

## USE OF COLEOPTERAN PREY BY *PHIDIPPUS AUDAX* (ARANEAE, SALTICIDAE) IN TALLGRASS PRAIRIE WETLANDS

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**ABSTRACT.** *Phidippus audax* (Hentz 1845) was observed in the field and tested in a laboratory in order to estimate its use of two locally abundant, soft-bodied coleopteran species, *Diabrotica undecimpunctata* (Chrysomelidae, Galerucinae) and *Chauliognathus pennsylvanicus* (Cantharidae). In the field, *Phidippus audax* was most commonly observed hunting on leaves or stems of the common milkweed and feeding upon species of Diptera or *Diabrotica undecimpunctata*. Despite high densities of *Chauliognathus pennsylvanicus*, *P. audax* was never observed feeding upon this species. In laboratory feeding trials, *P. audax* always retreated from *C. pennsylvanicus* and always attacked *D. undecimpunctata*. Also, *P. audax* retreated from models displaying the markings of *C. pennsylvanicus* in 88% and attacked models displaying the markings of *D. undecimpunctata* in 85% of the laboratory trials.

Jumping spiders (Salticidae) are diurnal stalking predators (Foelix 1979; Forster 1985) which may select prey from many insects and spiders (Snetsinger 1955; Foelix 1979; Forster 1985; Jackson 1992; Edwards & Jackson 1993). Several studies have suggested that *Phidippus audax* (Hentz 1845), a large and widely distributed salticid, favors Diptera as prey but will also take slow-moving caterpillars and beetles (Freed 1984; Forster 1985; Edwards & Jackson 1993). Beetles may be very common in habitats containing *P. audax*; however, there is little information on the interaction of *P. audax* with these insects. Givens (1978) suggested that *P. audax* avoided adult dermestid beetles because the hard dorsal prothoracic shield was impenetrable to the jaws of the spider. Not only do many beetles have very hard prothoracic shields and wing covers but also many beetles possess noxious defensive compounds (Blum 1981; Harborne 1993). As a result, Coleoptera are often avoided by spiders (Reichert & Harp 1987). Despite the general avoidance of beetles, certain species are taken as prey. In separate studies of the foraging behavior of *P. audax* by Edwards (1980) and Freed (1984), spiders took both *Chauliognathus* and *Disonycha* (Alticinae, Chrysomelidae) as prey.

In the tallgrass prairie of northeastern Kansas,

*P. audax* is a common species which is frequently encountered in moist lowlands (Fitch 1963; pers. obs.). In this habitat, two species of soft-bodied beetles, *Chauliognathus pennsylvanicus* and *Diabrotica undecimpunctata* are also common. The purpose of this study was to 1) estimate the density of *P. audax*, *C. pennsylvanicus*, and *D. undecimpunctata* in these lowlands, 2) determine the use of common soft-bodied prey species by *P. audax*, and 3) quantify how *P. audax* interacts with *C. pennsylvanicus* and *D. undecimpunctata*. Furthermore, a comparison of observed responses to prey species in the field with laboratory feeding trials and responses to models may shed light on salticid-coleopteran interactions in tallgrass prairie wetlands and the role of salticids in prairie spider assemblages (Robinson 1984).

### METHODS

The field portion of this study was conducted in the lowland portions of two annually burned and two biennially burned watersheds on the Konza Prairie Research Natural Area (KPRNA) located approximately 15 km south of the town of Manhattan, Kansas. In these watersheds, upland plant communities are dominated by big bluestem, *Andropogon gerardii*, and Indian grass, *Sorghastrum nutans*. Lowland plant communities are dominated by prairie cordgrass, *Spartina pectinata*, and switchgrass, *Panicum virgatum*. Common forbs in both upland and lowland communities are the common milkweed (*Asclepias*

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*syriaca*), tall thistle (*Cirsium altissimum*) and Baldwin's ironweed (*Vernonia baldwinii*).

In order to obtain a crude estimate of the average density of actively hunting *P. audax* in the field, I counted the numbers of spiders found on leaves of *A. syriaca*, *C. altissimum* and *V. baldwinii* along three parallel 25 m transects that ran through each lowland site. The densities of these three plants in the lowlands were estimated by taking 30 quadrat samples, each 0.1 m<sup>2</sup>, in the lowland sites (Johnson & Knapp 1995). I estimated the densities of *C. pennsylvanicus* and *D. undecimpunctata* using the same method supplemented by shaking the entire contents of inflorescences and upper leaves into a sweep net, then freezing and counting the number of insects collected. Because I was simultaneously observing spider behavior, I chose not to take sweep samples of common milkweed and tall thistle foliage so that the spiders would not be disturbed.

