Graellsia, 79(1): e193
enero-junio 2023
ISSN-L: 0367-5041
https://doi.org/10.3989/graellsia.2023.v79.350

Notas / *Notes*

All you can eat: autochthonous vertebrate and invertebrate predation by the alien spider *Parasteatoda tepidariorum* (C.L. Koch, 1841) (Araneae: Theridiidae) in two anthropogenic habitats of Italy

Javier Blasco-Aróstegui[1,*] & Arnau Calatayud-Mascarell[2]

[1] Faculdade de Ciências, Universidade de Lisboa, Campo Grande 016, 1749-016 Lisboa, Portugal.
Email: javierblasco77@gmail.com – ORCID iD: https://orcid.org/0000-0003-4230-9375

[2] Biodiversity Research Institute (IRBio), University of Barcelona, Av. Diagonal, 643, 08028 Barcelona, Spain.
Email: arnau.lycosa@gmail.com – ORCID iD: https://orcid.org/0000-0003-0627-2616
* Corresponding author: javierblasco77@gmail.com (J. Blasco-Aróstegui)

ABSTRACT

We report the two main autochthonous prey items of the alien spider *Parasteatoda tepidariorum* (C.L. Koch, 1841) in two anthropogenic habitats of the Italian Alps, namely a lizard and a scorpion species: *Podarcis siculus* (Rafinesque, 1810) and *Alpiscorpius sigma* Kovařík, Štundlová, Fet & Šťáhlavský, 2019. Additionally, we briefly describe the predatory behavior of this spider with both preys, highlight the scarcity of records of invertebrate predation on vertebrates in Europe, and address some concerns regarding how this might affect autochthonous populations.

Keywords: Araneae, Theridiidae, *Parasteatoda tepidariorum*, Europe, Ecology, Vertebrate predation, *Podarcis siculus*, *Alpiscorpius sigma*.

RESUMEN

Todo lo que puedas comer: depredación de vertebrados e invertebrados autóctonos por parte de la araña introducida *Parasteatoda tepidariorum* (C.L. Koch, 1837) (Araneae: Theridiidae) en dos hábitats antropogénicos de Italia

Reportamos las dos principales presas autóctonas de la araña introducida *Parasteatoda tepidariorum* (C.L. Koch, 1841) en dos hábitats antropogénicos de los Alpes italianos, específicamente una especie de lagartija y una especie de escorpión: *Podarcis siculus* (Rafinesque, 1810) y *Alpiscorpius sigma* Kovařík, Štundlová, Fet & Šťáhlavský, 2019. Además, describimos brevemente el comportamiento depredador de esta araña con ambas presas, destacamos la escasez de registros de depredación de invertebrados sobre vertebrados en Europa y comentamos posibles efectos negativos sobre las poblaciones autóctonas.

Palabras clave: Araneae, Theridiidae, *Parasteatoda tepidariorum*, Europa, Ecología, Depredación sobre vertebrados, *Podarcis siculus*, *Alpiscorpius sigma*.

Recibido/*Received*: 20/03/2022; **Aceptado/*Accepted***: 20/03/2023; **Publicado en línea/*Published online***: 12/05/2023

Cómo citar este artículo/*Citation*: Blasco-Aróstegui, J. & Calatayud-Mascarell, A. 2023. All you can eat: autochthonous vertebrate and invertebrate predation by the alien spider *Parasteatoda tepidariorum* (C.L. Koch, 1841) (Araneae: Theridiidae) in two anthropogenic habitats of Italy. *Graellsia*, 79(1): e193. https://doi.org/10.3989/graellsia.2023.v79.350

Predation was early identified as one of the primary elements involved in community stability (Glasser, 1979; Polis *et al.*, 1989). In the 'invertebrate world', the remarkable diversity of predators that interact and coexist with each other promotes the formation of guilds (Root, 1967; Polis *et al.*, 1989), which are composed of species that exploit and compete for similar and often limited resources. Along with the rest of the trophic levels, they form complex food-webs in which the imperative rule is basically ‘eat or be eaten’. This spawns generalist predators (Levins & MacArthur, 1969), which have been identified as one of the main stabilizers in food-webs (Parsons, 1992; Gross *et al.*, 2009; Brechtel *et al.*, 2019). Nevertheless, when generalist predators have been accidentally introduced by humans to new environments, they have frequently caused a negative impact on autochthonous species (Dickman, 1996; Nentwig, 2015).

