Great Basin Naturalist

Volume 40 | Number 2 Article 19

6-30-1980

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STINGER UTILIZATION AND PREDATION IN THE SCORPION *PARUROCTONUS BOREUS*

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Abstract.— The utilization of the stinger and the predatory technique of the scorpion, *Paruroctonus boreus,* was studied under laboratory conditions. During the study, 83 feedings were observed. Age of the scorpions and the percentage of prey stung by them were used to classify the scorpions into groups. The scorpions aged 13–61 days always stung prey. After 62 days the scorpions began to selectively utilize the stinger. Utilization declined until it reached 30 percent in the adult stage. The stinger is apparently necessary for prey capture only in the early life stages.

The role of the stinger in scorpion behavior has never really been studied or established. The available information is vague and inconsistent. Alexander (1959) reported that different groups of scorpions utilize the stinger differentially. Pocock (1893) and Stahnke (1966) stated that scorpions paralyze prey only when it does not submit to passive consumption. Finally Hadley and Williams (1968) reported that *Vejovis confusus* and *Paruroctonus mesaensis* and *P. baergi* stung prey (Williams 1972). These reports leave the adaptive significance of this potent device in doubt. In this study, we attempted to establish the use of the stinger through controlled experimentation and observation.

Methods and Materials

Scorpions were collected from southwestern Oregon on the Malheur National Wildlife Refuge and adjacent region. They were kept in 10-gallon terrariums containing three inches of soil and flat rocks from the natural habitat. In most cases, two scorpions were placed in each tank to induce intraspecific responses. A large population of grasshoppers and a small number of beetles, crickets, and termites were found in the area, and these were selected in relative proportions as the prey.

To maintain natural conditions, the terrariums remained outdoors except during periods of observation. Observations were conducted at night using red light. Red light provided visibility for us, but apparently did not affect the scorpions, which possess vision in the blue and ultraviolet wavelengths (Machan 1968).

Results

Over a two-year period several different groups of *Paruroctonus boreus* were observed. Predation techniques were the same for scorpions of all ages and sizes. Emergence from cover occurred between 2130 and 2300 hours. If emergence did not occur by 2300 the scorpions did not forage that night. After emergence, contact with prey was established through random encounter or active stalking. When actively stalking, the scorpions traveled with the pedipalps extended forward and held apart at a distance approximately equal to the maximum width of the abdomen. The telson was arched over the abdomen with the caudal vesicle above the midabdomen. When a potential prey was detected the scorpions rushed it.

Upon contact, the scorpions used their pedipalps to grasp the prey by one or more appendages. If stinging occurred at all, it occurred at this time. The telson was arched over the abdomen and at the same time the abdomen was quickly raised. This imparted a downward stabbing motion which allowed

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the stinger to penetrate the prey's abdomen. Resistance by the prey subsided within one minute after it was stung. Whether or not the prey was paralyzed, it was held motionless in the pedipalps for 10 to 30 minutes and then transferred to the chelicerae. Upon leaving the site of capture the prey was slung, ventral side up, onto the cephalothorax.The prey was carried about the terrarium in this position for up to several hours. When walking, the scorpions waved their pedipalps in front of their path in a "blindman" fashion, a slow exploratory touching.

Except when scorpions were with young, prey was taken beneath cover for consumption. Consumption time varied between 2 and 48 hours. Feeding began at the head of the prey and continued until the prey was consumed. The hard exoskeleton of beetles was left as an empty husk. Several of these husks were found with scorpions in the field. All scorpions used the same feeding techniques. However, the scorpions also underwent regular periods of nonfeeding which lasted up to five months.

The stinger was removed from two adult scorpions. These scorpions fed six times and utilized the same techniques as unimpaired individuals. However, they never attempted to sting any of the prey.

During intraspecific aggression or cannibalism, the method of capture was as described above with minor modifications. If there was a significant difference in size, the smaller scorpion attempted to avoid conflict, but the larger one often pursued. When aggression occurred, the scorpions grasped each other by the pedipalps and repeatedly attempted to sting. A size difference always resulted in the death of the smaller scorpion. Consumption proceeded normally after immobilization. In two instances of the scorpions being the same size, both animals were killed.