Observations were made between 1000–1600 h every other day from mid-July to late October 1992. At the beginning of this period, all *Phidippus audax* were large juveniles approximately 13–15 mm in body length. Length of spiders was obtained by measuring seven individuals which had been killed in ethyl acetate. I recorded the plant species on which these spiders were found, their positions on the plant, and whether or not they were engaged in feeding. If they were feeding, the type of prey they were feeding upon was recorded.

**Laboratory feeding trials.**—Five late instar juvenile *P. audax* were collected from the campus of Kansas State University (Manhattan) in early August 1992, when spiders were approximately 15 mm long. These spiders were kept and tested in 20 cm × 15 cm × 8 cm clear plastic boxes. Each box was fitted with an open, mesh covered top to maintain good internal air circulation. Distilled water was sprayed into the containers every other day to simulate morning dew or light rainfall. Containers were illuminated on a 16:8 h light:dark cycle with four fluorescent lights and two incandescent lights all supplemented with sunlight from a north-facing window. This provided a minimum illumination of 350 lx.

In order to clarify the interactions between *Phidippus audax* and *Diabrotica undecimpunctata* and *Chauliognathus pennsylvanicus* observed in the field, I collected these beetles from the field and introduced them to the spiders' containers. Either of the beetle species was given to spiders every five days in no repeating order.

Once a beetle was placed inside the test chamber, responses were observed over a 15 min period and categorized as either an attack or a retreat (see Jackson & Olphen 1992). Response data were analyzed using a Kruskal-Wallis non-parametric repeated measures analysis of variance in SAS at an  $\alpha = 0.5$  (Zar 1984; SAS Institute 1988).

**Responses to models.**—To further investigate how *P. audax* interacts with *C. pennsylvanicus* and *D. undecimpunctata*, models were made of both beetles. These models were made from 10 cm wide × 1.5 mm thick plastic sheets that were cut to the approximate length and width of *C. pennsylvanicus* (5 mm × 14 mm) and *D. undecimpunctata* (5 mm × 8.5 mm). The models were then painted to match the color and spot patterning of each beetle. Alternate sized models were also made of both types of spot patterning (*C. pennsylvanicus* size with *D. undecimpunctata* patterning and *vice versa*) to test the effects of size on spider response. Models were designed primarily to represent dorsal surfaces of the beetles. The models were manipulated outside of the spiders' containers which allowed free movement of the model and a clear view of the model to the spider without opening the spiders' containers (Fig. 1). Each model was mounted onto a 30 cm length of wire and manipulated by hand so that the path taken by the model could change direction and speed (approximately 1–10 mm/s). This speed range was based on observed behavior of beetles in the field and in the lab. The 30 cm length of wire allowed easy manipulation of the model while also greatly reducing observer effects on spider responses by keeping the manipulator's hand beyond the visual range of the spider. Both models were presented to each spider 30 times in no repeating order. Therefore, each spider was involved in a total of 120 interactions (30 trials/spider × 4 models) and each model was used 150 times (30 trials/spider × 5 spiders).

So that spiders might be interested in food but not starved, no spider-model trials were conducted within two and no later than four days following a feeding. Spider responses to models were recorded in a manner similar to that of the responses to live prey species. Response data were analyzed in the same way as the data from the feeding trial experiment.

## RESULTS AND DISCUSSION

Throughout the field study, *Phidippus audax* was observed primarily on *Asclepias syriaca* (79%