One example of generalist predators are webbing spiders, which include several cases of invasive or potentially invasive species (Vink *et al.*, 2011; Nentwig, 2015; Hänggi & Straub, 2016). *Parasteatoda tepidariorum* (C.L. Koch, 1841), a cobweb spider belonging to the family Theridiidae, native to Asia and now considered cosmopolitan, was originally introduced in Europe and other parts of the world (Bonnet, 1930; Nentwig, 2015; World Spider Catalog, 2022). Despite comprehensive molecular and developmental studies (Mittmann & Wolff, 2012; Schomburg *et al.*, 2015), scarce information regarding its diet in the newly invaded territories is available. Although diet specializations have been reported in some spiders of the family Theridiidae (i.e., dipterophagy) (Pekár *et al.*, 2012), they mainly exhibit an euryphagous diet, practically feeding on everything that gets trapped on their webs (Salomon, 2011; Pompozzi *et al.*, 2013; Mora-Rubio & Parejo-Pulido, 2021).

Here, we report the two main autochthonous prey items of this alien spider in two anthropogenic habitats of the Italian Alps. Additionally, we briefly describe the predatory behavior of this spider with both prey and address some concerns regarding how this might affect autochthonous populations.

The observation of the predation events took place at two different anthropogenic habitats located along the Italian Alps (Fig. 1). The first habitat was a wooden cabin next to a mountain road in the village of Sonvico [45.814664ºN, 10.1394958ºE, 623 m.a.s.l.]. The beams were full of spider webs with several *Parasteatoda tepidariorum* individuals and their trapped prey (Fig. 2A-B). In this location, the spiders were mainly feeding on a lizard species very abundant in the area (see below). The second habitat was a

