Diaspores of myrmecochorous plants as food for certain spiders

Author: Suvák, Martin

Source: Arachnologische Mitteilungen: Arachnology Letters, 57(1) : 31-36

Published By: Arachnologische Gesellschaft e.V.

URL: https://doi.org/10.30963/aramit5706
Diaspores of myrmecochorous plants as food for certain spiders

Martin Suvák

Abstract. Spiders eating diasporas (seeds and fruits) from myrmecochorous plants – i.e. those adapted to distribution by ants – is recorded here for the first time as a new case of herbivory in these typical predators. Having found seeds of Costus dubius (Afzel.) K. Schum. (1904) trapped in the web of a Parasteatoda spider (Theridiidae), tests with available myrmecochorous seeds and spiders in the greenhouses of the Botanical garden of the P.J. Šafárik University in Košice (Slovakia) were carried out. Parasteatoda spiders can actively collect C. dubius seeds near their webs and feed on them for a long time. Diaspores with elaiosomes (nutrient-rich appendages) from five other myrmecochorous plant species thrown directly into webs of Parasteatoda sp. and Uloborus plumipes Lucas, 1846 (Uloboridae), another spider species very abundant at this location, were also consumed. These initial observations show that the special chemical composition of elaiosomes, which imitates insect prey primarily for ants, can be attractive for some spider species too. Considering the tested taxa, in the case of Uloboridae contact with such food sources is improbable in their typical niches. However, at least some Theridiidae could also consume myrmecochorous diasporas in nature, especially if they are near source plants or paths of ants transporting these diasporas.

Keywords: Araneae, elaiosomes, herbivory, myrmecochory, Parasteatoda, Uloborus plumipes


Spiders are primarily known as predators, mainly feeding on small invertebrates. An exception is Bagheera kiplingi Peckham & Peckham, 1896 (Salticidae) which largely feeds on plant products (Beltian bodies and foliar nectar) from acacias (Vachellia sp.) (Meehan et al. 2009). Some other spiders occasionally supplement their diet with plant resources. Nyffeler et al. (2016) summarised 95 known incidents of spiders feeding on plants; mostly under natural conditions. In their review, plant resources used by spiders were divided into six main groups: 1. leaves (Beltian and Müllerian bodies, plant sap), 2. sugar solutions (floral and extrafloral nectar, honeydew as a plant-derived sugary fluid, stigmatic exudates), 3. pollen, 4. seeds, 5. spores and 6. plant material present in the guts of herbivorous prey. Among these cases, seed feeding by spiders consisted of only two reports. First, an orb-weaving spider, Neoscona adianta (Walckenaer, 1802) (Araneidae), was observed sucking a grass seed (Poaceae) (Berland 1933). Second, it was assumed by Nyffeler et al. (2016) that tiny airborne plant seeds trapped in spider webs become unintentionally ingested along with the old threads during the recycling process. Furthermore, raising spiders on a liquid diet made from the seeds of Glycine max (L.) Merr., 1917 (Fabaceae) under laboratory conditions was reported by Amalin et al. (1999, 2001).

Due to the above mentioned scarcity of reports of spiders feeding on plants, especially, it was a surprise to see (on 5.I.2018) two relatively heavy seeds of Costus dubius (Afzel.) K. Schum. (1904) (Costaceae) in the web of a Parasteatoda (Theridiidae) above the inner sill of a greenhouse window in the Botanical Garden of the P.J. Šafárik University in Košice (hereinafter BG PJŠU). About three weeks before (12.XII.2017), the seeds of C. dubius were intentionally scattered here to observe their transport by local ants (especially Lasius sp.). While preparing a study on ants in greenhouses many seeds remained on the window sill. The question was whether some seeds later entered the spider's web randomly or whether this spider actually pulled them up as a food. In the second option, it would be interesting to see whether diasporas of this type (seeds or fruits with elaiosomes) could also be used by other spiders.

Myrmecochory is a phenomenon more or less widespread all over the world, in which diasporas of myrmecochorous plant species are adapted for distribution by ants. Such diasporas are usually equipped with elaiosomes: appendages of specific composition, rich mainly in proteins and fatty acids. According to Lengyel et al. (2010), the number of myrmecochorous plant species can be estimated to be at least 11000 in 77 families and according to World Spider Catalog (2018), there are 47904 accepted spider species in 117 families. To date, consumption of such seeds or fruits by spiders has not been reported.

