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Structure, hatching rate and parasitism of egg-batches of *Thaumetopoea pinivora* (Tr.) (Lep. Thaumetopoeidae) near the Baltic Sea (*)

Abstract - Studies were carried out on egg material of *Thaumetopoea pinivora* (Treitschke, 1834) collected on *Pinus sylvestris* L. in a forest near Kaliningrad in September 1989 and 1990. Hatching of the caterpillars was observed at spring time of the following year from the egg-batches collected in 1989 and 1990. The hatching period was about two weeks. The egg-batches were formed from the tip to the bottom of the needle to 98% and situated in the middle of the needle length in most of the cases. For egg laying only one or two needles were used per individual. Often egg deposition started on one needle and used later another. The fertility can be more than 90% and egg parasitation rate was very low in both years. The only recorded egg parasitoids belonged to the genus *Kratoysma* (Eulophidae). Egg parasitoids did not influence population dynamics of the host. The egg-batches were arranged in 6 to 8 almost linear rows. A highly significant correlation ($r = 0.90$-0.94) could be found between the total number of eggs and the product of batch length and number of egg rows; the number of eggs per 1 cm egg row varied from 8.56 to 8.91. In the two years under study, the mean number of eggs per batch was 164 and 165, respectively.

Zusammenfassung - *Struktur, Schlupfrate und Parasitierung von Eigelegen von* Thaumatopoea pinivora *(Tr.) (Lep. Thaumetopoeidae).*

Eigelege von *Thaumetopoea pinivora* (Treitschke, 1834), die in einem Waldgebiet in der Nähe von Königsberg im September 1989 und 1990 an *Pinus sylvestris* L. gesammelt wurden, wurden auf ihre Struktur, die Schlupfrate der Raupen und Parasitierungsrate der Eier untersucht. Die Raupen schlüpften im Frühjahr des auf die Eiablage folgenden Jahres. Die Schlupfperiode der Raupen dauerte etwa zwei Wochen. Die Eigelege wur-

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den zu 98% von der Spitze der Nadel zur Basis hin angefertigt; sie befanden sich in den meisten Fällen im mittleren Längenbereich der Nadel. Zur Eiablage wurden vom Weibchen nur eine oder zwei Nadeln benötigt. Oft begann das Weibchen sein Eigelege an einer Nadel und zog in der Nähe der Nadelbasis eine zweite mit heran. Die Fertilität kann höher als 90% sein. Die Parasitierungsrate war in beiden Jahren sehr gering. Die einzigen ermittelten Eiparasitoide gehörten zur Gattung *Kratoysma* (Eulophidae). Eiparasitoide hatten somit keinen Einfluß auf die Populationsdynamik des Wirtes. Die Eigelege waren in 6-8 fast linearen Reihen angeordnet. Es wurde eine hochsignifikante Korrelation (r = 0,90-0,94) zwischen der Anzahl der Eier im Gelege und dem Produkt von Gelegelänge und Anzahl der Eireihen festgestellt; die Anzahl der Eier pro 1 cm Eireihe variierte von 8,56-8,91. In beiden Untersuchungsjahren betrug die mittlere Eizahl pro Gelege 164 bzw. 165.

Riassunto - *Struttura, percentuale di schiusura e parassitizzazione delle ovature di* Thaumetopoea pinivora *(Treitschke, 1834) (Lep. Thaumetopoeidae).*

Sono state esaminate le uova di *Thaumetopoea pinivora* (Treitschke, 1834) raccolte su *Pinus sylvestris* L. in una foresta vicino a Kaliningrad nel settembre 1989 e 1990. La schiusura delle uova è stata osservata nella primavera successiva alla loro raccolta e si prolunga per circa 2 settimane. Le deposizioni sono completate per il 98% dei casi dall'apice alla base degli aghi; nella maggior parte si trovano nella porzione mediana. Per l'ovideposizione sono usati solo 1 o 2 aghi per individuo. Spesso viene usato prima un ago, poi il successivo. La fertilità può essere superiore al 90% e la parassitizzazione è stata molto bassa in ambedue gli anni. L'unico parassitoide delle uova appartiene al genere *Kratoysma* (Eulophidae) e non influenza la dinamica di popolazioni dell'ospite. Le ovideposizioni sono allineate in 6-8 file lineari. Una correlazione elevata (r = 0,90-0,94) può essere osservata tra il numero totale di uova e il prodotto della lunghezza dell'ovatura e il numero di file di uova. Il numero di uova per cm varia da 8,50 a 8,91. Nei due anni di osservazioni il numero medio di uova per ago è stato ripsettivamente di 164 e 165.

