

The genus *Echiniscus* Schultzze 1840 (Tardigrada) in Costa Rican (Central America) rain forests with descriptions of two new species

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In 46 mosses lichens samples collected in Costa Rica 10 *Echiniscus* Schultzze 1840 species were recorded. Two of them were already known from Costa Rica, five are new to this country, further two (*E. dariae* n. sp. and *E. kosickii* n. sp.) are new to science, and one (*Echiniscus* sp.) could not be fully identified as only a single specimen was found. *Echiniscus* sp. is probably also new to science and therefore is described here in detail. *E. dariae* n. sp. differs from the most similar *E. kosickii* n. sp. by the absence of median plate 3, the presence of polygonal granulation on dorsal plates and the absence of pores, by longer lateral spines, shorter dorsal spines, cephalic papilla and clava and by a higher number of teeth on dentate collars. *E. kosickii* n. sp. also differs also from *E. cavagnaroi* Schuster & Grigarick 1966 by the presence of spines *B*, *D*, *C^d*, shorter cirri *A* and also by a smaller number of teeth on the dentate collars. Some zoogeographical and ecological remarks on the species are also given. Moreover, earlier records of the genus *Echiniscus* from Costa Rica are discussed.

KEY WORDS: *Echiniscus dariae* n. sp., *Echiniscus kosickii* n. sp., Heterotardigrada, zoogeography, Central America, Costa Rica.

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INTRODUCTION

Costa Rica is a small tropical country (slightly over 50,000 km²) located in Central America. It is situated between Nicaragua to the north and Panama to the south and with two long coastlines of the Pacific Ocean on the west and the Caribbean Sea on the east. While the country has only about 0.1% of the world's landmass, it is estimated it contains 5% of the World's biodiversity (JANZEN 1983). There are at least 12 types of forests known in Costa Rica: tropical dry forest, tropical moist forest, tropical wet forest, premontane moist forest, premontane wet forest, premontane rain forest, lower montane moist forest, lower montane wet forest, lower montane rain forest, montane wet forest, montane rain forest, and subalpine rain páramo (JANZEN 1983). Up to now ca 10,000 plants (including 1400 trees), 850 birds, 200 mammals, 160 amphibians, 220 reptiles, 130 fishes and 35,000 insects were recorded in Costa Rica. Moreover, numerous new species (mostly invertebrates) are described from this region each year (RACHOWIECKI & THOMPSON 2000).

Tardigrade fauna in Costa Rica is still very poorly known though several recent studies on the subject have been conducted (RIGGIN 1964; MEHLEN 1969; HERRERA-VÁSQUEZ 2003; HERRERA-VÁSQUEZ & VARGAS 2003; KACZMAREK 2003; KACZMAREK & MICHALCZYK 2004, 2007; KACZMAREK et al. 2006; MICHALCZYK & KACZMAREK 2006a, 2006b, 2006c, 2007; PILATO & KACZMAREK 2007). In these 12 papers 25 species were reported, including seven new taxa: *Calcarobiotus* (C.) *longinoi* Kaczmarek Michalczyk & Guidetti 2006, *Doryphoribius quadrilaterulatus* Kaczmarek & Michalczyk 2004, *Echiniscus ganczareki* Michalczyk & Kaczmarek 2007, *Macrobotus alvaroi* Pilato & Kaczmarek 2007, *M. huziori* Michalczyk & Kaczmarek 2006, *M. magdalenae* Michalczyk & Kaczmarek 2006, *Milnesium krzysztofi* Kaczmarek & Michalczyk 2007. Among all reported species only five belong to the genus *Echiniscus* Schultze 1840.

In this paper we present a complete list of all Costa Rican species of this genus with some remarks on the distribution and ecological preferences. We include the descriptions and figures of two new species and add another five new records to the Costa Rican species list.

MATERIAL AND METHODS

A total of 720 moss, liverwort and lichen samples collected in Costa Rica were examined. In 46 samples 10 species belonging to the genus *Echiniscus* Schultze 1840 were found. Detailed information on the collection sites for each species are given in the section "Taxonomic accounts" (see below). Specimens were observed and measured using Light Microscopes: Phase Contrast Microscope (PCM) and Nomarski Differential Interference Contrast Microscope (DIC). All measurements are given in micrometers [µm]. Structures were measured only if they were undamaged and their orientation was suitable. Body length was measured from the anterior margin to the end of the body, excluding the hind legs. Only external claws were measured.

TAXONOMIC ACCOUNTS

(* = new records for Costa Rica)

1. *Echiniscus angolensis* Da Cuhna & Ribeiro 1983*Material examined in this study.* None.

Remarks. This species has been reported from Costa Rica (HERRERA-VÁSQUEZ & VARGAS 2003) but it was not found in the present study. The species is also known from localities in Venezuela and Angola (McINNES 1994).

2. *Echiniscus arctomys* Ehrenberg 1853*Material examined in this study.* None.

Remarks. This species has been previously reported from Costa Rica (KACZMAREK 2003) but it was not found in the present study. It is known from many localities throughout the world (McINNES 1994), which suggests that this taxon is probably a complex of similar species rather than a single species. Within the last few years numerous new species of the arctomys group were described, therefore the Costa Rican record requires a re-examination.

3. *Echiniscus bigranulatus* Richters 1908*Material examined in this study.* Central America, Costa Rica.

