Revista Ibérica de Aracnología, nº **29** (31/12/2016): 57–60.
Grupo Ibérico de Aracnología (S.E.A.). ISSN: 1576 - 9518.

MITES (ACARI) INHABITING OOTHECAL CELLS OF PRAYING MANTISES (INSECTA: MANTIDAE) FROM SOUTHERN SPAIN

María L. Moraza[1] & Iñigo Sánchez[2]

[1] Universidad de Navarra, Facultad de Ciencias, Departamento de Biología Ambiental, Campus Universitario, 31080, Pamplona España. mlmoraza@unav.es
[2] Zoobotánico de Jerez, C/ Madreselva s/n, 11404 Jerez de la Frontera, España. bioinigo@gmail.com

Abstract: Mites associated with oothecal cells of *Mantis religiosa* (L.) and *Iris oratoria* (L.) have been identified based on specimens extracted from oothecae collected in southern Spain. A total of 36 species of Acari have been identified, 16 of them constituting first records for the Iberian Peninsula.
Key words: Acari, Mantodea, Mantidae, oothecae, Iberian Peninsula.

Ácaros (Acari) habitantes de ootecas de mántidos (Insecta: Mantidae) del sur de España
Resumen: Se han identificado 36 especies de ácaros extraídos de ootecas de *Mantis religiosa* (L.) and *Iris oratoria* (L.) recolectadas en el sur de España; 16 de estas especies son primeras citas para la Península Ibérica.
Palabras clave: Acari, Mantodea, Mantidae, ootecas, Península Ibérica.

Introduction

Ten species of insect Mantidae have been reported from southern Spain (Keen, 2006). *Mantis religiosa* (Linnaeus, 1758) is the most common European species (Chinery, 2000; Burr, 2010), and it is found throughout the Iberian Peninsula. Adults of this species are generally active from July to November (Chinery, 2000) near flowers or on foliage of undisturbed fields and pastures and along roadsides. During the day, the species hunts a wide variety of insects. Females attach egg cases to twigs and flat surfaces in late summer and fall, and the larvae emerge in spring when there is adequate food to survive.

Iris oratoria (Linnaeus, 1758) is found in central and northern Spain. The adults can be found from midsummer to late autumn. They usually rest on bushes. The species is capable of parthenogenic reproduction when males are scarce and its nymphs may emerge from their oothecae in the second season after the egg case is produced.

Mantid oothecae survive over winter and may produce 30 to 300 juveniles depending on the species. The juveniles may hatch all at once or in batches over a period of several weeks and after two or three weeks they are capable of mating.

Mites associated with oothecal cells of mantid insects have not been previously studied. This characteristic habitat may be described as a closed space where mites can live protected from climatic conditions, predators, parasites, and pathogens. Food resources might also be found inside oothecal cells. Living within the ootheca of a mantid insect or in its environment may be a good starting place to establish a relationship with a potential host or it may simply be a suitable place to find other resources or a safe haven.

It is well known that nest of social insects harbor many mite species, including predators, saprophages, fingivores and pollenophages, and many other mites use insects for dispersal (phoresy) to a new nest site or to a new habitat. A large number of mites, such as *Varroa*, have evolved ectoparasitic associations with their adult or brood host insects (Krantz, 2009) causing sometimes significant injury. In some cases active instars of the mite feed on the host or on its body secretions or are only carried by the host. In other cases, a single instar (usually the larva) develops a parasitic relationship with its insect host (Welbourn, 1983; Southcott, 1992, 1993, 1999). Some mites associated with insects should be also classified as commensals or mutualists rather than parasites.

Finding a mite inside an oothecal cell does not necessarily mean the existence of a direct association with the original tenant however if there is an usual mite presence and the mite may obtain certain benefits from this relationship with the insect, signs of a closer relationship would be strengthened.

The aim of this paper is to take a first approach to the mite community associated with this unique habitat and provide data for future studies in which the relationship between mites and mantids may be more precisely established.

Material and methods

Oothecal cells of *Mantis religiosa* and *Iris oratoria* were collected during winter season (December to February) in different habitats, from above 0 meters above sea level to the high wet regions (near 800 m), in Grazalema (Cadiz), South Spain. They were found under rocks, inside small crevices, on rough lateral rock surfaces, and on the branches of trees and shrubs. They were never found in places with a high risk of desiccation. Mites were manually removed from the inside of the oothecal cells using a fine brush under a binocular microscope and were later preserved in 70% alcohol. For further identification, specimens were cleared in Nesbitt's liquid and mounted using Hoyer's medium. Mite species were identified using taxonomic keys for the Palearctic region (Gilyarov & Breguetova, 1977; Gyliarov, 1978; Karg, 1993; Pérez-Iñigo, 1993, 1997) and using other specific resources. Higher mite taxonomic categories follow Lindquist *et al*., (2009) classifi-

cation. The specimens are on deposit at the Museo de Zoología, Universidad de Navarra (Pamplona, Spain).

