

BEHAVIORAL EVIDENCE OF CHEMORECEPTION ON THE LEGS OF THE SPIDER *ARANEUS DIADEMATUS* CL.

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ABSTRACT

Behavioral responses of the spider *Araneus diadematus* to chemically-treated prey support the hypothesis that hairs on the legs of spiders receive chemical stimuli. Analysis of movie films showed a definite withdrawal reaction of spiders to quinine-coated flies and repeated trials with quinine-treated flies led to significantly ($P < 0.01$) longer periods of time for the spiders to respond to prey.

The frame by frame analysis of movies has provided the evidence needed to conclude that spiders are capable of receiving sufficient signals to stimulate the chemosensitive hairs on the legs. While conducting an experiment on altering the behavioral pattern in the feeding of the spider, it was perceived that, when it was exposed to prey coated with a bitter solution, the animal did not have to touch the prey with its mouth parts to be repelled. Upon observing this, I thought a closer observation was necessary. A movie could freeze each action of the spider so that any movement which occurred, that was too fast for the naked eye, could easily be analyzed frame by frame. After a close study of the movie it was determined that the spider did not have to touch a quinine solution with its mouth parts at any time, in order to be repelled, even if the coated fly was moving about and vibrating.

Several hairs on the spiders' legs are morphologically similar to the hairs on the proboscis of the blowfly (Foelix, 1970). The blowfly has been studied morphologically and electrophysiologically by Dethier (1955, 1971) and Wolbarsht (1958) who established that the four chemoreceptors on the proboscis have many functions dealing with sensing, coding and transmitting. In the spider, chemoreceptor structures have been described but, "... there was never any supporting evidence" for the function (Foelix, 1970). McCook (1890) wrote "I have long entertained the opinion that the sense of smell in spiders abides entirely in the delicate hairs." Bays (1962) provided sufficient evidence that spiders could learn to distinguish between two vibrations and two different tastes: glucose (sweet) and quinine (bitter). The spiders in Bays' experiments, after a few trials, rejected the quinine-coated prey, which leads one to believe that for the spider there must be some aversive properties of the bitter solution.

Chemicals contained in the fresh silk or on a mature female spider appear to play a vital role in the pre-mating process. According to Kaston (1936) the male of *Dolomedes scriptus*, a non-orb-weaver, does not attempt to court if the female's leg has been dipped into ether, while courtship is elicited by the ether extract, after evaporation of the ether.

Wolff and Hempel (1951) find their spiders sensitive to chemical stimuli on touch, and Krafft (1971) interprets his observations of social spiders' interaction as transmitted through chemical and tactile signals.

There can be no doubt that spiders perceive non-volatile chemicals on contact (Kaston, 1936); but is a touch by the leg sufficient to receive the chemical indicating the taste of food?

METHOD

Twenty-four *Araneus diadematus* spiders were used in the experiment, 12 in each group, the experimental and control groups were kept on different diets. The laboratory conditions were controlled and the temperature was regulated (cool and dark from midnight until 8:30 a.m. and light and warm until midnight). The animals were kept in cages with screen on the sides and with glass in the front and back (for details see Witt, 1971). The experimental group was fed a suspension of 30 to 40 homogenized fly abdomens in approximately two teaspoons of water with a small quantity of sugar. About 0.01 ml was put into a syringe which was held to the mouth parts of the spiders until imbibed by the animal five times a week for 47 days. The control group received two untreated flies a week for 47 days.

The fly for the experimental spiders was first fully dipped into a suspension of quinine in water, then put onto the web. Usually the fly was wiggling when it was placed onto the web and this attracted the spider's attention. The spider approached the fly, touched it with a front leg or put all of its legs on the prey, then either went back up to the hub (center) of the web or wrapped it first and then went up. This sequence of events would follow the same pattern each time a quinine-covered fly was used. If the prey was not wiggling when it was put onto the web, the tuning fork (middle C) was held just below the prey to lure the spider. In some cases, an uncoated fly was held with forceps just below the quinine coated prey until the spider approached. The quinine coated prey was given each day on which the spider had built a new web.

RESULTS AND CONCLUSIONS

This experiment was originally performed as a followup study to experiments by Reed, *et al.* (1970) which indicated that while experience did not change web-building behavior, it influenced the spiders' handling of prey. The experimental spiders were "timed" after a period of 47 days, during which they were given the quinine coated prey, and compared to the control group's timing. With the aid of a stop-watch I ascertained the interval between the time when the prey was touched to the web and when the spider touched the prey. After several trials the spiders in the experimental group took significantly ($P < 0.01$) longer periods of time to get to the prey than did the control group (see Table 1): their feeding behavior was changed as a consequence of experience.

