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Remarks about *Mopsechiniscus tasmanicus* Dastych & Moscal, 1992 (Tardigrada, Echiniscidae)*

Bemerkungen zu *Mopsechiniscus tasmanicus* Dastych & Moscal, 1992 (Heterotardigrada, Echiniscidae)

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Summary: Using two new specimens of the rare Australian tardigrade species *Mopsechiniscus tasmanicus* Dastych & Moscal, 1992 we add some morphological details to the original description of this species (scuplturing of the dorsal plates, presence of platelets and claw length index) with the help of LM (phase contrast, interference contrast according to Nomarski) and for the first time SEM images. Further, we re-evaluate the complexly organized base („cirrophor") of the unusually long body appendages (setae) in A and E position (already described in the original description of this species), which appears spirally twisted and so far not described in this form, either in other *Mopsechiniscus* or other species of the Echiniscidae. They are remarkably similar to the base of putative (mechano)receptors known from marine heterotardigrades.

Key words: Tardigrada, Echiniscidae, *Mopsechiniscus*, cuticle, sculpture, setae A and E, sensory organs, Tasmania

Zusammenfassung: Anhand zweier neu aufgefundener Exemplare des seltenen australischen Bärtierchens *Mopsechiniscus tasmanicus* Dastych & Moscal, 1992 erweitern wir die Originalbeschreibung um einige morphologische Details (Skuplturierung der Rückenplatten, Vorhandensein von lateralen Plättchen, Krallenlängenindex) mit Hilfe von LM- (Phasenkontrast, Interferenzkontrast nach Nomarski) und erstmals anhand von REM-Aufnahmen. Darüber hinaus bewerten wir die bereits in der Erstbeschreibung dieser Art erwähnte komplexe Basis („cirrophor") der ungewöhnlich langen Körperanhänge (Setae) in den Positionen A und E, die spiralig gewunden erscheint und in dieser Form bisher weder bei anderen *Mopsechiniscus*-Arten noch bei anderen Arten der Echiniscidae beschrieben worden ist. Sie ähneln auffallend der Basis der als (Mechano)rezeptoren angesehenen Cirren (Setae) mariner Heterotardigraden.

Key words: Tardigrada, Echiniscidae, *Mopsechiniscus*, Cuticula, Setae A und E, (Mechano)rezeptoren, Tasmanien

1. Introduction

Currently, the heterotardigrade genus *Mopsechiniscus* du Bois-Marcus, 1944 (Echiniscidae) includes a total number of six species (see e.g. Dastych & Moscal 1992; Dastych 2001; Guidetti et al. 2014, 2017). *Mopsechiniscus* species are characterized by an asymmetry of the distal parts of their legs due to cuticular cushions, papillae and/or spines on one side (for summary see e.g. Kristensen 1987; Dastych 1999b, 2001; Guidetti et al. 2014). Most species have only been found in small numbers; their ecology is largely unexplored.

* In memoriam Antonius M. Moscal (Midway Point, Tasmania), obiit 21 May 2017. (https://www.anbg.gov.au/biography/moscal-antonius-mircea.html)

Mopsechiniscus tasmanicus was described on the basis of three specimens mounted in FAURE's medium (DASTYCH & MOSCAL 1992). This species differs clearly from other *Mopsechiniscus* congeners mainly by its lack of dorsal appendages, the presence of the E setae and, in particular, by a "unique internal sculpture at the base of all lateral appendages" (l.c. p. 221), i.e. the setae A and E. Recently in another sample from Tasmania (see CLAXTON & DASTYCH 2017) three further specimens of *M. tasmanicus* have been found. This find prompted us to re-check the previous information on this species analysing for the first time also SEM-images and to reassess the characteristic organization of the setae bases.

2. Material and methods

The three specimens of *Mopsechiniscus tasmanicus* came from a mixed sample of livermoss and lichens collected in the Tasmanian Central Highlands, in the Mount Field National Park, at the Baron Lady Creek. The material was sampled from non-calcareous substrate at the altitude of 980 m a. s. l. by A. M. MOSCAL on 12th March 1992 (for further locality details see CLAXTON & DASTYCH 2017).

One of the three specimens, a male, was mounted on a microscope slide in FAURE's medium. The following information and measured values refer, unless otherwise stated, to this specimen. The other two specimens were processed for SEM (as in DASTYCH et al. 2003), but only one specimen (sex unknown) was properly dried and stretched to be examined. Measurements were taken with eyepiece micrometer under phase contrast or taken directly from the SEM images.

