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Redescription of *Dactylobiotus grandipes* (SCHUSTER, TOFTNER & GRIGARICK, 1978), the type species for the genus *Dactylobiotus* (Tardigrada: Macrobiotidae)

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ABSTRACT. *Dactylobiotus grandipes*, the type species of the genus, is redescribed based on the type material. *D. grandipes* is most similar to *D. dispar*, *D. parthenogeneticus* and *D. selenicus* in the shape of egg processes and the presence of dorso-lateral papillae between legs III and IV, but it differs from these species mainly by morphometric characters of the buccal tube and claws as well as by some egg traits.

Key words: Tardigrada, taxonomy, *Dactylobiotus grandipes*, *Macrobiotus grandipes*, redescription,.

INTRODUCTION

Dactylobiotus grandipes was described by SCHUSTER *et al.* in 1977 as *Macrobiotus grandipes*. Later, in 1980 SCHUSTER *et al.* established the genus *Dactylobiotus* with *Macrobiotus grandipes* (SCHUSTER, TOFTNER & GRIGARICK, 1978) as the type species. The genus *Dactylobiotus* is characterised mainly by the presence of the *Macrobiotus* type buccal tube and claws of the *Dactylobiotus* type (for more details see SCHUSTER *et al.* 1980). *D. grandipes* was originally described from Lake Tahoe in California (USA) and up to now is known only from the USA (MCINNES 1994). In their paper SCHUSTER *et al.* in 1977 described in detail biology and some ecological (especially seasonal) aspects of *D. grandipes* in Tahoe Lake. They gave also some information about buccal tube morphology (ratio between buccal tube length and length of animal) but the description of the species is very brief and lacks taxonomically important details. Specifically,

SCHUSTER *et al.* in (1977) did not provide any information on the oral cavity morphology and gave only a brief description of eggs. Moreover, measurements of adults and eggs are very basic (except for the incomplete measurements of the holotype). Since the SHUSTER *et al.* paper many new valuable taxonomic characters have been established and they should be carefully examined in *D. grandipes*.

The genus *Dactylobiotus* is widespread throughout the world and contains 15 described species, however the taxonomic position of *D. macronyx* (DUJARDIN, 1851) is still unclear and further two species, *D. aquatilis* YANG, 1999 and *D. henanensis* YANG, 2002, are in need of revision since taxonomically important characters have not been provided in the original descriptions (KACZMAREK *et al.* 2008).

Here, we present a redescription of *D. grandipes* based on the type material and using modern taxonomy tools. In addition to the description and morphometric data of some new characters we also provide a detailed differential diagnosis with most similar species of the genus *Dactylobiotus*.

MATERIAL AND METHODS

We examined 46 paratypes (13 specimens, 18 specimens in simplex stage, 11 exuvia with eggs and 4 free eggs) of *Dactylobiotus grandipes* preserved at The Bohart Museum, Department of Entomology, University of California, Davis, USA. Unfortunately we were unable to examine the holotype.

All measurements of *D. grandipes* are given in micrometers [μm]. Structures were measured only if their orientations were suitable. Body length was measured from the anterior extremity to the end of the body, excluding the hind legs. Buccal tube length and the level of the stylet support insertion point were measured according to PILATO (1981). Buccal tube widths were measured as the external and internal diameters at the level of the stylet support insertion point. Claw lengths were measured according BINDA & PILATO (1999). Only external claws (anterior in case of claws IV) were measured. The *pt* ratio is the ratio of the length of a given structure to the length of the buccal tube, expressed as a percentage (PILATO 1981). The oral cavity armature nomenclature adapted after MICHALCZYK & KACZMAREK (2003). Photomicrographs were made using phase contrast microscope Olympus BX 41.

***Dactylobiotus grandipes* (SCHUSTER, TOFTNER & GRIGARICK, 1977)**

(Figs 1-9)

MATERIAL EXAMINED

46 paratypes (13 specimens, 18 specimens in simplex stage, 11 exuvia with eggs and 4 free eggs)

TYPE LOCALITY

Pope Beach, Lake Tahoe, California (USA)

DISTRIBUTION

Known only from three localities in the USA (California, New Hampshire, Tennessee).

REDESCRIPTION

Adult (for measurements see Table 1): Body yellow, eyes absent (Fig. 1). Cuticle smooth or slightly wrinkled, without gibbosities, spines or defined sculpture (Fig. 2). An oval papilla between legs III and IV on each side of the body is present (Fig. 3).

