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Morphology of eggs and spermatheca of *Odontotarsus purpureolineatus* (Heteroptera, Scutelleridae)

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Abstract: The morphology of the spermatheca and eggs of *Odontotarsus purpureolineatus* were studied by optical microscopy and scanning electron microscopy. The spherical eggs were about 1.35 mm long and 1.09 mm wide. The egg batches generally consist of 13–14 eggs. The egg surface is covered by polygonal (hexagonal and pentagonal shapes prevail) ridges and tiny chorionic tubercles. There were 8–10 aero-micropylar processes between the polygons. The spermatheca of *O. purpureolineatus* is characterized by a spherical spermathecal bulb, a pumping region, a flange of pump and dilation of spermathecal duct. Spermathecal processes and a median spermathecal dilation with sclerotized rod are missing. The spermathecal bulb and the pumping region possess many pores.

Key words: Heteroptera; Scutelleridae; *Odontotarsus purpureolineatus*; morphology; scanning electron microscopy

Introduction

The taxonomic and phylogenetic importance of eggshell structure in pterygote insects has been demonstrated in different orders at different taxonomic levels (Hinton 1981; Salkeld 1983, 1984; Margaritis 1985). Research on eggs of Heteroptera was reviewed by Southwood (1956) and Cobben (1968). Afterwards, egg surface structure of Heteroptera species has been studied by many authors (Esselbaugh 1946; Grigorov 1988; Javahery 1994; Simiczyjew 1994; Suludere et al. 1999; Bundy & McPherson 2000; Candan et al. 2001, 2005a, b; Candan & Suludere 2003, 2006a, b; Wolf & Reid 2003, 2004), however, accurate knowledge of the egg morphology is still lacking in many taxonomic groups, including Scutelleridae.

The spermatheca is an ectodermal gland, opening into the anterior tract of the common oviduct of the female insect. During mating, it is filled with spermatozoa which can be stored there for a long time until fertilization occurs (Davey 1965). The spermatheca has prominent glands serving in the nourishment of the spermatozoa. The first study on the spermatheca in Heteroptera was carried out by Dufour (1833), who erroneously regarded this organ as a sebaceous gland. Von Siebold (1837) published the first correct description of a spermatheca in a member of the Pentatomomorpha followed by other papers on the structure of the female genitalia in Heteroptera (Dupuis 1955; Pendergrast 1957; Scudder 1959; Kumar 1962; Mc Donald 1966). Servadei (1964) gave a detailed description of the spermathecae of Acanthosomatidae, Pentatomidae and Scutelleridae, with a key to subfamilies and genera. The spermatheca of Dinidoridae was studied by Durai (1987) and pertinent description of eleven species belonging to seven genera of Korean Podopinae and Asopinae were provided by Kim & Lee (1994). Kocorek & Danielczok-Demska (2002) compared the morphology of the spermathecae of eleven genera of the family Dinidoridae. These investigations were mainly done by light microscopy at low resolution and did not include scanning electron microscopy (SEM).

Here we describe for the first time the architecture of both spermatheca and eggs in *Odontotarsus purpureolineatus* (Rossi, 1790) (Scutelleridae) by using light microscopy (LM) and SEM.

Material and methods

Preparation of eggs

O. purpureolineatus was collected from Niğde, Ulukışla, Alihoca village, Turkey (6.VI.2006). Females were kept on graminaceous plants in plastic jars to lay eggs for analysis.

Approximately 30 eggs were examined and measured with an Olympus SZX12 light microscope. For SEM, freshly laid eggs were prepared according to Suludere (1988). Some of the cleaned and air dried eggs were mounted with double-sided tape on SEM stubs, coated with gold using a Polaron SC 502 Sputter Coater, and examined with a Jeol JSM 6060 SEM operated at 15 kV in Gazi University Electron Microscope Unit (Turkey).

Preparation of spermathecae

The specimens examined in this study were selected from dried museum material obtained from the field (deposited in Zoological Museum, Gazi University). First, the abdomens containing the spermathecae were soaked in 10% KOH for 5–10 minutes to soften the tissue. Then the spermathecae

