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Notes on the egg parasitoids of *Thaumetopoea pityocampa* (Den. & Schiff.) (Insecta Lepidoptera Thaumetopoeidae) collected on the Greek island Hydra (*)

Abstract - In the island Hydra pine trees are highly infested by the processionary moth. The egg-batches of the pest were attacked by the primary parasitoids *Ooencyrtus pityocampae* (Mercet) and *Baryscapus servadeii* (Dom.) and the hyperparasitoid *Baryscapus transversalis* Graham. In 1995, the hatching rate of the caterpillars was found at 50%, the impact of parasitoids was nearly 40%. *O. pityocampae* was the most frequent ooparasitoid, *B. servadeii* parasitized only 7% of the eggs studied. The emergent pattern of the parasitoids was presented for 1996 after hibernation. The primary parasitoids were equally distributed in the egg-batch, since the hyperparasitoid preferred the top part to more than 50%. The meconium of *B. transversalis* was presented for the first time.

Zusammenfassung - *Bemerkungen zu den Eiparasitoiden von* Thaumetopoea pityocampa *(Den. & Schiff.) auf der griechischen Insel Hydra.*

Auf der Insel Hydra sind die dort gruppenweise angepflanzten Pinien (meist *Pinus halepensis* Miller) vom Processionsspinner stark befallen. Die Eigelege des Schädlings werden von den Primärparasitoiden *Ooencyrtus pityocampae* (Mercet) und *Baryscapus servadeii* (Dom.) sowie vom Hyperparasitoiden *Baryscapus transversalis* Graham befallen. Im Jahre l995 lag the Schlupfrate des Wirtes bei 50%, die Befallsrate der Wirtseier durch Ooparasitoide war nahe 40%. *O. pityocampae* war am häufigsten vertreten, *B. servadeii* parasitierte nur 7% der Eier. Das Schlupfmuster der Parasitoide nach der Überwinterung wurde für l996 dargestellt. Während die Primärparasitoide die Wirtseier im Gelege homogen parasitierten, fanden sich mehr als 50% des Hyperparasitoiden in Eiern an der Spitze des Geleges. Das Mekonium von *B. transversalis* wird erstmals demonstriert.

Riassunto - *Osservazioni sui parassitoidi oofagi di* Thaumetopoea pityocampa *(Den. & Schiff.) sull'Isola greca di Hydra.*

Sull'isola di Hydra i pini sono fortemente infestati dalla processionaria. Le ovature dell'insetto vengono attaccate dai parassitoidi primari *Ooencyrtus pityocampae* (Mercet) e *Baryscarpus servadeii* (Dom.) e dall'iperparassitoide *Baryscapus transversalis* Graham. Nel 1995 la percentuale di uova schiuse dell'ospite era del

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50%, la percentuale di infestazione delle uova dell'ospite tramite parassitoidi oofagi è risultata di quasi 40%. *O. pityocampae* è stato più spesso riscontrato, *Baryscapus sevadeii* ha parassitizzato soltanto il 7% delle uova. Viene illustrato il modello di fuoriuscita dall'ovatura dei parassitoidi dopo lo svernamento nel 1996. Mentre i parassitoidi primari si sono distribuiti omogeneamente sull'ovatura, più del 50% degli iperparassitoidi hanno preferito la parte apicale. Il meconio di *B. transversalis* è presentato per la prima volta.

Key words: *Thaumetopoea pityocampa,* egg parasitoids, Greek island Hydra.

INTRODUCTION

The pine processionary moth, *Thaumetopoea pityocampa* (Den. & Schiff.) is widely distributed in the island Hydra, as in the mainland of Greece and the Peloponnes (Kailides, 1962a; Koutsaftikis, 1990). The main host species is *Pinus halepensis* Miller. Also, in many islands of Greece the pine pest is present, but studied there very little. Kailides (1962b) reported some observations on the egg parasitoids in Greece.

First detailed observations on egg parasitoids were made in the Peloponnes (Schmidt, 1988, 1990; Schmidt & Douma-Petridou, 1989). Special investigations of the ooparasitoid spectrum were performed by Bellin et al. (1990) with egg-batches from Chalkidiki and the Peloponnes. Additionally, some informations of the presence of the pest and its egg parasitoids are known from the Thracian and northern Aegain islands. During one week stay the first author had the possibility to observe the infestation of the pine trees and to collect some egg-batches for studying parasitism.