Cartago Province: Páramo, moss collected from a tree near the road No. 2, San Jose to San Isidro to El General about 7.5 km from the crossroads to the San Gerardo de Dota, 3329 m asl, GPS: 9.57307°N and 83.75758°W, 11.Dec.2002 (3 specimens), montane wet forest, mosses from trees collected in the Volcano Irazu National Park, near the top of the volcano and nearby, 3240 m asl, GPS: 9.98223°N and 83.84890°W, 17.Dec.2002 (5 specimens in 2 samples), montane wet forest, mosses from trees collected in the Volcano Irazu National Park, about 10 m from the top of the volcano, 3320 m asl, GPS: 9.97885°N and 83.84655°W, 17.Dec.2002 (5 specimens in 2 samples), montane wet forest, moss from tree collected near the road from the volcano to Cartago, 30.5 km before Cartago, 3335 m asl, GPS: 9.97795°N and 83.84160°W, 17.Dec.2002 (1 specimen).

San Jose Province: lower montane wet forest, moss from rocks collected near the road No. 2, San Isidro de El General to San Jose, 18.5 km from Division, 1300 m asl, GPS: 9.58062°N and 83.76235°W, 16.Dec.2002 (2 specimens).

Remarks. This species was reported from Costa Rica, Argentina, Ecuador (HERRERA-VÁSQUEZ & VARGAS 2003; KACZMAREK 2003; MICHALCZYK & KACZMAREK 2006c). Taxon reported also from Africa, however the African record is highly doubtful as all confirmed records of the *bigranulatus* group species are known only from South and Central America (MICHALCZYK & KACZMAREK

2006c, 2007). In Costa Rica the species is known from wet montane forest in the highest Costa Rican mountains.

4. *Echiniscus cavagnaroi* Schuster & Grigarick 1966 *

Material examined in this study. Central America, Costa Rica.

Alajuela Province: premontane wet forest, lichen from dead wood collected near the road No. 9 from the Volcano Poas to Puerto Viejo de Sarapiquí, 29.5 km from the volcano, 879 m asl, GPS: 10.26358°N and 84.17972°W, 24.Dec.2002 (3 specimens).

Guanacaste Province: tropical wet forest, lichen from tree collected near the road No. 164 from Bagaces to San Isidro, 29.0 km from Bagaces, 580 m asl, GPS: 10.76103°N and 85.19298°W, 06.Jan.2003 (3 specimens).

Heredia Province: lower montane rain forest, mosses from trees collected near the road No 9. from the Volcano Poas to Puerto Viejo de Sarapiquí, 18.5 km from the volcano, 1567 m asl, GPS: 10.20087°N and 84.15929°W, 24.Dec.2002 (7 specimens in 2 samples).

San Jose Province: lower montane rain forest, lichen and moss from tree and soil collected near the road from road No. 2 to Santa Maria de Dota, 6.0 km after the intersection with road No. 2, 1960 m asl, GPS: 9.69944°N and 83.97018°W, 16.Dec.2002 (5 specimens in 2 samples), lower montane wet forest, moss collected from a tree near the road No. 202, Frailes to Cartago, 11.0 km from Frailes, 1886 m asl, GPS: 9.81453°N and 84.02377°W, 16.Dec.2002 (1 specimen).

Remarks. The species was reported from USA (Texas, Georgia, Alabama, Louisiana, Florida), Galapagos Islands and Dominican Republic (McINNES 1994). In Costa Rica the species found mainly in premontane wet and rain forests (ca 550 m asl) and in lower montane wet and rain forests (ca 2000 m asl).

5. *Echiniscus crassispinosus* Murray 1907

Material examined in this study. None.

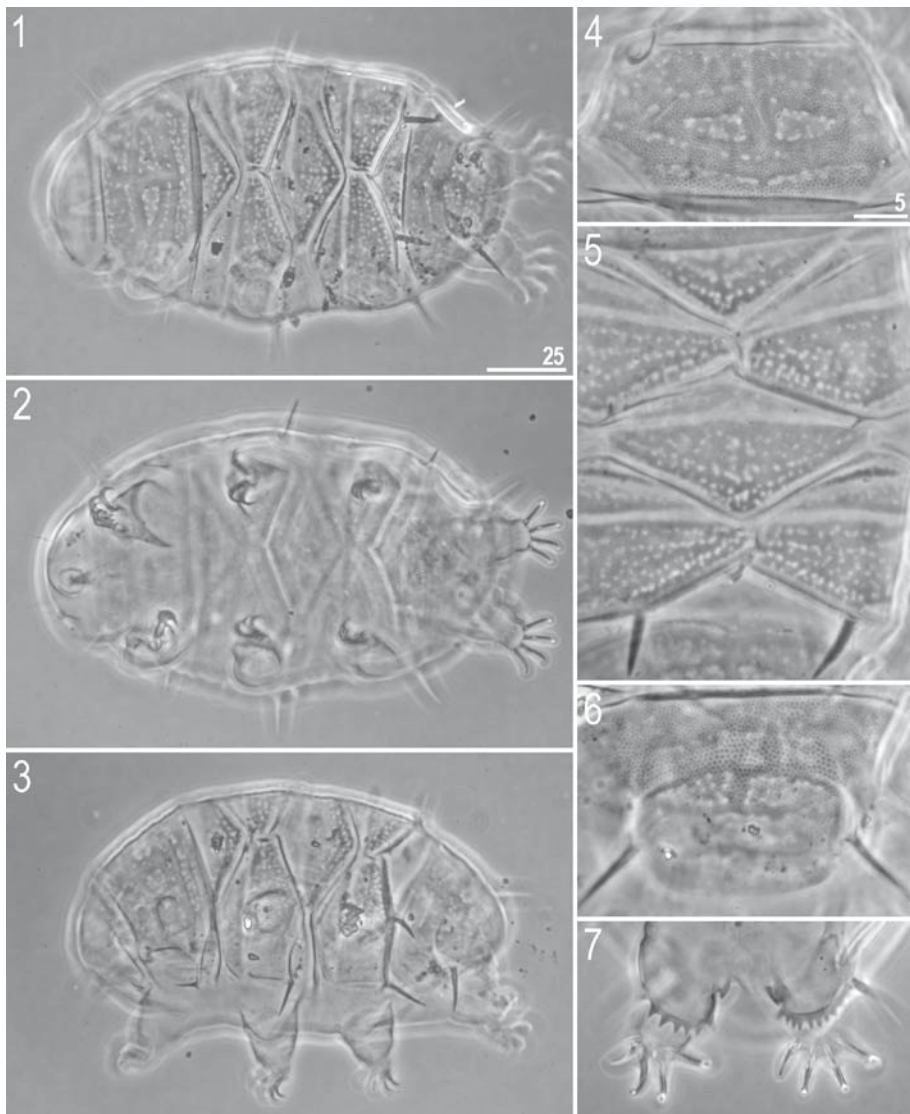
Remarks. This species has been previously reported from Costa Rica (KACZMAREK 2003 after earlier studies of different authors), however it was not found in the present study. The species also known from localities in Africa and China (McINNES 1994).

