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KEY TO THE SPECIES OF UKRAINIAN NOTODONTID MOTHS (LEPIDOPTERA, NOTODONTIDAE) ON THE EGG CHARACTERS

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Key to the Species of Ukrainian Notodontid Moths (Lepidoptera, Notodontidae) on the Egg Characters. Dolinskaya, I. V. — A key for identification of 39 species from 20 genera of Ukrainian notodontid moths based on the the eggs is provided. Reliable diagnostic characters, which do not disappear with the injury of eggs or eggs preserved for a long time in alcohol were used. The characters as egg shape, egg and chorion colour, shape of gnawed holes in eggs before setting out of caterpillars, the type of oviposition and the chorionic sculpture are applied. Clear characters that are typical for the live eggs, which vary in the process of egg development are revealed. These are characters of egg colour and pattern. In the key such characters are kept by stable signs that do not disappear after eggs traumatizing. The key is illustrated in details with photographs made using a digital camera and scanning electron microscope.
Key words: Lepidoptera, Notodontidae, egg, morphology, diagnostic characters, key, scanning electron microscopy, illustrations.

Introduction

The basis for paper writing was the preparation of a book on Notodontidae from the series Fauna of Ukraine. In order to identify the Notodontidae the first step should be eggs type determination. Macrolepidoptera eggs are of two types. These lying or bilateral symmetric eggs are typical for Geometridae, Saturniidae, Sphingidae, Lasiocampidae etc. and upright or radial symmetric eggs are typical for Notodontidae, Noctuidae, Erebidae, Nolidae, Rhopalocera and other (Döring, 1955; Hinton, 1981; Salkeld, 1984; Dolinskaya, 1990, 2014, 2016; Young, 2006; Nieves-Uribe et al., 2015, 2016 and others).

Most Notodontidae are characterized by a hemispherical egg shape and cellular sculpture of the chorion. In this paper we have tried in the first place to use characters that do not require high magnification optics. These are characrers as shape of the eggs, coloring eggs and chorion (persisting in living and fixed eggs), shape of gnawed holes in eggs before setting out of caterpillars, the type of oviposition. And of course one of the most reliable characters for the diagnosis of genera and species is a chorionic sculpture of the eggs. But for the observation of the last character requires special equipment. Not constant coloring of eggs in the key we use rarely, because it is varies throughout the development of the eggs. However, in some taxa such colouring and pattern are very characteristic and can be captured by the camera. In given cases, this character is accompanied by signs of shape or chorionic sculpture of the eggs. We were unable to identify reliable diagnostic characters that separate species *Clostera pigra* and *Clostera anachoreta*. However these two species are clearly differ in the colour and egg pattern that is typical only for living eggs.

Interestingly enough that belonging of species to *Cerura* or *Furcula* genera can be easily identified on the stage of egg than caterpillar, especially of early age.

Material and methods

This research is based on material collected in Ukraine. Eggs were obtained from females captured at light. Both dry egg chorions that were collected after hatching and fresh specimens fixed with alcohol were studied. Living eggs photographed in nature and laboratory conditions. The eggs were examined with the use of scanning electron microscopy (SEM). Color photos of some species notodontid eggs were kindly provided together with personal permission for publication by György Csóka (*Thaumetopoea processionea*), Paul Brothers (*Cerura vinula*), Wolfgang Wagner (*Ptilophora plumigera, Phalera bucephala*), Tymo Muus (*Harpyia milhauseri*), Paolo Mazzei (*Harpyia milhauseri*), Andrey Ponomarev (*Clostera anastomosis*) and Willi Wiewel (*Clostera pigra*, photo by Karl Rasch). Photo of the *Clostera anachoreta* eggs (photographer Olaf Beckmann) was taken from the web-site «Bestimmungshilfe für die in Europa nachgewiesenen Schmetterlingsarten". Description of the *Thaumetopoea processionea* oviposition is given according to J. A. Pascual (1988).

The characters of the eggs belonging to 39 notodontid species from the following genera were studied: *Cerura* Schrank, *Furcula* Lamarck, *Dicranura* Reichenbach, *Harpyia* Ochsenheimer, *Stauropus* Germar, *Drymonia* Hübner, *Notodonta* Ochsenheimer, *Peridea* Stephens, *Pheosia* Hübner, *Leucodonta* Staudinger, *Pterostoma* Germar, *Ptilodon* Hübner, *Odontosia* Hübner, *Ptilophora* Stephens, *Phalera* Hübner, *Spatalia* Hübner, *Gluphisia* Boisduval, *Pygaera* Ochsenheimer, *Clostera* Samouelle, *Thaumetopoea* Hübner. The systematic arrangement follows Schintlmeister (2008).

Results

Key to the Species of Ukrainian Notodontid Moths (Lepidoptera, Notodontidae) on the Egg Characters

1. Eggs laid in single-layer rectangular clusters (4–5 cm in length) and completely covered with anal scales female abdomen (fig. 1.1). ..... *Thaumetopoea processionea* (Linnaeus)
– Eggs laid in single-layer clusters, loose clusters or solitary. Oviposition open, eggs not covered with scales female abdomen. 2
2. Egg discoidal shape (figs 4.1, 4.2). 3
– Egg hemispherical shape (figs 4.3, 4.4). 4
3. Egg large, diameter 1.8–2.0 mm. Chorion opaque, solid, its color corresponds to color of eggs. Upper half of egg yellow-orange with brown broad patterns and white-yellow fringe on edge (figs 1.2, 1.3). .. .. *Cerura erminea* (Esper)
– Egg small, diameter 0.9–1.0 mm. Chorion transparent, white. Color of eggs pale-green. As egg develops it becomes grey. ..... *Spatalia argentina* (Denis et Schiffermüller)
4. Color of eggs, dark-brown, black or with group of dark spots or concentric bands on light background. Color of chorion identical egg color. 5
– Color of eggs, mostly dirty-white, darkens in the of egg development (figs 1.4, 1.5). Chorion white. Sometimes with dark concentric rim at top of egg. 10
5. Egg large, diameter 1.2–2.0 mm. Color dark-brown or black. If developed pattern, it looks like as dark patches on light background. Sculpture cellular. 6
– Egg small, diameter 0.9–1.0 mm. Color and pattern of eggs represented by light and dark-brown concentric bands (fig. 1.6). Sculpture looks like large densely placed pits (fig. 4.5). .... *Ptilophora plumigera* (Denis et Schiffermüller)
6. Egg large, diameter 1.6–2.0 mm. Color dark-brown (fig. 2.1) or pattern as dark patches on light background (fig. 2.2). Sculpture looks like small cells with concave smooth cell floor (fig. 4.6)..... 7
– Egg more small, diameter 1.2–1.4 mm. Color black (fig. 2.3). Sculpture looks like large cells with sharply developed large folds of cell floor (fig.5.1). 8
7. Egg and chorion dark brown (fig. 2.1). Typical species. In Ukraine everywhere. .... *Cerura vinula* (Linnaeus)
– Egg colouring and chorion from light beige or light-pink to pale-brown with dark patches on light background (fig. 2.2). Rare species. In Ukraine only from South coast of Crimea. .... *Cerura intermedia* (Teich)
8. Micropylar rosette with 11–17 cells (figs 5.2, 5.3). .... *Furcula furcula* (Clerck), *Furcula bicuspis* (Borkhausen)
– Micropylar rosette with 19–22 cells (figs 5.4, 5.5). 9
9. Typical species. In Ukraine everywhere. ..... *Furcula bifida* (Brahm)
– Rare species. In Ukraine only in Steppe zone. ..... *Furcula aeruginosa* (Christoph)
10. Sculpture of chorion pitted or looks like sharply expressed aeropyles (respiratory pores). 11
– Sculpture of chorion cellular. 16
11. Sculpture of chorion pitted. 12
– Sculpture of chorion with sharply expressed aeropyles. 13
12. Egg flattened dorsoventrally and with deep depression in micropylar area (fig. 5.6). Diameter 1.6–1.8 mm. Fresh egg white with pale-green tinge. Before caterpillar emergence egg becoming pale-purple, shining. Form of pits different in different parts of egg (figs 6.1– 6.5). ..... *Stauropus fagi* (Linnaeus)
– Egg hemispherical. Diameter 1.1–1.3 mm. Fresh egg grey-white with grey- green rim at top (fig. 2. 4). Before caterpillar emergence egg becoming pale-pink with green-brown rim (fig. 2.5). Sculpture looks like densely arranged large roundish and deep pits with tubercle inside (figs 6.6)..... ..... *Harpyia milhauseri* (Fabricius)
13. Sculpture looks like large, round aeropyles (figs 7.1–7.4). 14
– Sculpture looks like large aeropyles in form of 3 connected rays directed to opposite sides (fig. 7.5) .... *Pheosia gnoma* (Fabricius)

