

# First Record of Egg Parasitoids of Pistachio Processionary Moth, *Thaumetopoea solitaria* (Freyer) (Lepidoptera: Thaumetopoeidae)

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**Abstract:** During the period 2010-2012, egg parasitoids of pistachio processionary moth (*Thaumetopoea solitaria*) were studied in Bulgaria. A total of 215 egg clusters containing 26 453 eggs were collected on *Pistacia terebinthus* in 4 sample plots at 3 sites in the Eastern Rhodopes. Directly after collection, egg clusters with part of branches, about 5 cm long, were individually separated in test tubes, closed with cotton stoppers and stored under laboratory conditions at 20-22°C. As a result, three egg parasitoids were recorded for the first time in *T. solitaria*: *Anastatus bifasciatus* (Hymenoptera: Eupelmidae), *Ooencyrtus pityocampae* and *Ooencyrtus* sp., closely related to *O. masii* and *O. ascalaphi* (Hymenoptera: Encyrtidae). The new records enlarge the host ranges of polyphagous species *O. pityocampae* and *A. bifasciatus*. The main part of the parasitoids emerged after hibernation. Their survival was about 80%. The impact of egg parasitoids on the host was calculated to be 2.9-21.5%.

**Key words:** *Thaumetopoea solitaria*, egg parasitoids, impact, Bulgaria

## Introduction

Pistachio processionary moth, *Thaumetopoea solitaria* (FREYER, 1838) (Lepidoptera: Thaumetopoeidae) is much less studied than other processionary moth species. An objective reason for this is the fact that most of the other representatives of this genus are economically important pests, while pistachio processionary moth rarely causes heavy damages due to its trophic specialization on *Pistacia* spp. and relatively small size of the ranges in most of the countries where this species is distributed.

The most important studies on *T. solitaria* were conducted by AGENJO (1941), SERAFIMOWSKY (1957), DAVATCHI (1958) and HALPERIN (1983, 1990). The Bulgarian entomological literature provides data on the localities of the species and some aspects of its biology (BURESCH 1915, 1918/19; TSCHORBADJIEW 1938). However, there is insufficient knowledge about the biological factors that limit *T.*

*solitaria*. Studies on the biology and natural enemies of *T. solitaria* were conducted in Israel but only parasitoids of the family Tachinidae were recorded (HALPERIN 1983, 1990). Larval and pupal tachinid parasitoids of this host were also reported for Bulgaria (HUBENOV 1985). OMID *et al.* (2006) studied natural regulators of population density of *T. solitaria* but egg parasitoids have not been detected. Information about egg parasitoids of the species is also lacking in the monographic study by SERAFIMOWSKY (1957).

The present article reports the first records of egg parasitoids in pistachio processionary moth. Surveys of egg parasitoids in this species are important since they still are an unexplored area of knowledge. Moreover, *T. solitaria* coexists in some habitats with pine processionary moth, *Thaumetopoea pityocampa* (Denis & Schiffermüller, 1775), and the obtained results could be a basis for future analyses

of the species composition of both parasitoid complexes and their impact on the hosts.

## Material and Methods

The studies were conducted during the period 2010-2012. Biological material (egg clusters of *T. solitaria* with parts of branches about 5 cm in length) was collected from four sample plots at three sites from the Eastern Rhodopes, Bulgaria (Table 1). They were situated in the main area of distribution of *T. solitaria* in the country (MIRCHEV *et al.* 2004), where another representative of the family, *T. pityocampa*, also occurred. Both species were found in the protected area Dupkata near the town of Ivaylovgrad on karst habitat occupied by 50-year-old plantation of black pine, *Pinus nigra* Arn., and glades with turpentine tree (*Pistacia terebinthus* L.). Over the years of study, both processionary moth species had high population density.

