

First record from Italy of *Zatypota anomala* (Ichneumonidae, Ephialtini), a parasitoid of the cribellate spider *Dictyna pusilla* (Araneae, Dictynidae)

Stanislav Korenko



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Abstract. The polysphinctine wasp *Zatypota anomala* (Holmgren, 1860), a koinobiont ecto-parasitoid of spiders in the family Dictynidae, was recorded in Italy for the first time. Populations of both the wasp and its host, *Dictyna pusilla* Thorell, 1856, its host preference and the interaction between the parasitoid and the spider were documented in the field and by laboratory observations.

Keywords: ectoparasitoid, host parasitoid interaction, host range, host specialisation, spider web

Zusammenfassung. Erstnachweis von *Zatypota anomala* (Ichneumonidae, Ephialtini) für Italien, ein Parasitoid der cribellaten Spinne *Dictyna pusilla* (Araneae, Dictynidae). Die zu den Polysphinctinae gehörende Schlupfwespe *Zatypota anomala* (Holmgren, 1860), ein koinobionter Ektoparasit von Spinnen der Familie Dictynidae, wurde erstmals für Italien nachgewiesen. Es werden Populationen der Wespe und ihres Wirtes, *Dictyna pusilla* Thorell, 1856, die Wirtspräferenz und Interaktionen zwischen Parasitoid und Spinne aus dem Freiland und dem Labor dokumentiert.

With 50 described species, the genus *Zatypota* comprises highly specialised koinobiont ecto-parasitoids of spiders and is the largest genus of the *Polysphincta*-group in the world (Gauld & Dubois 2006, Matsumoto & Takasuka 2010, Yu et al. 2012, Fritzén 2014). *Zatypota* probably includes as many species as in all other genera of the *Polysphincta* genus-group combined, and many undescribed species still exist in museum collections (e.g. Gauld & Dubois 2006). All *Zatypota* species are narrowly associated with a specific host spider species or a small group of closely related spider species. *Zatypota* wasps are mostly parasitoids of theridiid spiders (Nielsen 1923, Fitton et al. 1988, Gauld & Dubois 2006, Korenko & Pekár 2011, Korenko et al. 2011), but three *Zatypota* species are associated with spiders other than theridiids (Matsumoto & Takasuka 2010, Korenko et al. 2015, Vincent 1979).

Eight species from the genus *Zatypota* occur in Europe (de Jong et al. 2014, Fritzén 2010, 2014). Six of them – *Zatypota percontatoria* (Müller, 1776), *Z. bohemani* (Holmgren, 1860), *Z. discolor* (Holmgren, 1860), *Z. kerstinae* Fritzén, 2010, *Z. albicoxa* (Walker, 1874) and *Z. flamma* Fritzén, 2014) – are strictly associated with tangle web weavers from the family Theridiidae. *Zatypota percontatoria*, *Z. bohemani*, *Z. discolor* and *Z. kerstinae* are associated with spiders from the genus *Theridion*, or closely-related genera (e.g. *Phylloneta*, *Neottiura*) with similar habitus and behaviour (Fitton et al. 1987, 1988, Korenko et al. 2011, Korenko & Pekár 2011, Fritzén 2010, 2014). By contrast, *Z. albicoxa* and *Z. flamma* are associated with the genus *Parasteatoda* (e.g. Fitton et al. 1987, 1988, Fritzén 2014). *Zatypota picticollis* (Thomson, 1888) is associated with orb web weavers from the family Araneidae (Zwakhals 2006, Korenko et al. 2015), while the species studied here, *Zatypota anomala* (Holmgren, 1860), which is distributed across the Holarctic, is known to be associated with space web weavers from the family Dictynidae (Vincent 1979, Yu et al. 2012).

The aim of this study was to analyse *Z. anomala* populations in the canopies of an ecological fruit orchard in northern Italy and to observe the interaction between the parasitoid larva and its spider host in the laboratory.

Material and methods

Web building spiders (Araneae, Orbicularia) and their ectoparasitoids (Hymenoptera, Ichneumonidae, *Polysphincta* genus group) were collected from tree canopies (between 40 cm and 200 cm above ground) in an organic hazelnut orchard in Bottonasco (44°25'13.9"N 7°23'40.2"E, 642 m a.s.l.) in the province of Cuneo (Piedmonte region, northern Italy) on the 4th November 2009.