Fig. 1. Eggs of Notodontidae: 1 — *Thaumetopoea processionea* (photo by György Csóka); 2 — *Cerura erminea*; *3 — Cerura erminea;* 4 — *Dicranura ulmi*; 5 — *Dicranura ulmi*; 6 — *Ptilophora plumigera* (photo by Wolfgang Wagner).

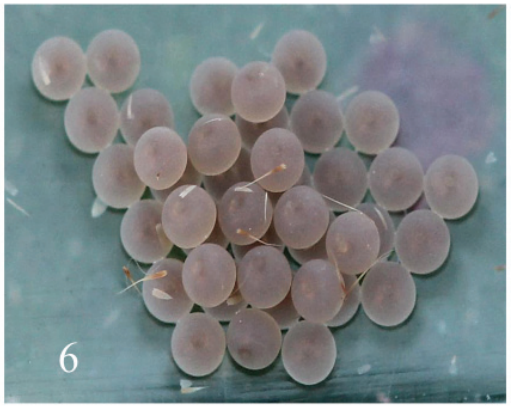

Fig. 2. Eggs of Notodontidae: 1 — *Cerura vinula* (photo by Paul Brothers); 2 — *Cerura intermedia*; 3 — *Furcula furcula*; 4 — *Harpyia milhauseri* (photo by Tymo Muus); 5 — *Harpyia milhauseri* (photo by Paolo Mazzei); 6 — *Clostera anastomosis* (photo by Andrey Ponomarev).

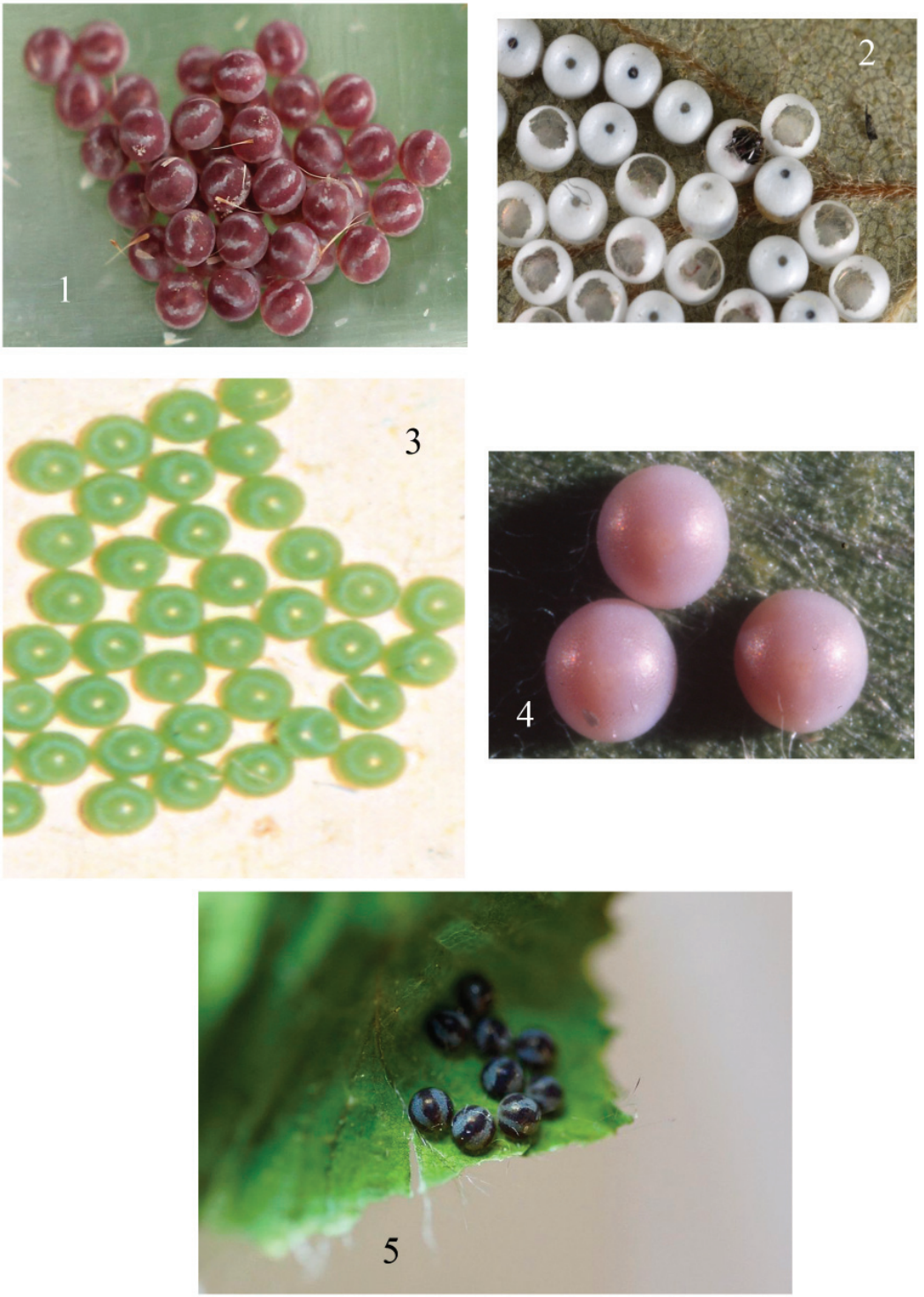

Fig. 3. Eggs of Notodontidae: 1 — *Clostera anastomosis* (photo by Andrey Ponomarev); 2 — *Phalera bucephala* (photo by Wolfgang Wagner); 3 — *Pygaera timon*; 4 — *Clostera pigra* (photo by Karl Rasch); 5 — *Clostera anachoreta* (photo by Olaf Beckmann).

