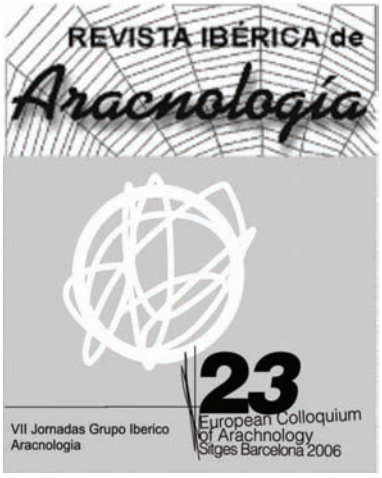

ARTÍCULO:

Taste while chewing? Sensory structures in the chelicerae of *Pseudocellus pearsei* (Chamberlin & Ivie, 1938) (Ricinulei, Arachnida)

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ARTÍCULO:

Taste while chewing? Sensory structures in the chelicerae of *Pseudocellus pearsei* (Chamberlin & Ivie, 1938) (Ricinulei, Arachnida)

Giovanni Talarico, José G. Palacios-Vargas & Gerd Alberti

Abstract

Ricinulei possess two jointed chelate chelicerae to grab, kill and to chew up their prey. The chelicerae of the Méxican cave dwelling species *Pseudocellus pearsei* were investigated by means of scanning and transmission electron microscopy. The movable and fixed fingers of the chelicerae bear numerous blunt tipped teeth. Single fine pores are present on the long distal tips of the finger and also on their shorter teeth. Furthermore, flat oval depressions can be observed near the articulation of the movable finger. Sections of the fingers reveal their multiple innervation. Ensheathed outer dendritic segments project into the teeth. Since muscles are absent inside the fingers a motor neuronal function of this innervation can beexcluded and a sensorial function has to be presumed. Ensheathed outer dendritic segments projecting towards single terminal pores characterize arthropod chemoreceptors with gustatory function.

Key words: Arthropoda, Arachnida, Ricinulei, *Pseudocellus*, Ultrastructure, Chelicera, Sensilla, México

¿Degustando mientras se mastica? Estructuras sensoriales en los quelíceros de *Pseudocellus pearsei* (Chamberlin & Ivie, 1938) (Ricinulei, Arachnida)

Resumen

Los ricinúlidos tienen dos quelíceros biarticulados utilizados para coger, matar y masticar a sus presas. Por medio del microscopio electrónico de barrido y del de transmisión se investigó su morfología y anatomía en la especie cavernícola mexicana *Pseudocellus pearsei*. Los dedos móvil y fijo de los quelíceros poseen numerosos dientes gruesos en su ápice. También presentan finos poros aislados en los alargados ápices de los dedos y en sus cortos dientes. Además se pueden observar depresiones aplanadas ovales cerca de la articulación del dedo móvil. Los cortes de los dedos revelan su inervación múltiple. Unos segmentos dendríticos envainados se proyectan dentro de los dientes. Ya que en los dedos no hay músculos, se puede excluir para esta inervación una función neuromotora y se puede suponer una función sensorial. Los segmentos dendríticos envainados que se proyectan hacia una simple terminación porosa son característicos de quimiorreceptores de artrópodos con función gustativa.

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Palabras clave: Arthropoda, Arachnida, Ricinulei, *Pseudocellus*, Ultraestructura, Quelícero, Sensila, México

Introduction

Arachnid sensilla have been investigated for a long time. In particular, numerous different types of sensilla are described for the pedipalps and walking legs (e.g., Haller, 1881; Blumenthal, 1935; Chu-Wang & Axtell, 1974; Barth & Stagl, 1976; Baker, 1985; Foelix, 1985; Alberti & Coons, 1999; Coons & Alberti, 1999). Unlike that, the knowledge of sensilla occurring on arachnid chelicerae is surprisingly poor, though, these extremities, as essential mouthparts, get in intense contact with the prey and its body liquids. The presence of sensorial innervation inside the cheliceral digits is known for some Acari (e.g., Nuzzaci & De Lillo, 1991, 1995; Alberti & Coons, 1999; Coons & Alberti, 1999; De Lillo et al., 2001; Nuzzaci & Di Palma, 2002; Alberti et al., 2004).

