SOIL ORGANISMS Volume 80 (2) 2008 217 – 221

ISSN: 1864 - 6417

SEM-Investigations on the exochorion of scutoverticid eggs

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Abstract

The exochorion of the eggs of four scutoverticid species – *Scutovertex minutus*, *S. sculptus, Scutovertex* sp. (Baltic Coast) and *Provertex kuehnelti* – were examined using scanning electron microscopy. The egg shell is very complexly structured in all these species, with a species-specific fine structure of the exochorion. *S. minutus* and *S. sculptus* eggs show similar but not identical fungiform surface textures, whereas *Scutovertex* sp. from the Baltic coast deposited eggs with an additional thin external layer. The exochorion of *P. kuehnelti* eggs has deep pores on its surface; its fine structure differs completely from the egg shells of the other species.

Keywords: Egg shell, endochorion, Oribatida, *Provertex*, *Scutovertex*

Zusammenfassung

Das Exochorion der Eier vier verschiedener Scutoverticidae – *Scutovertex minutus*, *S. sculptus, Scutovertex* sp. (Ostseeküste) und *Provertex kuehnelti* – wurde rasterelektronenmikroskopisch untersucht. Die Ausgestaltung der Eihülle ist bei allen untersuchten Arten sehr komplex, aber die Feinstruktur des Exochorions ist für jede Art spezifisch ausgebildet. Die Eier von *S. minutus* und *S. sculptus* zeigen zwar ähnliche aber dennoch nicht identische pilzförmige Oberflächenstrukturen. Die Eier der von der Ostseeküste stammenden Individuen von *Scutovertex* sp. wiesen zusätzlich eine dünne, das Chorion bedeckende Hülle auf. Das Exochorion der Eier von *P. kuehnelti* unterscheidet sich durch den Besitz tiefer Poren in seiner Oberfläche vollständig von den Eihüllen der anderen Arten.

1. Introduction

The egg shell of mites consists of the vitelline envelope, also termed endochorion, and a layer that is secreted onto the vitelline envelope during passage through the distal part of the oviduct, the exochorion. The endochorion probably protects the embryo from mechanical damage, whereas the exochorion is suggested to play a role as plastron as well as to avoid desiccation (Witaliński 1987). Furthermore, the exochorion can serve as an adhesive layer that fixes the egg to the substratum (Witaliński 1993, Alberti & Coons 1999). In oribatid mites the egg shell may exhibit diverse surface patterns, e.g. smooth in *Archegozetes longisetosus* (Heethoff et al. 2006) or heavily ornamented as in the two euphthiracarid genera *Rhysotritia* and *Microtritia* (Märkel & Meyer 1959).

2. Materials and methods

The adults of the four species were collected at the following sites: *Scutovertex minutus* – Bachsdorf (Styria, Austria), mosses on a roof; *S. sculptus* – Illmitz (Burgenland, Austria), moss on the shore of lake Zicksee; *Scutovertex* sp. – Darss-Zingst (Mecklenburg-Western Pomerania, Germany), coastal sand dunes; *Provertex kuehnelti* – Hochschwab-Fölzalm (Styria, Austria), mosses on rocks. Eggs deposited in breeding experiments were preserved in 70 % ethanol. For SEM-investigations the samples were dehydrated in ascending ethanol concentrations, air-dried and mounted on aluminium-stubs with double-sided sticky tape (the eggs slightly shrank using this method). The eggs were then sputter-coated with gold. SEM-micrographs were made at the Research Institute for Electron Microscopy and Fine Structure Research, Graz, University of Technology, with a Zeiss Leo Gemini DSM 982.

3. Results

The egg size of the four investigated species – *Scutovertex minutus* Koch, 1836, *S. sculptus* Michael, 1879*, Scutovertex* sp. (Baltic Coast) and *Provertex kuehnelti* Mihelčič, 1959 (Figs 1 – 4) – varies from 180 – 220 µm.