Key words: *Thaumetopoea pinivora*, structure, parasitism, hatching rate.

INTRODUCTION

Thaumetopoea pinivora (Treitschke) is widely distributed in Europe, especially in the north and east (Southern Scandinavia and Baltic countries, Poland, Rumania and Bulgaria). Some small populations can be found in Eastern Germany, France (see Schmidt, 1990a) and Central Spain (Agenjo,

1941; Montoya & Robredo, 1972). The species is not such a dangerous forest pest as *Thaumetopoea pityocampa* (Den. & Schiff.). Therefore, only few studies are available in the literature. Some authors have reported on the biology and annual cycle of *T. pinivora* (Koch, 1953; Hadjuk, 1963; Hering, 1968). In northern Europe the host plant is *Pinus sylvestris* L. Near Dresden (Saxony, FRG) the flight period was observed in July-August. Egg-laying started directly after emergence and copulation, as in other *Thaumetopoea* species. The eggs were laid in clusters on needles. The larvae hatched in the following spring (April-May). All five larval instars lived in aggregations in silky nests, but the nests were not so dense as in *T. pityocampa* and were constructed mainly near ramification of the host tree. Long processions, not only a single row, went from one tree to another, even though there was no lack of food.

Pupation took place in July or later in the soil at a depth of 8-20 cm. The pupae hibernated. The adults emerged in July-August of the following year in the evening hours. In September it was possible to find freshly laid egg-batches on the needles and pupae in the soil. Thus, years of many moths and those of many caterpillars will alternate (Koch, 1953; Hering, 1968). Some pupae have a prolonged diapause of several years as could be stated in other *Thaumetopoea* species. In this way they can adapt again to the normal cycle.

Apart from this 2-year cycle, a one-year cycle may exist in regions with higher temperatures. Koch (1953) documented Ekstein's work which showed in one-year generations the moths fly in May, the caterpillars are found from June to August-September and pupae hibernate until April of the consecutive year.

Recently a population of *T. pinivora* was found near Kaliningrad (Königsberg) in a forest on the shores of the Baltic Sea by Dr. A. D. Maslov (Institute of Forest Research, Puschkino near Moscow). No studies have been made on egg material of *T. pinivora* from this region, up to date. We received many egg-batches collected in 1989 and 1990 from this area, and decided to carry out investigations on the parasitism, hatching rate and structure of these egg-batches in comparison to those of *T. pityocampa*.

MATERIAL AND METHODS

The egg-batches studied were collected in September 1989 and 1990 on needles of *Pinus sylvestris* in the forest of Kurskja Kosa near Kaliningrad. In 1989 the egg-batches were isolated in small glass tubes and sent immediately to the Forest Research Institute at Sofia, Bulgaria. There, the glass tubes were exchanged for bigger ones, closed with cotton plugs and stored in the laboratory at room temperature (20°C) until the middle of January, 1990.

Table 1 - Mean values (± S. D.) of parameters concerning egg-batches of Thaumetopoea pinivora *collected in 1989 (33 egg-batches) and 1990 (48 egg-batches) on* Pinus sylvestris *L. near the Baltic Sea.*

	1989	1990
Length of needles (mm)	49 ± 6.4	47 ± 9.4
Distance from basis of needles to egg-batch (mm)	14 ± 6.1	13 ± 7.1
Length of egg-batch (mm)	25.0 ± 9.1	25.3 ± 5.6
Number of eggs per batch	164 ± 62	165 ± 38
Number of egg rows per batch	7.6 ± 0.7	7.4 ± 0.6

Then, a sample was stored outside under current weather conditions, another in a refrigerator at 4°C, and the rest at 20°C in the laboratory. Investigations of all three samples started in the middle of March 1990.

