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Checklist of amphipod crustaceans (Crustacea: Amphipoda) in Slovenia

Cene FIŠER[1], Borut MAVRIČ[2], Marijan GOVEDIČ[3], Anja PEKOLJ[1], Maja ZAGMAJSTER[1]

[1]SubBio Lab, Department of Biology, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 101, SI-1000 Ljubljana, Slovenia; E-mails: cene.fiser@bf.uni-lj.si, anja.pekolj@bf.uni-lj.si, maja.zagmajster@bf.uni-lj.si
[2]Marine Biological Station, National Institute of Biology, Fornače 41, SI-6339 Piran, Slovenia; E-mail: borut.mavric@nib.si
[3]Center za kartografijo favne in flore, pisarna Ljubljana, Tacenska 20, SI-1000 Ljubljana, Slovenia;
E-mail: marijan.govedic@ckff.si

Abstract. Amphipods are among the most species-rich orders of peracarid crustaceans, inhabiting marine and fresh waters, including subterranean waters, as well as semi-terrestrial environments. Data on amphipods from Slovenia are scattered among published and unpublished references. We gathered all available data on amphipods in the country, using published and unpublished records from two databases, supplemented by additional published information and unpublished records from two collections of two institutions. All data were critically evaluated and species names updated to the latest taxonomically valid name. In total, we listed 198 species, belonging to 85 genera and 41 families. About two thirds of the species are marine, while the rest are semiterrestrial, brackish and freshwater species. Among the latter, subterranean species dominate. In total, 26 species endemic to Slovenia were identified, one of which lives in surface freshwater, and the rest in groundwaters. Surprisingly, no presence of invasive freshwater amphipod species has currently been confirmed. We provided critical comments on nine amphipod species that were listed erroneously for the country. Our work revealed two major knowledge gaps. Marine species records come from occasional sampling campaigns, and we suggest that this group calls for a more systematic research. More work has been done on freshwater species, which revealed many taxonomic uncertainties that cannot be resolved at present and call for additional taxonomic research.

Key words: Amphipoda, checklist, marine, freshwater, subterranean, taxonomy, semiterrestrial

Izvleček. Seznam rakov postranic (Crustacea: Amphipoda) v Sloveniji – Postranice so eden izmed najbogatejših redov rakov valilničarjev, ki poseljujejo morske in sladke vode, površinske in podzemne, ter tudi obrežne habitate. O slovenskih postranicah so poročali številni raziskovalci, vendar so podatki raztreseni po številnih objavljenih in neobjavljenih virih. Zbrali smo vse razpoložljive podatke o postranicah v državi, tako objavljene kot tudi neobjavljene podatke iz dveh podatkovnih zbirk in zbirk preparatov dveh inštitucij. Vsi podatki so bili kritično vrednoteni, imena vrst pa posodobljena glede na zadnje veljavno taksonomsko ime. Skupno smo zbrali podatke o 198 vrstah postranic, ki pripadajo 85 rodovom in 41 družinam. Približno dve tretjini vrst je morskih, ostale pa so obrežne, brakične in sladkovodne. Med slednjimi prevladujejo podzemne vrste. Identificirali smo 26 vrst, ki so endemne za Slovenijo, od katerih vse žive v celinskih vodah, od teh le ena v površinskih, vse ostale pa v podzemnih vodah. Presenetljivo je, trenutno še nimamo potrjenega podatka o pojavljanju invazivnih vrst postranic v celinskih vodah v Sloveniji. Podajamo komentar devetih vrst, ki so jih napačno navajali kot živeče v Sloveniji. V našem delu smo zaznali dve vrzeli v raziskanosti postranic. Podatki o morskih vrstah prihajajo le z naključnih vzorčenj; to skupino bi morali raziskati sistematičneje. Več dela je bilo narejenega na sladkovodnih vrstah, kjer pa so problem številne taksonomske nejasnosti, ki jih lahko razrešimo šele z dodatnimi taksonomskimi raziskavami.

Ključne besede: Amphipoda, seznam vrst, morski, sladkovodni, podzemni, taksonomija, obrežne postranice

Introduction

With over 10,000 species, the order Amphipoda is one of the largest groups in the superorder Peracarida in the classis Crustacea (Horton et al. 2021). Amphipods are distributed in all aquatic and semiterrestrial habitats around the globe. About 80% of species live in marine environments (Väinölä et al. 2008), and span between supralittoral to deepest trenches, where they represent an important fraction of deep-sea communities (Jamieson et al. 2010). The remaining 20% are freshwater (Väinölä et al. 2008), living in all types of freshwater including groundwater (Sket 1999a, Zagmajster et al. 2014).

Amphipods represent an ecologically important group that contributes to nutrient cycling. They act as detritivores, shredders, suspension feeders, scavengers, parasites or predators (Kaestner 1967, MacNeil et al. 1997, Ruffo et al. 1998) – and constitute an important food source for fish. Some species are intermediate hosts to acanthocephalan parasites (Westram et al. 2011, Shaw et al. 2020), some are hosts to ciliates (Gudmundsdóttir et al. 2018) or temnocephalid flatworms (Matjašič 1990), while several species live in associations with other animals, such as other crustaceans, bryozoans, mollusks, or cnidarians (Lörz et al. 2014, Vader & Myers 1993, Vader & Tandberg 2013, 2020). Because of the absence of dispersal larvae (Myers & Lowry 2009), many species are narrow endemics (Trontelj et al. 2009, Bregović et al. 2019, Esmaeili-Rineh et al. 2020) and an important part of natural heritage. Yet, few species have been rapidly expanding their original distributional ranges, and as invasive species remarkably modified native freshwater communities across Europe (Jazdzewski et al. 2004, Grabowski et al. 2012, Dodd et al. 2014). Importantly, many amphipod species have been included into ecotoxicological bioassays and used in monitoring schemes of water quality (Feckler et al. 2012, Major et al. 2013).

