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Scale shape and colour of egg batches of some *Thaumetopoea* species (Insecta Lepidoptera Thaumetopoeidae) (*)

Abstract - In the present study the egg batches and scales of 5 different *Thaumetopoea* species, collected from 12 localities, were compared. The possibilities of differenciating these species and the relationships within them are discussed with the help of the egg batches and the shape of the scales. The egg batches of *T. processionea* are quite different from the others. More over the scales are smaller and pointed. In *T. pinivora* and *T. bonjeani* the scales were more or less of the same size, but the egg batches differed in colour and structure. The scales in *T. wilkinsoni* and *T. pityocampa* were found to be larger and wider than in the other species. *T. wilkinsoni* possessed somewhat round scales: in an average, they have more or less the same width as in *T. pityocampa* but are shorter than in their sister species. The scales at the base, in general, and at the top, in most cases, of the egg batches were smaller than those from the middle. It is, therefore, to suggest to use the scales from the middle for the taxonomic studies due to their uniform shape.

Riassunto - *Forma e colore delle squame delle ovature di alcune specie di* Thaumetopoea *(Insecta Lepidoptera Thaumetopoeidae).*

Vengono comparate le ovature e le squame di 5 diverse specie di *Thaumetopoea* raccolte in 12 località. Sono discusse la possibilità di differenziare queste specie e le loro interrelazioni con l'aiuto delle ovature e della forma delle squame. Le ovature di *T. processionea* si distinguono particolarmente da quelle delle altre e le squame sono piú piccole e appuntite. In *T. pinivora* e *T. bonjeani* le squame sono della medesima dimensione, ma le ovature differiscono nel colore e nell'aspetto. Le squame in *T. wilkinsoni* e *T. pityocampa* sono piú larghe e piú lunghe che nelle altre specie. *T. wilkinsoni* possiede a volte squame rotondeggianti: mediamente sono della stessa larghezza che in *T. pityocampa*, ma piú corte che nelle specie affini. Le squa-

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me alla base delle ovature in generale, e quelle all'apice nella maggior parte dei casi, sono piú piccole di quelle al centro. Tutto ciò suggerisce di usare le squame del centro delle ovature stesse per studi tassonomici, data la loro uniformità.

Zusammenfassung - *Die Form und Farbe der Schuppen von Eigelegen einiger* Thaumetopoea- *Arten (Insecta, Lepidoptera, Thaumetopoeidae).*

In der vorliegenden Untersuchung wurden die Eigelege und deren Deckschuppen von 5 verschiedenen *Thaumetopoea*-Arten von insgesamt 12 Fundorten verglichen. Es wird die Möglichkeit aufgezeigt, die einzelnen Arten aufgrund der Eigelege und unterschiedlichen Schuppenform zu determinieren. Außerdem werden mögliche Verwandschaftsbeziehungen diskutiert. Die Eigelege von *T. processionea* unterschieden sich von denen der anderen Arten am meisten. Auch die Schuppen waren sehr klein und spitz. Bei *T. pinivora* und *T. bonjeani* waren die Deckschuppen etwa gleich groß, doch ergaben sich Unterschiede in der Färbung. Längere und breitere Schuppen fanden sich bei *T. wilkinsoni* und *T. pityocampa.* Bei *T. wilkinsoni* wiesen sie eher eine etwas rundliche Form auf: Die Schuppen dieser Art hatten im Durchschnitt zwar die gleiche Breite wie die bei *T. pityocampa*, doch waren sie etwas kürzer als die der verwandten Spezies. Bei allen Arten fanden sich die kleinsten Schuppen an der Basis der Gelege; auch an der Spitze waren sie gewöhnlich kleiner. Für taxonomische Zwecke sollten daher die homogeneren und vielfach von der Form her typischeren Deckschuppen aus der Mitte der Gelege entnommen werden.

Key words: *Thaumetopoea*, egg batches, scale shape.

INTRODUCTION

In the genus *Thaumetopoea* the females cover the eggs, laid in batches, with scales which are numerously present on the tip of their abdomen (Tsankov, 1956, 1960; Szepanski & Tsankov, 1967; Bin & Tiberi, 1983; Demolin, 1987; Schmidt, 1988, 1990). Notes on the structure of the scales and the interspecific variability are very scarce, mostly only schematic and very short informations were given (Tams, 1925; Agenjo, 1941; Demolin, 1987). The investigations were related to taxonomic problems.

During the last years there were the opportunities to collect egg batches of five *Thaumetopoea* species from different regions of Europe and North Africa. These materials were used to study the structure of the scales covering the egg batches. Many intra- and interspecific differences in the form and colour could be found which are discussed in this paper.