The scapular plate index (sp) was used for the characteristics of the claw length. It expresses the percent ratio between the length of the claw and the length of the scapular (= shoulder) plate, taken along the dorsal midline of the plate (see DASTYCH 1999a, CLAXTON & DASTYCH 2017). Photomicrographs were made using the Photomikroskop III and Axioskop 2 (phase- and differential contrast microscopes) and scanning electron microscope "LEO 1512" (all Fa. Zeiss).

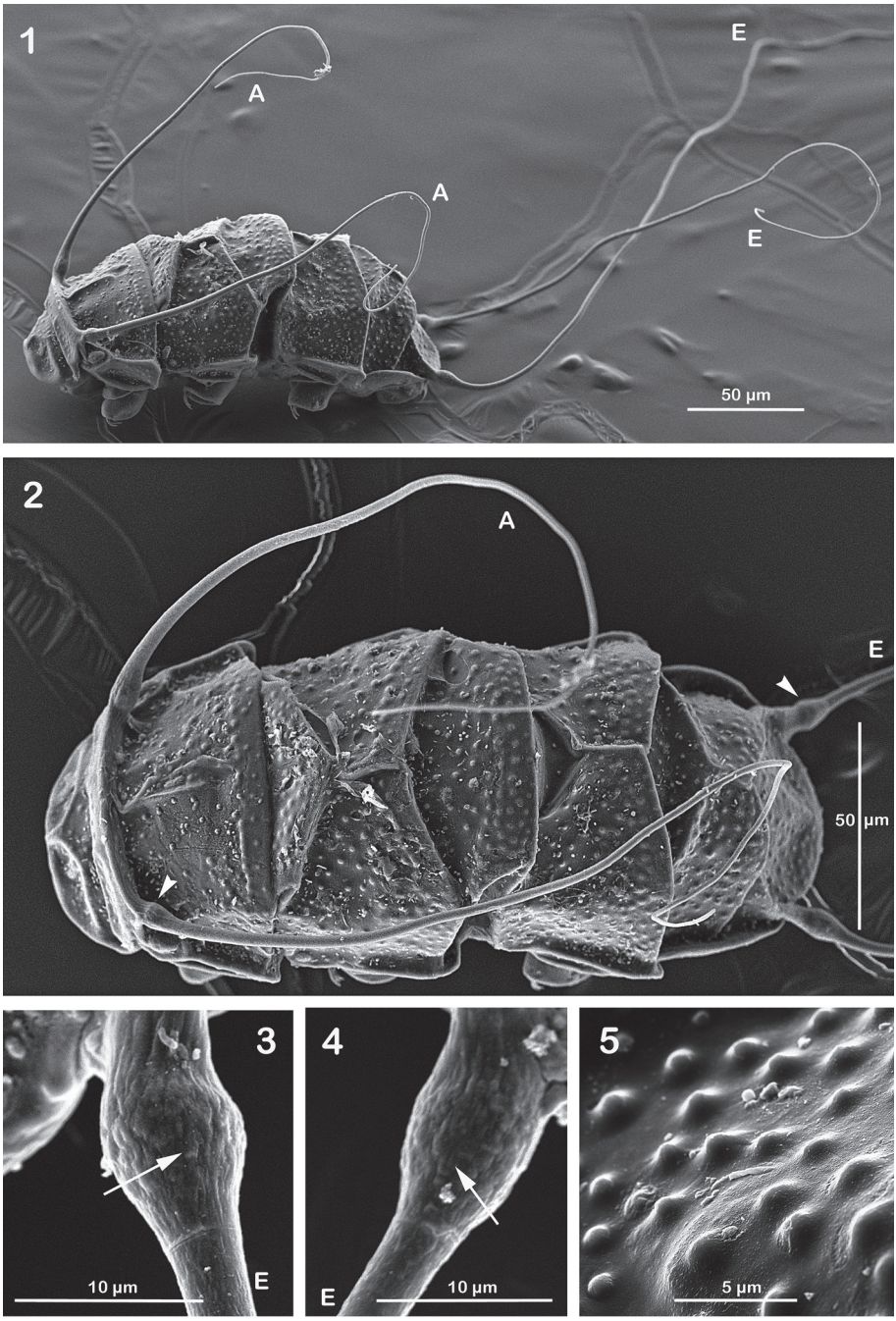
The examined specimen (in FAURE's medium) was compared with the material of *Mopsechiniscus tasmanicus* (holotype and paratype), *Mopsechiniscus imberbis* (Richters, 1908) (neotype), *Mopsechiniscus schusteri* Dastych, 1999 (paratype), *Mopsechiniscus frenoti* Dastych, 1999 (holotype) and *Mopsechiniscus granulosus* Mihelčič, 1967, all housed in the Zoologisches Museum Hamburg (ZMH). The microslide with the specimen in FAURE's medium will be deposited in the Tasmanian Museum and Art Gallery, Hobart (Tasmania, Australia).

