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FORMATION OF PATTERN AND DIAGNOSTIC INSTAR FEATURES OF THE HEAD IN CATERPILLARS FROM GENUS *PERIDEA* OF (LEPIDOPTERA, NOTODONTIDAE)

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Formation of Pattern and Diagnostic Instar Features of the Head in Caterpillars from Genus *Peridea* (Lepidoptera, Notodontidae). Dolinskaya I. V. — Pattern and colouration of caterpillar head of all larval instar of 7 species from genus *Peridea* Stephens, 1828 are studied. Formation of caterpillar head pattern in ontogenesis is discussed. Diagnostic characters, both specific and larval instars, are recorded for the first time. Key to species according to larval instars is given. Evidently, only larvae of the 1st instar demonstrate different directions in the pattern formation. This characteristic can be used for clearing of taxonomic relations in the genera and on the earliest ontogenetic stages (1st larval instar) only. In the following (2nd–5th) instars, the pattern became more or less of the same type. It depends on stripes shape or colouration only and can serve as good specific diagnostic character. To determine larval instar, both width of the head capsule and head pattern should be taken into account.

Key words: Notodontidae, *Peridea*, caterpillars, morphology, instars, head pattern, diagnostic characters.

Формирование рисунка и диагностико-возрастные особенности головы гусениц рода *Peridea* (Lepidoptera, Notodontidae). Долинская И. В. — Исследованы окраска и рисунок головы гусениц всех возрастов 7 видов Notodontidae рода *Peridea* Stephens, 1828. Показано формирование рисунка головы гусениц в процессе онтогенеза. Выделены диагностические, как видовые, так и возрастные признаки. Приведена таблица для определения видов по возрастам. Установлено, что различную направленность формирования рисунка можно наблюдать лишь у гусениц 1-го возраста. Этот признак может быть использован для выяснения родственных взаимоотношений внутривидовых таксонов и лишь на ранних стадиях онтогенеза (1-го возраста гусениц). В последующих (2-м–5-м) возрастах рисунок более или менее однотипен. Он связан лишь с формой или окраской полос и может служить надежным диагностическим признаком для видов. Для определения возраста гусеницы, помимо ширины головной капсулы, необходимо учитывать также и рисунок головы.

Ключевые слова: Notodontidae, *Peridea*, гусеницы, морфология, возраст, рисунок головы, диагностические признаки.

Introduction

Notodontid larvae were insufficiently known till now, consequently many taxonomic problems remained questionable. The classification on generic and supergeneric level was undertaken by Miller, 1991, while the lower taxons are still poorly studied. Also, such obscurities about the diagnostic characters (in particular, dried larval parts left after penetration of entomophages and caterpillars stored in alcohol for a long time) were the reason for making of this paper.

During the study I found out that the pattern of head capsule (as compared to the pattern of larval body) is more stable and therefore it is unique diagnostic character. Particular attention also should be paid to cuticular colouration which does not disappear after placing caterpillar into alcohol or being dried. Moreover, head capsule characters may be used for determination of broken caterpillars.

Thus, this paper represents results of investigations carried out by the author. Conclusions contain information useful for elucidating both theoretical and applied entomological problems.

For entomologists of biological, agricultural, plant-protection scientific institutions, and for zoologists need to determine separate parts of insect bodies.

Material and methods

The work is based on original material collected by author on the territory of Ukraine and Russian Far East (Primorski Krai). Eggs were obtained from females captured in the field. Hatched larvae were reared to pupae. The head capsules left after moulting of caterpillars and fresh material stored in alcohol were studied.

Larvae of 7 palaeartic species from genus *Peridea* Stephens, 1828: *P. anceps* (Goeze), *P. lativitta* (Wileman), *P. elzet* Kiriakoff, *P. gigantea* Butler, *P. oberthueri* (Staudinger), *P. moltrechti* (Oberthür) and *P. graeseri* (Staudinger) out of 18 species recorded for Palaeartic region (Schintlmeister, 2008) were examined.

Results

Pattern of larval head capsule of noctuid moths only was studied in more details (Beck, 1960; Merzheevskaya, 1967). Such studies on notodontid larvae were not carried out at all. There are only partial data on colouration of head in notodontid larvae (Dolinskaya, Plushch, 2003).

I discovered that epicranial pattern in notodontid larvae is not constant and varied in different instars. I think that head capsule's pattern of the investigated larvae from genus *Peridea* is directed in two ways.

First way. On the general light ground colour of the head, expressed as hypodermal colouration, dark cuticular stripes are formed.

In the **1st instar**, germ of the lateral stripe is already formed and looked like slight obscuration located either at the area of occipital parademe (*P. gigantea*, *P. elzet*, fig. 1, 1, 2) or both at the occipital parademe and apical part of the head (*P. anceps*, *P. lativitta*, fig. 1, 3–6).

It should be noted that, according to my observations, some peculiarities in formation of epicranial pattern in *P. oberthueri* (e. g., distinct enough obscuration extended particularly to its apical part, fig. 1, 7) may be considered as potential submedial and lateral stripes.

In the **2nd instar**, submedial and lateral stripes are already formed, although the first one is slightly expressed yet, light brown, narrow. However, in *P. oberthueri* this stripe is dark brown, wide, broadened into its apical part (fig. 2, 1).

Lateral stripe is brown, equally-broadened. It tends to become narrower in the disposition of occipital parademe. Such character is presented in the final instars and expressed mostly in *P. oberthueri* and *P. lativitta* (fig. 2, 2, 3). Stripes join together in apical part (*P. oberthueri*, *P. lativitta*, *P. gigantea*, fig. 2, 2–4) or both in apical and proximal areas (*P. elzet*, fig. 2, 5). Sometimes they are separate (*P. anceps*, fig. 2, 6) that is typical in the final instars.

