



The external micro anatomy of the cephalon of the asellotan isopod *Craseriella anops*

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Abstract

The micro-anatomy of the cephalon is described in the troglobic asellotan isopod *Craseriella anops* from the Nohoch Nah Chich anchialine cave system in southeast Mexico. The cephalon is entirely covered by cuticular scales bordered by marginal spines. The anterior end of the cephalon is bordered by a carina that is wider medially. The isopod is eyeless. The distal seventh portion of the cephalon is characterized by the presence of two sutures and six setae. A suture is found on each side of the distal margin of the cephalon. Each suture is found on each side of the distal margin of the cephalon. Each suture is bordered by microtrichs. Two simple setae with a sensory hair, articulated on the base by a socket, are found one on each side of each of the sutures. Two additional setae, similar in shape and size, occur medially on the cephalon. A terminal pore is absent on the sensory hairs of all setae. These setae are suggested to be mechanoreceptors that provide directional sensitivity and enhance the sensibility of turbulent motion, viscosity and changes of hydrostatic pressure.

Introduction

Adaptation is a central problem in evolutionary biology and an extraordinary topic for research in subterranean and deep-sea ecology (Christianen, 1992). Crustacea have been recognized as one of the most diversified and abundant groups inhabiting the anchialine cave systems in the tropics, the deep-sea and other interstitial habitats and have been used as models to exemplify how animals adapt to a life in total darkness with short food supply (Kaufman, 1994). Among the adaptations recorded in troglobic fauna are the reduction of size (Holsinger, 1986), the loss of pigment and of visual organs and the development of specialized sensorial structures (George, 1981).

Underwater cave systems remain in total darkness. The absence of light limits photosynthesis, which is the basis of the food web in other aquatic habitats. The food sources sustaining the cave system faunal assemblages depend on the import of debris from

the neighboring terrestrial and aquatic environments through the sinkholes. Organic material generally enters in dissolved or particulate form and is subsequently processed by bacteria (Eichem et al., 1993) and detritivores. The relationship between the food resources entering the cave systems and the consumers in the caves are not well documented; neither is the prey–predator relationship.

The cuticle of crustaceans is a dynamic system that has been recognized to perform diverse functions. In habitats where light is absent, structures on the epicuticle may provide a way to link the external environment with the sensory function and behavior. Isopods have been recognized as scavengers and predators that, in shallow habitats in presence of light, can utilize visual cues to locate their prey. An extensive terminology has been developed for describing the nature of crustacean cuticle. Studies on decapods date back to last century and early this century and have extensively described mechanosensory and chemosensory struc-

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tures. Experimental results have recognized the former to be related to the detection of movement and vibration produced by the prey or by the predators (Wägele, 1993). The latter have been considered to help detect the source and concentration of compounds of potential food sources (Laverack, 1989).

The asellotan isopod *Craseriella anops* (Creaser, 1936), is the dominant invertebrate in the community of anchialine cave systems in southeast Mexico. This species is troglitic and inhabits both the marine and fresh water masses of the cave system. To find the food used for growth, maintenance and reproduction in the isopod requires structural and functional features to facilitate a subterranean lifestyle. It is the purpose of this study to describe the external micro structures on the cephalic cuticle of *C. anops* and discuss the role of the observed cuticular appendages.

Sampling methods

Area of study

Nohoch Nah Chich are limestone caverns located in the eastern portion of the Yucatan Peninsula that drain into the northern Caribbean Sea with a known connection to the sea. The location named Main Entrance (20 17.9' N, 87 23.7' W), where sampling took place, is located 5 km inland from the coast near the city of Tulum. The cave passages develop at a halocline between 10 and 25 m water depths. Nohoch Nah Chich is an oligotrophic system characterized by the absence of light, constant temperature (26 °C) and low dissolved oxygen content ($2 \pm 0.2 \text{ mg O}_2 \cdot \text{L}^{-1}$). The system is subject to tidal influence and to seasonal input of freshwater and import of particulate organic matter (Alcocer et al., 1998).