Table 1. Measurements [in μm] and pt values of selected morphological structures of specimens of *Dactylobiotus grandipes* (RANGE refers to the smallest and the largest structure found among all measured specimens; N – number of specimens/structures measured, SD – standard deviation).

CHARACTER	N	RANGE		MEAN		SD	
		μm	pt	μm	pt	μm	pt
Body length	9	357.1 – 658.3	570.4 – 830.2	554.8	728.8	117.8	80.0
Buccal tube	9	59.4 – 88.8	–	75.6	–	11.8	–
Stylet support insertion point	9	43.2 – 63.7	70.6 – 73.8	54.7	72.3	8.7	1.1
Buccal tube external width	9	5.7 – 9.2	9.5 – 11.8	7.8	10.4	1.1	0.7
Buccal tube internal width	9	3.5 – 5.8	5.9 – 8.8	5.0	6.7	0.7	0.9
Ventral lamina length	6	36.3 – 48.5	54.1 – 58.0	45.1	55.7	4.6	1.8
Macroplacoid 1 length	9	17.7 – 29.9	29.8 – 34.5	24.2	31.9	4.6	1.9
Macroplacoid 2 length	9	10.4 – 19.0	17.0 – 21.4	14.8	19.4	3.1	1.4
Macroplacoid row length	9	31.4 – 52.4	52.7 – 59.1	42.1	55.4	7.9	2.5
Claw 1 - tc (ext) length	6	33.1 – 48.6	0.0 – 59.3	43.2	46.8	6.1	20.8
Claw 1 - sb (ext) length	6	8.3 – 13.5	0.0 – 16.2	11.8	12.8	1.9	5.7
Claw 2 - tc (ext) length	6	33.0 – 53.2	55.6 – 63.3	43.9	58.4	9.1	3.5
Claw 2 - sb (ext) length	6	9.0 – 17.8	14.7 – 21.2	13.2	17.4	3.7	2.3
Claw 3 - tc (ext) length	7	33.2 – 53.2	54.2 – 64.6	48.3	60.3	7.2	3.5
Claw 3 - sb (ext) length	7	9.5 – 17.6	15.5 – 21.0	14.9	18.5	2.6	2.0
Claw 4 - tc (ext/ant) length	7	45.9 – 74.8	70.7 – 89.2	65.5	82.4	9.7	7.0
Claw 4 - sb (ext/ant) length	7	14.7 – 22.5	21.7 – 27.5	20.2	25.4	2.7	2.1
Claw 1 - sb/tc length ratio	6	0.25 – 0.31	–	0.27	–	0.03	–
Claw 2 - sb/tc length ratio	6	0.26 – 0.33	–	0.30	–	0.03	–
Claw 3 - sb/tc length ratio	7	0.28 – 0.33	–	0.31	–	0.02	–
Claw 4 - sb/tc length ratio	7	0.30 – 0.32	–	0.31	–	0.01	–

Bucco-pharyngeal apparatus of the *Macrobiotus* type with ventral lamina and ten peribuccal lamellae (Fig. 4). Peribuccal papulae absent. Mouth antero-ventral. Oral cavity armature consisting of only one (*i.e.* second) band of teeth (Fig. 5). The first and the third band of teeth absent. The second band of teeth is placed in the posterior portion of the oral cavity. The band is continuous and composed of 4-5 irregular rows of small, dense teeth. Teeth in the shape of round or slightly oval granules/cones (spaces between teeth usually as wide as the teeth themselves). The band is continuous and looks the same on all oral cavity walls.

At the end of the buccal tube, triangular pharyngeal apophyses present. Pharyngeal bulb spherical with two rod-shaped macroplacoids, with sharpened edges. Macroplacoids situated very close one to another (Fig. 6). The first macroplacoid longer, with a central constriction, second shorter and with subterminal constriction and terminal projections (*i.e.* macroplacoid length configuration is 1-2). Microplacoid and septulum absent.

Claws of the *Dactylobiotus* type (configuration 2-1-1-2), similar in size and shape on all legs and with very short basal portions (Fig. 7). Primary branches of claws with small and short accessory points. Lunules are absent, but a robust semilunar cuticular connection between each external and internal claw is present. Claws I-III equal in length, but hind claws clearly larger.

Eggs (for measurements see Table 2): Large, laid freely. Spherical or slightly oval, with 52-57 processes on the circumference (Fig. 8). Processes in the shape of short and wide cones (base diameter of each process similar to its height) (Fig. 9). Processes and the surface between them smooth, *i.e.* no reticulation, granulation or areolation is visible in PCM.