The material collected in 1990 was also isolated in glass tubes, and was stored in Moscow at room temperature in the laboratory until early November 1990, when it was transferred to Sofia. There, the egg-batches were transferred to bigger glass tubes, and stored outside until mid-February, 1991. After that, investigations started.

Hatching of caterpillars and egg parasitoids was observed during both periods (1990 and 1991).

After one year of observations the egg-batches were transferred to Hannover to study the physical structure of the egg-batches and to count the parasitoids by means of a stereo-microscope and a calibrated ocular.

Table 2 - Larval development and parasitation rate in eggs of Thaumetopoea pinivora *collected in 1989 (33 batches studied) and 1990 (48 batches studied) near the Baltic Sea.*

	1989		1990	
	n	%	n	%
Total number of eggs investigated	5406	100.0	7941	100.0
Number of caterpillars not hatched (without opening in egg shell)	4846	89.6	350	4.4
Number of caterpillars not hatched, but with opening in egg shell	471	8.7	277	3.5
Number of hatched caterpillars	15	0.3	7170	90.3
Number of sterile eggs	74	1.4	140	1.8
Number of parasitized eggs	—	—	4	0.05

RESULTS

1. *Hatching of caterpillars*

From material collected in September 1989 hatching started in the first half of November of the same year, but the number of hatched caterpillars was very low (0.3% of total eggs), although the caterpillars were well developed inside the egg shell. Pathogens could not be found. There was no difference between the samples in the three different storing conditions.

Hatching of the caterpillars from eggs collected in September 1990 was more successful (90.3%) (compare Tab. 2). It started in the middle of February 1991 in the laboratory and lasted approximately two weeks.

2. *Structure and position of egg-batches*

For this purpose, 33 egg-batches collected in 1989 and 48 from 1990 were used. The results are given in Table 1. The eggs were deposited from the top to the bottom of the needles, only one egg-batch was prepared in opposite direction. This means that the top of the scales which cover the eggs was directed toward the top of the needles, thus leaving a short segment near the base of the needles free of eggs. The mean length of egg-batches was about half of the length of the needle; the batches were usually deposited almost in the middle of the needle. The data between the 2 years studied concur very well (Table 1).

In 1989, three of the egg-batches were deposited on a single needle, 23 on two needles and seven times the female started egg deposition on one needle and later on she used two ones (Fig. 1). In 1990, the distribution was similar: three egg-batches on one needle, 38 on two needles and in seven cases the female started on one but used two needles later on.

For parasitation rate and parasitism, similar results were found in the two periods studied (Table 2). The only difference was that in 1989 most of the well developed caterpillars did not hatch. If this point is not considered, the percentage of egg development was more than 98%. In 1989 most of the developed caterpillars died without opening the egg shell.

The parasitism rate was nihil in 1989 and very low in both years([1]). In 1990 only four egg openings made by parasitoids were found; it was not possible to identify the parasitoid from the remains as Kitt & Schmidt (1993) have done.

([1]) In 1989 two parasitoids were found in other egg material from the same region, not induced in the study. They belonged to the genus *Kratoysma* (Eulophidae); the species could not be determined.

This means, egg parasitoids cannot play a role in the regulation of populations, at least in this case.

The number of sterile eggs was very low in both years (less than 2%). This means that *T. pinivora* shows a very high fertility near the Baltic Sea.

3. *Determination of the number of eggs per egg-batch*

All the egg-batches under study were completely covered with scales, which means that they were collected shortly after deposition. After removing the scales it could be observed that the eggs were arranged in 6 to 8 almost linear rows. Fig. 2 shows a highly significant correlation ($r = 0.94$ and 0.90, respectively) between the total number of eggs and the product of batch length and number of egg rows (Fig. 2). Due to the low variance it was easily possible to obtain a quite accurate estimate of the number of eggs per batch on the basis of these two parameters (Bellin et al., 1990). But for that, the number of eggs per cm egg row must be calculated. It was 8.56 in 1989 and 8.91 in 1990. The

