Natural prey of the jumping spider *Heliophanus dunini* (Araneae: Salticidae) associated with *Eryngium* plants

Elchin Fizuli oglu Huseynov
Institute of Zoology, Azerbaijan Academy of Sciences,
Block 504, passage 1128, Baku 370073, Azerbaijan

Summary

The natural prey of the jumping spider *Heliophanus dunini* Rakov & Logunov, 1997 was studied in Absheron Peninsula, Azerbaijan. The percentage of specimens of *H. dunini* found while feeding was low (8.2%). However, adult females alone were observed feeding significantly more frequently (27.6%). Investigation has shown that *H. dunini* is a polyphagous predator feeding on a wide range of arthropods. Representatives of six arthropod orders were found in its diet. Most of the prey were soft-bodied, non-aggressive arthropods. Sometimes, however, *H. dunini* was found eating such dangerous prey as web-building spiders and a worker ant on alien webs. Moreover, *H. dunini* was repeatedly observed on the webs of web-building spiders without prey. It is suggested that the crucial factor influencing the evolution of this unusual web-invading behaviour in *H. dunini* is its close association with *Eryngium* plants. The length of prey killed by *H. dunini* ranged between 1.12 and 8.25 mm (mean 3.19 mm) and constituted from 32.1 to 244.4% (mean 81.4%) of the length of their captors. The most frequently captured prey were arthropods not exceeding the length of the spiders (74.4%).

Introduction

With over 5,000 described species, the family Salticidae is the largest family of spiders (Platnick, 2005). While some aspects of salticid biology, such as silk utilisation, sexual and predatory behaviour, have been relatively well studied (Jackson & Pollard, 1996; Richman & Jackson, 1992), little is known about their natural prey. A survey of spider literature revealed that more or less detailed quantitative data are available for only about a dozen species (Bartos, 2002; Dean *et al.*, 1987; Horner *et al.*, 1988; Jackson, 1977, 1988a, b; Jackson & Blest, 1982; Nyffeler *et al.*, 1990; Richman & Whitcomb, 1981; Wesołowska & Jackson, 2003; Young, 1989; Żabka & Kovac, 1996). Most of these spiders occur in the tropics or Nearctic, and the first study of Palaearctic species in this respect has been published only recently (Bartos, 2002) followed by a series of my works on this problem (Guseinov, 2004, 2005; Guseinov *et al.*, 2004; Huseynov, 2005; Huseynov *et al.*, 2005).

The present paper dealing with *Heliophanus dunini* Rakov & Logunov, 1997 is the sixth in my project undertaken to contribute to the knowledge of natural diets of Palaearctic jumping spiders (see above). So far this species is known from Azerbaijan and Barsakelmes Island (Aral Sea, Kazakhstan) only (Rakov & Logunov, 1997). In Azerbaijan *H. dunini* occurs in arid habitats including semi-deserts and mountain steppes (Logunov & Guseinov, 2002), where it is commonly found on low herbaceous vegetation (Guseinov, 2003).

Material and methods

The investigation was carried out in Absheron Peninsula, Azerbaijan. The two primary study sites were located near Shagan and Bina villages (40°30′N, 50°06′E and 40°27′N, 50°04′E respectively), where about 90% of total observation time was spent. These habitats were characterised by pines, *Pinus eldaricus* Medw., with an undergrowth of dwarf shrubs *Eryngium biebersteinianum* Newsky, *Alhagi pseudoalhagi* (M.B.) and *Noaea mucronata* (Forsk.), and also herbs and grasses, predominantly *Calendula persica* C.A.M., *Senecio vernalis* Willd. & Kar., *Medicago denticulata* Willd., *Carduus arabicus* Jaqu., *Hirschfeldia incana* (L.), *Erodium cicutarium* (L.), *Hedypnois cretica* W., *Pterotheca marschalliana* (Rchb.), *Anagalis coerulea* Schreb., *Poa bulbosa* L., *Aegilops biuncialis* Vis., *Avena ventricosa* Bal., *Hordeum leporinum* Link. and *Koeleria phleoides* (Vill.). Additionally, there were three secondary study sites located near Gres and Gala villages and Ganly-Gyol Lake. Except for being treeless, these sites had vegetation cover more or less similar to that of the primary sites.