MATERIALS AND METHODS

In Hydra, near to the northern shore there are many group-standing trees of *Pinus halepensis* Miller of various age strongly infested by the processionary moth. In spite of this strong infestation it was difficult to find numerous egg-batches at the beginning of April 1996, because in windy regions, as on islands, the dried up needles bearing the egg-batches fall down easily after hatching of the caterpillars. Thus, only eleven batches could be collected on 10.IV.1996. The batches were transferred by air directly to Hannover and mailed to the Forest Research Institute in Sofia, Bulgaria to carry out, almost daily, observations on emergence of the parasitoids. For that, the egg-batches were singled in test tubes, closed with cotton stoppers and stored at room temperature under laboratory conditions (20-22°C). Two weeks after collection the scales were removed and the emerged parasitoids could be recognized by the presence of a small hole. The parasitoids were removed and separated in plastic capsules for

determination. The final analysis followed in November 1996 at the Department of Zoology-Entomology, University of Hannover. Every egg without a hole and all eggs from which parasitoids were hatched through a small hole were opened carefully and the released meconia and remains of the emerged or dead insects were determined by means of a stereomicroscope (40 x magnification). Sclerotized remains showed that the egg was parasitized in an advanced developing stage.

RESULTS

The 11 egg-batches studied contained 1975 eggs, the mean per batch being 180 (range 107-227 eggs). The number of egg-rows per batch varied between 8-10, 1 cm egg-row contained a mean number of 10.15 eggs, the diameter of the egg-batches varied from 2.5-4.0 mm (mean 3.0 mm). The length of the needles on which an egg-batch was found varied between 56-115 mm (mean 71 mm) and the length of the batches ranged from 15-36 mm (mean 29 mm). The distance of the egg-batches from the base of the needles was measured between 7-82 mm.

To study parasitism rate a number of 1975 eggs was used, from which 981 (50%) caterpillars hatched in 1995 (before collection). The impact of parasitoids was nearly 40% and the rest of the eggs has to be added for calculation of the total mortality, because 73 (3.7%) caterpillars died in the eggs without opening from which 8 died after forming a hatching hole, 98 (5%) eggs showed dried-up yolk inside and 33 (1.7%) eggs were totally empty, without any remains.

Table 1 - Parasitoids found in the egg-batches collected in Hydra.

	O. pityocampae	*B. servadeii*	*B. transversalis*
Number emerged before collection	298	24	----------
number emerged after collection	222	85 (3 ♂♂)	11 ♀♀ + 3 ♂♂
number of adults died in eggs	10	10	4 ♀♀ + 4 ♂♂
number of pupae died in eggs	10	8	----------
number of larvae died in eggs	41	12	----------
Total	581	139	22

Ooencyrtus pityocampae (Mercet) was found most frequently and attacked 581 eggs (29.4%). All parasitoids found were females, most of them emerged before collection of the egg-batches. *B. servadeii* (Dom.) parasitized only 7% of the eggs; most of them emerged after collection of the egg-batches, three males were found. A small number of both parasitoids died as larvae, pupae or adults in the eggs (Tab. 1).

Among these primary parasitoids, a small number of the hyperparasitoid *B. transversalis* Graham appeared after collection of the batches, from which females and males emerged. We were able to demonstrate the meconium of *B. transversalis* (fig. 1).

