Neue Entomologische Nachrichten **67**: 3-21, Marktleuthen (2011)

Fine sculpture and phylogenetic implications of egg shell morphology in the Lasiocampidae

(Lepidoptera, Lasiocampidae)

by

VADIM V. ZOLOTUHIN & PAVEL A. KURSHAKOV

received 4.XII.2009

Summary: Fine sculpture of egg shell in some lasiocampid species is studied; their phylogenetic implications for a system of the Lasiocampidae are shortly discussed.

Zusammenfassung: Die Mikrofeinstrukturen der Eichorionoberfläche werden von einigen Lasiocampidae-Arten untersucht und deren Verwertbarkeit, im Hinblick auf die Phylogenie der Lasiocampiden, wird angesprochen.

In spite of the relatively large size and the ease of obtaining them, the fine sculpture of egg shell morphology has been studied only for very few species in the Lasiocampidae, mainly of the European fauna.

Egg shell structure was illustrated for 14 European species by DÖRING (1955) but undertaken at low magnification and mostly using a very schematic approach. Those were *Malacosoma neustria* (LINNAEUS, 1758), *M. castrense* (LINNAEUS, 1758), *M. franconica* ([DENIS & SCHIFFERMÜLLER], 1775), *Trichiura crataegi* (LINNAEUS, 1758), *Eriogaster lanestris* (LINNAEUS, 1758), *Lasiocampa quercus* (LINNAEUS, 1758), *Lasiocampa trifolii* ([DENIS & SCHIFFERMÜLLER], 1775), *Macrothylacia rubi* (LINNAEUS, 1758), *Euthrix potatoria* (LINNAEUS, 1758), *Cosmotriche lobulina* ([DENIS & SCHIFFERMÜLLER], 1775), *Gastropacha quercifolia* (LINNAEUS, 1758), *G. populifolia* (ESPER, 1784), *Odonestis pruni* (LINNAEUS, 1758), *Dendrolimus pini* (LINNAEUS, 1758). ROZHKOV (1963) gave a scheme of the micropylar rosette for *Dendrolimus superans sibiricus* TSCHETVERIKOV, 1908. Micropylar poles of the eggs of some Chinese species of pine-caterpillars were figured very schematically by HOU (1987).

More informative and useful are the articles and accompanying descriptions of fine structures enabled by SEM-photos. Among them, DIERL (1984) described eggs of *Poecilocampa populi* (LINNAEUS, 1758) and *P. alpina* FREY & WULSCHLEGEL, 1874, KOBES (1982) of *Dendrolimus cheela* (MOORE, 1879) (as for *D. benderi* DE LAJONQUIÈRE, 1975), PARENZAN & PORCELLI (1985) and MARINI & TRENTINI (1988) of *Pachypasa otus* (DRURY, 1773). DOLINSKAJA & PLUSTSCH (2000) illustrated fine sculpture of chorion for 9 species [*Euthrix potatoria ascoldensis (*OBERTHÜR, 1880), *E. albomaculata* (BREMER, 1861), *E. laeta sulphurea* (AURIVILLIUS, 1894), *Gastropacha quercifolia* (L.), *G. populifolia* (ESP.) (or ?*G. clathrata* BRYK, 1948), *Odonestis pruni rufescens* KARDAKOFF, 1928, *Dendrolimus pini* (L.), *D. superans sibiricus* TSCHETVERIKOV, 1908 and *Paralebeda femorata* MENÉTRIES. (as for *P. plagifera* WALKER, 1855)], mostly from Far East of Russia, and discussed its significance. ZOLOTUHIN & WITT (2007) described eggs of 3 species of *Pyrosis* OBERTHÜR, 1880 (*rotundipennis* de JOANNIS, 1929, *borneana* HOLLOWAY, 1987 and *idiota* GRAESER, 1888) in a revision of the genus. Quite recently, EITSCHBERGER (2008) gave descriptions of the eggs chorion for 8 species of the family.

In general, all articles listed above, only establish a peculiarity or describe eggs of chosen species (mainly of accidental selection) but do not make a comparative analysis of the fine structure of the chorion with a view to using these data in phylogenetic constructions.

The aim of the present article is to show a possibility of using peculiarities of fine sculpture of egg shells in the Lasiocampidae for phylogenetic purposes.

Methods: One aliquot of eggs was obtained from living ♀♀ and preserved immediately in 70% ethanol. A second small portion was prepared from the ovarioles of the ♀♀, preserved in alcohol and specially cleaned of tissues with forceps and brush. A third portion was prepared after the method proposed by EITSCHBERGER (pers. comm.) where the eggs are taken from the abdomen of dried specimens. In this procedure the abdomen is separated from the thorax, placed for 24 hours in 70% isopropanol, and a lateral incision made (after drying, the rest of abdomen may then be reattached to the thorax using glue). Well developed eggs together with ovarioles are placed in boiled water with drops of cleaner for a day and afterwards cleaned of residual tissue using pure water. The final operation is pricking of the chorion laterally with a fine entomological needle, drying in air and storage in a glass tube prior to microscopical examination.

The prepared eggs were covered with gold in a vacuum for 4 minutes and investigated with an HITACHI S 450 Scanning Electron Microscope. This investigation was supported by DFG-Stipendium in 1997 and took place in Zoologisches Foschungsinstitut and Museum Alexander KOENIG (Bonn, Germany).

From 6 to 10 eggs were obtained from each ♀ and later investigated; from some species a few ♀♀ were used to obtain eggs.

Fine structure of egg shells in Lepidoptera: In most species of the Lasiocampidae, the chorion is very extensively sculptured. The egg shell generally exhibits a characteristic surface sculpture also referred to as regional complexity. The surface of the chorion is marked by a faint reticulate pattern of polygonal cells, the disks of which appear to have a slightly roughened texture. These polygonal cells may be outlined by either ridges or furrows. To assist readers, data on egg structure are summarized here on the figs 1-4 (mainly after works of HINTON, 1981; FEHRENBACH, 1995 and ARBOGAST et al., 1980, with additions).

The micropylar region is generally composed of the following components:

Micropylar area - this is where spermatozoa enter the egg through the opening(s) of the micropylar canal [micropylar opening(s)] in the micropylar floor.

The small, circular micropylar plate in the centre bears from 3 up to 20 micropylar openings. The plate is generally surrounded by the micropylar rosette, which is composed of several petal-like panels. A micropylar zone of very varying sculpture mediates the transition to the surface of the main body of the eggs. It may be surrounded by a slightly elevated micropylar wall, which may be also bordered by a slightly depressed micropylar groove.

The pit is surrounded by petal-shaped primary cells radiating from the rim of the crater and outlined by prominent carinae. The primary cells are in turn partially or completely surrounded by series of secondary and tertiary cells, which are usually less boldly outlined.

The transitional zone is characterized by ridges which originate at the wall and gradually peter out.

The egg surface is studded with countless, small protuberances.

Aeropyles consist of shallow pits, 1.1 ± 0.5 µm in diameter, with openings around their peripheries. These openings lead into the trabecular layer, which constitutes the intrachorionic respiratory meshwork of the eggs. Aeropyles are usually scattered over the entire surface of the egg, although they are often more abundant in some areas than others and are sometimes restricted to a limited area (ARBOGAST et al., 1980). They are always situated at ridge intersections or on tubercles when these are present. The floor of the pit is formed by the inner layer of the chorion

Lasiocampid eggs are mostly of the flat type. They are broadly oval or roughly subcylindrical with rounded extremities and a flattened upper surface, with the micropyle at one end; the chorion is strong, tough, normally light coloured, often completely patterned. In most species the surface is smooth, weakly sculptured by very weak grooves connecting small cone-shaped aeropyles on the tops of 5(6)-angled cells, or lacking sculpture although in some [oriental] genera the sculpture is distinct and very elegant as shown below. The micropyle of the egg is situated laterally in the first two cases and on top of the egg in the last.

Genus *Chondrostega* LEDERER, 1858

Chondrostega vandalicia (MILLIÈRE, 1865) (figs 5-9)

Original material: ♀, Hispania (ZFMK).

Eggs are elongated keg-shaped, with chorion uniformly coloured. The preparation was not very successful, and the rest of the tissues was not completely cleaned from the micropylar pole.

The micropylar rosette is situated in a small depression, strongly dorsally, that typical for eggs laid in a cluster. The rosette is irregular, consisting of 5-6 leaves different in a size. The micropylar leaves are almost fused. The micropyles are situated on the centre of the floor, and only 2 per eggs were found in preparations seen. The transitional zone consists of 4 complete and the 5th incomplete row of irregular polygonal cells with strong carinae. The remainder of the chorion surface is weakly rugous, finely granulated on the base of the egg, without prominent sculptural pattern. The aeropyles (1.4 - 1.7 µm in diameter) are situated on small eminences, of irregular shape, often paired, buried or countersunk in egg base. The carinae are not expressed, and only their traces may be found as a hardly visible sutura, coming in rather regular, equilateral, 5-6 angled polygon.

Genus *Trichiura* STEPHENS, 1928

Trichiura kopetdaghi DUBATOLOV & ZOLOTUHIN, 1992 (figs 10-12)

Original material: ♀, Turkmenistan, Kopet-Dagh Mts, 1500 m, 25 km E of Nochur, Karayalchi Valley, 57°09'E, 38°21'N, 5.X.1991, leg. RONKAY & VARGA (MWM).

The micropylar rosette is regular, almost symmetric, consisting of 6-7 leaves (length 18-23 µm). The micropylar leaves are fused on 2/3 of the length. The micropyles are situated on the centre of the floor. The transitional zone consists of 2-3 complete and the 4th incomplete row of irregular polygonal cells with strong carinae. The remainder of the chorion surface is weakly rugous, finely granulated, without distinct prominent sculptural pattern. The aeropyles are small (ca. 0.48 µm in diameter), very innumerous, situated on small pits.

The same scheme is generally typical also for the generotypus *Trichiura crataegi* (LINNAEUS, 1758) (DÖRING, 1955), smooth structure of the chorion is probably a character for all species of the family, laying eggs in clusters.

Genus *Poecilocampa* STEPHENS, 1928

Poecilocampa populi populi (LINNAEUS, 1758) (figs 13-17)

Original material: ♀, North Hungari, Aggteleki Karzst, Szinpetri, 23.X.1980, leg. GYULAI P. (MWM).

The micropylar rosette is irregular but rather almost symmetrical, consisting of 9-11 strongly stretched leaves (length 17-41 µm), with angled tips. The micropylar leaves are fused on ½-2/3 of the length. The micropyles are large (ca. 10 µm in diameter) and situated on the center of a floor and covered with a chorion screen. The transitional zone consists of 5-9 complete rows of irregular 5-7-gonal cells with strong carinae forming symmetrical radial pattern. The cells are widened from 4-5th rows and their inner surface becomes celled or spongia-shaped; such structure is typical for the remainder of the egg surface. Below the transitional zone, carinae are visible as weak transversally wrinkled suturae with the aeropyles in the corners. The aeropyles are small (1.0 - 1.3 µm in diameter), and bordered with ringed rolls.

Poecilocampa populi pontica DE FREINA, 1999 (figs 18-20)

Original material: ♀, Türkei, Prov. Agri, 5 km E of Sarican, 1800 m, 42°39'E, 34°49'N, 19-21.X.1992, leg. HREBLAY & RONKAY (MWM, GU 5088).