During the study period *Heliophanus dunini* was abundant only on *Eryngium biebersteinianum*; observations were therefore concentrated exclusively on this plant. The prey of the spiders was sampled during four successive years: 1996 (2 June–3 August), 1997 (1 July–9 August), 1998 (14 June–25 July) and 1999 (21 June–31 July). A total of 57 surveys were conducted during these periods which took a total of about 104 hours. All surveys were done in daylight hours between 10:00 and 20:00. During the surveys *Eryngium* plants were thoroughly searched for *H. dunini*, and the mouthparts of each individual found were inspected with a hand-lens of ×4 magnification to avoid overlooking small prey. Spiders with prey in their chelicerae were captured with a transparent cup, placed in separate vials containing 75% ethyl alcohol, and brought back to the laboratory for measurement and prey identification. Spiders without prey were left in the field. At the same time, all spiders observed were classified into three groups according to their body coloration: (1) small juveniles, with black body and green legs; (2) large juveniles, which had zebra-like, black-and-white coloration; and (3) adults, with black body and legs. At the time of the study, the adults consisted exclusively of females. I assigned these three different colour forms to the same species, because when reared in the laboratory individuals of *H. dunini* successively passed through these colour patterns (Huseynov, unpubl. data). Moreover, the only other *Heliophanus* species occurring at the study sites, *H. equester* L. Koch, has a very different, green coloration. During every survey the numbers of spiders with and without prey were counted separately within each of these groups.

Results

Altogether, 613 individuals of *H. dunini* were observed, 50 of which (8.2%) had prey in their chelicerae. Among them 73 small juveniles (2 with prey [2.7%]), 511 large juveniles (40 with prey [7.8%]), and 29 females (8 with prey [27.6%]) were recorded. The percentage of feeding specimens among females was significantly higher than that among juveniles ($\chi^2=12.738$; df=1; $p<0.001$). In contrast, there was no statistically significant difference between the two size-groups of juveniles in this respect ($\chi^2=1.774$; df=1; $p>0.1$).

Three spiders seen with prey escaped, so 47 prey items were collected for dietary analysis. These were distributed among six orders of arthropods (Table 1), including five from class Insecta: Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, and one from class Arachnida: Araneae. Insects constituted about two-thirds of the total prey (63.8%). The dominant insect orders were Diptera and Lepidoptera, which together accounted for 70% of the insects captured. All lepidopterans were adult moths, represented by Notodontidae and Tortricidae. All dipterans were flies (Brachycera). Among these only three relatively large flies (two bombyliids and one usiid) could be determined to the family level, while the remaining small flies were greatly damaged. The Hymenoptera consisted of four parasitic wasps (Eurytomidae) and one worker ant (*Cataglyphis aenescens* Nylander). The rest of the insect prey consisted of two bugs (one anthocorid and one unidentified), one aphid (Aphidinea) and one leafhopper (Cicadinea).