Table 1 - Characterization of the egg batches of Thaumetopoea *spp. taken for the measurement of scales.*

Species	Number of egg batches	Locality	Altitude [m NN]	Date of collection	Host plant	Deposition place	Remarks
T. processionea (L.)	6	FRG (D) Freiburg	00	Oct. 1989	Quercus robur	branches	caterpillars had hatched
T. pinivora (Treitschke)	15	UdSSR (SU) Kaliningrad	00	Sept. 1989	Pinus sylvestris	needles	most of the caterpillars died within the closed egg shell
T. bonjeani (Powell)	2	Algeria (DZ) Chrea	800-900	March 1989	Cedrus atlantica	twigs	caterpillars had hatched
T. wilkinsoni Tams	16	Israel (IL) Beer Sheva Lahav Mountains	100	Sept. 1989	Pinus halepensis	needles	egg batches were partly prepared at the proximal end, the middle and the distal end of the needles; caterpillars hatched in lab
T. pityocampa (Den. & Schiff.)	15	Bulgaria (BG) Sandanski	300	March 1990	Pinus nigra	needles	in 21 collected egg batches, egg deposition started directly at the proximal end of the neddles
T. pityocampa (Den. & Schiff.)	2	Greece (GR) Kassandra (Kas.)	50	March 1989	Pinus halepensis	needles/ twigs	egg batches were partly prepared at the proximal end, the middle and the distal end of the needles; caterpillars had hatched
T. pityocampa (Den. & Schiff.)	2	Greece (GR) Kalogria (Kal.) Peloponnes	00	Sept. 1988	Pinus halepensis	needles/ twigs	in 40 collected egg batches, two third were prepared from the distal to the proximal end of the needles; caterpillars hatched in lab
T. pityocampa (Den. & Schiff.)	2	Greece (GR) Taigetos (Taig.) Peloponnes	800-1100	April 1990	Pinus nigra	needles	in 12 collected egg batches, egg deposition started directly at the proximal end of the needles; caterpillars had hatched
T. pityocampa (Den. & Schiff.)	8	Algeria (DZ) Tipasa	00	March 1989	Pinus halepensis	needles/ twigs	egg batches were partly prepared at the proximal end, the middle and the distal end of the needles; caterpillars had hatched
T. pityocampa (Den. & Schiff.)	4	Algeria (DZ) Chrea	800-900	March 1989	Cedrus atlantica	twigs	caterpillars had hatched
T. pityocampa (Den. & Schiff.)	4	Marocco (MA) Qued Chervat (Q.C.)	50	Sept. 1989	Pinus halepensis	needles	most of the caterpillars did not hatch
T. pityocampa (Den. & Schiff.)	2	Marocco (MA) Tizi Ifri (T.I.)	1800	July 1989	Cedrus atlantica	twigs	most of the caterpillars did not hatch

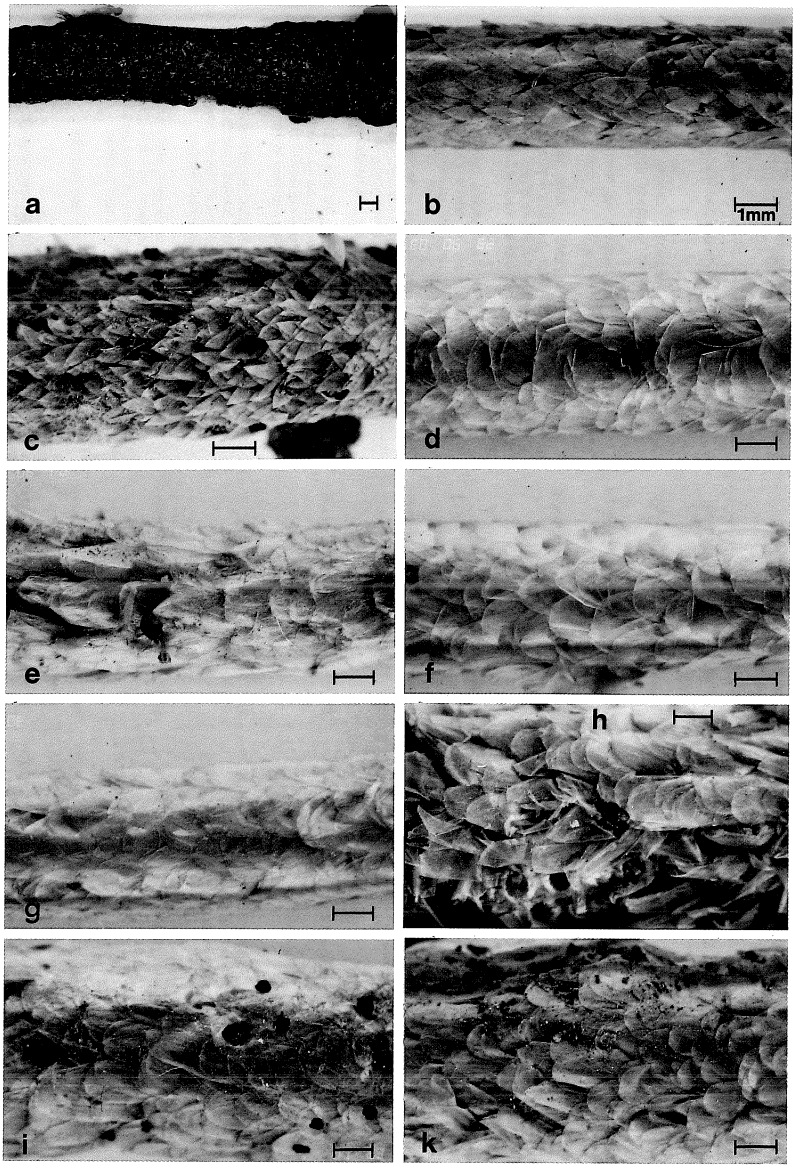

Fig. 1 - Parts of egg batches of *Thaumetopoea* spp. from different localities: *a*) *T. processionea* on bark, D; *b*) *T. pinivora* on needles, SU; *c*) *T. bonjeani* on twig, DZ; *d*) *T. wilkinsoni* on needles, IL; *e*) *T. pityocampa* on needles, BG; *f*) *T. pityocampa* on needles, GR/Kal.; *g*) *T. pityocampa* on needles, MA/Q.C.; *h*) *T. pityocampa* on twig, MA/T.I.; *i*) *T. pityocampa* on needles, DZ/Tipasa (with holes of parasitoids); *k*) *T. pityocampa* on twigs, DZ/Chrea.

