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Male of *Moraria radovnae* Brancelj, 1988 (Copepoda: Crustacea), and notes on endemic and rare copepod species from Slovenia and neighbouring countries

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Abstract

Slovenia (southeastern Europe, area 20 000 km^2) and neighbouring northeastern Italy (Venezia-Giulia) are rich with endemic taxa of Copepoda, most of them stygobionts. Untill now, only one could be considered as an epigean, rheophilic endemic taxon. In 1986 and 1987, several females were collected from the mountain Radovna River in northwestern Slovenia. They were recognised as new subspecies and described as *Moraria pectinata radovnae* Brancelj, 1988. Ten years later, three males and two females were found in a small mountain brook in northeastern Slovenia (about 100 km from *loc. typ.*) in different geology. This gave an opportunity to raise the taxon to the specific level. The male of *M. radovnae* differs clearly from *M. pectinata* Thiébaud & Pelosse, 1928; also it is evident that both taxa are closely related. A detailed description of the male of *M. radovnae* Brancelj, 1988 is given. Based on data from the literature and reports, 14 endemic taxa are found exclusively in Slovenia, and an additional 5 taxa have their type localities (*loc. typ.*) there. Several more taxa were described, but later they were synonymised. Five endemic taxa, namely *Diacyclops hypogeus* (Kiefer, 1930), *Nitocrella slovenica* Petkovski, 1959, *Elaphoidella franci* Petkovski 1983, *E. kieferi* Petkovski & Brancelj, 1985, and *Paracamptus gasparoi* Stoch, 1998, were reported only once. Three endemics were found on several occasions at the same location, and six taxa were found in more than one location within Slovenia. Of these, only *Elaphoidella stammeri* Chappuis, 1936, could be considered as a common endemic species. Most of the endemics were found exclusively in percolating water in caves. The five taxa with *loc. typ.* in Slovenia are known in some areas of neighbouring countries, namely Italy and Croatia.

Introduction

Slovenia is a small country in southeastern Europe with an area of about 20 000 km^2, but from the zoogeographic point of view, it has an interesting position. Four regions meet in Slovenia: Alpine (including sub-Alpine), Mediterranean, Dinaric (= Illyrian) and Panonian. Part of the sub-Alpine and Dinaric Regions extend westward into northeastern Italy. As a result, a very diverse fauna and flora exists there. Within freshwater Copepoda, we recorded 11 taxa of Calanoida, 50 Cyclopoida and 44 Harpacticoida, of them 1, 17 and 13 taxa, respectively, are cave-dwelling. Fourteen of them are endemic to Slovenia, and several more were described from Slovenia.

Before 1928, very little information on Copepoda from Slovenia (within the present-day borders) existed. In the 1930s, two specialists worked on Copepoda from Slovenia. Both gave special attention to cave-dwelling Copepoda. P. A. Chappuis specialised in Harpacticoida and described four new taxa, all from caves in southeastern Slovenia, e.g. Podpeška Jama and Krška Jama (Obergurker Höhle).

F. Kiefer specialised in cave-dwelling Cyclopoida, but he also worked on Harpacticoida. He described six new taxa from Škocjanske Jame (Höhle von St. Canzian) and Postojnska Jama (Adelsberger Höhlen = Höhlen von Adelsberg). There were 5 new taxa of Cyclopoida and 1 taxon of Harpacticoida. At that time, both caves were in territory governed by Italy.

From the 1960s onward, Petkovski worked on Slovenian fauna of Copepoda (Calanoida, Cyclopoida and Harpacticoida). He described several new endemics, mainly harpacticoids, all stygobionts. From the late 1980s, Brancelj continued work on Copepoda. During his work, he found several new locations of previously described taxa, and described several new taxa (Cyclopoida and Harpacticoida) from subterranean environments.

Until very recently, no endemic epigean taxa were known from Slovenia, but most of surface permanent standing waters were sampled several times (17 natural lakes and about 40 accumulations) (Brancelj, 1992a). Intermittent karstic lakes in southern part of Slovenia, intensively studied in the last three years, are inhabited by endemic Anostraca (Brancelj, 1999) but not Copepoda. So far, all taxa described from Slovenia, as endemics are stygobionts restricted to the karstic region in southern and southwestern part of Slovenia.

The only endemic epigean species from Slovenia was first described as a subspecies. In 1987 and 1988, several females were collected from the small alpine river Radovna near Bled (northwestern Slovenia), and were described as *Moraria pectinata radovnae* Brancelj, 1988. At that time, no males were found. Males were first described 10 years later from the same river; and a new species rank (*Moraria radovnae*) was established (Stoch, 1998a). Males and females have now been collected in a small mountain brook in northeastern Slovenia.

The main aim of this paper is to provide a detailed description of the male of *Moraria radovnae* and to summarise all information on rare and less known freshwater copepods, including endemics, from Slovenia and neighbouring countries based on published material and new field observations.

Results and discussion

Taxonomy

Moraria radovnae Brancelj, 1988 (*syn.*: *Moraria pectinata radovnae* Brancelj, 1988; see Stoch, 1998a).

Material: three males and two females; collected in a small, unnamed brook on Mount Smrekovec (northeastern Slovenia) at an altitude of 1100 m a.s.l. (Aug 1997). Additional material collected on several occasions in 1987, 1988 and 1997 in the montane river Radovna in northwestern Slovenia – about 600 m a.s.l. (for details see Brancelj, 1988; Stoch, 1998a).

Material deposition: two males (from Mt. Smrekovec) and two females (from Radovna River) designated as paratypes deposited in the British Museum–the Natural History Museum; Access No.: females–BMNH1999.603–604; males–BMNH 1999.605–606.

Female: Specimens from Mt. Smrekovec identical in size and all details to those from the Radovna River. For description of female, see Brancelj (1988).

Male: Body elongated and slim, smaller than female. Dorsally posterior margin of thoracic as well as all but last abdominal segments smooth; last segment with serrated margin (Fig. 1– Abd.d). Row of fine spinules on both sides of operculum, continuing onto ventral side. Ventrally abdominal segments 2–4 and anal somite each with row of fine spinules. Operculum triangular with rounded tip (Fig. 1–Abd.d).