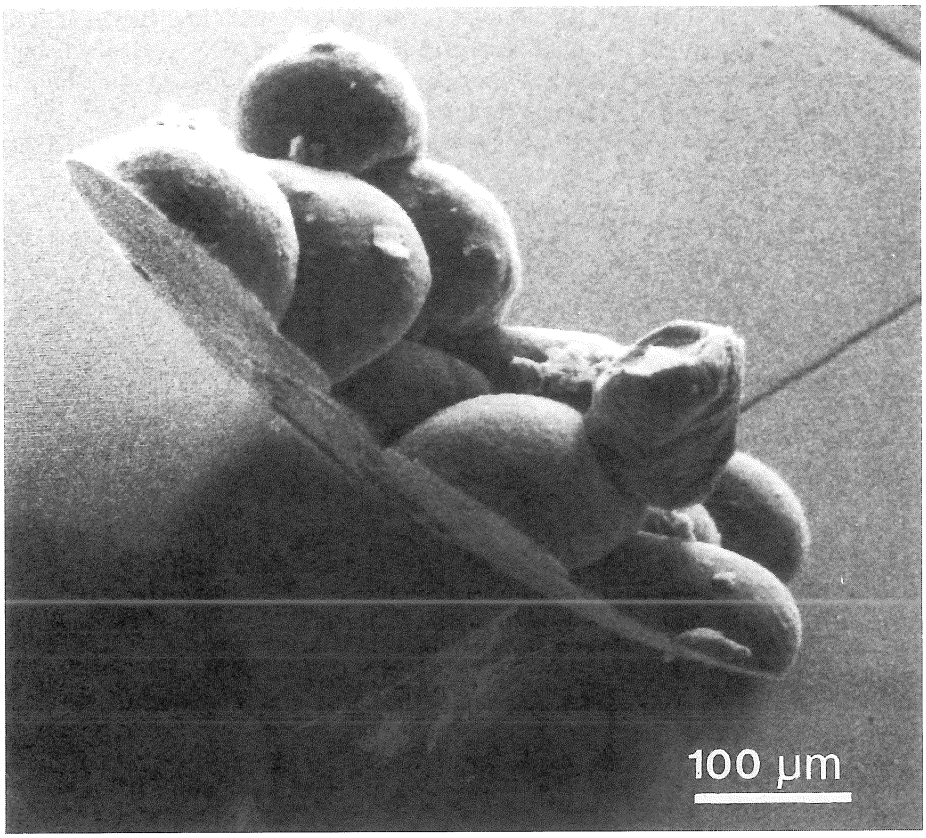

Fig. 1 - Meconium of *Baryscapus transversalis* Graham; the meconium of the hyperparasitoid shows globular aggregations of feces as found in *B. servadeii* after winter diapause (Schmidt & Kitt, 1994), it is placed on a thin bowl-like board which may be the remains of the primary parasitoid.

The distribution of the primary parasitoids in the different parts of the egg-batches was not significant, since the hyperparasitoid was found more than 50% at the top part of the egg-batches (fig. 2)

The emergent pattern of the egg parasitoids observed after collection of the batches is presented in fig. 3 for 1996. *B. transversalis* emerged on 29.IV.1996. *O. pityocampae* appeared from 2.V-30.VII. 1996 and the females of *B. servadeii* from 26. VIII-1.X.1996; the three males of the latter emerged on 2.V, 6.V and 17.IX.1996.

Both primary parasitoids attacked early and advanced embryonic stages of the host. After collection, from both parasitoids a higher percentage of adults emerged from eggs parasitized in advanced than in early embryonic stages. This was more prominent in *O. pityocampae* than in *B. servadeii* (fig. 4).

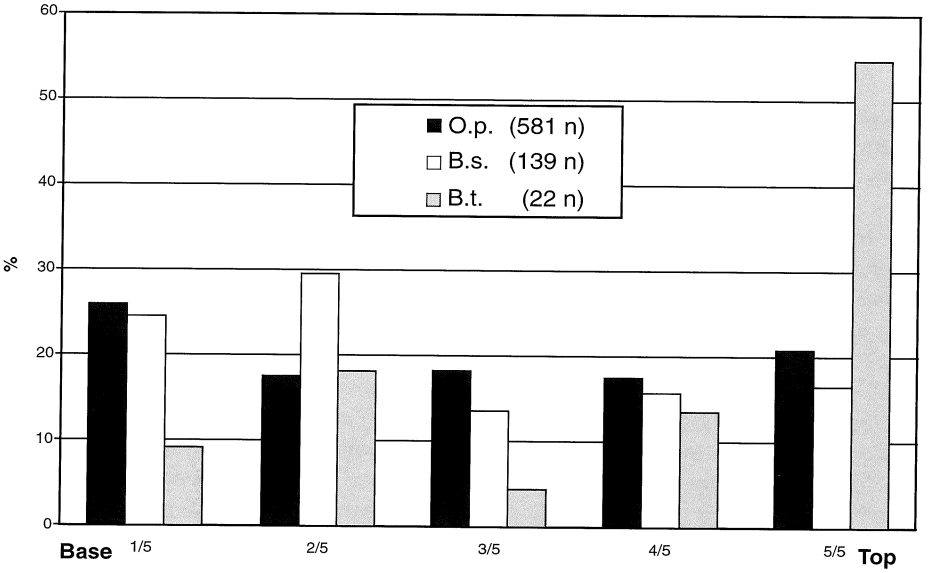

Fig. 2 - Distribution of egg parasitoids in different parts of the egg-batches collected at the island Hydra (Greece) on 10.IV.1996; each egg-batch was divided in five equal parts; O.p.: *Ooencyrtus pityocampae*; B.s.: *Baryscapus servadeii*; B.t.: *Baryscapus transversalis*; in brackets: number of individuals used for calculation.