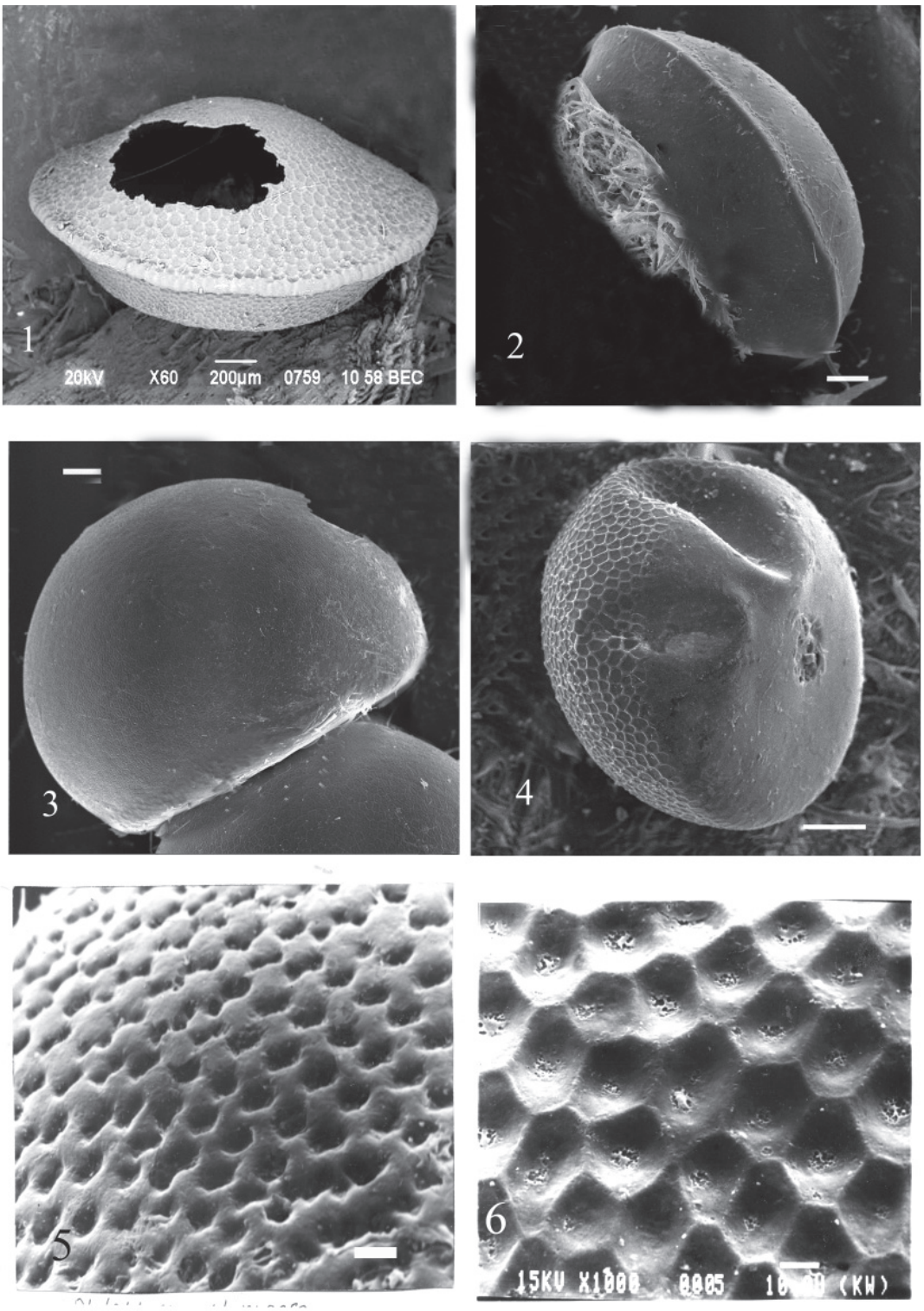

Fig. 4. Eggs of Notodontidae: 1 — *Cerura erminea*; *2* — *Spatalia argentina*; 3 — *Pterostoma palpina*; 4 — *Dicranura ulmi*; 5 — *Ptilophora plumigera,* part of lateral area; 6 — *Cerura vinula,* part of lateral area. Scale bars: 1 (200 µm); 2–4 (100 µm); 5, 6 (10 µm).

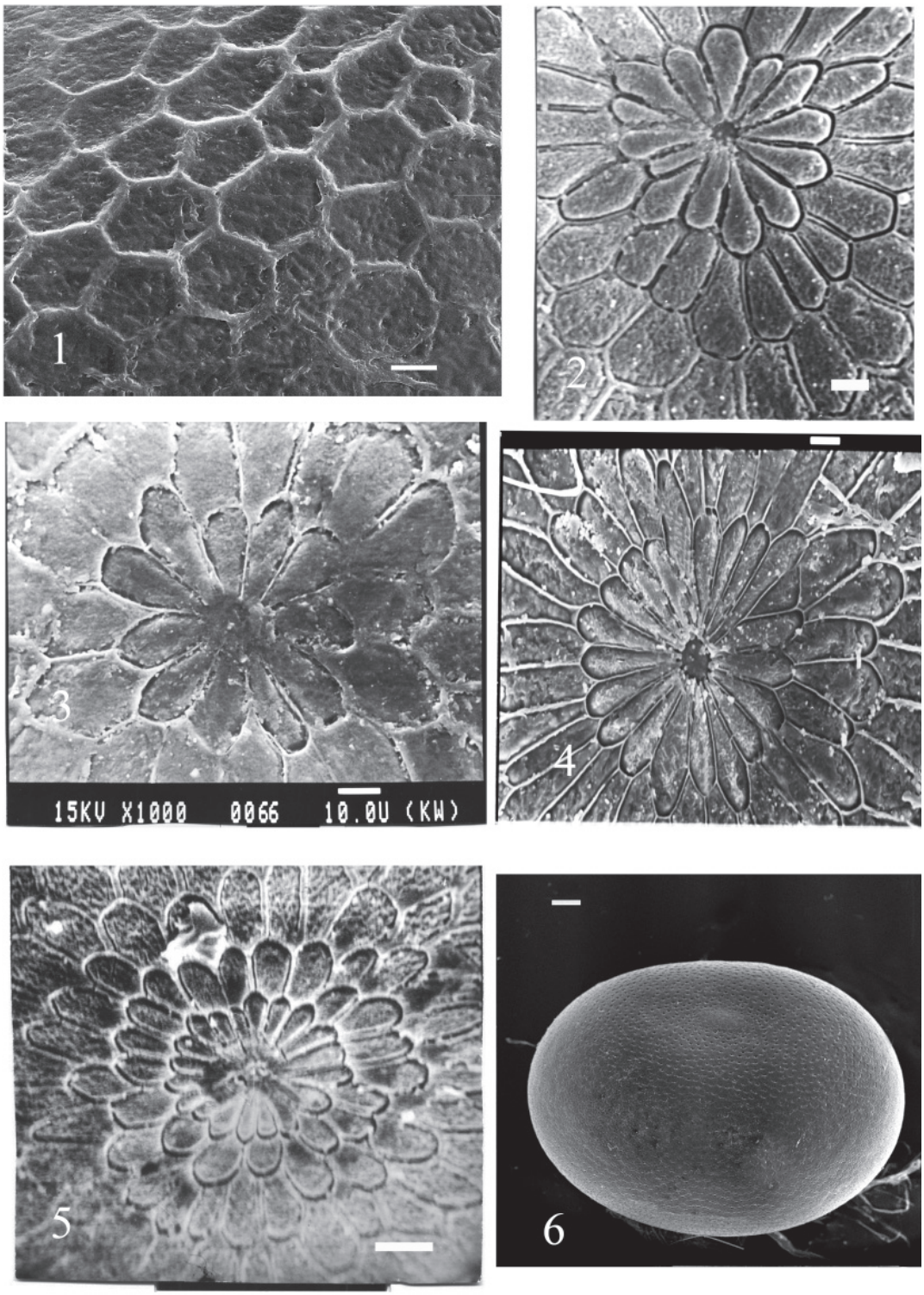

Fig. 5. Eggs of Notodontidae: 1 — *Furcula bifida,* part of lateral area; 2 — *Furcula furcula,* micropylar area; 3 — *Furcula bicuspis,* micropylar area; 4 — *Furcula bifida,* micropylar area; 5 — *Furcula aeruginosa,* micropylar area; 6 — *Stauropus fagi*. Scale bars: 6 (100 μm); 1–5 (10 μm).