Furcal rami divergent, twice as long as wide (Figs. 1 Abd.d. and Abd. v.). Inner side of ramus smooth, distalmost part with few spinules. Outer margin with two spine-like bristles, about half ramus length. Proximal bristle situated at midlength of ramus, distal bristle at 3/4 of its length. Dorsal side of ramus with one seta slightly shorter than ramus, situated on inner distal corner of ramus. Hyaline ridge, running parallel to inner margin of ramus from its base to insertion of dorsal seta. Inner terminal seta shorter than ramus; outer terminal seta about 4 times as long as inner one. Middle seta as long as abdomen and divergent.

Antennula (A1) 8-segmented (Fig.1–A1). Aesthetasc on segment 4 slim, not reaching end of antennula.

Antenna (A2) endopodite 2-segmented; distal segment of endopodite with 2 strong spines laterally, and 2 terminal spines and 2 setae; exopodite 1-segmented with 4 terminal spines and several bristles laterally (Fig. 1–A2).

Maxilliped 3-segmented, apical segment with sharp spine (Fig.l- Mxp).

Swimming legs (P1–P4) exopodites 3-segmented, endopodites 2-segmented. P1 (Fig. 1–P1) exopodite slightly longer than endopodite. Distal segment with 2 spines and 2 long setae. Distal segment of endopodite slightly shorter than proximal segment. Terminal seta very long, flagelliform, and almost 3 times longer than outer lateral seta. P2 (Fig. 1–P2), inner lateral spine on distal segment short. Inner terminal spine long and robust. Endopodite half length of exopodite. Proximal segment with hyaline process on outer margin. Distal segment with 2 flagelliform setae, inner seta twice as long as outer seta. P3 (Fig. 1–P3) exopodite similar

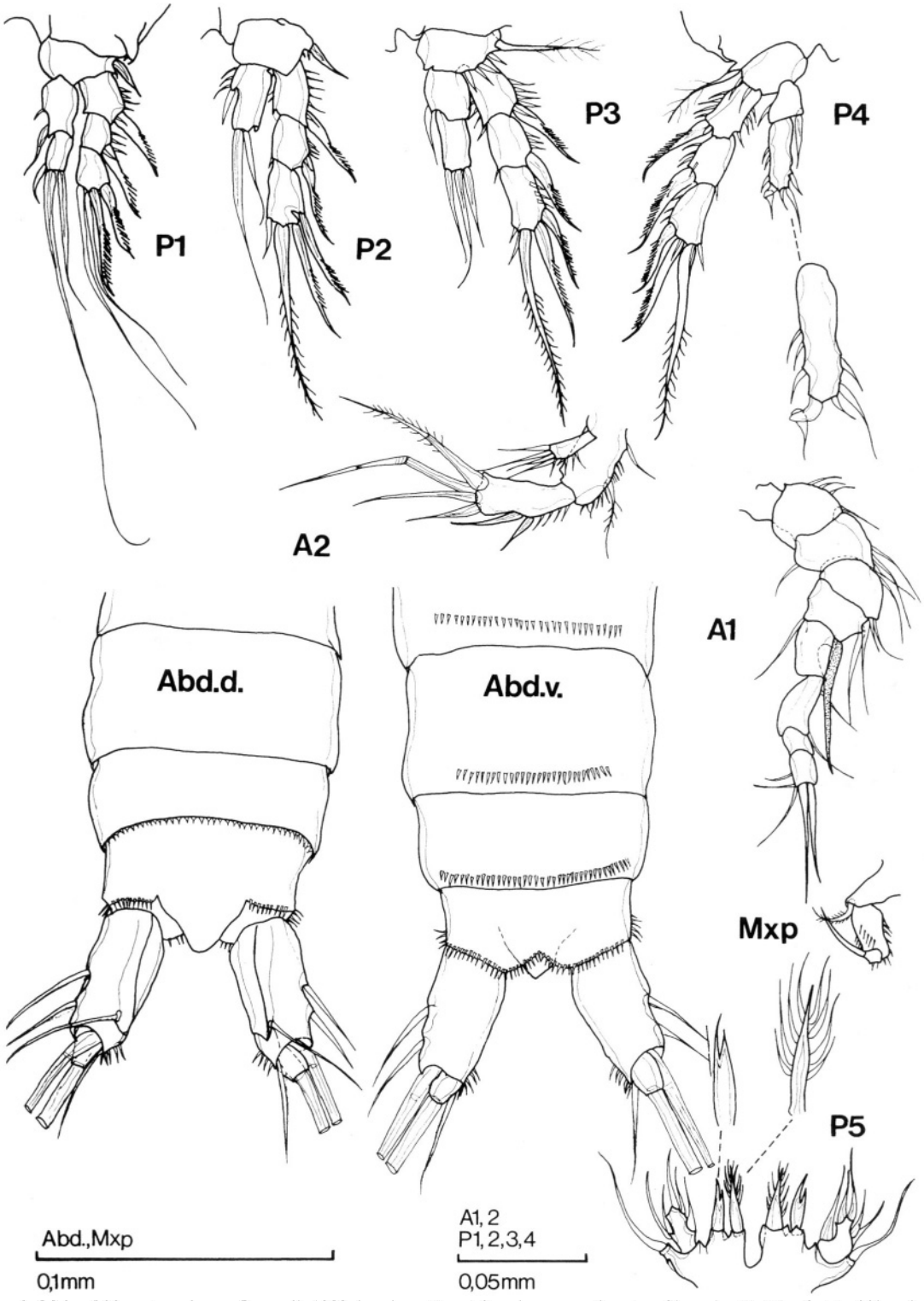

Figure 1. Male of *Moraria radovnae* Brancelj, 1988; brook on Mount Smrekovec, northeastern Slovenia; P1–P5 – first to fifth swimming leg; A1 – first antenna; A2 – second antenna; Mxp – mailliped; Abd.d. – abdomen dorsally; Abd.v. – abdomen ventrally.

to that of P2. Inner terminal spine long and robust. Endopodite half length of exopodite. Distal segment with 3 setae positioned terminally, middle seta longest. Proximal segment without outer spine. P4 (Fig. 1–P4) exopodite similar to those of P2 and P3. Endopodite as long as proximal 2 segments of exopodite. Proximal segment of endopodite with long, hyaline process on inner margin. Distal segment elongated, about 3 times as long as wide, with 4 spines (Fig. 1–P4). Outer terminal spine twisted. Setation formula of P1–P4 as follows:

Segment	*Exopodite*			*Endopodite*	
	1	2	3	1	2
P1	01	01	022	10	111
P2	01	01	121	10	020
P3	01	01	121	10	111
P4	01	01	121	10	121

P5: 2-segmented (Fig. 1–P5). Basipodite with 2 strong pinniform spines. Inner spine longer than outer spine, with strong denticles on both sides. Outer spine shorter, with 2–3 spines on both sides. Exopodite elongated with 5 spines. Innermost spine strong, unilaterally serrated, almost as long as terminal spine. Outer lateral spines small and close to each other.