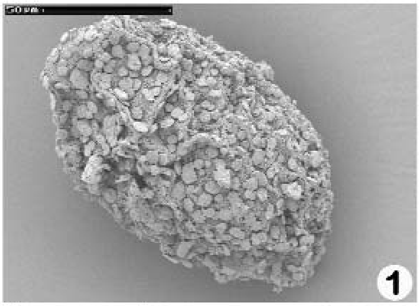
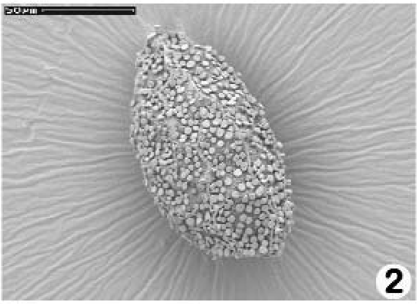
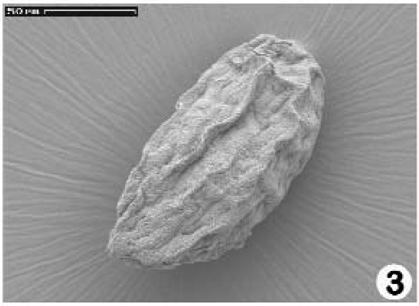
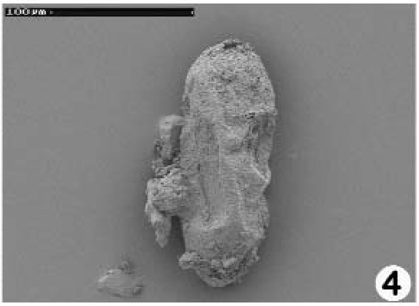

Fig. 1: Egg of *S. minutus.*
Fig. 2: Egg of *S. sculptus.*
Fig. 3: Egg of *Scutovertex* sp. (Baltic Coast).
Fig. 4: Egg of *P. kuehnelti.*

Each species produces an exochorion composed of different elements with an additional fine structure. The smooth endochorion in *S. minutus* is covered by densely packed small granules and scattered fungiform structures (Figs 5, 6), both more or less homogenously distributed. The tops of the 'mushrooms' (diameter 2 – 5 µm) are irregular, showing an uneven surface. The exochorion of *S. sculptus* is also composed of small and sometimes conical granules and fungiform formations (diameter 2 – 5 µm) adhering to the endochorion (Fig. 7). The latter are distinct structures with a granular surface (Fig. 8). The eggs of S*cutovertex* sp. from the Baltic coast possess an additional external thin layer that tightly envelops apical structures of the exochorion (Fig. 9). The basal textures are, again, little granules and fungiform structures (diameter 1 – 2 µm) (Fig. 10) arranged in distinct patterns. The tops of the fungiform formations are massive and spherical. The exochorion in *P. kuehnelti* consists of a thick layer with regularly distributed 'pores' (Figs 11, 12); these pores represent interstices between pillars based on the endochorion.

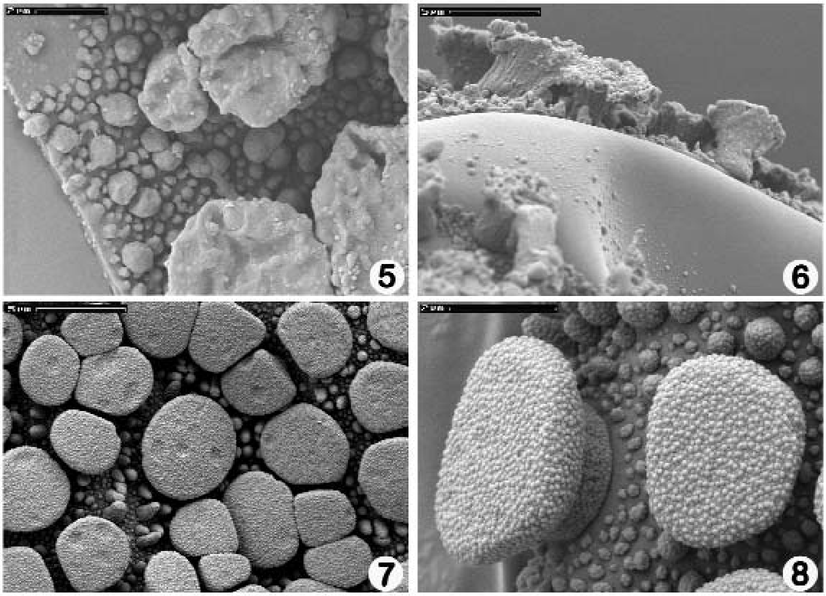

Fig. 5: *S. minutus* – surface of the exochorion in detail.
Fig. 7: *S. sculptus* – granules and fungiform structures.