The micropylar rosette is irregular and asymmetric, consisting of 7-9 stretched but broadened leaves with rounded tips and different in size (length is 18-27.9 µm). The micropylar leaves are fused on ¾ of the length. The micropyles are situated on the margin of a floor and well visible. The transitional zone consists of 6-8 rows of irregular 6-gonal cells with strong carinae, forming regular symmetric pattern and gradually disappearing. The cells are larger and more regular in comparison with the nominate subspecies. The remainder of the chorion surface with carinae visible as weak transversally wrinkled suturae with the aeropyles lie on the angles; the inner surface of the cells are more wrinkled than in *P. p. populi* (L.). The aeropyles are smaller (0.95 - 1.0 µm in diameter), bordered with a raised ring and sometimes paired.

Genus *Baodera* ZOLOTUHIN, 1992

Baodera khasiana (MOORE, 1879) (figs 25-28)

Original material: ♀, Sikkim, 1500-1800 m, VIII.1994, exp. CADIOU (MWM, GU 5060).

The micropylar rosette is almost symmetric, consisting of 5-8 stretched leaves with a length 18-31 µm. The micropylar leaves are fused on ½-2/3 of their length and their tips are swamped. The micropyles are moved to the centre of the floor. The transitional zone consists of 2 complete and the 3rd incomplete row of irregular polygonal cells with strong carinae laying in the grooves. Below the transitional zone consists of 5 complete rows, the egg is covered with shagreen protuberant processes, partially strongly curved and fusing into complicated pattern; the aeropyles are absent in this zone and are originated only in the lower third of the egg where this rugous sculpture is absent; the surface is smooth and the aeropyles are situated all over the surface without carinae or broadenings. They are present as simple depressions on the egg surface with the diameter from 1.0 to 3.1 µm.

Genus ***Crinocraspeda*** HAMPSON, [1893] 1892

Crinocraspeda torrida (MOORE, 1879) (figs 21-24)

Original material: ♀, N. Vietnam, Mt. Fan-si-pan, 16-1800 m, near Cha-pa, 22°20'N, 103°40'E, VI.1996, leg. local collector (MWM, GU 5060).

The micropylar rosette is irregular and asymmetric, consisting of 8-9 stretched and strongly widened to rounded tips leaves (length is 13-38 µm). The micropylar leaves are almost completely fused. 6-7 micropyles are situated on the margin of the floor. The transitional zone consists of 2-3 complete and the 4th incomplete row of irregular 6-gonal cells with strong carinae forming reticular pattern. The subtransitional zone (ca 110 µm) lacks any structures and relief. The remainder of the chorion surface bears distinct protruded pits with single aeropyles inside each. Some aeropyles are connected with weak raised carinae but generally the chorion lacks any characteristic pattern in this zone. The aeropyles are medium-sized (ca 1.3 µm in diameter).

Genus ***Euthrix*** MEIGEN, 1830

Some members of the genus were previously investigated. To establish the characters at specific level, eggs of an insular subspecies of *E. potatoria* (LINNAEUS, 1758) from Kunashir were studied.

Euthrix potatoria bergmani BRYK, 1941 (figs 29-30)

Original material: ♀, Kunashir, near Sernovodsk, VII.1991, V. ZOLOTUHIN leg. et coll.

The micropylar rosette is regular, almost symmetrical, consisting of 10 stretched leaves (length 20-25 µm) with rounded tips and similar in size. The micropylar leaves are fused on 2/3 of the length. About 10 micropyles are situated on the margin of the floor, and are well visible. The transitional zone consists of 4 complete rows of irregular wide polygonal cells with strong carinae and immediately changed by aeropylar zone, also with distinct carinae bearing spherical raised pits on the junction. To the bottom of the egg, the carinae become wider. Being similar generally to other subspecies, the egg shell here is finer and with a more regular relief pattern.

Genus ***Micropacha*** ROEPKE, 1953

Micropacha krocha ZOLOTUHIN, 1995 (figs 31-32)

Original material: ♀, Thailand, Changwat Nan, 30 km E of Pua, 1700m, 1.III.1998, leg. HREBLAY & SZABÓKY (MWM, GU 5064).

The micropylar rosette is irregular and almost symmetrical, consisting of 5-10 leaves with rounded tips and different in size (length 34-56 µm). The micropylar leaves are fused on 2/3-3/4 of the length. The micropyles are situated on the margin of the floor, they are distinct, varying in a number from 1 to 3. The transitional zone consists of 4-5 rows of irregular polygonal cells with strong carinae and it forms almost a symmetrical radial pattern. Three zones can be distinguished in the aeropylar zone. The first is bordered with the transitional zone and bears distinct carinae connecting pits. The second (median) zone lacks carinae and pointed only with pits raised under the egg surface; and the third (ventral) zone bears a characteristic pattern with all aeropyles joined with a widened edge into regular 6-gonal pattern around central depression of the cell. The aeropyles are distinct, ca 2.1 µm in diameter, laying in the spherical pits.

Genus ***Cosmotriche*** HÜBNER, [1820] 1816

Cosmotriche discitincta WILEMAN, 1914 (figs 33-36)

Original material: ♀, Taiwan, Provr. Miaoli, 49 km E of Tungshih, 121°03'E, 24°19'N, 2490 m, 23.III.1996, leg. CSOVARY & STEGER (MWM, GU 5067).

The micropylar rosette is regular and almost symmetric, consisting of 8 medium stretched leaves (length 26-29 µm) with angled corners. The micropylar leaves are fused on 2/3 of the length. The micropyles are situated on the centre of the floor. The transitional zone consists of 2 complete rows, leap to disappearing, with strong carinae. Below, the carinae are vanished but borders between cells are present as weakly developed depressions with tips bearing distinct spherical pits (0.5 µm in diameter), each with a narrow aeropyle (less as 0.1 µm in diameter). At the base of the egg, the pits are also vanished and aeropyles are situated directly on the chorion and their diameter is increased here up to 1.5 - 2.0 µm.

The egg of the genotype has a similar structure and is figered in DÖRING (1955).

Genus ***Gastropacha*** OCHSENHEIMER, 1810

The egg shell structure was already investigated in some species from subgenera *Gastropacha* and *Stenophyllodes*; here it is shown for *Gastropacha horishana* MATSUMURA, 1927. Two tropical members with unknown subgeneric belonging are studied here - *G. eberti* DE LAJONQUIÈRE and *G. encausta* HAMPSON.

Gastropacha horishana MATSUMURA, 1927 (fig. 44)

Original material: ♀, Taiwan. Prov. Kaoshiung, 25 km SE of Taoyuan, 1370 m, 120°52'E, 23°17'N, 4.XI 1996, leg. CSOVAZY & SZABOKY (MWM, GU 5054).

The chorion structure of the species is similar to other members of *Stenophyllodes*; here the figure shows reticular pattern of chorion with numerous aeropyles, placed on the carinae joined in circles. The aeropyles are rather large (about 3.0 µm in diameter) and are on the medial line of the carinae.

Gastropacha eberti DE LAJONQUIÈRE, 1967 (figs 37-40)

Original material: ♀, Pakistan, Margalla Hills, Pir Sohawa, 1000 m, 73°08'E, 33°49'N, 25.VII.1998, leg. CSORBA & RONKAY (MWM, GU 5079).

The micropylar rosette is rather regular, consisting of 9 stretched leaves (length is 18-25 µm). The micropylar leaves are fused on ¾ of the length. The micropyles are large, ca 3 µm in diameter, and are situated on the margin of the floor. The transitional zone consists of 1-2 rows of irregular polygonal (5-6-angled) cells with strong carinae laying in narrow grooves. Narrow (about 50 µm) subtransitional zone lacks carinae but bears some kind of cells pointed by distinct groves; lower this zone the aeropyles are originated as single openings on the small pits of irregular shape. The aeropyles are rather large (2.2 - 2.4 µm in diameter) and bordered with incomplete pit rings.

Gastropacha encausta HAMPSON, 1900 (figs 41-43)

Original material: ♀, Pakistan, Kashmir, Himalaya mts. 30 km N Murree, near Nathia Ghali, Ayubia vill., 2600 m, 25.-27.VI.1998, leg. FÁBIÁN & HERCZIG (MWM, GU 5080).

The micropylar rosette is irregular, consisting of 7-10 weakly stretched leaves (length 18-25 µm). The micropylar leaves are fused on 2/3-3/4 length. The micropyles are situated on the margin of the floor. The transitional zone consists of 2-3 rows of irregular

6-gonal cells with strong carinae lying in narrow grooves. Narrow (about 45 µm) subtransitional zone lacks carinae but bears some kind of cells pointed by distinct groves; below this zone, the aeropyles originate as central deepness in the cells (sometimes paired) a bit raised under the egg surface. Initially, the aeropyles were situated in the intercarinal zone on small pits; some such are visible on the border of the transitional zone in 1-2 lower rows in some eggs.

Genus *Paradoxopla* DE LAJONQUIÈRE, 1976

Paradoxopla undulifera (WALKER, 1855) (figs 45-47)
Original material: ♀, N-Pakistan, NW-Frontier, Murree, 1700 m, 29.VII.1979, leg. W. THOMAS (MWM, GU 5065).
The micropylar rosette is irregular and asymmetric, consisting of 10 leaves quite different in size (length is 33-40 µm) with rounded tips. The micropylar leaves are fused on ½-2/3 of the length. The micropylar floor is strongly raised and micropylar openings (6 per egg) are widely open. The transitional zone consists of 4 complete rows of cells immediately moving into the aeropylar zone presented by a complete stellar relief with carinae strongly widened and the inner part of the cell being round, smooth and somewhat deep. The aeropyles are situated on the bottom of triangular or irregularly tetragonal depressions lying rather symmetrically on the perimeter of the cell. The diameter of these depressions is 3.9-4.5 µm, but the aeropyles are considerably smaller.

Genus *Phyllodesma* HÜBNER, [1820] 1816

Phyllodesma japonicum arborea BLÖCKER, 1908 (figs 48-49)
Original material: ♀, Russia, Petersburg, [Poklon. Gora], 1918 (ZFMK).
The original preparation is unfortunately of poor quality and therefore only the following features are listed.
The micropylar rosette consists of 11 strongly stretched leaves with rounded tips. The micropylar leaves are fused on ¾ of the length. The micropyle is situated on the margin of the floor, large, well visible in a number of 3-4. Carinae are reduced in both micropylar and transitional zones and borders of the cells are pointed with local depressions. The transitional zone consists of 3-4 rows gradually moving into a structureless aeropylar zone. Aeropyles are rather large (2.2-2.4 µm in diameter) and lie on small cone-shaped pits in intersegmental parts of the cells.

Genus *Pachypasoides* MATSUMURA, 1927

Pachypasoides albisparsa WILEMAN, 1910 (figs 50-52)
Original material: ♀, Taiwan, Prov. Tai-Tung, Hsiangyang, Police station, 2320 m, 29.-30.IV.1997, leg. FÁBIÁN & KOVAZCS (MWM, GU 5066).
The micropylar rosette is irregular, sometimes rather symmetrical, consisting of 12 angled leaves different in size (length 39-51 µm). The micropyles are situated on the centre of the floor. The transitional zone consists of 5-6 rows of irregular 6-gonal cells with strong carinae forming radial symmetric pattern. The cells are enlarged in size from 5th row and form reticular pattern. The carinae are visible as wrinkled suturae also below the transitional zone. The aeropyles are small (ca 1.0 µm in diameter) and bordered with circular rolls.

Genus *Dendrolimus* GERMAR, 1812

Dendrolimus cheela (MOORE, 1879) (figs 53-56)
Original material: ♀, Indien, J & K, 3000 m, Baltal bei Sonamarg, 7.VIII.1980, leg. W. THOMAS (MWM, GU 5066).
The micropylar rosette is irregular, consisting of 7 broad leaves somewhat rounded. The micropyles are situated on the centre of the floor. The transitional zone consists of 6 complete rows of irregular 6-gonal cells with strong carinae forming a symmetric pattern. From the 3rd row the cells are widened and their carinae become finer. The remainder of the chorion surface is covered with celled or spongia-shaped relief without distinct carinae or just borders forming fine and prominent sculptural pattern. The aeropyles are small (ca 0.6 µm in diameter), lying in apical depressions of the cone-shaped pits.