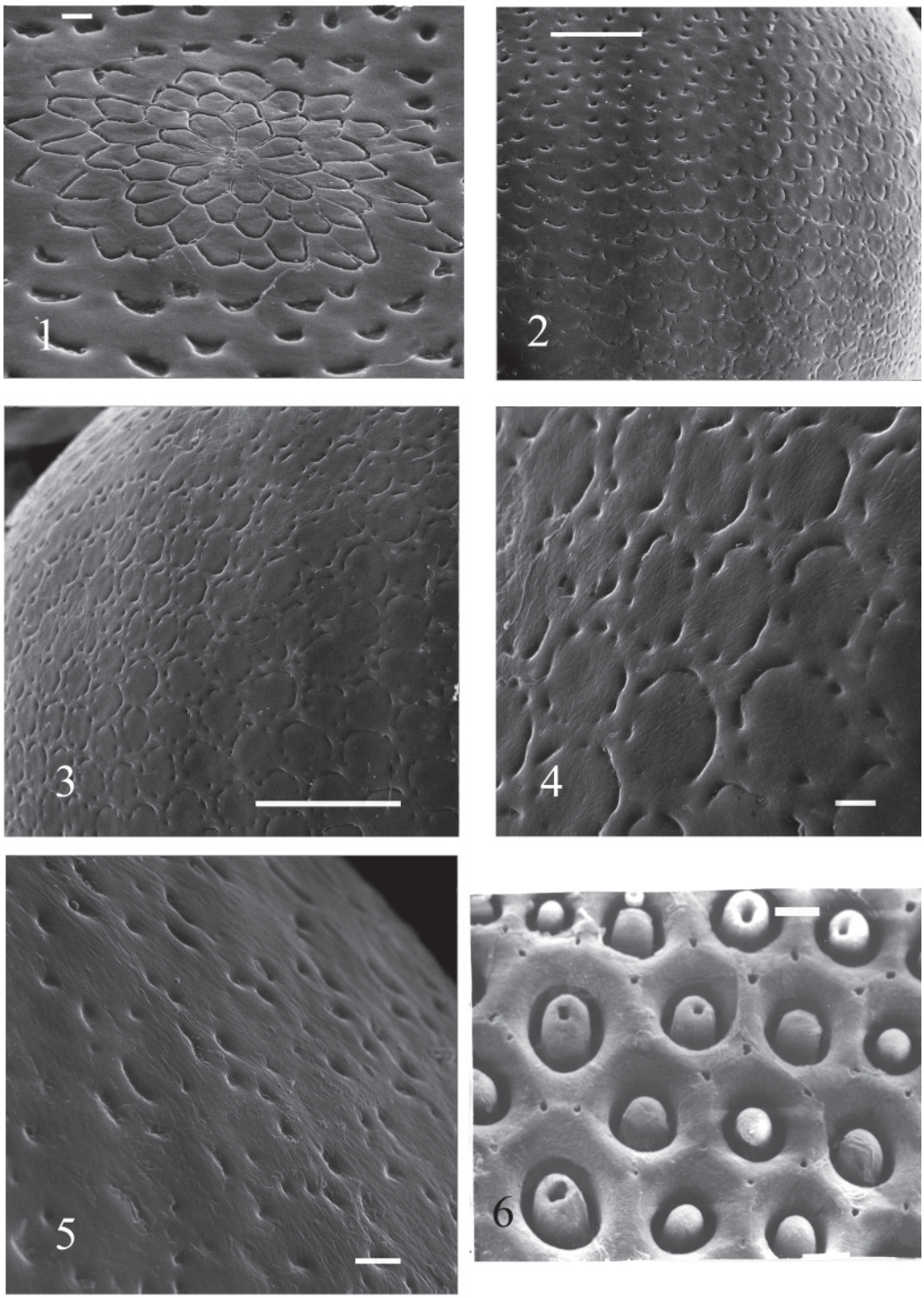

Fig. 6. Eggs of Notodontidae: 1 — *Stauropus fagi,* micropylar area; 2 — *Stauropus fagi,* apical and lateral regions; 3 — *Stauropus fagi,* lateral area; 4 — *Stauropus fagi,* part of lateral area; 5 — *Stauropus fagi,* area at base of egg; 6 — *Harpyia milhauseri,* part of lateral area. Scale bars: 2, 3 (100 μm); 1, 4, 5, 6 (10 μm).

