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First report on Copepoda and Ostracoda (Crustacea) from northern Apenninic springs (N. Italy): a faunal and biogeographical account

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ABSTRACT

The microcrustacean fauna of rheocrene and rheo-limnocrene springs in a protected area of the northern Apennines (Italy) was investigated for the first time. All springs are located in the catchments of the rivers Parma and Enza at altitudes between 800 and 1609 m a.s.l. Several of these springs are still in pristine condition while others are artificially modified or impacted to some degree. Surveys were carried out from April to June 2007. The sampling methods used for invertebrate fauna were: moss washing, artificial traps, and inserting drift tubes at the discharge point. A total of 14 harpacticoid, five cyclopoid, and 13 ostracod taxa were identified. Ostracods were mainly represented by crenophilic taxa; of particular interest was the collection of a specimen belonging to Pseudolimnocythere*, a stygobiont genus with only two living species and a reduced distribution. Faunal affinities between northern Apenninic springs and those in other Italian mountain systems are discussed. The investigated ecosystems support a high microcrustacean diversity that must be adequately preserved due to the increasing direct and indirect impacts on mountain springs and groundwater resources.*

Key words: Copepoda, Ostracoda, mountain springs, northern Apennines, Italy, biodiversity

1. INTRODUCTION

Springs are ecotonal systems at the interface between surface and ground waters (Williams 1991), characterised by a relative constancy of the physical and chemical features of their waters (Odum 1971). Spring fauna is composed of crenobiont (organisms found only in springs and spring brooks), crenophile (organisms preferring spring habitats, but which may also occupy other freshwater habitats) and crenoxene (organisms accidentally collected in springs) taxa. Springs support high biodiversity, especially for meiofauna, which is highly diverse and abundant in springs (Gerecke *et al*. 1998), its biomass often exceeding that of macrofauna (Stoch 2001). Among meiofauna, microcrustaceans are both numerically abundant and species rich (Dole-Olivier *et al*. 2000). Groundwaters and associated spring systems have great faunistic and biogeographical value; despite their importance, their biology and ecology have become a topic of intensive investigation only recently. Several research studies on mountain spring fauna have been conducted in Italy, mainly in the north-eastern Alpine and pre-Alpine area (Fig. 1) (Stoch 1993, 1997, 2003; Crema *et al*. 1996; Cantonati 1998; Mezzanotte & Stoch & Zomasin 2002; Sambugar 2004; Sambugar *et al*. 2006). So far, the only faunistic studies in Apenninic springs have been carried out in central and southern areas (e.g., Pesce *et al*. 1995; Pesce 1996; Galassi 1997; D'Ambrosio *et al*. 2003; Di Lorenzo *et al*. 2003; Fiasca *et al*. 2004; Di Sabatino *et al*. 2003).

The aim of the present study is to create a spring

Fig. 1. Geographical location of the study area (1) and other mountain spring systems listed in tables 3, 4, and 5. (2): Mezzanotte & Sambugar 2004; Stoch & Tomasin 2002. (3): Crema *et al*. 1996; Cantonati 1998; Stoch 1998b. (4): Meisch 2006; Stoch 2006; Sambugar *et al*. 2006. (5), D'Alberto & Sambugar 1998. Stoch 2003. (6): Stoch 1993, 1997, 2003. (7): Di Lorenzo *et al*. 2003; Pesce *et al*. 1995; Pesce 1996; Galassi, 1997; Galassi & De Laurentiis 1997a, b; D'Ambrosio *et al*. 2003; Fiasca *et al*. 2004.

inventory and to describe the microcrustacean fauna (Copepoda and Ostracoda) of the "Parco dei Cento Laghi", a protected area in the northern Apennines (Fig. 1). To our knowledge, this is the first extensive investigation of microcrustaceans from northern Apenninic springs. Data from previous studies indicate that two copepod orders are typical representatives of spring meiofauna: Harpacticoida and Cyclopoida. Most of the spring species are crenophile or crenoxene, very few are crenobiont. The assemblages of cyclopoids, which are generally rarer than harpacticoids in springs, are often composed of ubiquitary or rheophilic species (Stoch 2000-2005, 2006). Springs also host a diverse ostracod fauna; nevertheless, relatively few species can be considered truly crenobiont or are specifically found in waters connected to springs (Roca & Baltanás 1993; Mezquita *et al*. 1999, 2000; Rossetti *et al*. 2005; Meisch 2006; Pieri *et al*. 2007).

MATERIAL AND METHODS

In the present study, we analysed 19 rheocrene and rheo-limnocrene springs, located in the catchments of the rivers Parma and Enza at altitudes between 800 and 1609 m a.s.l. Several of these springs are still in pristine condition, others are artificially modified or impacted to some degree (Tab. 1).