In the **3rd instar**, submedial stripe becomes expressed more distinctly, brown or dark brown. The main modifications take place in the structure of lateral stripe. It becomes shorter and narrower in occipital parademe, while before it was broadened in the areas of stemmata, genae and postgenae. At the same time, this stripe becomes non-uniform, in the area of stemmata it is light brown or orange (*P. anceps*, *P. lativitta*, fig. 3, 1, 2).

In this instar, pattern typical for the final instars is already formed. Lateral stripe is kept dark brown only along the lower edge of its broadened part and in its narrower part. The rest area becomes light brown or orange brown (*P. gigantea*, *P. elzet*, fig. 3, 3, 4). However, it should be noted that above mentioned type of pattern was sometimes recorded also in preceding type characteristic for *P. anceps* and *P. lativitta*.

Concerning *P. oberthueri* it should be noted that in this species the elements of pattern character for preceding instar are kept. The stripes become narrower, submedial stripe is elongated, and widening in apical part disappear (fig. 3, 5, 6).

In the **4th** and **5th instars**, the above mentioned pattern is monotypic. Modifications are associated with the shape and colouration of the lateral stripe only. Its narrow part becomes shorter, light ground-colour extends completely on the whole broadened part (*P. anceps*, *P. lativitta*, fig. 4, 1, 2).

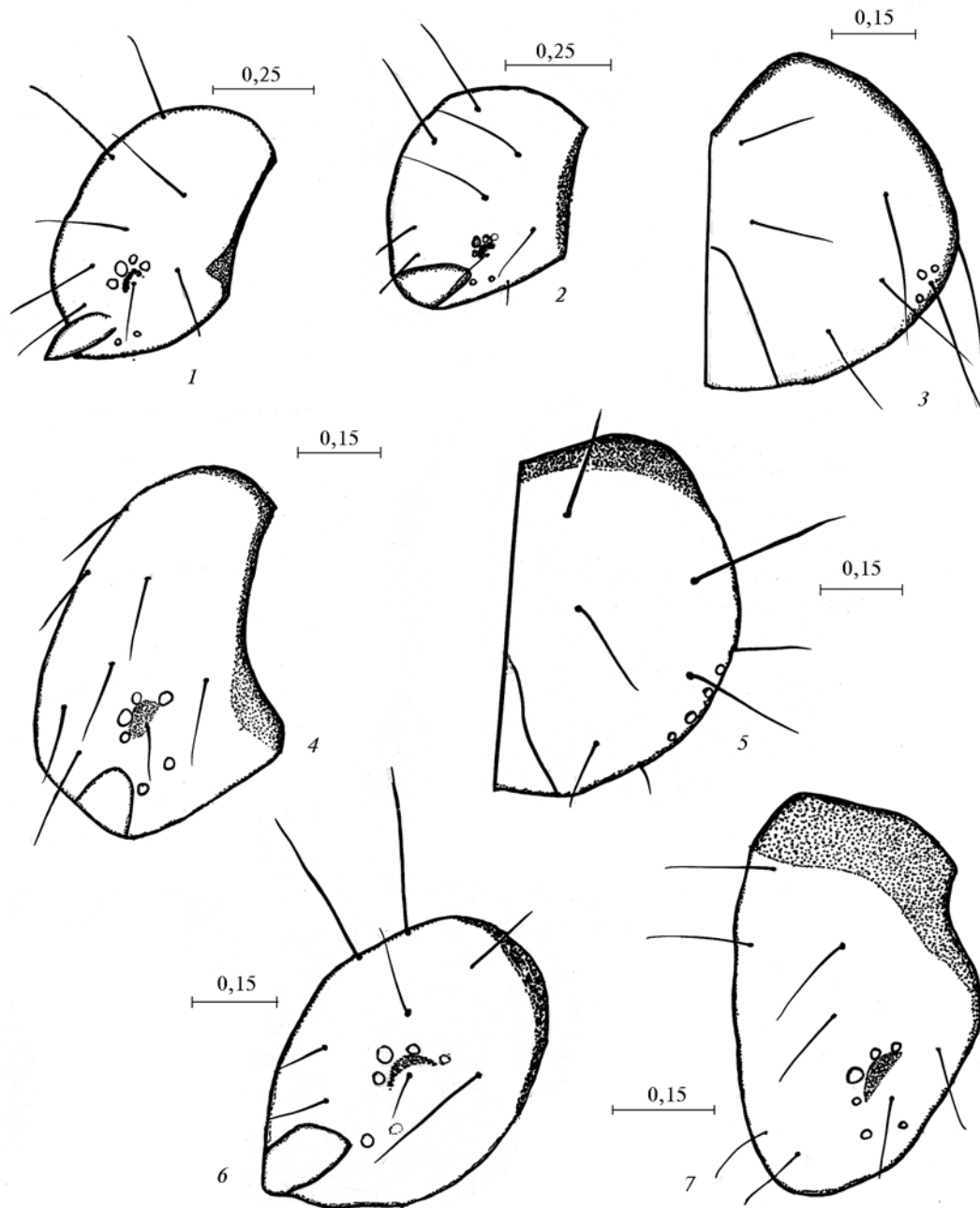


Fig. 1. Head pattern of the 1st instar caterpillar: 1 — *P. gigantea*, lateral view; 2 — *P. elzet*, lateral view; 3 — *P. anceps*, frontal view; 4 — *P. anceps*, lateral view; 5 — *P. lativitta*, frontal view; 6 — *P. lativitta*, lateral view; 7 — *P. oberthueri*, lateral view.

