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The Tardigrada Fauna of China with Descriptions of Three New Species of Echiniscidae

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Xiao-Chen Li, Li-Zhi Wang, and Di Yu (2007) The Tardigrada fauna of China with descriptions of three new species of Echiniscidae. *Zoological Studies* **46**(2): 135-147. The Tardigrada fauna of China is summarized. *Pseudechiniscus beasleyi* sp. nov., *Echiniscus nelsonae* sp. nov., and *E. shaanxiensis* sp. nov. from the Qinling Mountains of central Shaanxi Province, China are described as new to science. Photomicrographs and drawings are provided to illustrate the morphological characters of the new species. Four new species records of the Tardigrada are also reported from the Qinling Mountains: *E. ramazzotti* Binda and Pilato, *E. mediantus* Marcus, *E. tardus* Mihelčič (Echiniscidae), and *Diphascon rivularis* (Mihelčič) (Hypsibiidae). Type specimens are deposited at the College of Life Sciences, Shaanxi Normal University, Xian. A key to Chinese species of the Tardirada is also given. http://zoolstud.sinica.edu.tw/Journals/46.2/135.pdf

Key words: Tardigrada fauna, Taxonomy, New Species, New record, China.

Since the German priest J. A. E. Goeze described a freshwater tardigrade for the first time in 1773 (Ramazzotti and Maucci 1983, Nelson 1991, Kinchin 1994), over 960 species of Tardigrada have been described (Guidetti and Bertolani 2005). Of all the species described, most are from European countries, such as Italy, Germany, Poland, and the UK. Tardigrades are also well studied in the US, Japan, and Australia. However, the Tardigrada is relatively poorly studied in China although research in Chinese tardigrades has a history of 70 yrs. This situation has changed favorably in the past few years. So far, more than 16 papers by Chinese researchers on tardigrades have been published, and 45 species of Tardigrada have recently been reported or described from China.

In 2004 and 2005, the authors collected 3 new species and 4 new species records of the Tardigrda from the northern slopes of the Qinling Mountains of central Shaanxi Province, China. They are *Echiniscus nelsonae* sp. nov., *E. shaanxiensis* sp. nov., *Pseudechiniscus beasleyi* sp. nov., *E. ramazzotti* Binda and Pilato, *E. mediantus* Marcus, *E. tardus* Mihelčič, and *Diphascon rivularis* (Mihelčič). All specimens are deposited at the College of Life Sciences, Shaanxi Normal University, Xian, China. These new species and the new record species are described and figured in this article. The Tardigrada fauna of China is summarized. A key to Chinese species of the Tardigrada is also given.

MATERIALS AND METHODS

Specimens were extracted from moss samples using a pipette and were fixed by boiling 85% alcohol. All specimens were mounted in Hoyer's medium on microscope slides for identification, and the coverslips were sealed with epoxy paint. Observations and measurements were made using phase-contrast microscopy (PCM) (Leica DM LB2,Germany) with an eyepiece micrometer. Photomicrographs were made using PCM with a digital camera (Leica DFC Twain 6.1.1). Line

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drawings were made using PCM with a camera lucida. For scanning electron microscopy (SEM), fixed tardigrades were dehydrated in absolute alcohol, transferred to amyl acetate, and dried by the critical point method. Individuals were mounted on SEM stubs and coated with 2-3 nm of gold (Nelson and McInnes 2002).

In the description of *Diphascon rivularis*, *pt* is the percent ratio between the length of a structure and the length of the buccal tube measured from the mediodorsal transversal ridge to the base of the pharyngeal apophyses (Pilato 1981).

SYSTEMATIC ACCOUNTS

Echiniscidae Kristensen and Hallas (1980)
Echiniscus nelsonae sp. nov.
(Figs. 1-6, Table 1)

Material examined: Holotype (♀) (slide no. MTQ004) and 2 paratypes (slide nos. MTQ0041, ♂; MTQ00411, ♀) collected from Mt. Taibai, the highest peak of Qinling Mts., at 3320 m (33°56.66'N, 107°46.12'E) on 7 Aug. 2005.

Description of the holotype: Color red. Eyespots present. Cephalic appendages including internal buccal cirrus, cephalic papilla, external buccal cirrus; lateral and dorsal appendages including cirrus A and E, clava and dorsolateral teeth B present; armor consisting of a single cephalic plate, a scapular plate, 1st single median plate, 1st paired-plates, 2nd median plate transversely divided into 2 parts by a ridge, 2nd paired-plates, 3rd single median plate, and terminal plate with 2 usual notches (Figs. 1, 2); all plates decorated with closely spaced polygons and irregular pores (Figs. 3, 4), similar to cuticular sculpturing of *E. cheonyoungi* Moon and Kim, and the terminal plate with more and larger pores than on other plates (the largest pore on terminal plate 3.3 μm in diameter, the largest polygon on terminal plate 2.4 μm in longitudinal diameter) (Figs. 1, 3, 4); anterior part of median plate 2 smooth, cuticular sculpture absent on ventral side of body; dentate collar with 8 teeth present on 4th pair of legs, a papilla-like projection also present on lateral surface of 4th pair of legs, basal spurs which curve toward base present on 2 middle claws of all legs (Figs. 5, 6).

Eggs unknown.

Remarks: The paratypes are similar to the holotype in terms of the qualitative characters.

Etymology: This species is named in honor of Dr. Diane R. Nelson, professor at the Department of Biological Sciences, East Tennessee State University, Johnson City, TN, USA.

Differential diagnosis: *Echiniscus nelsonae* sp. nov. is similar to *E. maesi* Séméria (1985), but differs from it in having the 3rd median plate and cirrus D instead of spine D. This new species differs from *E. shaanxiensis* sp. nov. in lacking C^d and possessing median plate 3.

Table 1. Dimensions (in μm) of *Echiniscus nelsonae* sp. nov. and *E. shaanxiensis* sp. nov

