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SHORT COMMUNICATION

Influence of prey availability on seasonal fluctuation in body condition in the wolf spider, *Pardosa milvina* (Araneae: Lycosidae)

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Abstract. Foraging by an organism varies over the season in response to environmental conditions. Predatory arthropods, such as spiders, are frequently in a food-limited state despite their polyphagous habits and may feed opportunistically to enhance rates of growth, survival and reproduction. We predicted that, to circumvent food limitation, spider foraging would be related to prey availability. We examined the extent to which body condition of spiders, a correlate of recent foraging, was related to prey availability and habitat type. Wolf spiders *Pardosa milvina* (Hentz 1844) were collected between May and October in two habitat types, corn and soybean fields. To assess changes in spider condition, we calculated and compared multiple body condition indices derived from morphometric measures of individual spiders. Prey abundance was monitored over the same period using a vacuum suction sampler. Body condition indices provided qualitatively equivalent results. Interestingly, juvenile males were in better condition than adult males, but the opposite was the case for juvenile versus adult females. Although the availability of potential prey generally increased over the growing season, changes in body condition fluctuated independently of prey, suggesting that *Pardosa milvina* have life history differences in foraging and demand for resources that may influence foraging decisions.

Keywords: Foraging, predation, temporal dynamics

Landscape configuration, agricultural management and habitat complexity influence the abundance and diversity of spiders (Clough et al. 2005; Schmidt & Rypstra 2010). The fine-scale effects of management practices on predator biology are complex and often interrelated. For instance, the structure of the environment can influence the foraging rate of predators (Langellotto & Denno 2006) or can provide refuges from risk (Rypstra et al. 2007). Furthermore, the use of pesticides influences space use and foraging ecology/behavior of spiders (Deng et al. 2008). Although the effects of agricultural practices and landscape patterns on the body condition of spiders has received far less attention (e.g., Öberg 2009; Bucher & Entling 2011), condition indices have proven efficient at predicting important aspects of animal fitness, including recent foraging success (Jakob et al. 1996; Aisenberg et al. 2009), mate choice (Uetz et al. 2002; Pruitt et al. 2011) and sexual cannibalism (Moya-Laraño 2002; Wilder & Rypstra 2008; Pruitt et al. 2011). Body condition indices, calculated using morphometric measurements, show that spiders are commonly food-limited in nature (Bilde & Toft 1998; Wise 2006; Romero & Harwood 2010). Here we explore the seasonal dynamics of body condition of a common agrobiont spider and examine the relationship of body condition to prey abundance in two production systems, corn, *Zea mays* L. (Poales: Poaceae) and soybeans, *Glycine max* L. (Fabales: Fabaceae).

Research was conducted in a previously established experimental agroecosystem located at the Ecology Research Center, Butler County, Ohio, USA (39°31′42″ N, 84°43 ′48″ W). An array of 12 fields was established, each measuring 60 × 75 m and separated by 15-m grass borders. All fields were managed under standard no-till practices for this region with no insecticides applied at any time during the season. Six of the fields were planted with soybeans (Ebberts seed 1365RR, Ebberts Field Seeds, Covington, Ohio, USA). The other six fields were planted with corn (Steyer Seeds 1095VT3, Steyer Seeds, Tifton, Ohio, USA). None of the fields were sampled twice in the same month, or at the same locations within the field.

The focus of this study was the wolf spider, *Pardosa milvina* (Hentz 1844) (Araneae: Lycosidae). At least 20 spiders were hand collected every two weeks between May and October 2007 in two field types, corn and soybean fields. Hand collecting of spiders occurred by searching the interior of fields and not within 10 m of the edge. Individual spiders were held on ice in 1.5 ml Eppendorf tubes until they could be frozen at −20°C within 2 h. Six fields of each type were sampled throughout the season, and no two fields were sampled on consecutive sampling dates. Frozen spiders were identified to species by inspection of genitalia (Vogel 2004). We know from past studies that *P. milvina* represent 95% of species in the genus *Pardosa* in these fields (Marshall et al. 2002); therefore, although difficult to distinguish, it is unlikely that juveniles were from other species because all adults collected were *P. milvina*. To determine juvenile male or female status, we inspected the genital morphology for scleritization and associated adult characteristics. In an attempt to control for reproductive status, females with egg sacs were excluded from the analyses. We measured size, cephalothorax width (accuracy ± 0.01 mm), which is a rigid portion of the spider body representative of spider size (Jakob et al. 1996), and mass (accuracy ± 0.1 mg) in the laboratory. Although there are multiple methods to estimate body condition, here we analyzed the data using two common methods [i.e., body mass (García-Berthou 2001) and Scaled Mass Index (Peig & Green 2009)]. We elected to visually display the Scaled Mass Index (SMI) proposed by Peig & Green (2009), which was computed as

$$SMI = M_i \left[\frac{L_o}{L_i}\right]^b$$

where M_i is the body mass, L_i is the cephalothorax width of individual i, b is the scaling parameter estimated by the regression of mass on cephalothorax width and L_o is the arithmetic mean of cephalothorax width value for the study population. Here we focus on the SMI because it is easy to present and interpret, and it scales