Ricinuleids, with only 58 extant species, are one of the least investigated arachnid orders. This small order, consisting of the genera *Cryptocellus* Westwood, 1874, *Pseudocellus* Platnick, 1980 and *Ricinoides* Ewing, 1929, is exclusively distributed in the tropical regions of Central America and Western Africa. Only few works present ultrastructural aspects of these animals (Legg, 1976, 1977; Platnick & Shadab, 1976, 1977; Dumitresco & Juvara-Bals, 1977; Alberti & Palacios-Vargas, 1984; Harvey, 1984; Ludwig & Alberti, 1990; Ludwig et al., 1994; Adis et al., 1999; Talarico et al., 2005, 2006). Ricinulei do not possess poisonous glands (Moritz, 1993). Assisted by the pedipalps and the hood like cucullus, ricinuleids grasp their prey with the chelicerae and immediately start to chew and feed on it, while it is still alive (Pollock, 1967; own observations). The movable and fixed digits of ricinuleid chelicerae bear numerous blunt tipped teeth. The morphology and location of these cheliceral teeth may be useful for species identification (Cooke & Shadab, 1973).

In this study the cheliceral digits of the Méxican cave dwelling species *Pseudocellus pearsei* (Chamberlin & Ivie, 1938) were investigated by means of scanning and transmission electron microscopy.

Material and methods

Specimens of *P. pearsei* from the Yucatan peninsula (México) were collected in the caves Gruta Actún Chen, Gruta X-Caret (both Quintana Roo) and Gruta Sabac-Ha (Yucatán).

For scanning electron microscopy (SEM), specimens stored in ethanol (70%) were dehydrated in graded ethanols, critical-point dried (BAL-TEC CPD 030), fixed to aluminium stubs with adhesive film and coated with gold-palladium (Quorum Technologies SC7620). The chelicerae of four specimens (1 tritonymph, 1 adult male and 2 adult females) were examined with a LEO DSM 940A.

For transmission electron microscopy (TEM), one deutonymph was dissected in ice-cold 0.1 M Sörensen phosphate buffer (pH 7.4), fixed in 3.5% glutardialdehyde buffered in Sörensen phosphate buffer overnight and then postfixed in buffered 2% osmium tetroxide for 2 h. After rinsing in buffer and dehydration in graded ethanols, samples were embedded in Spurr´s medium (Spurr, 1969). Longitudinal ultrathin sections (50-70 nm) were made from the prosoma with a Diatome diamond knife on a Leica Ultracut. After staining the sections with saturated uranyl acetate (in 70% methanol) for 5 minutes and with lead citrate (Reynolds, 1963) for 15 minutes, the sections were examined with a Philips CM 10.