Abbreviations used: II – second pair of dorsal paired plates; A – lateral appendage A (= seta A); cl – claws; DIC – differential interference contrast microscope; E – lateral appendage E (= seta E); M3 – third median plate; mo – mouth opening; pc – primary clava; PHC – phase contrast microscope; PS – pseudosegmental plate; sc – secondary clava; SEM – scanning electron microscope; TP – terminal plate.

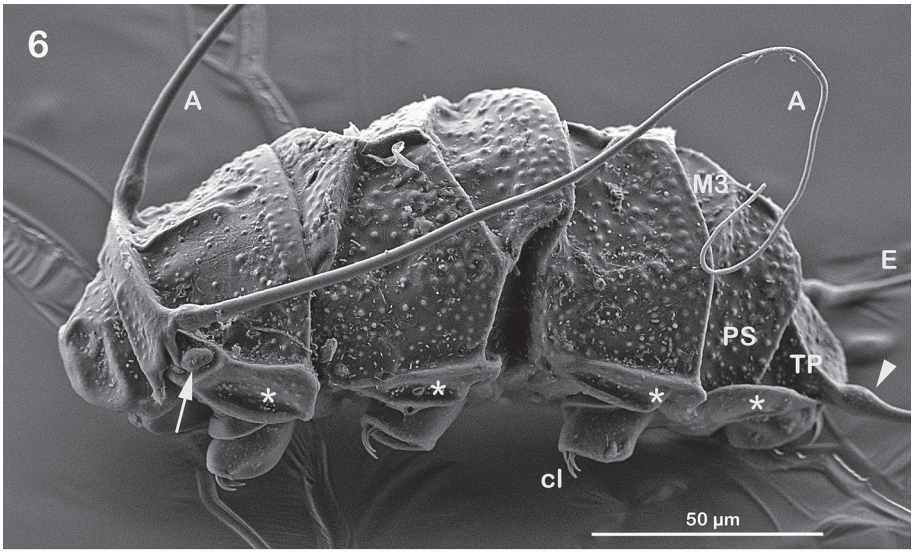
3. Results and discussion

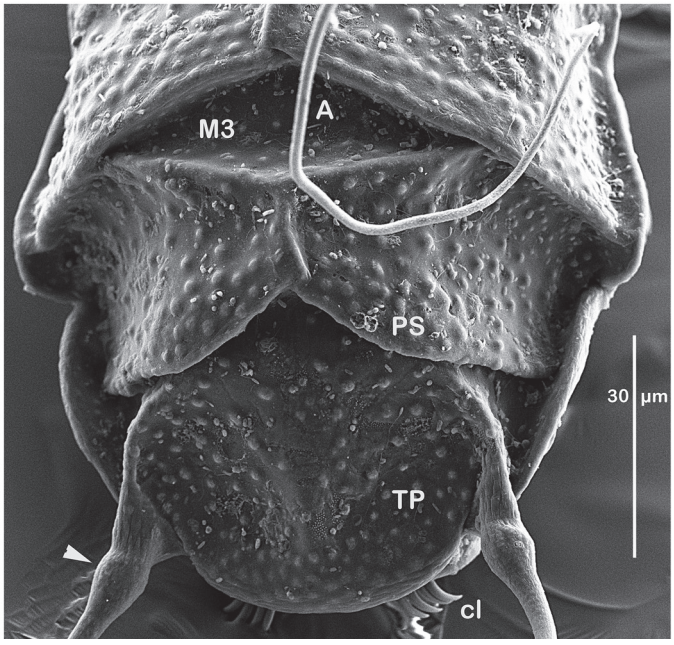
The body length of the male mounted in FAURE's medium is 274 µm. The specimen used for SEM is 185 µm long (the measurement was taken from the SEM-image); it seems to have shrunk a little during the drying procedure. This can be seen especially on the head and shoulder plate (Figs 1, 2, 6). The sculpture of the body plates