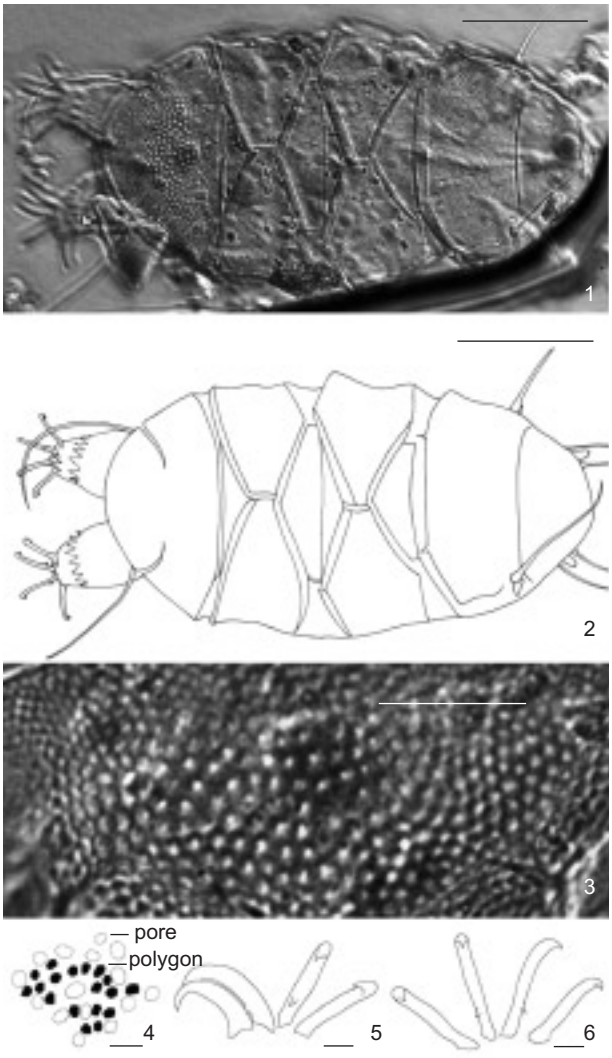
Structure	*E. nelsonae* sp. nov.			*E. shaanxiensis* sp. nov.	
	Holotype	Paratype 1	Paratype 2	Holotype	Paratype
Body length	203.6	146.2	172.3	161.8	187.9
Internal buccal cirrus	17.8	12.8	13.5	12.6	13.6
External buccal cirrus	22.2	14.4	18.3	13.5	18.3
Cephalic papilla	10.4	6.5	6.8	7.4	6.3
Cirrus A	53.5	41.8	41.8	45.7	62.6
Clava	7.8	4.4	5.2	5.2	6.5
C^d			20.9	18.3	
Cirrus E	109.6	49.6	73.1	193.2	190.5
Claws on 1st pair of legs	13.5	11.7	9.2	11.2	12.1
Claws on 2nd pair of legs	14.6	12.8	9.6	12.5	13.1
Claws on 3rd pair of legs	16.2	13.8	10.8	13.3	13.8
Claws on 4th pair of legs	17.7	15.1	12.6	14.4	14.6

C^d represents the dorsal spines on the 1st paired-plates.

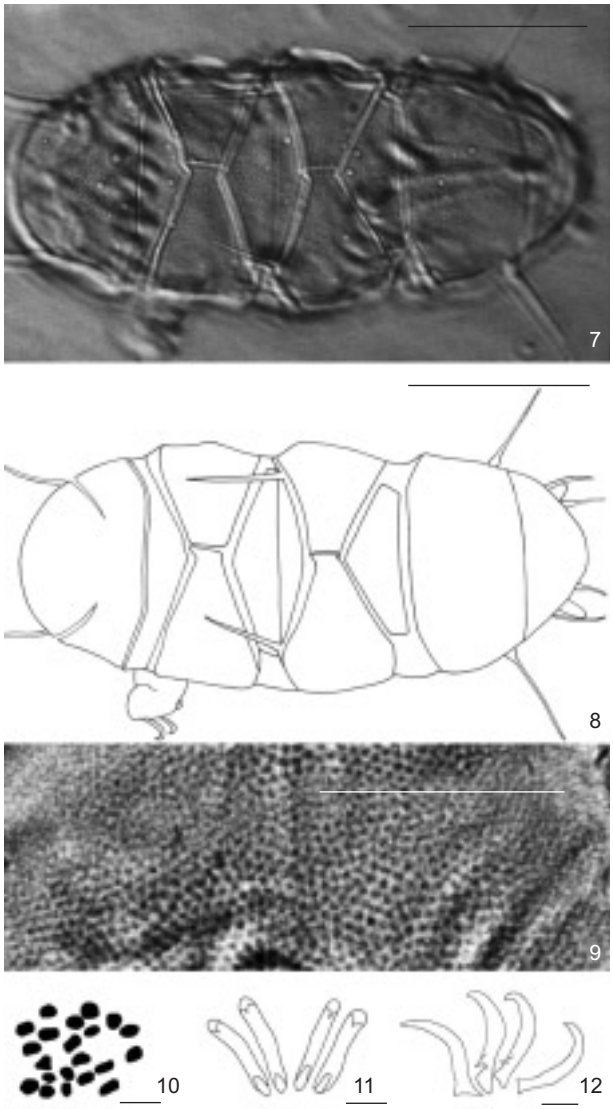
Echiniscus shaanxiensis sp. nov.
(Figs. 7-12, Table 1)

Material examined: Holotype (♂) (slide no. MTQ002) and 1 paratype (♂) (slide no. MTQ003) collected from Mt. Taibai at 3120 m (33°55.62'N, 107°46.53'E) on 8 Aug. 2005.

Description of holotype: Color red. Eyespots present. Cephalic appendages including internal buccal cirrus, cephalic papilla, and external buccal cirrus; lateral and dorsal appendages including cirrus A, clava, filament C^d, and cirrus E; armor consisting of a single cephalic plate, a scapular plate, 1st single median plate, 1st paired-plates, 2nd median plate transversely divided by a fine ridge into 2 parts or undivided, 2nd paired-plates, terminal plate with 2 usual notches; 3rd median plate absent (Figs. 7, 8); plates decorated with irregular polygonal depressions (the largest polygonal depression measuring 1.1 μm in longitudinal diameter) (Figs. 9, 10); anterior part of median plate 2 smooth, cuticular sculpturing absent on ventral



Figs. 1-6. *Echiniscus nelsonae* sp. nov. (holotype). **1.**, **2.** Habitus showing cuticular sculpturing, dorsal plates, cephalic appendages, and lateral and dorsal appendages. **3.**, **4.** Cuticular sculpturing on terminal plate. **5.** Claws on leg 3; **6.** Claws on leg 4 (1, 3. by phase-contrast microscopy). 1, 2. scale bars = 50 μm; **3.** scale bar = 15 μm; **4.** scale bar = 5 μm; **5.**, **6.** scale bars = 5 μm.



Figs. 7-12. *Echiniscus shaanxiensis* sp. nov. (holotype): **7.**, **8.** Habitus showing cuticular sculpturing, dorsal plates, cephalic appendages, and lateral and dorsal appendages. **9.**, **10.** Cuticular sculpturing on scapular plate. **11.** Claws on leg 2. **12.** Claws on leg 4 (7, 9. by phase-contrast microscopy). 7, 8. scale bars = 50 μm; 9. scale bar = 20 μm; 10. scale bar = 2 μm; 11, 12. scale bars = 5 μm.

side of body; dentate collar with 8 or 9 teeth present on 4th pair of legs, a papilla-like projection also present on lateral surface of 4th pair of legs, basal spurs which curve toward base present on 2 middle claws of 4th pair of legs, while spurs absent on 1st 3 pairs of legs (Figs. 11, 12).

Eggs unknown.

Remarks: The paratype is similar to the holotype in terms of the qualitative characters.

Etymology: This species is named after the locality, Shaanxi Prov., China.

Differential diagnosis: *Echiniscus shaanxiensis* sp. nov. is similar to *E. darienae* Miller, Horning and Dastych (1995), but differs from it in having a different position of the spurs on the claws and in having different cuticular sculpturing. This new species differs from *E. nelsonae* sp. nov. in possessing C^d and lacking median plate 3.