A total of 215 egg clusters containing 26 453 eggs were collected and examined during the entire study period. Directly after collection, the cuttings with egg clusters were individually separated in test tubes and closed with cotton stoppers. They were transported to the Entomological Laboratory of the Forest Research Institute, Sofia, and were kept at room temperature (20-22°C). The samples were examined daily to detect the emergence of egg parasitoids. The emerged individuals were removed from the test tubes. In order to determine the dead parasitoid specimens in eggs without emergence holes, as well as the parasitoids which had emerged before sample collection at the end of the observation period, the scales of the egg clusters were removed and all eggs were cut and analyzed in detail under a stereomicroscope (40 x magnification).

The emerged parasitoids were identified and deposited in the authors' collections. The species of the genus *Ooencyrtus* were confirmed or identified by Dr. John Noyes of the Natural History Museum, London, and Dr. Serguei V. Triapitsyn of the University of California. Specimens of *Ooencyrtus* sp. are deposited in the collections of both research centres.

## Results

Three parasitoid species were recorded for the first time in eggs of *T. solitaria*: *Anastatus bifasciatus* (Geoffroy, 1785) (Hymenoptea: Eupelmidae), *Ooencyrtus pityocampae* (Mercet, 1921) and *Ooencyrtus* sp. (Hymenoptea: Encyrtidae) (Table 2).

*A. bifasciatus* was found in all the sample plots in three studied localities of *T. solitaria* (Ivaylovgrad,

Belopolyane and Madzharovo) (Fig. 1). It was the most numerous species with the highest percentage (78.9-100.0) in the host parasitoid complex. The samples were collected in spring, i.e. development of the parasitoids in *T. solitaria* eggs had gone mainly under natural conditions. In this respect, the data on the parasitoid survival may be considered as representative. On average, about 15% of the specimens of *A. bifasciatus* completed their development but died as an imago in the host eggs. This percentage varied from 0 (Ivaylovgrad dam, 27 March 2010) to 19.1 (Dupkata, 13 April 2011). Dead specimens were also found in the sample Likanen, collected after the parasitoid emergence on 12 July 2010 (Table 2).

*Ooencyrtus* sp. was also found in all studied habitats of *T. solitaria* (Fig. 1). It occupied the second place in the host egg parasitoid complex, with about 10%, but in one sample (Likanen, 27 March 2012) its percentage reached 21.1% (Table 2). According to Dr. S. Triapitsyn and Dr. J. Noyes (personal communications), the species is closely related to *Ooencyrtus masii* (Mercet, 1921) and *Ooencyrtus ascalaphi* Hoffer, 1970.

Single specimens of *Ooencyrtus pityocampae* were found in two samples from the Dupkata site (Table 2). As mentioned above, *T. pityocampa* occurred in high numbers in this habitat.

The impact of the egg parasitoids on *T. solitaria* varied between 2.9 and 21.5% in different samples and localities. This impact included mortality caused by parasitoids that emerged before sample collection, parasitoids reared during laboratory observations and dead parasitoid specimens in host eggs (Table 2).

The parasitoids emerged mainly after the hibernation. The results from the analyses showed that the percentage of the emerged specimens before sample collection was about 15%, however in two samples

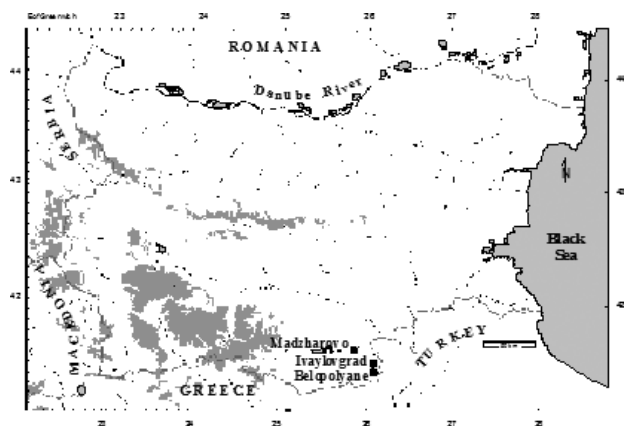


Fig. 1. Studied localities of *T. solitaria* in Bulgaria

from Madzharovo (12 April 2011 and 27 March 2012) these values were lower or higher – 8.4% and 28.3%, respectively. It should be noted, however, that the second sample was taken half a month earlier than the first one.