Amphipods thus constitute an important group of crustaceans for basic and applied research. Successful implementation of amphipod crustaceans into diverse research programs requires a resolved taxonomy, an easy identification system, good understanding of species' distributions, an estimation of potential threats and species' conservation status. On many occasions, this information is incomplete or completely lacking.

Slovenia has a long tradition in amphipod research. Yet, biological data on amphipod species are scattered in many sources or sometimes unpublished. As a consequence, we are facing larger or smaller knowledge gaps on the taxonomy, distribution, ecology and biology of many species. An updated checklist of species present in the country is the first step towards systematic studies of amphipods. Such a list is the most elementary document needed for inventory and planning of future research, be it basic or applied. The hitherto published lists of Slovenian amphipods (Karaman 1974, Sket 1996, Fišer 2002) have long been outdated and need to be revised and corrected. To progress towards proper and complete inventory of amphipods in Slovenia, we assembled all available published and unpublished data on amphipods and compiled the first comprehensive national checklist of all amphipods in coastal and inland waters.

Materials and methods

To assemble the list, we first used the records of all previously published checklists (Karaman 1974, Sket 1996, Fišer 2002), and supplemented it with data from literature published afterwards. For this, we used already extracted data stored in two databases, BioPortal (BioPortal, Centre for Cartography of Fauna and Flora – CKFF) and SubBioDB (SubBio Database, Subterranean Biology Laboratory at Department of Biology, Biotechnical Faculty, University of Ljubljana – SubBioLab). Additionally, we added new information from the specimen collections of the Marine Biological Station of Piran of the National Institute of Biology (hereinafter referred to as MBP) and of the SubBioLab. While preparing the checklist, we specifically considered the following points.

Names and taxonomy. We used the names evaluated as »accepted« in the World Register of Marine Species (Horton et al. 2021), with one exception, when we considered the relevant publication (Sket & Hou 2018 synonymized the genera *Chaetogammarus* and *Echinogammarus* into *Homoeogammarus*); all other names were discarded as synonyms and were not added to the checklist. We listed only formally described species, even though molecular analyses in many cases imply that morphological species comprise morphologically indistinguishable species complexes. These cryptic species (e.g., Copilaş-Ciocianu & Petrusek 2015, Mamos et al. 2016, Csapó et al. 2020, Hupało et al. 2020, Wattier et al. 2020) are not considered in this checklist, but we do discuss them when relevant. The possible new species candidates and problematic taxonomic cases are beyond the scope of this overview. The higher taxonomy of amphipods above the family rank has been challenged (Copilaș-Ciocianu et al. 2020). To keep the checklist simple and insensitive to taxonomic changes, we excluded ranks between order and family.

Ecology. Each species in the checklist is labelled according to its habitat where it can be primarily found. We introduced categories »marine«, »brackish«, »freshwater« (i.e. surface freshwater), »groundwater« (i.e., subterranean freshwater) and »semiterrestrial«, but do not make distinction among habitats within these categories (Trontelj et al. 2012, Culver & Pipan 2014). Species from springs, which some consider an ecotone between groundwater and surface waters, were assigned to the habitat typical for that genus.

Endemism. Present knowledge of many species is not sufficient to construct detailed maps of their distribution. We, however, indicated whether species are living within the political borders of Slovenia (endemics), or whether they are distributed also beyond the country borders.

Citation. Every species record is linked to the reference, supporting its presence in the country – either being a literature reference or a database. Therefore, the list of references should not be considered as a complete list of all references on amphipods of Slovenia. We selected the most comprehensive resources, to keep the list of supporting references at minimum.

Results

The checklist of amphipods of Slovenia encompasses a total of 198 species, belonging to 41 families and 85 genera (Tabs. 1, 2). Of all the species in the list, 77 are listed for the country for the first time, based on data coming from the collections of UL and MBP (Tab. 2).

Table 1. Numerical summary of all amphipod species confirmed to occur in Slovenia, according to the habitat they occur in. All three brackish species can also be found in surface freshwaters (to simplify, here referred to only as freshwater). [1]Members of some families and genera live in more than one environment, therefore the numbers do not simply sum up. The term endemic relates to species, occurring within Slovenian political borders only.

Tabela 1. Številčni povzetek vseh postranic, ki se potrjeno pojavljajo v Sloveniji, glede na habitate, kjer se pojavljajo. Vse tri brakične vrste so našli tudi v površinskih sladkih vodah. [1] Predstavniki nekaterih družin/rodov žive v več kot enem habitatu, zato se številke teh ne seštejejo. Oznaka »endemic« se nanaša na vrste, ki žive izključno znotraj političnih meja Slovenije.

	Number of families	Number of genera	Number of species	Number of endemics
marine	36	73	127	0
semiterrestrial	1	4	4	0
brackish	1	1	3	0
freshwater	2	4	7	1
groundwater	4	6	57	25
TOTAL[1]	41	85	198	26

Table 2. List of all amphipod species confirmed to occur in Slovenia, with notes on their main habitat, and whether they are distributed only within the political borders of Slovenia (endemics). The basis of the data assembly were the BioPortal (Centre for Cartography of Fauna and Flora) and the SubBioDB (SubBioLab – Subterranean Biology Laboratory) databases, but supplemented with data from morphological collections: MBP – the collection of the Marine Biological Station Piran (National Institute of Biology); SubBioLab –the collection of the SubBioLab (at Department of Biology, Biotechnical Faculty, University of Ljubljana). We retained only one reference, and do not list all references on the species for the country.