Table 2. Measurements [in μm] of selected morphological structures of free eggs of *Dactylobiotus grandipes* (RANGE refers to the smallest and the largest structure found among all measured eggs; N – number of eggs/structures measured, SD – standard deviation).

CHARACTER	N	MIN	MAX	MEAN	SD
Diameter of egg without processes	4	93.7	105.5	101.5	5.3
Diameter of egg with processes	4	99.9	111.2	107.1	5.0
Processes height	12	2.3	4.2	3.2	0.6
Processes base width	12	1.7	3.2	2.3	0.4
Distance between processes	12	1.2	2.6	2.0	0.4
Number of processes on the egg circumference	4	50	57	53.0	2.9

REMARKS

Only nine specimens of all examined paratypes were measured (the remaining individuals were either in the simplex stage or the orientation of their structures was unsuitable for measurements). Despite all the specimens we examined are clearly yellow, the original description does not mention body colouration. It is possible that the colour is a side effect of the mounting medium in which specimens were fixed, though given that yellow pigment is found in other *Dactylobiotus* species (e.g. *D. luci*) it is very likely that SCHUSTER *et al.* (1977) simply ignored this character. The absence of the third band of teeth is very unusual as in all other known species of the genus *Dactylobiotus* the oral cavity armature consists of two bands of teeth (in all the first band of teeth is missing). However, this should be confirmed in a fresh material as in the majority of examined specimens the oral cavity region was not visible well. Moreover, it is possible that although the third band was originally present in the specimens, it is no longer detectable due to the age of the type material (32 years). On the other hand, it is hard to conceive why the third band (normally consisting of large, ridge-shaped

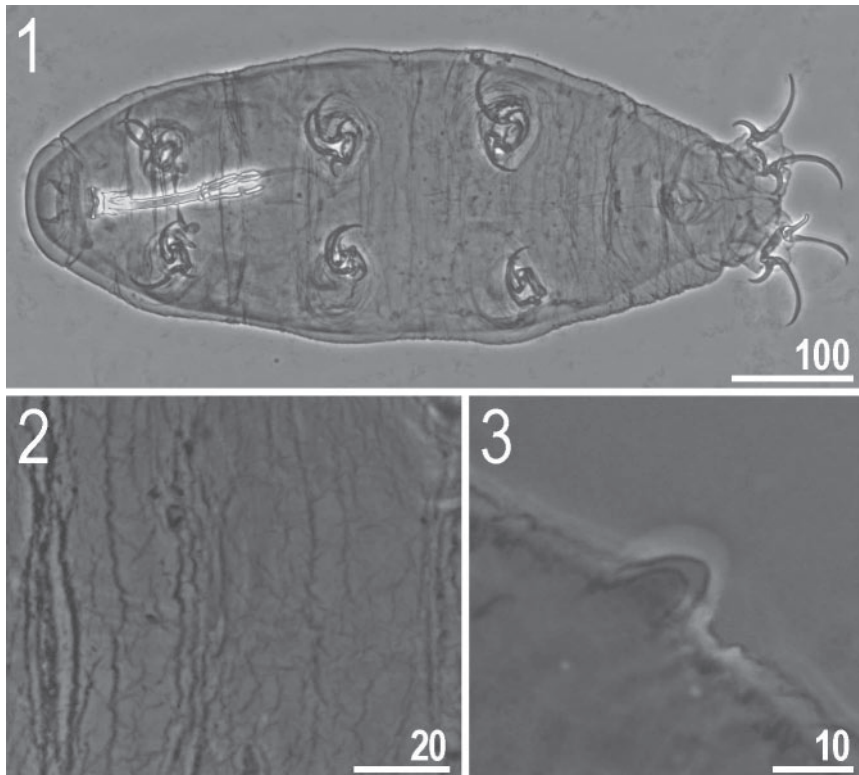
teeth) would disappear while the second band (which consists of small teeth) is still in a good condition.

In the original description SCHUSTER *et al.* (1977) have drawn dots between egg processes although this character was not mentioned in the text. We did not observe any sculpture, however it is possible that if it was indistinct it could have disappeared with time. Nevertheless, it is also possible that dotting was used by the authors simply to outline the egg surface and does not represent a granular appearance. Again, examination of fresh material should confirm the egg shell appearance.