The survival of parasitoids, calculated on the basis of samples with successfully developed and emerged imagoes (eggs with exit holes) averaged about 80%. The percentage of dead parasitoid larvae, pupae and imagoes in host eggs varied between 10.6 and 27.9%. The data show that there is no correlation between the parasitoid survival and the time of sampling. In samples collected on the same date (27 March 2010), the mortality at Dupkata (22.0%) was more than twice as much as that at Ivaylovgrad dam (10.6%) (Table 2).

## Discussion

In addition to the tachinid parasitoids in the larvae and pupae of *T. solitaria* (KUGLER 1966, HALPERIN 1983, 1990, HUBENOV 1985), another pupal parasitoid, *Conomorium patulum* (Walker) (Hymenoptera: Pteromalidae), was recently found in this host in Iran (GHAHARI *et al.* 2010). During the study of two of the most dangerous insect pests on *Pistacia atlantica* in Iran, *Ocneria terebinthina* Stgr. and *T. solitaria*, the parasitoid *Ooencyrtus masii* was reared from eggs of *O. terebinthina* (OMID *et al.* 2006, FALLAHZADEH, JAPOSHVILI 2010). Thus, this publication is the first report of egg parasitoids in *T. solitaria*.

Concerning the natural regulating factors of *T. solitaria*, HALPERIN (1983, 1990) provided information about a fungal disease caused by *Beauveria bassiana* (Balsamo-Crivelli) Vuillemin (Hypocreales: Cordycipitaceae). This fungus was found during laboratory rearings of pistachio processionary moth larvae in Israel. In Bulgaria the same pathogen was established in early stage larvae of the host at one site of this study, Dupkata (MIRCHEV *et al.* 2012a).

The polyphagous *A. bifasciatus* is known as a parasitoid in 30 hosts, belonging to 23 genera from 3 orders: Hemiptera (11 species), Orthoptera (2), and

Lepidoptera (17) (NOYES 2012). According to the author, the host range of the parasitoid includes three *Thaumetopoea* species: *T. pityocampa*, *T. processionea* and *T. wilkinsoni*. In this study, *T. solitaria* has been recorded as a new host of *A. bifasciatus*. In Dupkata locality, where both *T. pityocampa* and *T. solitaria* occur, *A. bifasciatus* has been regularly established in the egg parasitoid complex of pine processionary moth with relative abundance of about 10% (MIRCHEV *et al.* 2012b). At the same time, it is a dominant species with about 90% relative abundance in *T. solitaria* parasitoid complex.

During this study, 1109 parasitoid specimens have been reared from eggs of *T. solitaria*. Among them, only 2 specimens belong to *O. pityocampae*, which indicates that pistachio processionary moth is an occasional host for this parasitoid. In Dupkata locality, where this parasitoid has been recorded, the number of *T. pityocampa* is high, and *O. pityocampae* is one of the most numerous parasitoids of pine processionary moth, following *Baryscapus servadeii* with relative abundance of 35% (MIRCHEV *et al.* 2012b). The main reason for the negligible presence of *O. pityocampae* in the parasitoid complex of *T. solitaria* is most probably the low suitability of the host eggs to ensure the parasitoid development. The eggs of *T. solitaria* remain for a long time in natural conditions, and may be parasitized. The female moths of *T. solitaria* lay eggs in late September – early October (HALPERIN 1983), and the hatching of the caterpillars in the areas of this study occurs in March–April. According to MIRCHEV (2005), the percentage of *O. pityocampae* specimens that emerge from *T. pityocampa* eggs before the winter diapause usually varies between 26 and 56 in Bulgaria. We should mention that in Dupkata locality, this percentage reached 65 in mid-November (MIRCHEV *et al.* 2012b).