Size : 0.65 – 0.72 mm (without caudal setae).

Colour : pale, eye well visible.

Comparison among Moraria species

Moraria radovnae Brancelj, 1988, described from the small alpine Radovna River as a subspecies of *Moraria pectinata* Thiébaud & Pelosse, 1928, is an endemic species for Slovenia. This was confirmed by finding of several males in a small montane brook in northeastern Slovenia, as well as females and males in the Radovna River (= *loc. typ.*) (Stoch, 1998a). There is no doubt that both species are closely related, but *M. radovnae* differs from *M. pectinata* in several details. The most characteristic features of *M. radovnae* are the short and robust bristles and spines on the swimming legs, and particularly short spines on the P5 in the female. The ornamentation of the furcal rami, which are longer in *M. pectinata,* is slightly different. In *M. radovnae,* there is a series of small spines on the inner distal margin of the ramus, while in *M. pectinata* they are on the outer distal margin.

In males, the differences are as follows. Spines and bristles on P1–P4 in *M. radovnae* are shorter and more robust. Outer terminal spine on End P4 of *M. radovnae* is twisted in a spiral, while in *M. pectinata* it is straight. The spines on the basipodite of P5 in *M. radovnae* resemble a cone because of their very strong spinules. In *M. pectinata,* the spines are smooth.

Moraria radovnae also shares some characters with *M. brevipes* (Sars, 1863) (Dussart, 1967; Kiefer, 1968). The main differences between *M. radovnae* and *M. brevipes* are in the ornamentation of the abdominal segments of the female: the dorsal margin is smooth in *M. brevipes* and denticulate in *M. radovnae.* The inner margin of the furcal ramus lacks spinules in *M. brevipes,* but has short spinules on the distal part in *M. radovnae.* The female P5 basipodite is much longer than the exopodite in *M. brevipes,* but equal in length in *M. radovnae.* In males, the main differences between the species are in P2 (3 relatively short spines on the terminal segment of the endopodite in *M. brevipes* and 2 relatively long spines in *M. radovnae*), in P3 (in *M. radovnae* the inner terminal spine is not transformed in an arrow-head shape), and in P5 (2 robust pinniform spines on the basipodite in *M. radovnae* and more simplified and slender spines in *M. brevipes*).

***Ecology of** M. radovnae*

Specimens of *M. radovnae* were on both occasions collected from a fast-running montane river. The water was cold (between 6 and 8 °C) and saturated with oxygen. There is an important difference in geology between both locations. In the Radovna River, the river bed was composed by limestone, while Mt. Smrekovec is volcanic, with some traces of tephra. The water is much softer in the latter compared to the Radovna River. According to the present knowledge, *M. radovnae* is limited to fast-running montane rivers and brooks, with no particular affinity to geology.

Notes on endemic and rare species from Slovenia and neighbouring areas

In this section, I present and discuss the distributional characteristics of freshwater copepods from the study area. Some abbreviations were used to identify the collection sites, including: Jama or Höhle (meaning 'cave') and Jezero (meaning 'lake').

Species endemic for Slovenia (Fig. 2)

Cyclopoida

Diacyclops hypogeus (Kiefer, 1930)

Loc. typ.: Škocjanske Jame (Divača). Specimens were collected from two small pools filled with dripping