Echiniscus ramazzotti Binda and Pilato (1969)

Material examined: Only 1 specimen (♀) collected from Mt. Taibai at an elevation of 3590 m (33°57.12'N, 107°45.77'E).

Description: Color red. Cephalic appendages including internal buccal cirrus, cephalic papilla, and external buccal cirrus; lateral and dorsal appendages consisting of clava, cirrus A, B, B^d, C, and filament-like C^d and D; armor consisting of a single cephalic plate, a scapular palate, 1st single median plate, 1st paired-plates, 2nd median plate transversely divided into 2 parts, 2nd paired-plates; 3rd median plate absent; plates decorated with less-clear polygons and almost circular; dentate collar with 7 or 8 teeth present on 4th pair of legs, basal spurs present on internal claws of each leg, and basal spurs also present on external claws on 4th pair of legs.

Remarks: This species was described from moss on Salina I. (Eolie or Lipari I.), Sicily (Ramazzotti and Maucci 1983). This species is new to the Tardigrada fauna of China.

Echiniscus mediantus Marcus (1930)

Material examined: Only 1 specimen (♀) collected from Mt. Taibai at an elevation of 3590 m (33°57.12'N, 107°45.77'E).

Description: Color red. Eyespots red. Body length 331 μm. Cephalic appendages including internal buccal cirrus, cephalic papilla, and external buccal cirrus; lateral and dorsal appendages including cirrus A, clava, cirrus C, filament-like C^d, and spine-like D^d; armor consisting of a single cephalic plate, a scapular plate, 1st single median plate, 1st paired-plates, 2nd median plate, 2nd paired-plates, terminal plate; 3rd median plate absent; plates decorated with hexagonal sculpturing; dentate collar present on 4th pair of legs, a papilla-like projection also present on lateral surface of 4th pair of legs, spurs present on internal claws of each leg.

Remarks: This species is found at many localities in Europe, such as in Italy, Scotland, Spain, Switzerland, Hungary, Greece, Turkey, and Portugal. Our specimen was found in China for the 1st time. According to Ramazzotti and Maucci (1983), this species sometimes accompanies other species of the "*canadensis series*" ; our specimen was accompanied by *E. canadensis* Murray.

Echiniscus tardus Mihelčič (1951)

Material examined: Three specimens (♀♀) collected from Mt. Taibai at an elevation of 3590 m (33°57.12'N, 107°45.77'E).

Description: Color red. Eyespots absent, but a small cuticular projection present in place of each of the eyespots. Cephalic appendages including internal buccal cirrus, cephalic papilla, and external buccal cirrus; except for the cirrus A, no other lateral or dorsal appendages present; armor consisting of a single cephalic plate, a scapular plate, 1st single median plate, 1st paired-plates, 2nd median plate, 2nd paired-plates, terminal plate with normal notches; 3rd median plate absent; plates decorated with densely arranged hexagons; dentate collar with 9 teeth present on 4th pair of legs, spurs present on internal claws.

Remarks: This species is seldom collected, and always as a few number of individuals. Our specimens represent a new record of this species from China.

Pseudechiniscus beasleyi sp. nov.

(Figs. 13-17, Table 2)

Material examined: Holotype adult ♀ (slide no. QL04/10/002); 8 paratypes, adults, 6 ♀, 2 ♂♂ (slide nos. QL04/10/001, QL04/10/003-009).

Diagnosis: Color red. Cephalic appendages including internal buccal cirrus, very short and wide cephalic papilla, and external buccal cirrus; lateral appendages including cirrus A and clava. Scapular plate divided into 3 parts with segmental lateral plates, 1st and 2nd median plates with intersegmental lateral plates, all median plates undivided, lateral segmental plates present on 1st and

2nd paired plates, pseudosegmental plate paired with smooth posterior edge, terminal plate with notches, plates decorated with pearl-like granules of different sizes, much larger on paired dorsal plates, smaller on unpaired dorsal plates; a short and wide projection present near base of 4th pair of legs, spurs present on middle 2 claws of each leg.

Description of the holotype: Color red. Eyespot not detected. Cephalic appendages including internal buccal cirrus, short and wide cephalic papillae, and external buccal cirrus; lateral appendages including cirrus A and clava (Figs. 13, 14). No other appendages present. Dorsal plates covered with pearl-like, uniformly distributed granules which are larger on paired dorsal plates, much smaller on cephalic plate, scapular plate, median plates, and terminal plate.

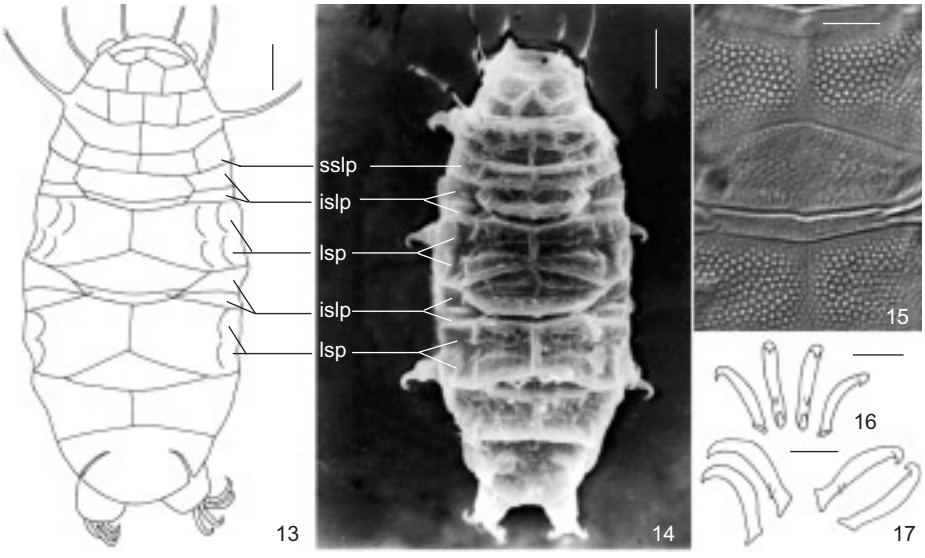
Cephalic plate facetted, anteroposteriorly subdivided into 2 parts. Anterior part composed of 2 smaller plates, posterior part composed of 3 small plates. Anterior part and middle part divided by a large W-shaped ridge. Scapular plate divided anteroposteriorly into 3 parts. Anterior part composed of 4 small plates, middle part composed of 2 larger plates, while posterior part composed of a pair of small plates in middle with a segmental lateral plate on outside. Second median plate slightly larger than 1st median plate; median plates undivided. Pseudosegmental plate paired without a lobe on posterior edge; plates decorated with pearl-like granules of different sizes, much larger on paired dorsal plates, smaller on unpaired dorsal plates (largest granule on paired-plates 1.6 μm in diameter) (Fig. 15). Other than main dorsal plates (i.e., scapular plate, median plates, and paired plates), some small plates also present, including 2 scapular segmental lateral plates on each side of scapular plate, an intersegmental lateral plate on each side of 1st and 2nd median plates, and 2 pairs of lateral segmental plates on each side (i.e., left and right side) of 1st and 2nd paired plates. Intersegmental lateral plates subdivided into larger anterior and smaller posterior parts (Figs. 13, 14).