Spider hosts and parasitoids at the larval stage attached to them were collected by beating tree branches and catching the spiders in a square shaped beating net (1 m² area) placed beneath the tree crown. Three samples (each sample was collected by beating 30 trees) were taken and preserved in 70 % alcohol. The collected spiders were identified to genus level using Nentwig et al. (2017) and matched to species both on the basis of formerly known occurring species in the investigated localities (Isaia et al. 2010, Korenko unpubl. data) and by rearing the collected specimens to adulthood.

Live unparasitised and parasitised spiders were collected by the same method (described above) and reared in the laboratory. Parasitoid larvae were reared to imagines. Hatched wasps were identified using Fitton et al. (1988) and Zwakhals (2006). The nomenclature of the wasps follows Yu et al. (2012). Voucher specimens were deposited in the collection of the author and in the collection of Kees Zwakhals (Netherlands).

The web architecture of non-parasitised (n = 12) and parasitised (n = 44) spiders was studied by placing spiders individually in square glass experimental arenas (100 × 100 mm base, 130 mm height) with an installed tree twig that provided three-dimensional space for the spider's webbing. Spiders were kept at room temperature (22 ± 3 °C) under a natural L:D regime and fed with a surplus of *Drosophila* flies. The webs of both unparasitised and parasitised spiders were recorded using a Canon EOS 500D digital camera with an EF-S 18–55 mm lens or a macro EF 100 mm f/2.8L IS USM lens.

Stanislav KORENKO, Department of Agroecology and Biometeorology, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Kamýcká 129, 165 21 Prague 6, Suchbát, Czech Republic;
E-mail: korenko.stanislav@gmail.com

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Results

Host community and incidence of parasitism. The family Dictynidae consisted almost exclusively of spiders of the genus *Dictyna* (reared adults identified as *D. pusilla*); only 1 % belonged to the genus *Nigma*. The space web weaver *D. pusilla* was one of the most abundant spider species in the investigated fruit orchard, representing 17.8 % of all collected spider individuals (from $n = 1.069$). The average incidence of parasitism of *D. pusilla* was 12 % (Tab. 1). The larvae were typically attached antero-dorsally close to the petiolus hidden between the abdomen and prosoma of the spider host. All parasitised spiders were juveniles with an average prosoma length of 0.64 mm (SD = 0.12, $n = 44$). Fifty-one percent of wasps reared in the laboratory reached the imaginal stadium. Mortality during ontogeny occurred when the spider-hosts died (43 %), when the parasitoid died at the larval stage (33 %) and when the parasitoid died at the pupal stage (24 %). All parasitoid wasps reared from *D. pusilla* were *Zatypota anomala* ($n = 22$). The pupal stage in laboratory rearing lasted on average 11.9 days (SD = 1.39, $n = 22$). During this study, *Z. anomala* was recorded in Italy for the first time.

Reared material. Province of Cuneo: Bottonasco, organic hazel nut orchard (Cascina Rosa), larva attached to *Dictyna pusilla*, leg. 4.XI.2009 adult emerged 15.XII.2009–30.I.2010 (11 males, 11 females), leg. S. Korenko, det. K. Zwakhals & S. Korenko.

Host parasitoid interaction. Unparasitised spiders built a typical cribellate (sticky) space web with a retreat formed from an aggregation of threads (Fig. 1). There was no observed modification of the spider web under the influence of the final stage parasitoid larva. Parasitized spiders took a position inside their retreat (100 %), where the larva killed the host, spun a cocoon, and pupated (Fig. 2). Cocoons were diaphanous, white, and sub-cylindrical, with a springy and very open construction of sparse loose whorls.

Discussion

The community of arboreal spiders in the studied fruit orchard was dominated by space web building spiders, and Dictynidae represented 17.8 % of all collected spiders. Dictynid spiders



Fig. 1: Normal web of an unparasitised spider *Dictyna pusilla*. Arrow shows the typical spider resting position in the centre of the tangle.

were relatively frequently parasitised by polysphinctine parasitoids (12 % average incidence of parasitism). The incidence of parasitism by polysphinctines among various spider species was mostly found to be low (often below 1–5 %) in Central Europe (Korenko et al. 2011), in Central America (Barrantes et al. 2008) and in Japan (Tanaka 2007), but several studies from northern Italy found relatively high parasitism rates, i.e. above 10 % (Korenko et al. 2014, 2015).

