

New records of tardigrades from China, with zoogeographical remarks

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Abstract: Tardigrades are small (0.05–1.20 mm), hygrophilous micrometazoans. This paper reports on 18 species of tardigrades found in Sichuan, Yunnan, and Xizang Provinces in China, primarily in lichens and mosses. Eight species are new records for China: *Echiniscus nepalensis* Dastyh, *E. reticulatus* Murray, *E. spiniger* Richters, *Isohypsibius sattleri* (Richters), *Diphascon* (*D.*) *pingue* (Marcus), *Diphascon* (*A.*) *prorsirostre* Thulin, *Mesocrista spitsbergensis* (Richters), and *Platicrista angustata* (Murray). Two species are new records for both Sichuan and Yunnan: *Minibiotus intermedius* (Plate) and *Hypsibius pallidus* Thulin; one species is new for Sichuan: *Pseudechiniscus suillus* (Ehrenberg); and three species are new for Yunnan: *Cornechiniscus lobatus* (Ramazzotti), *Pseudechiniscus jiroveci* Bartoš, and *Doryphoribius flavus* (Iharos). This and previous papers have reported on 86 species and subspecies of Tardigrada from China. This is only ca. 9% of the world limno-terrestrial and marine fauna of water bears. Among these 86 species only one is marine, three are found in freshwaters, and the others are terrestrial.

Key words: Tardigrada, water bears, new records, China, Tibet, Sichuan Province, Yunnan Province

INTRODUCTION

Tardigrades, known also as water bears, are small (0.05 to 1.20 mm), hygrophilous micrometazoans. They inhabit a variety of environments on all continents and seas. The habitats vary from marine to freshwater and terrestrial (such as the soil and moss or lichen cushions). However, tardigrades are only active in the presence of water. When water evaporates or freezes, many species (mainly terrestrial ones) undergo cryptobiosis. Despite some morphological and molecular data, the phylogenetic position of Tardigrada remains unclear (NELSON & MARLEY 2000). Water bears

are traditionally considered as a phylum placed in a larger group of Ecdysozoa (moulting animals), but justification of the latter group has been questioned recently (PILATO et al. 2005).

There is little published information on Chinese Tardigrada and no zoogeographic studies on the group have been conducted there so far, at least partly due to the political history of the country. During the 1930s, six papers were published by RAHM (1936–1937a, b, 1937) and MATHEWS (1937a, b, 1938). Afterwards none were published until BARTOŠ (1963) and PILATO (1974) each wrote a paper in the 1960s and 1970s. BEASLEY & CLEVELAND (1996) and BEASLEY (1999) published two papers in the 1990s. YANG (1999) published the first known paper on Tardigrada by a native Chinese, and later wrote also other papers (YANG 2002a, b, 2003). KACZMAREK & BEASLEY (2002) presented a report on Tardigrada from China, listing 55 species plus another 11 questionable species. In 2004 and 2005, other papers with descriptions of five new species, one new subspecies and two new records for China were published (LI et al. 2004, 2005, LI & LIU 2005, LI & WANG 2005). In those 16 papers a total of 72 species were reported from China.

The aim of this paper is to report additional tardigrade records for China, including new records for Sichuan, Yunnan, and Xizang Provinces.

MATERIALS AND METHODS

Ninety-four moss and lichens samples were collected from the following locations:

1. Twenty-two moss and lichen samples collected in Sichuan Province; Kangding, Nature Reserve; 30°02'N, 102°01'E; August, 2002; leg. Katarzyna Ratyńska.
2. Four moss samples collected in Xizang Province, Tibet; Ta Gong; August, 2002; leg. Katarzyna Ratyńska.
3. One lichen sample and one liverwort sample collected in Yunnan Province; Kunming, Western Hills; 25°01'N, 102°38'E; July, 1990; leg. Clark W. Beasley.
4. Sixty-seven moss and lichen samples collected in Yunnan Province; Bai Shui; ca. 27 km N of Lijiang (Dayan); 27°08'N, 100°15'E; July, 1996; leg. Clark W. Beasley.