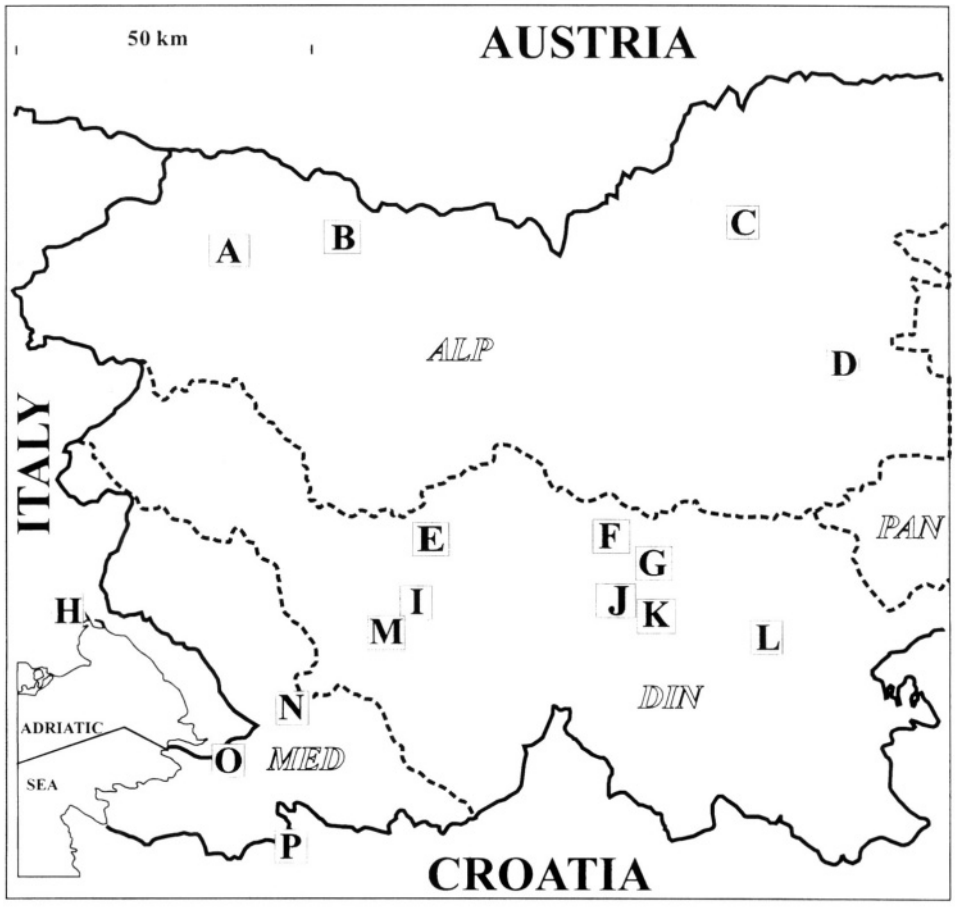

Figure 2. Endemic copepod species of Slovenia. ALP – Alpine Region; DIN – Dinaric Region; PAN – Panonian Region; MED –Mediterranean Region. Numbers after localities represent the occurrence of copepod species listed below. Underlined number = type locality. Localities: (A) – spring near Dvojno Jezero (1); (B) – Radovna River (2); (C) – small brook on Mt. Smrekovec (2); (D) – ground water near Celje (5); (E) – springs of Ljubljanica River (13); (F) – Cave Viršnica (4); (G) – cave Krška Jama (8); (H) – Italy (caves near Trieste) (14); (I) – cave Planinska Jama (8, 9, 14); (J) – cave Podpeška Jama (14); (K) – cave Kompoljska Jama (14); (L) – spring Tominšev Studenec (8, 10); (M) – cave Postojnska Jama (6, 11, 13, 14); (N) – caves škocjanske Jame (6, 7, 12); (O) – cave Osapska Jama (8, 10, 13); (P) – cave Jama pod Krogom (3, 13). Taxa: 1 – *Pseudomoraria triglavensis;* 2 – *Moraria radovnae*; 3 - *Paramorariopsis anae*; 4 – *Paracamptus gasparoi*; 5 – *Nitocrella slovenica*; 6 – *Morariopsis scotenophila*; 7 – *Elaphoidella kieferi*; 8 – *Elaphoidella jeannelli*; 9 – *Elaphoidella franci*; 10 – *Ceuthonectes rouchi*; 11 – *Metacyclops postojnae*; 12 – *Diacyclops hypogeus*; 13 – *Diacyclops slovenicus*; 14 – *Elaphoidella stammeri.*

water about 1 km inside the cave (Kiefer, 1930). No additional specimens were found.

Diacyclops slovenicus (Petkovski, 1954)

Loc. typ.: sources of the Ljubljanica River (Vrhnika) (Petkovski, 1954, 1984a). Described as a subspecies of *D. tantalus.* In SW Slovenia, many specimens were found in Postojnska Jama, Osapska Jama, and Jama pod Krogom. (Brancelj, 1987, 1992b). In caves, it was found in puddles filled with percolating water or trapped river water.

Metacyclops postojnae Brancelj, 1987

Loc. typ.: Postojnska Jama (Postojna). Found on several occasions in a pool (3 × 5 m, 0.2 m deep) filled with dripping water in a gallery of Spodnji Tratar (Brancelj, 1987). No other location is known.

Harpacticoida

Ceuthonectes rouchi Petkovski, 1984

Loc. typ.: Tominčev Studenec Spring (at Krka River). Only the male was found by Petkovski (1984a). One female was found in Osapska Jama (Koper) (Brancelj, 1991a) in a small puddle filled with groundwater. No additional information on distribution is available.

Elaphoidella franci Petkovski, 1983
Loc. typ.: Planinska Jama (Postojna). One male was found in dripping water, about 500 m from the entrance to the cave (Petkovski, 1983b).

Elaphoidella jeannelli Chappuis, 1928
Loc. typ.: Planinska Jama (including *E. charon* Chappuis, 1936 from Krška Jama) Later it was found in caves in southwestern Slovenia (Brancelj, 1992b). Detailed revision revealed that *E. charon* is a synonym of *E. jeanelli* (Brancelj, 1992b).

Elaphoidella kieferi Petkovski & Brancelj, 1985
Loc. typ.: Škocjanske Jame (Divača). One male was found in a plastic container, filled with percolating water near the end of an artificial gallery (Petkovski & Brancelj, 1985). No additional information on females or distribution is available.

Elaphoidella stammeri Chappuis, 1936
Loc. typ.: Podpeška Jama (Videm). Described from a puddle filled with percolating water (Chappuis, 1936). Later the species was found in similar habitats in Planinska Jama (Petkovski, 1983b), Postojnska Jama (Brancelj, 1986), and Kompoljska Jama, a cave next to Podpeška Jama (Brancelj, 1997). Specimens similar to *E. stammeri* were found also in northeastern Italy (Stoch, 1996).

Moraria radovnae Brancelj, 1988
Loc. typ.: Radovna River (Bled), material deposited: females: BMNH1999.603-604, males: BMNH1999.605-606. For details on distribution and ecology, see text above.

Nitocrella slovenica (Petkovski, 1959)
Loc. typ.: groundwater near Celje (Petkovski, 1959b). Found only once. Could be a synonym of *Nitocrella psammophila* (Stoch, pers. com.).

Paracamptus gasparoi Stoch, 1998
Loc. typ.: Viršnica Cave (Videm). Several specimens found in cave-water (Stoch, 1998b). No additional information on its distribution exists.

Paramorariopsis anae Brancelj, 1991
Loc. typ.: Jama pod Krogom (Koper); material deposited: BMNH: 1990.1243, 1990.1244; USNM: USNM 244234. Several males and females were collected in a small puddle near the entrance of the cave (Brancelj, 1991a). No additional locations reported. Other undescribed species of the genus were found on several occasions in northeastern Italy (Stoch, pers. com.).

Pseudomoraria triglavensis (Brancelj, 1994)
Loc. typ.: spring near Dvojno Jezero in Triglav National Park (Bled); material deposited: BM-NH: 1993.16–31; USNM: 259485. Found on several occasions only in this spring (Brancelj, 1994). Cold-water species, found only in springtime.