Рис. 1. Рисунок головы гусениц 1-го возраста: 1 — *P. gigantea*, вид сбоку; 2 — *P. elzet*, вид сбоку; 3 — *P. anceps*, вид спереди; 4 — *P. anceps*, вид сбоку; 5 — *P. lativitta*, вид спереди; 6 — *P. lativitta*, вид сбоку; 7 — *P. oberthueri*, вид сбоку.

In *P. oberthueri* in the 4th instar, lateral stripes are modified noticeably. Dark brown colouration is presented only along the lower and upper edges, while in the middle it becomes orange-brown (fig. 4, 3). In the 5th instar in *P. oberthueri*, the pattern is identical, however, stripes are narrower and lateral stripe is shortened in its narrow part (fig. 4, 4).

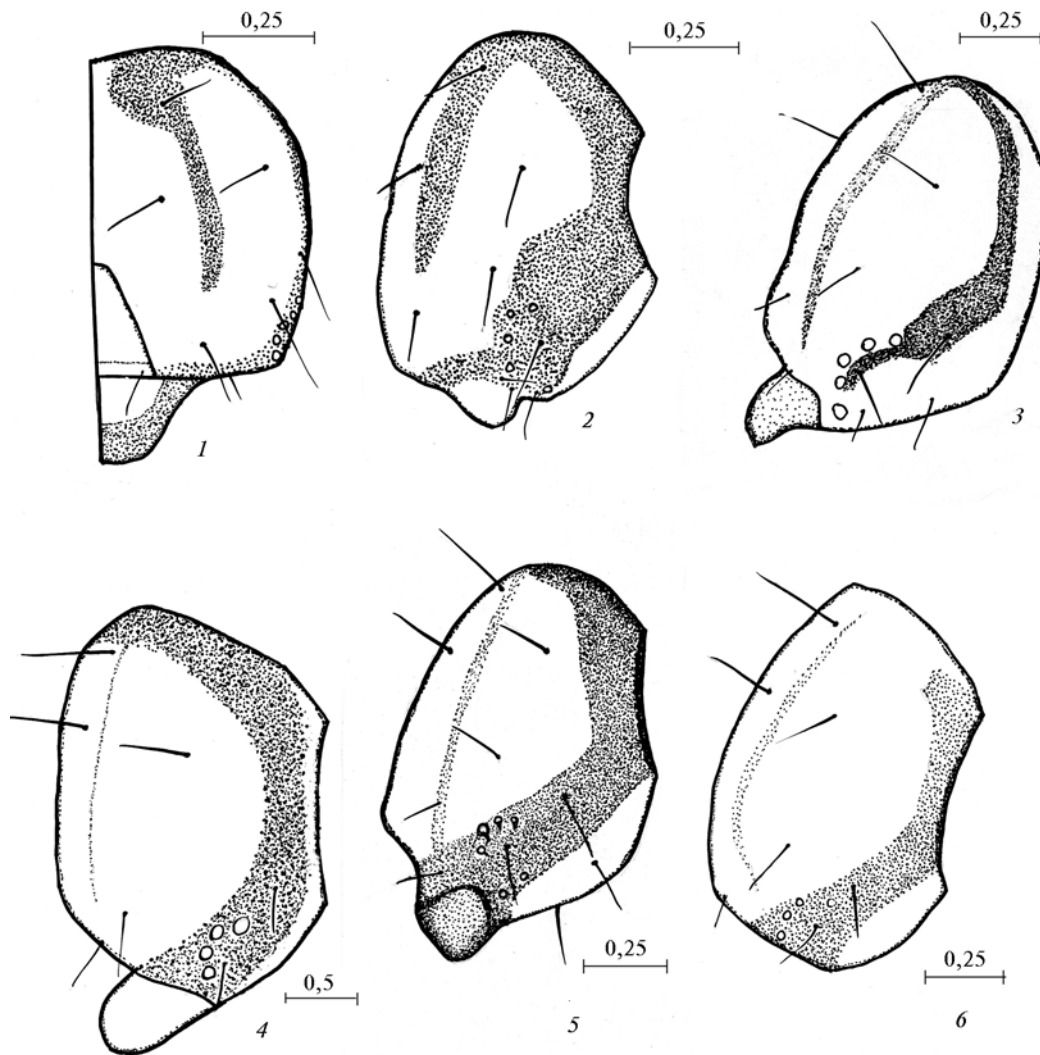


Fig. 2. Head pattern of the 2-nd instar caterpillar: 1 — *P. oberthueri*, frontal view; 2 — *P. oberthueri*, lateral view; 3 — *P. lativitta*, lateral view; 4 — *P. gigantea*, lateral view; 5 — *P. elzet*, lateral view; 6 — *P. anceps*, lateral view. Scale bars: 1–3, 5, 6 — 0.25 mm, 4 — 0.5 mm.

Рис. 2. Рисунок головы гусениц 2-го возраста: 1 — *P. oberthueri*, вид спереди; 2 — *P. oberthueri*, вид сбоку; 3 — *P. lativitta*, вид сбоку; 4 — *P. gigantea*, вид сбоку; 5 — *P. elzet*, вид сбоку; 6 — *P. anceps*, вид сбоку. Масштабные линейки: 1–3, 5, 6 — 0,25 мм, 4 — 0,5 мм.

The remaining species mainly have the same pattern as that in preceding instar (fig. 4, 5).

Second way. General dark ground-colour of the head expressed as cuticular colouration, transforms into submedial and lateral stripes. It is typical for two species — *P. graeseri* and *P. moltrechti*. Each of them differs by specific characters associated with pattern formation.

In the **1st instar**, the head capsules in both species are mainly brown. Also, the different degree of the pattern formation is observed. For example, in *P. graeseri* submedial and lateral stripes are fused, however prototype of the lateral stripe is visible (fig. 5, 1, 2). In *P. moltrechti*, prime separation of submedial and lateral stripes fused in the apical part takes place, and prototype of submedial stripe is developed in the medial part (fig. 5, 3–5).