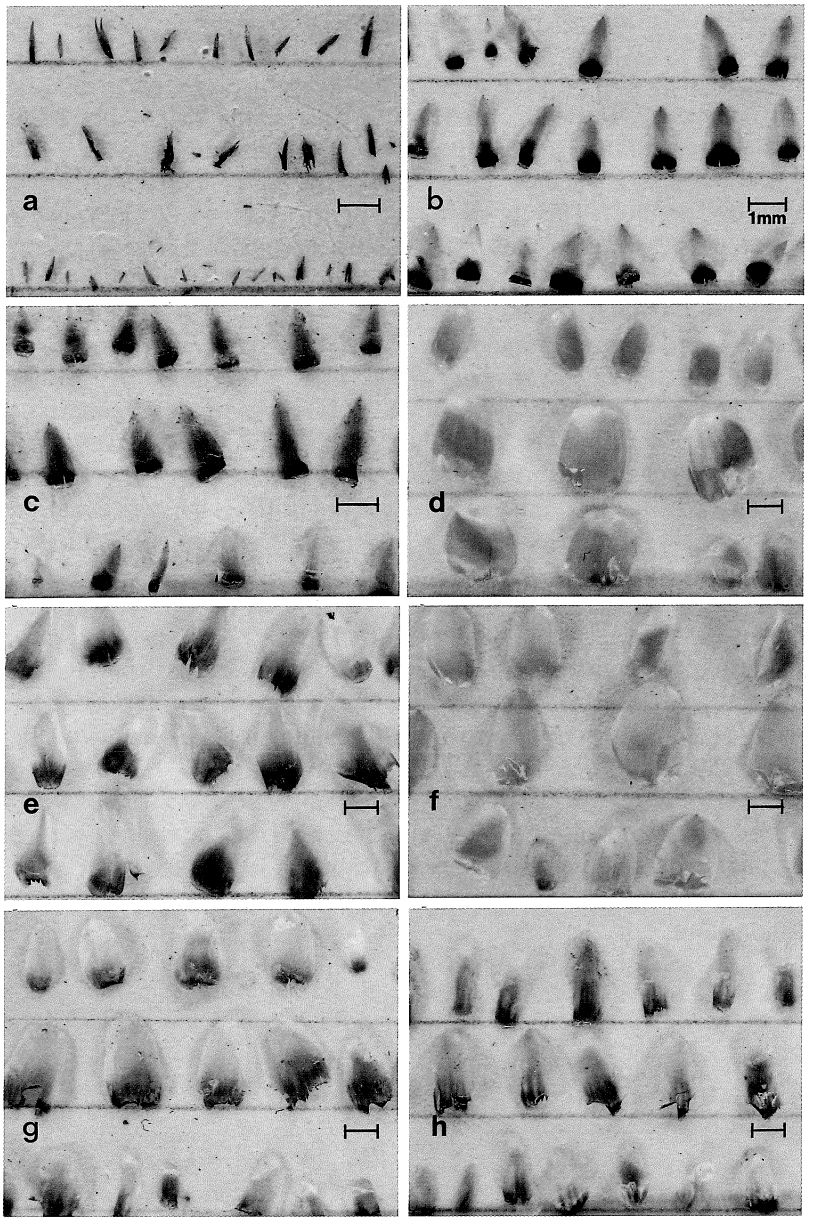

Fig. 2 - An overview of scales taken from the base (upper row), the middle (middle row) and the top (lower row) of the egg batches of *Thaumetopoea* spp. from different localities: *a*) *T. processionea*, D; *b*) *T. pinivora*, SU; *c*) *T. bonjeani*, DZ; *d*) *T. wilkinsoni*, IL; *e*) *T. pityocampa,* BG; *f*) - T. *pityocampa,* MA/Q.C.; g - T. pityocampa, DZ/Tipasa; *h*) *T. pityocampa*, DZ/Chrea.

MATERIAL AND METHODS

The egg batches laid on the needles and twigs of pines, twigs of *Cedrus* or bark of oak were collected in different seasons of the years 1988–1990 at 12 places in 7 countries. The details are given in Table 1.

Most of the egg batches collected for the investigation were deposited around pine needles. This is normally in the case of *T. pityocampa, T. wilkinsoni* and *T. pinivora.* But in all populations which have *Pinus halepensis* as host plant, some egg batches could be found around small twigs of the same plant species (Schmidt, 1988). The types of egg batches from Greek and Algerian *T. pityocampa* populations could be compared. The populations which lived on *Cedrus atlantica (T. bonjeani, T. pityocampa)* used only twigs for egg deposition. *T. processionea* deposited its eggs on oak branches. For *T. pityocampa* it is remarkable that in the populations fed on *Pinus nigra* the females started egg laying directly from the proximal end of the needles in each case (in Greece and Bulgaria). This is just opposite to the females which laid their eggs on the needles of *Pinus halepensis*, sometimes some cm from the proximal end (Schmidt, 1988).