Fig. 6: *S. minutus* – irregularly shaped fungiform structures.
Fig. 8: *S. sculptus* – surface in detail.

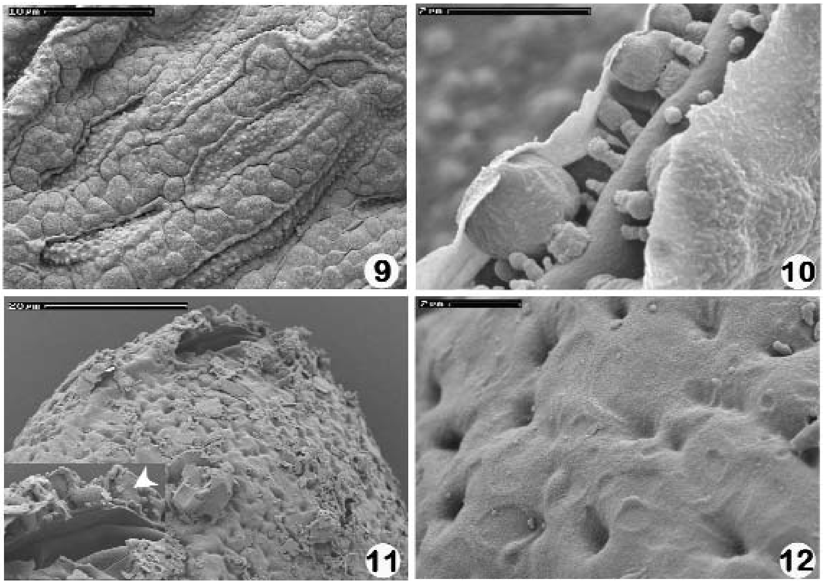

Fig. 9: *Scutovertex* sp. (Baltic Coast) – surface pattern of the exochorion.
Fig. 10: *Scutovertex* sp. (Baltic Coast) – external thin layer covering fungiform parts and granules.
Fig. 11: *P. kuehnelti* – exochorion. Small insert shows the rupture of the egg shell in detail; arrow indicates 'pillar'.
Fig. 12: *P. kuehnelti* – pores in detail.

4. Discussion

The differences in the exochorion of the investigated species lead to the hypothesis that egg shell structure is specific for each species. Fundamental structures such as granules and 'mushrooms' occur in *S. minutus*, *S. sculptus* and *Scutovertex* sp. These elements are therefore apparently typical for the genus *Scutovertex*, although they vary in shape and appearance among species. The egg shell of *P. kuehnelti* differs from the others in having a less complex differentiated exochorion. Species-specific surface patterns of egg shells are also known from hydrachnellid (Sokolov 1977), parasitid (Lee 1974, Witaliński 1977) and oribatid mites (Märkel & Meyer 1959). The basic structure of the exochorion seems to be quite constant within closely related taxa, but the fine structure varies. Therefore, exochorion variation could serve as an additional character in systematic and phylogenetic considerations.

The influence of the environment on egg shell formation is unclear. *Scutovertex minutus*, *S. sculptus* and *P. kuehnelti* occur in similar habitats with changing conditions from extremely dry to extremely wet. All of them colonise mosses and lichens growing on rocks, roofs or protosoils (e.g. Smrž 1992, Skubala 1995, Krisper & Schuster 2001) and show the same egg-deposition strategies. In general the exochorion should fulfil its functions as plastron and protection against desiccation independent of the specific fine structure (Witaliński 1977). The latter author stated that species with smooth eggs prefer dry places for egg laying, whereas species with 'rough' egg surfaces lay their eggs in damp conditions. The additional outer egg shell layer of *Scutovertex* sp. from the Baltic coast could protect the embryo from osmotic effects caused by exposure to rain or salt water.

The ability to permanently colonise extreme habitats and to utilise these ecological niches could be combined with an egg shell formation that is adapted to the respective environmental conditions. Zeh et al. (1989) already hypothesised a relationship between shell diversification and the expansion in the type of habitats utilised for oviposition in insect evolution, and supposed such a correlation for arachnids as well.

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Accepted 28 May 2008