Legs of normal length, a short and wide projection present on internal side near base of 4th pair of legs. Claws normally curved distally with spurs near bases of middle 2 claws on each leg (Figs. 16, 17).

Type locality: Qinling Mts., Shaanxi Prov., China.

Etymology: This new species is named in honor of Dr. Clark W. Beasley, professor at the Department of Biology, McMurry University, Abilene, TX, USA.

Remarks: Kristensen (1987) distinguished 2 groups in the genus *Pseudechiniscus*: the *suillus* group or the *conifer* group without trunk cirri, and the *victor* group with trunk cirri or spines. Apparently, *P. beasleyi* sp. nov. belongs to the *suillus*/*conifer* group since it has no trunk cirri. Compared with species of the *suillus*/*conifer*



Figs. 13-17. *Pseudechiniscus beasleyi* sp. nov. **13.** Habitus of holotype. **14.** Habitus of paratype (by scanning electron microscopy). **15.** Cuticular sculpturing on 1st and 2nd paired-plates and median plate 2 (paratype). **16.** Claws on leg 1 (paratype). **17.** Claws on leg 4 (paratype) (14, 15. by phase-contrast microscopy). 13, 14. scale bars = 20 μm; 15. scale bar = 10 μm; 16, 17. scale bars = 5 μm. sslp, scapular segmental lateral plate; islp, intersegmental lateral plate; lsp, lateral segmental plate.

group, *P. beasleyi* sp. nov. is similar to *P. asper* Abe, Utsugi and Takeda (1998). This new species differs from *P. asper*, *P. brevimountanus* Kendall-Fite and Nelson, *P. spinerectus* Pilato, Binda, Natolitano and Moncada, *P. insolitus* Maucci, *P. nataliae* Biserov, *P. alberti* Dastych, and *P. jubatus* Biserov in having no lobes or spines on the posterior edge of the pseudosegmental plate. It differs from *P. juanitae* Barros, *P. suillus* (Ehrenberg), *P. jiroveci* Bartos, *P. facettalis* Petersen, and *P. dicrani* Mihelčič in having a divided scapular plate, scapular segmental lateral plates, lateral segmental plates, and well-developed papilla on the 4th pair of legs. It differs from *P. clavatus* Mihelčič in having a normal clava and from *P. megacephalus* Mihelčič in having a normal-sized head and in having no type of papilla between cirrus A and the external buccal cirrus.

Hypsibiidae Pilato (1969)
***Diphascon rivularis* (Mihelčič) (1967)**
(Figs. 18, 19)

Material examined: Only 1 specimen (slide no. FYK050401) collected from the northern slope of the middle range of Qinling Mts. in 2005, at 1200 m (34°72'N, 108°35'E).

Description: Body very slender, colorless, cuticle smooth. Buccopharyngeal tube of the *Diphascon*-type, very narrow and long, without drop-shaped structure on it, posterior portion of buccopharyngeal tube flexible with spiral thickening on its wall, pharyngeal tube much longer than buccal tube, pharyngeal tube a little longer than pharynx; pharynx bulb very elongated; small apophyses present, and 2 macroplacoids in the shape of slender elongated rods present, 2nd macroplacoid much longer than 1st one, microplacoid present, very small; septulum absent (Figs.

Figs. 18, 19. *Diphascon rivularis*. **18.** Habitus in ventral view; **19.** Buccopharyngeal apparatus (18. by phase-contrast microscopy). 18. scale bar = 30 μm; 19. scale bar = 20 μm.

Table 2. Dimensions (in μm) of *Pseudechiniscus beasleyi* sp. nov.

Items	Holotype	MSI	MLI	Min.-Max.	Mean ± SD
Body length	185.3	122.7	216.6	122.7-216.6	180.1 ± 33.5 (9)
Cirrus A	26.1	23.5	28.7	23.5-31.3	26.1 ± 2.6 (9)
Clava		3.4	3.1	3.1-3.9	3.7 ± 0.3 (6)
Internal buccal cirrus	10.4		13.1	10.4-15.7	11.5 ± 2.1 (7)
External buccal cirrus	18.3		18.3	13.1-18.3	16.1 ± 2.8 (7)
Cephalic papilla	3.9		3.1	2.6-3.9	3.1 ± 0.5 (7)
Claws on 1st pair of legs	10.4	9.1	10.4	9.1-10.4	10.1 ± 0.6 (9)
Claws on 2nd pair of legs	10.4	9.1	10.4	9.1-10.4	10.1 ± 0.6 (9)
Claws on 3rd pair of legs	13.1	10.4	13.1	10.4-13.1	11.9 ± 1.1 (9)
Claws on 4th pair of legs	13.1	10.4	13.1	10.4-13.1	12.2 ± 1.2 (9)

MSI, measured smallest individual; MLI, measured largest individual. Numbers in parentheses indicate the sample size.