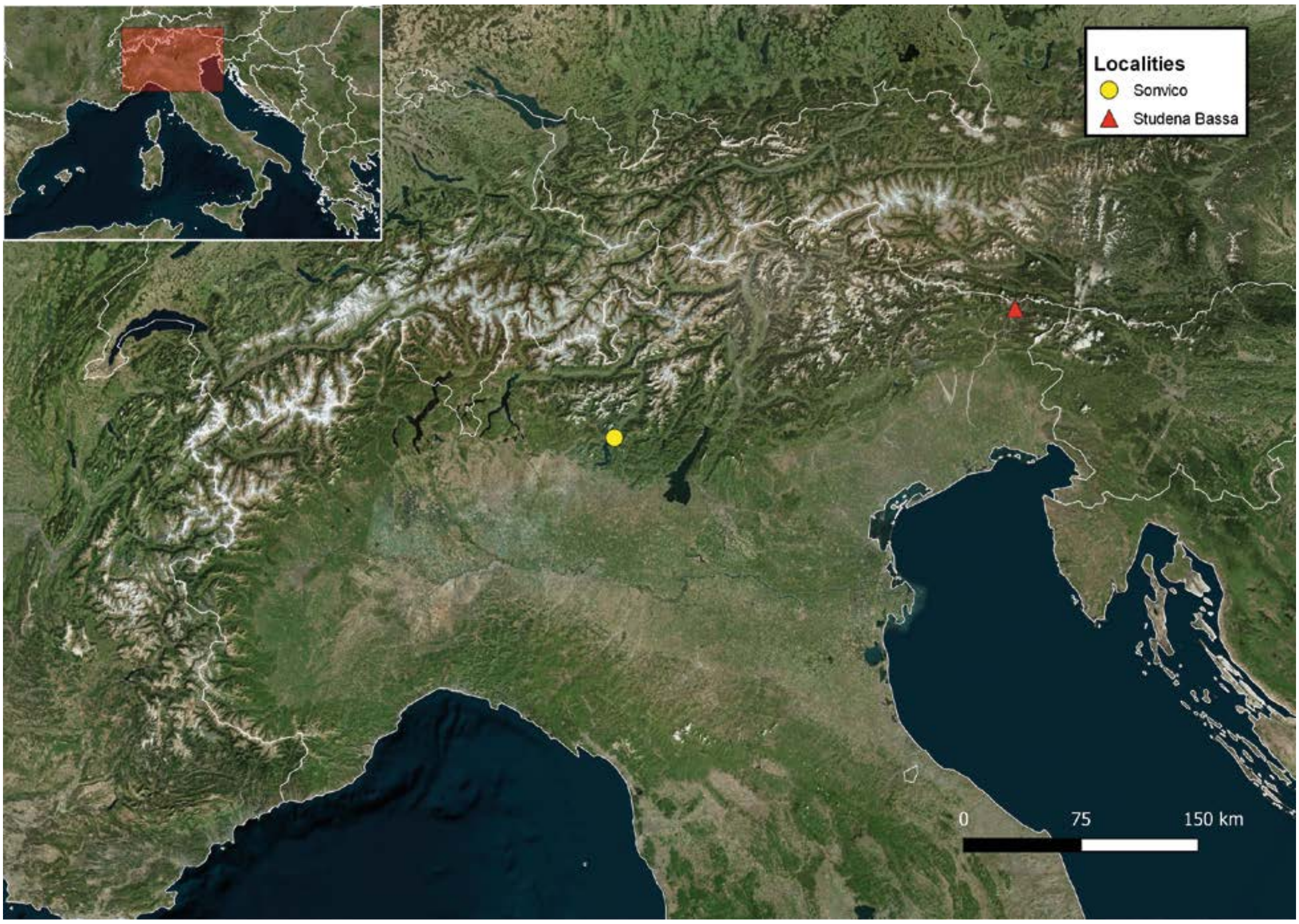

Fig. 1.– Map showing the two localities in which predation events involving *Parasteatoda tepidariorum* (C.L. Koch, 1837) were observed.

Fig. 1.– Mapa que muestra las dos localidades en las que se observaron los eventos de depredación de *Parasteatoda tepidariorum* (C.L. Koch, 1837).

Fig. 2.– *Parasteatoda tepidariorum* (C.L. Koch, 1837) feeding on the two different prey items. A) Predation of *Podarcis siculus* (Rafinesque, 1810). B) 'Biting the lizard's tail and running-away': strategy adopted by *P. tepidariorum* to feed on *P. siculus*. C) Predation of *Alpiscorpius sigma* Kovařík, Štundlová, Fet & Šťáhlavský, 2019. D) 'Rolling up the scorpion weaponry': strategy adopted by *P. tepidariorum* to feed on *A. sigma*.

Fig. 2.– *Parasteatoda tepidariorum* (C.L. Koch, 1837) alimentándose de las dos presas diferentes. A) Depredación de *Podarcis siculus* (Rafinesque, 1810). B) 'Morder la cola de la lagartija y huir': estrategia adoptada por *P. tepidariorum* para alimentarse de *P. siculus*. C) Depredación de *Alpiscorpius sigma* Kovařík, Štundlová, Fet & Šťáhlavský, 2019. D) 'Enrollando el armamento del escorpión': estrategia adoptada por *P. tepidariorum* para alimentarse de *A. sigma*.

concrete 'mossy' wall on the roadside of the main road towards Studena Bassa [46.518557ºN, 13.28285ºE, 674 m.a.s.l.]. Different arthropods inhabited the site such as woodlice or millipedes; however, the most abundant animals were *Parasteatoda tepidariorum* and scorpions of the genus *Alpiscorpius* Gantenbein *et al.*, 1999 (Fig. 2C-D), which were the main prey item trapped in the spider webs.

We collected the lizard prey items, the scorpion prey items and *Parasteatoda tepidariorum* specimens of both sexes. All specimens were preserved in 95% EtOH and were later determined using a Leica MZ16A dissection scope. Prey items were identified using a field guide of European reptiles (Speybroeck *et al.*, 2017) for the lizards, and following an identification key provided by Kovařík *et al.* (2019) in the case of scorpions. Spiders were identified following the online keys provided for the European species (Nentwig *et al.*, 2022). Photographs were taken with a Sigma 105mm macro lens attached to a Nikon D3500 camera. Voucher specimens have been deposited in the Entomological collection of the University of Valencia (Dr. J. Selfa).