6. *Echiniscus dariae* n. sp. * (Figs 1-7)

Type material. Puntarenas Province: premontane wet forest, hepatic collected from a tree near the road No. 237, Paso Real to San Vito, about 10.0 km from S. Vito, 834.0 m asl, GPS: 8.84393°N and 83.03996°W, 13.Dec.2002 (16 specimens).

Additional material. Central America, Costa Rica.

Alajuela Province: tropical wet forest, moss from tree collected near the road from Ciudad Quesada (San Carlos) to Zarcero 11.5 km from Ciudad Quesada, 180.0 m asl, GPS: 10.35999°N and 84.49378°W, 11.Jan.2003 (7 specimens).



Figs 1-7. — *Echiniscus dariae* n. sp. Figs 1-3 habitus (Fig. 1 dorsal view, Fig. 2 ventral view, Fig. 3 lateral view); Figs 4-6 details of dorsal cuticle (Fig. 4 scapular plate, Fig. 5 median and paired plates, Fig. 6 terminal plate); Fig. 7 dentate collars on hind legs. [Figs 1-2, 4-7 holotype, Fig. 3 paratype; scale on Figs 2-3 same as on 1, scale on Figs 5-7 same as on Fig. 4].

Guanacaste Province: premontane wet forest, lichens from trees were collected near Cenzosa Vista al Mar in Bosque Nacional Diria, 960.0 m asl, GPS: 10.12553°N and 85.63004°W, 03.Jan.2003 (43 specimens in 4 samples).

Type depositories. Holotype (slide No. CR 230/3) and 65 paratypes (slides No. CR 230/2, 230/3, 929/1 930/1 938/1, 938/2, 939/2, 939/3, 1226/2) are deposited in the Department of Animal Taxonomy and Ecology, A. Mickiewicz University, Poznań.

Description. Holotype (female): Body orange, 146.5 long (Figs 1-3). Eyes present (colour indeterminable after preparation). Apart from head appendages (internal cirri 10.2 long, external cirri 13.6 long and cephalic papillae 5.6 long) lateral and dorsal appendages in positions: *A* (in the shape of long and thin filaments 22.3 long, with oval clavae near the bases), *B* (12.7 long), *C* (17.8 long), *D* (18.9 long), *E* (23.7 long), *D'* (20.1 long), all generally long and stout spines but those in the position *B* are shorter and thinner, and *C'* (3.7 long, in the shape of very short spines/teeth). The cirrus *A*/body length ratio 0.15.

Dorsal plates covered with a complex ornamentation resembling that of *E. kofordi* Grigarick & Schuster 1966. There are thinner (i.e. brighter in PCM) and thicker (darker in PCM) fields of dorsal plates. The thinner areas vary in size considerably from small circles (ca 0.3 in diameter) through thin bars (up to 2.5 in length) to large triangles (up to 7.0 in width). When focusing down through the cuticle small polygonal dots (0.3-1.0 in diameter) appear under the cuticle surface (Figs 4-6). The dots are in fact cuticular pillars which are distributed regularly in all plates and are distinctly larger in the centre of the paired, median and terminal plates, and also on the posterior end of the scapular plate (about 1.0 in diameter). Cephalic, scapular, median 1 and 2 and terminal plates not divided. Paired plates I and II divided indistinctly into two parts (smaller anterior and larger posterior) by a stripe without ornamentation. Paired plates II with crenulated margins. Median plate 3 absent. Terminal plate with incisions. Ventral plates absent.

Spine on legs I and papilla on legs IV present. Dentate collar on legs IV with 7-12 large, triangular teeth (Fig. 7). External claws on all legs smooth (8.7 long), but internal with thin and long spur (2.0 long), oriented downwards and situated very close to the claw base.

Ecological remarks. Upland species found mainly between 600-1000 m asl in premontane wet forests in mosses, hepatics and lichens growing on trees.

Remarks. Measurements of the holotype and 10 paratypes are given in Table 1. The paratypes are similar to the holotype and differ from it by different diameters and numbers of collar teeth (see Table 1).