Dendrolimus himalayanus TSAI & LIU, 1964 (figs 57-60)
Original material: ♀, Nepal, Annapurna Himal, 1950 m, Talbagar, 83°39'E, 28°34'N, 24.VI.1996, leg. HREBLAY & SZABOKY (MWM, GU 5098).
The micropylar rosette is regular, almost symmetrical, consisting of 6-8 angled leaves (length 16-22 µm). The micropyles are situated on the margin of the floor and have a diameter of ca. 6 µm. The transitional zone consists of 4-5 rows of almost regular polygonal, mostly 6-gonal cells with distinct carinae gradually disappearing. The cells are widened from the 3rd row. The carinae are present as suturae below the transitional zone, and the aeropyles are situated in the corners of these suturae in a number. The aeropyles are large (1.1-3.0 µm in diameter) and rounded by a prominent ring.

Genus *Pyrosis* OBERTHÜR, 1888 (figs 61-63)

The egg shell was studied for 3 members of the genus: *Pyrosis borneana* HOLLOWAY, 1987 (original material from Borneo, Sabah Prov., Mt. Trus Madi bei Apin Apin, 1450 m, ex ovo, 2.-16.XII.1997, Martini (MWM, GU 5546)), *P. rotundipennis* DE JOANNIS, 1927 (original material from Thailand, Chiang Mai, in ZFMK) and *P. idiota* GRAESER, 1888 (original material from N China, Nei Monggu, in Museum für Naturkunde, Dresden). All three are very similar and can be characterized as follows:
The micropylar rosette is weakly irregular, rather asymmetrical, consisting of 7-8 stretched leaves with swamped to rounded angles, different in size (length 14-30, mostly 24-28 µm). The micropyles are ca. 4 µm in diameter and are situated on the margin of the floor. The transitional zone consists of 3-4 complete and two more additional incomplete rows of 6-gonal cells with distinct carinae lying in the grooves. Carinae are absent below the transitional zone where only weak groves are visible and small pits are situated in their angles. The aeropyles are sparse and innumerous, very small (0.9–1.0 µm in diameter), visible as weak depressions.

Genus *Metanastria* HÜBNER, [1820] 1816

Metanastria hyrtaca (CRAMER, 1779) (figs 65-66)
Original material: ♀, Taiwan, Prov. Taipei, 10 km SE of Pinglin, 450 m, 4.X.1996, leg, FÁBIÁN & NEMES (MWM, GU 5055).
The micropylar rosette is regular, consisting of 6-7 leaves (length ca 16 µm) with broadened tips. The micropyles (ca 3 µm in diameter) are situated on the centre of the floor. The transitional zone consists of 4-5 complete rows of 6-gonal cells gradually disappearing, with strong carinae and forming a radial symmetrical pattern. From 4th row, the cells are widened and rugous inside. The carinae are visible as weak transversally wrinkled suturae below the transitional zone, with aeropyles in the corners. The aeropyles are medium-sized (1.0 - 1.3 µm in diameter) on the tips of large spherical pits.

Genus *Suana* Walker, 1855

Suana concolor (de Lajonquière, 1855) (figs 67-68)

Original material: ♀, NE India, Meghalaya, Nokrek Nat. Park, 1150 m, Garo Hills, 2.-13.VII.1997, 25°40'N, ex ovo, leg. Afonin & Sinjaev (MWM, GU 5053).

The micropylar rosette is irregular and asymmetric, consisting of stretched leaves with angled tips, being 19-25 µm long. The transitional zone consists of 2 rows of strongly stretched cells disappearing and coming immediately to the aeropylar zone. The carinae are absent here and the borders of the cells are undermined only in the aeropylar pits lying in the corners of the cells. The aeropyles are small (1.3-1.4 µm in diameter) and bordered with low ringed folds.

Genus *Similodora* Zolotuhin & Witt, 2007

Similodora fia (Swinhoe, 1899) (figs 69-72)

Original material: ♀, Pakistan, Himalaya Mts, Kaghan Valley, Tathabaya, 2.250 m, 73°26'E, 34°36'N, 23.VII 1998, leg Fábián & Herczig (MWM, GU 5078).

The micropylar rosette consists of 7 medium-sized leaves (length is ca. 18 µm) with angled tips. The micropyles are situated on the centre of the floor and covered with a screen of the chorion. The transitional zone consists of 4-5 complete rows of polygonal cells gradually disappearing. Carinae are well visible and producing a rather symmetric pattern but gradually disappearing below the transitional zone. From 4th row the cells are widened, their borders are interrupted and their inner surface becomes spongia-shaped. The aeropyles are small, lying in the low spherical pits.

Similodora defreinai Zolotuhin & Witt, 2007 (figs 73-76)

Original material: ♀, Pakistan, Kashmir, Himalaya Mts, Deosai Mts, Bubin village, 3150 m, 74°58'E, 35°12'N, 19.VI.1998, leg. Fábián & Herczig (MWM, GU 5076).

The micropylar rosette consists of 7 medium-sized leaves (length is ca. 11-13 µm) with obtuse-angled tips. The micropyles are situated on the centre of the floor. The transitional zone consists of 4 complete rows of polygonal cells gradually disappearing. Carinae are well visible and producing a rather symmetric pattern but gradually disappearing below the transitional zone. From 4th row the cells are widened, their borders are interrupted and their inner surface becomes weakly wrinkled, more finely sculptured than in the previous species. The aeropyles are small and sparse, lying in indistinct pits.

Genus *Paralebeda* Aurivillius, 1894

Paralebeda femorata (Ménétriès, 1858) (fig. 64)

Original material: ♀, Russia, Far East, South Primorye, Lazo Reserve, VII.1990, leg. N. Beljakova (CVZU).

The chorion structure of the species was already illustrated by Dolinskaja & Plustsch (2000); here it is figured again to show reticular pattern of chorion with numerous aeropyles laid on the ribs.

Genus *Arguda* Moore, 1879

Arguda vinata Moore, 1865 (figs 77-80)

Original material: ♀, N-Vietnam, 1600 m, Mt. Fan-Si-Pan (Nord), Cha-pa, Primärurwald, 22°17'N, 103°44'E, IV.1995, leg. R. Brechlin (MWM).

The micropylar rosette is regular, consisting of 9 stretched leaves with tips broad and rounded on the corners. The micropylar leaves are fused almost on all length. The micropyles (5 µm in diameter) are situated on the centre of the floor. The transitional zone consists of 3-4 complete rows of irregular 6-gonal cells with strong carinae. Lower the transitional zone, the carinae are present as rugous sutures with aeropyles on the nodes. The aeropyles (1.5 µm in diameter) are rounded by protruded rings.

Arguda decurtata Moore, 1879 (figs 81-84)

Original material: ♀, Thailand, Changwat Nan, 30 km E of Pua, 1.700 m, 1.III.1998, leg. Hreblay & Szaboky (MWM, GU 5075).

The micropylar rosette is regular, almost symmetric, consisting of 12-17 strongly stretched leaves with tips broad and rounded on the corners. The micropylar leaves are fused almost on all length. The micropyles are situated on the centre of the floor. The transitional zone consists of 4-5 complete rows of irregular polygonal (5-6 angled) cells with well developed carinae. Lower the transitional zone, the carinae are present as suturae, with the aeropyles situated in the nodes. The aeropyles are small (about 0.6 µm in diameter) and rounded by protruded rings.

Genus *Bharetta* Moore, [1866] 1865

Bharetta cinnamomea Moore, [1866] 1865 (figs 85-89)

Original material: ♀, Sikkim, Mt. Kanchenjunga, 2225 m, 27°30'N, 88°20'E. 11-14.VIII.1995, leg. Afonin & Sinjaev (MWM, GU 5068).

The micropylar rosette is almost symmetrical, consisting of 7 stretched leaves (length 10-15 µm) with rounded tips. The micropyles are situated on the centre of the floor. The transitional zone consists of 4-5 complete rows of irregular polygonal cells with distinct carinae gradually disappearing. Below, the cells become larger and their inner surface becomes rugous or reticular, and the carinae present there as weak suturae with the aeropyles in the nodes. The aeropyles (ca 2.0 µm in diameter) are mostly of irregular shape, and situated in protruded spherical pits.

Genus *Hallicarnia* Kirby, 1892

Hallicarnia bidens (Zerny, 1928) Figs 90-92

Original material: ♀, Indonesien, Sulawesi centr., Namo, 650 m, Str. Paly-Gimpu, 21.-22.XI.1995, leg. S. Naumann (MWM, GU 5056).

The micropylar rosette is regular, almost symmetrical, consisting of 8-9 leaves (length 17-19 µm) with broad tips. Micropyles (6 µm in diameter) are situate on the centre of the floor. The transitional zone consists of 3-4 complete rows of irregular polygonal cells with strong carinae gradually disappearing and almost vanished below. The remainder of the chorion surface is covered with very broad raised suturae with innumerous aeropyles on some corners. The aeropyles are of medium size (ca 1.2 µm in diameter) and distinct.

Genus *Syrastrenopsis* Grünberg, 1914

Syrastrenopsis moltrechti Grünberg, 1914 (figs 93-95)

Original material: ♀, Russia, Far East, Primorie, Kedrovaja Padj, 1987 (MWM).

The micropylar rosette consists of 7-8 leaves (length is 14-20 µm). The micropyles (2 µm in diameter) are situated on the centre of the floor. The transitional zone consists of 4-5 rows gradually disappearing. The remainder of the chorion surface is covered with deep but narrow folds. The aeropyles are rather small (1.7 µm in diameter) and situated immediately on the chorion surface not on the pits.

Syrastrenopsis bilinea Kishida, 1995 (figs 96-97)
Original material: holotype ♀, Eastern Nepal, Kathmandu, Godavary, 1600 m (NSMT)].
The micropylar rosette consists of 6 rather stretched leaves (length is ca. 26 µm). The micropyles (3 µm in diameter) are situated on the margin of the floor and are covered with a screen of the chorion. The transitional zone consists of 3-4 rows gradually disappearing. The remainder of the chorion surface is weakly wrinkled without any geometric pattern. The aeropyles are rather small (0.7 µm in diameter) but well visible, on low protrusions.

Genus ***Syrastrena*** Moore, 1884

Syrastrena sinensis obliquilinea Kishida, 1985 Figs 98-100
Original material: ♀, Taiwan, Prov. Miaoli, 20 km E of Tungshih, 1335 m, 18.X.1995, 121°03'E, 24°19'N, Csovari & Steger (MWM, GU 5069).
The micropylar rosette is regular and symmetrical, consisting of 9-10 leaves (length ca 26 µm), with rounded tips, different in size. The micropylar leaves are fused almost on the entire length. The micropyles (5 µm in diameter) are situated on the margin of the floor and covered with a chorion screen. The transitional zone consists of 2-3 rows of irregular pentagonal cells with strong carinae gradually disappearing. The remainder of the chorion surface is presented by a complicated flower-shaped pattern with triangular to circular petals from broadened suturae and a funnel-shaped aeropylar pit in the centre of each 'flower'. The aeropyles (ca 1.0 µm in diameter) are lying in the bottom of the pit funnel.