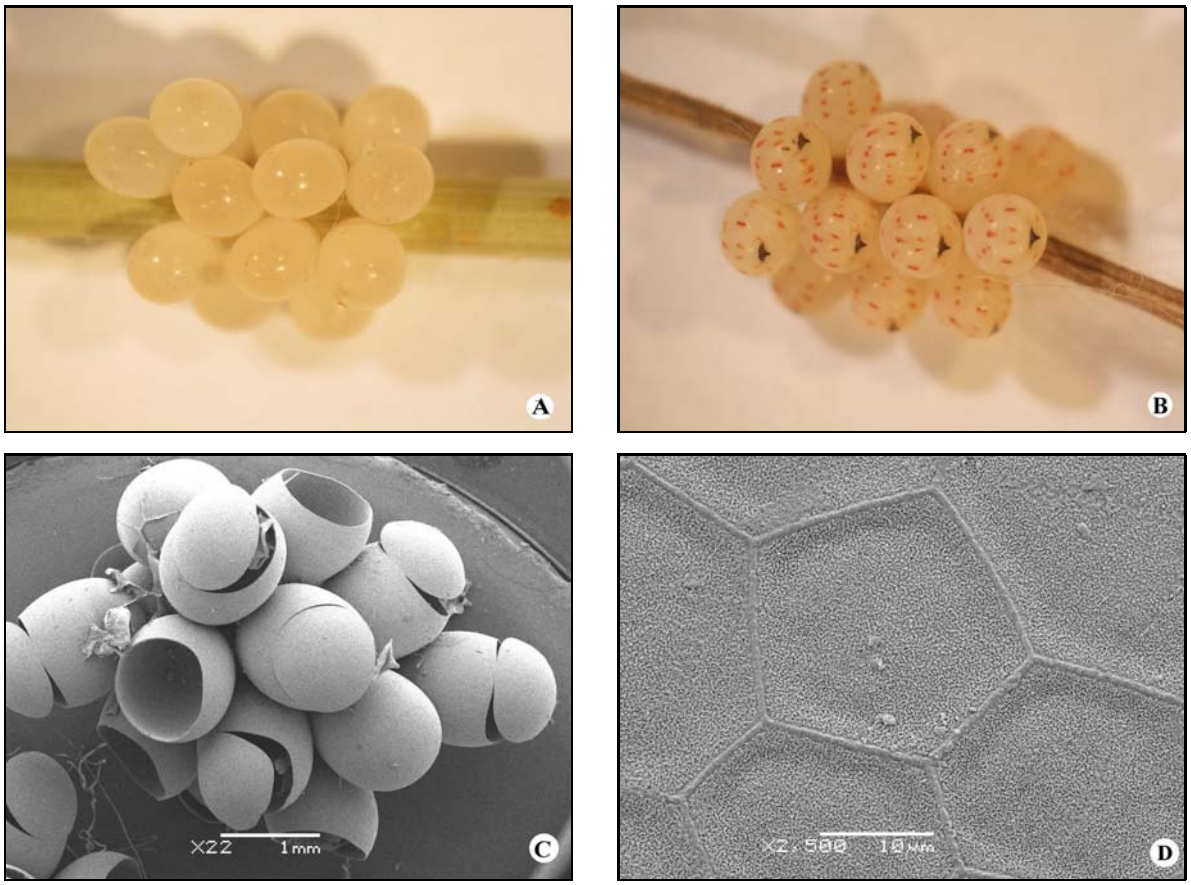

Fig. 1. Micrographs of eggs of *Odontotarsus purpureolineatus:* A – newly laid egg mass; B – egg-burster and red spots of embryo; C – scanning electron micrograph of an empty eggshells after hatching mass; D – polygonal pattern with tubercles at the egg surface.

Table 1. Abbreviations used in figures for the spermatheca.

B: Spermathecal bulb
Ddu: Distal part of spermathecal duct
Dl: Dilation of spermathecal duct
Fl: Flange of pump
P: Pumping region
Sdu: Proximal part of spermathecal duct
Rsc: Ring sclerites
Sc: Sclerite

were dissected and placed in 30% glycerol. Observations were made using standard optical equipment (stereoscopic microscope Olympus SZX12 at a magnification of ×40). The preparation of spermathecae for scanning electron microscopy was identical to that of the eggs.

The terminology for different sections of the spermatheca was adopted from Pendergrast (1957), Scudder (1959), and McDonald (1966). A list of abbreviations is given in Table 1.

Results

Eggs

The spherical shaped eggs are laid in three to four rows in an upright position and are fastened to stems of living plants at ground level under laboratory conditions. The egg batches generally consist of 14 eggs (13–14) (Figs 1A, B). Eggs are on average 1.35 mm (1.27–1.39 mm) long and 1.09 mm (1.04–1.12 mm) wide. Newly laid eggs are whitish, but they become light yellowish with the onset of embryonic development (Figs 1A, B). The egg surface of *O. purpureolineatus* shows a polygonal (generally hexagonal and pentagonal) ridges and tiny chorionic tubercles (Fig. 1D).

The eggs of *O. purpureolineatus* possess a ring of widely separated aero-micropylar processes around the anterior pole. The well-marked operculum intersects the ring of 8–10 aeromicropyles between polygonal patterns (Figs 2A, B).

The operculum is circular and the hatching line is clearly detectable in scanning electron micrograph. It forms a circle around the operculum (Figs 1C, 2A, C). The egg-burster becomes visible when the embryo is well developed and can be seen in motion during the last day of embryogenesis (Fig. 1B). Upon hatching, the operculum is lifted by the egg-burster, which is thick and highly sclerotized. It carries a dark T-shaped or triangular pattern (Figs 2C, D). Hatching begins by peristaltic contractions of the body of the developed larva moving from the back to the front and forcing the sclerotized portion of the egg bursters against the anterior pole of the egg. The egg-burster remains attached to the inner lateral face of the egg (Fig. 2C).

Spermatheca

The spermathecal bulb (B) is spherical and sclerotized.