Table 3. Checklist of Chinese species of Tardigrada•

Taxa	Reported by	Localities	Years
Heterotardigrada Marcus			
Echiniscoidea Marcus			
Echiniscidae Kristensen and Hallas			
Echiniscoides Palte			
Ec. sigismundi (Schultze)	Mathews	Shandong Prov.	1937a
Bryodelphax Thulin			
B. brevidentatus Kaczmarek *et al.**	Kaczmarek et al.	Sichuan Prov.	2005
*B. lijiangensis**	Yang	Yunnan Prov.	2002b
B. (*Bryodelphax*) *sinensis**	Pilato	Guangdong Prov.	1974
Cornechiniscus Maucci and Ramazzotti			
Co. cornutus (Richters)	Rahm	Beijing Municipality, Shandong Prov., Shanxi Prov.	1936-1937a, b
Co. lobatus (Ramazzotti)	Bartoš	Guangdong Prov.	1963
Co. tibetanus (Maucci)	Yang	Yunnan Prov.	2002a
Echiniscus Schultze			
E. angolensis da Cunha and do Nascimento Riberio	Yang	Yunnan Prov.	2002b
E. bisetosus Heinis	Wang and Li	Shaanxi Prov.	2005
E. blumi Richters	Rahm	Hebei Prov., Shanxi Prov.	1936-1937a, b
E. canadensis Murray	Li and Wang	Shaanxi Prov.	2005a
E. cavagnaroi Schuster and Grigarick	Yang	Yunnan Prov.	2002b
E. cheonyoungi Moon and Kim	Li et al.	Shaanxi Prov.	2005
E. clevelandi Beasley*	Beasley	Yunnan Prov.	1999
E. columinis Murray	Rahm	Hebei Prov., Inner Mongolia	1936-1937b, 1937
E. crassispinosus Murray	Rahm	Beijing Municipality, Tianjin Municipality	1936-1937a, b
E. japonicus Morikawa	Li and Wang	Shaanxi Prov.	2005a
E. limai da Cunha and Ribeiro	Beasley and Cleveland	Yunnan Prov.	1996
E. mediantus Marcus	Li, Wang, and Yu	Shaanxi Prov.	
E. melanophthalmus Bartoš	Li et al.	Shaanxi Prov.	2005
E. migiurtinus Franceschi	Yang	Yunnan Prov.	2002b
E. nelsonae sp. nov.	Li, Wang, and Yu	Shaanxi Prov.	
E. nepalensis Dastych	Beasley et al.	Sichuan Prov.	2006
E. quadrispinosus (Richters)	Yang	Sichuan Prov.	2003
E. ramazzottii Binda and Pilato	Li, Wang, and Yu	Shaanxi Prov.	
E. reticulatus Murray	Beasley et al.	Sichuan Prov.	2006
E. scabrospinosus Fontura	Beasley and Cleveland	Yunnan Prov.	1996
E. shaanxiensis sp. nov.	Li, Wang, and Yu	Shaanxi Prov.	
E. spiniger Richters	Beasley et al.	Sichuan Prov.	2006
E. taibaiensis Wang and Li*	Wang and Li	Shaanxi Prov.	2005
E. tardus Mihelčič	Li, Wang, and Yu	Shaanxi Prov.	
E. testudo (Doyère)	Pilato	Guangdong Prov., Hebei Prov.	1974
	Beasley et al.	Sichuan Prov.	2006
E. trisetosus Cuénot	Wang ad Li	Shaanxi Prov.	2005
E. wendti Richters	Rahm	Inner Mongolia	1936-1937b
Pseudechiniscus Thulin			
P. asper Abe, Utsugi and Takeda	Li et al.	Shaanxi Prov.	2005
P. beasleyi sp. nov.*	Li, Wang, and Yu	Shaanxi Prov.	
P. facetalis Petersen	Yang	Yunnan Prov.	2002b
P. jiroveci Bartoš*	Bartoš	Guangdong Prov.	1963
	Beasley et al.	Yunnan Prov.	2006
P. papillosus Li, Wang, Liu and Su*	Li et al.	Shaanxi Province	2005
P. shilinensis Yang*	Yang	Yunnan Prov.	2002a
P. sinensis Rahm*	Rahm	Hebei Prov.	1937
P. suillus (Ehrenberg)	Rahm	Beijing Municipality, Guangdong Prov., Hebei Prov.	1936-1937a, b 1937

Table 3. (Cont.)

Taxa	Reported by	Localities	Years
	Bartoš	Inner Mongolia	1963
	Beasley et al.	Sichuan Prov.	2006
Eutardigrada Marcus			
Parachela Schuster, Nelson, Grigarick and Christenberry			
Macrobiotidae Thulin			
Biserovus Guidetti and Pilato			
Biserovus xiae Li, Su and Yu*	Li, Su, and Yu	Zhejiang Prov.	2004
Macrobiotus Schultze			
M. gemmatus Bartoš	Bartoš	Guangdong Prov.	1963
M. harmsworthi Murray	Rahm	Beijing Municipality, Guangdong Prov.	1936-1937a, b 1937
	Bartoš	Shanxi Prov.	1963
	Beasley and Cleveland	Yunnan Prov.	1996
M. hufelandi Schultze	Rahm	Beijing Municipality, Hebei	1936-1937a
	Mathews	Prov., Guangdong Prov.	1937b
	Pilato	Inner Mongolia, Hong Kong	1974
M. insignis Bartoš*	Bartoš	Guangdong Prov.	1963
M. mandalaae Pilato*	Pilato	Guangdong Prov.	1974
M. maucci Pilato*	Pilato	Guangdong Prov.	1974
M. occidentalis Murray	Rahm	Beijing Municipality, Hebei Prov.	1936-1937b 1937
	Beasley and Cleveland	Yunnan Prov.	1996
M. persimilis Binda and Pilato	Yang	Beijing Municipality	1999
M. recens Cuénot	Rahm	Guangdong Prov.	1937
	Bartoš	Hebei Prov.	1963
M. richtersi Murray	Beasley and Cleveland	Yunnan Prov.	1996
M. rollei Heinis	Yang	Beijing Municipality	1999
M. shennongensis Yang*	Yang	Hubei Prov.	1999
M. terricola Mihelčič	Yang	Beijing Municipality, Hainan I., Jilin Prov.	1999
M. yunshanensis Yang*	Yang	Yunnan Prov.	2002b
Minibiotus Schuster, Nelson, Grigarick and Christenberry			
Minibiotus intermedius (Plate)	Rahm	Hainan I., Hebei Prov.	1936-1937b 1937
	Beasley et al.	Sichuan Prov., Yunnan Prov.	2006
Dactylobiotus Schuster, Nelson, Grigarick and Christenberry			
Da. aquatilis Yang*	Yang	Shandong Prov.	1999
Da. henanensis Yang*	Yang	Henan Prov.	2002a
Da. macronyx (Dujardin)	Rahm	Tianjin Municipality	1936-1937a, b
Richtersius Pilato and Binda			
Richtersius coronifer (Richters)	Li and Liu	Shaanxi Prov.	2005
Hypsibiidae Pilato			
Hypsibius Thulin			
H. biscuitiformis Bartoš	Yang	Yunnan Prov.	2002b
H. dujardini (Doyère)	Mathews	Hebei Prov.	1937b
H. kunmingensis Yang*	Yang	Yunnan Prov.	2002a
H. pallidus Thulin	Rahm	Hebei Prov., Inner Mongolia	1936-1937b 1937
	Beasley et al.	Sichuan Prov., Yunnan Prov.	2006
H. runae Bartoš	Yang	Yunnan Prov.	2002b
Isohypsibius Thulin			
I. borkini Tumanov	Li and Wang	Shaanxi Prov.	2006
I. changbaiensis Yang*	Yang	Jilin Prov.	1999

Table 3. (Cont.)