Tabela 2. Seznam vseh vrst postranic, ki se potrjeno pojavljajo v Sloveniji, s podatki o glavnem habitatu in morebitni razširjenosti le znotraj Slovenije (endemiti). Osnova za podatke sta bili zbirki podatkov BioPortal (Center za kartografijo favne in flore) in SubBioDB (SubBioLab- Raziskovalna skupina za speleobiologijo), ki smo ju dopolnili s podatki iz morfoloških zbirk MBP – zbirka Morske biološke postaje (Nacionalni inštitut za biologijo) in SubBioLab – zbirka skupine SubBioLab (Oddelek za biologijo, Biotehniška fakulteta, Univerza v Ljubljani). Za vsako vrsto navajamo le en vir in ne celotnega seznama vseh navedb iz Slovenije.

Family	Species	Habitat	Endemic	Reference
Ampeliscidae	*Ampelisca diadema* (Costa, 1853)	marine	no	SubBioLab
	Ampelisca intermedia Bellan-Santini & Diviacco, 1990	marine	no	SubBioLab
	Ampelisca pseudosarsi Bellan-Santini & Kaim-Malka, 1977	marine	no	SubBioLab
	Ampelisca pseudospinimana Bellan-Santini & Kaim-Malka, 1977	marine	no	SubBioLab
	Ampelisca ruffoi Bellan-Santini & Kaim-Malka, 1977	marine	no	SubBioLab
	Ampelisca sarsi Chevreux, 1888	marine	no	SubBioLab
	Ampelisca spinipes Boeck, 1861	marine	no	SubBioLab
	Ampelisca tenuicornis Liljeborg, 1856	marine	no	SubBioLab
	Ampelisca typica (Spence Bate, 1856)	marine	no	SubBioLab

Family	Species	Habitat	Endemic	Reference
	Ampelisca rubella A. Costa, 1864	marine	no	Ruffo et al. 1982
Amphilochidae	*Apolochus neapolitanus* (Della Valle, 1893)	marine	no	Fišer 2002
	Apolochus picadurus (J.L. Barnard, 1962)	marine	no	SubBioLab
Ampithoidae	*Ampithoe ramondi* Audouin, 1826	marine	no	Fišer 2002
	Ampithoe riedli Krapp-Schickel, 1968	marine	no	SubBioLab
	Biancolina algicola Della Valle, 1893	marine	no	SubBioLab
	Cymadusa crassicornis (Costa, 1853)	marine	no	SubBioLab
	Pleonexes helleri (Karaman, 1975)	marine	no	SubBioLab
	Sunamphitoe spuria (Krapp-Schickel, 1978)	marine	no	SubBioLab
Aoridae	*Aora spinicornis* Afonso, 1976	marine	no	Fišer 2002
	Autonoe spiniventris Della Valle, 1893	marine	no	MBP
	Lembos websteri Spence Bate, 1857	marine	no	SubBioLab
	Microdeutopus algicola Della Valle, 1893	marine	no	SubBioLab
	Microdeutopus anomalus (Rathke, 1843)	marine	no	Fišer 2002
	Microdeutopus chelifer (Spence Bate, 1862)	marine	no	SubBioLab
	Microdeutopus gryllotalpa Costa, 1853	marine	no	Fišer 2002
	Microdeutopus obtusatus Myers, 1973	marine	no	Fišer 2002
	Microdeutopus similis Myers, 1977	marine	no	SubBioLab
	Microdeutopus sporadhi Myers, 1969	marine	no	Fišer 2002
	Microdeutopus stationis Della Valle, 1893	marine	no	SubBioLab
	Microdeutopus versiculatus (Spence Bate, 1857)	marine	no	Fišer 2002
Aristiidae	*Perrierella audouiniana* (Spence Bate, 1857)	marine	no	MBP
Atylidae	*Nototropis guttatus* Costa, 1853	marine	no	SubBioLab
	Nototropis vedlomensis (Spence Bate & Westwood, 1862)	marine	no	MBP
Bogidiellidae	*Bogidiella albertimagni* Hertzog, 1933	groundwater	no	Karaman 1974
	Bogidiella semidenticulata Meštrov, 1962	groundwater	no	Karaman 1974
Calliopiidae	*Apherusa alacris* Krapp-Schickel, 1969	marine	no	Fišer 2002
	Apherusa chiereghinii Giordani-Soika, 1949	marine	no	Fišer 2002
Caprellidae	*Caprella acanthifera* Leach, 1814	marine	no	SubBioLab
	Caprella danilevskii Czerniavski, 1868	marine	no	SubBioLab
	Caprella equilibra Say, 1818	marine	no	SubBioLab
	Caprella scaura Templeton, 1836	marine	no	MBP
	Phtisica marina Slabber, 1769	marine	no	SubBioLab
	Pseudolirius kroyeri (Haller, 1879)	marine	no	MBP
	Pseudoprotella phasma (Montagu, 1804)	marine	no	SubBioLab
Cheirocratidae	*Cheirocratus sundevallii* (Rathke, 1843)	marine	no	SubBioLab
Cheluridae	*Chelura terebrans* Philippi, 1839	marine	no	MBP
Corophiidae	*Apocorophium acutum* (Chevreux, 1908)	marine	no	SubBioLab
	Corophium orientale Schellenberg, 1928	marine	no	SubBioLab
	Leptocheirus longimanus Ledoyer, 1973	marine	no	SubBioLab