Using a stereomicroscope, the scales were safely separated from the eggs located on the top, in the middle and at the base of the batches, where the female started egg laying. The length and width of these scales were measured by means of an ocular micrometer. From each egg batch about 30-40 scales were studied, most of which were from the middle of the batches. Altogether more than 2500 scales were measured.

The means were calculated and were compared using the «two sample t-test» for equal and unequal variances. Length of the scales were plotted against their width and regressions were calculated.

The egg batches and separated scales were photographed to show the exact form and colour.

RESULTS

1. Morphology of the egg batches

Figure 1 shows parts of typical egg batches of the material studied. The dark grey coloured egg masses of *T. processionea* are quite different from the others; they were laid on oak branches. In the other *Thaumetopoea* species which used both the twigs and the needles for egg laying, the egg batches on the twigs were generally wider than those around the needles. The females may use not only

one pair but two or three pairs of needles for egg laying and in such cases, the width of the egg batches may approach to those laid on the twigs.

The surface of the egg batches is still interesting but the differences are due to varying colour and shape of the scales.

2. Colour and shape of scales

Scales from the base, the middle and the top of typical egg batches are shown in Fig. 2. The colour of the scales varies not only between the different *Thaumetopoea* species but also within *T. pityocampa* from different localities. The examined scales of *T. pinivora* are conspicuous because of their dark proximal part. On the other hand, dark colour could not be observed on some scales, when taken from the base of the egg batches. In *T. bonjeani* the brown colour could be seen to be spread from the proximal to the distal part of the scales - only the distal end was lighter. Some black colour could also be found on *T. pityocampa* scales from Algeria and Bulgaria. The scales of *T. wilkinsoni*

*Table 2 - Mean length and width, standard deviation and number (n) of scales taken from the base, middle and the top of the egg batches. Significance to the corresponding value (length resp. width) of the scales from the middle of the egg batches: *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, ns = not significant.*

	from base of egg batches			from middle of egg batches			from top of egg batches		
	length [mm]	width [mm]	n	length [mm]	width [mm]	n	length [mm]	width [mm]	n
T. processionea FRG	0.55 ±0.15***	0.11 ±0.03***	36	0.73 ±0.17	0.15 ±0.04	52	0.78 ±0.17^{ns}	0.14 ±0.03^{ns}	36
T. pinivora UdSSR	1.58 ±0.25^{ns}	0.71 ±0.16**	29	1.62 ±0.18	0.81 ±0.17	169	1.71 ±0.19**	0.72 ±0.21**	30
T. bonjeani Algeria	1.47 ±0.19***	0.63 ±0.17***	26	1.74 ±0.27	0.85 ±0.20	87	1.58 ±0.19**	0.67 ±0.12***	26
T. wilkinsoni Israel	2.22 ±0.32**	1.60 ±0.43^{ns}	29	2.38 ±0.30	1.59 ±0.29	538	2.24 ±0.25*	1.36 ±0.27***	33
T. pityocampa Bulgaria	2.84 ±0.36***	1.23 ±0.27***	27	3.07 ±0.30	1.52 ±0.22	171	2.62 ±0.30***	1.35 ±0.23***	28
T. pityocampa GR/Kassandra	2.39 ±0.29***	1.41 ±0.27*	18	2.77 ±0.22	1.58 ±0.15	50	2.43 ±0.30***	1.49 ±0.22^{ns}	21
T. pityocampa GR/Kalogria	2.44 ±0.40**	2.01 ±0.39^{ns}	14	2.75 ±0.32	1.83 ±0.27	98	2.60 ±0.31^{ns}	1.61 ±0.23**	15
T. pityocampa GR/Taigetos	2.39 ±0.32***	1.60 ±0.36^{ns}	25	2.97 ±0.33	1.74 ±0.28	84	2.79 ±0.32*	1.42 ±0.31***	27
T. pityocampa DZ/Tipasa	2.29 ±0.33***	1.40 ±0.18***	30	2.81 ±0.25	1.72 ±0.26	120	2.58 ±0.23***	1.36 ±0.18***	28
T. pityocampa DZ/Chrea	1.96 ±0.31***	1.04 ±0.24***	35	2.69 ±0.34	1.29 ±0.25	131	2.39 ±0.32***	1.07 ±0.36***	34
T. pityocampa MA/Q. Chervat	2.22 ±0.22***	1.51 ±0.41*	34	2.88 ±0.28	1.65 ±0.24	332	2.56 ±0.27***	1.47 ±0.24***	38
T. pityocampa MA/Tizi Ifri	2.68 ±0.22***	1.68 ±0.38^{ns}	12	3.22 ±0.28	1.46 ±0.14	96	2.83 ±0.28***	1.57 ±0.11*	12