Baited scavenger traps were deployed by means of cave diving. The traps used to collect the isopods were placed below the halocline at positions marked on a permanent line. The distances were 30–100 m from the cave entrance for a period of 12 h. This study used scanning electron microscopy to examine the external cuticular micro structures of the cephalon using a modified technique than the one described by Felgenhauer (1987). The heads of specimens were sectioned and fixed in a 2.5% glutaraldehyde solution prepared in the field with cave water and phosphate buffer at 0.1 M and pH 7 in 60 ml glass jars. Post processing in the laboratory included several baths with phosphate solution 0.1 M at pH 7 and post fixation

with 2% OsO₄ followed by new baths and dehydration with ethanol baths and acetone. Specimens were dried to critical point in a Samdri-780 dryer substituting the acetone with CO₂ in a vacuum. Heads were mounted and covered with Au–Pd in a 1:1 ratio using a metal ionizer JEOL-JFC 1100. Scanning electron microscopy observations and microphotographs were taken using a JEOL SEM model JSM-5410LV at high vacuum.

Scales and setae were described using the classification scheme of Watling (1989) and on those structures not considered we used the setal classification of Fish (1972). Scale morphotype was based on average measurements of length and width as in spider cuticular scales (Townsend & Felgenhauer, 1998). SEM micrographs were used to determine cuticular scale length and width of at least 30 scales from 10 specimens. The number and length of marginal setae were recorded.

Results

C. anops lacks body pigment. Cuticular scales cover the external surface of the cephalon as well as the body, the scales rest parallel to the surface of the cuticle and overlap slightly, they are spatulate. The surface is smooth. The scales are bordered by marginal spines 5 μm in length. The dimensions of the scales range 22 to 28 μm wide and 17 to 30 μm long (Fig. 1). The anterior end of the cephalon is bordered by a carina that widens slightly medially (230 μm) and expands to a triangular rostrum that is ventrally directed. The carina extends beyond the right and left borders of the cephalon (Fig. 2).

The eyes are absent on the lateral, ventral or frontal regions of the cephalon (Fig. 2). Omatidia, lenses or reflecting pigment membranes are absent. Two sutures, one on each side, are located on the distal seventh portion of the cephalon almost parallel to the border at each margin. The sutures extend medially approximately 90 μm and are 2 μm wide. The sutures are bordered by microtrichs (Figs 2 and 3). Two simple, non-annulated, robust setae with one sensory hair are located 20 to 25 μm from each suture. The setae are 1.3 μm wide and 55–70 μm in length. The surface of the setal shaft is smooth. The sensory hair is 15–20% of the total length of the setae. The apical portion of the sensory hair is acute, a terminal pore is absent both on the setae and sensory hair. The setae articulate with the cuticle by a socket (Figs 3–5).