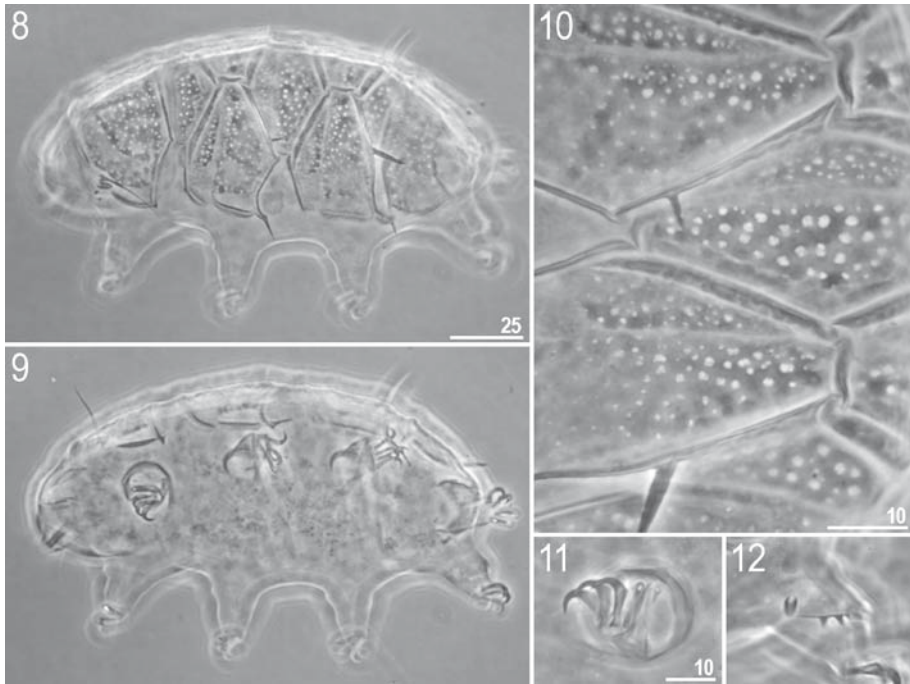
Etymology. The species is named after the first author's very good friend and a promising young Polish acarologist Dr Daria Bajerlein.

Differential diagnosis. *E. dariae* n. sp. differs from *E. kofordi* by the presence of other than cirrus internus, externus and cirri A cuticular appendages and by the absence of the third median plate.

Table 1.

Lengths [in μm] and length ratios of selected morphological structures of adults of *Echiniscus dariae* n. sp. (Min and Max refer to the smallest and the largest structure found among all measured specimens; SD = Standard Deviation, N = number of specimens/structures measured).

Character	N	Min	Max	Mean	SD
Body length	11	136.4	166.1	152.0	9.1
Cirrus internus length	8	7.9	12.2	10.5	1.5
Cephalic papilla length	10	3.9	5.9	4.9	0.7
Cirrus externus length	9	9.9	15.1	12.9	1.5
Cirrus A length	10	20.2	24.0	21.9	1.2
Cirrus B length	11	8.2	12.7	10.4	1.4
Cirrus C length	11	13.5	18.0	15.8	1.7
Cirrus C ^d length	10	2.5	5.0	3.5	0.7
Cirrus D length	11	15.6	18.9	17.4	1.1
Cirrus D ^d length	11	12.1	20.1	14.8	2.3
Cirrus E length	11	16.4	23.7	18.8	2.2
Clava length	5	3.5	5.0	4.3	0.6
Spine on leg I length	6	1.5	2.6	2.1	0.5
Papilla on leg IV length	4	3.0	3.5	3.3	0.2
Number of teeth on collar	9	7	12	9	1
Notch length	8	10.5	14.4	12.0	1.4
Claw I length	10	7.0	9.0	8.0	0.8
Claw IV length	9	7.6	11.0	9.9	1.3
Spur I length	10	1.5	2.2	1.8	0.2
Spur IV length	5	2.1	2.5	2.2	0.2
Cirrus A/Body ratio	10	0.13	0.17	0.15	0.01
Cirrus int/ext ratio	7	0.74	0.96	0.85	0.08
Cirrus int/A ratio	7	0.37	0.57	0.47	0.07
Cirrus ext/A ratio	8	0.48	0.64	0.57	0.06
Spur II/Claw I ratio	10	0.17	0.26	0.23	0.04
Spur IV/Claw IV ratio	5	0.19	0.28	0.23	0.04



Figs 8-12. — *Echiniscus kosickii* n. sp. Figs. 8-9 habitus (Fig. 8 dorso-lateral view, Fig. 9 ventro-lateral view); Fig. 10 details of dorsal cuticle; Fig. 11 claws I, Fig. 12 dentate collars on hind legs. [Figs 8-11 holotype, Fig. 12 paratype, scale on Fig. 9 same as on Fig. 8, scale on Fig. 12 same as on Fig. 11].

The new species differs also from *E. virginicus* Riggin 1963 (which has similar ornamentation on dorsal plates) by the absence of median plate 3, the presence of spines *B*, slightly shorter spines *C^d* (2.5-5.0 in the new species and ca 7.0 in *E. virginicus*) and slightly longer spines *D^d* (12.1-20.1 in *E. dariae* and 10.8-14.4 in *E. virginicus*).

Moreover, *E. dariae* n. sp. differs from *E. kosickii* n. sp. by the absence of median plate 3, the presence of polygonal granulation and the absence of pores on dorsal plates, longer lateral spines, shorter dorsal spines, cephalic papilla and clava (see Tables 1-2) and also by a slightly higher number of teeth on the dentate collar (7-12 in *E. dariae* n. sp. and 6-8 in *E. kosickii* n. sp.).

