

Jumping spiders (Araneae: Salticidae) that feed on nectar

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Abstract

Nectivory was studied in 90 species from the spider family Salticidae. Observations of 31 of these species feeding on nectar from flowers in nature was the impetus for laboratory tests in which all 90 species fed from flowers. That sugar, not just water, is relevant to salticids was implied by choice tests where salticids spent more time drinking from a simulated nectar source (30% sucrose solution) than from distilled water. Our findings suggest that nectar feeding may be widespread, if not routine, in salticid spiders.

Key words: jumping spiders, Salticidae, nectar feeding, energy source

INTRODUCTION

Trophic switching (Cohen, 1996) and feeding at more than one trophic level (Pimm & Lawton, 1978), or omnivory, are common themes in the evolution of predatory insects, with numerous predatory insects being known to feed facultatively on plants and plant products (Smith, 1965; Coll & Ridgway, 1995; Coll, 1996; Coll & Izraylevich, 1997), including nectar and pollen. However, use of plants and plant products as food is not a widely appreciated feature of spider biology.

Spiders are one of the major groups of predatory arthropods (Foelix, 1996), with the Salticidae being the largest family. Although taking of live prey, especially insects, appears to be the dominant feeding method of spiders, various spider species are known also to feed on dead arthropods (scavenging), web silk, their own shed exoskeletons and, in captivity, exotic foods such as bananas, marmalade, milk, egg yolk and sausages (Bonnet, 1924; Dondale, 1965; Peck & Whitcomb, 1968; Decae, 1986; Nentwig, 1987; Riechert & Harp, 1987; Wise, 1993). Spider webs may function not only to ensnare insects, but also to provide spiders with pollen meals. Pollen that is caught in webs may be ingested when the spider feeds on its web, and pollen meals have been shown to substantially enhance survival in young spiders (Smith & Mommsen, 1984; Vogelei & Greissl, 1989).

By being an exceptionally rich source of sugar, and

often containing significant quantities of amino acids and other nutrients, nectar may be an especially rewarding addition to the diet of predatory arthropods. Access to nectar may not be routine for web-building spiders, but hunting spiders (i.e. spiders that do not use webs) might have more encounters with flowers. Although spiders seen on flowers are typically envisaged as being there for the nectar-feeding insects, not the nectar itself, recent studies have documented nectivory by a wide variety of hunting spiders, including species of Anyphaenidae, Corinnidae, Clubionidae and Thomisidae (Beck & Connor, 1992; Pollard, Beck & Dodson, 1995; Taylor & Foster, 1996). Eyesight for these spider families is rudimentary, and many of the species belonging to these families are nocturnal. Possibly the difficulty of observing nocturnal hunting spiders foraging in the field accounts for reports of spider nectivory being scarce (see Taylor & Foster, 1996).

Nectivory by salticids is of particular interest, as these common spiders have unique, complex eyes, acute vision and diurnal habits (Land, 1969*a,b*; Blest, O'Carroll & Carter, 1990; Jackson & Pollard, 1996). There seems to be only one published observation of a salticid feeding on nectar in the field (Edmunds, 1978), and no experimental studies in the laboratory. Although this might suggest that nectivory is rare in salticids, our own observations suggested the opposite conclusion. Having observed 31 salticid species in the field with their mouthparts pressed against flowers, we investigated a total of 90 species in the laboratory.

CONFIRMATION THAT SALTICIDS FEED FROM FLOWERS

Laboratory cultures of each species studied were maintained using standard procedures that have been described elsewhere in detail (Jackson & Hallas, 1986). Only early instars of each species were used for laboratory testing in this initial study because the salticids seen feeding in the field were all early instar juveniles (all collected and reared to maturity for identification). Mature voucher specimens of all 90 species have been lodged at the Florida State Collection of Arthropods (Division of Plant Industry) in Gainesville, Florida (U.S.A.) and the Taxonomy Laboratory of the International Rice Research Institute (IRRI) in Los Baños, Laguna (Philippines).

Using a crocodile clip, an intact flower was held vertical on a stand. A salticid was placed on the stand close to the flower and watched through a camera macro lens. Flowers were not identified, and the number of tests per individual and per species was not standardized, as our objective was simply to ascertain, from closer observation than was feasible in the field, whether each species in culture ingested nectar. None of the salticids studied failed to take nectar in the laboratory (i.e. all brought their mouthparts into contact with nectar and the nectar pool diminished during contact).

TESTS USING SUCROSE AS ARTIFICIAL NECTAR

Nectar is a potential source of both water and sugar for a salticid. Adopting testing procedures similar to those in an earlier study on thomisids (Pollard *et al.*, 1995), an experiment was carried out to ascertain whether salticids have an active interest in sugar independent of any baseline attraction to water.