Prey	N	%
Insecta		
Diptera	[13]	[27.7]
Brachycera		
Bombyliidae	2	4.2
Usiidae	1	2.1
Others	10	21.3
Lepidoptera	[8]	[17.0]
Notodontidae	2	4.2
Tortricidae	6	12.8
Hymenoptera	[5]	[10.6]
Chalcidoidea		
Eurytomidae	4	8.5
Formicoidea		
Cataglyphis aenescens	1	2.1
Hemiptera	[2]	[4.2]
Anthocoridae	1	2.1
Other	1	2.1
Homoptera	[2]	[4.2]
Aphidinea	1	2.1
Cicadinea	1	2.1
Arachnida		
Araneae	[17]	[36.2]
Salticidae		
Heliophanus dunini	2	4.2
Heliophanus equester	1	2.1
Pellenes epularis	1	2.1
Yllenus guseinovi	1	2.1
Unidentified	1	2.1
Thomisidae		
Thomisus onustus	4	8.5
Xysticus sp.	2	4.2
Theridiidae		
Kochiura aulica	1	2.1
Steatoda paykulliana	1	2.1
Theridion sp.	1	2.1
Dictynidae		
Dictyna sp.	1	2.1
Araneidae		
Unidentified	1	2.1
Total	47	100.0

Table 1: Prey composition of *Heliophanus dunini*.

Spiders, represented by 12 species from 5 families, were the most frequently captured prey order (36.2%). Among these, wandering spiders of the families Salticidae (6 individuals of 5 species) and Thomisidae (6 of 2) predominated (70.6% of spiders caught). Web-building spiders consisted of three families: Theridiidae (3 of 3), Dictynidae (1) and Araneidae (1). Interestingly, on three occasions *H. dunini* were found eating web-spiders (*Kochiura*, *Dictyna*, *Steatoda*) on their webs. It should also be noted that the only worker ant captured was also consumed on a theridiid web. Furthermore, 24 individuals of *H. dunini* were observed on the webs of other spiders (21 theridiids and 3 dictynids) without prey. Most of these webs, sometimes very dense, lacked their hosts, but on at least five occasions the resident spiders were present. Moreover, two individuals of *H. dunini* were seen stalking across the webs towards their hosts (*Kochiura aulica* (C. L. Koch, 1838) and *Simitidion simile* (C. L. Koch, 1836)), which were at the opposite edge of the web apparently trying to avoid predation by the invader. Additionally, two dead, probably eaten, *H. dunini* were found in the webs of *Kochiura* and *Dictyna*.

Forty-three prey items were measured. Their length varied from 1.12 to 8.25 mm (mean ± SD: 3.19 ± 1.90 mm) and constituted from 32.1 to 244.4% (81.4 ± 49.3%) of the length of their captors, which ranged from 1.87 to 7.00 mm (3.97 ± 0.98 mm). The size distribution of the prey in relation to the sizes of their captors is shown in Fig. 1. Most of the prey did not exceed the length of their captors (32, =74.4%), with small (not exceeding half the length of the spiders) and medium-sized (from 50–100% of spider body length) prey being equally common (each 16, =37.2%). Among the large prey, exceeding the length of the spiders, six items (14.0%) were less than 150% of spider body length, while five items (11.6%) were larger.

Discussion

The percentage of specimens of *H. dunini* found while feeding was low (<10%), reflecting the short duration of the observations as well as a low frequency of feeding that is typical of cursorial spiders (Nentwig, 1986; Nyffeler *et al.*, 1994) and salticids in particular (Dean *et al.*, 1987; Guseinov, 2004, 2005; Jackson, 1977; Young, 1989). However, the percentage of feeding specimens among adult females alone was much higher, with no comparable value found in other salticids studied in this respect. The reason for this fact remains unknown.

This investigation has shown that *H. dunini* is a polyphagous predator feeding on a wide range of arthropods. Most of its prey were soft-bodied non-aggressive arthropods, as is common with many other jumping spiders (Richman & Jackson, 1992). However, several