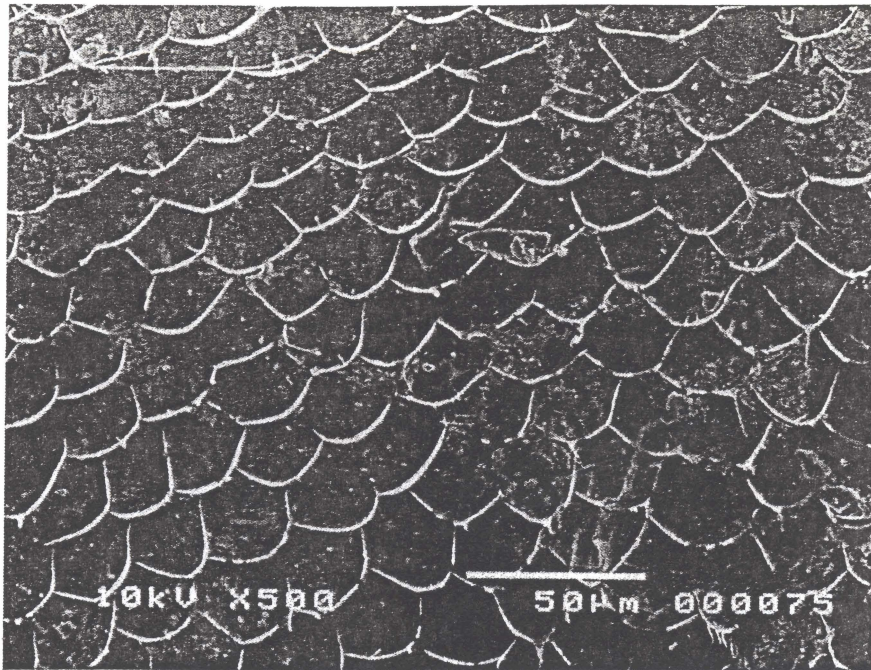


Figure 1. Cuticular scales covering the cephalon. The scales are bordered by marginal spines (ms). Scale bar is 50 μm .

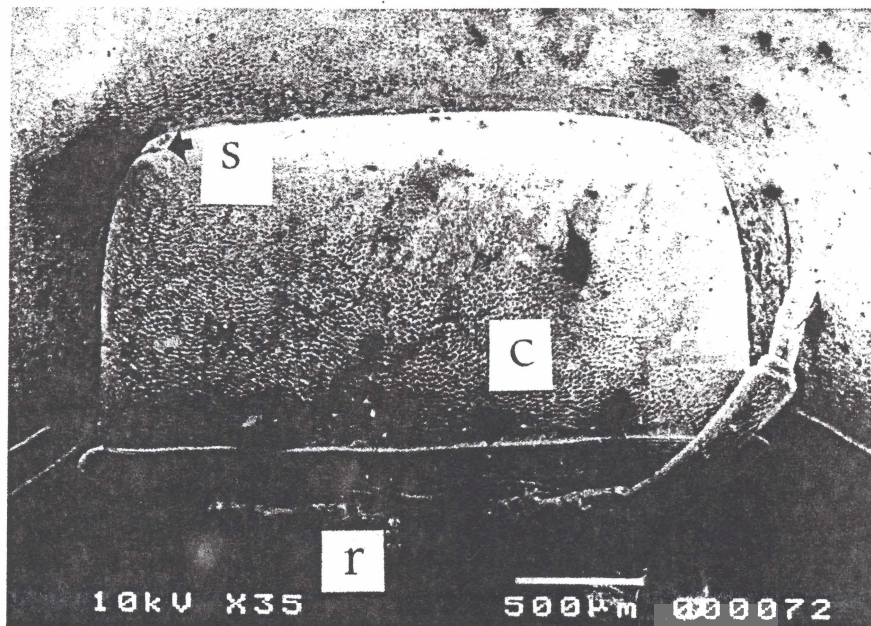


Figure 2. Anterior view of the cephalon showing the carinal (c). Rostrum (r), suture (s). Scale bar is 500 μm .

Two similar setae as described above are located medially on the cephalon 800 μm from the lateral margins and 28 μm from the distal border. A total of six setae are present on the cephalon. All setae are equal in length, have similar ornamentation, bear a sensory hair

and are articulated to the cuticle by a socket inserted in a supra cuticular mode. The setae occur isolated on the cephalon.