Immature scorpions did not capture prey until they were 13 days old. Prior to this time they consumed their casting left at birth and their first exuvium. After the juveniles dispersed at 9 to 11 days, the female began feeding with an alteration in feeding technique. The adult female consumed prey in the open and its young congregated about the adult's cephlathorax. On day 14 the young began to capture prey. Table 1 summarizes the percentages of prey stung by the early instars and all other age groups.

Discussion and Analysis

No age group beyond 84 days was observed due to our inability to keep juveniles alive. This resulted mainly from a high degree of cannibalism and mishandling of a few remaining scorpions. Data on cannibalism were excluded from Table 1 because of the bias it would introduce inasmuch as intraspecific aggression always elicited stinger utilization. Two scorpions per tank and the limited dispersal range of the young led to an unnatural increase in incidents of cannibalism. Data on the six feedings by the scorpions with stinger removed were also excluded due to their inability to sting.

During active stalking, the scorpions rushed prey. Some stimulus must have been present which alerted the scorpions. *Paruroctonus boreus*, like other desert scorpions, may be able to detect and utilize Rayleigh waves for prey location (Brownell 1977). A Rayleigh wave is a slow-moving secondary vibration created by movement and propagated through sand.

The stinger was not essential for feeding by the adult scorpions. A low percentage of prey was paralyzed, and stinger-impaired individuals were able to feed without difficulty. Scorpions are also capable of surviving prolonged periods without food (Stahnke 1966). Considering these factors, we suggest that the amount of food which would be lost to an adult incapable of stinging would not have a significant or deleterious effect upon its survival.

If stinging occurs, it is triggered by two stimuli. One, as stated by Pocock (1893) and

TABLE 1. Relationship between age and stinger utilization.

Age group in days	Number of feedings	Number stung	Percent stung
01–12*	0	0	00.0
13–61	40	40	100.0
62–84	13	9	69.2
Adult	30	10	30.0

*Fed on exuviae and adult pellets.

Stahnke (1966), is an attempt by the prey to resist capture. This is not the only stimulus. Struggling hard-bodied or powerful prey, such as grasshoppers, were stung. Termites and other soft-bodied prey were held in the pedipalps until resistance subsided. The factors that elicited a sting were resistance in combination with the characteristics of the prey species. This strongly suggests a form of selective stinger utilization.

The selection process develops over time. The first instars feed on the exuviae and possibly on small pellets dropped by the adult during feeding (Stahnke 1966). Utilization of pellets for food suggests the reason for the change in feeding technique by the adult female, with the young gathered about her cephalothorax. The next age group, 13–61 days, paralyzed all prey (Table 1). The cause of this may be that the pedipalps were not sufficiently developed at this point to hold prey against struggle. Therefore, in order to insure the maximum number of feedings and promote growth and development, the juveniles must sting prey at first contact. As development occurs the pedipalps strengthen, and certain prey types, such as small termites, no longer must be paralyzed. This would reduce the use of toxin and be energy efficient by reducing the manufacture of more toxin.

Stinger utilization drops from 100 to 30 percent in the adults (Table 1). This decrease began about the second month and continued until the adult stage. The actual percentage utilization in the group aged 62–84 days may have been biased in that this group was not fed a representative class of prey, but instead was fed whatever small insects and arachnids happened to be available. Nevertheless, this group still demonstrates the beginning of the process of differential selection for stinger utilization in that not all prey was stung.

In conclusion, the stinger functions as a necessary device for prey capture by the early instars. As physical development occurs, the pedipalps can hold certain types of prey and there is a reduction in the use of the stinger. This decline continues until the adult stage, where only a small percentage of prey is stung and these are not essential for survival. However, the stinger is still utilized for intraspecific aggression and possibly for defense.

Acknowledgment

We thank Dr. John Mates, University of California, Davis, for his early help in this project, and Dr. Andrew Sheldon, Department of Zoology, University of Montana, for his critical review of this manuscript.

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