Fresh samples were placed in small paper bags and allowed to dry slowly. In the lab, samples were soaked in water for a minimum of two hours. Next, the wet samples were examined with a dissecting microscope for tardigrades and their eggs. The tardigrades and eggs were mounted either in the Hoyer or Heinz polyvinyl alcohol mounting medium. Phase Contrast (PCM) and Nomarski Differential Interference Contrast (DIC) microscopes were used to examine the specimens. Species were identified on the basis of a key to the world fauna of Tardigrada (RAMAZZOTTI & MAUCCI 1983) and several original papers. Information about the world distribution of species is given according to MCINNIS (1994) and original data. The material is kept in the collections of the Adam Mickiewicz University, Poznań, Poland, and the McMurry University, Abilene, Texas, USA.

RESULTS

The following 18 species were found:

1. *Cornechiniscus lobatus* (Ramazzotti, 1943)

Material examined: 4 specimens, Yunnan Province, 2100 m asl (Location 3), liverworts and lichens on rocks.

Remarks: This is the first record from Yunnan Province. Previously it has been reported from Guangdong Province, China (BARTOŠ 1963).

Distribution: Europe, Eurasia, Asia, North and Central America.

2. *Echiniscus nepalensis* Dastych, 1975

Material examined: 3 specimens, Sichuan Province, 3700 m asl (Location 1), moss from soil.

Remarks: This is a new record for China. Its type locality is near Nepal (DASTYCH 1975). According to DASTYCH (1987) the species is frequent in the alpine zone of the Himalayas.

Distribution: Asia.

3. *Echiniscus reticulatus* Murray, 1905

Material examined: 5 specimens, Sichuan Province, 3650 m asl (Location 1), lichens from tree.

Remarks: It is a new record for China. Previously it has been reported from North Korea (DASTYCH 1974), Korea (KIM & MOON 1988), India, Pakistan, and Nepal (DASTYCH 1975, 1976). DASTYCH (1988) considered it to be a northern mountain species, which is consistent with this record.

Distribution: Europe, Africa, Asia.

4. *Echiniscus spiniger* Richters, 1904

Material examined: 2 specimens, Sichuan Province, 3650 m asl (Location 1), lichen from tree.

Remarks: This is a new record for China. It has been previously reported from Japan (MATHEWS 1936–1937, UTSUGI 1990) and Korea (KIM & MOON 1988).

Distribution: Europe, Asia, Indonesia, Australia, New Zealand, North and South America.

5. *Echiniscus testudo* (Doyere, 1840)

Material examined: 16 specimens, Sichuan Province, 3650 m asl (Location 1), lichen from tree.

Remarks: It has been previously reported from Guangdong, Hebei, and Sichuan Provinces (RAHM 1936–1937b, 1937, PILATO 1974).

Distribution: Europe, Africa, Eurasia, Asia, North and South America.

6. *Pseudechiniscus jiroveci* Bartoš, 1963

Material examined: 27 specimens, Yunnan Province, 2800, 2900, 3100, 3200 m asl (Location 4), lichens from shrubs and small trees (9 specimens), moss and pine needles (18 specimens).

Remarks: This is a new record for Yunnan Province. It has been previously reported from Guangdong Province (BARTOŠ 1963).

Distribution: Africa, Asia.

7. *Pseudechiniscus suillus* (Ehrenberg, 1853)

Material examined: 7 specimens, Sichuan Province, 3700 m asl (Location 1), lichen from tree.

Remarks: It is a new record for Sichuan Province. It has been previously reported from Guangdong Province (BARTOŠ 1963), Hebei Province (RAHM 1937), Beijing Municipality (RAHM 1936–1937a, b), and Mongolia (IHAROS 1968).

Distribution: Europe, Arctic, Africa, Eurasia, Asia, Indonesia, Indian Islands, Australia, Pacific and Atlantic Islands, North, Central and South America, Antarctica.