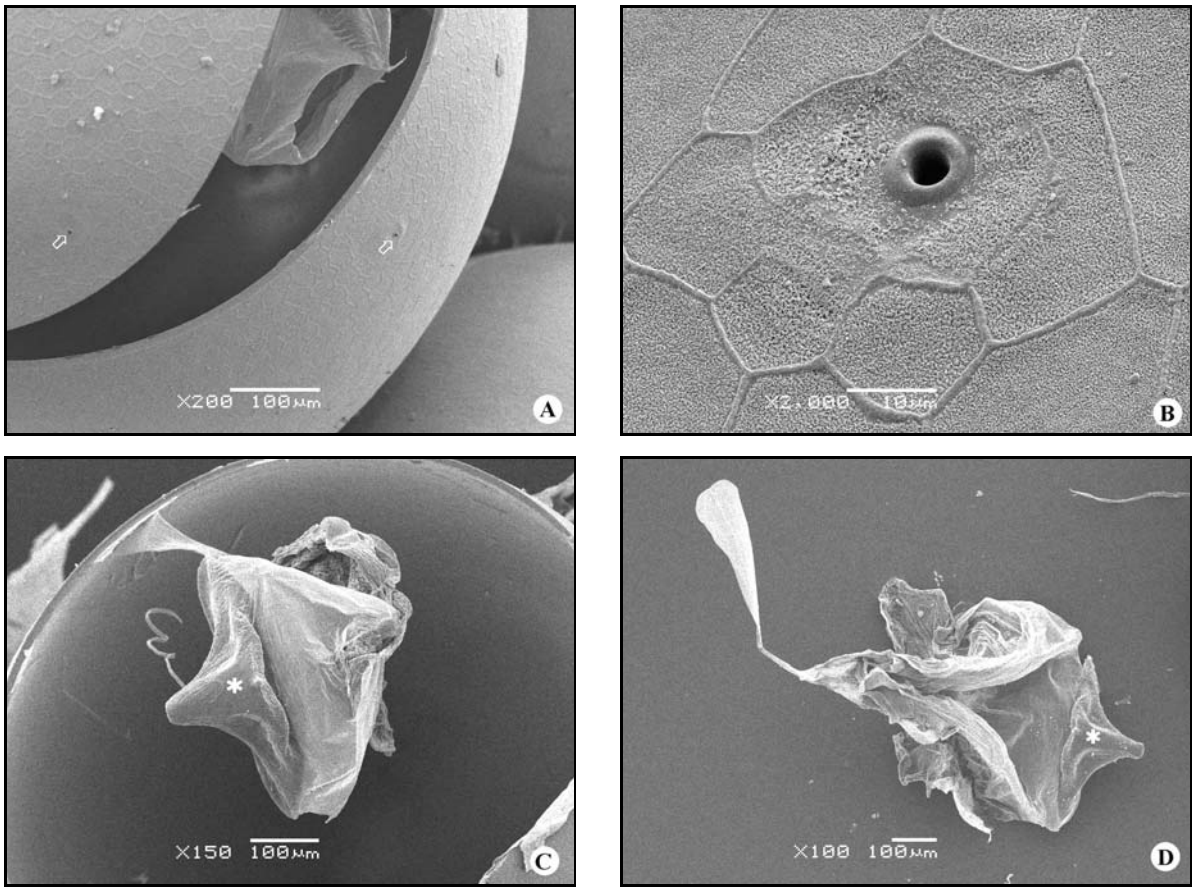

Fig. 2. Scanning electron micrographs of eggs of *Odontotarsus purpureolineatus*: A – aeromicropyles (⇒) and egg-burster in hatched eggs; B – aero-micropylar process between polygons with tubercles; C, D – front of the egg-burster (∗) and tail of egg burster.

The surface of the bulb is covered with the pores. The diameter of the bulb is 280–310 μm (Figs 3A–C). The pumping region (P) has a dilated posterior portion. The pumping region is about 400 μm long and its surface is covered with pores (Figs 3D, E). The distal flange (Fl) of the spermathecal pump (89 μm) is sclerotized and separated from the bulb (Fig. 3F). The proximal spermathecal ducts (Sdu) (444 μm) are about twice as long as the distal ones (Ddu) (280 μm). Each duct consists of a cuticular tube surrounded by a layer of muscles (Fig. 4A). The median portion of the dilated spermathecal duct is swollen, transparent and not sclerotized (Fig. 4B). The dilated portion of the spermathecal duct (Dl) (425 μm) shows thin membraneous muscular walls. These are regularly textured (Fig. 4C). One sclerite (Sc) is near the opening of the spermathecal duct.

This structure is sclerotized and triangular in shape. Distal and proximal regions of the spermathecal duct are narrow, very light, muscular, and convoluted like an accordion (Fig. 4A). The proximal region of the spermathecal ducts opens into the anterior vagina (Fig. 4D).

Two ring sclerites (Rsc) are located at both lateral sides of the genital chamber (Figs 3A, 4D).