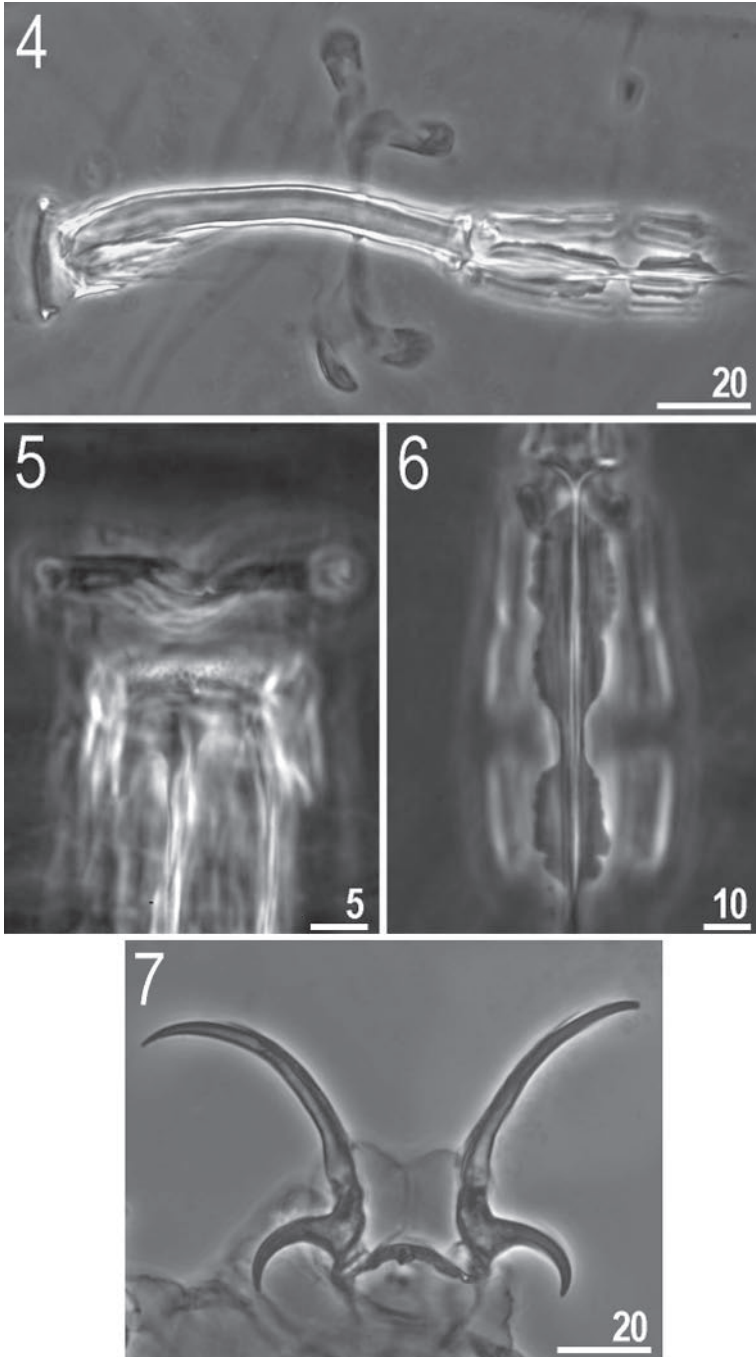
DIFFERENTIAL DIAGNOSIS

Dactylobiotus grandipes is in the general shape of egg processes and the presence of dorso-lateral papillae most similar to three other known *Dactylobiotus* species: *D. dispar* (MURRAY, 1907), *D. parthenogeneticus* BERTOLANI, 1981 and *D. selenicus* BERTOLANI, 1981.

D. grandipes differs from *D. dispar* mainly by: having egg processes without flexible apices, a higher number of egg processes on the egg circumference (50-57 in *D. grandipes* and only *ca.* 35 in *D. parthenogeneticus* (based on the drawing in BINDA



