; Witt, 1963; and others). Included among endogenous factors of importance in controlling rate of web production are nutritional state (Breed et al, 1964), age and maturity (Witt & Baum, 1964), and biological rhythms (Witt et al, 1968). Exogenous factors of importance in controlling web-spinning activity include the structure of the available space for a web (Peters, 1967), the amount of available light (Witt, 1956; Witt et al, 1968), and temperature and humidity (Witt et al, 1968). Two incompletely studied factors of reported importance in controlling web spinning are level of food deprivation and amount of available food in the animal's environment.

Data reporting the effect of food deprivation on the rate of web spinning comes from two sources: nutritional studies (Witt & Baum, 1960; Witt, 1963; Breed et al, 1964; Witt et al, 1968) and, secondly, incidental observations on web spinning following feeding activity (Wiehle, 1927; Peters, 1932; Koenig, 1951; Wolff & Hempel, 1951; Witt et al, 1968). Nutritional studies which have manipulated deprivation schedules or have varied the food supply condition have typically found effects on web spinning activity. Additional food results in additional body weight, which in turn requires a heavier thread to support the increased

weight (Witt et al, 1968). Findings on web size have not been related to food deprivation except above 10 days' duration (Witt et al, 1968). At shorter duration deprivations, web mesh size may increase and the thread diameter may decrease as a means of saving silk, but overall web size (i.e., area) is unvaried. While it is reasonable to hypothesize that as the web represents a food-securing activity and should show a reliable relationship to "hunger drives," no studies have specifically studied food deprivation as a stimulus condition for onset of rate of web spinning activity.

Incidental observations of web spinning generally agree that heavy feeding is in general followed by several days' latency of this activity. Witt et al (1968) interpret this behavior as a reduction in hunger drive which lowers the threshold for releasers like light and temperature to operate. If "hunger" is a stimulus condition for web-spinning activity in spiders, then low levels of food deprivation should result in an increase of the behavior.

A second factor of interest in this paper is the effect of available food on web-spinning activity. It has been shown that the spider is sensitive to vibrational stimulation (Walcott & Van der Kloot, 1959) and that the web serves as a transducer of proximal vibrational stimulation from sources such as trapped prey or approaching males during courtship (Boys, 1880; Barrows, 1915; Walcott, 1963; Szlep, 1964; Parry, 1965; and others) and also for distal vibrational sources such as flying prey (Frings & Frings, 1966; Witt et al, 1966). Such vibrational stimulation from a food source could well in itself act as a releaser or a facilitator of web-spinning activity, although this relationship has not been studied.

The web of this species is a loose irregular mass which is usually built in the upper corners of rooms, among rocks, and in similar suitable habitats (Emerton, 1920). Preliminary observations indicated that the webs were built anew each day, if no prey had been caught within 24 h in the original web. Sometimes the spiders destroyed and ate their old webs, although no data were available on the frequency of this behavior. These laboratory observations cannot be used to draw

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Fig. 1.

conclusions in regard to the behavior of unconfined spiders. Spiders in an uncontrolled environment may renew with greater or lesser frequency. No data were available on the length of time it takes a spider to build a complete web. When caged, spiders built webs within the first 24 h after being placed in a cage. All webs were built across the upper corners of the cages, undoubtedly because the tridimensional surfaces presented by the corners readily lent themselves to the construction of the therid web. This observation agreed with that of Turnbull (1964), who also studied this species using test cages.

In the present investigation, it was hypothesized that low levels of food deprivation would increase web-spinning activity and that the amount of feeding just prior to testing would be negatively correlated with rate of web spinning. It was further hypothesized that stimulation due to the amount of available food in the environment would be positively related to rate of web spinning. No prediction was made on the interaction of deprivation level and food availability.

METHODS

Achaearanea tepidariorum (Koch) were obtained from an abandoned house near St. John's, Newfoundland, transported to the laboratory in small collecting bottles, and placed singly in 40 x 23 x 20 cm clear plastic cages. Ss were maintained at $20^{\circ} \pm 1^{\circ}\text{C}$ in an air-conditioned room, fed daily 15 *Drosophila melanogaster* and exposed to a 16-h daylight/8-h darkness cycle. All animals were held under these conditions for at least 1 week prior to testing.