Discussion

Several authors state that the eggs of Heteroptera are deposited upright and attached to each other as well as to the substrate with an adhesive secreted by the female (Southwood 1956; Cobben 1968; Hinton 1981; Javahery 1994). The eggs of *O. purpureolineatus* correspond to this pattern. Newly laid eggs are whitish, but then their color slightly changes to light yellowish with time after embryonic development and this is a normal development in insects including most of the Scutelleridae and Pentatomidae (Hinton 1981; Javahery 1994). In Scutelleridae, eggs may be spherical or barrel shaped with polygonic ridges, but a smooth chorion has also been reported (Hinton 1981; Javahery 1994; Candan & Suludere 2003). The eggs of *O. purpureolineatus* are spherical and sculptured with hexagonal and pentagonal ridges.

The eggs of Pentatomoidea examined so far differ widely in their surface morphologies. Most of them have a so called "spinose" chorion which is characterized by spines dotting the surface. This pattern has been found in *Graphosoma lineatum* (L., 1758) (Candan & Suludere 1999), *Codophila varia* (F., 1787) (Candan et al. 2001), *Mormidea* sp. (Javahery 1994; Wolf & Reid 2001), *Eocanthecona furcellatus* Wolff, 1811 (Kumar et al. 2002), *Euschistus serva* Say, 1832, *E. obscura* Palisot, 1817, *E. quadrator* Rolston, 1974, *E. tristigma* Say, 1832 (Bundy & McPherson 2000), *Aelia albovittata* Fieber, 1868 and *A. rostrata* Boheman, 1852 (Candan & Suludere 2006a).

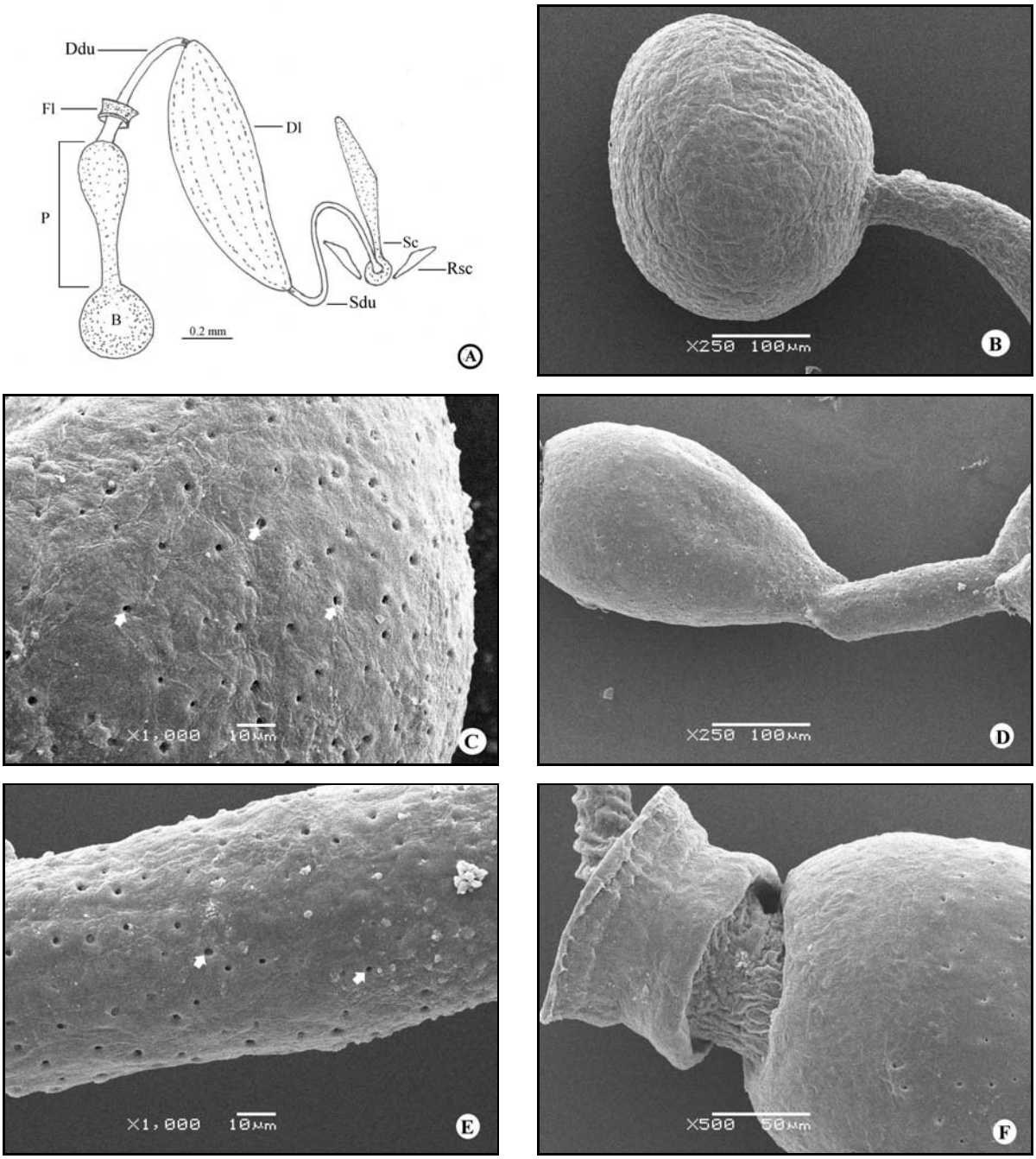

Fig. 3. Drawing and scanning electron micrographs of the spermatheca of *Odontotarsus purpureolineatus*: A – drawing of the gross morphology of the spermatheca; B – spermathecal bulb; C – pores on the spermathecal bulb (⇒); D – pumping region; E – pores on the pumping region (⇒); F – flange of pump.