Abb. 1-5: *Mopsechiniscus tasmanicus*. **1** Latero-dorsale Ansicht. Man beachte die auffallend langen Setae A und E. **2** Dorso-laterale Ansicht: knollige Basen der Seten A und E (Pfeilspitze). **3** Knollige Basis der Seta E; winzige Skulpturierung auf der Oberfläche der Seta-Basis (Pfeil). **4** Dito. **5** Kutikuläre Skulpturierung auf der zweiten paarigen Rumpfplatte. (REM-Aufnahmen).



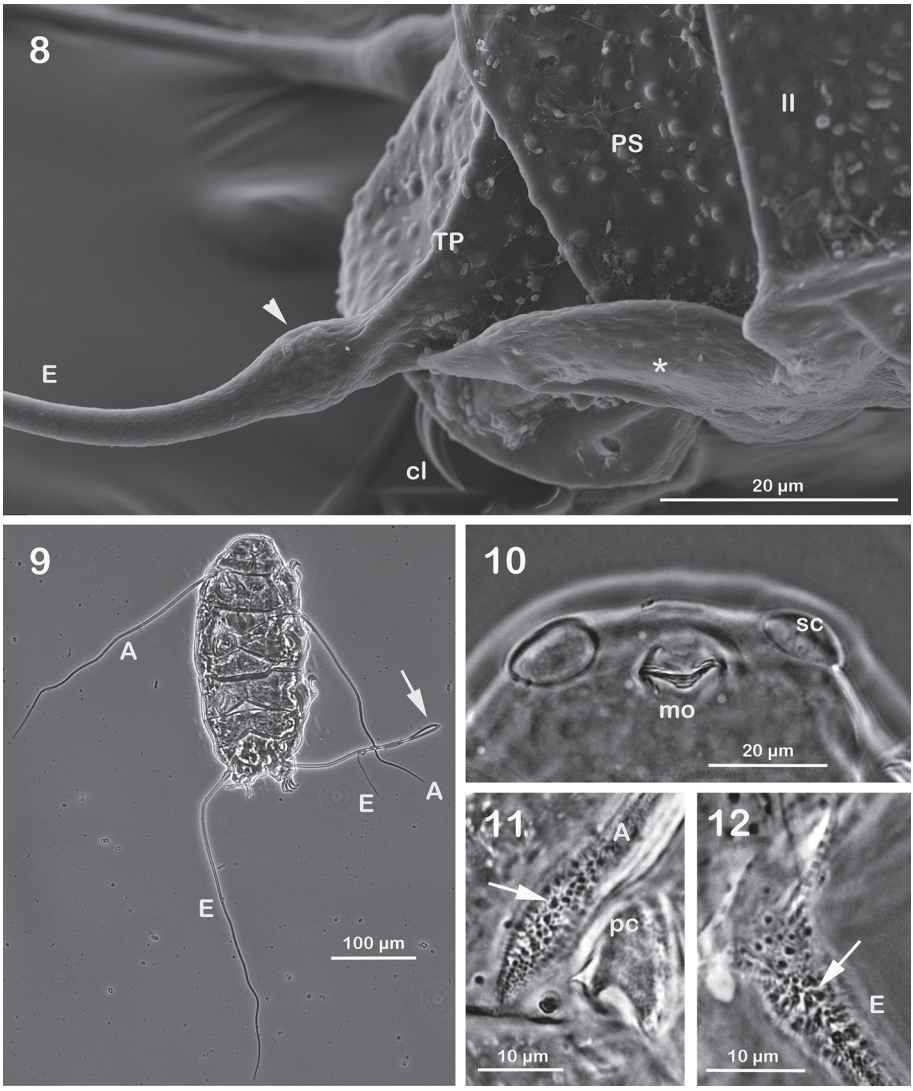
Figs 1-5: *Mopsechiniscus tasmanicus*. **1** Latero-dorsal view. Note strikingly long setae A and E. **2** Dorso-lateral view: bulb-like bases of setae A and E (arrowhead). **3** Bulb-like base of seta E: minute sculpturing on the surface of the seta base (arrow). **4** Ditto. **5** Sculpturing of the paired II plate. (SEM-images).