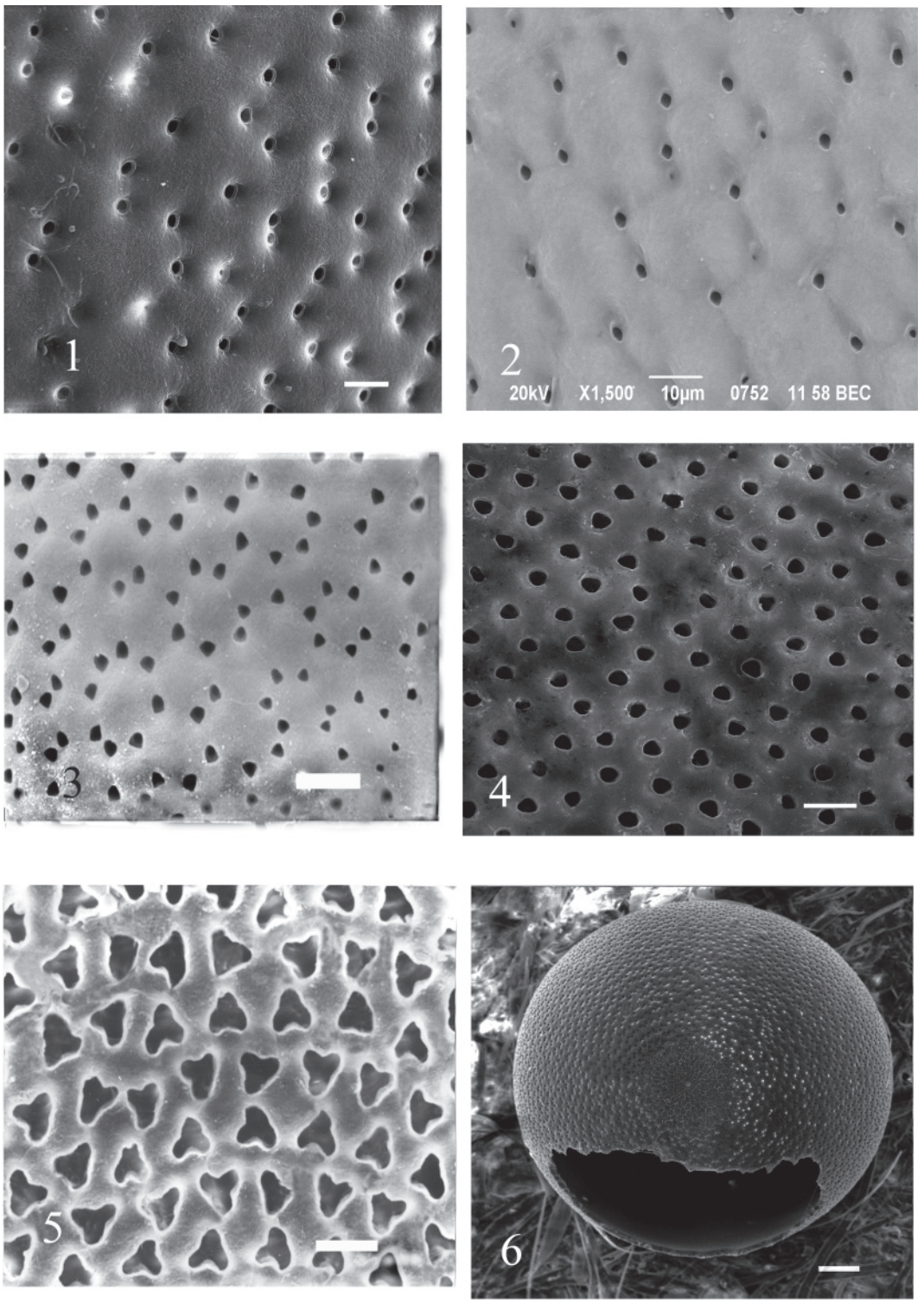

Fig. 7. Eggs of Notodontidae: 1 — *Notodonta ziczac,* part of lateral area; 2 — *Notodonta dromedarius,* part of lateral area; 3 — *Clostera anastomosis,* part of lateral area; 4 — *Pheosia tremula,* part of lateral area; 5 — *Pheosia gnoma,* part of lateral area; 6 — *Notodonta ziczac*. Scale bars: 6 (100 µm); 1–5 (10 µm).

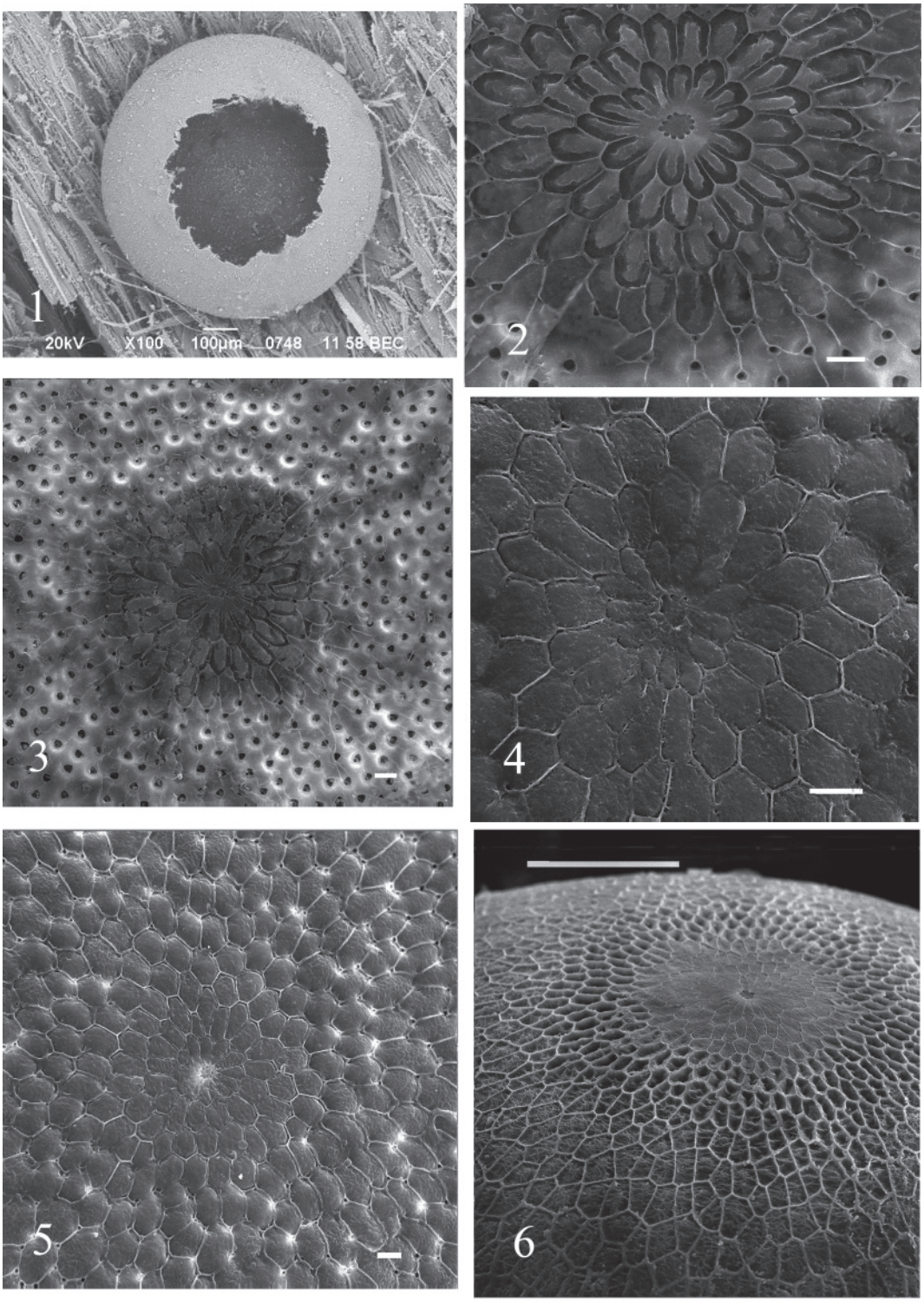

Fig. 8. Eggs of Notodontidae: 1 — *Clostera anastomosis*; 2 — *Pheosia tremula,* micropylar area; 3— *Pheosia tremula,* apical region; 4 — *Notodonta tritophus,* micropylar area; 5 —*Notodonta tritophus,* apical region; 6 — *Pterostoma palpina,* apical region. Scale bars: 1, 6 (100 µm); 2–5 (10 µm).