Discussion: Thus, the following preliminary conclusions can be made. Based on chorion structure, the eggs can be divided into the following groups:
The first group has rather keg-shaped to subcylindrical eggs with all the chorion sculpture lying only on the micropylar pole. Aeropyles are also moved here to the micropylar pole, especially for *Malacosoma* species, or at least lack special surrounded structures like pits or wrinkled rings. This similarity is surely convergent and occurs in the species laying egg masses in clusters (*Chondrostega* and *Eriogaster*, less so *Trichiura* where clusters are much sparser and not glued to the substrate by a hidden gland or covered with scales). In *Malacosoma*, for example, the eggs are glued together with a so-called spumaline up to the micropylar rosette and therefore any sculpture outside the rosette would be senseless.
The second group of species has an egg shell structure rather typical and similar to the ground plan of the Bombycoides. Three main zones may be divided here - the micropylar rosette, the transitional zone and the aeropylar zone, their sculpture is usually weak, sometimes completely absent and only aeropylar pits are rather distinct, often connecting with the help of grooves or low suturae in a complete polygonal net. Such kind of sculptural patterning is typical for *Poecilocampa* and *Hallicarnia*.
The third group of genera, resembling generally the second, has hence the sculptural relief especially prominent in transitional and aeropylar zones, their inner parts of forming cells are especially sculptured, sometimes raised or supplied with additional processes forming sometimes very elegant geometrical or flower-like patterns. Probably it is a character more systematic or diagnostic than a phylogenetic one but it was found in such genera as *Arguda*, *Bharetta*, *Syrastrena*, *Syrastrenopsis* considered to be closely related, and also in *Similodora* and *Dendrolimus cheela* Moore. The forthcoming research will show if it is really a good diagnostic character for some phylogenetic branches.
At the same time, the structure of the chorion can help us to solve some taxonomic questions. For example, the egg shell of *D. cheela* Moore is so different from all other *Dendrolimus* species that it provides additional support to its separation into its own genus. This idea was already delivered because of modified wing pattern in moths, and ♂ and ♀ genitalia of another ground plan. This phylogenetic branch joins two related species (*D. cheela* Moore and *D. phantom* Zolotuhin & Witt, 2000), more related to *Pachyposoides* than to *Dendrolimus*. This separation will be made later in a further article.

References

Abrogast, R. T., Lecato, G. L. & R. Van Byrd (1980): External morphology of some eggs of stored-product moths (Lepidoptera: Pyralidae, Gelechiidae, Tineidae). - Int. J. Insect Morphol. & Embryol. **9**: 165-177, New Brunswick.

Dierl, W. (1984): Das Ei von *Poecilocampa populi* Linnaeus und *alpina* Frey (Lepidoptera, Lasiocampidae). - Nachrbl. Bayer. Ent. **33**: 32-33, München.

Döring, E. (1955): Zur Morphologie der Schmetterlingseier. - Akademie-Verlag, Berlin.

Dolinskaya, I. V. & I. G. Plustsch (2000): External morphology of the eggs of some lappet moths (Lepidoptera, Lasiocampidae). - Vestnik zoologii **34**: 49-60, Kiev.

Eitschberger, U. (2008a): REM-Bilder der Eier von drei *Poecilocampa* Stephens, 1828-Taxa: *Poecilocampa alpina alpina* (Frey & Wulschlegel, 1874), *Poecilocampa alpina canensis* (Millière, 1875), *Poecilocampa populi populi* (Linnaeus, 1758) (Lepidoptera, Lasiocampidae). - Neue Entomologische Nachrichten **62**: 134-138, Marktleuthen.

Eitschberger, U. (2008b): REM-Bilder der Eier von drei *Eriogaster* Germar, 1810-Arten im Vergleich: *Eriogaster arbusculae arbusculae* Freyer, 1849, *Eriogaster catax* (Linnaeus, 1758), *Eriogaster lanestris lanestris* (Linnaeus, 1758) (Lepidoptera, Lasiocampidae). - Neue Entomologische Nachrichten **62**: 139-143, Marktleuthen.

Eitschberger, U. (2008c): REM-Bilder der Eier von *Macrothylacia digramma alfacarica* Ribbe, 1910 und *Macrothylacia rubi rubi* (Linnaeus, 1758) (Lepidoptera, Lasiocampidae). - Neue Entomologische Nachrichten **62**: 145-147, Marktleuthen.

Eitschberger, U. (2008d): REM-Bilder der Eier von zwei *Dendrolimus pini* (Linnaeus, 1758)-Unterarten im Vergleich: *Dendrolimus pini pini* (Linnaeus, 1758), *Dendrolimus pini schultzeana* Rebel, 1934 (Lepidoptera, Lasiocampidae). - Neue Entomologische Nachrichten **62**: 148-150, Marktleuthen.

Fehrenbach, H. (1995): Egg shells of Lepidoptera - fine structure and phylogenetic implification. - Zool. Anz. **234**: 19-41, ?????.

Hinton, H. E. (1981): Biology of insect eggs **1-3**: 1-1125. - Pergamon Press, Oxford.

HOU, TAO-QIAN (1987): The pine caterpillars in China. - Science Press, Beijing [in Chinese].

KOBES, L. M. (1982): Die ersten Stände von *Dendrolimus benderi* DE LAJONQUIÈRE, 1975 (Lepidoptera, Lasiocampidae). - Entomofauna **3**: 271-278, Ansfelden.

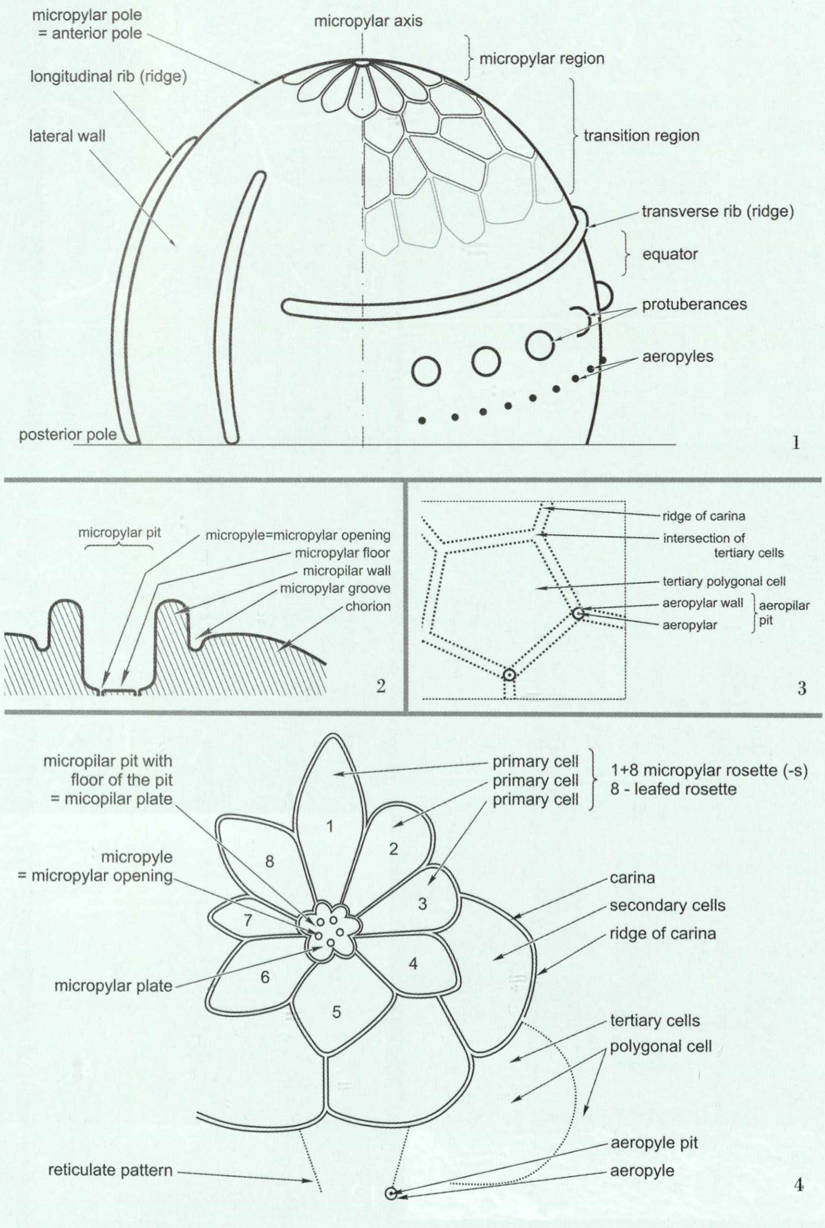
MARINI, M. & M. TRENTINI (1988): *Pachypasa otus* (DRURY): aspetti di oomorfologia e cariologia (Lepidoptera, Lasiocampidae). - Bol. Soc. ent. Ital. **120**: 223-226, Rome.

PARENZAN, P. & F. PORCELLI (1985): Notizie bio-etologiche sulla *Pachypasa otus* DRURY (Lepidoptera-Lasiocampidae) in Italia meridionale. - Entomologica **20**: 109-123, Bari.

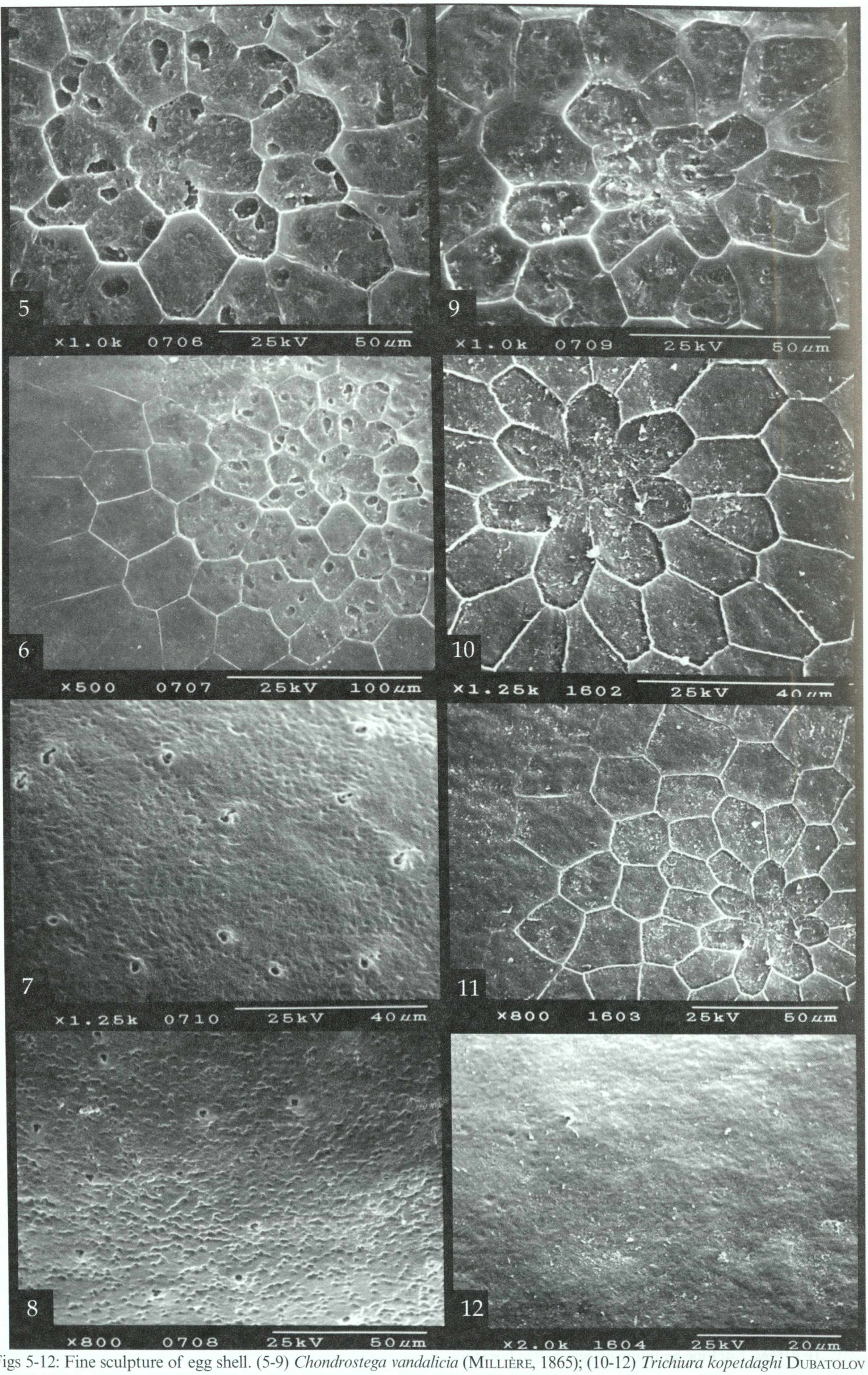
ROZHKOV, A. S. (1963): [Sibirskij shelkoprjad] *Dendrolimus sibiricus*. Systematic position, phylogeny, distribution, economic importance, morphology, bionomics. - Moskva (in Russian).