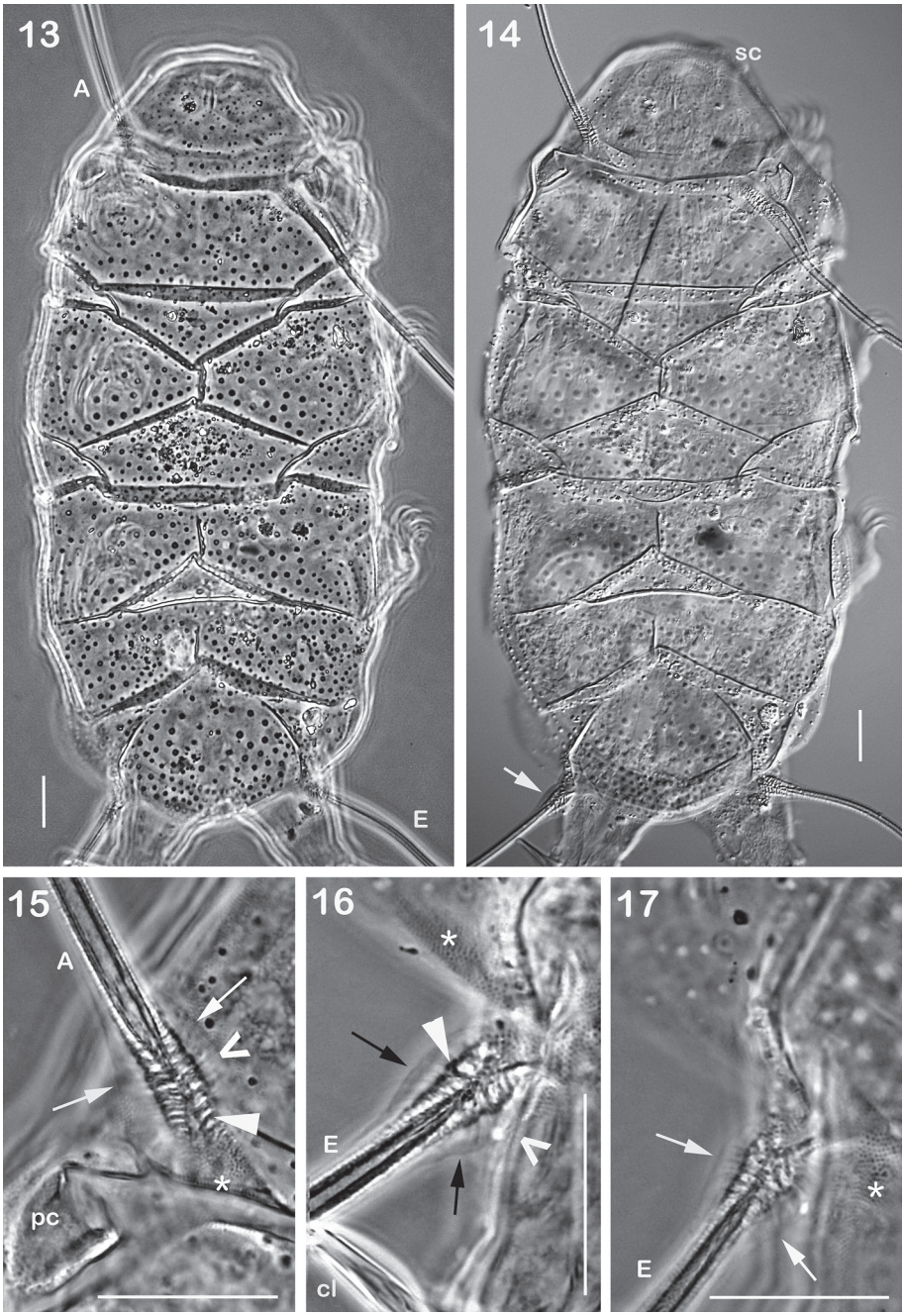
Figs 6-7: *Mopsechiniscus tasmanicus*. **6** Latero-dorsal view. **7** Rear of the body, dorsal view. Bases of setae E (arrowheads); primary clava (arrow); platelets (asterisks). (SEM-images).
Abb. 6-7: *Mopsechiniscus tasmanicus*. **6** Latero-dorsale Ansicht. **7** Hinteres Körperende, dorsale Ansicht. Basen der Seten E (Pfeilspitzen); primäre Clava (Pfeil): seitlichen Plättchen (Sterne). (REM-Aufnahmen).