Material and methods

More than 4000 higher plant taxa are registered in the BG PJŠU (48.735°N, 21.238°E, 220–370 m a.s.l.), about 2500 of them from tropical and subtropical areas growing in heated greenhouses (Mártoniová et al. 2010). Adaptations for myrmecochory are known for about 300 species but in fact diasporas were disposable only from one tropical species, Costus

doi: 10.30963/aramin5706

Martin Suvák: Botanical Garden of P. J. Šafárik University, Mánosova 23, 043 52 Košice, Slovakia; E-mail: martin.suvak@upj.sk

Material and methods

More than 4000 higher plant taxa are registered in the BG PJŠU (48.735°N, 21.238°E, 220–370 m a.s.l.), about 2500 of them from tropical and subtropical areas growing in heated greenhouses (Mártoniová et al. 2010). Adaptations for myrmecochory are known for about 300 species but in fact diasporas were disposable only from one tropical species, Costus
20 seeds were put on the window sill inside the greenhouses of BG PJŠU below the spiders. In the following days some seeds were pulled up or later dropped from the web by the spiders. 0 seeds were put on the window sill inside the greenhouse of BG PJŠU below the spiders.

Fig. 1: Number of seeds of Costus dubius on the web (in the area above underlay) of the selected nine spiders Parasteatoda sp. (P01–P17) each day (1.–20., 11.–31.I.18) during checking time, beginning (day 0). 10.I.18.

Fig. 2: Number of seeds in spider’s web.

Fig. 3: Number of seeds in spider’s web.

Fig. 4: Number of seeds in spider’s web.

Fig. 5: Number of seeds in spider’s web.

Fig. 6: Number of seeds in spider’s web.

Fig. 7: Number of seeds in spider’s web.

Fig. 8: Number of seeds in spider’s web.

Fig. 9: Number of seeds in spider’s web.

Fig. 10: Number of seeds in spider’s web.

Fig. 11: Number of seeds in spider’s web.

Fig. 12: Number of seeds in spider’s web.

Fig. 13: Number of seeds in spider’s web.

Fig. 14: Number of seeds in spider’s web.

Fig. 15: Number of seeds in spider’s web.

Fig. 16: Number of seeds in spider’s web.

Fig. 17: Number of seeds in spider’s web.

Fig. 18: Number of seeds in spider’s web.

Fig. 19: Number of seeds in spider’s web.

Fig. 20: Number of seeds in spider’s web.

Fig. 21: Number of seeds in spider’s web.

Fig. 22: Number of seeds in spider’s web.
dubius from West Africa, and from five species of European temperate regions: Chelidonium majus L. (1753), Corydalis solida (L. 1753) Clairv. 1811 (Papaveraceae), Galanthus nivalis L. (1753) (Amaryllidaceae), Asarum europaeum L. (1753) (Aristolochiaceae) and Hepatica nobilis Schreb. 1771 (Ranunculaceae).

The arachnofauna of heated greenhouses in the BG PJŠU comprises 62 spider taxa in 21 families (Šestáková et al. 2017). Parasteatoda tepidariorum (C. L. Koch, 1841) (Theridiidae) and Uloborus plumipes Lucas, 1846 (Uloboridae) are the most abundant spider species here and were confronted with the diaspores of myrmecochorous plants mentioned above. As the syntopic P. tepidariorum and Parasteatoda tabulata (Levi, 1980) are barely distinguishable in their webs, they are usually referred together here as Parasteatoda sp. in this paper.

Some spiders, especially cobweb spiders (Theridiidae), reside in the same place for a long time. Seventeen such sites with spider individuals (coded as P01–P17) were selected along inner sides of greenhouses. Below each selected spider, 20 seeds of Costus dubius were placed on the sill, trying not to touch nearby sticky threads anchored to the sill (Fig. 2a). In the following 20 days the number of seeds picked up was checked (once a day, usually around midday). Only nine Parasteatoda who stayed for the full 20 days at the same site (others disappeared in the meantime) were included in the final evaluation (Fig. 1, 2).