Another surface pattern is referred to as "coarsely reticulate, foveate" by Bundy & McPherson (2000), is characterized by the presence of pits, which are hexagonally arranged over the egg surface. This chorion type has been found in *Coptosoma siamicum* Walker (Mohan 1988), *Eurydema rugulosum* (Dohrn, 1860) (Suludere et al. 1999) *Acrosternum hilaris* Say, 1832 (Javahery 1994), *A. marginatum* Palisot, 1811 (Wolf et al. 2003), *Rhaphigaster nebulosa* (Poda, 1761) (Candan & Suludere 2001).

A spongy and mushroom shaped chorion type has been found in *Ancyrosoma leucogrammes* (Gmelin, 1790) (Candan 1999), a wart-like chorion in *Edessa bifida* (Wolf & Reid 2003) and polymorphic tubercles on the chorionic surface in *Eurydema ventrale* Kolenati, 1846*, E. blandum* Horv. (Suludere et al. 1999). In addition, polygonal reticulated pattern with ridges has been found over the surface of *O. purpureolineatus* and another Scutelleridae, *Eurygaster maura* (L., 1758) (Candan & Suludere 2006b).

In *O. purpureolineatus,* there is a ring of widely separated aero-micropyles around the anterior pole. The well-marked operculum intersects the ring of micropyles. Similar aeromicropylar structures are seen in other Scutelleridae, e.g., *E. maura* (Candan & Suludere 2006b). Micropylar processes are arranged around

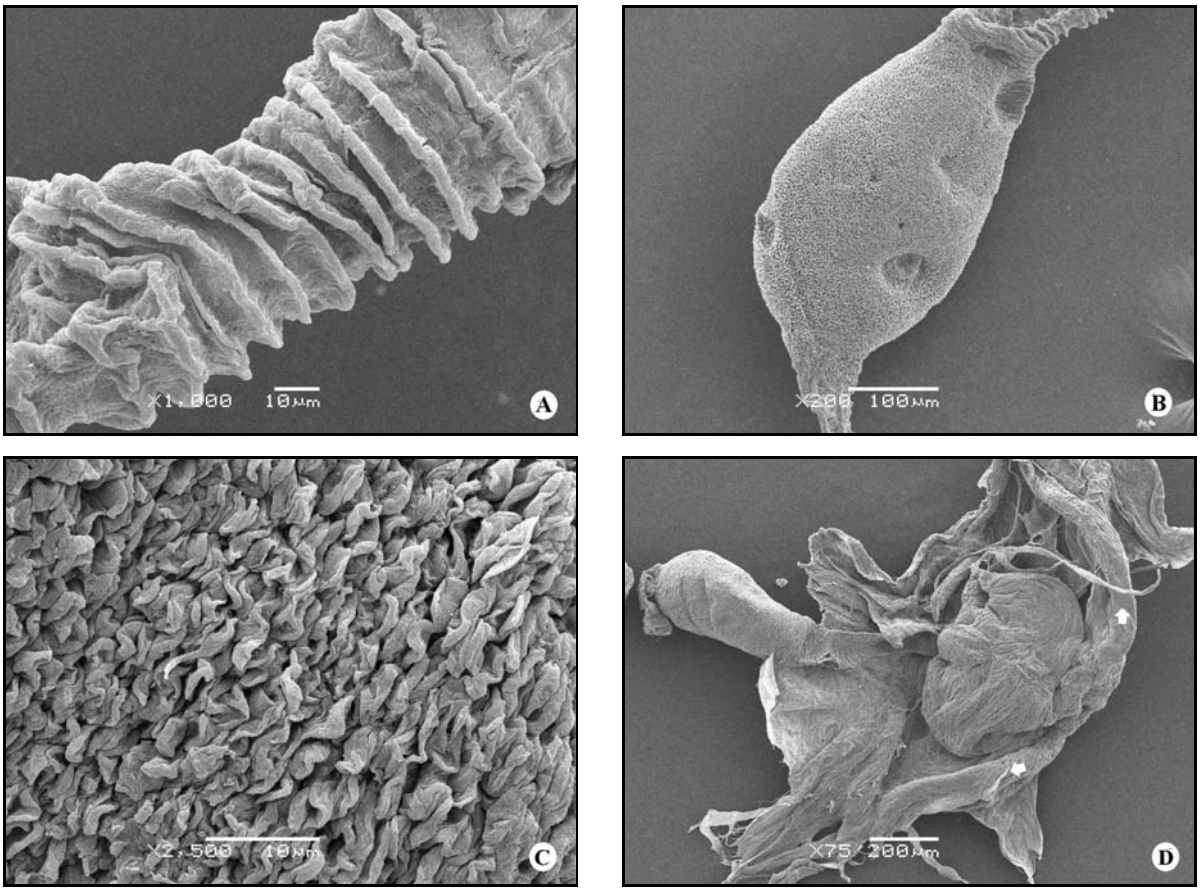

Fig. 4. Scanning electron micrographs of the spermatheca of *Odontotarsus purpureolineatus*: A – distal and proximal parts with muscles of spermathecal duct; B – dilation of spermathecal duct; C – surface of the dilated portion of the spermathecal duct; D – two ring sclerites at both lateral sides of genital chamber (⇒).

