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Impact of parasitoids in egg-batches of *Thaumetopoea pityocampa* (Den. & Schiff.) in Algeria (*)

Abstract - Twenty egg-batches of *Thaumetopoea pityocampa* (Den. & Schiff.) (Lep.: Thaumetopoeidae) collected in Algeria at Mt. Orest (1480-1550 mNN) in February 1993 were singled in test tubes with cotton stoppers and kept at 20-22°C. All batches were deposited in the fall of 1992, and exposed to the parasitoids during the whole developmental period of the host. Daily observations were made until May 1993, and on 25.VIII.1993 after removing the egg scales. A final observation of the egg-batches was carried out on 21.VI.1994. All eggs without a hole in the shell were opened carefully, and the meconia and remains were identified.

The mean number of eggs per batch was 154, oviposited in 6-9 rows. In all cases, oviposition occurred from the base to tip of the needles. The hatching rate of caterpillars was 55.8%. The parasitoid impact on the total mortality was 76.1%. The most frequent egg-parasitoid was *Baryscapus servadeii* (Dom.) followed by *Ooencyrtus pityocampae* (Mercet). In one egg, multiparasitism could be observed. *B. servadeii* oviposited more frequently in later embryonic stages of the host than *O. pityocampae*.

Most of the egg parasitoids emerged after a winter diapause, this was more noticeable *in B. servadeii* than in *O. pityocampae*. The latter had a shorter diapause period than the former. Only one male of each ooparasitoid species could be detected. The base and top of the egg-batches were preferred for parasitizing by *B. servadeii*, and only the basal part by *O. pityocampae*, inspite of many unscaled eggs being avialable in the middle part of the batches.

Zusammenfassung - *Parasitierung an Eigelegen von Thaumetopoea pityocampae* (Den. & Schiff.) in Algerien.

Zwanzig Eigelege von *Thaumetopoea pityocampae* (Den.&Schiff.) (Lep., Thaumetopoeidae) wurden im Februar 1993 in Algerien am Mt. Orest in 1480-1550 mNN gesammelt und einzeln in Reagenzgläsern mit Wattestopfen bei 20-22°C im Labor gelagert; sie waren im Herbst 1992 angefertigt worden und während der gesamten Entwicklungszeit des Wirtes den Eiparasitoiden

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ausgesetzt. Bis Mai 1993 wurden die Gelege täglich kontrolliert, die geschlüpften Parasitoide eingesammelt und notiert. Nach einer weiteren Kontrolle am 25.08.1993 wurden die Gelegeschuppen entfernt. Die letzte Analyse erfolgte am 21.06.1994. Alle Eier ohne Schlupfloch wurden sorgfältig geöffnet und die sich in ihnen entwickelten Parasitoide anhand der Mekonien und Rückstände bestimmt.
Die mittlere Eizahl pro Gelege betrug 154 Eier, die in 6-9 Reihen angeordnet waren. Alle Gelege waren von der Nadelbasis beginnend angefertigt worden. Die Schlupfrate der Raupen betrug 55,8%. Die Beteiligung der Eiparasitoiden an der Mortalität des Wirtes war 76,1%. *Baryscapus servadeii* (Dom.) war der häufigste Eiparasitoid, gefolgt von *Ooencyrtus pityocampae* (Mercet). In einem Ei wurde Multiparasitierung gefunden. *B. servadeii* parasitierte häufiger spätere Embryonalstadien des Wirtes als *O. pityocampae*.
Die meisten Eiparasitoide, insbesondere *B. servadeii*, schlüpften nach einer Winterdiapause. *O. pityocampae* hatte eine kürzere Diapausezeit als *B. servadeii*. Von beiden Eiparasitoiden wurde jeweils nur ein Männchen erhalten. Anfang and Ende der Gelege wurden von *B. servadeii* deutlich stärker parasitiert als der mittlere Bereich, obgleich auch hier viele Eier unbeschuppt waren. *O. pityocampae* bevorzugte nur den basalen Bereich.