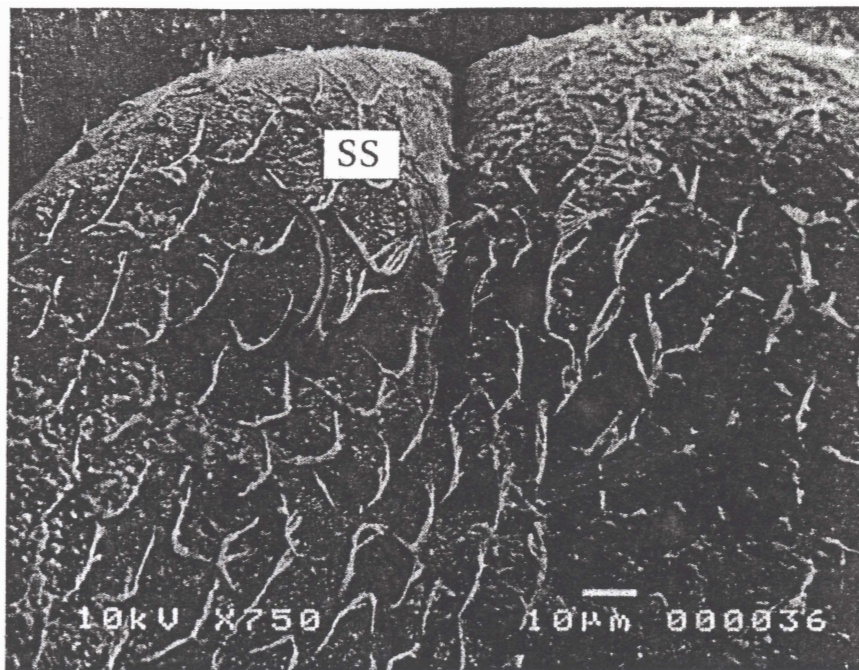


Figure 3. Suture on the left lateral angle of the cephalon. One simple setae (ss), is shown on the left side of the image. Scale bar is 10 μm .

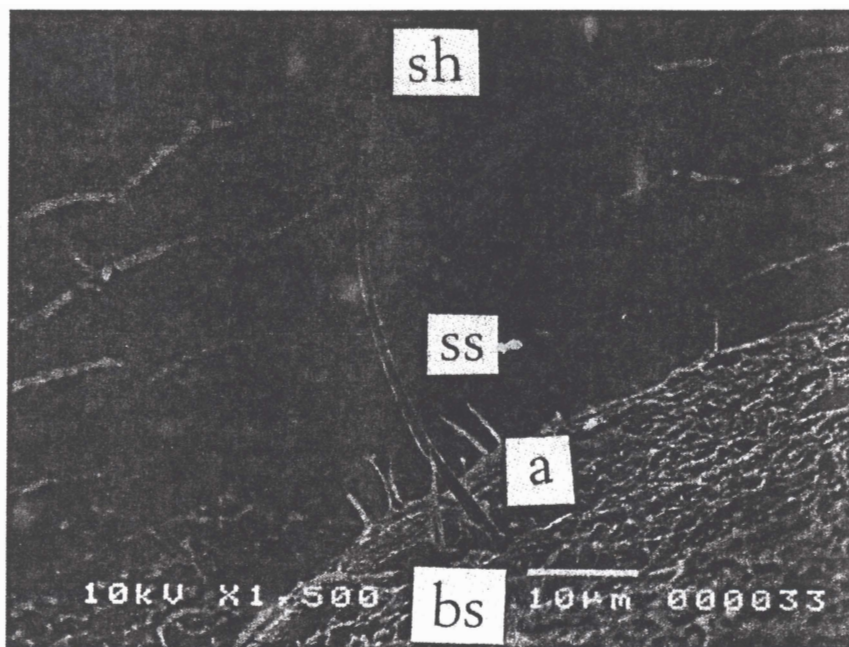


Figure 4. Simple setae (ss) with sensory hair (sh) annulation (a) and basal socket (bs). Scale bar is 10 μm .

Discussion

Constraints imposed by submerged caves, impoverishment and monotony of available food resources coupled with the aphotic nature of the habitat, have led

in a surround of the isopod to use chemosensory and mechanoreceptor mechanisms. As other archetypal troglitic organisms, the isopods display morphological characteristics linked to the physical limitations of the cave environment, such as a general lack of