the cap in a ring in Pentatomidae or tend to project from the inner side to outer side of the shell in Acanthosomatidae, Cydnidae and Thyreocoridae (Javahery 1994; Candan & Suludere 1999; Wolf & Reid 2001). *O. purpureolineatus* has 8 to 10 aero-micropylar processes between the polygon pattern. The number of micropyles varies from 5–10 in *Elasmucha lateralis* (Say, 1831) (Acanthosomatidae), *Galgupha atra* Amyot et Serville, 1843 (Thyreocoridae), 16–24 in *Apateticus cynica* Say, 1832 (Cydnidae), *Eurygaster alternata* (Say, 1828), *E. integriceps* Puton, 1881, *E. maura* (Scutelleridae) to 54 in *Acrosternum marginatum* Palisot, 1811 (Pentatomidae) (Javahery 1994; Wolf et al. 2003; Candan & Suludere 2006b).

A T-shaped egg-burster is common in most representatives of Scutelleridae and Pentatomidae and a Y-shaped egg-burster is found in Acanthosomatidae, Cydnidae and Thyreocoridae (Schumacher 1917; Southwood 1956; Puchkova 1959, 1966; Cobben 1968; Hinton 1981; Javahery 1994).

The egg-burster has taxonomic importance similar to the egg morphology, including the number of micropylar projections and the chorionic pattern (Puchkova 1966; Hinton 1981).

A spermatheca is present in all Pentatomoidea and usually consists of a spermathecal duct, leading from the vagina to a dilated spermathecal bulb, and is characterized by a well-marked pumping region (McDonald 1966). The spermatheca of *O. purpureolineatus* has a spermathecal bulb, a pumping region, a flange of pump, and dilation of spermathecal duct, while other portions such as the spermathecal processes and median spermathecal dilation with sclerotized rod are missing. The spherical bulb of *O. purpureolineatus* is also present in other Scutelleridae, such as *E. alternata, Symphylus caribbeanus* Kirkaldy, 1909, an elongate cylindrical type of bulb was found in *Pachycoris torridus* Scopoli, 1772, *Diolcus irroratus* F., 1775, an elongate and rod like bulb in *Acantholomidea porosa* (Germar, 1839) (McDonald 1966). In some Pentatomidae (e.g., Podopinae), the spermathecal bulb is spherical, but it deviates from the spherical shape in all Asopinae and has two or three spermathecal processes (Kim & Lee 1994). The spermathecal bulb and the pumping region in *O. purpureolineatus* have many pores, but this feature is not mentioned in other Scutelleridae and Pentatomoidea species (McDonald 1966; Kim & Lee 1994; Adams 2001; Kocorek & Danielczok-Demska 2002).

In some Pentatomoidea including Scutellerinae, the pumping region is well developed and connected to the spermathecal dilation by a short duct and has one or two flanges (McDonald 1966; Kocorek & Danielczok-Demska 2002). In some Dinidoridae, e.g., *Cyclopelta obscura* (Lepeletier et Serville), *Coridius putoni* (Boli-

var), flanges are well developed but they are inconspicuous in other species (Kocorek & Danielczok-Demska 2002). The spermatheca of Pentatomidae has also a pumping region with two flanges (distal and proximal flanges). Their size and shape vary. The two flanges of *Graphosoma rubrolineatum* (Westwood, 1873) and *Dybowskyia reticulata* (Dallas, 1851) are of the same diameter, but the distal flange of *Scotinophara lurida* (Burmeister) is wider than the proximal one (Kim & Lee 1994). Within Scutelleridae, proximal and distal flanges are well developed in *Pachycoris torridus* Scopoli, 1772, but the distal one is reduced in *A. porosa* while the proximal flange is reduced in *Chelysomidea guttata* (Herrich-Schaeffer, 1839) (McDonald 1966). *O. purpureolineatus* has a distinct distal flange.

The spermathecal duct in Scutelleridae varies from short (*Eurygaster alternata*) to long (*Euptychodera corrugata* Van Duzee, 1904), like in *O. purpureolineatus* (McDonald 1966). The spermathecal duct adjacent to the bulb is modified as the intermediate piece or pump, the cuticular lining of which is unsclerotized and flexible (Lee & Pendergrast 1983). The presence of a spermathecal process is an important taxonomic character below the generic levels, but its function is not clear (Kim & Lee 1994). The spermathecal bulb is covered by secretory cells located outside the epithelium of the spermatheca. Sperm is stored there (Kocorek & Danielczok-Demska 2002).