In the **2nd instar**, head colouration in both species becomes lighter because of decrease of the brown ground-colour, and after all it is of brownish-yellowish or brown-

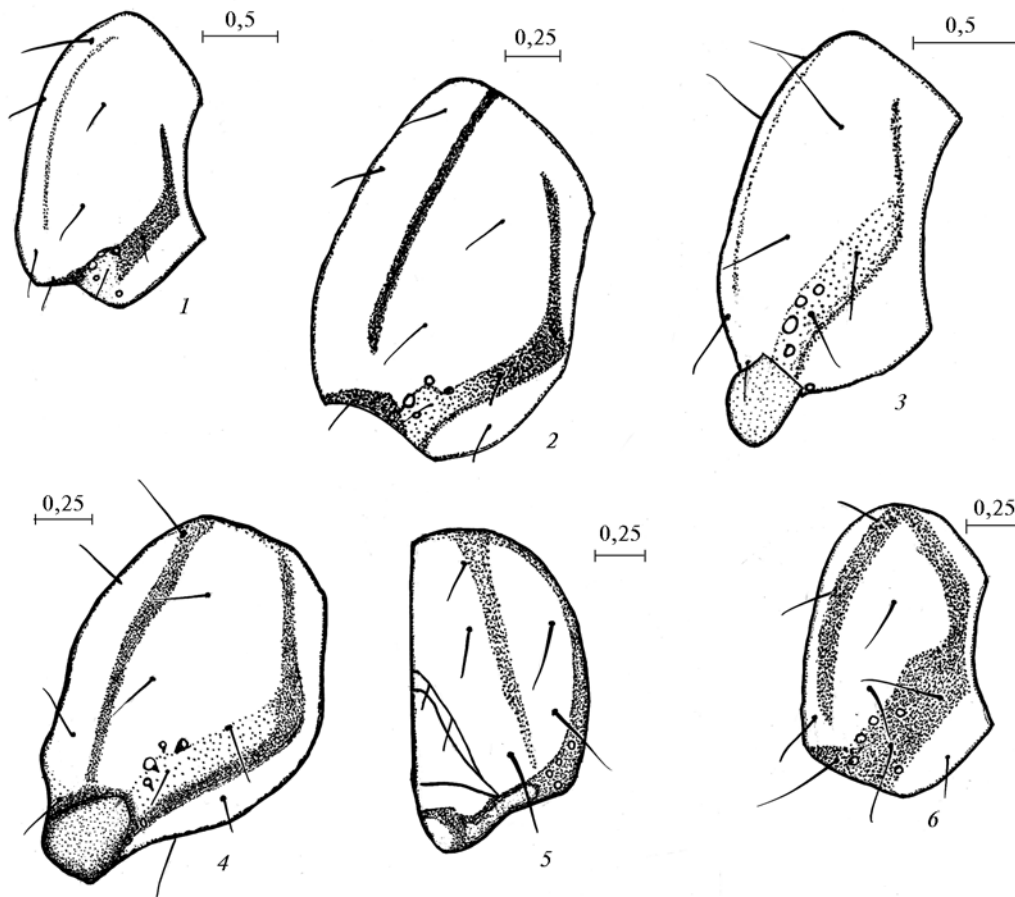


Fig. 3. Head pattern of the 3-rd instar caterpillar: 1 — *P. anceps*, lateral view; 2 — *P. lativitta*, lateral view; 3 — *P. gigantea*, lateral view; 4 — *P. elzet*, lateral view; 5 — *P. oberthueri*, frontal view; 6 — *P. oberthueri*, lateral view.

Рис. 3. Рисунок головы гусениц 3-го возраста: 1 — *P. anceps*, вид сбоку; 2 — *P. lativitta*, вид сбоку; 3 — *P. gigantea*, вид сбоку; 4 — *P. elzet*, вид сбоку; 5 — *P. oberthueri*, вид спереди; 6 — *P. oberthueri*, вид сбоку.

ish-greenish colour. In *P. graeseri*, the light part extended till apical part of the head (fig. 6, 1). Submedial and lateral stripes are not separated yet (fig. 6, 2). In *P. moltrechti* broad submedial and lateral stripes are already formed and fused in the apical part. Stripes are often covered with light spots (fig. 6, 3). At the same time, submedial stripe is already replaced aside from medial part and rather elongated (fig. 6, 4). Evidently, pattern in the second species is formed quicker.

In the **3rd instar** in *P. graeseri*, the main dark ground colour divided into submedial and lateral stripes. Stripes in their apical parts are already separated while in proximal part they are jointed. Submedial stripe is broad, wavy, light brown in colour (fig. 7, 1). Lateral stripe is brown everywhere, dark brown and short from the beginning of the upper part of occipital parademe (fig. 7, 2).

Interesting, that in this instar, a type of pattern transitional between preceding instar (where stripes are not separated yet) and pattern of the mature larvae is observed. In this case, it is visible how these stripes are formed from the mutual dark ground-colour. Lateral stripes are already separated while submedial one is represented as branched area on the whole frontal part (fig. 7, 3). Larvae of *P. moltrechti* in this instar were not examined because of the lack of material.