Taxa	Reported by	Localities	Years
I. jingshanensis Yang*	Yang	Hubei Prov.	2003
I. liae Li and Wang*	Li and Wang	Shaanxi Prov.	2006
I. macrodactylus Maucci	Yang	Henan Prov.	2003
I. qinlingensis Li, Wang and Yu*	Li, Wang, and Yu	Shaanxi Prov.e	2005
I. rahmi Li and Wang*	Li and Wang	Shaanxi Prov.	2006
I. sattleri (Richters)	Beasley et al.	Sichuan Prov., Yunnan Prov.	2006
I. stenostomus (Richters)	Yang	Beijing Municipality	1999
I. taibaiensis Li and Wang*	Li and Wang	Shaanxi Prov.	2005b
I. tetradactyloides Richters	Mathews	Hebei Prov.	1937b
I. tuberculatus (Plate)	Rahm	Beijing Municipality, Sichuan Prov.	1936-1937b
	Yang	Shandong Prov., Hainan I.	1999
I. vietnamensis (Iharos)	Beasley and Cleveland	Yunnan Prov.	1996
I. yunnanensis Yang*	Yang	Yunnan Prov.	2002b
Doryphoribius Pilatio			
Dor. flavus (Iharos)	Pilato	Guangdong Prov.	1974
	Beasley et al.	Yunnan Prov.	2006
Dor. qinlingensis Li, Su and Yu*	Li, Su, and Yu	Shaanxi Prov.	2004
Pseudobiotus Schuster, Nelson, Grigarick and Christenberry			
Psb. megalonyx (Thulin)	Mathews	Hebei Prov.	1937b
Astatumen Pilato			
Astatumen trinacriae (Iharos)	Beasley and Cleveland	Yunnan Prov.	1996
Murrayon Bertolani and Pilato			
Murrayon hibernicus (Murray)	Beasley et al.	Sichuan Prov.	2006
Diphascon Plato			
D. (*Diphascon*) *alpinum* Murray	Rahm	Beijing Municipality, Sichuan Prov.	1936- 1937b
D. (*Diphascon*) *bisbullatum* Iharos	Yang	Beijing Municipality	1999
D. (*Diphascon*) *chilenense* Plate	Rahm	Hainan I., Hebei Prov., Sichuan Prov., Inner Mongolia	1936-1937b 1937
D. (*Diphascon*) *pingue* Marcus	Beasley et al.	Yunnan Prov,, Sichuan Prov.	2006
D. (*Adropion*) *clavatum* Bartoš	Yang	Yunnan Prov.	2002b
D. (*Adropion*) *prorsirostre* Thulin	Beasley et al.	Yunnan Prov.	2006
D. (*Adropion*) *scoticum* Murray	Li and Liu	Shaanxi Prov,	2005
D. (*Adropion*) *rivularis* (Mihelčič)	Li, Wang, and Yu	Shaanxi Prov.	
Mesocrista Pilato			
Mesocrista spitsbergensis (Richters)	Beasley et al.	Sichuan Prov.	2006
Platicrista Pilato			
Platicrista angustata (Murray)	Beasley et al.	Yunnan Prov.	2006
Ramazzottius Binda and Pilato			
Ramazzottius oberhaeuseri (Doyère)	Rahm	Fujian Prov.	1936-1937a, b
Apochela Schuster, Nelson, Grigarick and Christenberry			
Milnesiidae Ramazzotti			
Milnesium Doyère			
Mil. dujiangensis Yang*	Yang	Yunnan Prov.	2003
Mil. katarzynae Kaczmarek, Michalczyk and Beasely*	Kaczmarek et al.	Sichuan Prov.	2004
Mil. tardigradum Doyère	Rahm	Beijing Municipality, Shanghai Municipality, Tianjin Municipality, Hebei Prov., Shanxi Prov.	1936-1937a, b 1937
	Beasley and Cleveland	Sichuan Prov,. Yunnan Prov.	1996
	Beasley et al.	Sichuan Prov., Tibet	2006

• Generic names are abbreviated according to Ramazzotti and Maucci (1983). * Described as new species.

18, 19). Claws of *Hypsibius*-type with a sequence of 2121, the 2 diploclaws on each leg greatly differing from each other in size and shape, principal branch long and slender, with small accessory points near tip of principal branch, lunules present on base of external claws of 1st 3 pairs of legs and on base of posterior claws of 4th pair of legs (Fig. 18).

Measurements: Body length 289 μm. Buccal tube length 26.6 μm, buccal tube width 2.5 μm with *pt* = 9.4, stylet support insertion point *pt* = 83.46, pharyngeal tube external diameter 2.2 μm; 1st macroplacoid length 9.9 μm with *pt* = 37.22, 2nd placoid length 16.8 μm with *pt* = 63.16. Length of primary branch (PB) of external claw (EC) on 1st pair of legs 18.8 μm with *pt* = 70.68, length of 2nd branch (SB) of EC on 1st pair of legs 11.7 μm with *pt* = 43.98, length of PB of internal claw (IC) on 1st pair of legs 10.8 μm with *pt* = 40.6, length of SB of IC on 1st pair of legs 7.1 μm with *pt* = 26.69; length of PB of EC on 2nd pair of legs 24.8 μm with *pt* = 93.23, length of SB of EC on 2nd pair of legs 13.6 μm with *pt* = 51.13, length of PB of IC on 2nd pair of legs 13.8 μm with *pt* = 51.88, length of SB of IC on 2nd pair of legs 7.7 μm with *pt* = 28.95; length of PB of EC on 3rd pair of legs 22.9 μm with *pt* = 86.09, length of SB of EC on 3rd pair of legs 12.3 μm with *pt* = 46.24, length of PB of IC on 3rd pair of legs 14.6 μm with *pt* = 54.89, length of SB of IC on 3rd pair of legs 7.8 μm with *pt* = 29.32; length of PB of EC on 4th pair of legs 25.1 μm with *pt* = 94.36, length of SB of EC on 4th pair of legs 13.8 μm with *pt* = 51.88, length of PB of IC on 4th pair of legs 15.2 μm with *pt* = 57.14, length of SB of IC on 4th pair of legs 8.7 μm with *pt* = 32.71.

Remarks: The genus *Diphascon* is divided into the subgenus *Diphascon* with a drop-shaped thickening present on the buccopharyngeal tube and the subgenus *Adropion* without a drop-shaped thickening on the buccopharyngeal tube (Pilato 1987). *Diphascon rivularis* (Mihelčič) belongs to the subgenus *Adropion* since it has no drop-shaped thickening present on the buccopharyngeal tube. In the original description of this species, Mihelčič did not mention whether the drop-shaped thickening was present on the buccopharyngeal tube; however, our specimen confirms that the drop-shaped thickening is lacking in this species. This species has never been reported from China before, so our specimen represents a new record of this species from China.

Checklist of Chinese species of Tardigrada

So far the total number of the Chinese Tardigrada species has reached 100, which almost doubles the number reported by Kaczmarek and Beasley (2002) (Table 3).