7. *Echiniscus ganczareki* Michalczyk & Kaczmarek 2007

Material examined in this study. Central America, Costa Rica.

Cartago Province: montane wet forest, mosses and hepatics from trees collected in the Volcan Irazu National Park, on the top of the volcano and its neighbourhood, 3240 m asl, GPS: 9.98223°N and 83.84890°W, 17.Dec.2002 (68 specimens in 2 samples).

San Jose Province: lower montane wet forest, moss collected from soil near the road No. 2, San Isidro de El General to San Jose, 18.5 km from Division, 1300 m asl, GPS: 9.58062°N and 83.76235°W, 16.Dec.2002 (1 specimen), Páramo, moss collected from a stone near the road No. 2, San Isidro de El General to San Jose, 19.0 km from Division, 3333 m asl, GPS: 9.57702°N and 83.75993°W, 16.Dec.2002 (7 specimens).

Remarks. The species belongs to the *bigranulatus* group and it is known only from several high mountain localities in Costa Rica (MICHALCZYK & KACZMAREK 2007; the present study).

8. *Echiniscus kofordi* Schuster & Grigarick 1966

Material examined in this study. Central America, Costa Rica.

Alajuela Province: premontane wet forest, lichen collected from dead wood near the road No. 9 from the Volcano Poas to Puerto Viejo de Sarapiquí, 29.5 km from the volcano, 879 m asl, GPS: 10.26358°N and 84.17972°W, 24.Dec.2002 (1 specimen), tropical moist forest, lichen collected from tree near the road No. 6 from Coribici to Upala, 48.0 km from Coribici, 80 m asl, GPS: 10.82256°N and 85.03843°W, 06.Jan.2003 (1 specimen), tropical moist forest, moss collected from a tree near the road No. 6 from Coribici to Upala, 53.0 km from Coribici, 63 m asl, GPS: 10.86250°N and 85.03613°W, 06.Jan.2003 (1 specimen).

Guanacaste Province: premontane wet forest, lichen collected from a tree near Cenzosa Vista al Mar in Bosque Nacional Diria, 960 m asl, GPS: 10.12553°N and 85.63004°W, 03.Jan.2003 (2 specimens), premontane wet forest, lichen collected from a tree near the road from Cenzosa Vista al Mar to Santa Cruz, 0.5 km from Co. V. al. Mar, Bosque Nacional Diria, 901 m asl, GPS: 10.12882°N and 85.63038°W, 03.Jan.2003 (1 specimen), agricultural area, lichen collected from a tree near the road No. 4 from Santa Cecilia to Brasilia, 9.0 km from Brasilia, 340 m asl, GPS: 11.05737°N and 85.41192°W, 04.Jan.2003 (6 specimens).

Puntarenas Province: premontane wet forest, hepatic collected from a tree near the road No. 237, Paso Real to San Vito, about 25.0 km from S. Vito, 623 m asl, GPS: 8.91194°N and 83.08464°W, 13.Dec.2002 (1 specimen).

Remarks. The species has been previously reported from the southern USA (Alabama, Louisiana, Florida), Galapagos Islands, Venezuela and southern Mexico (McINNES 1994). In Costa Rica the species is known mainly from lichens collected from premontane wet forest and tropical moist forest.

9. *Echiniscus kosickii* n. sp. * (Figs 8-12)

Type material. Central America, Costa Rica, Puntarenas Province: premontane rain forest, moss collected from a tree near the road No. 237, San Vito to Ciudad Neily,

Table 2.

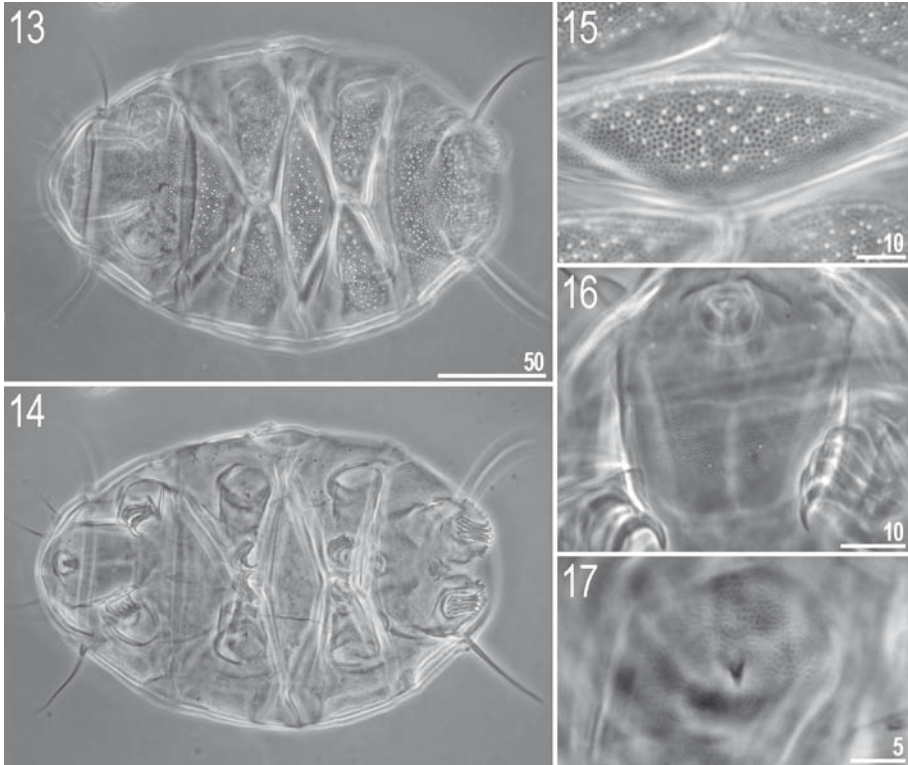
Lengths [in μm] and length ratios of selected morphological structures of adults of *Echiniscus kosickii* n. sp. (in body length order).