Address of the authors

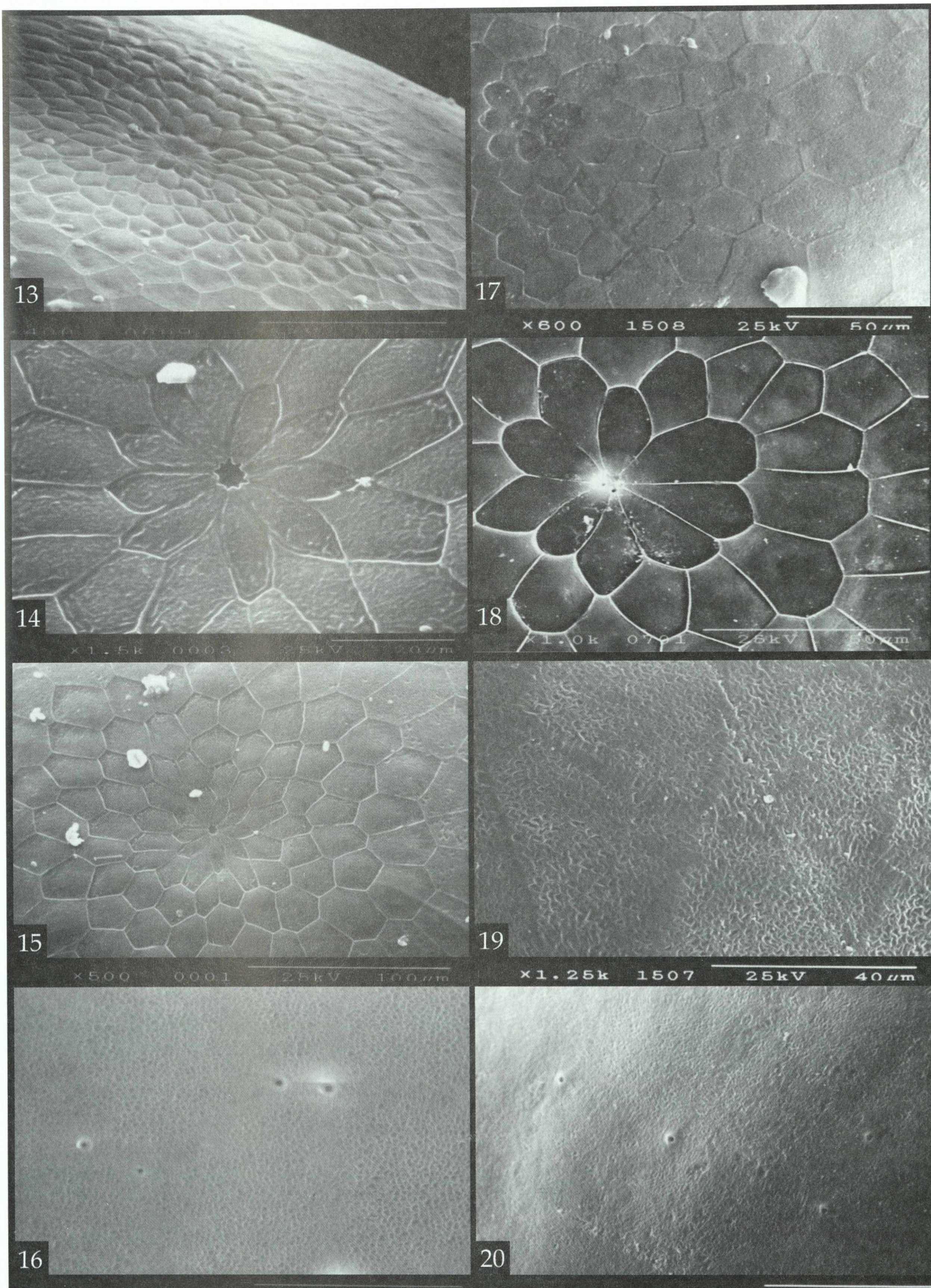
DR. VADIM ZOLOTUHIN & PAVEL A. KURSHAKOV
Department of Zoology
State pedagogical University of Ulyanovsk
Pl. 100-letiya Lenina 4
RUSSIA-432700 Ulyanovsk
e-mail: v.zolot@mail.ru



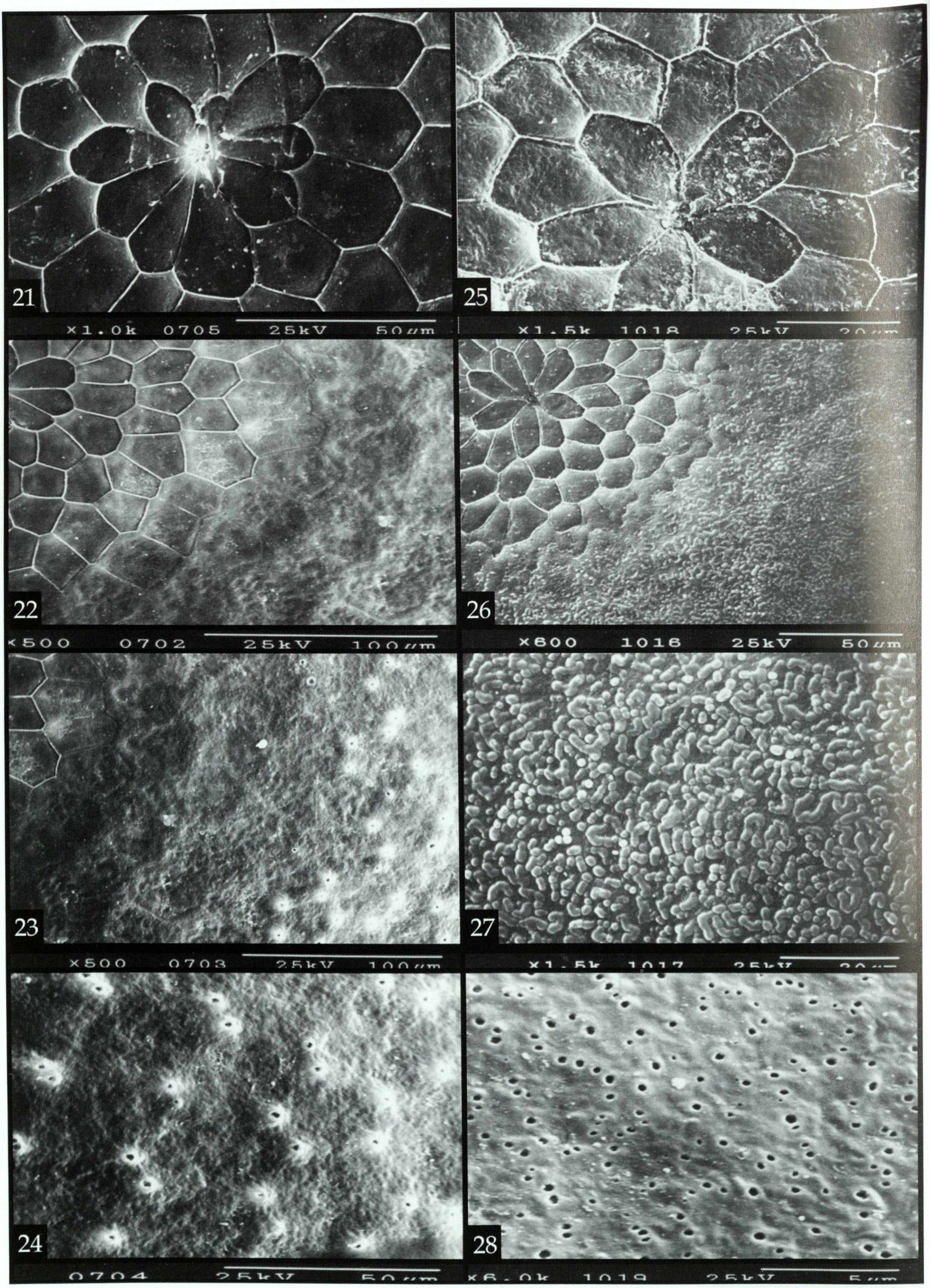
Figs. 1-4: Fine sculpture of egg shell in Lepidoptera: morphological schemes (made by A. SOLOVYEV).



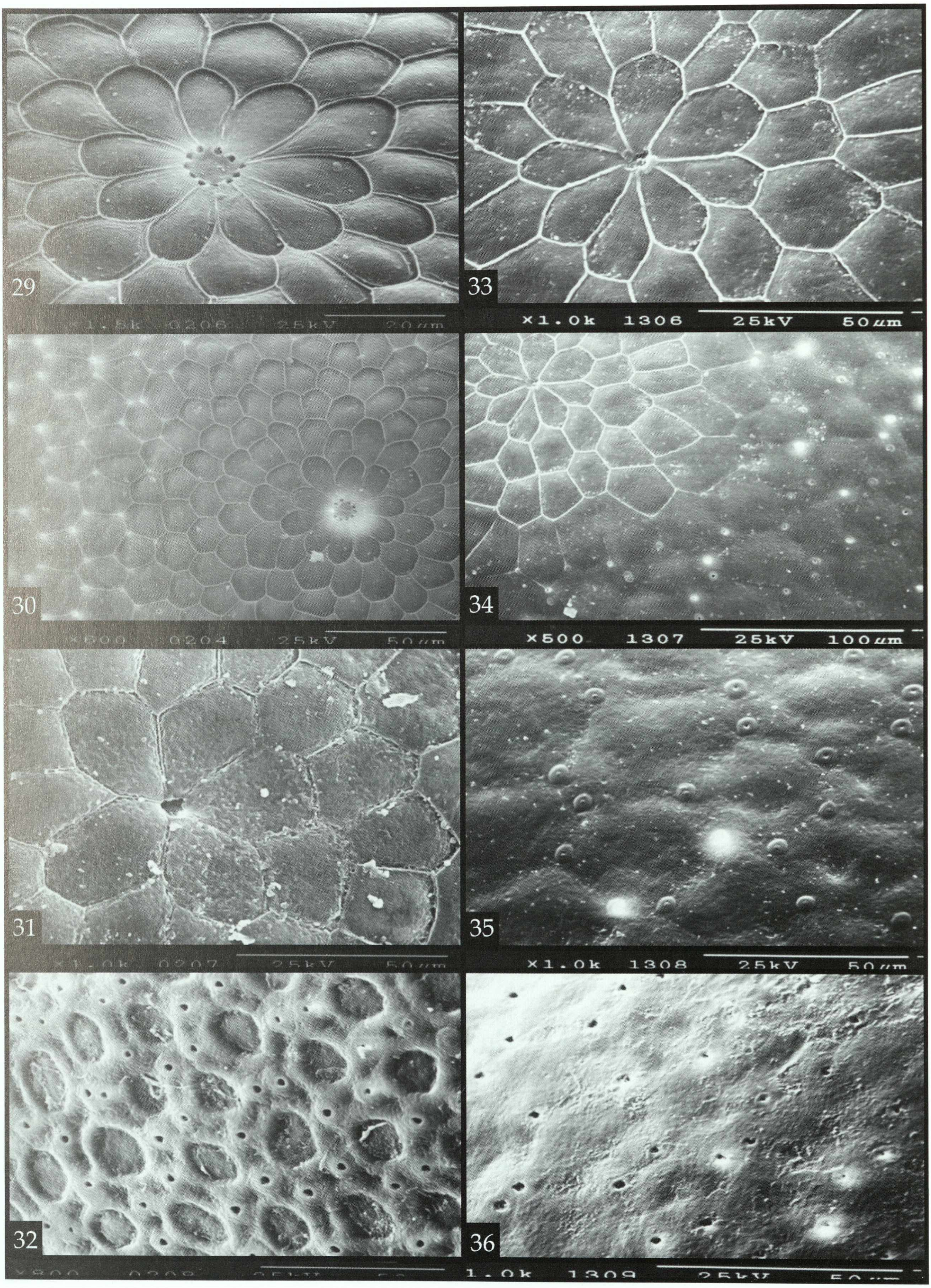
Figs 5-12: Fine sculpture of egg shell. (5-9) *Chondrostega vandalicia* (Millière, 1865); (10-12) *Trichiura kopetdaghi* Dubatolov & Zolotuhin, 1992.



