Diaspores of myrmecochorous plants as food for certain spiders

Author: Martin Suvák
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 diaspores (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 diaspores in nature, especially if they are near source plants or paths of ants transporting these diaspores.

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

Zusammenfassung. Diasporen von Pflanzen mit Myrmekochorie als Nahrung für manche Spinnen. Als neuer Fall von Herbivorie durch typischerweise räuberische Spinnen wird erstmals belegt, dass Spinnen Diasporen (Samen und Früchte) von Pflanzen mit Myrmekochorie (Ameisenausbreitung) fressen. Als Samen von Costus dubius (Afzel) K. Schum. (1904) im Netz von Parasteatoda-Arten (Theridiidae) gefunden wurden, wurden Test mit verfügbar Samen von Pflanzen mit Myrmekochorie und Spinnen in den Gewächshäusern des Botanischen Gartens der P.J. Šafárik Universität in Košice (Slowakei) durchgeführt. Es konnte bestätigt werden, dass Parasteatoda-Arten aktiv Samen von C. dubius in der Nähe ihrer Netze sammeln und sich davon über längere Zeit ernähren können. Diasporen mit Elaiosomen (energie reiche Anhängsel, „Ölkörperchen“) von fünf weiteren Pflanzenarten mit Myrmekochorie, die direkt in die Netze von Parasteatoda sp. und von Uloborus plumipes Lucas, 1846 (Uloboridae) gegeben wurden – letztere Art kam ebenfalls sehr häufig vor, wurden ebenfalls gefressen. Diese ersten Beobachtungen zeigen, dass die besondere chemische Zusammensetzung der Elaiosomen, die primär Insektennahrung für Ameisen imitieren, auch attraktiv für manche Spinnenarten sein können. Im Fall der untersuchten Uloboridae ist ein Kontakt mit solcher Nahrung in ihrem typischen Lebensraum unwahrscheinlich. Aber mindestens einige Theridiidae- Arten könnten in ihrem natürlichen Lebensraum Diasporen von Pflanzen mit Myrmekochorie ebenfalls fressen, insbesondere in der Nähe der Pflanzen oder von Ameisenstraßen, wo solche Diasporen transportiert werden.

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 diaspores were disposable only from one tropical species, Costus
Some seeds were pulled up or later dropped from the web by the spiders. In the following days some seeds were pulled up or later dropped from the web by the spiders.

![Graph](https://example.com/graph.png)

Fig 1: Number of seeds of *Costus dubius* in the webs (in the air above underlay) of the selected nine spiders.

| Day | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 |
|-----|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|
| 1   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 2   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 3   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 4   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 5   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 6   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 7   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 8   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 9   |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 10  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 11  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 12  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 13  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 14  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 15  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 16  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 17  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 18  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 19  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |
| 20  |   |   |   |   |   | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 |

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.
Diaspores as food for spiders

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), *Astrum europaeum* L. (1753) (Aristolochiaceae) and *Hepatica nobilis* Schreb. 1771 (Ranunculaceae).

The arachnofauna of heated greenhouses in the BG PŠU 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](https://bioone.org/journals/Arachnologische-Mitteilungen:-Arachnology-Letters/2019-04-27/33/10.12500/31/31-4.png)

**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 PŠU. **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](https://bioone.org/journals/Arachnologische-Mitteilungen:-Arachnology-Letters/2019-04-27/33/10.12500/31/31-5.png)

**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
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 diaspores.

**Discussion**

Elaiosomes, as juicy or fleshy appendages of diaspores, 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 diaspores 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 diaspores.

During plant evolution, elaiosomes appeared in many independent events after ants started to dominate terrestrial ecosystems (Dunn et al. 2007, Lengyl et al. 2010). It proved advantageous for many plant species to distribute themselves with the help of these omnipresent ant predators. Such plants evolved diaspores equipped with imitations of insect prey (elaiosomes as a reward for ants). This is usually a mutually advantageous relationship in which ants transport diaspores, utilise highly nutritional elaiosomes and leave the rest of diaspores untouched in more or less remote sites. Therefore myrmecochory could 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 diaspores, but other generalist predators such as some ground beetles (Ohara & 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 diaspores 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 diaspores 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 diaspores 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 (Linnæus, 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 trophic 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-