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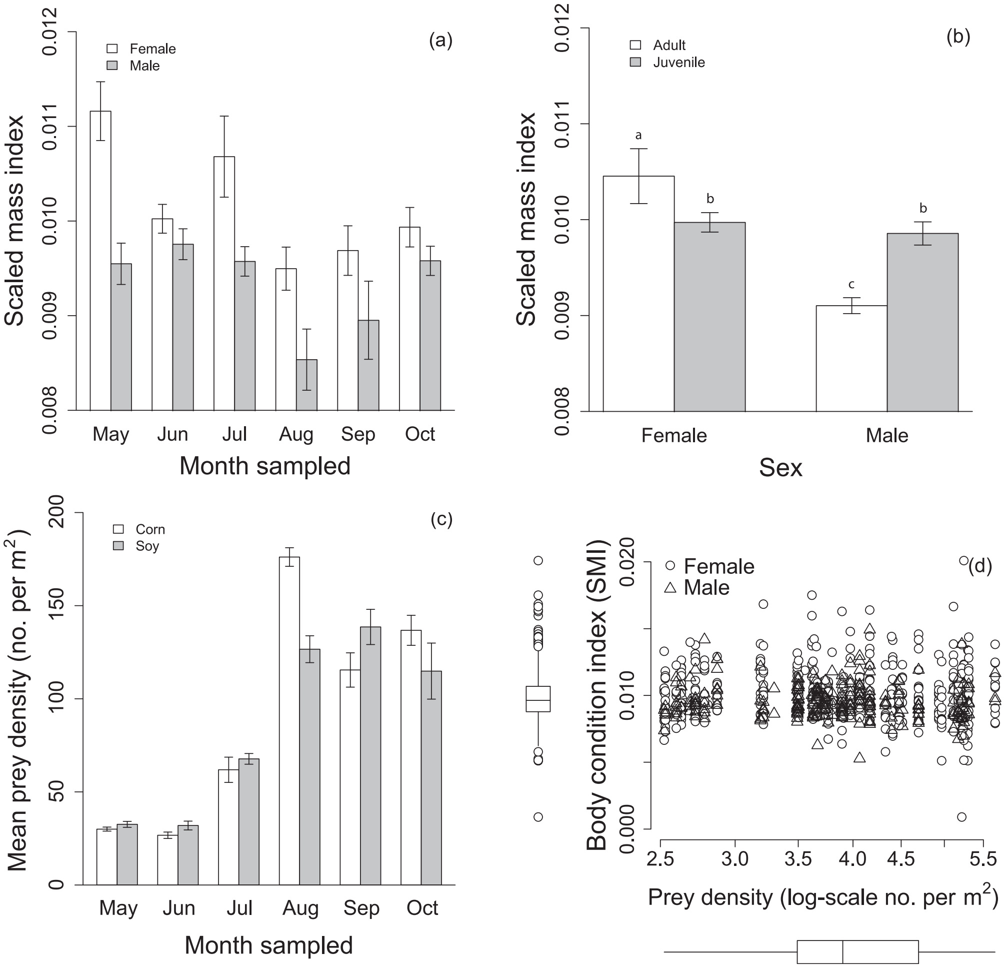

Figure 1.—Body condition (Scaled Body Condition Index, SMI) of *Pardosa milvina* over a growing season in corn and soybean fields in Oxford, Ohio, and the associated density of arthropod prey. Panel (a) represents the mean ± 1 SE fluctuation in body condition during the season for reproductively mature female and males; panel (b) represents the comparison of mean ± 1SE body condition between adult and juvenile males and females (Bonferoni adjusted comparisons are indicated by different letters $P < 0.05$); panel (c) represents the fluctuation in mean ± 1SE arthropod density; and panel (d) represents body condition index (SMI) plotted as a function of prey density (number per m^2) with axis box and whisker bars to represent the distribution of each continuous variable.

body condition according to the size distribution of the spiders sampled. We provide supplemental material on other body condition indices, online at www.bioone.org/doi/suppl/10.1636/P13-18.