Riassunto - *Parassitizzazione di ovature di* Thaumetopoea pityocampa *(Den. & Schiff.) in Algeria.*

Venti ovature di *T. pityocampa* (Den. & Schiff.) (Lep. Thaumetopoeidae) sono state prelevate nel febbraio del 1993 in Algeria sul Monte Orest ad una altitudine compresa tra i 1480 ed i 1550 m. s.l.m. e trasferite in laboratorio, a una temperatura tra 20 e 22°C, poste singolarmente in provette chiuse con tappi di spugna.
Le ovature, deposte nell'autunno 1992, sono dunque state esposte ai parassitoidi oofagi durante l'intero periodo del loro sviluppo. Fino a maggio le ovature sono state controllate giornalmente, prendendo nota dei parassitoidi sfarfallati. Dopo un ulteriore controllo il 25.VIII.'93 sono state asportate le squame. L'ultimo esame fu eseguito il 21.VI.'94. Tutte le uova senza foro di sfarfallamento sono state aperte per la determinazione dei parassitoidi sviluppatisi mediante i loro meconii ed i residui dell'ospite stesso. La media del numero di uova risulta di 154, disposte da 6 a 9 file. Tutte le ovature erano state deposte iniziando dalla base della foglia. La quota di schiusura delle larve è risultata del 55,8%. La mortalità indotta dalla parassitizzazione degli oofagi è stata del 76,1%. *Baryscapus servadeii* (Dom.) è risultata essere la specie più frequente, seguita da *Ooencyrtus pityocampae* (Mercet). In un solo uovo si è osservata multiparassitizzazione. *B. servadeii* ha parassitizzato più frequentemente stadi embrionali dell'ospite più avanzati che *O. pityocampae*.
La maggior parte dei parassitoidi, in special modo *B. servadeii,* sfarfallano dopo una diapausa invernale. *O. pityocampae* ha evidenziato una diapausa piu corta di *B. servadeii*. Di ambedue i parassitoidi sono stati ottenuti soltanto un individuo maschio per specie. *B. servadeii* parassitizza soprattutto l'apice e la base dell'ovatura, piuttosto che la parte mediale, sebbene anche in

questa molte uova non siano protette dalle squame. *O. pityocampae* ha preferito invece parassitizzare la parte basale dell'ovatura.

Key words: *Thaumetopoea pityocampa*, egg parasitoids, *Baryscapus servadeii*, *Ooencyrtus pityocampae*, parasitism, host mortality, impact, Algeria.

INTRODUCTION

In Algeria, two species of the genus *Thaumetopoea* occur: *T. pityocampae* (Den.&Schiff.) and *T. bonjeani* (Povel) (Demolin, 1988). The latter attacks only *Cedrus atlantica* Man., the former mainly pine trees, but also *Cedrus* can be a host plant. *T. bonjeani* is distributed on the Atlas mountains, while *T. pityocampa* is widely spread in northern Africa and southern Europe, where it is known as the most important defoliator of pine trees.

In Algeria, both defoliator species are found up to altitudes of 2000 mNN. The moths of *T. pityocampa* appear in July-August, a little earlier than those of *T. bonjeani*. After emergence and copulation, oviposition follows immediately in both species. The caterpillars hatch after about six weeks, while the eggs of *T. bonjeani* have a winter diapause, until April of the following year. In *T. pityocampa* pupation takes place in March-April of the successive year after overwintering in a tight web, serving as a winter nest. In *T. bonjeani* the caterpillars form aggregations without weaving silky tents, and pupate in June-July after accelerated larval development (Demolin, 1988).

Both species have the same parasitoids, which can attack the eggs from June until about October, depending on the temperature.

Three egg parasitoids are known in Algeria: *Baryscapus servadeii* (Dom.), *Ooencyrtus pityocampae* (Mercet) and *Trichogramma* sp.. So far, no investigations have been made on the impact of the parasitoids on host mortality.

MATERIAL AND METHODS

Twenty egg-batches of *Thaumetopoea pityocampa* (Den. & Schiff.) (Lep.: Thaumetopoeidae) were collected from 15-20 years old *Pinus halepensis* (Miller) in Algeria, at Mt. Orest, in the Forest Farm Bouhmana, 1480-1550 mNN, in February 1993 by Prof. B. Rosnev, Sofia. All egg-batches were deposited in the fall of 1992, and were exposed to the parasitoids during the whole developmental period of the host. The material was transferred directly to the Forest Research Institute in Sofia, Bulgaria. After arrival, the egg-batches were put singly in test tubes with

cotton stoppers and stored at room temperature under laboratory conditions (20-22 °C).

From 12.II.1993 until end of May 1993, daily observations were made, and the emerged egg parasitoids were removed and separated in plastic capsules for determination. A further observation of the egg-batches was made on 25.VIII.1993, and the final analysis followed on 21.VI.1994 at the Department of Zoology-Entomology, University of Hannover.