Results

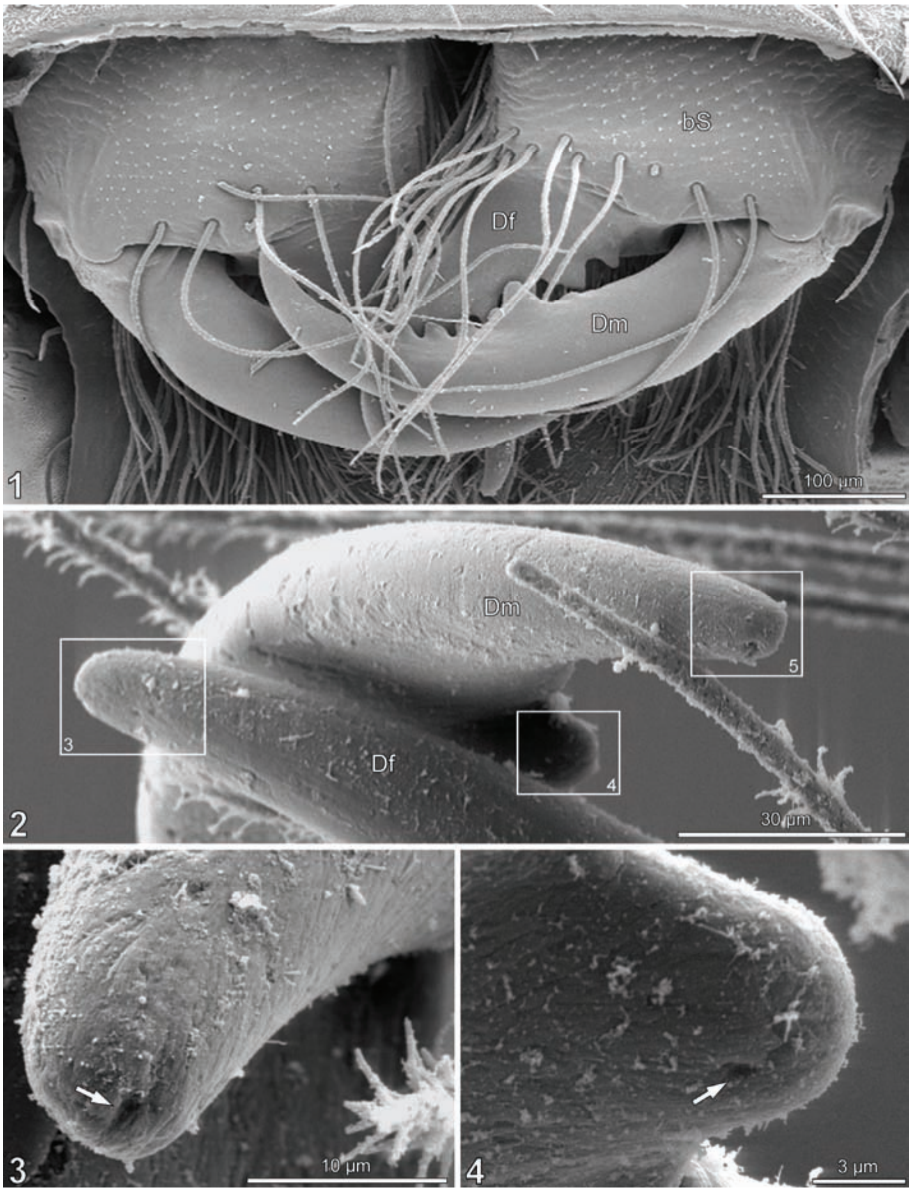
Like all Ricinulei *P. pearsei* possesses two jointed chelate chelicerae (Fig. 1). When withdrawn and the cucullus is closed, the chelicerae are completely covered by the cucullus. When protruded or the cucullus is lifted up, the chelicerae become visible (Fig. 9). The chelicerae are orientated horizontally (Fig. 1). The fixed digit (length 0.24 mm) projects in retrolateral direction from the retrolateral region of the basal segment. On the lateral region of the basal segment, the movable digit (length 0.4 mm) is articulated. The fixed digit is slightly curved towards the movable digit, while the latter is strongly curved towards the fixed digit. The tip of the movable digit crosses the tip of the fixed digit dorsally when the chelicera is closed (Fig. 1).

Both, movable and fixed, cheliceral digits bear a single row of blunt tipped teeth of different size (Figs. 1, 6). The tips of the cheliceral teeth of *P. pearsei* often show traces of abrasion (Figs. 3-8). The degree of abrasion determines the shape and size of the teeth (Fig. 6). Higher magnifications reveal the presence of single fine pores on the long distal tips of the digits (Figs. 2, 3, 5) and also on their shorter teeth (Figs. 4, 6-8). The diameter of these pores (0.75-2 µm) varies according to the degree of abrasion. Furthermore, flat oval depressions can be observed on the basal segment of the chelicerae near the articulation of the movable digit (Figs. 9, 10).

Sections of the basal part of the cheliceral digits reveal the presence of multiple innervations (Fig. 11, 16). Up to eleven nerves, each composed of several inner dendritic segments are present inside the digit. The nerves are surrounded by enveloping glial cells, which are connected among each other via septate junctions (Fig. 12). Further distally, basal bodies appear inside the inner dendritic segments and numerous microvilli can be observed close to the inner dendritic segments (Fig. 13). Starting with the basal bodies, groups of outer dendritic segments (Figs. 14-18) are formed. Each group is surrounded by an electron dense dendritic sheath (Figs. 14-18) which is produced by a sheath cell. Single groups of outer dendritic segments, surrounded by dendritic sheaths, project towards the cheliceral cuticle and also penetrate the integument to enter the cheliceral teeth (Fig. 18).