Quinine solution has no odor, so there is no airborne stimulus. It is true that the spider could detect the quinine-coated fly was wet to the touch; but how did the spider know that the fly had not been dipped into a glucose solution, which it usually takes without hesitation (Bays, 1962)? There was a definite withdrawal reaction from the quinine, indicating that the spider perceived an unpleasant stimulus through sense organs on the tarsi (see Figs. 1, 2). Combining these observations with those of Foelix (1974) it seems

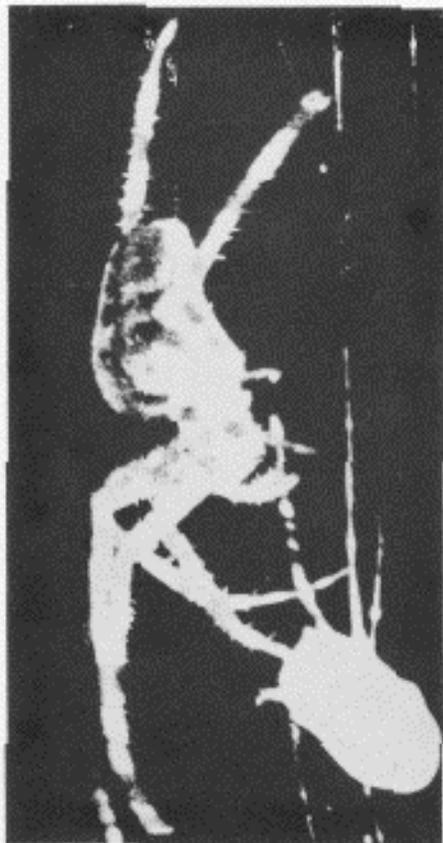
safe to suggest that the spider received sufficient chemical stimuli with the chemosensitive hairs on the tarsus to recognize the substance. Such a hypothesis is supported through the frame by frame observation of the spider's movements in a movie film, as the animal approaches the quinine covered prey, and responds.

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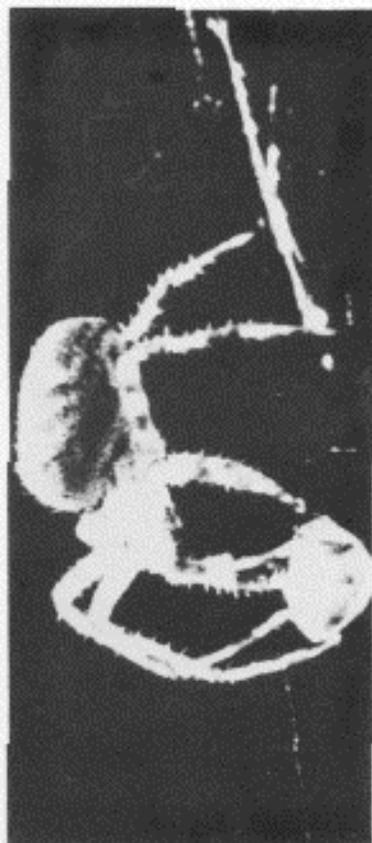


Fig. 1.—This is an enlarged picture taken from one frame of a 16 mm movie. It shows a female *Araneus diadematus* spider (on left) at its closest distance to a fly coated with quinine (below on the right). The frames before and after this picture reveal the spider at a farther distance from the fly. (Notice that the bitter substance is touched by the tarsus only, before the spider retreats.)

Fig. 2.—This shows a different *Araneus diadematus* female spider under similar circumstances as in Fig. 1. Notice the spider (on the left) touches the prey (on the right) with the tips of all the legs except the back ones which hold on to the web. In this sequence, the mouth did not come in contact with the prey at any time.



1



2

Fig. 1.—This is an enlarged picture taken from one frame of a 16 mm movie. It shows a female *Araneus diadematus* spider (on left) at its closest distance to a fly coated with guanine (below on the right). The frames before and after this picture reveal the spider at a farther distance from the fly. (Notice that the bitter substance is touched by the tarsus only, before the spider retreats.)

Fig. 2.—This shows a different *Araneus diadematus* female spider under similar circumstances as in Fig. 1. Notice the spider (on the left) touches the prey (on the right) with the tips of all the legs except the back ones which hold on to the web. In this sequence, the mouth did not come in contact with the prey at any time.

Table 1.—Mean and standard deviation of time it took female *Araneus diadematus* littermates to reach prey at 1.4 cm distance, after the experimental group had been offered quinine-coated flies under similar circumstances for 47 days, five times a week, and had been fed spider suspension from a syringe held to the mouth, while controls caught flies in webs. The difference in time is significant below the 1 per cent level.

	Number of Animals	Mean time for prey in seconds	Standard Deviation
Control Group	21	9.66	± 9.25
Experimental Group	6	38.16	± 36.22

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