Family	Species	Habitat	Endemic	Reference
	Leptocheirus mariae Karaman, 1973	marine	no	SubBioLab
	Leptocheirus pectinatus (Norman, 1869)	marine	no	SubBioLab
	Medicorophium annulatum (Chevreux, 1908)	marine	no	MBP
	Medicorophium rotundirostre (Stephensen, 1915)	marine	no	MBP
	Medicorophium runcicorne (Della Valle, 1893)	marine	no	SubBioLab
	Monocorophium insidiosum (Crawford, 1937)	marine	no	Fišer 2002
	Monocorophium sextonae (Crawford, 1937)	marine	no	Fišer 2002
	Monocorophium acherusicum (Costa, 1853)	marine	no	Heller 1866
Crangonyctidae	*Synurella ambulans* (F. Müller, 1846)	freshwater	no	Pekolj 2020
Cyproideidae	*Peltocoxa marioni* Catta, 1875	marine	no	Fišer 2002
Dexaminidae	*Dexamine spiniventris* (Costa, 1853)	marine	no	Fišer 2002
	Dexamine spinosa (Montagu, 1813)	marine	no	Fišer 2002
	Tritaeta gibbosa (Spence Bate, 1862)	marine	no	SubBioLab
Eusiridae	*Eusirus longipes* Boeck, 1861	marine	no	MBP
Gammaridae	*Homoeogammarus olivii* (H. Milne Edwards, 1830)	marine	no	Fišer 2002
	Homoeogammarus pungens (H. Milne Edwards, 1840)	brackish, freshwater	no	Karaman 1974
	Homoeogammarus stammeri (S. Karaman 1931)	freshwater	no	Karaman 1974
	Homoeogammarus stocki G. Karaman, 1970	brackish, freshwater	no	Karaman 1974
	Homoeogammarus veneris (Heller, 1865)	brackish, freshwater	no	Karaman 1974
	Gammarus aequicauda (Martynov, 1931)	marine	no	Fišer 2002
	Gammarus balcanicus Schäferna, 1923	freshwater	no	Sket et al. 2010
	Gammarus crinicornis Stock, 1966	marine	no	SubBioLab
	Gammarus fossarum Koch, 1836	freshwater	no	Fišer et al. 2007
	Gammarus insensibilis Stock, 1966	marine	no	SubBioLab
	Gammarus lacustris G.O. Sars, 1863	freshwater	no	Alther et al. 2016
	Gammarus roeselii Gervais, 1835	freshwater	no	Karaman 1974
	Gammarus subtypicus Stock, 1966	marine	no	Fišer 2002
	Jugogammarus kusceri (S. Karaman, 1931)	freshwater	yes	Karaman 1974
Hyalidae	*Apohyale crassipes* (Heller, 1866)	marine	no	Fišer 2002
	Apohyale perieri (Lucas, 1846)	marine	no	Fišer 2002
	Hyale stebbingi Chevreux, 1888	marine	no	SubBioLab
	Parhyale aquilina (Costa, 1857)	marine	no	Fišer 2002
	Protohyale grimaldii (Chevreux, 1891)	marine	no	SubBioLab
	Protohyale camptonyx (Heller, 1866)	marine	no	Fišer 2002

Family	Species	Habitat	Endemic	Reference
Ingolfiellidae	*Ingolfiella beatricis* Ruffo & Vonk, 2001	groundwater	yes	Sket 2000
Iphimediidae	*Iphimedia minuta* G.O. Sars, 1883	marine	no	MBP
Isaeidae	*Isaea montagui* H. Milne Edwards, 1830	marine	no	Heller 1866
Ischyroceridae	*Centraloecetes dellavallei* (Stebbing, 1899)	marine	no	SubBioLab
	Coxischyrocerus inexpectatus (Ruffo, 1959)	marine	no	Fišer 2002
	Ericthonius brasiliensis (Dana, 1853)	marine	no	SubBioLab
	Ericthonius punctatus (Spence Bate, 1857)	marine	no	Fišer 2002
	Jassa marmorata Holmes, 1905	marine	no	MBP
	Plumulojassa ocia (Spence Bate, 1862)	marine	no	Fišer 2002
Leucothoidae	*Leucothoe incisa* Robertson, 1892	marine	no	MBP
	Leucothoe oboa Karaman, 1971	marine	no	SubBioLab
	Leucothoe occulta Krapp-Schickel, 1975	marine	no	SubBioLab
	Leucothoe pachycera Della Valle, 1893	marine	no	SubBioLab
	Leucothoe richiardii Lessona, 1865	marine	no	Fišer 2002
	Leucothoe serraticarpa Della Valle, 1893	marine	no	MBP
	Leucothoe spinicarpa (Abildgaard, 1789)	marine	no	Fišer 2002
Liljeborgiidae	*Liljeborgia dellavallei* Stebbing, 1906	marine	no	Fišer 2002
Lysianassidae	*Lysianassa costae* H. Milne Edwards, 1830	marine	no	Fišer 2002
	Lysianassa pilicornis Heller, 1866	marine	no	MBP
Maeridae	*Abludomelita gladiosa* (Spence Bate, 1862)	marine	no	Ruffo et al. 1982
	Ceradocus orchestiipes Costa, 1853	marine	no	Ruffo et al. 1982
	Elasmopus brasiliensis (Dana, 1853)	marine	no	SubBioLab
	Elasmopus pocillimanus (Spence Bate, 1862)	marine	no	Fišer 2002
	Elasmopus rapax Costa, 1853	marine	no	Fišer 2002
	Maera grossimana (Montagu, 1808)	marine	no	Fišer 2002
	Othomaera schmidtii (Stephensen, 1915)	marine	no	MBP
	Quadrimaera inaequipes (A. Costa & Hope, 1851)	marine	no	Fišer 2002
Melitidae	*Melita hergensis* Reid, 1939	marine	no	Fišer 2002
	Melita palmata (Montagu, 1804)	marine	no	Fišer 2002
Microprotopidae	*Microprotopus maculatus* Norman, 1867	marine	no	Fišer 2002
Niphargidae	*Carinurella paradoxa* (Sket, 1964)	groundwater	no	Sket 1964
	Niphargobates orophobata Sket, 1981	groundwater	yes	Sket 1981
	Niphargus aberrans Sket, 1972	groundwater	no	Sket 1972
	Niphargus arbiter G. Karaman, 1984	groundwater	no	Delić et al. 2017a
	Niphargus arcanus G. Karaman, 1988	groundwater	yes	Karaman 1988
	Niphargus brachytelson S. Karaman, 1952	groundwater	yes	Karaman 1952
	Niphargus carniolicus Sket, 1960	groundwater	yes	Sket 1960
	Niphargus chagankae Delić, Trontelj & Fišer, 2017	groundwater	yes	Delić et al. 2017b
	Niphargus cvajcki Delić, Trontelj & Fišer, 2017	groundwater	yes	Delić et al. 2017b