Key to Chinese species of Tardigrada

1 Lateral cirri A present..... 2
- Lateral cirri A absent.....43
2(1) Each leg ending with 5-11 claws..... .....*Echiniscoides sigismundi* (Schultze)
- Each leg ending with 4 claws (1st larval instar may have 2 claws).....3
3(2) Terminal plate without notches.....*Bryodelphax* Thulin....4
- Terminal plate usually with notches.....6
4(3) Besides A, cirri B, C, D, and E present..... *B. lijiangensis* Yang
- Other than cirri A, other lateral appendages absent 5
5(4) With dentate collar on leg 4..... .....*B. brevidentatus* Kaczmarek et al.
- No dentate collar on leg 4.....*B.* (*Bryodelphax*) *sinensis* Pilato
6(3) Pseudosegmental plate present..... 7
- Pseudosegmental plate absent... *Echiniscus* Schultze...17
7(6) Cirri A short, thick and scimitar-shaped.....*Cornechiniscus*
- Maucci and Ramazzotti.....8
- Cirri A normal.....*Pseudechiniscus* Thulin.....10
8(7) Lobes or spine present on posterior edge of pseudosegmental plate.....9
- Pseudosegmental plate with straight caudal margin..... .....*Co. cornutus* (Richters)
9(8) Caudal margin of pseudosegmental plate with strong triangular spines..... *Co. tibetanus* (Maucci)
- Caudal margin of pseudosegmental plate with lobe-shaped structure.....*Co. lobatus* (Ramazzotti)
10(7) Besides cirri A, other appendages present.....11
- Besides cirri A, other appendages absent.....12
11(10) Besides lateral appendages A, B, C and D, cirri E present..... *P. sinensis* Rahm
- Besides lateral appendages A, B, C and D, cirri E absent.....*P. shilinensis* Yang
12(10) Median plate 2 and 3 present.....13
- Median plate 2 and 3 absent..... *P. jiroveci* Bartoš
13(12) Cuticular sculpturing papilla-like..... *P. papillosus* Li et al.
- Cuticular sculpturing different.....14
14(13) Lobes present on posterior edge of pseudosegmental plate.....*P. asper* Abe, Utsugi and Takeda
- Lobes absent from posterior edge of pseudosegmental plate.....15
15(14) Scapular plate and median plates with lateral plates..... *P. beasleyi* sp. nov.
- Lateral plate absent.....16
16(15) Cephalic and terminal plates facetted, pseudosegmental plate usually divided.....*P. facetalis* Petersen
- Cephalic and terminal plates not facetted, pseudosegmental plate usually undivided.....*P. suillus* (Ehrenberg)
17(6) Other than cirri A, other appendages, dorsal and lateral absent..... 18
- Besides cirri A, other appendages present..... 22
18(17) Median plate 3 present.....*E. reticulatus* Murray
- Median plate 3 absent.....19

19(18) Plates decorated with small flattened depressions with circular or hexagonal margins.....*E. japonicus* Morikawa
Cuticular sculpturing different from *E. japonicus* Morikawa.....20
20(19) Cirri A very short; cephalic plate, scapular plate, and terminal plate carinate and facetted.....
.....*E. limai* da Cunha and Ribeiro
- Cirri A normal; cephalic plate, scapular plate, and terminal plate not facetted.....21
21(20) Eyespots present..... *E. wendti* Richters
- Eyespots absent..... *E. tardus* Mihelčič
22(17) Dorsal appendages absent.....*E. nelsonae* sp. nov.
- Dorsal appendages present.....23
23(22) Median plate 3 present.....24
- Median plate 3 absent.....33
24(23) Well-developed spines or filaments E always present.....
..... 25
- Spines or filaments E absent or sometimes poorly developed spines E may be present.....31
25(24) Cirri B present.....26
- Cirri B absent..... 29
26(25) Lateral appendages short spine-like.....
.....*E. clevelandi* Beasley
- Lateral appendages filament-like.....27
27(26) C^d filament-like.....*E. columinis* Murray
- C^d spine-like..... 28
28(27) Spurs present on internal claws of leg 4.....
.....*E. quadrispinosus* Richters
- Spurs absent from claws of leg 4.....
..... *E. cheonyoungi* Moon and Kim
29(25) Other than cirri A and E, other lateral appendages present
..... 30
- Other than cirri A and E, other lateral appendages absent.....
.....*E. angolensis* da Cunha and do Nascimento Ribeiro
30(29) Spines D present.....*E. scabrospinosus* Fontura
- Spines D absent..... *E. cavagnaroi* Schuster and Grigarick
31(24) Cirri B present.....*E. blumi* Richters
- Cirri B absent..... 32
32(31) Cirri C and D present..... *E. trisetosus* Cuénot
- Cirri C and D absent.....*E. canadensis* Murray
33(23) Spines or filaments E present..... 34
- Spines or filaments E absent..... 39
34(33) Other than A and E, other lateral appendages absent.....
.....*E. shaanxiensis* sp. nov.
- Other than A and E, other lateral appendages present.....
..... 35
35(34) Spines D or filaments D present..... 36
- Spines D or filaments D absent.....38
36(35) Spines B present.....*E. spiniger* Richters
- Spines B absent.....37
37(36) Spines Cd present..... *E. taibaiensis* Wang and Li
- Spines Cd absent..... *E. crassispinosus* Murray
38(35) C^d present, D^d absent..... *E. nepalensis* Dastych
- C^d absent, D^d present..... *E. testudo* (Dyere)
39(33) Lateral appendages present.....40
- Lateral appendages absent.....*E. migiurtinus* Franceschi
40(39) Cirri B present.....41
- Cirri B absent.....42
41(40) Filaments B^d present, D^d absent.....
..... *E. ramazzottii* Binda and Pilato
- Filaments B^d absent, D^d present.....
.....*E. melanophthalmus* Bartoš
42(40) Cirri C filament-like..... *E. mediantus* Marcus
- Cirri C spine-like..... *E. bisetosus* Heinis

43(1) Primary and secondary branches of diploclaws separate, pharynx without placoids..... *Milnesium* Doyère.....44
- Diploclaws connected at base, pharynx usually with placoids.....46
44(43) Dorsal side of body with fine reticular design, eyes absent.....*Mil. katarzynae* Kaczmarek et al.
- Dorsal side of the body without reticular design, eyes present..... 45
45(44) Claws of typical *Milnesium*-type... Mil. tardigradum Doyere
- Claws very different from typical *Milnesium*-type.....
..... *Mil. dujiangensis* Yang
46(43) External and internal diploclaws similar in size and shape on each leg, with a 2112 branching sequence.....47
- External and internal diploclaws very different in size and shape on each leg, with a 2121 branching sequence.....66
47(46) Two double claws connected at base by cuticular structure.....*Dactylobiotus* Schuster et al. 48
- Two double claws separate at base.....50
48(47) Pharynx with 3 macroplacoids..... *Da. aquatilis* Yang
- Pharynx with 2 macroplacoids..... 49
49(48) Cuticle sculptured with densely distributed tubercles, 1st macroplacoid constricted in middle.. *Da. henanensis* Yang
- Cuticle smooth, 1st macroplacoid not constricted.....
..... *Da. macronyx* (Dujardin)
50(47) Claws with a trapezoidal basal peduncle (when observed laterally).....*Murrayon hibernicus* (Murray)
- Double claws of each leg of basic macrobiotid-type..... 51
51(50) Posterior portion of buccal tube with spiral thickenings.....*Biserovus xiae* Li, Su and Yu
- Buccal tube without spiral thickenings..... 52
52(51) Mouth with 10 peribuccal papulae, peribuccal lamellae absent; buccal tube narrow (≤ 12% of buccal tube length)..... *Minibiotus intermedius* (Plate)
- Peribuccal papulae absent, peribuccal lamellae present; buccal tube broad.....53
53(52) Buccal tube apophyses very remarkably raised, claws with well-developed dentate collar.....
.....*Richtersius coronifer* (Richters)
- Buccal tube apophyses normal; lunules normal, usually without dentate collar.....*Macrobiotus* Schultze.....54
54(53) Entire dorsal and lateral surface of the body covered with smooth gibbosities..... *M. rollei* Heinis
- Gibbosities absent.....55
55(54) Microplacoid present.....56
- Microplacoid absent..... 60
56(55) Pharynx with 3 macroplacoids..... 57
- Pharynx with 2 macroplacoids..... 61
57(56) First macroplacoid small and spherical...*M. insignis* Bartoš
- First macroplacoid rod-shaped.....58
58(57) Eyespots present.....*M. harmsworthi* Murray
- Eyespots absent..... 59
59(58) First macroplacoid longest, 2nd shortest; eggs with conical projections..... *M. maucci* Pilato
- First and 2nd macroplacoids equal in length; eggs with truncate conical projections.....*M. richtersi* Murray
60(55) Cuticle decorated with small pores... *M. gemmatus* Bartoš
- Cuticle smooth without pores.....*M. yunshanensis* Yang
61(56) Eyespots absent.....*M. shennongensis*
- Eyespots present..... 62
62(61) Eggs ornamented with projections shaped like overturned egg cups.....63
- Eggs ornamented with projections shaped like cones.....
.....64
63(62) Macroplacoids longer, and stylet supports inserted lower on buccal tube ..... *M. hufelandi* Schultze