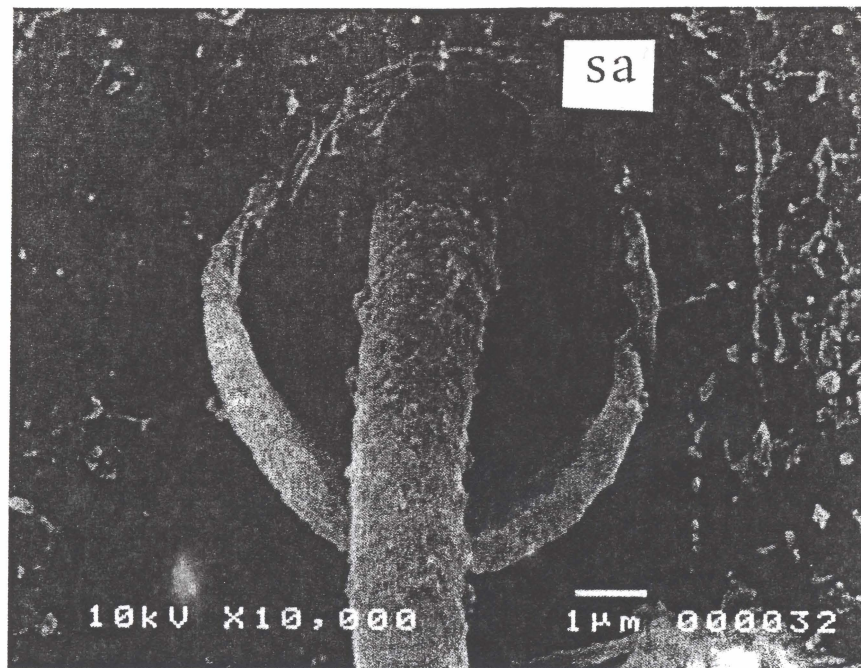


Figure 5. (a) Socket articulation and shaft of simple seta. Scale bar is 1µm. (b) Enlargement of the simple seta. Suture (s). Scale bar is 10µm.

pigmentation, an ocular regression, and hypertrophy of sensory organs (Christiansen, 1992). Adaptive responses for increased efficiency at food finding and avoiding predators can be observed in cephalic cuticular structures of Crustacea.

Cuticular ornamentation and scales can have an important function (Wägele, 1993) and in trying to understand evolutionary trends within Crustacean (Spano & Rapisarda, 1995, 1997). The functions attributed to the polygonal scales include enhancing chemical communication, interspecific defense, mechanical sensibility and thermoregulation as has been recognized in insects (Birch et al., 1990; Scoble, 1995). However it has been suggested that scales, as well as other micro structures, might be the result of differences in phylogeny and not function. Structures as the frontal carina, common to several isopod species, has been suggested to reduce friction and drag during displacement in the deep-sea (Lazier & Mann, 1989). Anophtalmy may be compensated by the complex setal arrangement on the cephalon that can be used as mechanoreceptors that provide the organisms with means to determine direction of vibration in the surrounding medium (De Lattin, 1939); the vibration would then be concentrated in the stalk and passed to underlying nerves. The movement provided by the setal socket may allow the bending of the setae and eli-

cit mechanosensory transduction to the nervous cells (Felgenhauer, 1992).

Mechanoreceptive setae, involved in the detection of currents and directional sensitivity, have a variable external morphology. A way of assessing the function of the seta at the ultra structural level is provided by electro physiological tests (Derby, 1989). Micro anatomy may describe the innervation of these receptors. However, a common feature of mechanoreceptive setae is the presence of a movable socket at the base of the sensillum (Felgenhauer, 1992). In contrast chemoreceptive setae usually bear an apical pore or very thin cuticle (Laverack, 1989).

Little is known on the biology of troglitic isopods in Mexico, most efforts include the description of new species (Bowman, 1975; Contreras-Balderas & Purata-Velarde, 1982; Rodríguez-Almaraz & Bowman, 1995), their natural history and habitat (Bolivar & Pietain, 1950) and the compiling of faunal lists (Redell, 1981). Few studies have described the physiology of cave Crustacea (Derby, 1989) and lesser number have described the mechanoreceptors in aquatic isopods (Menzies, 1956; Fish, 1972; Wägele, 1993). Further studies are needed in this direction.

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