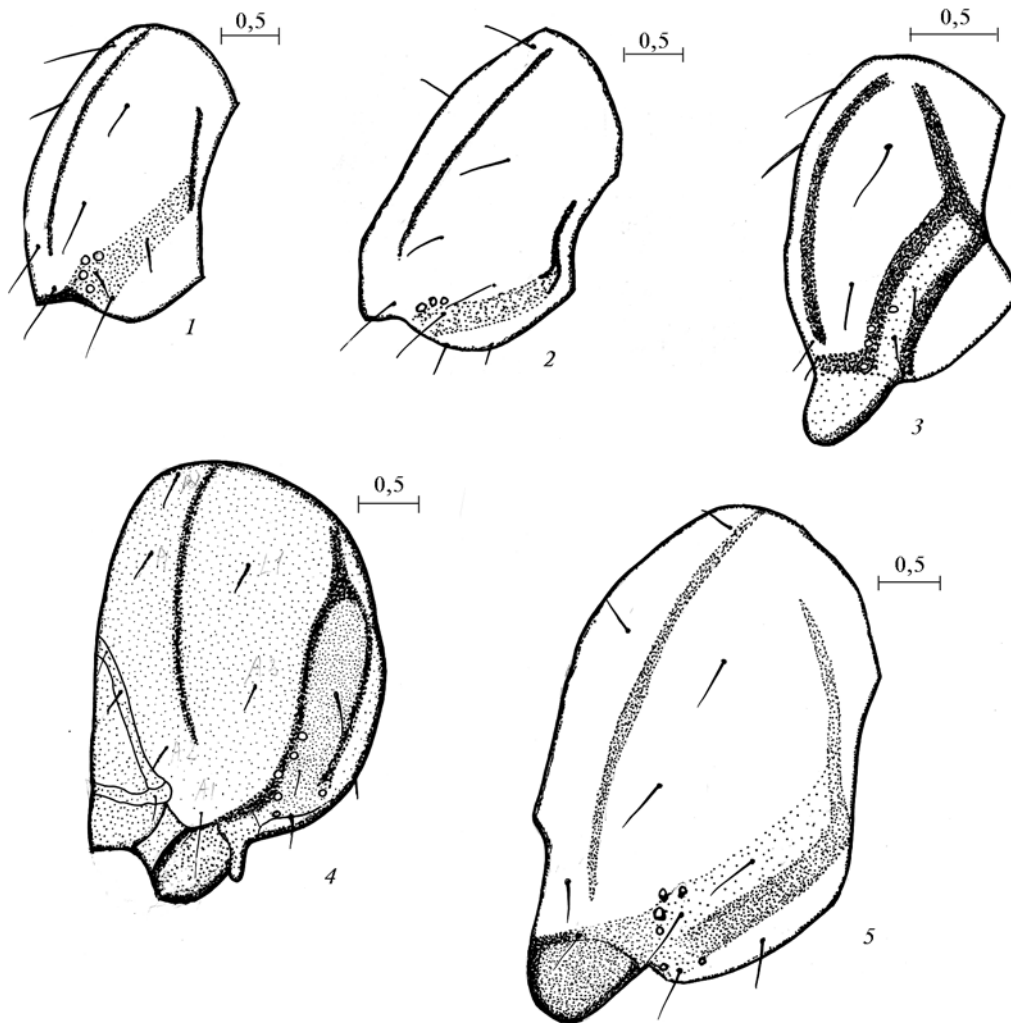


Fig. 4. Head pattern of the 4th-5th instars caterpillar: 1 — *P. anceps*, 4-th instar, lateral view; 2 — *P. lativitta*, 4-th instar, lateral view; 3 — *P. oberthueri*, 4-th instar, lateral view; 4 — *P. oberthueri*, 5-th instar, lateral view; 5 — *P. elzet*, 5-th instar, lateral view.

Рис. 4. Рисунок головы гусениц 4-5-го возрастов: 1 — *P. anceps*, 4-й возраст, вид сбоку; 2 — *P. lativitta*, 4-й возраст, вид сбоку; 3 — *P. oberthueri*, 4-й возраст, вид сбоку; 4 — *P. oberthueri*, 5-й возраст, вид сбоку; 5 — *P. elzet*, 5-й возраст, вид сбоку.

In the **4th** and **5th instars**, the pattern is mainly of the same type. Submedial stripe in both species becomes slender, and in *P. graeseri* is more wavy (fig. 7, 4). Moreover, in the 4th and particularly in the 5th instar head sculpture looks like group of well developed tubercles. The latter are mostly distinct on the dark stripes. In *P. graeseri* they have the tint same as stripes (fig. 7, 5), while in *P. moltrechti* they are light and finely expressed (fig. 7, 6).

Determination of the larval instars is very important for larval diagnostic (Dyar, 1890; Keler, 1933). After my studies on the species from genus *Peridea* it is clear that the above mentioned characters should be used for determination of larval instars thanks to well expressed instar modifications (tabl. 1).

Table 1 shows that in the 1st instar the width of the head capsule in majority species varies from 0.57 mm to 1.0 mm. Only in *P. graeseri* it is greater — 1.25–1.4 mm that is correlated with the measurements of the 2-nd instar. In the 2-nd instar this cha-