14. Egg of average size. Height 0.55–0.8 mm, diameter 0.9–1.4 mm. Fresh egg off-white, then with violet tinge. Eggs laid solitary or loose clusters. Before emergence caterpillars nibble out oval opening at lateral part of egg (fig. 7.6). 15
– Egg small. Height 0.35–0.55mm, diameter 0.8–0.9 mm. Fresh egg greenish-grey, then becomes darkly-raspberry with 2 rey arcuate stripes (figs 2.6, 3.1) and then dark-grey. Eggs laid in single-layer tight clusters where they pressed one to another. Before emergence caterpillars nibble out rounded opening at apical part of eggs (fig. 8.1). ..... *Clostera anastomosis* (Linnaeus)
15. Micropylar area represented by rosette and 2–3 rows cells. Cells quite characteristic: they with large concave along margin, and convex in middle part (figs 8.2, 8.3). Aeropyles densely placed on all egg surfaces (fig. 7.4). ..... *Pheosia tremula* (Clerck)
– Micropylar area represented by rosette and 4–6 rows slightly convex cells. Then follow 4–7 rows of more large cells with narrow, filiform ribs (figs 8.4, 8.5). Aeropyles thinly placed on all egg surfaces and concentrated in cells (figs 7.1, 7.2). .... *Notodonta ziczac* (Linnaeus), *N. dromedarius* (Linnaeus), *N. torva* (Hübner), *N. tritophus* (Siebert)
16. Chorion solid, opaque. 17
– Chorion thin, translucent or transparent. 18
17. Cellular sculpture in different parts of egg surface expressed more or less clearly. It weaker in micropylar and lateral areas and sharply expressed in transition zone (located between micropylar and lateral areas). Transition region consists of 7–9 bands of cell, where first 3–4 bands expressed most sharply and represented by cells with deeply concave, folded cell floor. The following 4–5 bands represented by flat cells with cell floor in densely interwoven fibers (figs 8.6, 9.1). Cells of remaining egg surface with broader and flat ribs. Cell floor folded with large pits (fig. 9.2). Micropylar rosette with 21–22 cells (fig. 9.3). ..... *Pterostoma palpina* (Clerck)
– Clear border is not observed between the micropylar region and remaining egg surface. Sculpture of eggs looks like cells with narrow ribs. Cell floor in densely interwoven fibers (fig. 9.4). Micropylar rosette with 14–16 cells (fig. 9.5). ..... *Peridea anceps* (Goeze)
18. Before emergence caterpillars nibble out large rounded or arcuate opening at apical part of eggs. (figs 9.6, 10.1, 10.2). 19
– Before emergence caterpillars nibble out oval opening at lateral part of egg (fig. 10.3). 26
19. Eggs layd solitary (figs 1.4, 1.5). Chorionic sculpture looks like sharply expressed and strongly concave cells. Ribs sharply prominent above cell surface (figs 10.4, 10.5). .... *Dicranura ulmi* (Denis et Schiffermüller)
– Eggs laid in single-layer tight clusters where they pressed one to another (fig. 9.6). Chorion sculpture in form of weakly or moderately expressed cells and ribs. 20
20. Chorion with dark spot in apical part (fig. 3.2). 21
– Chorion without dark spot in apical part. 22
21. Cells of greater egg surface with thin ribs (fig. 10.6). Typical species. In Ukraine everywhere. .... *Phalera bucephala* (Linnaeus)
– Cells of greater part egg surface with broad ribs (fig. 11.1). In Ukraine species very rare. Observed in Khmelnitskiy and Transcarpathian regions (Dolinskaya, 2012). .... *Phalera bucephaloides* (Ochsenheimer)
22. Micropylar area expressed more sharply compared with remaining egg surface (fig. 11.2) 23
– Micropylar area inseparable from remaining egg surface. .... *Leucodonta bicoloria* (Denis et Schiffermüller)
23. Cells of greater part egg surface poorly developed, with narrow ribs (figs 11.2, 11.3). 24
– Cells of greater part egg surface moderately developed, with more or less broad ribs (figs 11.4, 11.5). 25
24. Egg turquoise-green with three pale green concentric band (fig. 3.3). As egg develops it becomes dark-brown and then violet-grey. Before emergence caterpillars nibble out wide arcuate opening around the perimeter of apical part of eggs; only central cover on "stem" remained (fig. 10.2). .... *Pygaera timon* (Hübner)
– Egg green, then becomes blue-green. Before emergence caterpillars nibble out round opening at apical area of egg. ..... *Clostera curtula* (Linnaeus)
25. Egg greenish-gray. Then becomes pinkish-red (fig. 3.4). ..... *Clostera pigra* (Hufnagel)
– Egg with black and grey arcuate bands (fig. 3.5), then becomes dark grey. .... *Clostera anachoreta* (Denis et Schiffermüller)
26. Egg height 0.3–0.4 mm. Cell of greater part egg surface with wider ribs compared with cells micropylar area. Developed groove between the ribs, and each cell surrounded by only his ribs (fig. 11. 6) .... *Gluphisia crenata* (Esper)

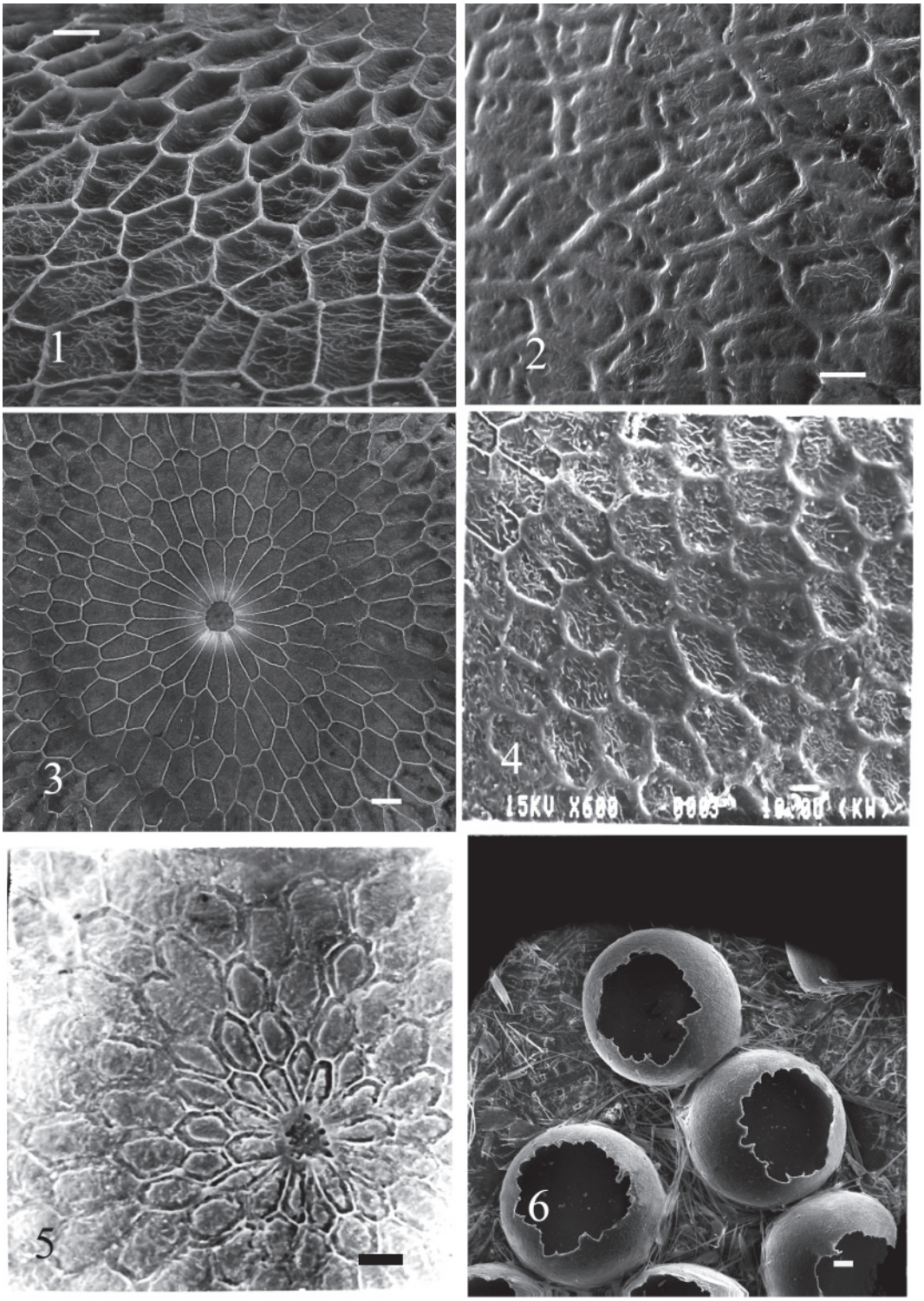

Fig. 9. Eggs of Notodontidae: *1 — Pterostoma palpina,* transition region; *2 — Pterostoma palpina,* part of lateral area; *3 — Pterostoma palpina,* micropylar area; *4 — Peridea anceps,* part of lateral area; *5 — Peridea anceps,* micropylar area; *6 — Phalera bucephala*; Scale bars: 6 (100 μm); 1–5 (10 μm).