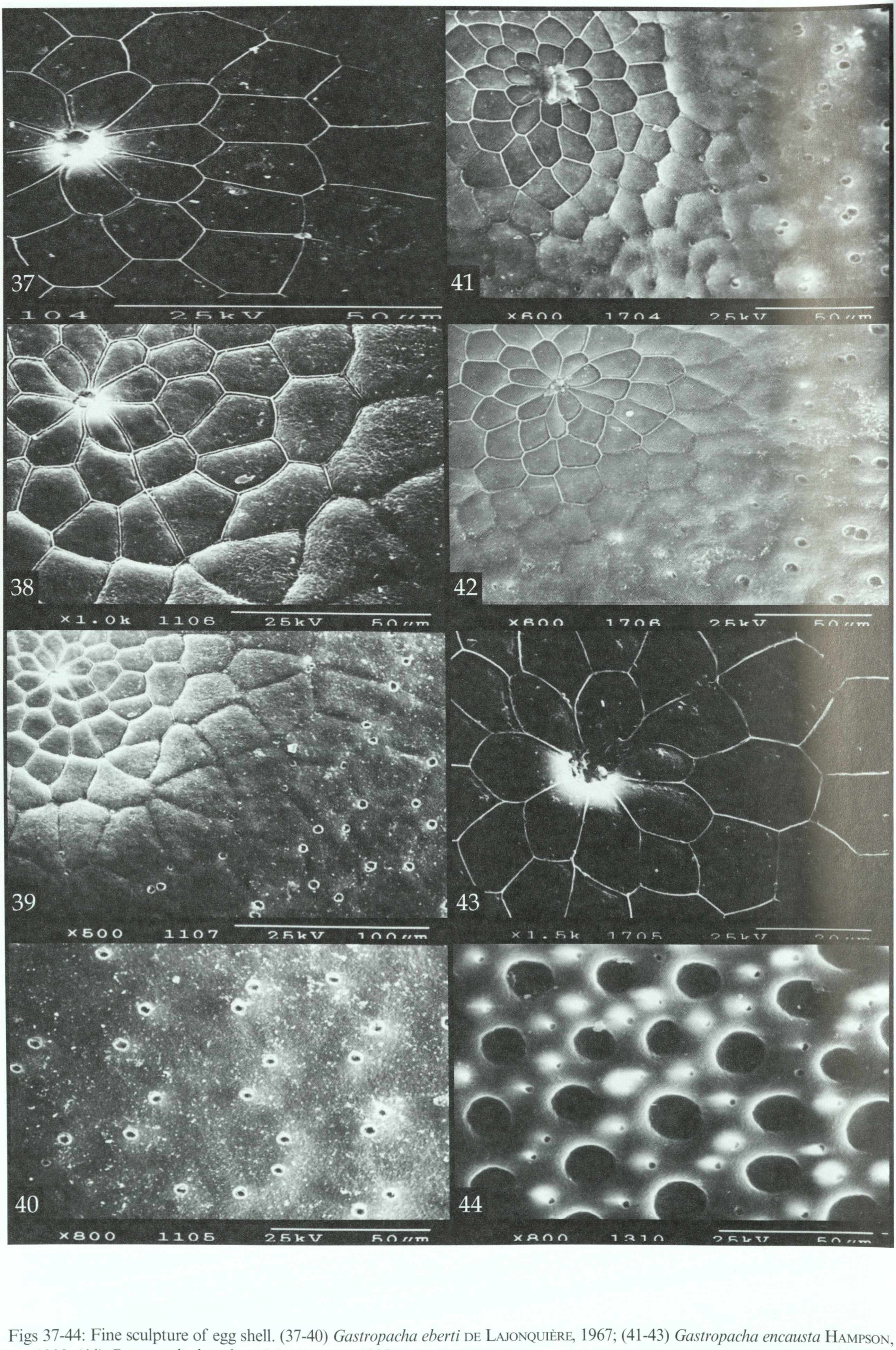
Figs 13-20: Fine sculpture of egg shell. (13-17) *Poecilocampa populi populi* (LINNAEUS, 1758); (18-20) *Poecilocampa populi pontica* DE FREINA, 1999.



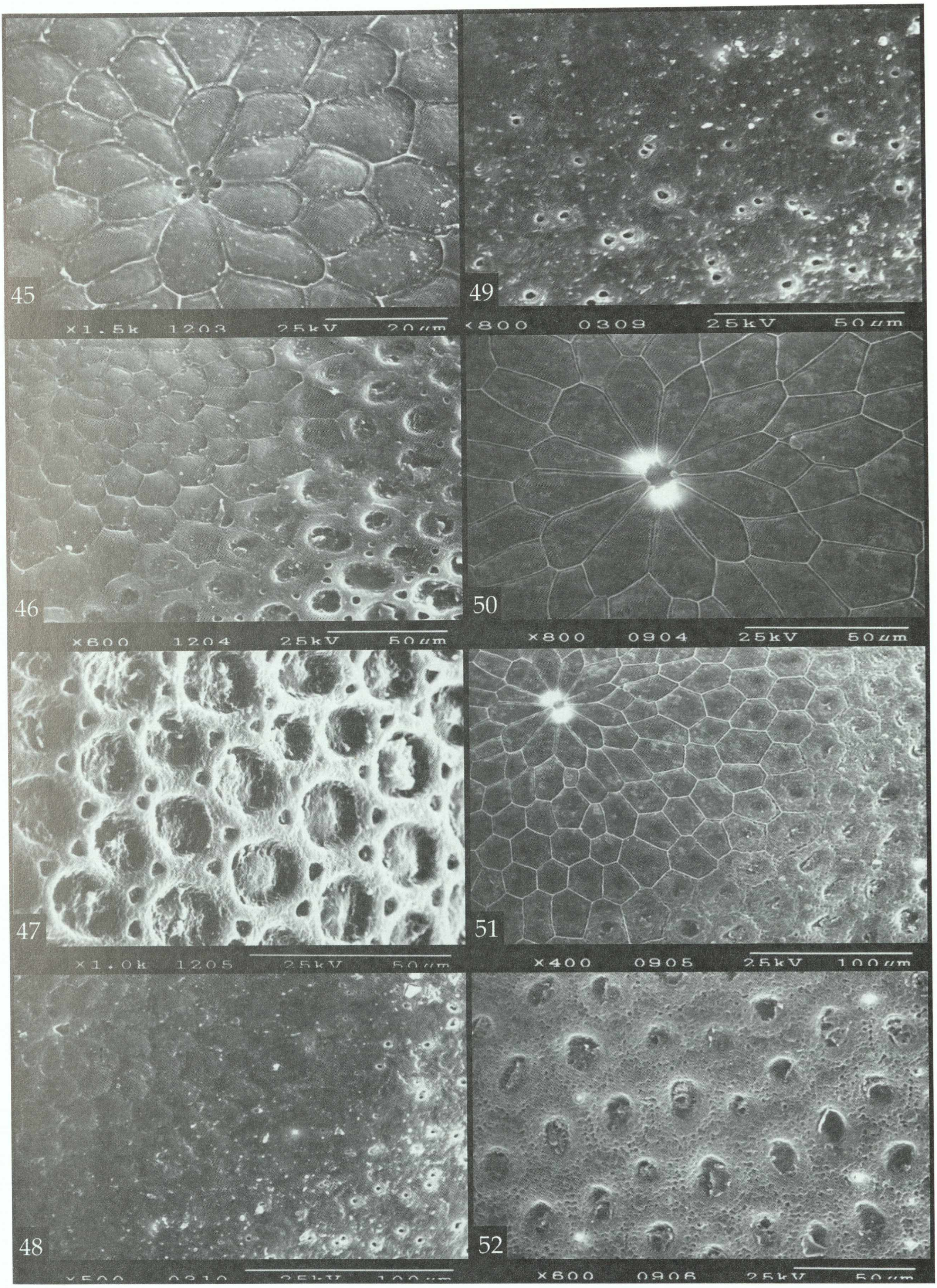
Figs 21-28: Fine sculpture of egg shell. (21-24) *Crinocraspeda torrida* (MOORE, 1879); (25-28) *Baodera khasiana* (MOORE, 1879).