*O. pityocampae* is a broadly polyphagous species. It is related to 27 species of 20 genera and 7 families of the orders Hemiptera and Lepidoptera, including 5 processionary moth species: *Thaumetopoea pityocampa*, *T. bonjeani*, *T. pinivora*, *T. wilkinsoni*

**Table 1.** Main characteristics of studied areas

Sample plot	Locality	Geographical coordinates	Altitude, m
Dupkata	Ivaylovgrad town	41°31'41.7" N; 26°06'57.1" E	320
Ivaylovgrad Dam	Ivaylovgrad town	41°35'03.2" N; 26°06'33.7" E	140
Likanen	Belopolyane village	41°26'51.4" N; 26°08'38.2" E	200
Madzharovo	Madzharovo town	41°38'50.1" N; 25°52'54.3" E	200

Table 2. Parasitoids and parasitation of *T. solitaria* egg clusters

Site of collection	Dupkata	Dupkata	Dupkata	Dam	Likanen	Likanen	Likanen	Madzharovo	Madzharovo
Date of collection	27.3.2010	13.4.2011	27.3.2012	27.3.2010	12.7.2010	27.3.2012	12.04.2011	27.3.2012	27.3.2012
Number of egg clusters collected	33	34	39	5	13	48	23	20	20
Total number of eggs	4076	4228	4833	526	1541	5447	2970	2832	2832
Determined parasitoids	n (%)	125 (100)	183 (100)	86 (100)	4 (100)	142 (100)	165 (100)	44 (100)	44 (100)
<i>Anastatus bifasciatus</i> (Geoffroy, 1785) Hymenoptera: Eupelmidae	n (%)	110 (88.0)	176 (96.2)	74 (86.0)	4 (100.0)	112 (78.9)	150 (90.9)	39 (88.6)	39 (88.6)
◆ Emerged after collection	n	89	149	74	0	91	128	33	33
◆ Adults died in eggs	n	21	27	0	4	21	22	6	6
<i>Ooencyrtus</i> sp. (Hymenoptera: Encyrtidae)	n (%)	14 (11.2)	7 (3.8)	12 (14.0)	0 (0.0)	30 (21.1)	15 (9.1)	5 (11.4)	5 (11.4)
◆ Emerged after collection	n	11	6	12	0	23	14	4	4
◆ Adults died in eggs	n	3	1	0	0	7	1	1	1
<i>Ooencyrtus pityocampae</i> (Mercet, 1921) (Hymenoptera: Encyrtidae)	n (%)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
◆ Emerged after collection	n	1	0	0	0	0	0	0	0
Parasitoids emerged before collection	n	34	52	15	39	37	17	49	49
Undetermined larvae and pupae of parasitoids	n	18	52	12	2	21	20	27	27
Impact of parasitoids	n (%)	460 (11.3)	177 (4.2)	113 (21.5)	45 (2.9)	254 (4.7)	202 (6.8)	173 (6.1)	173 (6.1)

and *Traumatocampa ispartaensis* Doğanlar & Avci (NOYES 2012). In this study we report *T. solitaria* as a new host for *O. pityocampae*.

*T. solitaria* is significantly less vulnerable to the impact of parasitoids compared to *T. pityocampa*. This conclusion is based on comparison of the data from the three years of study, which show the regulating effect of the egg parasitoids on the population density of these two processionary moth species in Dupkata locality. In 2010, the impact of the parasitoids on the number of *T. solitaria* at the egg stage was 11.3% versus 20.1% for *T. pityocampa*

(MIRCHEV *et al.* 2012b). The same impact in 2011 and 2012 was 4.2% vs. 29.1% and 5.9% vs. 26.3%, respectively. Thus, as a whole, the reduction caused by egg parasitoids in the numbers of *T. pityocampa* was 2-7 times higher than that in *T. solitaria*.

