Copulation and Sperm Induction by Normal and Palpless Male Linyphiid Spiders

Abstract. *The performance by palpless male linyphiid spiders of behaviors associated with copulation and sperm induction indicates that occurrence of these sexual activities does not depend on peripheral input from the palps.*

All male spiders must perform sperm induction in order to fertilize the female. Sperm induction involves the building of a sperm web, deposition of seminal fluid, and the filling of the palpal receptacles with sperm. During copulation, the palps are inserted into the female's genital opening. Gerhardt (*1*) suggested that the readiness of a male to display courtship behavior depends on a sense of fullness in the palps following sperm induction; that is, proprioceptive feedback by way of palpal nerves is a prerequisite for this behavior in spiders. Other authors (*2, 3*) have restated this hypothesis. In light of the recent finding (*4*) that onset of courtship behavior in spiders does not depend on prior sperm induction, I attempted to determine if the palps were essential for the occurrence of other aspects of sexual behavior.

Ten male *Linyphia triangularis* were forced to autotomize their palps during the subadult stage. After the final molt, these males lacked palps, although stumplike appendages of one segment sometimes were present. The behavior of these males was compared to that of six intact animals.

In the copulatory position used by linyphiids, both sexes hang inverted beneath the silk sheet of the female's web, the male being above the female. Primary contact between the spiders occurs during the insertion of the palp into the female's genital opening. Occasionally the legs of the male contact those of the female at several points. The point of the male's cephalothorax near the eye region may pivot on the female's chelicerae. Thus, the embrace is relatively loose.

After assuming this position, the male *L. triangularis* inserted each palp, in alternation, from about 50 to 100 times. After each insertion, the palp was passed between the chelicerae ("palpal lubrication"), an action assumed to function in facilitating palpal insertions (*3*). The male occasionally dismounted, wandered about the web, and then remounted the female. The end of this initial phase of copulation was marked by the construction of the first sperm web, which occurred from 51 to 107 minutes (mean, 73) after the onset of copulation.

The spider began sperm induction activities by tearing a hole in the female's web. In this space the male built a small, triangular web. While above this web, he rubbed his genital region against the silk, released a drop of fluid, and then returned to an inverted position beneath the sperm web. He dipped the palps into the sperm drop and took the fluid up. This latter activity, sperm absorption, lasted from 1 to 2 minutes. The male then remounted the female and initiated another copulation. During the entire mating, which I observed for up to 4 hours, males usually performed two sperm inductions.

The behavior shown by the 10 males lacking palps was similar in many ways to that of intact animals. Palpless males courted and successfully mounted the females. A copulatory position like that of normal linyphiid spiders was maintained for a variable length of time. The male's eye region pivoted on the female's chelicerae or, further posterior, on her sternum. Sometimes the male was more steeply inclined than were normal males in similar situations. At intervals, some males pressed forward as though attempting palpal insertion. They often performed rhythmical, cheliceral "chewing" movements, which in the normal spider accompany the so-called palpal lubrication. Palpless males typically dismounted from the female more frequently than normal males did.

After 23 to 102 minutes (mean, 58) of such "pseudocopulation," the palpless male constructed a sperm web and deposited seminal fluid upon it. He then swung beneath the web and hung for about 1 minute in a position similar to that used by normal males during sperm absorption. The male then remounted the female. One or more additional "pseudosperm inductions" were performed during the remainder of the mating. I observed matings involving palpless males for up to 7 hours.

On three or more successive days after the initial occurrence, additional pseudocopulations involving the palpless males were seen. Such was not the case in intact animals. After mating with intact males, females no longer were sexually receptive. The persistence of receptivity in females paired with palpless males provides additional evidence for van Helsdingen's (*5*) hypothesis that termination of receptivity in linyphiid females is triggered by sperm transferral.

The similarity of pseudocopulation in palpless males to the behavior of normal spiders demonstrates that the initiation and regulation of many aspects of copulation are independent of proprioceptive feedback from the palps. Although palpal insertions are not possible, both partners maintain the copulatory position for very long periods of time. Apparently, stimuli arising from the few points of contact between the spiders are sufficient for the persistence in both sexes of the copulatory posture (*6*).

The performance by palpless males of activities associated with sperm induction indicates that this aspect of sexual behavior also is independent of proprioceptive stimuli from the palps. Previous workers (*1, 2*) have suggested that the stimulus for sperm induction is probably a sense of emptiness in the palps. It now appears that sperm induction, as well as courtship and certain aspects of copulation, are largely independent of such hypothesized stimuli. The occurrence of palpal lubrication movements in palpless males provides an additional example of a behavior in these animals whose control is largely central.

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References and Notes

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3. R. L. Gering, *Smithsonian Inst. Misc. Collect.* **121**, No. 4 (1953).
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6. The behavior of some palpless males after many hours of pseudocopulation lent support to this hypothesis. These individuals occasionally adopted and maintained a position to one side or the other of the female's body. The male's eye region pivoted on a basal segment of one of the female's legs. Examination of the eye region revealed a patch of hairs, which are much longer in the male than in the female. Tactile or chemical stimulation of these hairs may be sufficient for maintenance of the copulatory posture. Frequent observation of a minute gap at the pivot point, rather than contact of the male's head surface with the female's leg, supported the latter idea. Occurrence of copulation during the night indicated that visual stimuli are not important in this behavior.
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