Petri dishes (diameter 90 mm) containing two strips of blotting paper (40 × 10 mm) were used as test chambers. The strips of blotting paper were placed on opposite sides of the petri dish; one strip was soaked in 30% sucrose and the other in distilled water (side for sucrose chosen at random). Testing, which began when a salticid was placed in the centre of a test chamber, lasted 10 min.

How much time each salticid spent feeding (face pressed against the paper) on each strip was recorded to the nearest second using a stopwatch and compared using Wilcoxon signed-ranks tests for paired data (Sokal & Rohlf, 1995). For displaying data, a score was calculated for each spider (time spent feeding on sugar solution minus time spent feeding on distilled water).

As a precaution against chemical traces left by previous spiders, test chambers were washed with 80% ethanol, followed by distilled water, then allowed to dry, between tests. No individual salticid was tested more than once. The laboratory light regime was 12L : 12D, with lights coming on at 08:00. All tests were carried out between 09:00 and 17:00 using salticids that

had been deprived of food and water for the previous 24 h.

In choice tests, each species spent longer with mouthparts on sucrose solutions than on distilled water (Table 1).

FEEDING BEHAVIOUR

For details on feeding behaviour, four species (*Myrmarchne bakeri*, *M. assimilis*, *Phintella platensis* and *Cosmophasis estrellaensis*) were tested by being placed together with a flower (*Plumiera acutifolia* Poir (Apocynaceae)) in a petri dish (diameter 40 mm) and observed under a microscope (one spider per test). A terminology convention comparable to that in earlier salticid studies (Jackson & Hallas, 1986) was adopted: 'usually' or 'routine' 'sometimes' or 'other times' and 'infrequently' were used to indicate frequencies of occurrence of > 80%, 20–80% or < 20%, respectively.

Each spider actively endeavoured to extract nectar. With legs I and II flexed sharply, spiders sometimes lowered their cephalothoraces and brought their mouthparts against free nectar encountered on flower. Other times, they positioned their chelicerae around flowers and inserted their fangs. Feeding tended to be in a series of bouts, with the duration of bouts varying from as short as 2 s to as long as 4 min. Grooming, especially of the mouthparts, was common between bouts. During feeding bouts, spiders usually kept legs lowered and pulled in close to the body, with faint side-to-side and up-and-down abdominal movement being routine, sometimes accompanied by quivering of chelicerae.

Spiders sometimes pushed nectar toward their mouths by using palps and legs I. Appendages were also used to sop up nectar. To do this, one palp at a time was dipped into a drop of nectar, then placed between the chelicerae. Closing the chelicerae around the palp, nectar was squeezed off the palp and into the spider's mouth. Infrequently, legs I were used in a comparable way except that only the tip of the leg tarsus was dipped into the nectar.

DISCUSSION

There are nearly 5000 described salticid species (Coddington & Levi, 1991; Zabka, 1993), and it is the largest family of spiders. Although only a small fraction of the species in this largely tropical family were studied, nectar feeding was confirmed in each of the 90 species studied. This suggests that nectar feeding is a widespread, if not routine, feeding supplement at least for the early instars of salticids. As nectar is taken in as a liquid, it might seem relevant to ask whether salticids are truly feeding, instead of simply drinking, from flowers. However, in spiders, drinking and feeding are overlapping processes. Along with many insects, all arachnids practise external digestion and ingest nutrients only in liquid form. Spiders typically use some