Family	Species	Habitat	Endemic	Reference
	Niphargus danconai Benedetti, 1942	groundwater	no	Sket 1996
	Niphargus dobati Sket, 1999	groundwater	yes	Sket 1999b
	Niphargus fongi Fišer & Zagmajster, 2009	groundwater	yes	Fišer & Zagmajster 2009
	Niphargus goricae Delić, Trontelj & Fišer, 2017	groundwater	yes	Delić et al. 2017b
	Niphargus gottscheeanensis Delić, Trontelj & Fišer, 2017	groundwater	yes	Delić et al. 2017b
	Niphargus grandii Ruffo, 1936	groundwater	no	Sket 1972
	Niphargus hadzii Rejic, 1956	groundwater	yes	Rejic 1956
	Niphargus hebereri Schellenberg, 1933	groundwater	no	Sket 1996
	Niphargus iskae Delić, Trontelj & Fišer, 2017	groundwater	yes	Delić et al. 2017b
	Niphargus karamani Schellenberg, 1935	groundwater	no	Delić et al. 2017b
	Niphargus kenki S. Karaman, 1952	groundwater	no	Karaman 1952
	Niphargus krameri Schellenberg, 1935	groundwater	no	Fišer et al. 2006a
	Niphargus labacensis Sket, 1956	groundwater	no	Prevorčnik et al. 2019
	Niphargus lattingerae G. Karaman, 1983	groundwater	no	Prevorčnik et al. 2019
	Niphargus liburnicus G. Karaman & Sket, 1989	groundwater	no	Zakšek et al. 2019
	Niphargus longidactylus Ruffo, 1937	groundwater	no	Prevorčnik et al. 2019
	Niphargus longiflagellum S. Karaman, 1950	groundwater	yes	Karaman 1950
	Niphargus malagorae Delić, Trontelj & Fišer, 2017	groundwater	yes	Delić et al. 2017b
	Niphargus microcerberus Sket, 1972	groundwater	no	Sket 1972
	Niphargus minor Sket, 1956	groundwater	no	Prevorčnik et al. 2019
	Niphargus multipennatus Sket, 1956	groundwater	no	Sket 1972
	Niphargus novomestanus S. Karaman, 1952	groundwater	yes	Karaman 1952
	Niphargus orcinus Joseph, 1869	groundwater	no	Fišer et al. 2006b
	Niphargus pachytelson Sket, 1960	groundwater	yes	Sket 1960
	Niphargus parapupetta G. Karaman, 1984	groundwater	no	Prevorčnik et al. 2019
	Niphargus pectinicauda Sket, 1971	groundwater	yes	Sket 1971
	Niphargus podpecanus S. Karaman, 1952	groundwater	yes	Karaman 1952
	Niphargus pupetta (Sket, 1962)	groundwater	no	Sket 1971
	Niphargus rejici Sket, 1958	groundwater	yes	Sket 1958
	Niphargus scopicauda Fišer, Coleman, Zagmajster, Zwittnig, Gerecke & Sket, 2010	groundwater	yes	Fišer et al. 2010
	Niphargus serbicus S. Karaman, 1960	groundwater	no	Sket 1972
	Niphargus slovenicus S. Karaman, 1932	groundwater	yes	Karaman 1932
	Niphargus sphagnicolus Rejic, 1956	groundwater	yes	Rejic 1956
	Niphargus spinulifemur S. Karaman, 1954	groundwater	no	Fišer et al. 2006a