Prey abundance was estimated in these same fields by extracting five suction samples (0.08m^2/ sample) in both field types on each sample date using a D-VAC suction sampler (Model 24, Rincon-Vitova Insectaries, Ventura, California, USA). Locations for suction sampling were determined by selecting numbers from a random number table to correspond with x, y coordinates of the field such that no locations were sampled within 10 m of the field margin. Suction samples were sorted to form a prey density estimate (i.e., no. prey/0.4m^2). We counted Diptera, Collembola, Homoptera, Thysanoptera, small Orthoptera and small Araneae because these are the groups *Pardosa* are known to consume (Nyffeler 1999). Generalized least squares (GLS, Pinheiro & Bates 2000) analysis models were used to explore the effect of four predictors on body condition: field type, sampling date, spider age and overall prey density.

A total of 732 spiders were collected through the field season (Supplemental Materials, Table S1). Body condition was highly variable over the growing season in both soybean and corn fields (GLS, see Supplemental Materials Table S2; $F_{1,722} = 15.28$, $P = 0.0001$, Fig. 1a), and there were no significant interactive effects of season, field type or prey availability on body condition (GLS, see Supplemental Materials Table S2, 1a).There were significant sex differences in body condition ($F_{1,722} = 7.768$, $P = 0.0055$, Fig. 1b); however, the interaction between age and sex suggests that adult males are typically in poorer condition than juvenile males, and the pattern for females suggests that adults were in better condition than juvenile females ($F_{1,722} = 9.492$, $P = 0.0021$, Fig. 1b). Females were predicted to be in better condition, so this result is not surprising. However, the significant interaction is of interest because this indicates that juvenile males, with unscleritized pedipalps, were in better condition and may feed more often to increase size. Fitting the different body condition indices, described above, resulted in equivalent qualitative results (Table S2).

Prey density, a variable that should influence the growth and body condition of polyphagous predators, increased over the growing season (GLS, $F_{1,60} = 4.335$, $P < 0.0007$, Fig. 1c; slope estimate on log transformed data = 0.069 (0.02), $t = 3.21$, $P = 0.0014$), and differed between field types sampled ($F_{1,60} = 35.441$, $P < 0.0001$). A significant interaction between field and date sampled indicates that the density of prey in each field type was not consistent over the season ($F_{1,60} = 46.45$, $P < 0.0001$, Fig. 1c). Notably, the densities are similar in May through July, whereas the abundance is higher or lower between the two field types during August, September and October (Fig. 1c). Although both the condition of predators (Fig. 1a) and availability of prey (Fig. 1c) varied over the season in relation to date and field type, body condition was not significantly related to prey density (see Table S2 for full analysis; $F_{1,722} = 0.59$, $P = 0.442$, Fig. 1d).

Although there was fluctuation in foraging, as indicated by body condition, of male and female *P. milvina* over the growing season within a soybean and corn crop, body condition did not appear to track prey abundance in this system. Inconsistent with other species of spider, body condition is sometimes related to prey availability (Bucher & Entling 2011). Our study suggests that prey availability and field type are not strong predictors of body condition in this wolf spider population. Although our sampling method for prey availability assessed density of prey in a given area, the types that spiders are able to catch or prefer are not necessarily representative of overall abundance. However, based on our results, we emphasize the growing shift in our understanding of the feeding ecology of spiders under field conditions (Chapman et al. 2013). The density of prey alone appears insufficient to predict fitness, especially when prey abundance is high, and for spiders a number of potentially competing prey variables influence foraging decisions. The risk, toxicity (Toft 1999) and nutritional value of prey (reviewed by Wilder 2011) can all affect consumption.

These results indicate life-stage-specific patterns in body condition. Juvenile males must quickly build body tissues by consuming high numbers of prey or selectively consuming high-energy nutrients and protein to fuel fast development (Moya-Laraño et al. 2008). Adult males have reached their growth potential, so low levels of foraging would be sufficient to facilitate mate searching and courtship. In contrast, female foraging responses in short-term laboratory studies indicate that an increase in body condition and number of prey killed is strongly driven by prey density (Walker & Rypstra 2002), but in an open field context we show that body condition was not influenced by prey density. These results suggest that prey selection and foraging strategies during juvenile stages of development do not differ, but the sexes subsequently switch to different strategies following reproductive maturity, where females continue to forage at high levels to improve egg development and males reduce energy needs, only requiring low energy levels to scurry around searching for mates.

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