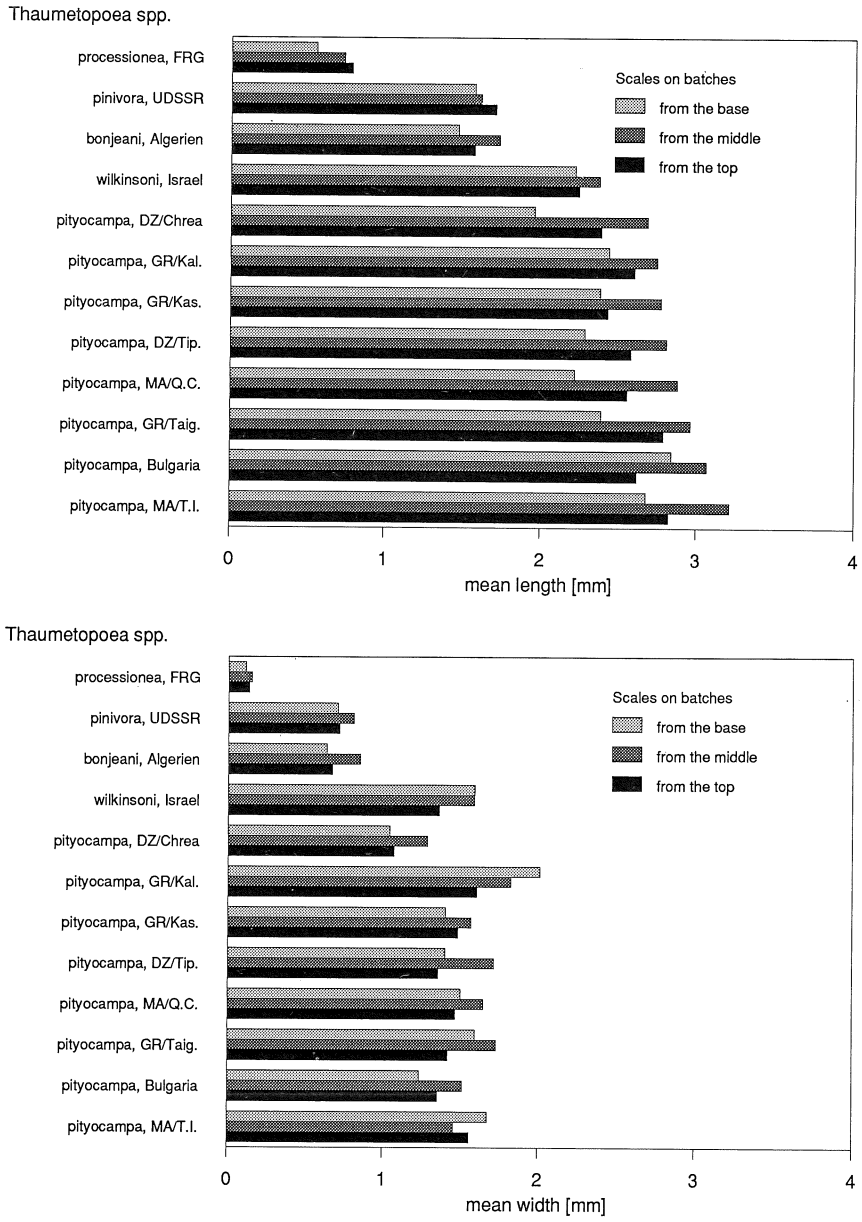

Fig. 3 - Mean length and width of scales taken from the base, middle and the top of the egg batches. For standard deviation compare Table 2.

and *T. pityocampa* from Marocco were without black spots; they are light yellowish brown in colour.

The shape and size of the scales differed within the investigated species, too. The mean length and width of scales taken from egg batches from different locations is presented in Table 2. For a better comparison the mean values are given graphically in Fig. 3.

The smallest and most pointed scales could be found in *T. processionea*. The scales of *T. pinivora* and *T. bonjeani* are somewhat larger and also pointed, but differed clearly from those of *T. wilkinsoni* and *T. pityocampa*, which, on an average, were always longer than 2 mm and wider than 1 mm.

In *T. wilkinsoni* the scales were wider – sometimes almost round. A small pointed projection could be noticed at the middle of the distal end of each scale (comp. Fig. 1 and 2).

Some of the scales of *T. pityocampa* were pear-shaped. The projection at the distal end was shorter than in *T. wilkinsoni*. The longest scales of all the studied material were found in *T. pityocampa* from Marocco and the widest from the same species collected in Greece (Kalogria).

As shown in Fig. 2 and 3 and Table 2 large differences in the scales could be found not only between different species from various localities but also within the scales from the same egg batch. In all cases, the scales from the base of the egg batches were the smallest. That means, the eggs laid at first are covered with smaller scales than the later ones. When examined, the scales on the ventral and dorsal part of the anal tuft were smaller, whereas those from the middle were comparatively larger. In most cases, the last laid eggs were also covered with smaller scales except in *T. processionea* and *T. pinivora*. In both species the longest scales were found at the top of the egg batches. Because the scales from the middle part of the egg batches were more homogenous, it was justifiable to take such scales for an inter- and intraspecific comparative study.

Table 3 demonstrates the significance within the means of the length and width of the scales from the middle of the egg batches.

3. Relations between length and width of the scales

A graphic presentation of the length against the width of the scales from the middle part of the egg batches of *Thaumetopoea* species from different regions could present the clear differences within scales. Fig. 4 shows the characteristic groups of plots.

Because *T. processionea* has the smallest scales, the plots are found in the lower left corner of the diagram. In *T. bonjeani* the width is as long as the half of the length. The group of plots lie almost in the same place as in *T. pinivora*.