Character	Paratype 1	Holotype	Paratype 2
Body length	129.7	152.0	158.0
Cirrus internus length	8.2	8.9	9.1
Cephalic papilla length	6.3	6.8	6.5
Cirrus externus length	13.0	14.3	12.5
Cirrus A length	22.6	20.8	23.0
Cirrus B length	4.8	6.8	4.6
Cirrus C length	11.1	11.6	10.0
Cirrus C ^d length	9.3	11.2	7.0
Cirrus D length	10.2	12.1	7.2
Cirrus D ^d length	15.8	18.1	13.1
Cirrus E length	10.8	13.1	9.8
Clava length	5.0	5.6	5.1
Spine on leg I length	2.0	?	2.6
Papilla on leg IV length	3.5	4.0	3.6
Number of teeth on collar	6	8	6
Notch length	11.0	12.0	15.0
Claw I length	8.5	9.0	9.0
Claw IV length	7.9	9.9	9.1
Spur I length	1.0	1.0	1.0
Spur IV length	?	?	1.0
Cirrus A/Body ratio	0.17	0.14	0.15
Cirrus int/ext ratio	0.63	0.62	0.73
Cirrus int/A ratio	0.36	0.43	0.40
Cirrus ext/A ratio	0.58	0.69	0.54
Spur I/Claw I ratio	0.12	0.11	0.11
Spur IV/Claw IV ratio	?	?	0.11

about 10.0 km from Ciudad Neily, 955 m asl, GPS: 8.69942°N and 82.93407°W, 14.Dec.2002 (3 specimens).

Type depositories. Holotype and 2 paratypes on a single slide (No. CR 268/1) are deposited in the Department of Animal Taxonomy and Ecology, A. Mickiewicz University, Poznań.

Description. Holotype (female): Body orange, 152.0 long (Figs 8-9). Eyes present (colour indeterminable after preparation). Apart from head appendages



Figs 13-17. — *Echiniscus* sp. Figs 13-14 habitus (Fig. 13 dorsal view, Fig. 14 ventral view); Fig. 15 details of dorsal cuticle (median plate II); Fig. 16 two ventral plates with pores; Fig. 17 spine on legs II. [scale on Fig. 14 same as on Fig. 13].

(internal cirri 8.9 long, external cirri 14.3 long and cephalic papillae 6.8 long) lateral and dorsal appendages in positions *A* (in the shape of long and thin filaments 20.8 long, with oval clava near the base), *B* (very short spines 6.8 long), *C* (11.6 long), *D* (12.1 long), *E* (13.1 long), all long and thin spines, *C^d* (11.2 long) and *D^d* (18.1 long) in the shape of long and stout spines. Appendages *C^d* placed closer to the median line of the body than in other species of the genus. The cirrus *A*/body length ratio 0.14.

Dorsal plates covered with large (about 1.5-2.5 in diameter) pores distributed on plates irregularly (Fig. 10). The largest pores appear to be several smaller pores merged into a single pore (hence a 'raspberry-like' shape of the pore edges). Pores distinctly smaller on the margins of the plates (about 0.5-1.0 in diameter). Cephalic, scapular, median 1, median and terminal plates not divided. Paired plates I, II and median plate 2 divided into two parts (smaller anterior and larger posterior) by a stripe without ornamentation. Terminal plate with incisions. Ventral plates absent.

Spine on legs I and papilla on legs IV present. Dentate collar on legs IV with 8 small, triangular teeth (Fig. 12). External claws on all legs smooth (9.9

long), but internal with thin and long spur (1.0 long, oriented downwards) situated very close to the claw base (Fig. 11).

Ecological remarks. Only found in a single moss sample collected in premontane wet forest.

Remarks. Measurements of the holotype and two paratypes are given in Table 2. The paratypes are similar to the holotype and differ from it mainly by different dimensions and numbers of collar teeth (see Table 2).

Etymology. The species is named after the first author's very good friend and a promising young Polish ecologist Dr Jakub Kosicki.

Differential diagnosis. *E. kosickii* n. sp. differs from the most similar *E. spiniger* Richters 1904 by the presence of median plate 3 and sharp teeth on the dentate collar (blunt teeth in *E. spiniger*).

The new species differs also from *E. dariae* n. sp. by the presence of median plate 3, lacking of polygonal granulation and the presence of large pores on dorsal plates, shorter lateral spines, longer dorsal spines, cephalic papilla and clava and also by a lower number of teeth on dentate collar (see Tables 1-2).

Moreover, *E. kosickii* n. sp. differs from *E. cavagnaroi* (which has a similar ornamentation on dorsal plates) by the presence of spines *B*, *D*, *C^d*, shorter filaments *A* (14%-17% of the body length in the new species and ca 26% in *E. cavagnaroi*) and also by a lower number of teeth on dentate collars (6-8 in *E. kosickii* n. sp. and 8-12 in *E. cavagnaroi*).