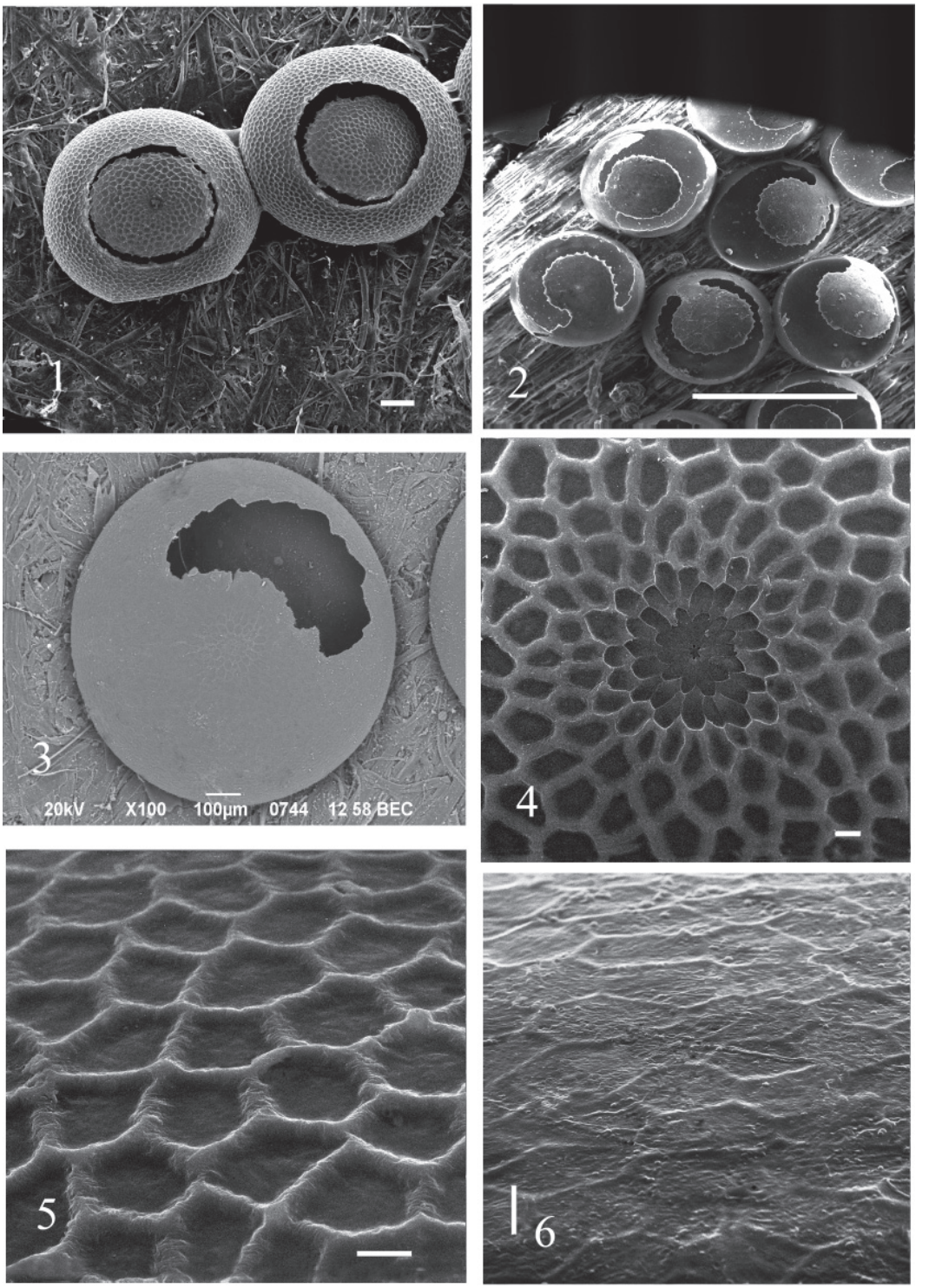

Fig. 10. Eggs of Notodontidae: 1 — *Dicranura ulmi*; 2 — *Pygaera timon*; 3 — *Gluphisia crenata*; 4 —*Dicranura ulmi,* apical region; 5 — *Dicranura ulmi,* part of lateral area; 6 —*Phalera bucephala,* part of lateral area. Scale bars: 1–3 (100 µm); 4–6 (10 µm).

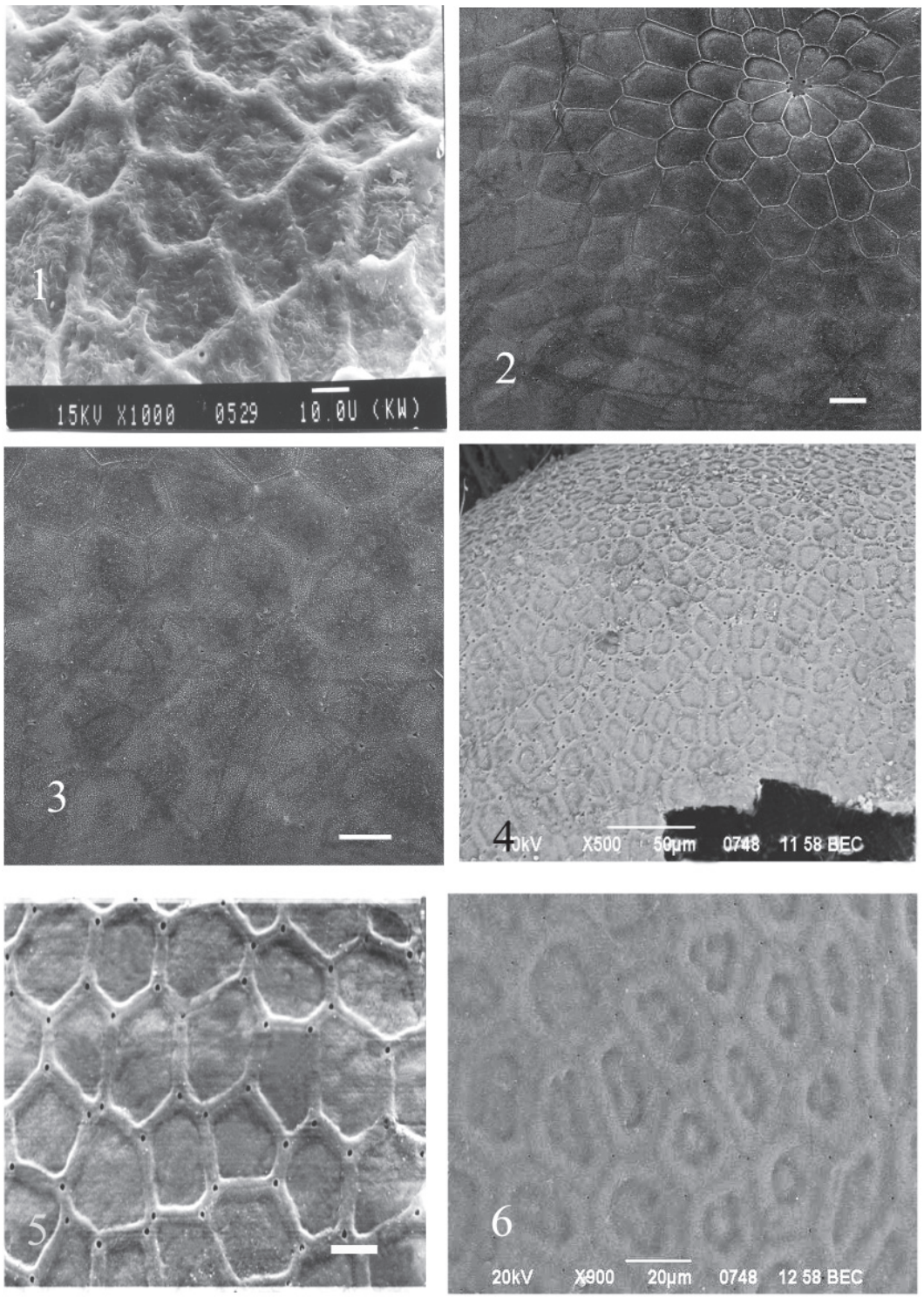

Fig. 11. Eggs of Notodontidae: 1 — *Phalera bucephaloides,* part of lateral area; 2 — *Pygaera timon,* part of apical region; 3 — *Pygaera timon,* part of lateral area; 4 — *Clostera pigra,* lateral area; 5 — *Clostera anachoreta,* part of lateral area; 6 — *Gluphisia crenata,* part of lateral area. Scale bars: 4 (50 µm); 6 (20 µm); 1–3, 5 (10 µm).