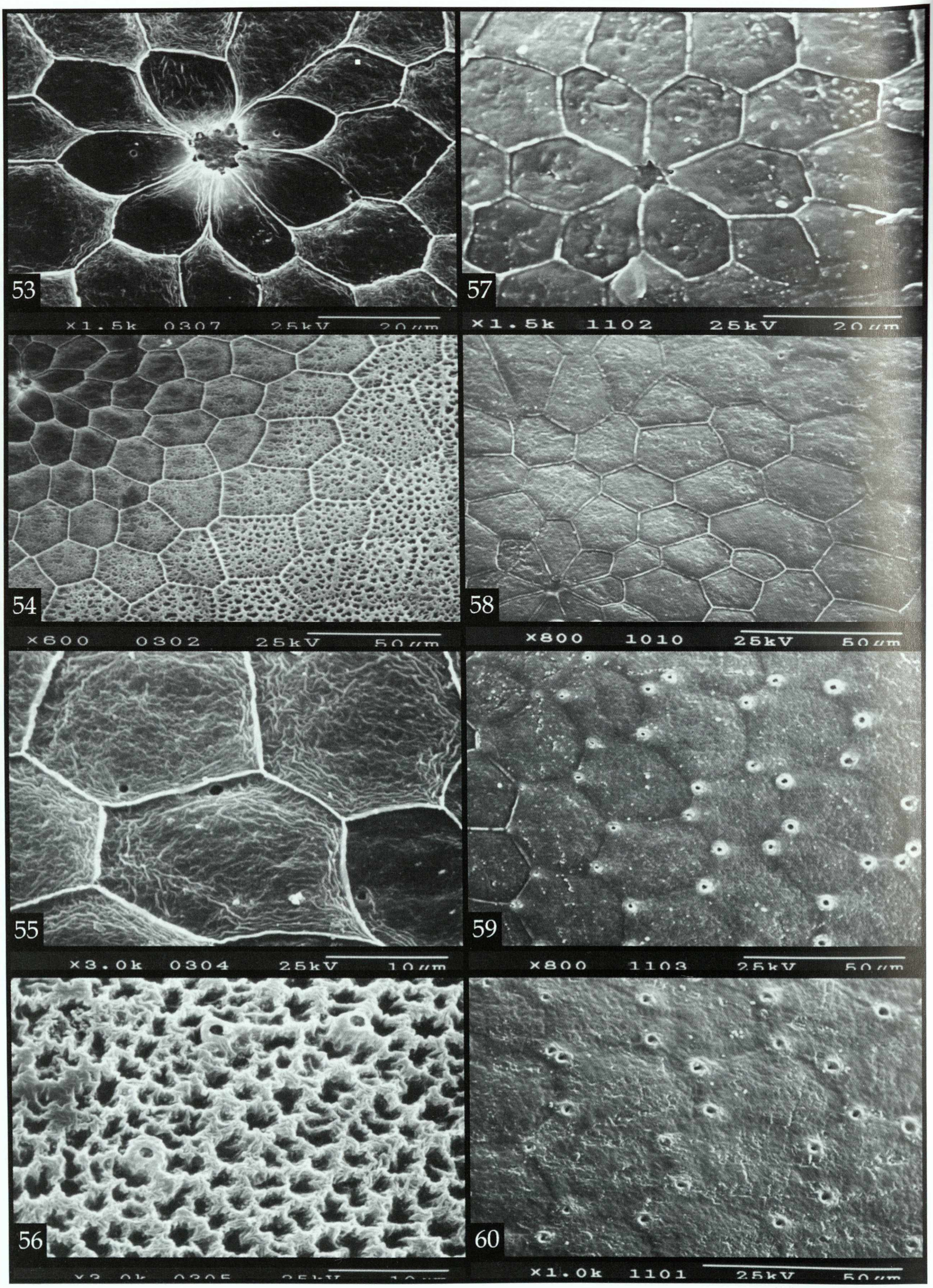
Figs 29-36: Fine sculpture of egg shell. (29-30) *Euthrix potatoria bergmani* Bryk, 1941; (31-32) *Micropacha krocha* Zolotuhin, 1995; (33-36) *Cosmotriche discitincta* Wileman, 1914.



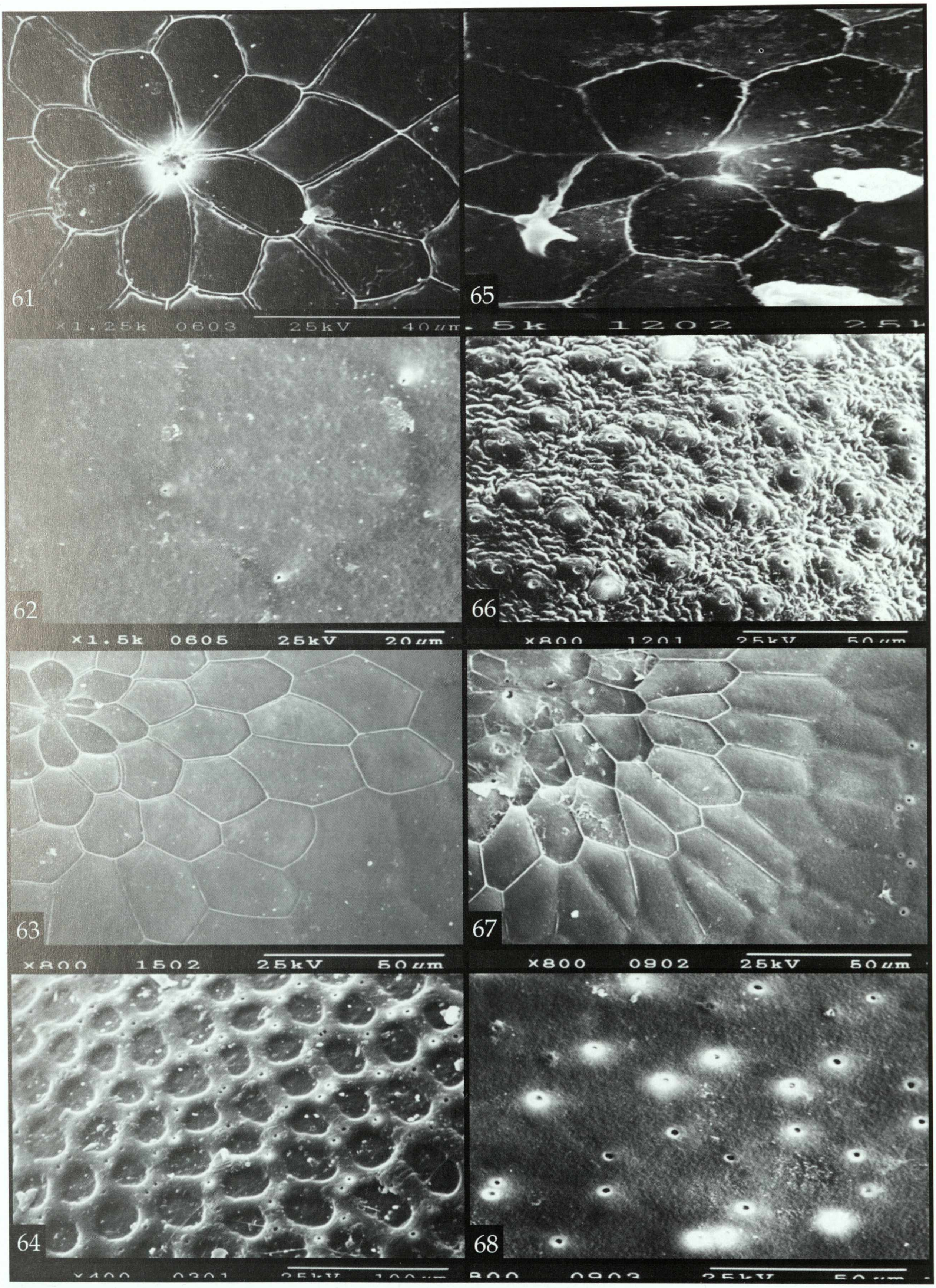
Figs 37-44: Fine sculpture of egg shell. (37-40) *Gastropacha eberti* DE LAJONQUIÈRE, 1967; (41-43) *Gastropacha encausta* HAMPSON, 1900; (44) *Gastropacha horishana* MATSUMURA, 1927.



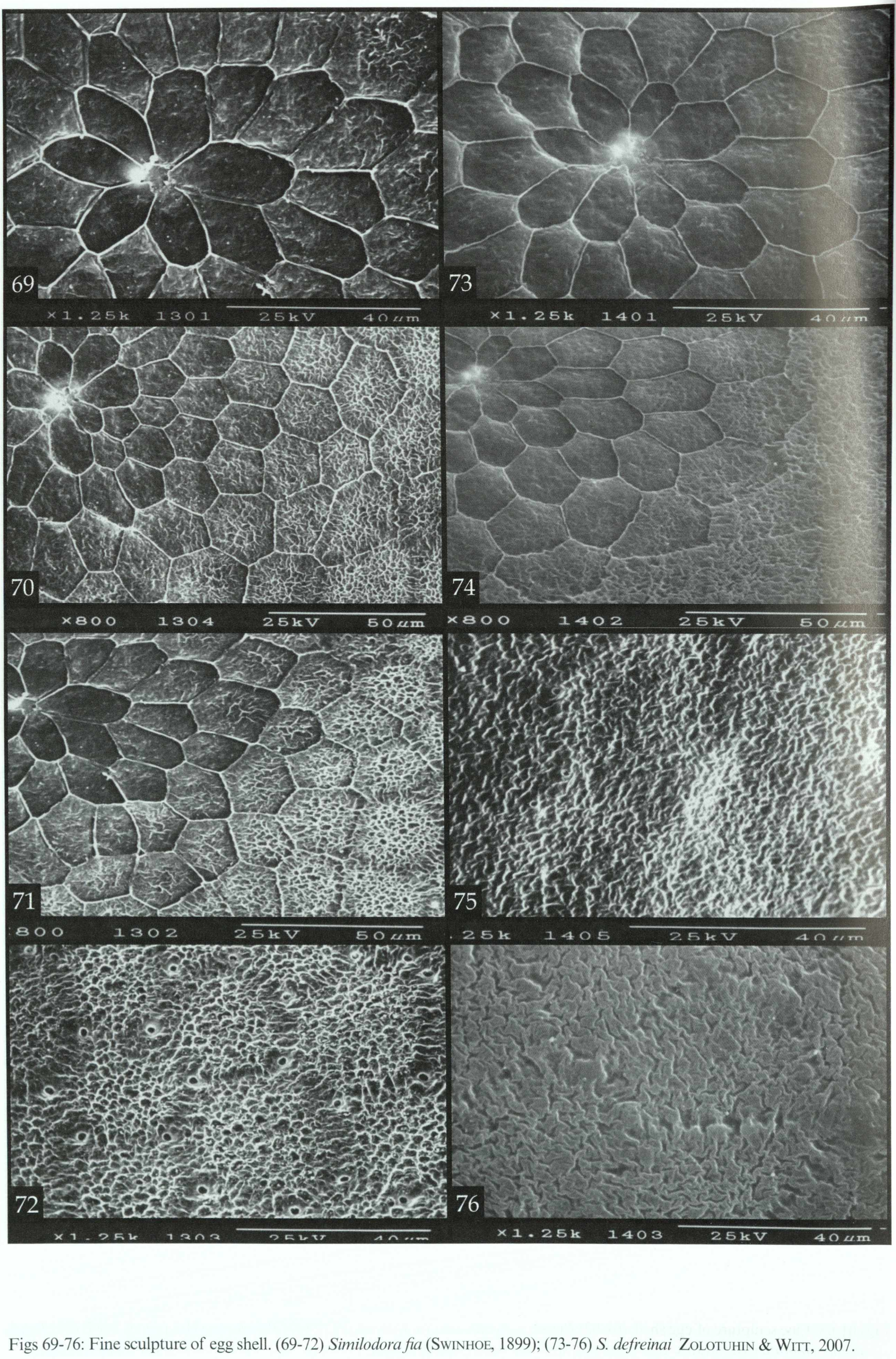
Figs 45-52: Fine sculpture of egg shell. (45-47) *Paradoxopla undulifera* (Walker, 1855); (48-49) *Phyllodesma japonicum arborea* Blöcker, 1908; (50-52) *Pachypasoides albisparsa* Wileman, 1910.