**Fig. 5:** Simultaneous occurrence of two seeds of Costus dubius and a worker of Lasius brunneus in the web of Parasteatoda sp. spider with the code P16, 15.I.2018 (see text and Fig. 1 for other details).
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
Amalin DM, Reiskind J, McSorley R & Pena JE 1999 Survival of the hunting spider, *Hibana velox* (Araneae, Anyphaenidae), raised on different artificial diets. – Journal of Arachnology 27: 692-696
Amalin DM, Pena JE, Reiskind J & McSorley R 2001 Comparison of the survival of three species of sac spiders on natural and artificial diets. – Journal of Arachnology 29: 253-262 – doi: 10.1636/0161-8202(2001)029[0253:COTSOT]2.0.CO;2
Berland L 1933 Contribution à l'étude de la biologie des arachnides (3è mémoire). – Archives de zoologie expérimentale et générale (Notes et Revues) 76: 1-23
Dunn RR, Gove AD, Barraclough TG, Givnish TJ & Majer JD 2007 Convergent evolution of an ant–plant mutualism across plant families, continents, and time. – Evolutionary Ecology Research 9: 1349-1362
Fenner M & Thompson K 2005 The ecology of seeds. Cambridge University Press, New York. 261 pp.
Fischer RC, Richter A, Hadacek F & Mayer V 2008 Chemical differences between seeds and elaiosomes indicate an adaptation to nutritional needs of ants. – Oecologia 155: 539-547 – doi: 10.1007/s00442-007-0931-8
Hughes L, Westoby M & Jurado E 1994 Convergence of elaiosomes and insect prey: Evidence from ant foraging behaviour and fatty acid composition. – Functional Ecology 8: 358-365 – doi: 10.2307/2398289
Leins P & Erbar C 2010 Flower and fruit. Morphology, ontogeny, phylogeny, function, ecology. Schweizerbart Science Publishers, Stuttgart. 439 pp.
Lengyel S, Gove AD, Latimer AM, Majer JD & Dunn RR 2010 Convergent evolution of seed dispersal by ants, and phylogeny and biogeography in flowering plants: A global survey. – Perspectives in Plant Ecology, Evolution and Systematics 12: 43-55 – doi: 10.1016/j.ppees.2009.08.001
Mártoniová L, Mochnacký S, Fridman P, Repčáková K, Kelbel P & Gregorek R 2010 Catalogue of plant collections no. 5. P. J. Šafárik University Botanical Garden, Košice. 96 pp.
Meehan CJ, Olson EJ, Reudink MW, Kyser TK & Curry RL 2009 Herbivory in a spider through exploitation of an ant–plant mutualism. – Current Biology 19: R892-R893 – doi: 10.1016/j.cub.2009.08.049
Nyffeler M, Olson EJ & Symondson WOC 2016 Plant-eating by spiders. – Journal of Arachnology 44: 15-27 – doi: 10.1636/P15-45.1
Ohara M & Higashi S 1987 Interference by ground beetles with the dispersal by ants of seeds of *Trillium* species (Liliaceae). – Journal of Ecology 75: 1091-1098 – doi: 10.2307/2260316
Rico-Gray V & Oliveira PS 2007 The ecology and evolution of ant–plant interactions. University of Chicago Press, Chicago and London. 320 pp. – doi: 10.7208/chicago/9780226713540.001.0001
Sanders D 2013 Herbivory in spiders. In: Nentwig W (ed.) Spider ecolphysiology. Springer, Bern. pp. 385-391 – doi: 10.1007/978-3-642-33989-9_28
Šestáková A, Suvák M, Krajčovičová K, Kaňuchová A & Christophorová J 2017 Arachnids from the greenhouses of the Botanical Garden of the P. J. Šafárik University in Košice, Slovakia (Arachnida: Araneae, Opiliones, Palpigradi, Pseudoscorpiones). – Arachnologische Mitteilungen 53: 19-28 – doi: 10.5431/armit5304
World Spider Catalog 2018 World Spider Catalog. Version 19.5. Natural History Museum Bern. – Internet: http://wsc.nmbe.ch (December 17, 2018) – doi: 10.24436/2