The spermatheca of *O. purpureolineatus* does not have spermathecal processes nor a median spermathecal dilation with sclerotized rod. Therefore, the structure is slightly different from other Pentatomidae, but the basic gross morphology of the spermatheca is similar to other members of the Pentatomoidea. Morphological characters of spermathecae and eggs are important in classification higher than at the generic level of the Heteroptera taxa and its taxonomic importance was established. The survey revealed a wide variety of spermatheca patters in Heteroptera. More work involving SEM is needed to establish clear trends within this taxonomic group.

References

Adams T.S. 2001. Morphology of the internal reproductive system of the male and female two-spotted stink bug, *Perillus bioculatus* (F.) (Heteroptera: Pentatomidae) and the transfer of products during mating. Invertebr. Reprod. Dev. **39:** 45–53.

Bundy C.S. & McPherson R.M. 2000. Morphological examination of stink bug (Heteroptera: Pentatomidae) eggs on cotton and soybeans, with a key to genera. Ann. Entomol. Soc. Am. **93:** 616–624.

Candan S. 1999. External morphology of eggs of *Ancyrosoma leucogrammes* (Gmelin) (Heteroptera: Pentatomidae). G. U. Journal of Science **12:** 933–941. [In Turkish with English summary].

Candan, S. & Suludere Z. 1999. Chorionic structure of *Graphosoma lineatum* (Linneaus, 1758) (Heteroptera, Pentatomidae). J. Entomol. Res. Soc. **1 (3):** 1–7.

Candan S. & Suludere Z. 2001. Chorionic structure of eggs with parasites and normal of *Rhaphigaster nebulosa* (Poda, 1761) (Heteroptera: Pentatomidae). Türk. Entomol. Derg. **25:** 41–48. [In Turkish with English summary].

Candan S. & Suludere Z. 2003. Scanning electron microscope studies of the eggs of *Psacasta exanthematica* Scopoli, 1763 (Hemiptera: Heteroptera: Scutelleridae). Pol. Pismo Entomol. **72:** 241–247.

Candan S. & Suludere Z. 2006a. Chorion morphology of eggs of *Aelia albovittata* Fieber, 1868 and *Aelia rostrata* Boheman, 1852 (Heteroptera: Pentatomidae). J. Entomol. Res. Soc. **8:** 61–71.

Candan S. & Suludere Z. 2006b. Studies on the external morphology of the eggs of *Eurygaster maura* (Linnaeus, 1758) (Heteroptera: Scutelleridae). Polish J. Entomol. **75:** 369–374.

Candan S., Suludere Z. & Açýkgöz F. 2005a. Chorion morphology of eggs of the North American stink bug *Euschistus variolarius* (Palisot de Beauvois, 1817) (Heteroptera: Pentatomidae): A scanning electron microscopy study. Entomol. News **116:** 177–182.

Candan S., Suludere Z. & Durak D. 2005b. Ultrastructure of the eggs chorion of *Ceraleptus obtusus* (Brullé, 1839) (Heteroptera: Coreidae). Ohio J. Sci. **105:** 138–141.

Candan S., Suludere Z. & Kýyak S. 2001. External morphology of eggs of *Codophila varia* (Fabricus, 1787) (Heteroptera: Pentatomidae). J. Entomol. Res. Soc. **3:** 33–39.

Cobben R.H. 1968. Evolutionary Trends in Heteroptera. Part 1. Eggs, Architecture of the Shell, Gross Embryology and Eclosion. Centre for Agricultural Publishing and Documentation, Wageningen, The Netherlands, 475 pp.

Davey K.G. 1965. Reproduction in the Insects. Oliver and Boyd, Edinburg, 96 pp.

Dufour L. 1833. Recherches anatomique et physiologiques sur les Hemipteres. Mem. Pres. Acad. Sci. **IV:** 133–461; pls. I–XIX.

Dupuis C. 1955. Les génitalia des Hémiptères Hétéroptères (Génitalia externes des deux sexes; Voies ectodermiques femelles). Revue de la morphologie. Lexique de la nomenclature. Index bibliographique analytique. Mém. Mus. Hist. Nat. Paris **6:** 183–278.

Durai P.S.S. 1987. A revision of the Dinidoridae of the World (Heteroptera: Pentatomoidea). Orient. Insects **21:** 163–360.

Esselbaugh C.O. 1946. A study of the eggs of the Pentatomidae (Hemiptera). Ann. Entomol. Soc. Am. **39:** 667–691.

Grigorov P. 1988. Electron-microscopic study of the egg's chorion [sic] in species of the genus *Eurygaster* Lap. (Heteroptera, Scutelleridae). Rasteniev'dni Nauki [Plant Science] **25:** 94–99.

Hinton H.E. 1981. Biology of Insect Eggs. Pergamon Press, Oxford, Vols I–III, 1125 pp.

Javahery M. 1994. Development of eggs in some true bugs (Hemiptera: Heteroptera) Part I. Pentatomoidea. Can. Entomol. **126:** 401–433.