Table 1. Scores from choice tests. Salticid given access to two strips of blotting paper, one soaked in 30% sucrose solution, the other in distilled water. Score: time spent feeding on sugar minus time spent feeding on water. See text for details. Data analysis: Wilcoxon signed-ranks test (null hypothesis: score of zero). * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Species	Collection locality	<i>n</i>	1st quartile	Median (s)	3rd quartile
<i>Aelurillus aeruginosus</i> (Simon)	Israel	16	25	67**	192
<i>Afraflacilla</i> sp. 1 ^a	Kenya	44	-6	62***	313
<i>Afraflacilla</i> sp. 2 ^a	Kenya	43	0	66***	122
<i>Asemonea murphyae</i> Wanless ^a	Kenya	17	28	112***	271
<i>Asemonea tenuipes</i> O. P. Cambridge	Sri Lanka	14	186	226**	421
<i>Bavia aericeps</i> Simon ^a	Australia	23	17	79***	168
<i>Bavia sexpunctata</i> (Doleschall)	Philippines	14	19	129**	311
<i>Bianor maculatus</i> (Keyserling)	Philippines	13	36	161**	237
<i>Brettus albolimbatus</i> Simon	Sri Lanka	12	171	203**	215
<i>Carrhotus sannio</i> (Thorell)	Philippines	16	38	101**	210
<i>Carrhotus viduus</i> (C. L. Koch)	Philippines	15	11	148**	205
<i>Chalcotropis gulosa</i> (Simon) ^a	Philippines	22	-1	51***	99
<i>Chalcotropis luceroi</i> Barrion & Litsinger	Philippines	15	16	104**	184
<i>Chrysilla lauta</i> Thorell ^a	Philippines	32	34	102***	157
<i>Cosmophasis estrellaensis</i> Barrion & Litsinger ^a	Philippines	39	58	118***	230
<i>Cosmophasis micarioides</i> (L. Koch) ^a	Australia	18	19	108**	165
<i>Cosmophasis modesta</i> (L. Koch)	Australia	12	-10	24*	261
<i>Cyrba algerina</i> (Lucas) ^a	Israel	38	37	85***	143
<i>Cyrba ocellata</i> (Kroneberg)	Kenya	14	94	162**	306
<i>Cytaea</i> sp. ^a	Australia	39	2	53***	118
<i>Cytaea alburna</i> (Keyserling)	Australia	14	30	118**	209
<i>Emathis weyersi</i> Simon	Philippines	18	10	151**	222
<i>Epeus hawigalboguttatus</i> Barrion & Litsinger ^a	Philippines	19	46	275***	441
<i>Epocilla</i> sp.	Singapore	16	9	152**	198
<i>Euophrys gambosa</i> (Simon)	Israel	14	-16	118*	223
<i>Euryattus</i> sp. ^a	Australia	17	12	36***	141
<i>Evarcha patagiata</i> O. P.- Cambridge	Israel	14	11	153*	228
<i>Gambaquezonina itimana</i> Barrion & Litsinger	Philippines	15	37	116*	219
<i>Goleba puella</i> (Simon) ^a	Kenya	16	82	181**	327
<i>Harmochirus brachiatus</i> (Thorell) ^a	Philippines	22	14	85**	293
<i>Hasarius adansoni</i> (Audouin)	Australia	14	15	118**	216
<i>Heliophanillus fulgens</i> (O. P.-Cambridge) ^a	Israel	30	38	92***	266
<i>Heliophanus debilis</i> Simon ^a	Kenya	36	15	124***	419
<i>Heliophanus mordax</i> O. P.- Cambridge	Israel	13	-16	98*	253
<i>Helpis minitabunda</i> (L. Koch)	Australia	52	0	71***	160
<i>Hentzia palmarum</i> (Hentz) ^a	U.S.A.	17	-2	73**	288
<i>Heratemita alboplagiata</i> (Simon) ^a	Philippines	20	33	92***	280
<i>Hyllus dotatum</i> (Peckham & Peckham)	Kenya	16	25	148**	323
<i>Icius</i> sp.	Philippines	21	0	52**	148
<i>Jacksonoides queenslandicus</i> Wanless	Australia	15	25	107**	193
<i>Lagnus</i> sp.	Philippines	23	1	92***	293
<i>Lepidemathis sericea</i> (Simon) ^a	Philippines	23	32	199***	531
<i>Lyssomanes viridis</i> (Walckenaer) ^a	U.S.A.	22	0	102***	231
<i>Mantisatta longicauda</i> Cutler & Wanless	Philippines	30	34	96***	196
<i>Marengo crassipes</i> Peckham & Peckham	Sri Lanka	16	98	263***	321
<i>Marpissa marina</i> Goyen	New Zealand	22	9	117***	227
<i>Menemerus bivittatus</i> (Dufour)	Australia	17	-8	137**	205
<i>Menemerus</i> sp.	Kenya	49	21	84***	175
<i>Mogrus logunovi</i> Proszynski	Israel	27	0	43***	154
<i>Mopsus mormon</i> Karsch	Australia	20	21	100***	194
<i>Myrmarachne assimilis</i> Banks ^a	Philippines	27	15	62***	407
<i>Myrmarachne bakeri</i> Banks ^a	Philippines	85	45	104***	168
<i>Myrmarachne bidentata</i> Banks	Philippines	18	80	114***	194
<i>Myrmarachne lupata</i> (L. Koch) ^a	Australia	19	18	123**	172
<i>Myrmarachne maxillosa</i> (C. L. Koch)	Philippines	16	26	134**	210
<i>Myrmarachne plataleoides</i> O.P.-Cambridge	Sri Lanka	15	73	197**	279
<i>Myrmarachne</i> sp. 1 ^a	Kenya	20	30	136**	335
<i>Myrmarachne</i> sp. 2	Kenya	25	0	100***	193
<i>Natta rufopicta</i> Simon ^a	Kenya	39	52	108***	139
<i>Natta</i> sp.	Kenya	14	89	233**	290
<i>Orthrus bicolor</i> Simon	Philippines	16	5	70**	147
<i>Pachyballus cordiformis</i> Berland & Millot	Kenya	21	75	119***	263

Table 1. (cont.)