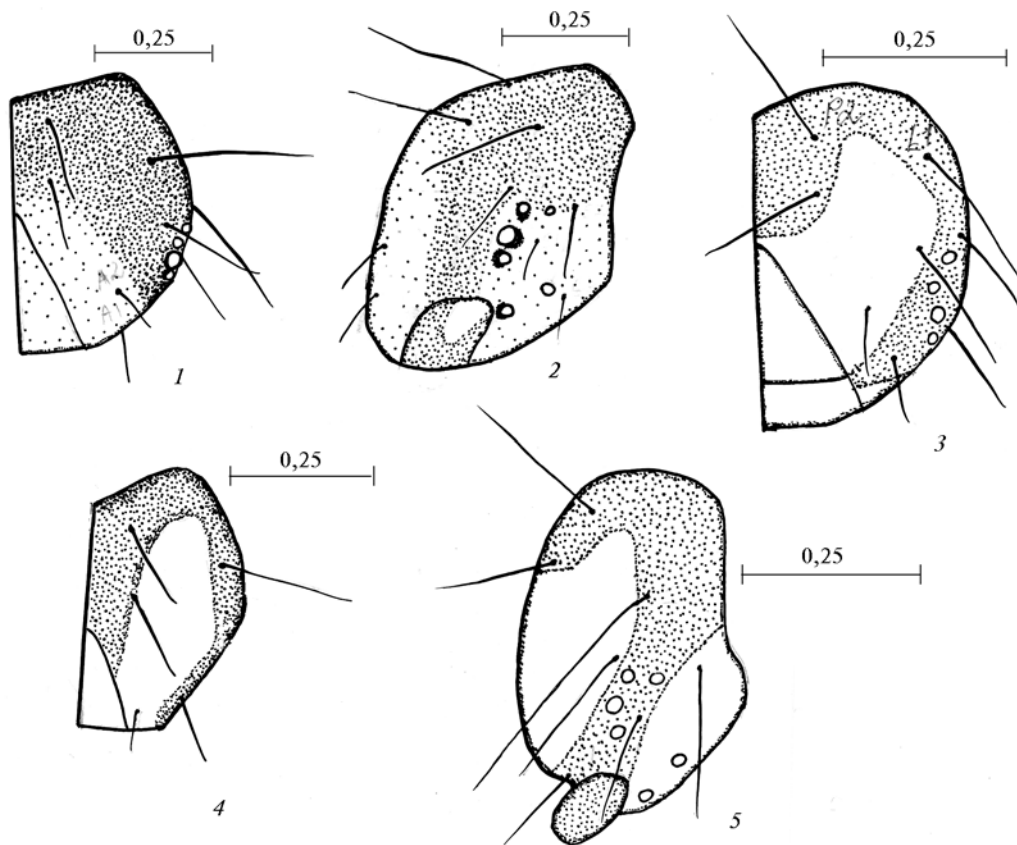


Fig. 5. Head pattern of the 1st instar caterpillar: 1 — *P. graeseri*, frontal view; 2 — *P. graeseri*, lateral view; 3 — *P. moltrechti*, frontal view; 4 — *P. moltrechti*, frontal view; 5 — *P. moltrechti*, lateral view.

Рис. 5. Рисунок головы гусениц 1-го возраста: 1 — *P. graeseri*, вид спереди; 2 — *P. graeseri*, вид сбоку; 3 — *P. moltrechti*, вид спереди; 4 — *P. moltrechti*, вид спереди; 5 — *P. moltrechti*, вид сбоку.

racter is 0.9–1.6 mm; in the 3-rd — 1.5–2.4 mm; in the 4th instar — 2.0–3.8 mm and in the 5th — 3.9–6.2 mm. The less size of the head capsule is in *P. oberthueri*.

Although the head width is a good character, it has some peculiarities. During the breeding of larvae, I observed several times that width of head capsule in larvae of one instar was smaller. It is also obvious from the table with the measurements of the 4th instar of *P. oberthueri*. I think that such situation may be due unfavourable conditions of life and development. Therefore it is necessary to pay attention to the head pattern also.

Table 1. Width of the head capsule in each larval instars in the genus *Peridea*

Таблица 1. Ширина головной капсулы по возрастам у гусениц рода *Peridea*

Species	Instars				
	1st	2st	3st	4-st	5st
<i>P. anceps</i> (Goeze)	0,8–0,9	1,4–1,6	2,0–2,4	3,7–4,5	5,1–5,6
<i>P. lativitta</i> (Wileman)	0,75–0,8	1,45–1,5	2,0–2,4	3,5–3,8	5,7–6,2
<i>P. elzet</i> Kiriakoff	0,65–0,7	1,15–1,3	1,9–2,0	2,6–3,7	4,8–5,1
<i>P. gigantean</i> Butler	0,75–1,0	1,3–1,5	2,0–2,1	2,8–3,8	4,25–4,7
<i>P. oberthueri</i> (Staudinger)	0,6–0,65	1,0–1,1	1,5–1,7	2,0–3,2 often 2,5–2,7	3,9–4,5
<i>P. moltrechti</i> (Oberthür)	0,57–0,6	0,9–1,5	—	3,4–3,7	4,8–5,1
<i>P. graeseri</i> (Staudinger)	1,25–1,4	1,5–1,6	2,0–2,4	3,3–3,5	4,9–5,4

Note. Extreme measurements in mm are shown in the table.

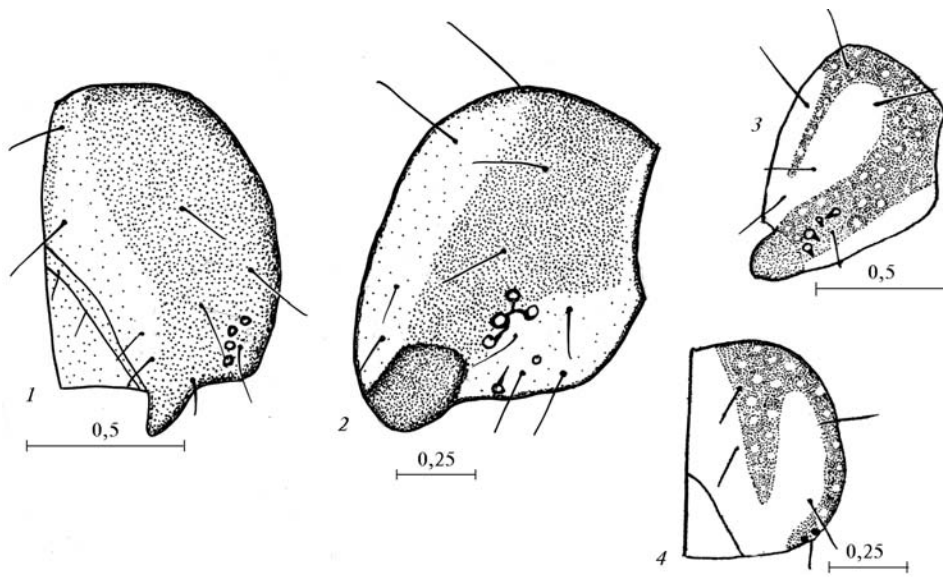


Fig. 6. Head pattern of the 2-nd instar Caterpillar: 1 — *P. graeseri*, frontal view; 2 — *P. graeseri*, lateral view; 3 — *P. moltrechti*, lateral view; 4 — *P. moltrechti*, frontal view.