Kim R.H. & Lee C.E. 1994. Morphological studies on the spermathecae of Korean Podopinae and Asopinae (Heteroptera: Pentatomidae). Korean J. Entomol. **24:** 217–223.

Kocorek A. & Danielczok-Demska T. 2002. Comparative morphology of the spermatheca within the family Dinidoridae (Hemiptera: Heteroptera). Eur. J. Entomol. **99:** 91–98.

Kumar R. 1962. Morpho-taxonomical studies on the genitalia and salivary glands of some Pentatomoidea. Entomol. Tidskr. **83:** 44–84.

Kumar V., Morrison M.N., Babu A.M. & Thiagarajan V. 2002. Egg shell architecture of the stink bug, *Eocanthecona furcellata* (Wolff.): Ultrastructure of micropylar processes and egg burster. Insect Sci. Appl. **22:** 67–74.

Lee C.E. & Pendergrast J.G. 1983. The spermathecae of New Zealand Aradidae (Hemiptera: Heteroptera). J. Nat. Hist. **17:** 113–122.

Margaritis L.H. 1985. Structure and Physiology of the Eggshell, pp. 153–230. In: Kerkut G.A. & Gilbert L.I. (eds), Comprehensive Insect Physiology, Biochemistry and Pharmacology 1, Pergamon Pres, Oxford.

McDonald F.J.D. 1966. The genitalia of North American Pentatomoidea (Hemiptera: Heteroptera). Quaest. Entomol. **2:** 7–150.

Mohan D. 1988. Host plant relationships with reference to the biology of fern infesting pentatomid, *Coptosoma siamicum*

Walker, with notes on the fine architecture of the egg. J. Entomol. Res. (New Delhi). **12:** 149–153.
Pendergrast J.G. 1957. Studies on the reproductive organs of the Heteroptera with a consideration of their bearing on classification. Trans. R. Entomol. Soc. Lond. **109:** 1–63.
Puchkova L.V. 1959. The eggs of true bugs (Hemiptera-Heteroptera) V. Pentatomoidea, I. Entomol. Obozr. **38:** 634–648.
Puchkova L.V. 1966. The morphology and biology of the eggs of the terrestrial bugs (Hemiptera). Horae Soc. Entomol. Ross. **51:** 75–132.
Salkeld E.H. 1983. A catalogue of the eggs of some Canadian Geometridae (Lepidoptera), with comments. Mem. Entomol. Soc. Can. **126:** 1–271.
Salkeld E.H. 1984. A catalogue of the eggs of some Canadian Noctuidae (Lepidoptera). Mem. Entomol. Soc. Can. **127**: 1–167.
Schumacher F. 1917. Eisprenger bei Wanzen aus der groupe der Pentatomiden (Hemiptera-Heteroptera). Sitz. Ber. Ges. Naturforsch. Freunde Berlin **1917:** 438–443.
Scudder G.G.E. 1959. The female genitalia of the Heteroptera: Morphology and bearing on classification. Trans. R. Entomol. Soc. Lond. **111:** 405–467.
Servadei A. 1964. Il valore tassonomico delle spermateche degli emitteri eterotteri (Fam. Pentatomidae e Acanthosomatidae). Atti Acad. Naz. Ital. Entomol. **11:** 58–86.
Siebold Von C.TH. 1837. Fernere Beobachtungen über die Spermatozoen der wirbellosen Tiere. Arch. Anat. Physiol. Wiss. Medic. **1837:** 381–439.
Simiczyjew B. 1994. Egg morphology and chorion fine structure of *Hydrometra stagnorum* (Heteroptera). Zool. Pol. **39:** 79–86.
Southwood T.R.E. 1956. The structure of the eggs of the terrestrial Heteroptera and its relationship to the classification of the group. Trans R. Entomol. Soc. Lond. **108:** 163–221.
Suludere Z. 1988. Studies on the external morphology of the eggs of some Argynninae species (Satyridae: Lepidoptera). Commun. Fac. Sci. Univ. Ank. (Ser. C) **6:** 9–28.
Suludere Z., Candan S. & Kalender Y. 1999. Chorionic sculpturing in eggs of six species of *Eurydema* (Heteroptera, Pentatomidae) A scanning electron microscope investigation. J. Entomol. Res. Soc. **1 (2):** 27–56.
Wolf K.W. & Reid W. 2001. Egg morphology and hatching in *Mormidea pictiventris* (Hemiptera: Pentatomidae). Can. J. Zool. **79:** 726–736.
Wolf K.W. & Reid W. 2003. The wart-like chorion of *Edessa bifida* (Hemiptera: Pentatomidae). J. Submicrosc. Cytol. Pathol. **35:** 469–473.
Wolf W.K. & Reid W. 2004. Post depositional dynamics of eggs of *Podisus sagitta* (Hemiptera: Pentatomidae: Asopinae). A light and scanning electron microscopy study. J. Entomol. Res. Soc. **6:** 1–11.
Wolf K.W., Reid W. & Schrauf M. 2003. Optical illusions in scanning electron micrographs: the case of the eggshell of *Acrosternum* (*Chinavia*) *marginatum* (Hemiptera: Pentatomidae). Micron **34:** 57–62.

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