Mantid oothecae were collected in the following localities and dates on the province of Cádiz:

BT: Barbate (Cádiz), Sierra del Retín, 30STF40, 04-XII-08 and 14-XII-2010.
BN: Benaocaz (Cádiz), 30STF86, 19-II-2006.
SJ: San José del Valle (Cádiz), Dehesa Picado, 30STF65, 19-II-2006, 19-II-2007 and 09-XII-2010.
SR: San Roque (Cádiz), La Alcaidesa, 30STF31, 24-II-2008.
VJ: Vejer (Cádiz) 30STF31, 14-XII-2010.
VL: Villaluenga del Rosario (Cádiz), Llanos del Republicano, 30STF96, 01-III-2009.

Results

A total number of 146 oothecae were examined looking for associated mites, of which 122 belonged to *M. religiosa* and 23 to *I. oratoria*. Besides countless Astigmata mites (belonging to one no identified species), 480 specimens were identified.

The percentage of oothecae occupied by alive mantid larvae at the collecting date was low. The results suggest that inhabited mantid oothecal cells always lack mites, which may indicate that only after the larvae emerge, or die, as frequently occurs as a consequence of low humidity during very dry years, mites would inhabit the cells. In several occasions mites have been found cohabiting with the death mantid larvae, probably feeding on them.

The percentage of oothecal cells occupied by mites was high, 64.6% (73 of 122 cells) in the case of *M. religiosa*, and 78.3% (18 of 23 cells) in the case of *I. oratoria* oothecal cells.

A total of 36 species of mites were found inside the oothecae (Table I). Species firstly reported in the Iberian Peninsula are denoted by an asterisk (*). The mite community was more diverse in the oothecal cells of *Mantis religiosa* (36 species), whereas only 11 out of the 36 were present in the oothecae of *Iris oratoria*.

Prostigmata mites (O. Trombidiformes) were the most frequent and abundant group (17 species of 10 families). These mites are a diverse assemblage of predators, phytophages, saprophages and parasites. The species associated with mantid oothecae are poorly sclerotized mites. The family Smarididae is the most abundantly represented inside the oothecal cells. Adults and nymphal instars of *Fessonia* sp. were collected with a high abundance (one to 60 mites/cell). This species was present in 27.4% of the examined oothecae of *M. religiosa* and in 16.6% of the *Iris*'s cells. Its frequency inside colonized oothecae was 63% (Table I).

Four species of the family Bdellidae were found, three of them frequent (18-33%). An abundant species, *Spinibdella* sp, was found in oothecae of *I. oratoria* (30 mites /cell). Mites of this family are predators of small arthropods and their eggs.

Two species of the family Anystidae (soft bodied, long-legged predatory mites, which frequent plants and bare rocky surfaces) were found to inhabit the cells; *Anystis baccarum* (Linnaeus) may be associated with these insects since it was frequently found (18.5%).

Eight species of Oribatida mites (O. Sarcoptiformes) inhabit the oothecae. The family Oribatulidae is the best represented in this habitat and the genus *Zygoribatula* is especially abundant (1 to 15 mites/ cell) and frequent (11-30%).

Mesostigmata mites embrace a wide variety of life styles and habitats. The family Cercomegistidae (one species) and Laelapidae (three species) include insect-associated mites, phoretic and/or predators in their galleries (Walter & Krantz, 2009).

Based on the abundance and frequency of occurrence in oothecal cells, we may conclude that the assemblage of mites associated to this habitat includes the predatory prostigmatid species *Fessonia* sp., *Spinibdella* sp., *Biscirus* sp., *Anystis baccarum* and *Bdella taurica* Kuznetsov & Livshits, and oribatid species *Zygoribatula frisidae* (Oudemans), *Allogalumna alamellae* (Jacot), *Zygoribatula undulata* (Berlese), *Peloribates glaber* Mihelcic and *Bipassalozetes bidactilus* (Coggi) (Table I). Most of these species occupy the oothecal cells of the two mantid species, suggesting a close relationship with these insects.

Remarks

The 36 species associated with mantid oothecal cells represent the main trophic groups of mites.