Family	Species	Habitat	Endemic	Reference
	Niphargus spoeckeri Schellenberg, 1933	groundwater	yes	Schellenberg 1933
	Niphargus stenopus Sket, 1960	groundwater	yes	Sket 1960
	Niphargus steueri Schellenberg, 1935	groundwater	no	Zakšek et al. 2019
	Niphargus stochi G. Karaman, 1994	groundwater	no	Trontelj et al. 2012
	Niphargus stygius (Schiödte, 1847)	groundwater	no	Delić et al. 2021
	Niphargus subtypicus Sket, 1960	groundwater	no	Zakšek et al. 2019
	Niphargus timavi S. Karaman, 1954	groundwater	no	Fišer et al. 2006a
	Niphargus transitivus Sket, 1971	groundwater	no	SubBioDB
	Niphargus valachicus Dobreanu & Manolache, 1933	groundwater	no	Karaman 1974
	Niphargus wolfi Schellenberg, 1933	groundwater	no	Schellenberg 1933
	Niphargus zagrebensis S. Karaman, 1950	groundwater	no	Delić et al. 2017b
Nuuanuidae	*Gammarella fucicola* (Leach, 1814)	marine	no	Fišer 2002
Oedicerotidae	*Deflexilodes acutipes* (Ledoyer, 1983)	marine	no	MBP
	Deflexilodes gibbosus (Chevreux, 1888)	marine	no	SubBioLab
	Deflexilodes griseus (Della Valle, 1893)	marine	no	MBP
	Deflexilodes subnudus (Norman, 1889)	marine	no	MBP
	Perioculodes aequimanus (Kossman, 1880)	marine	no	SubBioLab
	Perioculodes longimanus (Spence Bate & Westwood, 1868)	marine	no	Fišer 2002
	Synchelidium longidigitatum Ruffo, 1947	marine	no	Fišer 2002
	Westwoodilla rectirostris (Della Valle, 1893)	marine	no	MBP
Phliantidae	*Pereionotus testudo* (Montagu, 1808)	marine	no	SubBioLab
Photidae	*Gammaropsis crenulata* Krapp-Schickel & Myers, 1979	marine	no	SubBioLab
	Gammaropsis maculata (Johnston, 1828)	marine	no	Fišer 2002
	Megamphopus brevidactylus Myers, 1976	marine	no	SubBioLab
Phoxocephalidae	*Harpinia antennaria* Meinert, 1890	marine	no	MBP
	Harpinia dellavallei Chevreux, 1910	marine	no	MBP
Podoceridae	*Podocerus variegatus* Leach, 1814	marine	no	SubBioLab
Podoprionidae	*Podoprion bolivari* Chevreux, 1891	marine	no	MBP
Pontogeneiidae	*Eusiroides dellavallei* Chevreux, 1899	marine	no	SubBioLab
Scopelocheiridae	*Scopelocheirus crenatus* Spence Bate, 1857	marine	no	Ruffo et al. 1989
	Scopelocheirus hopei (Costa & Hope, 1851)	marine	no	Heller 1866
Stenothoidae	*Stenothoe monoculoides* (Montagu, 1813)	marine	no	Fišer 2002
	Stenothoe tergestina (Nebeski, 1881)	marine	no	Fišer 2002
Talitridae	*Orchestia mediterranea* Costa, 1853	semiterrestrial	no	Fišer 2002
	Speziorchestia stephenseni (Cecchini, 1928)	semiterrestrial	no	Fišer 2002
	Talitrus saltator (Montagu, 1808)	semiterrestrial	no	SubBioLab
	Cryptorchestia garbinii Ruffo, Tarocco & Latella, 2014	semiterrestrial	no	MBP

Family	Species	Habitat	Endemic	Reference
Tryphosidae	*Hippomedon bidentatus* Chevreux, 1903	marine	no	MBP
	Lepidepecreum longicorne (Spence Bate & Westwood, 1861)	marine	no	MBP
	Orchomene humilis (Costa, 1853)	marine	no	Fišer 2002
	Tryphosa nana (Krøyer, 1846)	marine	no	Fišer 2002
Uristidae	*Tmetonyx nardonis* (Heller, 1867)	marine	no	Heller 1866

About two thirds of species (127 species, 73 genera and 36 families) are marine, one family with four genera totalling four species are semiterrestrial, three species can be found in both brackish and freshwaters, whereas the rest of the species (65) live in freshwater only. Among the latter, subterranean species (57 species) predominate. There are 26 species endemic to the country, of which only one is from surface freshwater, while all the rest are from groundwater (Tabs. 1, 2). We detected two alien marine species, of which one is invasive, but found no alien freshwater species.

Nine species are considered as erroneously listed for Slovenia, with detailed explanations on the reasoning behind exclusion from the national list of amphipods explained in Tab. 3.

Table 3. A list of amphipod species erroneously listed as present in Slovenia in previous papers. In a separate column, we justify their removal from the Slovenian checklist.
Tabela 3. Seznam vrst postranic, ki jih starejša dela zmotno navajajo kot del slovenske favne – kar je napaka. V ločenem stolpcu utemeljujemo njihovo odstranitev s seznama slovenske favne.

Family	Species	Reason to remove	Source
Hadziidae	*Hadzia fragilis stochi* Karaman, 1989	Present on Carso Goriziano, Italy, but its presence in Slovenia was never confirmed. Also Sket (1996) listed its presence as doubtful, with question mark added.	Sket 1996
Gammaridae	*Gammarus wautieri* Roux, 1967	A species distributed in France, identified using the identification key of Karaman and Pinkster (1977). According to molecular evidence, this is an error; it likely represents an unknown species from the complex *Gammarus fossarum.*	Sket 1970
Niphargidae	*Niphargus aquilex*	This species is one of the first described *Niphargus* species. It lives in Northern and Central Europe (McInerney et al. 2014), but morphologically similar species are found across the entire Europe. Mentioned as group or aggregate. The first records under the name *N. aquliex* agg. refer to *N. dobati*.	Sket 2000, Rejic 1958
	Niphargus croaticus (Jurinac, 1887)	This species lives in Croatia and Bosnia and Herzegovina (Delić et al. 2016, Zakšek et al. 2019). Before the revision, it was often erroneously confused with another species, *N. arbiter* (Karaman 1984). In Sket (2000) it is listed as *N.* cf. *croaticus*, which may lead to wrong conclusion of *N. croaticus* presence in Slovenia.	Sket 2000