8. *Minibiotus intermedius* (Plate, 1888)

Material examined: 21 specimens, Sichuan Province, 2600 m asl (Location 1), lichens from trees; and 10 specimens, Yunnan Province, 2800, 3100 m asl (Location 4), moss from soil.

Remarks: It has been previously reported from Hebei Province (RAHM 1937) and Hainan Island (RAHM 1936–1937b). Rahm's specimens may not correspond to *M. intermedius*. Within the genus *Minibiotus*, this species belongs to a group that lacks cuticular pores. All specimens from the genus *Minibiotus*, with or without cuticular pores, used to be assigned to *Minibiotus intermedius*. Recently, many species of the genus *Minibiotus* have been described on the basis of morphometric characters and both distribution and shape of pores (BINDA & PILATO 1995a, b, CLAXTON 1998, GUIL & GUIDETTI 2005, MICHALCZYK & KACZMAREK 2003, 2004, PILATO et al. 2003a). RAHM (1936–1937b, 1937) did not give any information on pores, so the correct identification of his specimens is impossible.

Distribution: see remarks.

9. *Murrayon hibernicus* (Murray, 1911)

Material examined: 4 specimens, Sichuan Province, 3700 m asl (Location 1), moss from soil.

Remarks: This is a new record for China. It is the second record of *Murrayon* species reported from Asia (ITO 1997, 1999, MCINNES 1994).

Distribution: Europe, Asia, North America.

10. *Hypsibius pallidus* Thulin, 1911

Material examined: 5 specimens, Sichuan Province, 3700, 3800 m asl (Location 1), moss on soil and lichen on tree, 20 specimens and 2 exuviae, Yunnan Province, 3100 m asl (Location 4), lichen from tree and moss from soil.

Remarks: It has been previously reported from Hebei Province (RAHM 1937) and Mongolia (RAHM 1936–1937b).

Distribution: Europe, Africa, Asia, North, Central and South America.

11. *Isohypsibius sattleri* (Richters, 1902)

Material examined: 5 specimens, Sichuan Province, 2600 m asl (Location 1), moss from tree, 2 specimens, Yunnan Province, 3100 m asl (Location 4), lichen on rhododendron trunk.

Remarks: This is a new record for China. It has been previously reported from India (IHAROS 1969), the Himalayas (MURRAY 1907), Vietnam (WEGLARSKA 1962), Mongolia (IHAROS 1968, 1973), and Korea (IHAROS 1973).

Distribution: Europe, Africa, Eurasia, Asia, Indonesia, Australia, New Zealand, Indian Islands, North, South and Central America.

12. *Doryphoribius flavus* (Iharos, 1966)

Material examined: 14 specimens, Yunnan Province, 3100 m asl (Location 4), moss on rock and tree.

Remarks: This is a new record for Yunnan Province. It has been previously reported from Guangdong Province (PILATO 1974).

Distribution: Europe, Africa, Asia, Central and South America.

13. *Diphascion (Diphascion) pingue* Marcus, 1936

Material examined: 12 specimens, Sichuan Province, 3800 m asl (Location 1), moss on soil, 7 specimens, Yunnan Province, 2900, 3100 m asl (Location 4), moss on soil and lichen on shrubs.

Remarks: This is a new record for Yunnan Province. It has been previously reported from India (IHAROS 1969), Vietnam (WEGLARSKA 1962), Japan (ITO & UTSUGI 1992, ITO 1999), and Mongolia (IHAROS 1968, 1973).

Distribution: Europe, Asia, Indonesia, North and South America, Antarctica.

14. *Diphascion (Adropion) scoticum* Murray, 1905

Material examined: 1 specimen, Sichuan Province, 3800 m asl (Location 1), moss from soil, 4 specimens and exuviae, Yunnan Province, 3100 m asl (Location 4), moss from soil.