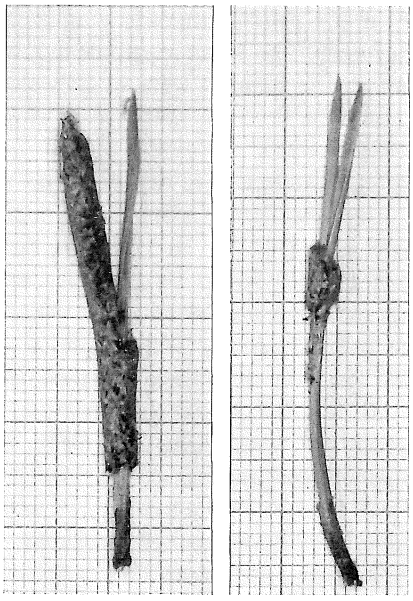

Fig. 1 - Egg-batches of *T. pinivora* (Tr.) collected near the Baltic Sea. Left: if the needles are spread apart, the female starts egg laying on one needle and uses two if the needles come close to each other near the base. Right: even a very small egg-batch can be prepared on two needles if they are close enough to each other.

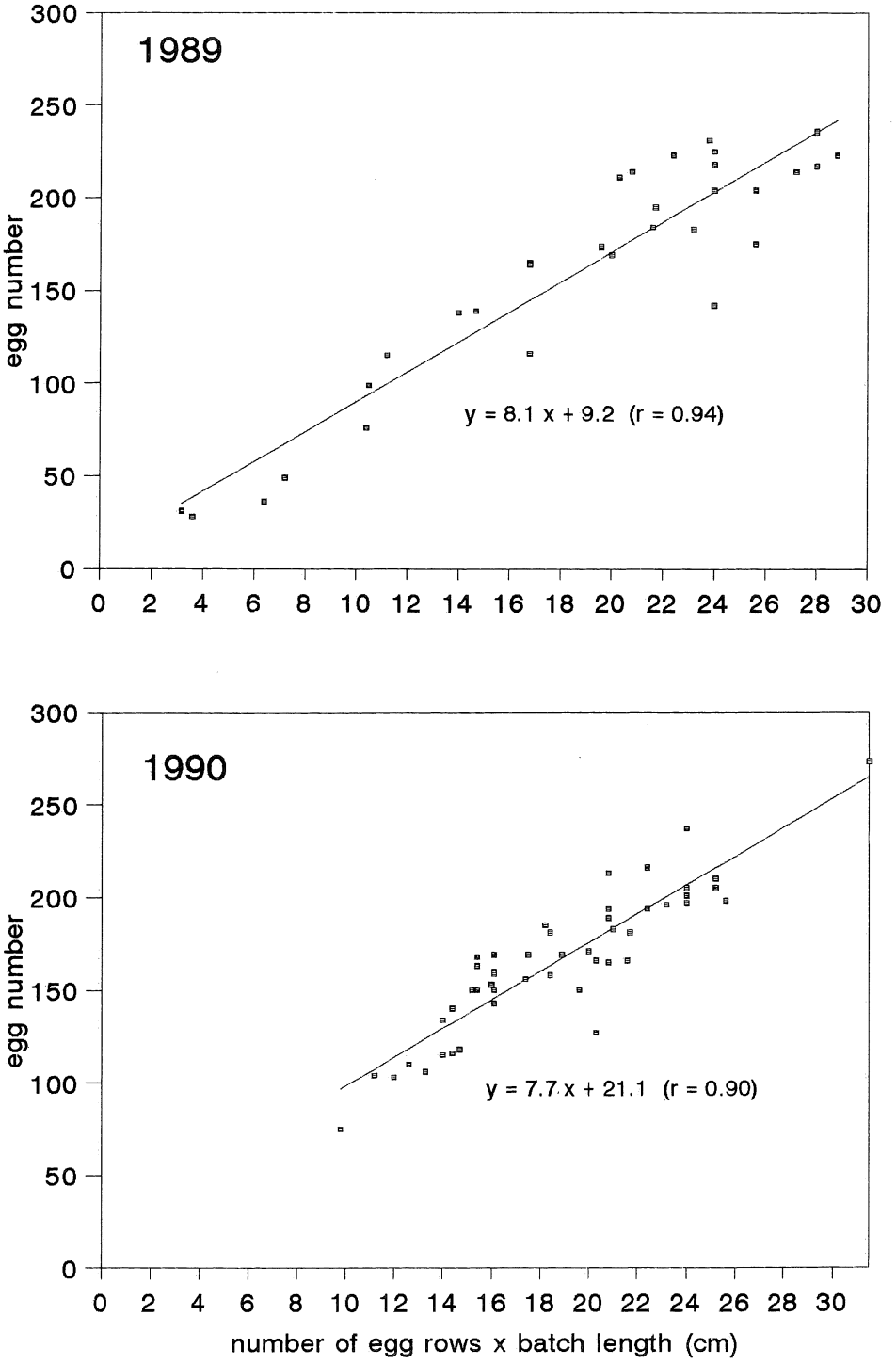

Fig. 2 - Relationship between egg number and two egg-batch size parameters of *T. pinivora* (Tr.) near the Baltic Sea demonstrated for two years.

following formula can be used: N (number of eggs/batch) = n (number of egg rows) x l (length of egg batch) x f (number of eggs/ cm egg row). By means of this formula the mean number of eggs per batch was calculated as 164 and 165, respectively, for the two years.

DISCUSSION

Comparing our results with those found in the literature of the related species, *T. pityocampa*, it is remarkable that there was a very low rate of egg parasitism in *T. pinivora* on the shores of the Baltic Sea. No egg parasitoids like *Ooencyrthus* sp. and *Baryscapus* sp. which are very common in the Mediterranean (Halperin, 1970, 1990; Bellin et al., 1990; Tiberi, 1990; Tsankov, 1990; Kitt & Schmidt 1993) could be found. Normally, egg parasitism occurs soon after deposition of the eggs.

Although almost all eggs develop into larvae (in 1989 without hatching), the population density remains low. Therefore, we have to assume that factors other than egg parasitoids limit population growth in *T. pinivora*. One of these factors seems to be the temperature at winter time: in 1989 the development of most larvae was so much impeded that most could not leave the egg shell. An influence of microorganisms was not observed. All the eggs were covered by scales and protected in this way.