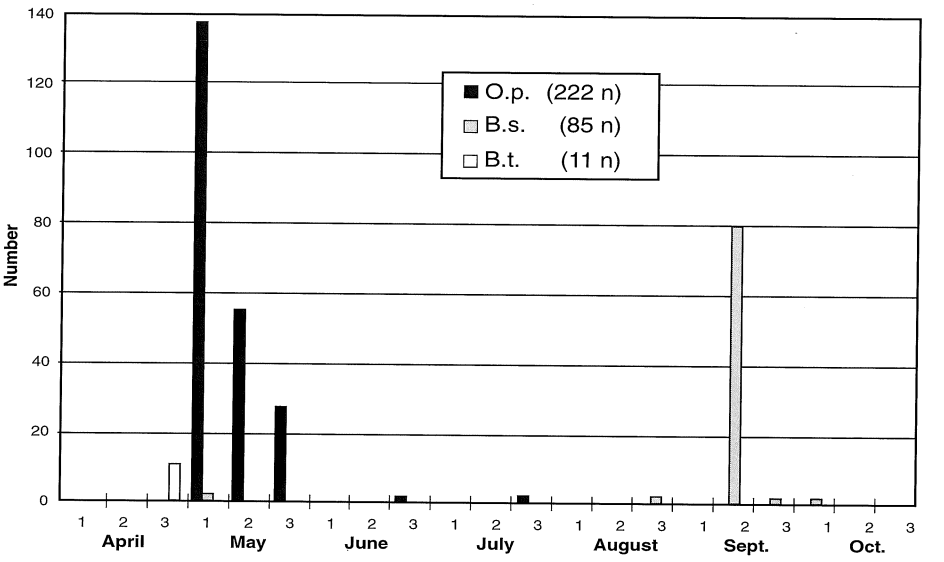

Fig. 3 - The pattern of emergence of the egg parasitoids from the egg-batches collected at the Greek island Hydra on 10.IV.1996; O.p.: *O. pityocampae*; B.s.: *B. servadeii*, B.t.: *B. transversalis*.

DISCUSSION

Compared with other Greek regions, the mean number of eggs per batch collected in Hydra was equal or little lower of that found in the northern Peloponnes by Schmidt (1988, 1990) and Schmidt & Douma-Petridou (1989) and in the peninsula Kassandra (northern Greece) by Bellin et al. (1990). In Israel, a mean number of 178 eggs per batch was registered (Kitt & Schmidt, 1993).

In Hydra, only two species of primary egg parasitoids were responsible for an impact on the mortality of the pine pest. *O. pityocampae* was most frequent destroying almost 30% of the eggs, followed by *B. servadeii* attacking only 7%. The multiplication of the eulophid may be reduced by its obligatory hyperparasitoid, *B. transversalis* (2.2% of the emerged parasitoids). In Greece, both *Baryscapus* species were found at all places studied and this may enhence the relatively high abundance of *O. pityocampae* in some regions. On the other hand, Bellin et al. (1990) found at Kassandra that *B. servadeii* is more abundant than *O. pityocampae*, in spite of a high percentage (6.3%) of *B. transversalis* which can produce six generations per year if eggs are available parasitized by the primary parasitoid larvae. No remains were found in the hyperparasitized eggs, thus *B. tranversalis* will attack its host at the larval stage.