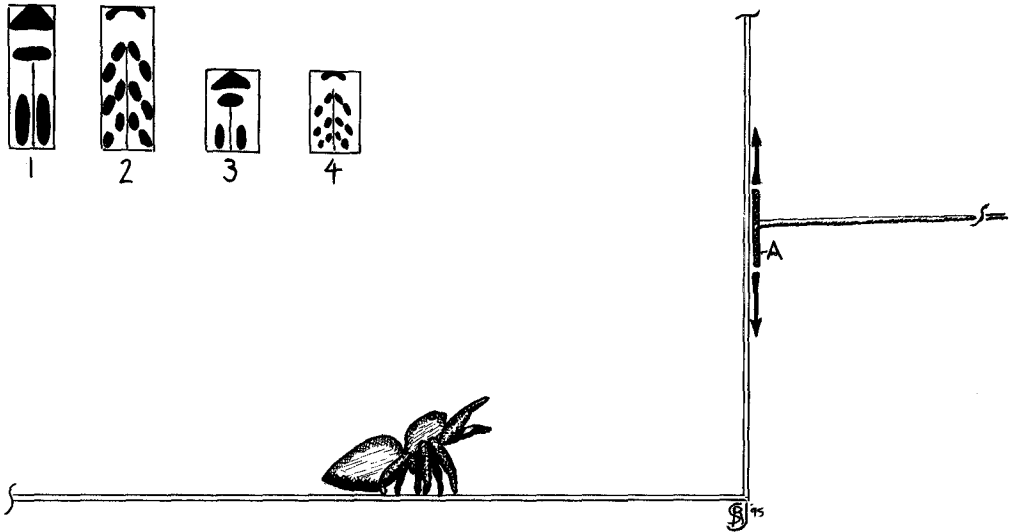


Figure 1.—Arrangement of test chamber and position of model (A) relative to spider. Appearance of models is shown in upper left corner. 1, *Chauliognathus pennsylvanicus* normal size (ChN); 2, *Diabrotica undecimpunctata* large size (DiL); 3, *C. pennsylvanicus* small size (ChS); and 4, *D. undecimpunctata* normal size (DiN).

of all observations,  $n = 45$ ) or *Cirsium altissimum* (21% of all observations) with an estimated density of  $3.2 \pm 0.5$  spiders/m<sup>2</sup>. Estimated densities of *D. undecimpunctata* were  $10.9 \pm 1.8$  beetles/m<sup>2</sup> and  $20.3 \pm 5.2$  beetles/m<sup>2</sup>, for *C. pennsylvanicus*. Both beetles were most concentrated on *C. altissimum* and *V. baldwinii* (Fig.

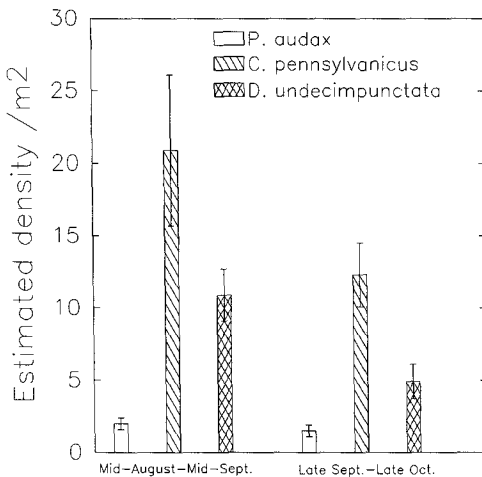


Figure 2.—Estimated density of *Phidippus audax*, *Diabrotica undecimpunctata* and *Chauliognathus pennsylvanicus* in lowlands on Konza Prairie Research Natural Area from mid-summer to mid-autumn, 1992. Vertical bars indicate one standard error of the mean for 12 transects.

2). From late September–late October, estimated densities of *P. audax* and both beetles were lower (Fig. 2).

In a total of 25 field observations of spiders with prey, *P. audax* was most often found feeding upon *Archytas* sp. (Diptera, Tachinidae) (75% of observations) or upon *D. undecimpunctata* (15% of observations). In the remaining 10% of observations, *P. audax* was feeding upon small moths (unidentified), juvenile grasshoppers (unidentified), *Tetragnatha laboriosa* (Araneae, Araneidae), *Hibana gracilis* (Araneae, Anyphenidae), juvenile *Araneus* sp. or gnaphosid spiders.

**Laboratory feeding trials.**—In the laboratory feeding trials, all *P. audax* attacked and ate *D. undecimpunctata* in 100% of feeding trials. Conversely, interactions between *P. audax* and *C. pennsylvanicus* involved either no response or actual retreat by the spiders in 100% of the trials.