10. *Echiniscus manuelae* da Cunha & Nascimento Ribeiro 1962 *

Material examined in this study. Central America, Costa Rica, Heredia Province: urban area, lichen from tree collected in Heredia, 1161 m asl, GPS: 10.00285°N and 84.11289°W, 07.Dec.2002 (10 specimens).

Remarks. This species was previously reported only from its *locus typicus* on Madera Island (Atlantic Ocean) (McINNES 1994). The fact that in Costa Rica the species was found only in one sample in a big city and in a very similar habitat to that of the *locus typicus* could suggest that *E. manuelae* is not indigenous to the region but was brought to Costa Rica by humans. Further study is needed to validate the hypothesis.

11. *Echiniscus perviridis* Ramazzotti 1959 *

Material examined in this study. Central America, Costa Rica, Cartago Province: urban area, moss collected from a concrete wall in Turrialba, near the Interamericana Hotel, 628 m asl, GPS: 9.90327°N and 83.68105°W, 17.Dec.2002 (28 specimens).

Remarks. Known from many localities in North America, Europe and northern Asia (McINNES 1994). In Costa Rica the species was found only in a

single sample in a large city near an international hotel which could suggest (as in *E. manuelae*) that *E. perviridis* is not an indigenous species but has been brought to Costa Rica by humans.

12. *Echiniscus virginicus* Riggin 1964 *

Material examined in this study. Central America, Costa Rica.

Cartago Province: urban area, hepatic collected from a tree near the road No. 2, San Jose to San Isidro to El General about 12 km from Cartago, 1692 m asl, GPS: 9.79878°N and 83.94926°W, 11.Dec.2002 (95 specimens), agriculture area, moss collected from a tree near the road No. 2, San Jose to San Isidro to El General about 4 km from the crossroads to San Cristobal Norte (near a cattle farm), 1880 m asl, GPS: 9.77846°N and 83.99136°W, 11.Dec.2002 (1 specimen), montane rain forest, moss collected from a tree near the road No. 2, San Jose to San Isidro to El General about 11 km from the crossroads to Jardin, 2540 m asl, GPS: 9.67439°N and 83.89197°W, 11.Dec.2002 (1 specimen), agriculture area, moss collected from a concrete wall near the road from Pacayas to Turrialba by Santa Cruz, 23.0 km from Turrialba, 1708 m asl, GPS: 9.94649°N and 83.77539°W, 17.Dec.2002 (1 specimen).

Heredia Province: lower montane rain forest, moss from dead wood collected near the road No. 9 from the Volcano Poas to Puerto Viejo de Sarapiquí, 14.5 km from the volcano, 1821 m asl, GPS: 10.16850°N and 84.15696°W, 24.Dec.2002 (1 specimen), lower montane rain forest, mosses collected from trees near the road No. 9 from the Volcano Poas to Puerto Viejo de Sarapiquí, 18.5 km from the volcano, 1567 m asl, GPS: 10.20087°N and 84.15929°W, 24.Dec.2002 (4 specimens in 2 samples).

Puntarenas Province: urban area, moss collected from a tree in Sabalito near the city border, 920 m asl, GPS: 8.82051°N and 82.91540°W, 13.Dec.2002 (2 specimens).

San Jose Province: lower montane wet forest, moss collected from stone and lichen from soil near the San Gerardo de Dota (East of the city), 2002 m asl, GPS: 9.53429°N and 83.82375°W, 11.Dec.2002 (7 specimens in 2 samples), lower montane wet forest, lichen collected from a tree near the road No. 202, Frailes to Cartago, 11.0 km from Frailes, 1886 m asl, GPS: 9.81453°N and 84.02377°W, 16.Dec.2002 (6 specimens).

Remarks. The species was reported from the southern USA, Dominican Republic and Venezuela (McINNES 1994). In Costa Rica the species is known from mountain localities, mostly in lower montane wet forests.

13. *Echiniscus* sp. * (Figs 13-17)

Material examined in this study. Central America, Costa Rica, Guanacaste Province: premontane rain forest, moss collected from dead wood in the Rincon de la Vieja National Park, on the slope of the Volcano R. de la Vieja, 3.0 km from the Park Reception, 969 m asl, GPS: 10.78618°N and 85.35638°W, 05.Jan.2003 (1 specimen).

Description. Body length 206.0 (Figs 13-14). Body red, eyes present (colour indeterminable after preparation). Apart from head appendages (internal cirri 22.9 long, external cirri 28.0 long, cephalic papillae 9.0 long) lateral appendages occur in positions: *A* (39.3 long) (in the shape of long and thin filaments with oval clava near the base), *C* (3.8 long, in the shape of very short spines) and *E* (46.2 long, in the shape of long filaments). The cirrus *A*/body length ratio is 0.19.

Dorsal plates with 'double granulation', i.e. with small cuticular pillars (appearing as polygonal granules) and covered with slightly larger oval pores distributed irregularly (Fig. 15). Cephalic, scapular, median 1 and 2 and terminal plates not divided. Paired plates I and II divided into two parts (smaller anterior and larger posterior). Terminal plate with incisions. Median plate 3 absent. On the ventral side of the body, posteriorly to the mouth opening, two plates with several small pores are present (Fig. 16).

Triangular spine on legs I-III (lengths: I-2.5, II-2.9, III-3.3, see Fig. 17) and papilla on legs IV present. Dentate collar on legs IV with 20 small, triangular teeth. External claws on all legs smooth (13.0-15.0 long), but internal with spur (3.0 long), oriented downwards and situated very close to the claw base.