Species with loc. typ *in Slovenia, found also in neighbouring countries, and vice versa (Fig. 3)*

Calanoida

Troglodiaptomus sketi Petkovski, 1978 *Loc. typ.*: anchialine Veštar Cave (near Rovinj, Croatia) (Petkovski, 1978). It was found in many caves in northeastern Italy (Stoch, 1984, 1985, 1988; Stoch & Dolce, 1994), in Slovenia (Petkovski, 1984b; Brancelj, 1987, 1991b, 1992b, 1997), and several caves in Dalmatia and Bosnia (Brancelj, 1991b). Two populations could be distinguished according to the shape of P5 in both sexes (Brancelj, 1991 b).

Cyclopoida

Acanthocyclops venustus stammeri (Kiefer, 1930)
Loc. typ.: Škocjanske Jame (Divača). Described from a small puddle filled with percolating water. Later it was found frequently in Postojnska Jama and Planinska Jama (Brancelj, 1987), Jama Luknja (near Novo mesto), Kompoljska Jama (Brancelj, 1997), on several locations in northeastern Italy (Stoch, 1987a), and Bosnia and Herzegovina (Brancelj, 1990). There are reports from Montenegro (Kiefer, 1938) and interstitial waters from the Caucasus (Monchenko, 1984). Populations from Slovenia, Bosnia, Herzegovina, and NE Italy are exclusively stygobitic species, restricted to percolating water and adjacent water bodies. Populations from Montenegro and the Caucasus inhabit different water bodies; thus, they may not be the same taxon, and further analyses are needed.

Diacyclops charon (Kiefer, 1931)
Loc. typ.: Postojnska Jama (Postojna). Described from a puddle filled with percolating water in Tartarus Gallery (Kiefer, 1931). The taxon was repeatedly found in the whole system of Postojnska Jama and Planinska Jama (Brancelj, 1987), nearby Mačkovica Cave and Logarček Cave. (Brancelj, pers. obs.), Kompoljska Jama (Brancelj, 1997), Osapska Jama and Jama pod Krogom (Brancelj, 1991a, 1992b). In Italy, it was