Fig. 2: A Parasteatoda sp. (in red circle) with the code P05 (see text and Fig. 1 for other details) with the seeds of Costus dubius (in blue circles) in a greenhouse of BG PJŠU. a. 20 seeds put on the sill below spider (10.I.2018) at the beginning of the test; b. Three days later (13.I.2018), 13 seeds were pulled up from the sill by this spider; c. Detail of the spider with some of the pulled up seeds (11.I.2018); d. Detail of the spider feeding on one of the seeds (15.I.2018)

Fig. 3: Different individuals of Parasteatoda sp. with the diaspores of: a. Costus dubius; b. Galanthus nivalis; c. Hepatica nobilis; d. Chelidonium majus
Additional observations were made on several other individuals of Parasteatoda and Uloborus plumipes to assess their responses when disposable myrmecochorous diaspores were thrown directly into their webs.

Additional tests offering seeds of Costus dubius as potential food were conducted with Pholcus sp. (Pholcidae), Agelena labyrinthica (Clerck, 1757) (Agelenidae), Hasarius adansoni (Audouin, 1826) (Salticidae) and Mangora acalypha (Walckenaer, 1802) (Araneidae).

Results

Parasteatoda (Theridiidae) can actively collect myrmecochorous diaspores (Costus dubius) in the vicinity of their webs

Some seeds of C. dubius were pulled up from the sill by spiders and other seeds were thrown out from the web (Fig. 1). Usually the picked up seeds remained in the web long enough for counting once a day. A possible source of error could be ants carrying the seeds away from below the spiders. Nevertheless, the results show the ability of Parasteatoda sp. spiders to find the seeds in the vicinity of their webs, pull them up and consume them (Fig. 2). In the humid conditions of greenhouses, the attractive properties of the selected seeds with their elaiosomes were preserved for at least three weeks after their separation from mother plants (Fig. 1).

Selected myrmecochorous diaspores placed directly into the webs of Parasteatoda sp. and Uloborus plumipes were consumed in most cases

Myrmecochorous diaspores from different plants were placed into the webs of five Parasteatoda sp. (1× C. dubius, 1× G. nivalis, 2× H. nobilis and 1× C. majus) and 24 U. plumipes (3× A. europaeum, 4× C. dubius, 5× C. solida, 1× G. nivalis, 4× H. nobilis and 7× C. majus). Times between putting a seed into the web and the approach of a spider to the potential food source varied. Especially in the case of U. plumipes a seed may not be touched for several hours. However, sooner or later, the diaspores of all tested myrmecochorous plants were eaten (Fig. 3, 4). Only one subadult female of U. plumipes threw out three seeds of C. majus from its web shortly after finding them, probably without initial feeding. In all other cases seed eating took minutes to hours. Sometimes seeds were first wrapped with silk (Fig. 4c) just like in real prey capture.

Tests with other spider species

Some other, less common spider species were also offered seeds of C. dubius as potential food. These additional tests included the following spider species: Pholcus sp. (n = 5), Mangora acalypha (n = 1), Agelena labyrinthica (n = 1) and Hasarius adansoni (n = 3). None of the tested spiders was observed feeding on seeds. However, when three seeds were put into

Fig. 4: Different individuals of Uloborus plumipes with diaspores of:

a. Asarum europaeum; b. Corydalis solida; c. Costus dubius; d. Galanthus nivalis; e. Hepatica nobilis; f. Chelidonium majus
the periphery of the web of *Agelena labyrinthica*, all of them were found closer to the center after 3–4 days. Due to the small number of tested spider individuals, these observations are not necessarily conclusive, but they at least show a trend indicating that different spider species may differ in their propensity to consume myrmecochorous diasporas.