Zatypota anomala is known to be associated with cribellate tangle web weaving spiders belonging to the family Dictynidae (Aubert 1969). Vincent (1979) found this wasp to be associated with *Mallos pallidus* (Banks, 1904) in North America; and the species was repeatedly reared from *Dictyna* sp. and *D. pusilla* in Europe (Miller et al. 2013, this study). *Zatypota*

Tab. 1: Relative spider host abundance (Ab.), average incidence of parasitism (PR), and wasp species documented in the studied locality (Korenko et al. 2014, Korenko et al. 2015, Korenko unpubl. data, this study). Foraging guild classification follows Cardoso et al. (2011).

Host family	Foraging guild	n	Ab. (%)	PR (%)	Associated parasitoids
Araneidae	Orb web weavers	42	3,9	11	<i>Polysphincta tuberosa</i> , <i>P. boops</i> , <i>Zatypota picticollis</i> , <i>Sinarachna pallipes</i>
Tetragnathidae	Orb web weavers	12	1,1	0	
Dictynidae	Space web weavers	190	17,8	12	<i>Zatypota anomala</i>
Theridiidae	Space web weavers	611	57,2	4	<i>Zatypota percontatoria</i>
Linyphiidae	Sheet web weavers	2	0,2	0	
Mimetidae	Specialists	2	0,2	0	
Anyphaenidae	Hunters	52	4,9	0	
Clubionidae	Hunters	7	0,7	0	
Eutichuridae	Hunters	1	0,1	0	
Philodromidae	Hunters	139	13,0	0	
Salticidae	Hunters	1	0,1	0	
Thomisidae	Ambush hunters	10	0,9	0	
Total		1069	100	5	



Fig. 2: Web of a parasitised spider. Arrow shows wasp cocoon located at the spider's resting position.

anomala seems to be exclusively associated with the genus *Dictyna* in Europe (Miller et al. 2013, Gauld & Dubois 2006, Korenko unpubl. data, this study). A similarly narrow host specialisation can be found in *Z. kerstinae* known only from Finland, which is assumed to be associated only with *Theridion palmgreni* Marusik & Tselarijus, 1986 (Fritzén 2010). In contrast, *Zatypota percontatoria* attacks several closely related host species from the family Theridiidae (Korenko et al. 2011), while *Z. picticollis* from central and western Europe attacks three araneid species from three different genera, namely *Cyclosa conica* (Pallas, 1772), *Mangora acalypha* (Walckenaer, 1802) and *Zilla diodia* (Walckenaer, 1802) (Zwakhals 2006, Korenko et al. 2015).

Dictynids are cribellate spiders, i.e. spiders which use silk produced by a special silk spinning organ called the cribellum. Cribellate silk not only serves to capture prey, but could also protect the spider against predators or parasitoids. Presumably, *Zatypota anomala* developed a way to avoid this barrier and to use this silk mass for its own protection during the pupal stage. However, there is no other polysphinctine parasitoid which is known to be able to associate with any cribellate spider. The way in which *Zatypota albicoxa* lures the spider host, how it avoids being captured by the silk, and how it oviposits on the spider host hidden inside the tangle web was documented by Takasuka et al. (2009) and Takasuka & Matsumoto (2011). The related species *Z. albicoxa* decoys the spider out from its retreat by pulling on threads in such a way as to imitate prey captured on the edge of the web (Takasuka et al. 2009). This luring of the spider host, also called “ambush-style”, would be expected in *Z. anomala*. Unfortunately, observation of oviposition by *Z. anomala* is missing and merits further investigation.

Zatypota species associated with space web weavers use the spider's innate 3D web as protection for their pupation. Some wasps are known to force their spider hosts to build an additional 3D structure and thereby to improve protection for wasp pupation (*Z. percontatoria* and *Z. discolor*) (Korenko

& Pekár 2011, Korenko unpubl. data). Others, like *Z. kerstinae*, do not induce any changes in the host webbing (Fritzén pers. comm.). The studied species, *Z. anomala*, did not induce changes in web architecture, presumably because of the location of the parasitoid pupa inside the innate “sticky” space web of the *Dictyna* spider. The innate web of the dictynid host seems to provide sufficient protection for the parasitoid during its pupal stage, meaning that there is no reason to waste energy or resources on modifying it.

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Autor(en)/Author(s): Korenko Stanislav

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