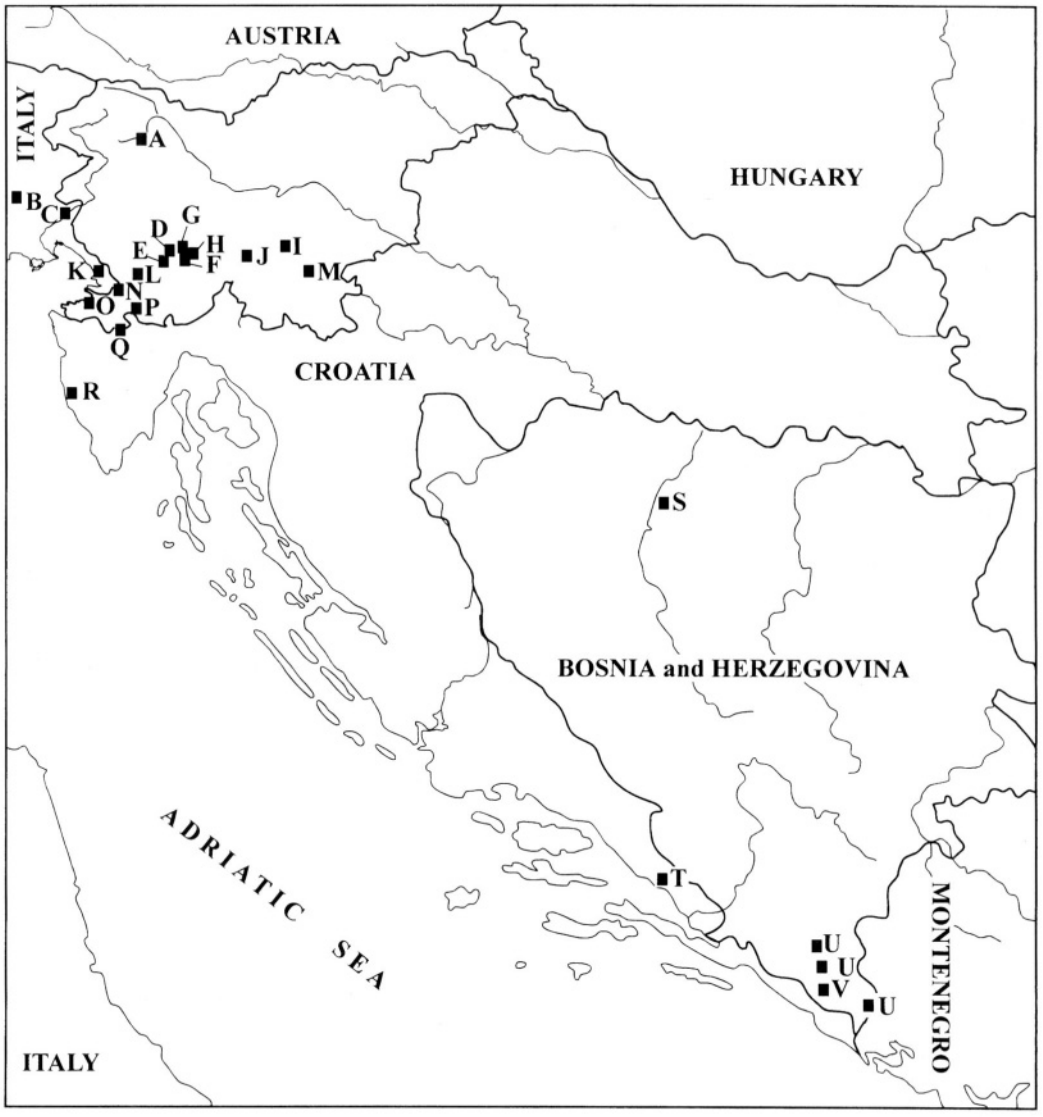

Figure 3. Species with type locality in Slovenia found also in neighbouring countries, and vice-versa. Numbers after localities represent the occurrence of copepod species listed below. Underlined number = type locality. Localities: (A) – spring near Sava Dolinka River (5, 6); (B) – Adige River (7); (C) – cave near Jamiano (4); (D) – Planinska Jama Cave (1, 2, 3, 5, 6); (E) – Postojnska Jama Cave (1, 2, 3, 5, 6); (F) – Mačkovica Cave (2, 3); (G) – Logarček Cave (2, 3); (H) – Zelške Jame Caves (5); (I) – Tominčev Studenec Spring (1); (J) – Kompoljska Jama Cave (1, 2, 3); (K) – caves and springs near Trieste (1, 2, 3, 4, 5); (L) – Škocjanske Jame Caves (2, 5, 6); (M) – Jama Luknja Cave (2); (N) – Osapska Jama Cave 1, 3, 4); (O) – Rižana River (7); (P) – Dimnice Cave (5); (Q) - Jama pod Krogom Cave (1, 3); (R) – anchialine Veštar Cave (1); (S) – Suvaja Cave (1, 3); (T) – Tihaljina Cave (1, 2); (U) – caves in Herzegovina (1, 2); (V) – Baba Pećina Cave (1, 2, 3). Taxa: 1 – *Troglodiaptomus sketi*; 2 – *Acanthocyclops venustus stammeri*; 3 – *Diacyclops charon*; 4 – *Metacyclops gasparoi*; 5 – *Speocyclops infernus*; 6 – *Elaphoidella cvetkae*; 7 – *Nitocrella psammophila*

found in several caves and springs near Trieste (Stoch, 1985, 1987a, 1988; Stoch & Dolce, 1994). In Bosnia, the species was collected in Suvaja Cave (Brancelj, 1990), and in Herzegovina in Baba PećinaCave (Popovo Polje) (Petkovski, 1981). For the former location, it is likely that sub-adults determined as *D. charon* were actually closely related *D. karamani.*

Metacyclops gasparoi Stoch, 1987

Loc. typ.: Pozzo presso Jamiano Cave (near Gorizia, Italy) (Stoch, 1987b). It was repeatedly found in caves and springs in northeastern Italy (Stoch &

Dolce, 1994). In Slovenia it was found only once in Osapska Jama (Brancelj, 1992b).

Speocyclops infernus (Kiefer, 1930)
Loc. typ.: Škocjanske Jame (Divača). Described from the same water body as *Diacyclops hypogeus.* Found in several caves in Slovenia (Postojnska Jama, Zelške Jame, Dimnice Cave) (Petkovski, 1984b), as well as in several northeastern Italian caves (Kiefer, 1968; Petkovski, 1984b; Stoch, 1987a, 1997) and in Bulgaria. In Slovenia, it was always found in percolating water or puddles filled with it. Exceptionally found in a large sub-Alpine spring near the Sava Dolinka River (Soteska) (Brancelj, pers. obs.).

Harpacticoida
Elaphoidella cvetkae Petkovski, 1983
Loc. typ.: Planinska Jama (Postojna). Repeatedly found in Planinska Jama, Postojnska Jama (Brancelj, 1986), and Škocjanske Jame (Petkovski & Brancelj, 1985). The most northern location is a large sub-alpine spring near the Sava Dolinka River (Soteska) (Brancelj, pers. obs.), about 100 km northeast from the *loc. typ.* Also found in some caves in NE Italy, close to the border with Slovenia (Stoch, 1997).

Morariopsis scotenophila (Kiefer, 1930)
Loc. typ.: Škocjanske Jame (Divača). Found in puddle filled with percolating water. More then 50 years later two specimens were found in similar habitat in Črna Jama (part of Postojnska Jama) (Brancelj, 1986). The preferred habitat appears to be wet mosses near the entrance of caves (= shafts). It used to be an endemic genus for Slovenia, but was later found in Dalmatia (Petkovski, 1959a) and near Lake Baikal (Borutskii, 1974).

Nitocrella psammophila Chappuis, 1954
Loc. typ.: Adige River (northeastern Italy). Species of interstitial water (Dussart, 1967; Stoch, 1996), found on several occasions (Kiefer, 1963). In Slovenia, several specimens were found once in the small Rižana River (near Dekani, Koper) in shallow water (water temperature about 20 °C, bottom covered by dense algae cover, indicating moderate organic pollution).

Rare and interesting species of Slovenia (Fig. 4)

Calanoida *Eudiaptomus hadzici* (Brehm, 1939)
Loc. typ.: mountain lake in Macedonia. It is endemic to Balkans, and Slovenia is the most northern location for this species. Locations in Slovenia: puddles near the intermittent lake Cerkniško Jezero (550 m a.s.l); Podpeško Jezero (300 m a.s.l.) (Petkovski, 1983a), Jezero na Planini pri Jezeru (1450 m a.s.l.) (Brancelj, pers. obs.). Lakes are warm (water temperature up to 20 °C) and eutrophic. In Podpeško Jezero, the species co-exists with the predatory *Leptodora kindtii.* Only puddles near Cerkniško Jezero dried out during summer. Locations in Slovenia, cited in Einsle (1993), were erroneously cited as Slovakia.

Cyclopoida
Acanthocyclops gordani Petkovski, 1971
Loc. typ.: well near Farmaci (Macedonia) (Petkovski, 1971). Later, it was found in Veštar Cave near Rovinj (Petkovski, 1978) and in several locations near Goricia and Trieste (northeastern Italy) (Stoch, 1987b; Stoch & Dolce, 1994). In Slovenia, the species was found only in Osapska Jama (Brancelj, 1992b).

Acanthocyclops troglophilus (Kiefer, 1932)
Loc. typ.: Vjetrenica Cave (near Zavala, Popovo polje) (Kiefer, 1932). Later reported from the nearby Baba Pećina Cave (Kiefer, 1938). In Bosnia, it was found in Suvaja Cave (Brancelj, 1990), and in northeastern Italy in several caves and wells (Stoch, 1987b; Stoch & Dolce, 1994). The only known location in Slovenia is Osapska Jama (Brancelj, 1992b).

Diacyclops antrincola Kiefer, 1967
Loc. typ.: Grotta del Fiume (near Marche, Italy) (Kiefer, 1967). Later it was found in many caves in Italy and southern Europe (Stoch, 1987b; Stoch & Dolce, 1994), also in one cave in Istria (Petkovski, 1978). In Slovenia, the species was found only in Osapska Jama, accompanied by *Troglodiaptomus sketi* (Brancelj, 1992b).