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## References

- AGENJO R. 1941. Monographia de la familia Thaumetopoeidae. – *Eos Madrid*, **17**: 69-130.
- BURESCH I. 1915. Die Nachtschmetterlinge Bulgariens mit besonderer Berücksichtigung der schädlichen Arten. – *Travaux dela Société Bulgare des Scinces Naruelles*, **7**: 9-100.
- BURESCH JW. 1918/19. Beitrag zur Lepidopterenfauna des Pirin-gebirges (Pirin Planina) in Mazedonien. – *Zeitschrift für wissenschaftliche Insectenbiologie*, **14**: 97-281.
- DAVATCHI G. A. 1958. Etude biologique de la faune entomologique des *Pistacia* sauvages et cultivées. – *Revue de Pathologie Végétale et d'Entomologie Agricole de France*, **37**: 3-166.
- FALLAHZADEH M., G. JAPSHVILI 2010. Checklist of Iranian Encyrtids (Hymenoptera: Chalcidoidea) with descriptions of new species. – *Journal of Insect Science*, **10** (68): 1-26.
- GHAHARI H., J. HUANG, H. OSTOVAN, J. RASTEGAR 2010. Notes on the Iranian fauna of Pteromalidae (Hymenoptera). – *Ef-flatounia*, **10**: 21-25.
- HALPERIN J. 1983. *Thaumetopoea solitaria* FREYER. (Lepidoptera: Thaumetopoeidae) in Israel. – *Phytoparasitica*, **11**, 71-82.
- HALPERIN J. 1990. Natural enemies of *Thaumetopoea* spp. (Lep., Thaumetopoeidae) in Israel. – *Journal of Applied Entomology*, **109**: 425-435.
- HUBENOV Z. 1985. On hosts of family Tachinidae (Diptera) species in Bulgaria. – *Acta zoologica bulgarica*, **27**: 27-35 (In Bulgarian, English and Russian summaries).
- KUGLER J. 1966. A list of parasites of Lepidoptera from Israel. – *Israel Journal of Entomology*, **1**: 75-88.
- MIRCHEV P., G. TSANKOV, R. NENCHEV 2004. Distribution of *Thaumetopoea solitaria* Fr. in Bulgaria. – *Acta entomologica bulgarica*, **10** (1): 49-52. (In Bulgarian, English summary).
- MIRCHEV P. 2005. Egg parasitoids on pine processionary moth *Thaumetopoea pityocampa* (Den. & Schiff.) (Lepidoptera: Thaumetopoeidae) in countries of Balkan Peninsula. DSc Thesis, Sofia, 64 pp. (In Bulgarian, English summary).
- MIRCHEV P., G. GEORGIEV, S. DRAGANOVA 2012a. Disease caused by *Beauveria bassiana* (Bals.-Criv.) Vuill. on new hatched larvae of *Thaumetopoea solitaria* Freyer, 1838. – *Silva Balcanica*, **13** (1): 61-65.
- MIRCHEV P., G. GEORGIEV, P. BOYADZHEV, M. MATOVA 2012b. Impact of entomophages on density of *Thaumetopoea pityocampa* in egg stage near Ivayvovgrad, Bulgaria. – *Acta zoologica bulgarica*, Supplement **4**: 103-110.
- NOYES J. S. 2012. Universal Chalcidoidea Database. World Wide Web electronic publication. <http://www.nhm.ac.uk/chalcidoids>.
- OMID R., E. AZIZKHANI, H. ASKARY, V. R. MONIRI 2006. Study on key pests of wild pistachio, *Pistacia atlantica*, and their natural enemies in Khojir Protected Area, Iran. – *Acta Horticulturae*, **726**: 525-527.
- SERAFIMOWSKY AL. 1957. *Thaumetopoea solitaria* var. *iranica* BANG-HASS. – *Bulletin of Forest Institute of the Popular Republic Macedonia, Skopje*, **1**: 59-86. (In Macedonian, Germany summary).
- TSCHORBADJIEV P. 1938. Materialien über die Schädlichen Insekten und anderen Feinde der Kulturpflanzen in Bulgarien. – *Mitteilungen der Bulgarischen Entomologischen Gesellschaft in Sofia*, **10**: 55-72 (In Bulgarian).

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