Species	Collection locality	<i>n</i>	1st quartile	Median (s)	3rd quartile
<i>Padillothorax taprobanicus</i> Simon	Sri Lanka	16	48	143***	227
<i>Peckhamia americana</i> (Peckham & Peckham)	U.S.A.	12	18	83**	133
<i>Pellenes simoni</i> (O. P.-Cambridge)	Israel	15	-12	106**	175
<i>Phidippus otiosus</i> (Hentz)	U.S.A.	15	13	92**	188
<i>Philaeus chrysops</i> (Poda)	Israel	16	22	105***	139
<i>Phintella aequipes</i> (Peckham & Peckham) ^a	Kenya	43	6	59***	113
<i>Phintella piatensis</i> Barrion & Litsinger ^a	Philippines	32	63	119***	173
<i>Plexippus petersi</i> (Karsch)	Philippines	15	21	90**	192
<i>Portia africana</i> (Simon)	Uganda	14	26	66**	147
<i>Portia fimbriata</i> (Doleschall) ^a	Australia	21	22	187**	333
<i>Portia labiata</i> (Thorell)	Sri Lanka	17	-8	105**	151
<i>Salticus tricinctus</i> (C. L. Koch)	Israel	15	10	94**	140
<i>Siler semiglaucus</i> Simon ^a	Philippines	37	44	134***	416
<i>Simaetha paetula</i> (Keyserling)	Australia	16	37	63***	161
<i>Synageles dalmaticus</i> (Keyserling)	Israel	30	22	69***	152
<i>Taula lepidus</i> Wanless ^a	Philippines	23	0	77***	166
<i>Telamonia masinloc</i> Barrion & Litsinger	Philippines	24	0	31***	119
<i>Thiania bhamoensis</i> Thorell	Singapore	14	41	214**	293
<i>Thiania</i> sp.	Philippines	18	8	50**	234
<i>Thianitara</i> sp.	Philippines	14	24	157**	273
<i>Thiodina silvana</i> Hentz	U.S.A.	23	95	174***	227
<i>Thorelliola ensifera</i> (Thorell)	Singapore	15	32	102**	316
<i>Thyene leighi</i> Peckham & Peckham	Kenya	15	7	59**	141
<i>Trite planiceps</i> Urquhart	New Zealand	24	12	94***	162
<i>Xenocytaea</i> sp. ^a	Philippines	32	28	65***	172
<i>Zenodorus durvillei</i> (Walckenaer)	Australia	16	43	75**	193
<i>Zenodorus orbiculatus</i> (Keyserling)	Australia	19	0	96***	262
<i>Zygoballus rufipes</i> Peckham & Peckham	U.S.A.	16	40	153**	320

^aObserved feeding from flower in field (flower species not identified)

combination of powerful chelicerae and legs, venom and silk to immobilize prey, then undertake a protracted feeding cycle of pumping digestive fluid into the prey and sucking out partially digested nutrients (Collatz, 1987; Pollard, 1990; Foelix, 1996). Salticids and other spiders sometimes drink water independently of feeding (Vollmer & MacMahon, 1974; Pulz, 1987), but nectar is a solution of sugar and other potential nutrients, not simply water. Evidently, sugar is relevant to the salticid because each species we tested took dissolved sugar in preference to distilled water. Pollard *et al.* (1995) obtained similar results with male *Misumenoides formosipes*.

Along with earlier studies on thomisids (Beck & Connor, 1992; Pollard, 1993; Pollard *et al.*, 1995) and wandering spiders (Taylor & Foster, 1996), the present study suggests that nectar feeding may be a widespread, but largely overlooked, strategy in spiders.

Pollard *et al.* (1995) showed increased longevity in male *M. formosipes* spiders given access to nectar and suggested that nectar feeding may have evolved because of the selective advantage of increased longevity. Vogelei & Greissl (1989) and Taylor & Foster (1996) both showed that spiderlings given access to a simulated nectar source (i.e. a sucrose solution), survived longer than spiders given access to water alone. As argued by Vogelei & Greissl (1989) access to real nectar might enhance longevity even further because of the amino

acids, lipids, vitamins and minerals normally found in nectar in addition to sugars (Baker & Baker, 1983).

By feeding on flowers spiders might avoid some of the risks and energetic costs that go along with stalking insects and other active prey. Flowers do not flee, nor do they physically injure spiders by fighting back. Even after capture, prey may require expensive processing that does not apply to nectivory (i.e. injecting venom and digestive enzymes when feeding on nectar would seem to be unnecessary).

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