Experiment 1

Ss were assigned randomly to one of two food deprivation conditions (24 or 72 h). At the onset of the food-deprivation period, the home cage of the test animal was cleaned of stored food and old webs. No food was placed in the cage for the designated duration of deprivation. At the completion of the deprivation period, the area of the webs that were constructed

was recorded. Although the web of a *A. tepidariorum* is tridimensional, height of the web (distance from top of web to floor of container) varied little. The walls of the test cages were marked in a grid of 1-cm squares, using thin strips of black tape. The outline of the web was measured on this grid. These data were transferred to 1-sq-cm graph paper for later measurement and calculation of area. A typical measurement of a web is illustrated in Fig. 1. Old webs were left in the cages. The animals were then assigned randomly to one of three food availability conditions: (1) no *Drosophila melanogaster* introduced into the test cage, (2) 25 flies introduced into the test cage, or (3) 100 flies introduced into the test cage. After the flies were placed in the test cage, the animal was left undisturbed for 48 h. Following the test period, areas added to the initial web were recorded as previously described. The area of web construction during the test period under the two deprivation conditions and the three fly stimulation conditions were incorporated into a 2 by 3 factorial analysis of variance design with three Ss per cell.

Experiment 2

On completion of this work, additional study was conducted by releasing 30 *Drosophila melanogaster* into each cage daily and counting the number of flies consumed. The amount of web increase during the following 24-h period was then recorded and measured, and Ss were then divided into three groups: those that consumed no flies, those that consumed fewer than 15 flies, and those consuming more than 15 flies per 24-h period. A simple randomized analysis of variance tested differences in web size increase between the groups.

RESULTS

Means, in square centimeters, and standard deviations of changes in web area (Experiment 1) are presented in Table 1. Analysis of variance indicates that the interaction of Deprivation Level by Number of Flies in the environment is significant ($F = 5.02, p < .05$), and the main effect of number of flies in the environment is significant ($F = 4.14, p < .05$).

Data for Experiment 2 on the mean web size increase, in square centimeters, and standard deviations of changes in web area in relation to the number of flies consumed is presented in Table 2. Analysis of variance indicated overall significance ($F = 7.73, p < .005$) and

Table 1
Means (in Square Centimeters) and Standard Deviations of Web Area Increase During 48-h Test Period Under Food Deprivation and Food Supply Conditions

Number of Flies in the Environment		Hours of Food Deprivation		
		24	72	Sum
0	Mean	5.6	19.3	2.5
	SD	8.4	27.4	27.5
25	Mean	93.0	62.6	77.8
	SD	71.0	10.5	194.0
100	Mean	54.0	48.0	51.0
	SD	76.0	67.0	114.0
Sum	Mean	50.9	43.3	47.1
	SD	63.8	46.7	50.5

multiple comparisons indicated that each group is different from the other groups.

DISCUSSION

Web-spinning activity in both experiments was found to be inversely related to the amount of feeding immediately prior to testing. This may be interpreted in several ways. It is consistent with the data to hypothesize that the drive condition which produced the initial differences in feeding rates may have persisted into the test period and that this accounts for the differences in web-spinning activity between groups. Under this interpretation, it could be concluded that there is a positive relationship between the drive conditions which elicit food consumption and web-spinning activities. Alternatively, it is consistent with the data to hypothesize that the positive relationship found between rate of spinning and feeding is related to nutritional level or ingestion-/digestion-related arousal. This investigation does not allow us to separate these possible relationships.

At the levels of food deprivation utilized in this investigation, "hunger drives" do not appear to act as significant releasers or facilitators of web-spinning activity and there was a lack of effect of deprivation on web mesh size. These data would indicate that onset and rate of web-spinning activity are controlled by other factors.

The significant interaction between amount of available food (number of flies) and hours of food deprivation occurred because of the effectiveness of fly stimulation at the 25-fly level and the 24-h deprivation condition. This appears to be an optimal level of deprivation and environmental stimulation in facilitating web spinning. In light of the overall nonsignificance of the effects of food deprivation, this should perhaps be interpreted as an artifact of the testing situation and stimulation levels, as only brief pilot work was done to determine the food-deprivation condition and the number of flies released to the test chamber. It appears that, for chambers of this size, future studies should use lower densities of flies and also explore periods of milder deprivation.

Interaction between levels of food availability and hours of deprivation were statistically significant ($p < .05$). This occurred because of differences between the no-fly and 100-fly conditions. No

significant difference was found between the 25- and 100-fly conditions, and thus it is not possible to state the level of stimulation that is effective in eliciting web spinning, but only that some fly stimulation is a significant factor in web-spinning activity.

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Table 2
Change in Web Size During a 24-h Period in Relation to the Number of Flies Consumed

	Mean Web Size Increase (in sq cm)	SD	Number
No Flies Consumed	0	0	6
0-15 Flies Consumed	25.0	55.0	5
15-30 Flies Consumed	75.1	63.3	7