*Table 3 - Significance within the means of the length (upper triangle) and the width (lower triangle) of the scales taken from the middle of the egg batches: *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, ns = not significant.*

	processionea FRG	*pinivora* UdSSR	*bonjeani* Algeria	*wilkinsoni* Israel	*pityocampa* Bulgaria	*pityocampa* GR/Kass.	*pityocampa* GR/Kal.	*pityocampa* GR/Taig.	*pityocampa* DZ/Tip.	*pityocampa* DZ/Chrea	*pityocampa* MA/Q.C.	*pityocampa* MA/T.I.
	length											
T. processionea FRG		***	***	***	***	***	***	***	***	***	***	***
T. pinivora UdSSR	***		***	***	***	***	***	***	***	***	***	***
T. bonjeani Algeria	***	ns		***	***	***	***	***	***	***	***	***
T. wilkinsoni Israel	***	***	***		***	***	***	***	***	***	***	***
T. pityocampa Bulgaria	***	***	***	***		***	***	*	***	***	***	***
T. pityocampa GR/Kassandra	***	***	***	ns	*		ns	***	ns	*	*	***
T. pityocampa GR/Kalogria	***	***	***	***	***	***		***	ns	***	***	***
T. pityocampa GR/Taigetos	***	***	***	***	***	***	*		***	***	*	***
T. pityocampa DZ/Tipasa	***	***	***	***	***	***	**	ns		***	*	***
T. pityocampa DZ/Chrea	***	***	***	***	***	***	***	***	***		***	***
T. pityocampa MA/Q. Chervat	***	***	***	***	***	**	***	**	*	***		***
T. pityocampa MA/Tizi Ifri	***	***	***	***	*	***	***	***	***	***	***	
	width											

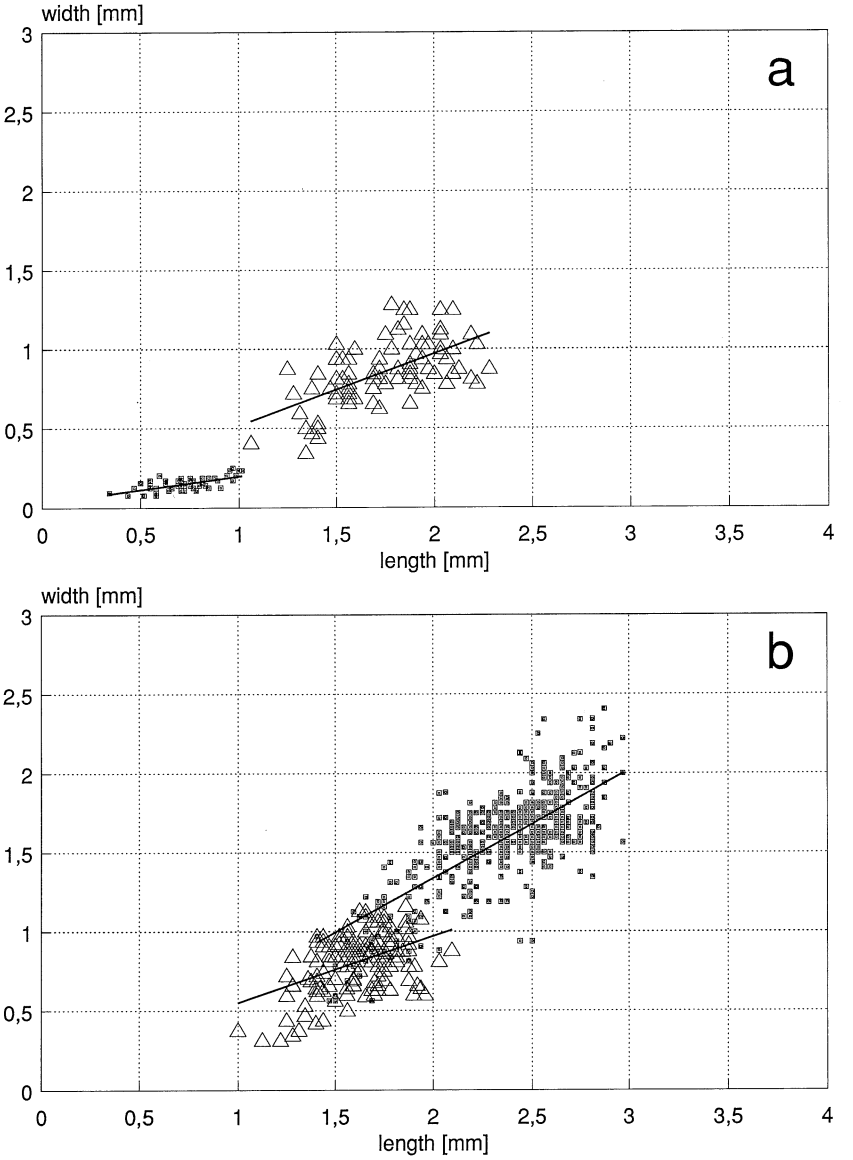

Fig. 4 - Plot diagram of length and width of scales taken from the middle of the egg batches. *Thaumetopoea* spp., regressions and correlation coefficients (r):

a - ■	*T. processionea*, D	y = 0.17x + 0.04	r = 0.63
△	*T. bonjeani*, DZ	y = 0.45x + 0.06	r = 0.61
b - ■	*T. wilkinsoni*, IL	y = 0.69x - 0.04	r = 0.72
△	*T. pinivora*, SU	y = 0.42x + 0.13	r = 0.45