The lizards captured by the *Parasteatoda tepidariorum* specimens were determined as *Podarcis siculus* (Rafinesque, 1810) (Fig. 2A-B). In most of the cases, *Podarcis siculus* individuals were barely entangled in the spider webs. They could move freely and were actively trying to release themselves. Accordingly, the strategy adopted by the spiders to prey on them was to continuously bite the lizard's tail (Fig. 2B), move up and down the web avoiding a possible counterattack, and progressively paralyze it after several bites. Once the whole body was completely immobilized, the spiders started digesting the lizards (Fig. 2A).

On the other hand, the scorpions were identified as *Alpiscorpius sigma* Kovařík, Štundlová, Fet & Šťáhlavský, 2019 (Fig. 2C-D). As shown in Figure 2C-D, once the scorpion was trapped in the webs, *P. tepidariorum* individuals rapidly started rolling up its pincers and stinger with silk, preventing a possible pedipalp or metasomal strike.

Whereas scorpions and spiders are natural enemies worldwide (Williams *et al.*, 2006; Blasco-Aróstegui *et al.*, 2020; Duberstein & Sherwood, 2020; Mora-Rubio & Parejo-Pulido, 2021; Da Silva *et al.*, 2021), most of the interactions having an arthropod as the predator and a vertebrate as the prey normally occur in tropical areas of the world (Valdez, 2020). In Europe, the scarce records of this type of encounters generally involve a spider, often from the family Theridiidae (Nyffeler & Pussey, 2014; O'Shea & Kelly, 2017). This might be determined by the potent venom within the family and its specific toxins targeting vertebrates (e.g., α-latrotoxin) (Gendreau *et al.*, 2017).

Parasteatoda tepidariorum represents an ideal model organism to study this idea: a potentially invasive, true generalist predator with a great plasticity in its diet, often synanthropic and with a venom capable of killing small vertebrates (Fig. 2A-B). This is remarkable, as contrarily to other Theridiidae, α-latrotoxin is absent in the venom composition of this species (reported by Gendreau *et al.*, 2017). From our observations, we hypothesize that this spider might be adapting its diet depending on prey availability in each area. This phenomenon is called 'prey switching' and has long been associated with foraging adaptation (Murdoch, 1969; Chesson, 1984; Baudrot *et al.*, 2016). Whether this switching is having a positive effect (i.e., predator over-consumes a prey or another predator whose proportion increases and regulates its density) or a negative effect (i.e., predator over-consumes a prey or another abundant predator but severely decreases its numbers leading to extinction in the ecosystem) has yet to be investigated. In this sense, a change in top predator presence or abundance may dramatically alter food-web structure or even ecosystem state (Terborgh *et al.*, 2001; Dobson *et al.*, 2006). Uncovering how this might be affecting the autochthonous populations of the species *P. tepidariorum* prey upon –including their possible depletion– and how this may affect trophic chain stability in Europe or other invaded territories, would be of extreme importance if we intend to preserve native biodiversity.

Acknowledgements

We want to thank Dr. Jesús Selfa and the University of Valencia (Valencia, Spain) for granting us access to the facilities and allowing us to use their equipment. Thanks are extended to Alberto Sánchez-Vialas and Ignazio Avella for their help confirming the lizard species.

References

Baudrot, V., Perasso, A., Fritsch, C, Giraudoux, P. & Raoul, F., 2016. The adaptation of generalist predators' diet in a multi-prey context: Insights from new functional responses. *Ecology*, 97: 1832–1841. https://doi.org/10.1890/15-0427.1

Blasco-Aróstegui, J., García-Gila, J. & Francke, O. F., 2020. Ecological aspects of the interactions between *Centruroides limbatus* and *Tityus ocelote* (Scorpiones: Buthidae) in a Caribbean Forest of Costa Rica. *Revista Mexicana de Biodiversidad*, 91: 1–14. e913418

Bonnet, P., 1930. Les araignées exotiques en Europe. *Annales de la Société Entomologique de France*, 99: 49–64.