Fessonia sp. was undoubtedly the most significant species found. Deutonymphs and adults of the family Smaridae are active predators of small arthropods, and its larvae have been reported as parasites of a range of insect hosts (Walter *et al*., 2009; Southcott, 1992). *Fessonia* sp. was collected as free predatory nymphs and adult instars. Given the life cycle of this family we may suggest a parasitic association of the larval instar with the mantid insect. Adult mantid females may carry parasitic mite larvae which may detach at the time of preparation of the oothecal cells and egg deposition. Detached larvae would then complete their life cycle adjacent to the oothecal cells. This setting presupposes a close mite-mantid association. The mite may have adapted to live in habitats chosen by female mantids to lay her eggs. Female mites would be ready to lay eggs and leave larvae willing to attach to the mantid's juvenile instars when preparing to exit the oothecal cells. This attachment may also occur when gravid mantid females are laying their eggs and thus the mite moves and settles elsewhere.

Nymph and adult mite instars may use the empty oothecal cells as a protective habitat and hunting resource after they are abandoned by juvenile mantids. This species could be a harmless feeder on any remaining oothecal cells or a predator that feeds on other microorganisms and small invertebrates and their eggs in the microhabitat created by the oothecal cell.

However, since no *Fessonia* larvae have been detected on the body of the studied mantid species we cannot ensure the link between the mite larva and the mantids. We already know that larvae of *Charletonia venus* Southcott and *Charletonia krendowskyi* (Feider) have been found parasiting *M. religiosa* in southern Europa (Southcott, 1961; Beron, 1975).

Mites of the family Bdellidae and Anystidae are predators on small arthropods and their eggs (Walter, 2009) and probably share the oothecal habitats with their prey. Tydeidae is a large and cosmopolitan family of mites, recorded as predators, fungus, pollen, and plant feeders, as well as scavengers. Some species are phoretic on noctuid moths. Others are associated with bees, mammals, humans and domestic animals (Walter, 2009).

Oribatid mites frequently inhabit litter and the organic layer of the soil (Perez-Iñigo, 1993) and are mostly particle-feeding saprophages and mycophages mites, although they

Table I: Checklist of Acari species found in oothecae of *Mantis religiosa* (number of specimens=x) and *Iris oratoria* (number of specimens = y) (xx / yy) in the studied localities (species in bold refers to the most abundant and frequent species in the oothecae). Nº ej.= number of specimens; Nº e/c= number of specimens per oothecal cell; Fr= frecuency.

Tabla I: Lista de especies de Acari encontrados en ooteecas of *Mantis religiosa* (número de ejemplares= x) y *Iris oratoria* (número ejemplares= y) (xx / yy) en cada una de las localidades estudiadas (las especies en negrita son las más abundantes y frecuentes en las ootecas). Nº ej.= número de ejemplares; Nº e/cl= número de ejemplares en una ooteca; Fr= frecuencia.