Differential diagnosis. *Echiniscus* sp. differs from the most similar *E. perarmatus* Murray 1907 by the absence of lateral spines *B* and *D*, and dorsal *D*^d. *Echiniscus* sp. differs also from *E. maesi* Séméria 1985 by lacking spine *D*, external buccal cirri longer than the internal ones, more densely placed pores on dorsal plates, longer filaments *A* and *E* (39.3 and 46.2 in a specimen of *Echiniscus* sp. 205.9 long and 33.0 and 35.0 in a specimen of *E. maesi* 231.0), a higher number of teeth on the dentate collar (20 in *Echiniscus* sp. and 15 in *E. maesi*) and probably also by the presence of spines on legs II-III and the presence ventral plates (these characters were omitted in the original description of *E. maesi*).

Remarks. Given that only a single specimen of this species was found and therefore no data on morphological variability are available, describing a new species is not possible. Similarity of *E. sp.* and *E. perarmatus* is evident, especially considering that sometimes in specimens of *E. perarmatus* lateral spines *B* and *D* can be absent and dorsal *D*^d are very small (RAMAZZOTTI & MAUCCI 1983, GRIGARICK et al. 1983). Such variability in *E. perarmatus* may suggest that the taxon comprises of more than one species. Therefore, a revision of *E. perarmatus* is needed. Despite *E. sp.* being similar to *E. maesi* it is not possible to truly compare these two taxa without examining the type material of *E. maesi* as the original description was sketchy and, by current standards, incomplete.

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REFERENCES

- GRIGARICK A.A., SCHUSTER R.O. & NELSON D.R. 1983. Heterotardigrada of Venezuela (Tardigrada). *Pan-Pacific Entomologist* 59 (1-4): 64-77.
- HERRERA-VÁSQUEZ J. 2003. Diversidad y densidad de tardígrados (Tardigrada) en cuatro zonas de vida de Costa Rica. *Brenesia* 59-60: 77-82.
- HERRERA-VÁSQUEZ J. & VARGAS M. 2003. Tardigrades (Tardigrada) from the western part of the Central Valley, Costa Rica with some ecological annotations. *Brenesia* 59-60: 69-76.
- JANZEN D.H. 1983. Costa Rican natural history. *Chicago: The University of Chicago Press*, 816pp.
- KACZMAREK Ł. 2003. New records of and key to Tardigrada from Costa Rica. *Zootaxa* 177: 1-4.
- KACZMAREK Ł. & MICHALCZYK Ł. 2004. First record of the genus *Doryphoribius* Pilato 1969 from Costa Rica (Central America) and description of a new species *Doryphoribius quadrituberculatus* (Tardigrada: Hypsibiidae). *Genus* 15 (3): 447-453.
- KACZMAREK Ł. & MICHALCZYK Ł. 2007. A new species of Tardigrada (Eutardigrada: Milnesiidae): *Milnesium krzysztofi* from Costa Rica (Central America). *New Zealand Journal of Zoology* 34: 297-302.
- KACZMAREK Ł., MICHALCZYK Ł. & GUIDETTI R. 2006. Description of the new species *Calcarobiotus* (C.) *longinoi* n. sp. (Eutardigrada, Macrobiotidae) from Costa Rica with the diagnostic key to the genus *Calcarobiotus*. *Italian Journal of Zoology* 73 (3): 247-253.
- MCINNES S.J. 1994. Zoogeographic distribution of terrestrial/freshwater tardigrades from current literature. *Journal of Natural History* 28: 257-352.
- MEHLEN R.H. 1969. Tardigrada: taxonomy and distribution in Costa Rica. *Transactions of the American Microscopical Society* 88 (4): 498-505.
- MICHALCZYK Ł. & KACZMAREK Ł. 2006a. *Macrobiotus huziori*, a new species of Tardigrada (Eutardigrada: Macrobiotidae) from Costa Rica (Central America). *Zootaxa* 1169: 47-59.
- MICHALCZYK Ł. & KACZMAREK Ł. 2006b. A new species *Macrobiotus magdalenae* (Tardigrada: Eutardigrada: Macrobiotidae, *richtersi* group) from Costa Rican rain forest (Central America). *New Zealand Journal of Zoology* 33: 189-196.
- MICHALCZYK Ł. & KACZMAREK Ł. 2006c. Revision of the *Echiniscus bigranulatus* group with a description of a new species *Echiniscus madonnae* (Tardigrada: Heterotardigrada: Echiniscidae) from South America. *Zootaxa* 1154: 1-26.
- MICHALCZYK Ł. & KACZMAREK Ł. 2007. *Echiniscus ganczareki*, a new species of Tardigrada (Heterotardigrada: Echiniscidae, *bigranulatus* group) from Costa Rica. *Zootaxa* 1471: 15-25.

- PILATO G. & KACZMAREK Ł. 2007. *Macrobiotus alvaroi*, a new species of eutardigrade (Tardigrada, Macrobiotidae) of the *polyopus* group from Costa Rica (Central America). *Zootaxa* 1479: 1-7.
- RACHOWIECKI R. & THOMPSON J. 2000. Costa Rica, 4th edition. London: Lonely Planet Publications Pty Ltd, 593 pp.
- RAMAZZOTTI G. & MAUCCI W. 1983. Il phylum Tardigrada. *Memorie dell'Istituto Italiano di Idrobiologia* 41: 1-1012.
- RIGGIN G.T. 1963. Tardigrades from Costa Rica. *Proceedings of the Louisiana Academy of Sciences* 25: 15-17.