Рис. 6. Рисунок головы гусениц 2-го возраста: 1 — *P. graeseri*, вид спереди; 2 — *P. graeseri*, вид сбоку; 3 — *P. moltrechti*, вид сбоку; 4 — *P. moltrechti*, вид спереди.

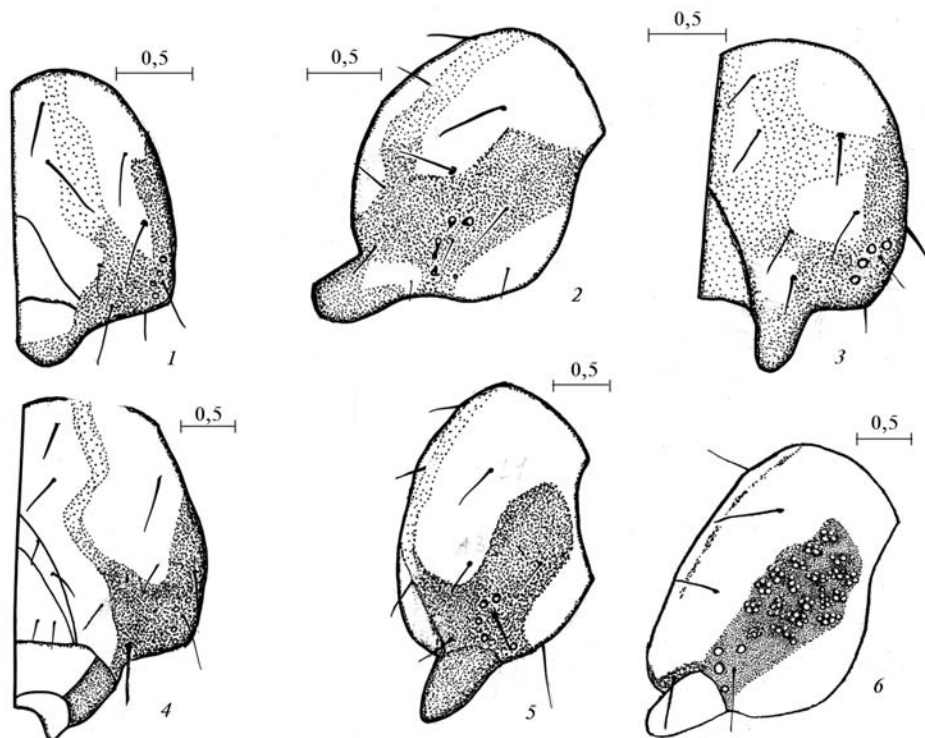


Fig. 7. Head pattern of the 3th-5th instars caterpillar: 1 — *P. graeseri*, 3-th instar, frontal view; 2 — *P. graeseri*, 3-th instar, lateral view; 3 — *P. graeseri*, 3-th instar, frontal view; 4 — *P. graeseri*, 4-th instar, frontal view; 5 — *P. graeseri*, 4-th instar, lateral view; 6 — *P. moltrechti*, 5-th instar, lateral view.

Рис. 7. Рисунок головы гусениц 3-5-го возрастов: 1 — *P. graeseri*, 3-й возраст, вид спереди; 2 — *P. graeseri*, 3-й возраст, вид сбоку; 3 — *P. graeseri*, 3-й возраст, вид спереди; 4 — *P. graeseri*, 4-й возраст, вид спереди; 5 — *P. graeseri*, 4-й возраст, вид сбоку; 6 — *P. moltrechti*, 5-й возраст, вид сбоку.

Key to *Peridea* species based on the characters of larval head**Таблица для определения видов рода *Peridea*****1st instar**

- 1 (4). Sizeable dark brown darkening covered setae P1, P2 and L1 in medial, apical and lateral areas.
- 2 (3). Dark brown darkening entirely covered stemmata 1–4 and seta A1 (fig. 5, 3, 5). Width of head is 0.57–0.6 mm. *P. moltrechti*
- 3 (2). Dark brown darkening covered only upper edge of stemmata 1–4. Seta A1 located in light brown area (fig. 5, 2). Width of head is 1.25–1.4 mm. *P. graeseri*
- 4 (1). Very small darkening located in the area of occipital parademe only or both occipital parademe and apical part of head. Setae P1, P2, L1 are not covered with dark brown darkening.
- 5 (8). Dark brown darkening located only in the area of occipital parademe.
- 6 (7). Darkening wedge-shaped broadened in lower part of occipital parademe (fig. 1, 1). Width of epicranium is 0.75–1.0 mm. *P. gigantea*
- 7 (6). Darkening is not broadened in lower part of occipital parademe (fig. 1.2). Width of epicranium is 0.65–0.7 mm. *P. elzet*
- 8 (5). Dark brown darkening located both in occipital parademe and apical part of head.
- 9 (10). Darkening is slightly visible in apical part and broadened in lower part of occipital parademe (fig. 1, 4). *P. anceps*
- 10 (9). Darkening in apical part is wider than that in occipital parademe area becoming narrower towards its lower part.
- 11 (12). Lower edge of darkening of apical part is above seta P2 (fig. 1, 7). Diameter of head capsule is 0.6–0.65 mm. *P. oberthueri*
- 12 (11). Lower edge of darkening is approximately on equal distance from seta P2 and upper edge of apical part of head (fig. 1, 5). Diameter of head capsule is 0.75–0.8 mm. *P. lativitta*