Discussion

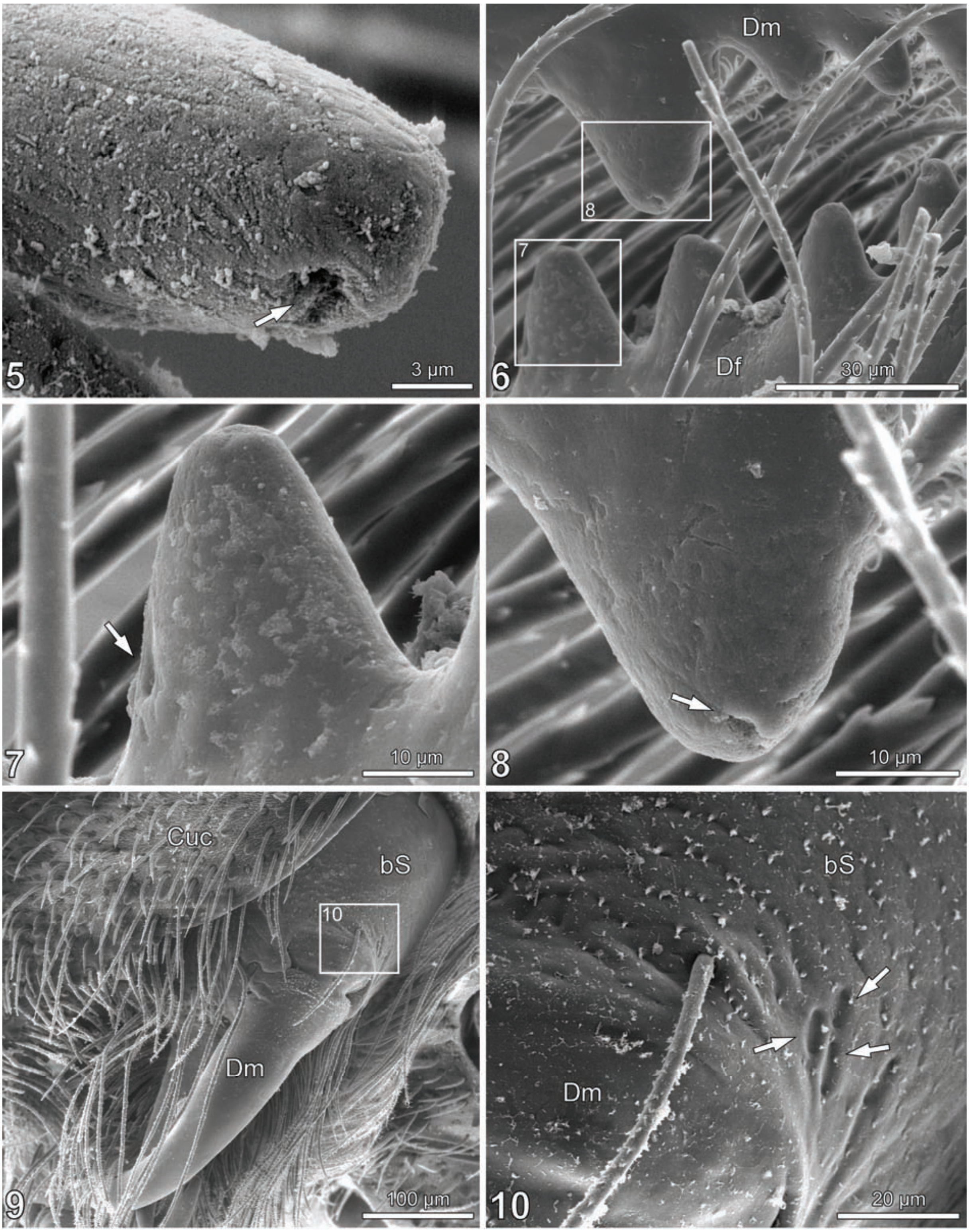
Ricinuleid chelicerae had been of taxonomic interest for