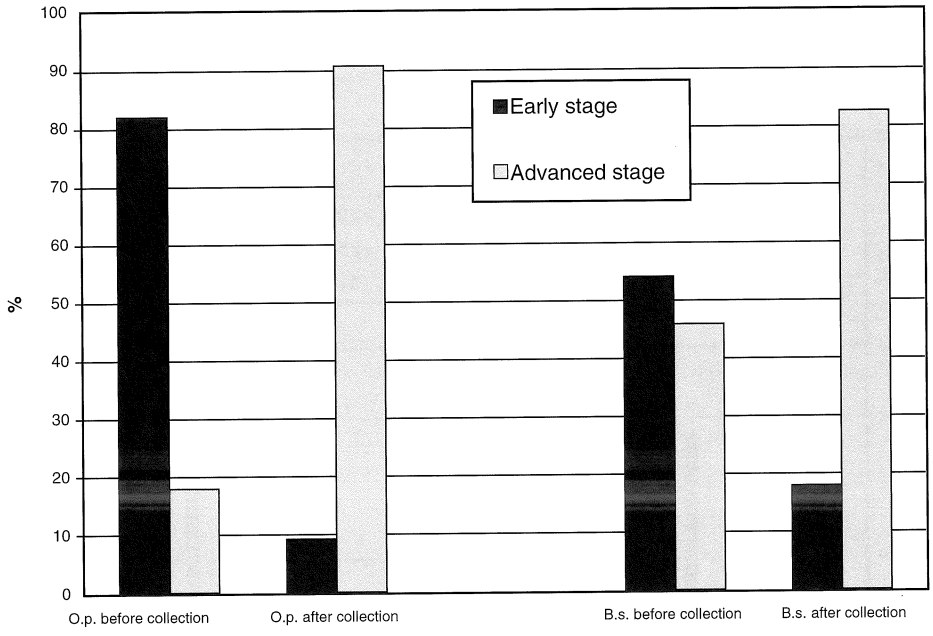

Fig. 4 - Emergent pattern of the primary egg parasitoids depending on before and after collection of the batches in Hydra and the parasitism of the developing stages; B.s.: *Baryscapus servadeii*, O.p.: *O. pityocampae*.

fig. 4 shows the meconium of *B. transversalis*.The female/male ratio was found between 2:1 to 1:1. Males arise from arrhenotocal parthenogenesis (Bellin, 1995). The main production period will be the seasons of spring to autumn of the year following host oviposition when the primary egg parasitoids are in diapause as mature larvae.

The primary egg parasitoids were equally distributed in the egg-batches, in contrast to the hyperparasitoid which appeared more frequently at the top part of the batch, as found near Marikostino/Bulgaria (Tsankov et al., 1996) and Kassandra/northern Greece (Bellin, 1995). In Italy, where no hyperparasitoid was recorded, *B. servadeii* was found more frequently in the apical part of the egg-batch and *O. pityocampae* in the basal sectors (Tiberi, 1990). On the contrary, in Morocco *B. servadeii* was found more frequently in the basal part und *O. pityocampae* in the apical part of the egg-batch (Schmidt et al., 1997), since in Algeria the latter preferred the basal part of the batch for parasitism (Tsankov et al., 1995).

B. servadeii parasitized relatively more host embryos (13.8%) in advanced stages than *O. pityocampae* (0.8%) indicated by sclerotized head parts. This was found also in Israel (Halperin, 1990), Bulgaria (Tsankov, 1990), Algeria (Tsankov et al., 1995), and Morocco (Schmidt et al., 1997). After parasitizing advanced embryonic stages, both egg parasitoids can hibernate as mature larvae and can emerge in the following year. In hyperparasitized eggs no caterpillar remains were found.

Comparing the phenology of the adult parasitoids, *O. pityocampae* emerged much earlier in the year than *B. servadeii.* Both species showed one emergent peak after hibernation. Emergence of *O pityocampae* occurred in May and that of *B. servadeii* in the midth of September, after a diapause of 11-12 months showing that only the eulophid is perfectly synchronized to the period of egg deposition of the host which will occur in autumn. In *O. pityocampae,* the diapause lasted only 7-8 months. At Hydra, in May no *Thaumetopoea* embryo is present for reproduction and no hyperparasitism was observed in the encyrthid. Reaching sucessfully the next host generation the parasitoid needs another host which is still unknown at Hydra. A similar situation was found at Kalogria/western Peloponnes (Bellin et al., 1990). At Kassandra/northern Greece a small emergent peak was observed additionally in September (Bellin et al., 1990). At Marikostino/Bulgaria the encyrtid emerged from March to September with a peak in May and at Plosky/Bulgaria in June. At the latter place the emergent pattern of the eulophid was found from April to July (Tsankov et al., 1996).

All individuals of *B. transversalis* emerged as obligatory hyperparasitoids on 29.IV.96. Also, at Plosky/Bulgaria almost all individuals of the latter species emerged in April after hibernation. No indication was found for an emergence in the year of hyperparasitism (before hibernation). Bellin et al., (1990) observed periods of emergence until August and Tsankov et al. (1996) until June from egg-batches which could be hyperparasitized only before hybernation.

A relatively low rate of developing stages of the parasitoids dying in the eggs, was found in egg material collected in Algeria (Tsankov et al., 1995). In the egg-batches studied, there was no reference to any hyper-and superparasitism of primary para-

sitoids as Masutti (1964) proposed. Much higher percentages of dead developing stages of egg parasitoids were recorded by Kitt & Schmidt (1993) in Israel and Tsankov et al. (1996) in Bulgaria than found in Hydra.

In the batches collected at Hydra a small rate of sterile eggs was present, besides a similar percentage of eggs totally empty as reported from other regions (Bellin et al., 1990; Tsankov et al., 1995, 1996; Schmidt et al., 1997).

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