2nd instar

- 1 (12). Head capsule mostly light. Submedial and lateral stripes are distinct. Setae L1 and A3 are in light area.
- 2 (3). Submedial and lateral stripes fused in apical and proximal parts of head (fig. 2, 5). *P. elzet*
- 3 (2). Submedial and lateral stripes fused only in apical part of head or they are separated.
- 4 (5). Submedial and lateral stripes are separated in apical part of head (fig. 2, 6). *P. anceps*
- 5 (4). Submedial and lateral stripes fused in apical part of head.
- 6 (7). Lateral stripe in occipital parademe is broad, its edge lies near seta L1 (fig. 6, 3). *P. moltrechti*
- 7 (6). Lateral stripe in occipital parademe is not broad. Seta L1 is on considerable distance away from it.
- 8 (9). Submedial stripe is broadened in apical part, seta P2 is in stripe area (fig. 2, 1). *P. oberthueri*
- 9 (8). Submedial stripe is not broadened in apical part, seta P2 is out of stripe.
- 10 (11). Lateral stripe narrow in area of 1–4 stemmata and is under them (fig. 2, 3). *P. lativitta*
- 11 (10). Lateral stripe in area of stemmata is not narrowed, broad, covered stemmata 1–4 from both sides (fig. 2, 4). *P. gigantea*
- 12 (1). Head capsule mostly dark. Submedial and lateral stripes are not distinct. Setae A1 and A3 are in dark area (fig. 6, 1, 2). *P. graeseri*

3rd instar

- 1 (8). Lateral stripe is shortened, begins below level of seta P1 or between P1 and P2.
- 2 (3). Submedial stripe is wavy, broad. In proximal part fused with lateral stripe. The latter is broad all along, not narrowing in area of occipital parademe; its upper edge reached seta A3 (fig. 7, 1, 2). *P. graeseri*
- 3 (2). Submedial stripe straight, slender, not fused with lateral stripe in proximal part. Lateral stripe narrow, its upper edge noticeably not reached seta A3; narrowed in area of occipital parademe.
- 4 (5). Lateral stripe dark brown in its narrowing part and along lower edge of broadened part, whereas its upper part is light-brown or orange-brown (fig. 3, 3). *P. gigantea*
- 5 (4). Lateral stripe dark brown all along, and light brown or orange only in stemmata area (fig. 3, 1, 2).
- 6 (7). Submedial stripe dark brown. *P. lativitta*
- 7 (6). Submedial stripe brown. *P. anceps*
- 8 (1). Lateral stripe long, begins from level of seta P2 or raising until fused with submedial stripe.
- 9 (10). Lateral stripe non unicolored, dark brown in its lower part and light brown or orange-brown in its upper part (fig. 3, 4). *P. elzet*
- 10 (9). Lateral stripe unicolored, dark brown (fig. 3, 6). *P. oberthueri*

4th and 5th instars

- 1 (4). Lateral stripe broad, not narrowed in area of occipital parademe.
- 2 (3). Submedial stripe wavy. Groups of tubercles in area of dark-brown lateral stripe are of same as colour, indistinct (fig. 7, 4, 5). *P. graeseri*
- 3 (2). Submedial stripe straight. Groups of tubercles in area of dark brown lateral stripe are light brown, well expressed looking like light spots (fig. 7, 6). *P. moltrechti*

- 4 (1). Lateral stripe narrow in area of occipital parademe.
 5 (6). Broadened part of lateral stripe dark brown in its upper and lower edges, and light brown in the middle (fig. 4, 4) *P. oberthueri*
 6 (5). Broadened part of lateral stripe entirely light brown or dark brown in its lower edge.
 7 (8). Broadened part of lateral stripe entirely light brown (fig. 4, 1, 2). *P. anceps*, *P. lativitta*
 8 (7). Broadened part of lateral stripe dark brown in its lower edge (fig. 4, 5). *P. elzet*, *P. gigantea*

Discussion

According to the results of these investigations, I can state that the pattern of head capsule is not stable and varies depending of instars. Thus, all examined species from genus *Peridea* are characterized by the pattern represented by submedial and lateral stripes. Stripes are formed in two different ways. Such formation is expressed well in the 1st larval instar only.

In the first way, dark cuticular stripes formed on the general light ground colour of the head consists of hypodermal colouration. Such way is typical for *P. anceps*, *P. lativitta*, *P. elzet*, *P. gigantea* and *P. oberthueri*.

In the second way, formation of submedial and lateral stripes took place as a result of their separation from the common ground colour of the head, and this is characteristic for *P. moltrechti* and *P. graeseri*.

The stripes in *P. anceps*, *P. lativitta*, *P. elzet*, *P. gigantea* and *P. oberthueri* are represented as slight darkening, while the stripes in *P. moltrechti* and *P. graeseri* were already partly formed.

Based on the results of the above studies, I guess that *P. moltrechti* and *P. graeseri* are closer related as compared to the other five species.

Summarizing data presented in this paper, I think that only larvae of the 1st instar demonstrate different ways of the pattern formation. This sign can be used for clearing of taxonomic relations in the genera and in the earliest ontogenetic stages (1st larval instar) only. In the following (2nd–5th) instars, the pattern became more or less monotypical. It depends on stripes shape or colouration only and can serve as good diagnostic specific character.

It is clear, that for determination of larval instar it is necessary to take into account not only width of the head capsule, but head pattern as well.

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