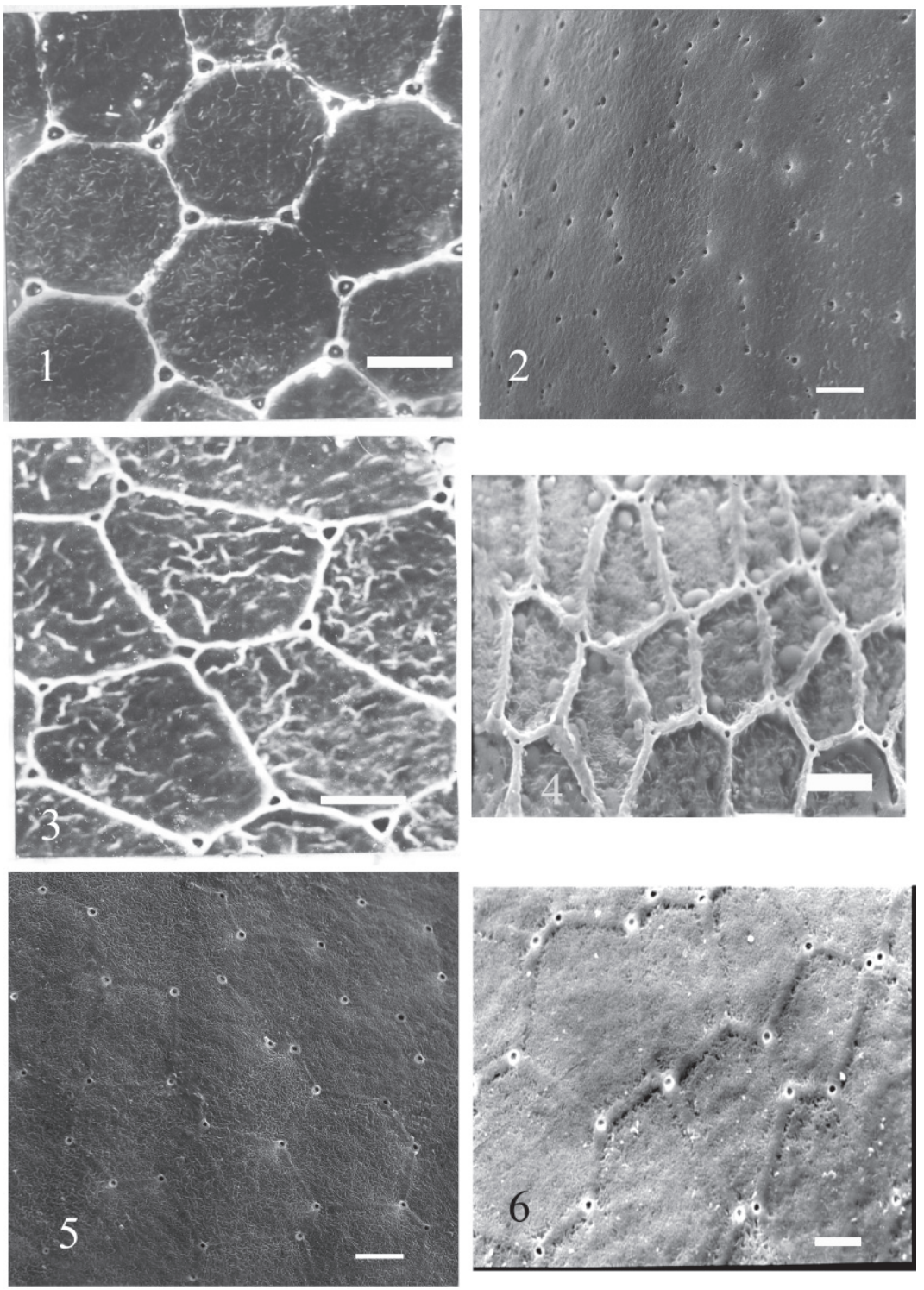

Fig. 12. Eggs of Notodontidae: 1 — *Odontosia carmelita,* part of lateral area; 2 — *Drymonia velitaris,* part of lateral area; 3 — *Odontosia sieversii,* part of lateral area; 4 — *Drymonia dodonaea,* part of lateral area; 5 — *Ptilodon capucina,* part of lateral area; 6 — *Ptilodon cucullina,* part of lateral area. Scale bars 1–6 (10 μm).

– Egg height 0.5–0.85 mm. Cell of greater part egg surface with narrower ribs compared with cells micropylar area or ribs absent. If ribs are expressed that cells share common ribs (fig. 12.1). 27
27. Cells of greater part egg surface with very poorly expressed ribs or looks like as aeropyles..... 28
– Cells of greater part egg surface with moderately expressed ribs and aeropyles. 29
28. Cells of greater part egg surface represented by small aeropyles (fig. 12. 2). .... *Drymonia obliterata* (Esper), *Drymonia velitaris* (Hufnagel)
– Cells of greater part egg surface represented by very poorly expressed ribs. 30
29. Cells of greater part egg surface with narrow ribs ans large aeropyles significantly greater than width of ribs (figs 12.1, 12.3). ..... *Odontosia carmelita* (Esper), *Odontosia sieversii* (Ménétries)
– Cells of greater part egg surface with ribs of moderate width. Aeropyles not exceed width of ribs (fig. 12. 4). ..... *Drymonia obliterata* (Esper), *Drymonia velitaris* (Hufnagel)
30. Egg matte-white. Chorion translucent. Cells of greater part egg surface with with very narrow, filiform ribs (0.2 mm) and aeropyles (1.7–1.9 mm (fig. 12.5). ..... *Ptilodon capucina* (Linnaeus)
– Egg light-yellow, then becoming brownish tinge. Chorion transparent. Cells of greater part egg surface with flat, wider ribs (2.5–3.4 mm) and aeropyles (2.9–3.2 mm) (fig. 12.6). .... *Ptilodon cucullina* (Denis et Schiffermüller)

Discussion

The key showes that *Thaumetopoea processionea* is different from other prominent moths by oviposition. This oviposition is typical for some Lymantriinae and Erebidae species.

Clostera anastomosis is sharply different from the other species of the genus *Clostera* by its chorionic sculpture. We have not found clear differences between species *Clostera anachoreta* and *C. pigra*. Differences are observed only in color and pattern live eggs. *Clostera anachoreta* and *C. anastomosis* have a common character — pattern live eggs.

The genus *Notodonta* not revealed species differences. Characters of eggs shows only signs characteristic for the genus.

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