Diacyclops tantalus Kiefer, 1937
Loc. typ.: Baba Pećina Cave (Herzegovina); found also in the nearby Vjetrenica Cave. No other locations are known from Herzegovina. In Italy, it was found in several caves near Trieste (Stoch, 1987b; Stoch & Dolce, 1994). In Slovenia it is known from Osapska Jama (near Koper) (Brancelj, 1992b) and Kompoljska Jama (Brancelj, 1997).

Harpacticoida
Bryocamptus pyrenaicus (Chappuis, 1923)
Loc. typ.: Bettaram Cave (western France). In Slov-

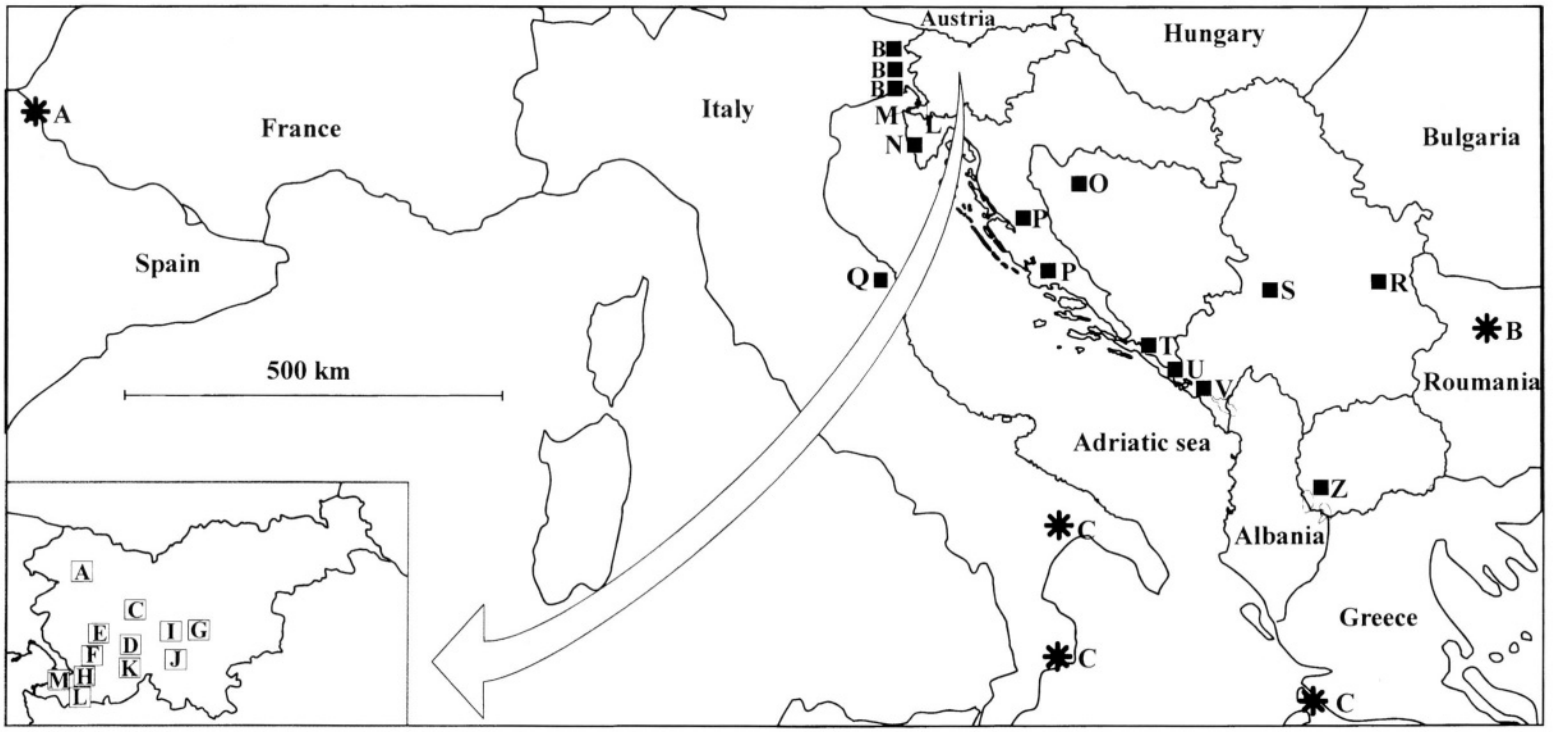

Figure 4. Rare and less known species in Slovenia. Numbers after localities represent the occurrence of copepod species listed below. Underlined number = type locality. Localities: (A) – Jezero na Planini pri Jezeru Lake (1); (B) – several caves and wells in NE Italy (2, 3, 5, 7, 8); (C) – Podpeško Jezero Lake (1); (D) – Cerkniško Jezero Lake (1); (E) – Planinska Jama Cave (6); (F) – Postojnska Jama Cave (6, 8); (G) – Krška Jama Cave (6); (H) – Škocjanske Jame Caves (9); (I) – Kompoljska Jama Cave (5, 7); (J) – Podpeška Jama Cave (6, 7); (K) – Križna Jama Cave (6); (L) – Dimnice Cave (10); (M) – Osapska Jama Cave (2, 3, 4, 5, 7); (N) – Veštar Cave (2, 4); (O) – Suvaja Cave (3); (P) – some locations in Croatia (1); (Q) – Cave del Fiume, Marche (4); (R) – Prekonoška Pešter Cave (7, 9); (S) – brook in Sveta Voda (8); (T) – Vjetrenica Cave (3, 5); (U) – Baba Pećina Cave (3, 5); (V) – well near Farmaci (2); (Z) – mountain lake in Macedonia (1); ∗A – caves in E Pyrenees (incl.Bettaram Cave) (6); ∗B – caves in Roumunia (7); ∗C – caves in S Europe (Greece, S Italy, Montenegro) (4). Taxa: 1 – *Eudiaptomus hadzici*; 2 – *Acanthocyclops gordani*; 3 – *Acanthocyclops troglophilus*; 4 – *Diacyclops antrincola*; 5 – *Diacyclops tantalus*; 6 – *Bryocamptus pyrenaicus*; 7 – *Ceuthonectes serbicus*; 8 – *Echinocamptus georgevitchi*; 9 – *Moraria stankovitchi*.

enia it was found in caves Podpeška Jama, Krišna Jama (Kreutzberg Höhle) and Krška Jama (reported as *B. balcanicus)* (Chappuis, 1936). A rich population was found in Planinska Jama and Postojnska Jama in percolating water (Petkovski, 1983b; Brancelj, 1986).