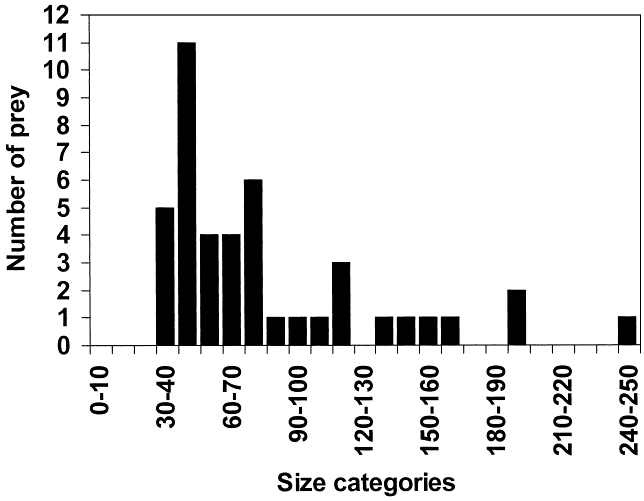

Fig. 1: Distribution of prey in different size categories (body lengths of prey expressed as percentages of the body lengths of their captors).

observations of *H. dunini* eating web-building spiders on their webs indicate that this species also includes "difficult" prey in its diet. The webs of spiders serve not only for prey capture, but are also efficient defensive devices. Thus only a small minority of jumping spiders are able to invade alien webs and prey upon their residents (Jackson & Pollard, 1996). Representatives of the subfamily Spartaeinae use complex vibratory behaviour, imitating the struggle of an insect ensnared in the silk, to lure and attack resident spiders (Li & Jackson, 1996). In contrast, some other salticids leap from an appropriate position onto the web-spider sitting on its web (Lamore, 1958; Robinson & Valerio, 1977; Jackson, 1985a, b, 1988a, b, 1989). A few field observations of web-invading behaviour by *H. dunini* showed that this salticid simply walked across the web attempting to approach the host spider. In these cases *H. dunini* moved with evident difficulty over the alien silk. It seems that this behaviour is not as efficient as that of spartaeines. This suggestion is partly confirmed by the finding of dead, apparently killed, *H. dunini* in the webs of web-building spiders. Moreover, the percentage of *H. dunini* found on alien webs was much lower compared with that of a spartaeine, *Portia fimbriata* (Doleschall, 1859) (see Jackson & Blest, 1982). However, even this relatively small amount of observations seems unusual. None of about 40 other salticid species occurring in Absheron Peninsula has ever been observed on the webs of other spiders (Guseinov, 1999, unpubl. data), despite a large total number of observations (over 20,000). Instead, when some of these salticids encountered alien webs, they steered a wide path around their perimeter, thereby avoiding contact with the silk (Guseinov, 2004).

Another dangerous prey found in the diet of *H. dunini* was a worker ant, *Cataglyphis aenescens*. Interestingly, this ant was consumed entangled in the web of a theridiid spider. Thus, this was probably a case of kleptoparasitism. Ant workers, possessing effective defensive equipment (strong mandibles, formic acid, hard cuticle), are not vulnerable prey to most jumping spiders (Li & Jackson, 1996). *Heliophanus dunini* is apparently not an exception, because in the laboratory it regularly refused worker ants as prey (Huseynov, unpubl. data). Perhaps, however, with the aid of alien silk *H. dunini* is occasionally able to overpower this well-defended prey.

A possible explanation for *H. dunini* having evolved a web-invading strategy is its habitat. In the first half of the summer, in Absheron Peninsula, *Eryngium* is by far the most abundant flowering plant, and it is certainly the most attractive plant for insect pollinators. Web-spiders are known to prefer hunting sites characterised by high prey density (e.g. Turnbull, 1964; Lubin *et al.*, 1993; Ward & Lubin, 1993). It is not surprising, therefore, that they are very numerous on *Eryngium*. Thus the habitat of *H. dunini* might have been a crucial factor influencing the evolution of a web-invading habit in this species.

The experimental study of prey-size preferences in spiders has shown that most cursorial spiders, including salticids, do not accept prey exceeding 150% of their own body length. The preferred prey length tends to be equal to or less than the length of the spider (Nentwig & Wissel, 1986). My findings agree with this generalisation. About three-quarters of the prey of *H. dunini* (74.4%) were smaller than the spiders, while those larger than their captors usually did not exceed 150% of the length of the spider.

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