Brechtel, A., Gross, T. & Drossel, B., 2019. Far-ranging generalist top predators enhance the stability of meta-food webs. *Scientific Reports*, 9: 1–15. https://doi.org/10.1038/s41598-019-48731-y

Brose, U., Williams, R. J. & Martinez, N. D., 2006. Allometric scaling enhances stability in complex food webs. *Ecology Letters*, 9: 1228–1236. https://doi.org/10.1111/j.1461-0248.2006.00978.x

Chesson, P. L., 1984. Variable predators and switching behavior. *Theoretical Population Biology*, 26: 1–26. https://doi.org/10.1016/0040-5809(84)90021-2

Da Silva, A. A., Rohde, C. & De Lira, A. F. A., 2021. Record of mygalomorph spider (Araneae: Theraphosidae) predation by a scorpion (Scorpiones: Buthidae) in a Brazilian seasonally dry tropical forest. *Arachnology*, 18: 1068–1069. https://doi.org/10.13156/arac.2021.18.9.1068

Dickman, C. R., 1996. Impact of exotic generalist predators on the native fauna of Australia. *Wildlife Biology*, 2: 185–195. https://doi.org/10.2981/wlb.1996.018

Dobson, A., Lodge, D., Alder, J., Cumming, G. S., Keymer, J., McGlade, J., ... & Xenopoulos, M. A., 2006. Habitat loss, trophic collapse, and the decline of ecosystem services. *Ecology*, 87: 1915–1924. DOI: 10.1890/0012-9658(2006)87[1915:hltcat]2.0.co;2

Duberstein, J. N. & Sherwood, D., 2020. Predation of *Paravaejovis spinigerus* (Wood, 1863) (Scopriones: Vaejovidae) by *Aphonopelma chalcodes* Chamerlin, 1940 (Araneae: Theraphosidae) in Arizona. *Arachnology*, 18: 496–498. https://doi.org/10.13156/arac.2020.18.5.496

Gendreau, K. L., Haney, R. A., Schwager, E. E., Wierschin, T., Stanke, M., Richards, S. & Garb, J. E., 2017. House spider genome uncovers evolutionary shifts in the diversity and expression of black widow venom proteins associated with extreme toxicity. *BMC Genomics*, 18: 178. https://doi.org/10.1186/s12864-017-3551-7

Glasser, J. W., 1979. The role of predation in shaping and maintaining the structure of communities. *The American Naturalist*, 113: 631–641.

Gross, T., Rudolf, L., Levin, S. A. & Dieckmann, U., 2009. Generalized models reveal stabilizing factors in food webs. *Science*, 325: 747–750. https://doi.org/10.1126/science.1173536

Hänggi, A. & Straub, S., 2016. Storage buildings and greenhouses as stepping stones for non-native potentially invasive spiders (Araneae)–a baseline study in Basel, Switzerland. *Arachnologische Mitteilungen*, 51: 1–8.

Kovařík, F. Štundlová, J., Fet, V., & Šťáhlavský, F., 2019. Seven new Alpine species of the genus *Alpiscorpius* Gantenbein *et al.*, 1999, stat. n. (Scorpiones: Euscorpiidae). *Euscorpius*, 287: 1–29. https://doi.org/10.18590/euscorpius.2019.vol2019.iss287.1

Levins, R. & Macarthur, R., 1969. An hypothesis to explain the incidence of monophagy. *Ecology*, 50: 910–911. https://doi.org/10.2307/1933709

May, R., 1972. Will a Large Complex System be Stable? *Nature*, 238: 413–414. https://doi.org/10.1038/238413a0

Mittmann, B. & Wolff, C., 2012. Embryonic development and staging of the cobweb spider *Parasteatoda tepidariorum* C.L. Koch, 1841 (syn.: *Achaearanea tepidariorum*; Araneomorphae; Theridiidae). *Development Genes and Evolution*, 222: 189–216. https://doi.org/10.1007/s00427-012-0401-0

Mora-Rubio, C. & Parejo-Pulido, D., 2021. Notas sobre la dieta de la viuda negra mediterránea *Latrodectus tredecimguttatus* (Rossi, 1790) (Araneae: Theridiidae) en el suroeste de la península ibérica. *Graellsia*, 77: e138. https://doi.org/10.3989/graellsia.2021.v77.297

Murdoch, W. W., 1969. Switching in general predators: experiments on predator specificity and stability of populations. *Ecological Monographs*, 39: 335–354. https://doi.org/10.2307/1942352

Nentwig, W., 2015. Introduction, establishment rate, pathways and impact of spiders alien to Europe. *Biological Invasions*, 17: 2757–2778. https://doi.org/10.1007/s10530-015-0912-5

Nentwig, W., Blick, T., Gloor, D., Hänggi, A. & Kropf, C., 2022. Spiders of Europe, online at https://araneae.nmbe.ch/, accessed on {21-02-2022}.