- Macroplacoids somewhat shorter, and stylet supports inserted higher on buccal tube..... *M. persimilis* Binda and Pilato
64(62) Cuticles covered with larger pores, microplacoid very small..... *M. occidentalis* Murray
- Cuticle without pores or with smaller pores, microplacoid normal in size.....65
65(64) A pronounced ring of dashes present at base of each cone, basal portion of cones remarkably constricted..... *M. recens* Cuénot
- Ring-shaped structure absent at base of each cone, basal portion of cones not constricted..... *M. mandalaae* Pilato
66(46) Buccal tube without spiral thickenings..... 67
- Buccal tube with spiral thickenings..... 89
67(66) Ventral laminae present on buccal tube..... *Doryphoribius* Pilato 68
- Ventral laminae absent from buccal tube.....69
68(67) Cuticle smooth, pharynx with 3 macroplacoids..... *Dor. qinlingensis* Li, Su and Yu
- Cuticle sculptured in a protruding crest which outlines areolated polygons..... *Dor. flavus* (Iharos)
69(67) Two double claws similar on each leg.....70
- Two double claws very different on each leg..... 84
70(69) Peribuccal lamellae present..... *Pseudobiotus megalonyx* (Thulin)
- Peribuccal lamellae absent..... *Isohypsibius* Thulin.....71
71(70) Cuticle with reticular sculpturing, with tubercles and/or gibbosities.....72
- Cuticle smooth, without tubercles or gibbosities.....80
72(71) Cuticle with gibbosities..... 73
- Cuticle with reticular sculpturing or tubercles..... 77
73(72) Eyespots present.....74
- Eyespots absent.....76
74(73) Pharynx with 3 macroplacoids..... *I. vietnamensis* (Iharos)
- Pharynx with 2 macroplacoids.....75
75(74) Cuticular bars present on 1st 3 pairs of legs..... *I. tuberculatus* (Plate)
- Cuticular bars absent on 1st 3 pairs of legs..... *I. sattleri* (Richters)
76(73) Cuticular bars present on 1st 3 pairs of legs..... *I. rahmi* Li and Wang
- Cuticular bars absent on 1st 3 pairs of legs..... *I. qinlingensis* Li et al.
77(72) Pharynx with 2 macroplacoids..... *I. changbaiensis* Yang
- Pharynx with 3 macroplacoids.....78
78(77) Eyespots present.....79
- Eyespots absent..... *I. liae* Li and Wang
79(78) Lunules present at base of claws..... *I. jingshanensis* Yang
- Lunules absent from base of claws... *I. yunnanensis* Yang
80(71) Cuticle decorated with numerous granules of black pigment on dorsal side..... *I. macrodactylus* Maucci
- Cuticle with no black pigment.....81
81(80) Pharynx with 2 macroplacoids, eyespots absent..... *I. borkini* Tumanov
- Pharynx with 3 macroplacoids, eyespots present.....82
82(81) Lunules and cuticular bars present on 1st pair of legs..... *I. taibaiensis* Li and Wang
- Lunules and cuticular bars absent 83
83(82) Macroplacoids long-rod-shaped, microplacoids present..... *I. stenostomus* (Richters)
- Macroplacoids short-rod-shaped, microplacoids absent..... *I. tetradactyloides* Richters
84(69) External and internal claws very different, cephalic elliptical organs present....*Ramazzottius oberhaeuseri* (Doyère)
- External and internal claws slightly different, cephalic elliptical organs absent..... *Hypsibius* Thulin..... 85
85(84) Eyespots present..... 86
- Eyespots absent..... *H. kunmingensis* Yang
86(85) Cuticle sculptured with granules or papillae.....87
- Cuticle smooth..... 88
87(86) Cuticle with granules..... *H. biscuitiformis* Bartoš
- Cuticle with small papillae..... *H. runae* Bartoš
88(86) Septulum usually present..... *H. dujardini* (Doyère)
- Septulum absent..... *H. pallidus* Thulin
89(66) Pharynx without apophyses or placoids..... *Astatumen trinacriae* (Iharos)
- Pharynx with apophyses and placoids.....90
90(89) Buccopharyngeal tube narrow, buccal tube apophyses bluntly hook-shaped..... *Diphascon* Plate.....91
- Buccopharyngeal tube broader, buccal tube apophyses flat..... 98
91(90) With a drop-like structure between buccal tube and pharyngeal tube..... 92
- No drop-like structure between buccal tube and pharyngeal tube..... 95
92(91) Cuticle sculptured with gibbosities, pharynx with 2 macroplacoids..... *D.* (*Diphascon*) *bisbullatum* Iharos
- Cuticle smooth, pharynx with 3 macroplacoids.....93
93(92) Lunules present on posterior claws of legs 4..... *D.* (*Diphascon*) *pingue* Marcus
- Lunules absent from posterior claws of legs 4.....94
94(93) Three macroplacoids increasing in length from 1st to 3rd..... *D.* (*Diphascon*) *alpinum* Murray
- Three macroplacoids equal in length..... *D.* (*Diphascon*) *chilenense* Plate
95(91) Microplacoids present..... 96
- Microplacoids absent..... 97
96(95) Pharynx with 2 macroplacoids, lunules present on posterior claws of legs 4..... *D.* (*Adropion*) *rivulare* (Mihelčič)
- Pharynx with 3 macroplacoids, lunules absent..... *D.* (*Adropion*) *scoticum* Murray
97(95) Caudal end of dorsal surface covered with polygonal granules, 1st and 2nd macroplacoids equal in length, 3rd longer..... *D.* (*Adropion*) *clavatum* Bartoš
- Entire cuticle smooth, 3 macroplacoids increasing in length from 1st to 3rd..... *D.* (*Adropion*) *prorsirostre* Thulin
98(90) Buccal tube apophyses wide and flat, stylet supports inserted at very end of buccal tube..... *Platicrista angustata* (Murray)
- Buccal tube apophyses very wide and flat, stylet supports inserted on buccal tube more caudally than at 2/3 of its length..... *Mesocrista spitsbergensis* (Richters)

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