In contrast to *T. pityocampa* in Greece (Schmidt, 1988, 1990b) and *T. wilkinsoni* in Israel (Kitt & Schmidt, 1993), the egg-batches of *T. pinivora* were deposited by the female from the top to the bottom of the needle in both years. Often the female started egg laying on one needle, then later on she used two needles. In all cases, on *Pinus sylvestris* a maximum of two needles was used by the female of *T. pinivora*; on *Pinus halepensis*, *T. pityocampa* females prepared an egg-batch on a maximum of eight needles, and in Greece only 62.5% were formed from the tip to the bottom of the needle (Schmidt, 1988). It is unknown, whether this difference depends on the tree or moth species. The smaller diameter of egg-batches was observed in *T. pinivora*: only 6-8 almost linear egg rows per batch were counted. In *T. pityocampa*, Bellin et al. (1990) observed 5-15 spiral rows in egg-batches collected in Greece. Additionally, in egg-batches of *T. pinivora* the number of eggs per cm egg row was lower than in those of *T. pityocampa*, although the egg size is similar in both species. Two other parameters may be involved besides egg size: egg shape and distance between eggs. The eggs of *T. pinivora* are more round than those of *T. pityocampa*. But the most important factor responsible for the smaller egg number per cm egg row seems to be the bigger distance between the eggs.

In comparison to *T. pityocampa* (Schmidt, 1988; Bellin et al., 1990;

Tsankov, 1990) and *T. wilkinsoni* (Halperin, 1970; Kitt & Schmidt, 1993), in which the mean number of eggs per batch varied from 190 to 230, we counted for *T. pinivora* only 164 and 165 eggs per batch, on the average. The lesser impact of parasitoids may be due to the lower egg number per female in *T. pinivora*.

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