Nyffeler, M. & Pusey, B. J., 2014. Fish predation by semi-aquatic spiders: a global pattern. *PLoS ONE*, 9: e99459. https://doi.org/10.1371/journal.pone.0099459

O'Shea, M. & Kelly, K., 2017. Predation on a weasel skink (*Saproscincus mustelinus*) (Squamata: Scincidae: Lygosominae) by a redback spider (*Latrodectus hasselti*) (Araneae: Araneomorpha: Theridiidae), with a review of other *Latrodectus* predation events involving squamates. *Herpetofauna*, 44: 49–55.

Parsons, T., 1992. The removal of marine predators by fisheries and the impact of trophic structure. *Marine Pollution Bulletin*, 25: 51–53. https://doi.org/10.1007/s00427-012-0401-0

Pekár, S., Coddington, J. A. & Blackledge, T. A., 2012. Evolution of stenophagy in spiders (Araneae): Evidence based on the comparative analysis of spider diets. *Evolution*, 66: 776–806. https://doi.org/10.1111/j.1558-5646.2011.01471.x

Polis, G. A., Myers, C. A. & Holt, R. D., 1989. The ecology and evolution of intraguild predation: potential competitors that eat each other. *Annual Review of Ecology and Systematics*, 20: 297–330. https://doi.org/10.1146/annurev.es.20.110189.001501

Pompozzi, G., Ferretti, N., Schwerdt, L., Copperi, S., Ferrero, A. A. & Simó, M., 2013. The diet of the black widow spider *Latrodectus mirabilis* (Theridiidae) in two cereal crops of central Argentina. *Iheringia. Série Zoologia*, 103: 388–392. https://doi.org/10.1590/S0073-47212013000400009

Root, R. B., 1967. The niche exploitation pattern of the blue-gray gnatcatcher. *Ecological Monographs*, 37: 317–350. https://doi.org/10.2307/1942327

Salomon, M., 2011. The natural diet of a polyphagous predator, *Latrodectus hesperus* (Araneae: Theridiidae), over one year. *The Journal of Arachnology*, 39: 154–160. https://doi.org/10.1636/P10-25.1

Schomburg, C., Turetzek, N., Schacht, M. I., Schneider, J., Kirfel, P., Prpic, N. M. & Posnien, N., 2015. Molecular characterization and embryonic origin of the eyes in the common house spider *Parasteatoda tepidariorum*. *EvoDevo*, 6: 1–14. https://doi.org/10.1186/s13227-015-0011-9

Speybroeck, J., Beukema, W., Bok, B. & Van der Voort, J., 2017. *Guía de campo de los Anfibios y Reptiles de España y de Europa*. Ediciones Omega, pp. 302.

Terborgh, J., Lopez, L., Nuñez, P., Rao, M., Shahabuddin, G., Orihuela, G., Riveros, M., Ascanio, R., Adler, G. H., Lambert, T. D. & Balbas, L., 2001. Ecological meltdown in predator-free forest fragments. *Science*, 294: 1923–1926. https://doi.org/10.1126/science.1064397

Valdez, J. W., 2020. Arthropods as vertebrate predators: A review of global patterns. *Global Ecology and Biogeography*, 29: 1691–1703. https://doi.org/10.1111/geb.13157

Vink, C. J., Derraik, J. G., Phillips, C. B. & Sirvid, P. J., 2011. The invasive Australian redback spider, *Latrodectus hasseltii* Thorell 1870 (Araneae: Theridiidae): current and potential distributions, and likely impacts. *Biological Invasions*, 13: 1003–1019. https://doi.org/10.1007/s10530-010-9885-6

Williams, J. L., Moya-Laraño, J. & Wise, D. H., 2006. Burrow decorations as antipredatory devices. *Behavioral Ecology*, 17: 586–590. https://doi.org/10.1093/beheco/ark003

World Spider Catalog, 2022. World Spider Catalog. Version 23.0. Natural History Museum Bern, online at http://wsc.nmbe.ch, accessed on {21-02-2022}. https://doi.org/10.24436/2