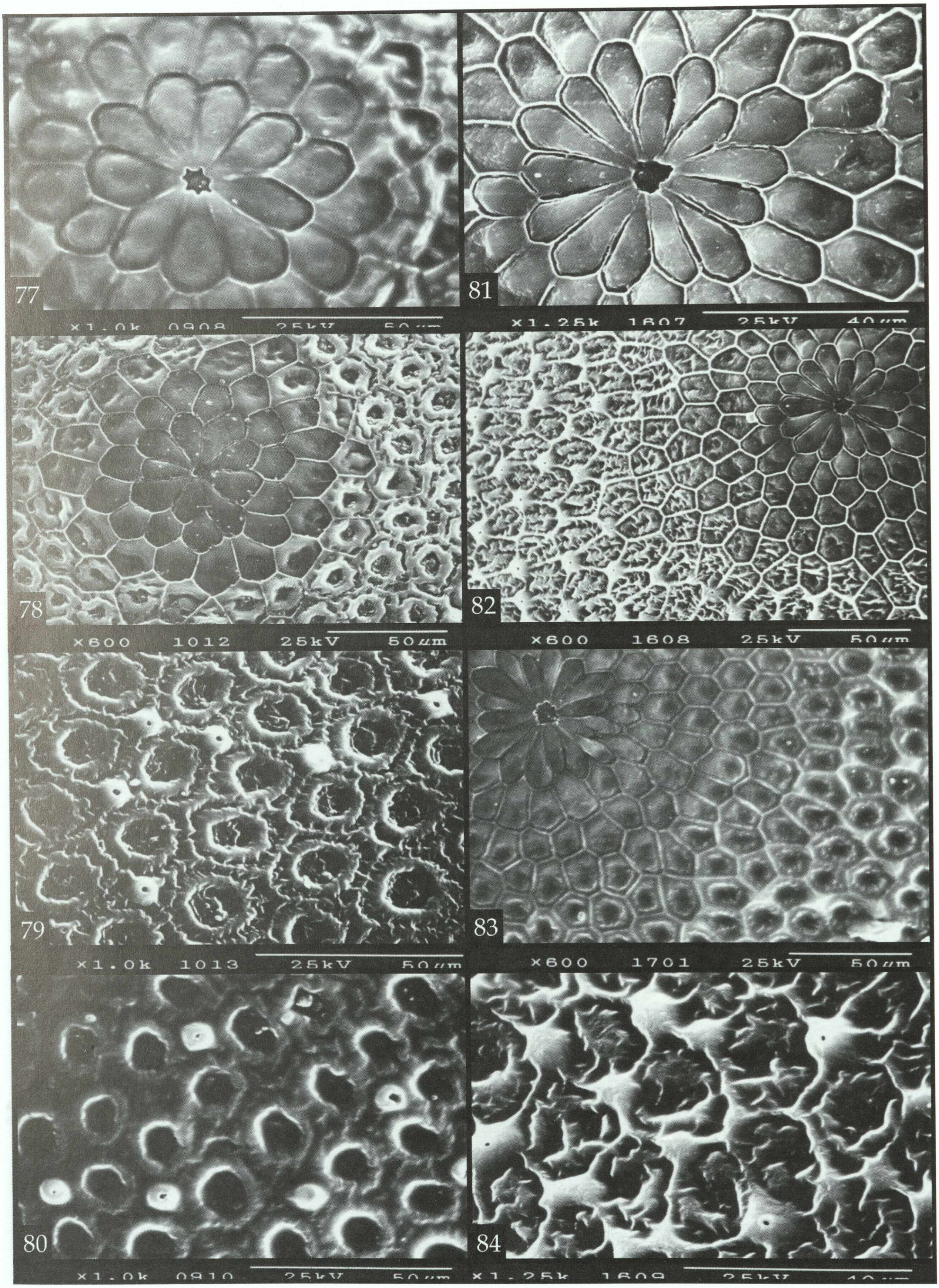
Figs 53-60: Fine sculpture of egg shell. (53-56) *Dendrolimus cheela* (Moore, 1879); (57-60) *Dendrolimus himalayanus* Tsai & Liu, 1964.



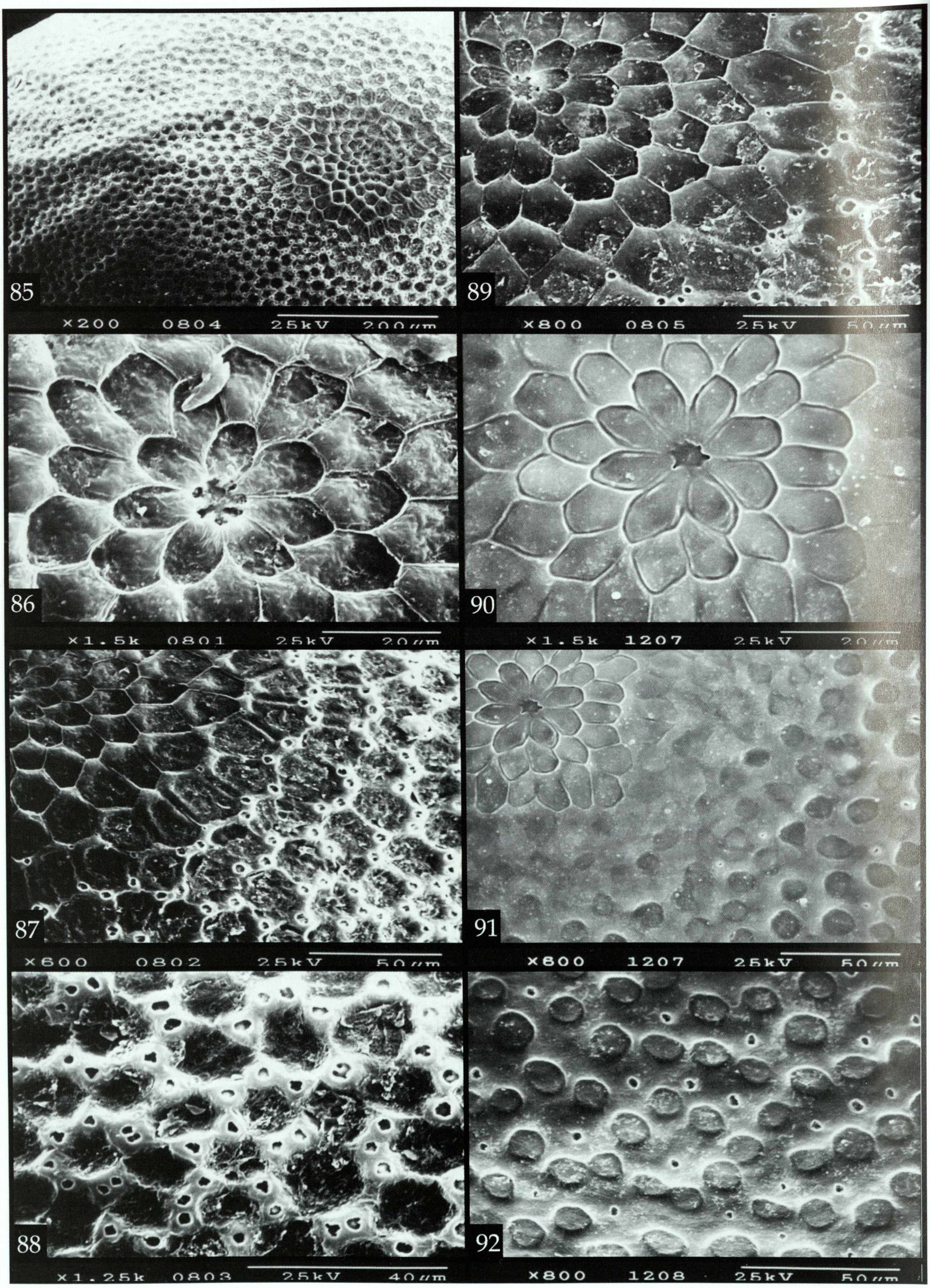
Figs 61-68: Fine sculpture of egg shell. (61-62) *Pyrosis rotundipennis* de Joannis, 1927; (63) *P. borneana* Holloway, 1987; (64) *Paralebeda femorata* (Ménétriès, 1858); (65-66) *Metanastria hyrtaca* (Cramer, 1779); (67-68) *Suana concolor* (Walker, 1855).



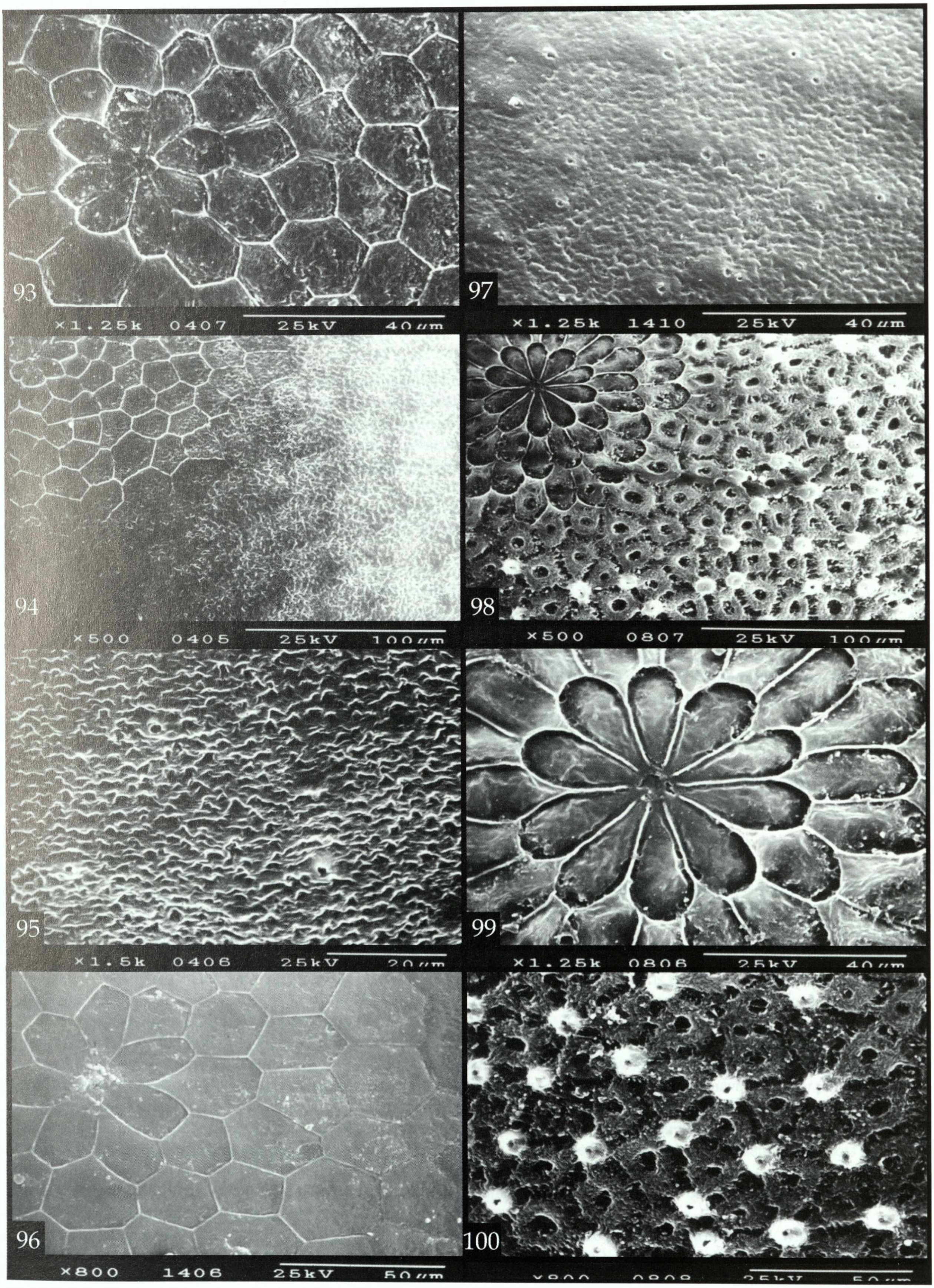
Figs 69-76: Fine sculpture of egg shell. (69-72) *Similodora fia* (SWINHOE, 1899); (73-76) *S. defreinai* ZOLOTUHIN & WITT, 2007.



Figs 77-84: Fine sculpture of egg shell. (77-80) *Arguda vinata* MOORE, 1865; (81-84) *A. decurtata* MOORE, 1879.



Figs 85-92: Fine sculpture of egg shell. (85-89) *Bharetta cinnamomea* MOORE, [1866] 1865; (90-92) *Hallicarnia bidens* (ZERNY, 1928).



Figs 93-100: Fine sculpture of egg shell. (93-95) *Syrastrenopsis moltrechti* GRÜNBERG, 1914; (96-97) *S. bilinea* KISHIDA, 1995; (98-100) *Syrastrena sinensis obliquilinea* KISHIDA, 1985.