	BT	SJ	BN	VL	SR	VJ	Nº ej.	Nº e/c	Fr
O. Mesostigmata									
F. Cercomegistidae Trägardh, 1937									
**Asternoseius ciliatus* Berlese, 1910	1♂	–	–	–	–	–	1	1	3,7
F. Laelapidae Berlese, 1892									
Androlaelaps sp.	3♀	–	–	–	–	–	3	1	11,1
**Laelaspis equitans* (Michael, 1891)	–	2♀	–	–	–	–	2	1	3,7
Reticulolaelaps sp.	–	–	–	–	1♀	–	1	1	3,7
F. Phytoseiidae Berlese, 1916									
Proprioseiopsis messor (Wainstein, 1960)	–	1♀	–	–	–	–	1	1	3,7
F. Oplitidae Johnston, 1968									
Oplitis sp.	–	1♀	–	–	–	–	1	1	3,7
F. Trachyurododidae Berlese, 1917									
Trachyuropoda sp.	1♂ / 1N	–	–	–	–	–	2	2	3,7
O. Trombidiformes									
F. Eupodidae Koch, 1842									
**Eupodes ocellatus* Willmann 1952	1	–	–	–	–	–	1	1	3,7
Eupodes sp.	–	–	–	–	–	2	2	1	7,4
F. Anystidae Oudemans, 1936									
****Anystis baccarum** (Linnaeus, 1758)*	2	1 / 2	–	–	–	–	**5**	**1-2**	**18,5**
**Bechsteinia schneideri* Oudemans 1936	–	2	–	–	–	–	2	1	3,7
F. Smaridídae Kramer, 1878									
Fessonia sp.	6+137	35 / 5	12	5	–	–	**200**	**1-60**	**63,0**
F. Trombiculidae (Shaw, 1790)									
Trombicula sp.	–	7	–	–	–	–	7	7	3,7
F. Raphignatidae (Kramer, 1877)									
**Raphignathus collegiatus* Atyeo, Baker & Crossley, 1961	–	4 / 4	–	–	–	–	8	4	3,7
Barbutia sp.	–	–	–	1	–	–	1	1	3,7
F. Caligonellidae Grand jean (1944)									
**Caligonella humilis* (C.L. Koch, 1838)	–	1	1	–	–	–	1	1	3,7
** Caligonella humilis* Kuznetsov, 1978	–	1 / 1	–	–	–	–	2	1	3,7
F. Tydeidae Kramer, 1877									
**Paralorryia livshitzi* Kuznetzov, 1974	–	–	4	–	–	–	4	4	3,7
Paralorryia sp	2	–	2	–	–	–	2	2	3,7
F. Bdellidae Dugès, 1834									
Odontoscirus sp.	–	–	1	–	–	–	1	1	3,7
****Bdella taurica*** Kuznetsov & Livshits 1979 c.f.	1	5	5	–	2	–	**9**	**1-3**	**18,5**
Biscirus sp	6	3 / 9	–	–	–	–	**18**	**1-5**	**33,3**
Spinibdella sp.	2	6 / 30	4	–	–	–	**40**	**1-30**	**22,2**
F. Tarsonemidae Kramer, 1877									
**Daidalotarsonemus vandevriei* Suski, 1967	3	1♂, 2Lv	–	–	–	–	3	3	3,7
F. Stigmaeidae Oudemans, 1931									
**Storchia robustus* (Berlese, 1885)	–	–	–	1	–	–	1	1	3,7
O. Sarcoptiformes									
Acaridae Latreille, 1802									
Acaridae	>100	–	–	–	–	–	–	–	–
Tyrophagus sp.	8	–	–	–	–	–	9	–	19
F. Nanorchestidae Grandjean 1937									
Speleorchestes sp. Tragardh 1909	–	–	1	–	–	–	1	1	3,7
F. Damaeidae. Berlese, 1896									
Metabelbella janae Pérez-Íñigo, 1991	2	1	–	–	–	–	3	1-2	7,4
F. Passalozetidae Grandjean, 1954									
Bipassalozetes bidactilus (Coggi, 1900)	1	9 / 8	–	–	1	–	**19**	**1-8**	**14,8**
F. Haplozetidae Grandjean, 1936									
Peloribates glaber Mihelcic, 1956	18	–	1	–	–	3	**22**	**1-5**	**22,2**
F. Galumnidae Jacot, 1925									
Allogalumna alamellae (Jacot 1935)	25	1	–	–	–	–	**26**	**1-21**	**18,5**
F. Oribatulidae Thor, 1929									
Phauloppia pilosa (C.L. Cock, 1841)	–	–	–	–	25	–	25	25	3,7
Zygoribatula cognata (Oudemans, 1902)	–	1 / 1	2	–	–	–	4	1	11,1
Zygoribatula frisidae (Oudemans, 1900)	5	4 / 5	–	–	–	22	**36**	**1-15**	**37,0**
Zygoribatula undulata (Berlese, 1916)	1	10 / 2 / 1	–	–	–	–	**13**	**1-5**	**29,6**
Oribatidos inmaduros	5	5 / 4	–	–	–	–	9	1-3	14,8
							480		
Number of species *M. religiosa* / *I. oratoria*	**20 / 2**	**22 / 11**	**10**	**3**	**4**	**3**	**36 / 11**		

have also been reported as predators on nematodes and other microfauna, and as necrophages on small arthropods (Norton & Pelletier, 2009). For the associated species, the oothecal niche would appear to be an excellent potential food resource and a good place from which to defend against predators.

Mesostigmata mites embrace a diverse variety of life styles and habitats. Many of them are parasites or symbionts of arthropods and vertebrates (Lindquist *et al*., 2009). The family Cercomegistidae includes insect-associated mites, phoretic on bark beetles and predators in their galleries (Lindquist *et al*., 2009). The family Laelapidae is a diverse group of free-living predators and is associated with arthropods, mammals and birds. The Uropodina families Trachyuropodidae and Oplitidae have been described as mirmecophilous, and at least two species of *Oplitis* were collected among termites (Lindquist *et al*., 2009).

We may conclude that oothecal cells shelter a highly diverse community of mites and therefore the conservation of the species of mantids would impact directly not only on the diversity of insects but also on all their associated fauna.

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