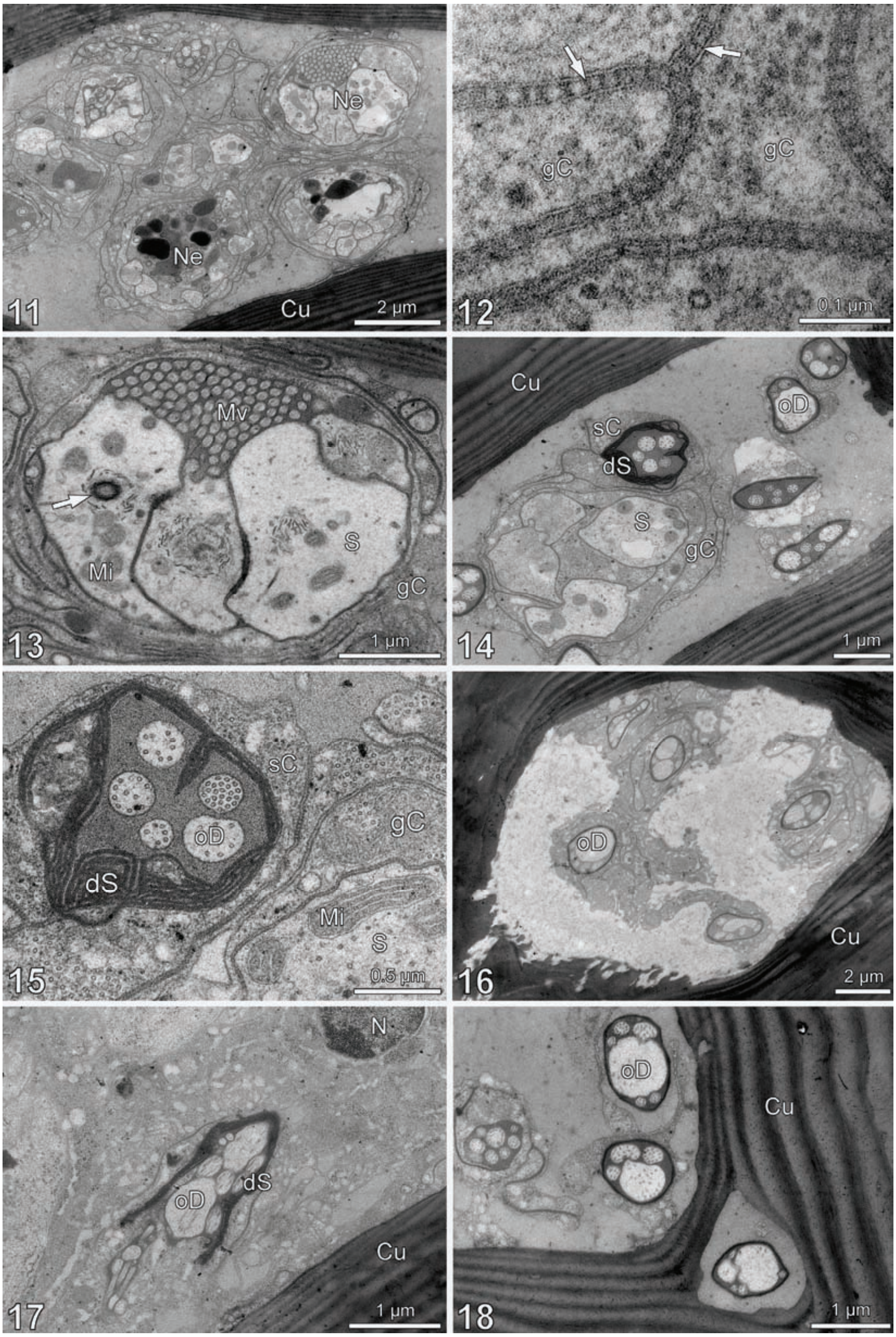
Figures 1-4. SEM of chelicerae of different developmental stages of *Pseudocellus pearse*i. **1.** Frontal view on the withdrawn chelicerae of an adult male. The cucullus has been removed. **2.** Distal tips of right chelicera of a male tritonymph (medioventral view). Frames indicate subsequent pictures of details. **3.** Distal tip of the fixed finger. Note the apical pore opening (arrow). **4.** First median tooth of the movable finger. Note the lateral pore opening (arrow). bS = basal segment, Df = fixed finger (Digitus fixus), Dm = movable finger (Digitus mobilis).

a long time (Cooke & Shadab, 1973). Since dissimilarities between different developmental stages and also between left and right chelicerae of the same individual had been recovered (Pittard & Mitchell, 1972), the value of this character became doubtful. Functional interpretations of the cheliceral morphology focused on the long plumose setae (see Figs. 1, 9), which arise dorsally and ventrally from the apical region of the basal segment and which are thought to support the transport of the prey's body liquids towards the preoral cavity (Hansen & Sørensen, 1904; Pittard & Mitchell, 1972).