Family	Species	Reason to remove	Source
	Niphargus kochianus	This species is one of the first described *Niphargus* species. It lives in Northern and Central Europe (McInerney et al. 2014), but morphologically similar species are found across the entire Europe. The first records under the name *N.* group *kochianus* refer to populations of *N. longidactylus, N. labacensis* and *N. minor.* Mentioned as *Niphargus kochianus* ssp. or *N.* gr. *kochianus*.	Sket 1972, Sket 1979, Sket & Velkovrh 1981, Sket 2000
	Niphargus jovanovici	This species lives in Macedonia and Greece (Karaman 2017), but several species from Slovenia were assigned as closely-related species or subspecies (*N. grandii*, *N. multipennatus*). Mentioned as *N. jovanovici* ssp. (Sket 1972).	Sket 1972
	Niphargus hrabei S. Karaman, 1932	This species is distributed throughout the Pannonian basin and could be expected in Slovenia (Copilaș-Ciocianu et al. 2017). However, its presence has never been confirmed, even though a related undescribed species lives in Krakovski gozd (Borko et al. 2021). Sket (1996) mentiones this species with question mark.	Sket 1996
	Niphargus puteanus (Koch & Panzer, 1836)	*Niphargus puteanus* is distributed in the Rhine and upper Danube basins and Luxembourg (Weber et al. 2020). However, this is the first *Niphargus* species to be described, and many other species were originally described as its subspecies. In Slovenia, *N. spoeckeri* and *N. krameri* were probably confused with this species.	Gherlizza 1999, Megušar 1914, Perko 1910
	Niphargus tauri	This species lives in Turkey, but similar species were reported from Western Balkans, including Slovenia. *N. carniolucus* was initially affiliated to this species. It was reported as *N. tauri* ssp. or as *N. tauri* gr.	Matjašič & Sket 1971, Sket 1970, Sket 1979, Sket & Velkovrh 1981

Discussion

In this contribution, we are increasing the number of registered species for Slovenia, as we list 77 (nearly 39%) of all amphipod species for the first time for our country. The large majority of species (131 species, 66% of all) is marine, found in the Slovenian part of the Northern Adriatic Sea. Two species (*Caprella scaura*, *Jassa marmorata*) are alien and one (*Monocorophium sextonae*) is cryptogenic (EASIN 2021). The marine species represent approximately 29% (127 out of 451) of all Mediterranean species (Ruffo et al. 1998). This is a relatively large share of regional species richness even though the Northern Adriatic Sea

represents only a small fraction of the entire Mediterranean Sea, with Slovenian sea representing even smaller fraction. The share of marine against all Slovenian amphipods (64%), however, is somewhat lower than their respective share on a global scale (80%, Horton et al. 2021). This deviation can be in part explained by the fact that marine amphipods have not been systematically studied, in contrast to intensively studied freshwater amphipods. We believe that more intense research should expand the list of inhabitants of Slovenian sea. For example, the monograph of Mediterranean amphipods reported six species from the sea near Rovinj (Croatia) and Trieste (Italy), i.e., south and north of Slovenian coast, respectively, the presence of which can be highly expected in the Slovenian sea as well (Krapp-Schickel & Zavodnik 1996, Ruffo et al. 1998). Finally, we found some individuals that may belong to alien species, but need a confirmation from a specialist for these families.

Among freshwater amphipod species, subterranean amphipod species (groundwater species) represent the main share of species (57 out of 64 freshwater species). Subterranean amphipods comprise species from currently six genera, *Bogidiella*, *Carinurella*, *Ingolfiella*, *Niphargus*, *Niphargobates* and *Synurella.* Two of them, *Niphargobates* and *Carinurella*, are in need of taxonomic revision, as they are nested in phylogenetic trees within the genus *Niphargus* (Esmaeili-Rineh et al. 2015, Borko et al. 2021). Species of the genus *Niphargus* dominate in groundwaters (53 species). The high number of *Niphargus* species seems to be a result of turbulent geological history that in a broader region of the Western Balkans prompted multiple evolutionary radiations, descendants of which dispersed into the territory that is nowadays called Slovenia (Borko et al. 2021). The number of current species of this genus is rather underestimated since the morphological identification of *Niphargus* species is challenging and the taxonomy of the genus incomplete. We estimate there might be between 30–50% additional and yet undescribed species (Borko et al., in revision).

The only *Synurella* species listed in the checklist needs further clarifications. Slovenian populations of *S. ambulans* colonized a number of Slovenian caves, with each subterranean population differing from neighbouring surface populations and hence suggesting multiple independent colonization events and probable ongoing speciation (Pekolj 2020). Some authors considered morphologically differentiated subterranean populations as a distinct subspecies named *S. ambulans subterranea* (Karaman 1931). Subterranean *Synurella* resembles the evolutionary history of the isopod species *Asellus aquaticus* (Linnaeus, 1758), which independently colonized subterranean waters several times, and molecular studies suggest that most of these cave populations deserve separate species status (Verovnik et al. 2009, Konec et al. 2015). By analogy, we assume that subterranean populations of *Synurella* represent distinct species, a hypothesis that should be tested using molecular tools.

Most endemic species are groundwater species, although there is one endemic species in the surface freshwater. The term »endemic« requires a caution note. For the needs of this checklist, we considered »endemic« those species the distributional range of which falls completely within the political borders of Slovenia. However, there are species having small distribution ranges, which also occur in either of the neighbouring countries (Italy, Croatia). Even though they are not national endemics, they are endemic to very small geographic area (often called subendemic). A different case of missed national endemics in the current list are some large-ranged species that may have genetically distinct populations in Slovenia (e.g. *N. liburnicus*, *N. krameri*) and await to be taxonomically evaluated, formally described as species, and put on a list of national endemics.