**Responses to prey models.**—In the model presentation experiments, there was no significant difference in response to models based on size alone ( $F_{0.05, 1, 1} = 2.08$ ,  $P > 0.1$ ); however, the differences in response were significant when based on pattern alone ( $F_{0.05, 1, 1} = 47.51$ ,  $P < 0.01$ ). The normal sized model of *C. pennsylvanicus* elicited retreat behavior in  $88 \pm 2\%$  of the trials while the small model elicited retreat behavior in  $80 \pm 3\%$  of the trials. There was no significant difference between the number of attack and retreat responses to the large model of

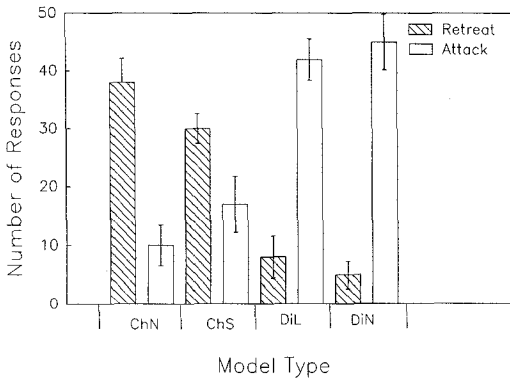


Figure 3.—Number and type of response elicited in *Phidippus audax* by the normal (ChN) and small (ChS) models of *Chauliognathus pennsylvanicus* and the large (DiL) and normal (DiN) sized models of *Diabrotica undecimpunctata*. Vertical bars indicate one standard error of the mean for 150 trials.

*D. undecimpunctata* while the normal sized model of *D. undecimpunctata* elicited attack behavior in the spiders in  $85 \pm 2\%$  of the trials (Fig. 3). Therefore, the avoidance response of *P. audax* to the models of *C. pennsylvanicus* was more related to the species spot patterns than to size.

The responses of these spiders indicate that in northeastern Kansas they may actively avoid *C. pennsylvanicus*. This may be a regional difference in response since *P. audax* from Florida, as observed by Edwards (1980) and Freed (1984), did take the congener *C. maginatus* as prey. *Chauliognathus pennsylvanicus* may have been avoided by the *P. audax* in this study because of regional differences in the toxicity of the beetles, or because the beetles were different species.

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#### LITERATURE CITED

- Blum, M. S. 1981. Chemical defenses of arthropods. Academic Press, New York.
- Edwards, G. B. 1980. Taxonomy, ethology and ecology of *Phidippus* (Araneae: Salticidae) in eastern North America. Ph.D. dissertation, Univ. Florida.
- Edwards, G. B. & R. R. Jackson. 1993. Use of prey specific predatory behaviour by North American jumping spiders (Araneae: Salticidae) of the genus *Phidippus*. J. Zool. London, 229:709-716.
- Fitch, H. S. 1963. Spiders of the University of Kansas natural history reservation and Rockefeller experimental tract. Univ. Kansas Mus. Nat. Hist., misc. publ., 712-MP-33, Lawrence.
- Foelix, R. F. 1979. The biology of spiders. Harvard Univ. Press, Cambridge.
- Forster, L. 1985. Target discrimination in jumping spiders. In Neurobiology of arachnids (F. G. Barth, ed.). Springer-Verlag, New York.
- Freed, A. N. 1984. Foraging behaviour in the jumping spider *Phidippus audax*: basis for selectivity. J. Zool. London, 203:49-61.
- Givens, R. P. 1978. Dimorphic foraging strategies of a salticid spider (*Phidippus audax*). Ecology, 59:309-321.
- Jackson, R. R. 1992. Eight legged tricksters, spiders that specialize in catching other spiders. BioScience, 42:590-598.
- Johnson, S. R. & A. K. Knapp. 1995. The influence of fire on *Spartina pectinata* wetland communities in a northeastern Kansas tallgrass prairie. Canadian J. Bot., 73:84-90.
- Harborne, J. B. 1993. Introduction to ecological biochemistry. Academic Press, New York.
- Reichert, S. E. & J. M. Harp. 1987. Nutritional ecology of spiders. In Nutritional ecology of Insects, mites, spiders and related invertebrates (F. Slansky & J. G. Rodriguez, eds.). John Wiley, New York.
- Robinson, J. V. 1984. Size and seasonal activity patterns of abundant sympatric spider species in Cache County, Utah. Great Basin Nat., 44:104-110.
- SAS Institute, Inc. 1988. SAS/STAT<sup>®</sup> user's guide, version 6 edition. SAS Institute Inc., Cary, North Carolina.
- Snetsinger, R. 1955. Observations on two species of *Phidippus* (jumping spiders). Entomol. News, 66:9-15.
- Wells, M. S. 1988. Effects of body size and resource value on fighting behavior in a jumping spider. Anim. Behav., 36:321-326.
- Zar, J. H. 1984. Biostatistical analysis. Prentice-Hall, New Jersey.

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