The present study provides the first ultrastructural investigation on the cheliceral digits of Ricinulei. The presence of multiple innervations inside the cheliceral digits (Figs. 11, 14, 16, 18) and the presence of single terminal pores on the tips of the cheliceral teeth (Figs. 2-8) has been revealed. Since muscles are absent inside the cheliceral digits (Figs. 11, 14, 16, 18) a motor neuronal function of this innervation can be excluded and a sensorial function has to be presumed. Single terminal pores (Figs. 2-8) and ensheathed outer dendritic segments (Figs. 14-18) projecting towards these pores are typical characters of arthropod contact chemoreceptors with gustatory function (Foelix & Chu-Wang, 1973; Altner, 1977). On the extremities of arthropods (e.g., antennae, pedipalps and walking legs) these gustatory sensilla often appear as long, slender and sigmoidally curved setae. In Ricinulei this type is known for the distal tarsomeres of the walking legs (Talarico et al., 2006). Taste sensory organs located in the cheliceral digits are known from well studied Acari, e.g., Ixodida, Gamasida, Actinedida and Oribatida (e.g., Nuzzaci & De Lillo, 1989, 1991, 1995; Alberti & Coons, 1999; Coons & Alberti, 1999; De Lillo et al., 2001; Nuzzaci & Di Palma, 2002; Alberti et al., 2004). The findings in *P. pearsei* resemble widely the sensorial structures inside the chelicerae of the investigated Acari. Other Arachnida are barely investigated in this respect, though it appears likely that sensorial organs could be present on and inside the chelicerae because they get in intense



Figures 5-10. SEM of chelicerae of different developmental stages of *Pseudocellus pearsei*. **5.** Distal tip of the movable finger of a male tritonymph. Note the lateral pore opening (arrow). **6.** Median teeth of left chelicera of an adult female (dorsal view). Frames indicate subsequent pictures. **7.** Largest median tooth of the fixed finger. Note the basolateral pore opening (arrow). **8.** Largest median tooth of the movable finger. Note the apical pore opening (arrow). **9.** Lateral view on left chelicera of an adult female. Frame indicates the subsequent picture. **10.** Detail of the joint area. Note three flat oval depressions (arrows). bS = basal segment, Cuc = cucullus, Df = fixed finger (Digitus fixus), Dm = movable finger (Digitus mobilis).



Figures 11-18. TEM of the left chelicera of a deutonymph of *Pseudocellus pearsei*. **11.** Transversal section of the basal portion of the movable finger showing numerous nerves inside the finger. **12.** Septate junctions (arrows) connect the glial cells which envelope the nerves. **13.** Nerve consisting of four inner dendritic segments of sensory cells. Note the basal body (arrow) indicating the formation of an outer dendritic segment (cilium). **14.** In the apical part of the movable finger outer dendritc segments surrounded by dense dendritic sheaths are present. **15.** A group of outer dendritic segments. The dendritic sheath is formed by the sheath producing cell. The shape of the sheath is somewhat irregular indicating that the formation of this dendritic sheath has just begun. **16.** Transverse section of the apical part of the fixed finger. **17.** Oblique section of a dendritic sheath surrounding a group of outer dendritic segments inside the fixed finger. **18.** One dendritic sheath containing several outer dendritic segments is penetrating the cuticle on the base of a median tooth of the movable finger of the chelicera. Cu = cuticle, dS = dendritic sheath, gC = glial cell, Mi = mitochondrium, Mv = microvilli, N = nucleus, Ne = nerve, oD = outer dendritic segment, S = sensory cell, sC = sheath-producing cell.

contact with the preys body liquids. The poor knowledge about the internal structures inside the chelicerae might be explained with the extraordinarily hard cuticle of the digits, which hinders the penetration of fixatives and also complicates ultrathin sectioning. The flat oval depressions near the base of the movable digit represent slit sensory organs with mechanoreceptive function (Lindquist, 1984) which also can be found on other body parts of Ricinulei (Talarico et al., 2006).

Concluding, we believe that by means of the gustatory sensilla, Ricinulei are able to evaluate the quality of their food. Furthermore, on the base of the findings for Acari and Ricinulei, we suppose that gustatory sensilla inside the cheliceral digits may be a general feature of arachnids, though this has to be proofed for other orders.

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