Ceuthonectes serbicus Chappuis, 1924

Loc. typ.: Prekonoška Pešter Cave (Serbia). According to Borutskii (1964), some specimens were found in the Transcaucasus and described as a new subspecies. In Slovenia it was recorded in three caves: Podpeška Jama (Chappuis, 1936), the nearby Kompoljska Jama (Brancelj, 1997), and Osapska Jama (Brancelj, 1992b). In Italy it was reported only once by Chappuis (Stoch, 1997).

Echinocamptus georgevitchi (Chappuis, 1924)

Loc. typ.: brook in Sveta Voda (Serbia). Reported from Romania (Borutskii, 1964). In Slovenia it was reported from Postojnska Jama (Črna Jama) by Kiefer and Chappuis (Petkovski, 1983). Found also in springs near the Timavo River, Italy (Stoch & Dolce, 1994).

Moraria stankovitchi Chappuis, 1923

Loc. typ.: Prekonoška Peštera Cave (Serbia). Two specimens were collected from a small plastic container filled with percolating water in Škocjanske Jame (Petkovski & Brancelj, 1985). This was the first time the species was found outside Serbia.

Phyllognathopus viguieri (Maupas, 1892)

was reported from Dimnice Cave by Chappuis (Petkovski, 1983b), but never collected again in Slovenia.

Distributional features of the copepod species

Some of the species listed above are considered 'endemics' because of insufficient knowledge of their distribution and in most cases, only few specimens were found. In Italy, very intensive studies were carried out in caves and springs in the last years along the border with Slovenia (Stoch, 1987b, 1996, 1997; Stoch & Dolce, 1994). In Slovenia, studies were mainly focused on some well-known touristic or easily accessible caves (Postojnska Jama, Planinska Jama, Škocjanske Jame, Križna Jama, etc.). Additional sampling in remote springs and caves in Slovenia will certainly provide more information, including possible new endemics. In addition, the taxonomical status and biogeography of several species listed in this paper may change after revision of the material collected so far.

A list of 'Slovenian endemics' is not relevant from the biogeographical point of view, but only of practical value to define the fauna of a country. In fact, the northeastern Italian Karst from Isonzo River (Soča River) to the Slovenian border belongs to the common Dynaric Karst, and the same is true for part of the most northern Slovenian karst, the pre-Alpine and Alpine Karst.

The species listed in this review could be separated in three groups: (A) endemics for Slovenia, (B) endemics for Slovenia, west Croatia, and northeastern Italy, and (C) endemics to Balkans, including rare and less known species.

The number of species in the first group is surprisingly high: 14 in total (3 Cyclopoida and 11 Harpacticoida). All but one (*M. radovnae*) are stygobiotic species, restricted mainly to percolating water. Also, *D. slovenicus, C. rouchi, P. gasparoi,* and *H. triglavensis* were found in subterranean rivers or springs, and *H. triglavensis* even in a mountain spring and pool. Three specialists working in Slovenia in the last four decades (Petkovski, Brancelj, and Stoch) confirmed all but one species (*D. hypogeus*). Only specimens of *D. slovenicus, E. stammeri* and *H. triglavensis* were found in more than one location (<3) or in great numbers (<100 specimens). Of the remaining species, one (in the cases of *E. kieferi* and *E. franci*) or only a few specimens were found. Most species from this group have almost unknown ecology and distribution, and were found exclusively in small puddles filled with percolating water, water-filled crevices and wet mosses. From the zoogeographical point of view, *M. radovnae* and *H. triglavensis* are elements of the sub-alpine alpine region while the rest of the group belongs to elements of the Dinaric Region (Mršić, 1997; Sket, 1998).

In the second group, i.e. species endemics for Slovenia, west Croatia and northeastern Italy, there is a total of 7 taxa. Four of them were found for the first time in Slovenia (*loc. typ.*), and an additional 3 were described from nearby locations in Italy or Croatia and later found in some places in Slovenia. Three of them (*T. sketi, A. v. stammeri* and *D. charon*) have a relatively wide distribution throughout the Dinaric Region. They were found in many caves and springs from northeastern Italy to Bosnia and Herzegovina (west of the Neretva River). They are representatives of the so-called western Illyrian-Balkan fauna (*sensu* Sket, 1970; Stoch & Dolce, 1994). Some taxa with

very wide distribution reported by some authors (e.g. *A. v. stammeri,* Rylov, 1963) should be revised by new taxonomic techniques to confirm or reject the identity of different populations.

Four taxa of the second group are restricted only to the far northwest part of this region (Slovenia and northeastern Italy). Three of them are stygobitic species, restricted mainly to percolating water, but also found in springs in the northernmost area of their distribution (*S. infernus, E. cvetkae*). Of this group, only *N. psammophila* was found in semi-epigean environments in Slovenia. As small springs are quite common in that region, it is possible that the specimens were washed out by accident.

In the third group (rare and interesting species recorded in Slovenia), 7 of 10 taxa have Illyrian-Balkans distribution. *E. hadzici* is known from different locations from Macedonia to Slovenia, primarily in mountain lakes. Similar geographical distributions are also found for *A. gordani, C. serbicus, E. georgevitchi* and *M. stankovitchi,* which are restricted mainly to subterranean waters. Only *A. troglophilus* and *D. tantalus* are representatives of the so-called western Illyrian-Balkan fauna (sensu Sket, 1970; Stoch & Dolce, 1994).

Three taxa of the third group have very diverse distribution patterns. *Diacyclops antrincola* has a trans-Adriatic distribution (Stoch & Dolce, 1994); *B. pyrenaicus* was found in the Pyrenees and Classical karst (western Slovenia, northeastern Italy); while *P. viguieri* is widely distributed all over Europe but has been reported only once from Slovenia.

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