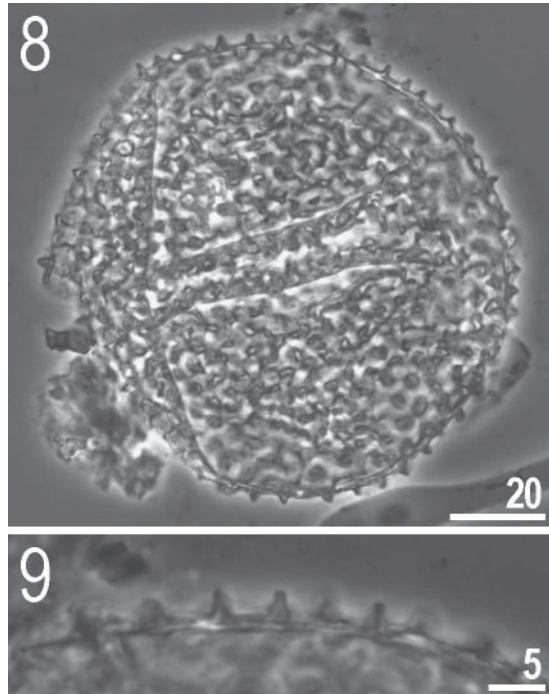
1-3. *Dactylobiotus grandipes*: 1 – habitus (ventral view), 2 – wrinkles on ventral cuticle, 3 – dorso-lateral papillae between legs III and IV



4-7. *Dactylobiotus grandipes*: 4 – buccal apparatus (lateral view), 5 – oral cavity armature consisting of a single band of small teeth, 6 – ventral macroplacoids, 7 – *Dactylobiotus grandipes*: claws IV

& PILATO 1999), the absence of the third band of teeth (note that this character needs to be confirmed, see Remarks), the absence of eyes, a longer buccal tube (59.4 in *D. grandipes* specimen 372.9 long and 51.2 in *D. dispar* specimen 389.0 long), a narrower buccal tube (5.7 in *D. grandipes* specimen 372.9 long and 9.1 in *D. dispar* specimen 389.0 long), a lower *pt* of the buccal tube width (9.5-11.8 in *D. grandipes* and 14.4-17.7 in *D. dispar*), longer claws III (33.0 in *D. grandipes* specimen 372.9 long and 19.5 in *D. dispar* specimen 389.0 long), higher *pt* of claws II-III (54.2-64.6 in *D. grandipes* and 37.6-43.0 in *D. dispar*), longer claws IV (45.9 in *D. grandipes* specimen 372.9 long and 25.0 in *D. dispar* specimen 389.0 long), a higher *pt* value of claws IV (70.7-89.2 in *D. grandipes* and 46.8-54.9 in *D. dispar*). All measurements are given/calculated according to RAMAZZOTTI & MAUCCI (1983) and BINDA & PILATO (1999).

D. grandipes differs from *D. parthenogeneticus* mainly by: having slightly shorter egg processes and without indentations (2.3-3.7 in *D. grandipes* and 4.0-4.5 in *D. parthenogeneticus*), a higher number of egg processes on the egg circumference (50-57 in *D. grandipes* and *ca.* 40 in *D. parthenogeneticus* (based on the drawing in Binda & Pilato 1999), the absence of the third band of teeth (note that this character needs to be confirmed, see Remarks), the absence of eyes, a longer buccal tube (73.9 in *D. grandipes* specimen 558.6 long and 58.8 in *D. parthenogeneticus* specimen



8-9. *Dactylobiotus grandipes*: 8 – egg surface, 9 – egg processes (mid section)

581.4 long), longer macroplacoids (I = 25.5 ($pt = 34.5$), II = 13.7 ($pt = 18.5$) in *D. grandipes* specimen 558.6 long and I = 16.4 ($pt = 27.9$), II = 10.6 ($pt = 18.0$) in *D. parthenogeneticus* specimen 581.4 long), less evident accessory points, longer claws II-III (33.0-53.2 ($pt = 54.2-64.6$) in *D. grandipes* and 13.0-21.5 ($pt = 31.2-48.8$) in *D. parthenogeneticus*), much longer claws IV (45.9-74.8 ($pt = 70.7-89.2$) in *D. grandipes* and 17.1-27.9 ($pt = 41.2-53.2$) in *D. parthenogeneticus*). All measurements are given/calculated according BERTOLANI (1981) and BINDA & PILATO (1999).

D. grandipes differs from *D. selenicus* mainly by: having a different shape of egg processes (wide cones without indentations in *D. grandipes* and crater-shaped in *D. selenicus*), the absence of the third band of teeth (note that this character needs to be confirmed, see Remarks), the absence of eyes, a longer buccal tube (73.9 in *D. grandipes* specimen 558.6 long and 65.7 in *D. selenicus* specimen 563.0 long), the first macroplacoid with a central constriction, a higher pt of claws IV (70.7-89.2 in *D. grandipes* and about 59.0 in *D. selenicus*). All measurements are given and calculated according BERTOLANI (1981) and BINDA & PILATO (1999).

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