The most species from poor ecological categories are species from the surface water and species from brackish water. These include genera *Homoeogammarus*, *Gammarus, Jugogammarus* and *Synurella.* Taxonomically unambiguous is the monotypic species *Jugogammarus kusceri*, a narrow endemic species living in springs within the catchment of the Krka River (Sket 1996). The taxonomic status of species from other genera is highly questionable. Individuals characterized as nominal species *G. fossarum, G. balcanicus, G. roeselii* and *S. ambulans* in fact belong to species-rich complexes (Copilaş-Ciocianu & Petrusek 2015, Mamos et al. 2016, Csapó et al. 2020, Hupało et al. 2020, Wattier et al. 2020). With rare exceptions (Alther et al. 2017), most of Slovenian freshwater gammarids have never been studied genetically and we thus cannot evaluate their taxonomic status nor the true number of potential species. Consequently, distribution of these species in Slovenia and their conservation status remains poorly known.

Contrary to our expectations, as of present time and up to our knowledge, there is no confirmed record of invasive freshwater amphipod species presence from Slovenia. Many Ponto-Caspian species of the genera *Dikerogammarus, Chelicorophium* and *Obesogammarus* spread across the continent and through rivers and artificial channels and have reached Poland, Germany, France and Switzerland (Altermatt et al. 2014, Copilaş-Ciocianu et al. 2021). These species were recorded in the Drava and Sava Rivers in the territories of Croatia and Serbia more than a decade and five decades ago, respectively (Karaman 1974, Žganec et al. 2009). The probability that these species could be present also in Slovenia or could colonize Slovenian rivers, streams, and lakes in the near future is quite high. Thus, the here presented checklist offers a challenge to researchers, to look carefully into riverine benthos and check whether native fauna has encountered Pontocaspian newcomers.

Finally, while preparing and critically evaluating the checklist, several erroneous names resurfaced. Changes of species names are an integral part of taxonomic practice. Some species were in due revisions transferred to other genera during revisions, recognized as junior synonyms or erected from subspecies to species status. These names can be traced as synonyms on the World Register of Marine Species (Horton et al. 2021) and are not problematic. However, some sources of erroneous records can create confusion with the risk to be repeated when checklists are revised. First, some species were erroneously identified. As an example, in the past, individuals could have been identified as a widespread species (like *Niphargus puteanus*), but subsequent taxonomic work unveiled this individual belongs to another species (in this example, *N. krameri*) and the previously identified species (in this case *N. puteanus*) is not present in Slovenia (Weber et al. 2020). A similar confusion may derive from identification to the species level (e.g., *N. aquilex*) rather than to the subspecies level (in this case *N. aquilex dobati*), and subsequent taxonomic work raised subspecies to the species level (*N. dobati*); also in this example, nominal species does not live in the country (McInnerney et al. 2014). The last problem deals with dubious records, not backed with data. With the aim to remove such species from further lists, we decided to list them in this contribution, with the hope that they will no longer be listed as representatives of Slovenian amphipod fauna.

Povzetek

Postranice (Amphipoda) so z 10.000 vrstami med največjimi redovi rakov valilničarjev (Horton et al. 2021). Večina vrst je morskih (80 %), ostale (20 %) pa naseljujejo celinske vode vključno s podzemnimi vodami (Sket 1999a, Väinölä et al. 2008, Zagmajster et al. 2014). V tem delu smo posodobili seznam morskih in sladkovodnih vrst postranic z območja Slovenije. Posodobljeni seznam smo sestavili iz že objavljenih seznamov in jih dopolnili s podatki, objavljenimi po letu 2002. Slednje smo pridobili iz podatkovnih zbirk BioPortal (Center za kartografijo favne in flore) in SubBioDB (Raziskovalna skupina za speleobiologijo – SubBioLab). Ta seznam smo dopolnili z novejšimi in neobjavljenimi podatki iz zbirk Morske biološke postaje v Piranu (Nacionalni inštitut za biologijo) in skupine SubBioLab (Oddelek za biologijo, Biotehniška fakulteta Univerze v Ljubljani). V seznam smo vključili le formalno opisane vrste; navajamo pa jih z imeni, ki jih zbirka World Register of Marine Species (Horton et al. 2021) obravnava kot veljavna. Vsaki vrsti smo pripisali ekološko kategorijo (morska, morska, brakična, obrežna, površinska sladkovodna, podzemna sladkovodna) in morebiten status državnega endemita. Pojavljanje vrste v Sloveniji je podkrepljena z enim verodostojnim virom, bodisi objavo bodisi podatkom iz zbirke.

V Sloveniji smo do danes našli 198 vrst postranic, ki pripadajo 85 rodovom in 41 družinam. Za 77 vrst iz seznama je to prva navedba o njihovem pojavljanju na našem območju. Dve tretjini (127 vrst) sestavljajo morske postranice. Štiri vrste živijo na kopnem oz. obrežjih, tri vrste najdemo tako v brakičnih kot tudi celinskih vodah. Preostale vrste (64 vrst) živijo samo v celinskih vodah, od katerih prevladujejo tiste, ki jih najdemo v podzemnih vodah (57 vrst). Endemne vrste (26) so le v celinskih vodah in so, z eno izjemo, podzemne. Tujerodne vrste smo našli v morju, v celinskih vodah pa jih presenetljivo še nismo našli. Za devet vrst, ki pripadajo trem družinam in jih starejša dela navajajo kot del slovenske favne, smo ovrgli njihovo pojavljanje v Sloveniji.

Pregled seznama vrst razkriva dve osrednji težavi v razumevanju vrstne pestrosti postranic v Sloveniji. Morske vrste so bile vzorčene le priložnostno; njihovo število je podcenjeno zlasti na račun skromnega vzorčenja. Pri vrstah, ki naseljujejo celinske vode, so težave drugačne narave. Te vrste so pogosto kompleksi t. i. kriptičnih vrst. Razjasnitev njihovega taksonomskega statusa zahteva uporabo molekulske taksonomije, kar je zamuden proces in epilog lahko pričakujemo šele v naslednjih letih.

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