After removing the scales, every egg without a hole in its shell was opened carefully and the meconia and remains of the emerged or dead insects were determined by means of a stereomicroscope (40 x magnification). The method was presented schematically in Tsankov et al. (1995).

RESULTS

The 20 egg-batches studied contained 3078 eggs, the mean per batch being 154 (range: 125-245) eggs. The number of egg-rows per batch varied between 6-9, 1 cm egg-row contained a mean number of 10.2 (9.8-10.6) eggs. The length of the needles varied between 38-70 mm, that of the egg-batches between 12-45 mm, with a diameter of 3-4 mm. All egg-batches were formed arround two needles, only one on four needles. The distance of egg-batches to the base of the needles varied from zero to 25 mm. In all cases oviposition occurred from base to tip of the needles. Not all eggs were covered with scales, uncovered eggs were located not only on both ends of the egg-batches, but also in the middle sections.

A number of 3078 eggs (100%) were used to study parasitism rate, from which 1716 (55.8%) caterpillars hatched. From a total mortality of 44.2% (1362 eggs), 66 (4.9%) caterpillars died without opening the egg-shell, 13 (0.9%) were found dead inside the egg-shell with an opening, 98 (7.2%) eggs were sterile, 1037 (76.1%) eggs were parasitized, and 148 (10.9%) eggs were destroyed by predators.

From the 1037 parasitized eggs, 783 (75.1%) *B. servadeii*, 219 (21.1%) *O. pityocampae*, and 32 (3.1%) dead larvae of parasitoids, not determinable, were found; from three eggs *Trichogramma* sp. emerged. In one egg, two dead, but well developed pupae were observed, one of *B. servadeii* and one of *O. pityocampae*.

More detailed investigations showed that not all parasitoids emerged, some died inside the egg-shell at different stages of development. Tab.1 shows the results for *B. servadeii*.

From 725 adults, 81 (11.2%) emerged before, and 644 (88.8%) after collection of the egg-batches. In 707 cases the hole from which the imago emerged, was at the top of the egg-shell, and in 18 cases on the side. The last group of parasitoids definitly emerged after hatching of the caterpillars, through a hole made by another

Table 1 - Analysis of the contents of eggs parasitized by Baryscapus servadeii *(Dom.).*

Number of eggs observed	783 n (100%)	
Number of adults emerged	725 n (92.6%)	in 70 (9.6%) with remains of the host
Number of dead larvae	4 n (0.5%)	in 3 with remains of the host
Number of dead pupae	26 n (3.3%)	in 2 with remains of the host
Number of dead adults without opening in the egg-shell	28 n (3.5%)	in 16 with remains of the host

parasitoid or caterpillar. A total of 11.7% developed in embryos of the host of advanced stages, showing remains like sclerotized head capsules and mandibles.

Although the egg-batches were stored from February 1993 at temperatures appropriate for the emergence of adult parasitoids, no emergence of *B. servadeii* was observed before end of May 1993. On 25.VIII.1993, 630 adults were found in the test tubes, and until the last observation in June 1994, further 14 adults emerged. Only one male was collected.

In Tab.2 the results are shown for *O. pityocampae.*

Table 2 - Analysis of the contents of eggs parasitized by Ooencyrtus pityocampae *(Mercet)*

Number of eggs observed	219 n (100%)	
Number of adults emerged	194 n (88.6%)	in 1 case with remains of the host
Number of dead larvae	1 n (0.04%)	
Number of dead pupae	11 n (5.0%)	
Number of dead adults without opening in the egg-shell	13 n (6.0%)	in 2 cases with remains of the host

From 194 adults of *O. pityocampae* 175 (90.2%) emerged through a hole made at the top of the egg-shell, and in 19 (9.8%) cases the hole was on the side reaching the neighbour egg, where a hole had been made by a previously hatched parasitoid. It was recorded that 79 (40.7%) adults emerged before, and 115 (59.3%) after collection of the egg-batches. At room temperature, the emergence started on the 24.III.1993. Before the end of May, 107 adults had emerged, most of them between the end of April and the beginning of May. Only eight adults emerged later on (until the 25.VII.1993). After August 1993, there was no further emergence of *O. pityocampae.* Only one male was found (14.IV.1993).