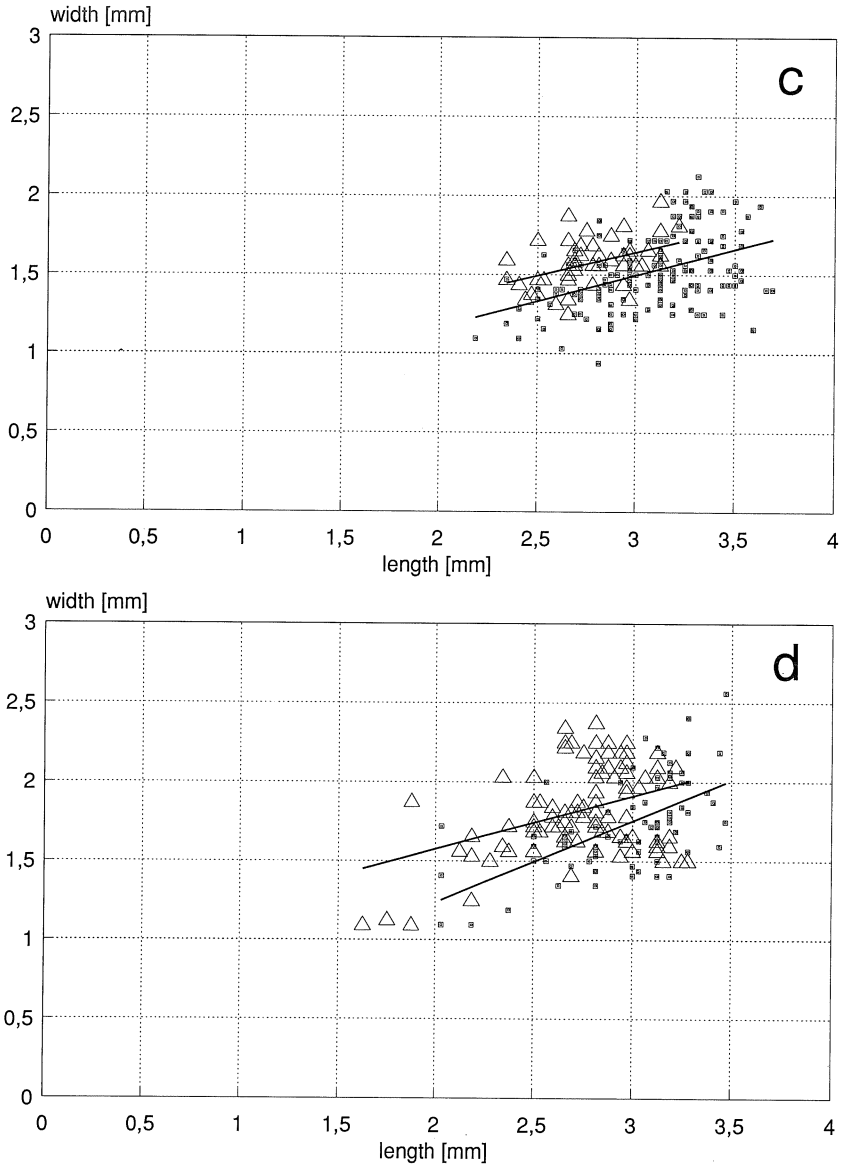

Fig. 4 - Plot diagram of length and width of scales taken from the middle of the egg batches. *Thaumetopoea* spp., regressions and correlation coefficients (r):

c - ■	*T. pityocampa*, BG	y = 0.33x + 0.50	r = 0.45
△	*T. pityocampa*, GR/Kas.	y = 0.30x + 0.74	r = 0.45
d - ■	*T. pityocampa*, GR/Taig.	y = 0.52x + 0.20	r = 0,61
△	*T. pityocampa*, GR/Kal.	y = 0.34x + 0.90	r = 0.40