**Discussion**

Elaiosomes, as juicy or fleshy appendages of diasporas, can be formed from various tissues of seeds, fruits or even other plant parts. Their chemical composition is quite different from all other plant structures (Leins & Erbar 2010). According to Fisher et al. (2008), elaiosomes of 15 plant species from seven different families were more similar to each other than each was to the other seed parts of the same species. The high nutritional value of elaiosomes is related especially to fats and sugars, but they also contain proteins, vitamins and other substances (Leins & Erbar 2010). Some of these chemicals have signalling effects on ants. For example diglyceride 1,2-diolein, which is also a component of insect hemolymph, is supposed to be the main signalling compound for ants collecting diasporas with elaiosomes (Rico-Gray & Oliveira 2007). Even purely carnivorous ant species, which usually avoid plant resources, are attracted to elaiosomes whose composition is more similar to insects than other plant tissues (Hughes et al. 1994). This is probably the reason why some spiders, which are otherwise obligate predators, can consume myrmecochorous diasporas.

During plant evolution, elaiosomes appeared in many independent events after ants started to dominate terrestrial ecosystems (Dunn et al. 2007, Lengyel et al. 2010). It proved advantageous for many plant species to distribute themselves with the help of these omnipresent ant predators. Such plants evolved diasporas equipped with imitations of insect prey (elaiosomes as a reward for ants). This is usually a mutually advantageous relationship in which ants transport diasporas, utilise highly nutritional elaiosomes and leave the rest of diasporas untouched in more or less remote sites. Therefore myrmecochy should arise from exploitation of predator–prey relationships (Fenner & Thompson 2005). Formation of such structures by plants was ‘targetted’ towards omnivorous and carnivorous ants so that they would distribute diasporas, but other generalist predators such as some ground beetles (Obara & Higashi 1987) can use this resource as well. Animals consuming elaiosomes without dispersing the seeds disrupt ant–plant mutualism (Rico-Gray & Oliveira 2007) and, as is shown in this paper, some spiders can be included – from an ecological point of view – in this disruptive group too.

As shown here, spiders can consume diasporas with elaiosomes. Another question is how widespread this phenomenon is in the natural environment? In the case of *Uloboridae* it does not probably occur, because such diasporas would rarely get into their webs. But in the case of *Theridiidae*, with threads attached to the ground, it is more probable. Especially when a web is constructed near the source plants, or above ant trials where diasporas are transported. Many *Theridiidae* species catch ants using sticky threads anchored to the substrate. Even in our greenhouses, individuals of all the common ant species [Lasius niger (Linnaeus, 1758), Lasius brunneus (Latreille, 1798), Lasius emarginatus (Olivier, 1792), Camponotus fallax (Nylander, 1856), Tetramorium sp.] were documented as prey of *P. tepidariorum* or *P. tabulata*. Workers of the same spectrum of ant species readily grab the myrmecochorous seeds on offer. In the context of the above findings, a spider could consume both a worker ant and the seed carried along and abandoned after attack. Direct observation of such activities is missing so far, but the simultaneous occurrence of seeds and ants in the web was registered (Fig. 5). Overall, it seems to be another example of tritrophic interactions between spiders, plants and ants. The possible interactions of some *Theridiidae* spiders with myrmecochorous plants and ants are not as specific as in the salticid *Bagheera kiplingi* on *Vachellia* sp. acacias with *Pseudomyrmex* sp. ants (Meehan et al. 2009).

Nyffeler et al. (2016) documented spiders feeding on plant materials representing about 20 different plant families. In the current paper, it is shown that spiders feed on plant materials representing five additional families (Amaryllidaceae, Aristolochiaceae, Costaceae, Papaveraceae and Ranunculaceae). Considering high number of other non-tested myrmecochorous plants and spiders, other families might be expected to supplement this list. On the one hand, there may be differences in detailed chemical composition of elaiosomes in individual plant species, on the other, there are various food strategies and preferences of spiders with different opportu-
nities to encounter such diaspores. Sanders (2013) assumed greater potential for interactions between plants and spiders, especially based on the wide range of spider families using nectar as supplementary resource. Another very widespread potential plant resource – diaspores with elaiosomes, in connection with preliminary observations described in this paper, show that herbivory in spiders may be more common than previously assumed.

Acknowledgements
I would like to thank the reviewers Martin Nyffeler and Rainer Foelix for their valuable comments on the earlier version of the manuscript, although any possible remaining errors are my own.

References
Berland L 1933 Contribution à l'étude de la biologie des arachnides (3é mémoire). – Archives de zoologie expérimentale et générale (Notes et Revues) 76: 1-23