Remarks: It has been previously reported from Shaanxi Province (LI & LIU 2005). In Asia, it was also reported from India (IHAROS 1969) and Japan (ITO 1986, 1999, UTSUGI 1987, ITO & UTSUGI 1992, ITO & ABE 2001).

Distribution: Europe, Arctic, Africa, Eurasia, Asia, Indonesia, Australia, New Zealand, Pacific Islands, North, Central and South America, Indian Islands, Antarctica.

15. *Diphascion (Adropion) prorsirostre* Thulin, 1928

Material examined: 1 specimen, Yunnan Province, 3100 m asl (Location 4), moss from soil.

Remarks: This is a new record for China. It has been previously reported from Mongolia (IHAROS 1968) and Japan (ITO & UTSUGI 1992, ITO 1999, ITO & ABE 2001).

Distribution: Europe, Asia, New Zealand, North and South America.

16. *Mesocrista spitsbergensis* (Richters, 1903)

Material examined: 10 specimens, Sichuan Province, 3800 m asl (Location 1), moss from soil.

Remarks: This is a new record for China. It has been previously reported in Asia only from Japan (ITO 1986, 1999, UTSUGI 1986, ITO & ABE 2001).

17. *Platicrista angustata* (Murray, 1905)

Material examined: 3 specimens, Yunnan Province, 3100 m asl (Location 4), moss from rock.

Remarks: This is a new record for China. It has been previously reported in Asia only from Japan (ITO 1986, 1999, ITO & ABE 2001) and Himalayas (DASTYCH 1975).

Distribution: Europe, Arctic, Africa, Asia, North and South America.

18. *Milnesium tardigradum* Doyère, 1840

Material examined: 21 specimens, Sichuan Province, 3700 m asl (Location 1), and Xizang Province, Tibet, 3800 m asl (Location 2), mosses on soil.

Remarks: It has been previously reported in China from Beijing and Tianjin Municipalities, Sichuan Province (RAHM 1936–1937b), Hebei Province (RAHM 1936–1937b, 1937), Shansi Province (RAHM 1936–1937a, b), Shanghai Municipality (RAHM 1936–1937a), and Yunnan Province (BEASLEY & CLEVELAND 1996).

Distribution: Europe, Africa, Eurasia, Asia, Indonesia, Pacific Islands, Australia, New Zealand, North, Central and South America, Indian Islands, Atlantic Islands, Antarctica.

DISCUSSION

This and previous papers report only 86 species and subspecies of Tardigrada from China, which is only ca. 9% of the world limno-terrestrial and marine fauna of water bears (GUIDETTI & BERTOLANI 2005). Among these 86 species, only one is marine, three are found in freshwaters, and the others are terrestrial.

The Tardigrada fauna of Asia is known insufficiently. More research has been carried out only in Japan. At least 115 species and subspecies have been reported from the Oriental region so far (PILATO et al. 2004), At least 500 taxa are known from the Palaeartic region, and more than half of them from Europe (PILATO et al. 2003b). Thus, the Palaeartic tardigrade fauna is the best known in the world. For comparison, in some of the best-investigated European countries, like Poland or Italy, about 100 and 250 taxa, respectively, have been identified and still new species are described from these countries (e.g. PILATO et al. 2003c, PILATO & BERTOLANI 2005). Only some of the species described from Europe are regarded as cosmopolitan. However, it is very likely that their distribution is more limited and specimens from other continents ascribed to these cosmopolitan species are in fact very similar, but different species. PILATO & BINDA (2001) suggested also that the geographic distribution of Tardigrada is a reflection of the major palaeogeographic events. This hypothesis is strongly supported by the distribution of closely related species within the genera *Macrobotus* (especially in the *hufelandi* group, *richtersi* group and *harmsworthi* group) and *Minibiotus*, in which many new species have been described recently.

It is very difficult to assess the diversity of Tardigrada in China on the basis of available data. Therefore, any conclusive statements on this subject are impossible now, especially in light of the estimate that there can be ca. 10 000 Tardigrada species in the whole world (KRISTENSEN pers. comm.).

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