consists of relative widely and more or less regularly distributed small hemispherical knobs (Figs 5, 13) approx. 2 µm in diameter and not depressions as stated in the original description (corrected in DASTYCH 2001). The largest knobs (ca. 2.7 µm) are on the first paired plates and the terminal plate. The length of shoulder plate is 45 µm. On lateral sides of dorsal plates occur small, partly separated areas (platelets: Fig. 6: as-



Figs 8-12: *Mopsechiniscus tasmanicus*. **8** Rear of the body, lateral view: platelet (asterisk). **9** Holotype, dorsal view. Note the strikingly long setae A and E: a loop of distal part of seta E (arrow). **10** Head segment, ventral view: collapsed mouth opening (mo). **11** Base of seta A and primary clava (pc), dorsal view: nubs/rod-like structures (arrow). **12** Base of seta E, dorsal view: nubs/rod-like structures (arrow). (Fig. 8: SEM-image; others: PHC-images).

Abb. 8-12: *Mopsechiniscus tasmanicus*. **8** Hinteres Körperende, Seitenansicht: Plättchen (Stern). **9** Holotypus, Dorsalansicht. Man beachte die auffallend lange Setae A und E: eine Schlaufe im distaler Teil der Seta E (Pfeil). **10** Kopfsegment, Ventralansicht: kollabierte Mundöffnung (mo). **11** Basis von Seta A und primäre Clava (pc), dorsale Ansicht: Noppen/Stäbchen ähnliche Strukturen (Pfeil). **12** Basis der Seta E, dorsale Ansicht: Noppen/Stäbchen ähnliche Strukturen (Pfeil). (Abb. 8: REM-Aufnahme; andere: PHC-Aufnahmen).



Figs 13-17: *Mopsechiniscus tasmanicus*. **13** Dorsal view. **14** Ditto. **15** Base of seta A and primary clava (pc). **16** Base of seta E. **17** Ditto. The surface of the external stratum of the seta base (arrows); irregularly shaped internal short nubs/rod-like structures (arrowheads); hourglass-like constriction of the lumen inside the seta base (<); tiny cuticular granulation (asterisks). Scale bars: 20 μm. (Fig. 14: DIC-image; others: PHC-images).

terisks). The platelets are poorly or even not discernible in dorsal view. The sub-cephalic plates are poorly formed and covered with tiny, densely and regularly arranged granules. No other ventral plates are present. Such a granulation covers also the venter of the specimen, particularly the surrounding of the gonoporus (its diameter ca. 5.5 µm), but is often hardly visible.

Only legs IV have distinct papilla; legs I have neither papillae nor spines, legs I-III exhibit small granules on their external surface, which are smaller but more regularly arranged granulation on the proximal part of legs IV. The distal parts of the legs are symmetrically formed, i.e. there are no external or internal spines, papillae or cushion-like thickenings unlike the other *Mopsechiniscus* species (e.g. Dastych 1999a-c).

Of the four claws of legs IV the two inner claws are 23 µm long; the two outer claws could not be measured due to unfavourable position. The sp index of the internal claws IV equals ca. 51 %.

The respective data for the type material (not given in the original description) are for the external claws IV of the holotype (male): sp = 51.1 % (21.6 µm) and for the internal claws IV sp = 49.0 % (20.7 µm). The length of shoulder plate in the holotype equals 42.3 µm. In the paratype (juv.) the sp index for the external claws IV is 40.0 % (16.2 µm) and for internal claws IV 37.7 % (15.3 µm), indicating relative smaller size of claws in juveniles. Its shoulder plate is 40.5 µm long. The secondary clava is oval and 13.5 µm wide (Figs 10, 14: sc). The primary clava has a wide base (7 µm), is 12 µm long and is located in a small cavity (Figs 11 pc; 13, 14). The setae positioned at A (shoulder plate) and E (terminal plate) are extremely long measuring 324 or 355 µm (setae A) and 288 or 394 µm setae E, respectively. They insert with a thickened bulb-like basal part, which is slightly thinner proximally, but gradually tapers distally. The special structure of the setae bases has already been emphasized in the first description of this species and has been covered there with detailed illustrations, but has not been further specified (see Dastych & Moscal 1992). After a thorough examination of the available preparations, also from other *Mopsechiniscus* species (see Material & methods) and by reviewing what is known from marine heterotardigrades in this regard, we believe despite the not adequate preservation of the animals that the appearance of the base can be described and interpreted as follows:

In *Mopsechiniscus tasmanicus*, the immediate bases of setae A and E originate relatively broad at the neck plate and terminal plate, respectively, then thickens bulb-like (Figs 2-4, 6) – here it seems moderately sculptured in SEM images (Figs 3, 4) – and gradually merges into the thin shaft of the seta ("flagellum"). If one uses the definition of van der Land (1968), it is a cirrophorus (= bulbous base, p. 141), which seems to be common in position A in other *Mopsechinicus* species. The thickened base and at least parts of the thin distal shaft seem to have a lumen, which appears constricted in the base (Figs 15-17: hour-glass structure). The lumen of the shaft is limited by a thin highly refractive cuticle (to be seen in phase contrast). The cuticle surface of the equally thickened transparent layer of the bulb shows a similar image with all light microscopical methods used, as being supposedly smooth (Figs 15-17: arrows). It looks as the cover surrounding cuticular nubs/rod-like structures (Figs 15, 16: arrowhead) which are circularly arranged around the lumen/mid-

Abb. 13-17: *Mopsechiniscus tasmanicus*. **13** Dorsalansicht. **14** Dito. **15** Basis von Seta A und primäre Clava (pc). **16** Basis der Seta E. **17** Dito. Die Oberfläche der äußeren Schicht der Seta-Basis (Pfeile); innere, unregelmäßig geformte kurze Stäbchen (Pfeilspitzen); sanduhrartige Verengung des Lumens innerhalb der Seta-Basis (<); winzige und regelmäßige kutikuläre Granulation (Sterne). Maßstab: 20 µm. (Abb. 14: DIC-Bild; andere: PHC-Bilder).

line of the bulb. When observed dorsally, the nubs/rod-like structures are mainly visible as irregularly sized granules (Fig. 11: arrow), but it depends strongly on the plane in which the bulb is photographed (comp. Fig. 12: arrow; for their DIC image see Dastych & Moscal 1992, fig. 14: is).

On SEM images, the nubs/rod-like structures might be visible only as an irregular and minute sculpturing (Figs 3, 4: arrow; Fig. 8: arrowhead). They are projected on the surface of the artificially flattened layer (transparent in LM microscopy: Figs 15-17: arrows), the latter being collapsed (shrunk) during the SEM preparation procedure.

As far as we know, bases of trunk appendages at A and E structured in this way are not known either from other *Mopsechiniscus* species (see e.g. Kristensen 1987; Dastych 2001) or from terrestrial Echiniscidae in general, but have been described for some Coronarctidae (Arthrotardigrada) as "accordeon-like" (Renaud-Mornant 1987) and for a representative of the marine Echiniscoidea, genus *Isoechiniscoide*s having "a spiral sculpture at the basis" (Møbjerg et al. 2016). In addition, there are TEM studies of the trunk appendages in A and E of *Batillipes mirus* Richters, 1909 and in A of *Halechiniscus greveni* Renaud-Mornant & Deroux, 1976 (Arthrotardigrada) showing that their bases are covered by a delicate and thin cuticle layer followed by an empty space (in our preparations probably represented by the thick transparent covering surrounding the bulb that is hardly or not visible in the light microscope and not seen in SEM), a ribbed (in sections) cuticular layer (our nubs/rod-like structures) and the cytoplasmic part containing the ciliary structures (not preserved in our preparations) (see Kristensen 1981). In their "mixotardigrade", Møbjerg et al. (2019, p. 809) show the body plan of a hypothetical ancestral tardigrade with a composite of characters from different evolutionary lineage with innervated cirri at A and E with an accordion-like basis. To our knowledge the innervation of the head and trunk appendages in Echiniscidae has never been clearly proven. However, with regard to the head appendages and also for the seta (cirrus) A an innervation is not to be doubted (see Schultze & Schmidt-Rhaesa 2013; Gross et al. 2021) and on the basis of the considerations set out here, it should also apply to seta (cirrus) E. It remains to be seen whether this type of sensory organ is more widespread among the Echiniscidae or whether *M. tasmanicus* occupies a special position in this respect.

The presence of setae E, absence of dorsal trunk appendages, the symmetry of distal parts of legs, the absence there internal and/or external spines, papillae and cushion-like thickenings and the presence of unique sensory organs in the bases of setae A and E may indicate a distinct separate phyletic status of *M. tasmanicus* within the genus *Mopsechiniscus* in the rank of a new genus.

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