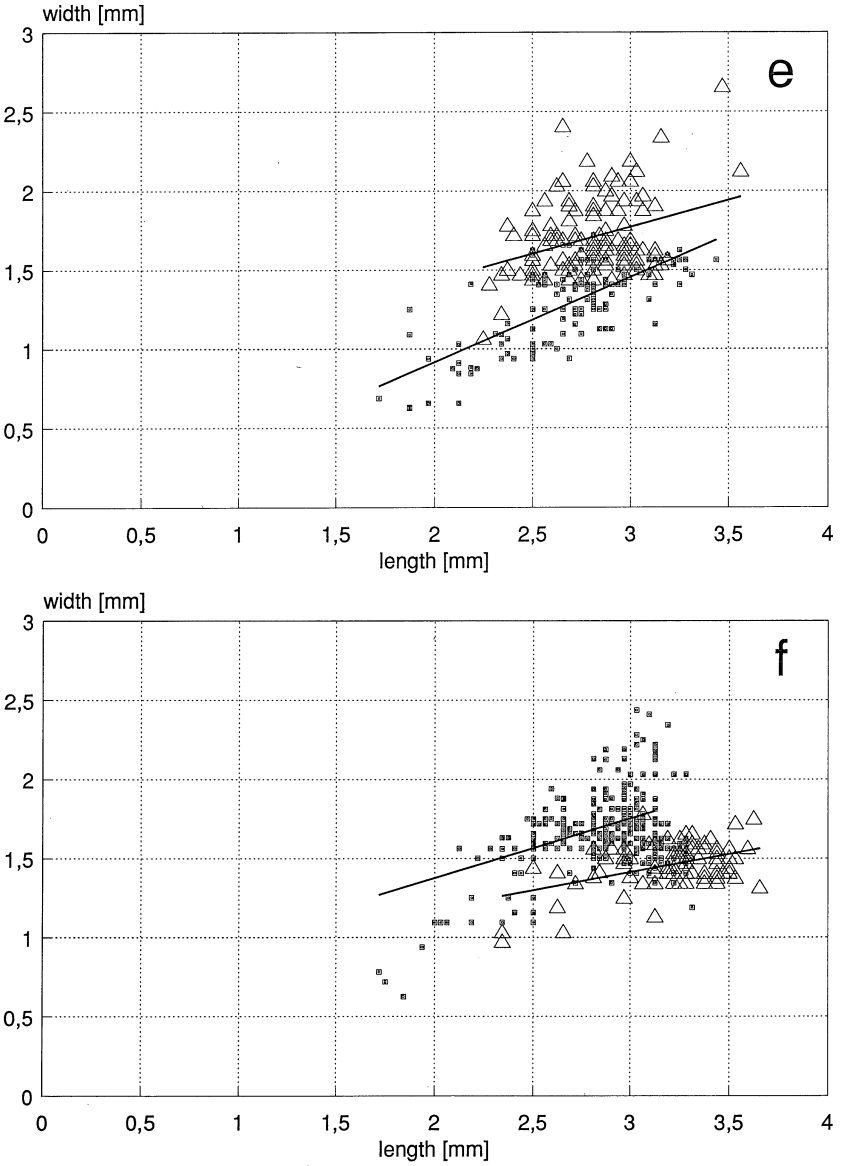

Fig. 4 - Plot diagram of length and width of scales taken from the middle of the egg batches. *Thaumetopoea* spp., regressions and correlation coefficients (r):

e - ■	*T. pityocampa*, DZ/Chrea	y = 0,53x – 0.13	r = 0.73
△	*T. pityocampa*, DZ/Tipasa	y = 0.34x + 0.75	r = 0.33
f - ■	*T. pityocampa*, MA/Q.C.	y = 0.33x + 0.70	r = 0.40
△	*T. pityocampa*, MA/T.I.	y = 0.23x + 0.72	r = 0.47

Interestingly enough, the plots in case of *T. processionea, T. bonjeani, T. pinivora* and *T. wilkinsoni* lie on the regression line, y = 0.87 x - 0.52. The correlation coefficient is r = 0.92.

Although there are some differences in *T. pityocampa* from various locations, the groups of plots were found still to overlap. These groups are located slightly to the right of those from *T. wilkinsoni*, i.e. most of the scales, on an average, have the same width but are slightly longer than in *T. wilkinsoni*.

Though the observed materials in case of *T. pityocampa* originating from different regions, the slopes of the regression lines were still somewhat similar (m = 0.30 - 0.34). Only the materials from the higher altitudes (GR/Taigetos, DZ/Chrea, MA/Tizi Ifri) showed a higher or lower coefficient (m = 0.52, 0.53, 0.23). The measured values of Algerian and Maroccan samples lay slightly lower, as compared to those from other regions.

DISCUSSION

Our investigation on the egg scales of 12 different populations of *Thaumetopoea* species showed differences in structure, shape and colour. The very small and pointed scales of *T. processionea* demonstrated that this species is least similar to the other species studied. This species laid the eggs on *Quercus*, whereas the other species prefer coniferous trees (e.g. *Pinus, Cedrus*).

The scales of the egg batches of *T. pinivora* and *T. bonjeani* were very similar in size and shape; in both species they were relatively small. The colour of the scales of *T. bonjeani* also showed some similarities to *T. pinivora* although the colour and structure of the egg batches of both species were different. This may be due to the oviposition on needles in *T. pinivora* and on twigs in *T. bonjeani*. These investigations on the scales of the egg batches also confirm the postulations of Demolin (1987) that under systematic point of view *T. bonjeani* is near to *T. pinivora*.

The shape of the scales varied a lot within the populations of *T. pityocampa* from different regions. It could not be seen which parameter influences the shape of the scales: the altitude has no role on the shape and size of the scales, e.g. in the material from Greece (egg batches from Taigetos when compared to those from Kalogria and/or Kassandra). This is also not to be expected because in higher regions the caterpillars hatch earlier in the fall than in lower areas governed by higher temperatures. Thus, the stronger and longer winter does not influence the embryonic development of the eggs, either covered with longer scales or smaller ones.

On the other hand, the species in which the hatching of the caterpillars takes

place in summer or spring, the scales are smaller and are not so wide as those in «winter» species (Demolin, 1987).

The scales of the egg batches of *T. pityocampa* from higher altitudes in Marocco and Algeria showed even a smaller width than those of comparable populations from sea level. These scales were taken from egg batches deposited on the twigs of *Cedrus*.

The scales of *T. wilkinsoni* are conspicuous because of the more or less round shape and small projection at the distal end. But such characteristics could also be found in case of *T. pityocampa*: the scales of this species from Marocco at sea level showed some similarities to those of *T. wilkinsoni* (comp. Fig. 2). This demonstrates the close relationship between these two species. Still, there is an interesting difference: the scales of *T. wilkinsoni* have more or less the same width as in *T. pityocampa*, the scales are but clearly shorter.

The results demonstrated that the morphology of the egg batches and the shape of the scales, though, can differ from locality to locality within the same species, the differences, cited above, are good enough to differentiate one species from the other. For taxonomic studies the scales from the middle of the egg batches would be suitable because of their more uniform and often representative typical form.

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