For both egg parasitoids, most of the adults emerged after a winter diapause, *O. pityocampae* considerably earlier than *B. servadeii.*

The location of the parasitized eggs, in the batches, is shown in Tab. 3.

Table 3 - Location of the eggs parasitized by Baryscapus servadeii *(B.s.) and* Ooencyrtus pityocampae *(O.p.) in the egg-batches; each batch was divided in five equal parts.*

base to top		1/5	2/5	3/5	4/5	5/5	total
B.s.	n	180	129	107	155	208	779
	%	23.1	16.6	13.7	19.9	26.7	100
O.p.	n	62	49	35	34	39	219
	%	28.3	22.4	16.0	15.5	17.8	100

Considering the egg-batches studied divided in five equal parts, from the at base to the top, it was obvious that *B. servadeii* preferred the first and last (5th) part of the batch. *O. pityocampae* emerged more frequently from the basal parts (1/5 – 2/5) than from the others.

DISCUSSION

A low mean number of eggs per batch (154n) was found in *T. pityocampa* in Algeria. In Israel, Halperin (1970) found a mean of 191 eggs and Kitt & Schmidt (1993) 178 eggs per batch in *T. wilkinsoni* Tams, a species closely related to *T. pityocampa*. In Greece, Schmidt & Douma-Petridou (1989) counted 184, in the southern part (Peloponnes), and Schmidt (1990) a mean of 208 eggs per batch, near Kalogria (Peloponnes). Including the northern part of Greece, Bellin et al.(1990) recorded a mean number of 193 eggs per batch. The highest mean (223 eggs/batch) was reported from Bulgaria by Tsankov (1972), and mean numbers of 220 to 253 eggs per batch were counted by Tsankov et al. (1995).

In Algeria, *B. servadeii* was the most frequent parasitoid in egg-batches of *T. pityocampa* followed by *O. pityocampae*. The same was reported from northern Greece (Bellin et al., 1990) and Israel (Kitt & Schmidt, 1993). In Italy, *B. servadeii* is the most abundant species in the warmer regions of the central and southern parts (Tiberi, 1990).

Our detailed studies showed that *B. servadeii* parasitized the host embryos in later stages, at a higher rate than *O. pityocampae*. This may be related to the longer winter diapause of *B. servadeii,* which lasted for a minimum of seven months and could not be broken by higher temperatures. Thus, emergence of *B. servadeii* is synchronized with the beginning of the egg-laying season of both *Thaumetopoea* species (June-August), since the adult parasitoids can survive on honey-

dew for several months (Kitt & Schmidt, 1993). *O. pityocampae* had a shorter winter diapause and a reduced adult lifespan.

Both parasitoids emerged in higher numbers in the spring than in the fall in which oviposition took place. But in comparison to *B. servadeii*, the rate of emergence of *O. pityocampae* was distinctly higher before collection of the egg-batches and the diapausing number relatively low. Under laboratory conditions, the emergence of *O. pityocampae* started at the end of March, about five weeks after sampling of the egg-batches, and almost all adults had emerged by the beginning of May 1993. This was considerably earlier than in *B. servadeii*.

Inspite of many unscaled eggs also being present in the middle of the egg-batches, there was a distinct preference for parasitism at the base and top of the egg-batches by *B. servadeii,* as reported by Kitt & Schmidt (1993). In *O. pityocampae,* only the basal part was preferred for oviposition, as found also in Israel by the authors mentioned before.

Parasitism rate cannot thus be evaluated by counting the small round holes at the top of the scaled egg-shell. There are many other holes at the side of the egg-shell, not to be seen from above, after removing the scales. Such holes were already in the egg-shells when the neighbour insect hatched. From these observations, it can be inferred that the parasitoids orient to the most transparent spot of the egg-shell, where they make the emergence hole.

In one egg only, a very rare case of double parasitism was observed: one dead pupae of each parasitoid species was found.

The hatching rate of the caterpillars was relatively high (55.8%); a higher rate has only been reported by Schmidt & Douma-Petridou (1989) from the Peloponnes, and Bellin et al. (1990) from northern Greece, where the parasitoids could attack the hosts embryos only during one third of their developmental period. An extended field exposure of the egg-batches to seven months, reduced the rate of caterpillar hatching to 33%. The parasitoid impact on the total mortality (44.2%) was only 76.1%, although the sampling of the egg-batches took place in February of the year following oviposition.

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