Surveys were carried out from April 3rd to June 20th, 2007. Sampling methods for invertebrate fauna were chosen to avoid damaging the spring habitats as much as possible, given the intrinsic fragility and the small size of these ecosystems. Mosses, when present, were collected in splash zones and along the spring outlet; artificial traps were placed in the surficial sediments, and drift tubes were inserted only in three springs which had a well defined discharge point (Tab. 1). Moss washing was carried out in the laboratory, and the resulting water was filtered through a 50 μm mesh net to collect the invertebrates. Traps were built with modified PVC test-tubes (length 100 mm; inner diameter 28 mm); two to six traps per station were partially dug into the sediment, covered with a stone to hide them from view and to keep them in place. They were filled with gravel (0.3–1 cm), leaving an opening of about 5 mm at one end for the animals to enter the trap and placing a 50 μm net at the other specimens. To account for differing migration patterns among specimens, the traps were oriented with the opening towards or against the stream flow. Some of the traps were baited with ham fat. Drift tubes were built with PVC pipes (length 160 mm; inner diameter 48 or 80 mm, depending on the size of the spring discharge point) closed at one end by a 50 μm mesh net. The traps and the drift tubes were left in situ for seven days before being removed and taken to the laboratory. At the laboratory traps and drift tubes were emptied and their contents were carefully washed and filtered through a 50 μm

Tab. 1. Characteristics of the springs considered in this study. Geographical coordinates are indicated in UTM (WGS 84) system of coordinates. Habitat type: RL, rheo-limnocrene; RH, rheocrene; N, natural; A, altered.

Spring name	Code	Height (m a.s.l.)	Long E	Lat N	Watershed	Lithology	Habitat type	Sampling methods		
								Trap	Mosses	Drift tubes
Acque Assai	AAS1	856	582039.59	922541.35	Parma	Clay-Limestone	RL, A	x		
Acquarola	ACQ1	1185	588393.59	915151.57	Enza	Sandstone	RH, A	x		
Biam 1	BIA1	919	587772.24	921004.54	Parma	Sandstone	RH, A	x	x	x
Biam 2	BIA2	959	587819.54	920573.34	Parma	Sandstone	RH, N		x	
Chiastra 1	CHI1	1175	580560.38	919078.56	Parma	Sandstone	RH, A	x	x	
Cirone 2	CIR2	1124	580516.93	922501.23	Parma	Limestone	RL, N	x	x	
Copello	COP1	1150	588109.32	914612.91	Enza	Sandstone	RH, A	x		
Fontanabona	FNB1	1310	585981.90	916511.62	Enza	Sandstone	RH, A		x	
Lagdei Torbiera	LGD1	1244	580378.89	918429.69	Parma	Sandstone	RL, A	x		
Lagdei Rifugio	LGD2	1252	580311.77	918259.08	Parma	Sandstone	RL, N	x		
Maccetta	MAC1	1300	581875.23	918287.04	Parma	Clay-Limestone	RH, A	x	x	x
Marmagna	MAR1	1609	580071.23	916692.81	Parma	Sandstone	RH, N	x	x	
Marmagna Torbiera	MAR2	1580	580289.39	916692.81	Parma	Sandstone	RL, N		x	
Orneda	ORN1	1208	588052.95	913936.47	Enza	Sandstone	RL, N	x	x	
Lago Padre	PAD1	1587	579939.78	917176.67	Parma	Sandstone	RH, N		x	
I Piani	PIA1	800	586749.28	924288.99	Parma	Sandstone	RH, N	x		x
Ponte Rotto	POR1	1583	579858.67	917839.54	Parma	Sandstone	RH, N		x	
Lago Santo	SAN1	1513	580155.14	917254.99	Parma	Sandstone	RH, N		x	
La Vezzosa	VEZ1	1150	580831.99	919000.25	Parma	Sandstone	RH, N	x		

mesh to collect the spring fauna. All samples were fixed in 95% ethanol and invertebrates were sorted under a dissecting microscope.

Copepod specimens of each taxon were mounted in permanent slides with Faure's medium. Adults and last larval stages (copepodid V) were identified to species level following Dussart (1967, 1969), Pesce *et al*. (1987, 1994), Stoch (1998a), Karaytug (1999), Mirabdullayev & Defaye (2002), and Cottarelli *et al*. (2005). Ostracod specific allocation was based on adult specimens. Identification remained at the generic level when few individuals, damaged material, or only female specimens were available. Both soft parts, dissected in glycerine and stored in sealed slides, and valves were checked for species identification, using Baltanás *et al*. (1993) for the genus *Psychrodromus*, Karanovic & Pesce (2001) for the genus *Pseudolimnocythere*, and Meisch (2000) for the remaining taxa.

RESULTS AND DISCUSSION

Samples from three springs (LGD1, PIA1, and SAN1) did not contain any copepods or ostracods. A total of 416 harpacticoid and 52 cyclopoid copepods were collected, represented respectively by 14 and 5 species (Tab. 2).

The number of recorded species is the highest that has been recorded for studies on Italian spring systems. All taxa were collected in the remaining springs, except for the harpacticoid *M. vejdovskyi truncatus*, and the cyclopoids *Acanthocyclops* aff. *trajani*, *Diacyclops bisetosus*, and *Megacyclops viridis* (Tab. 2). Harpacticoids represented 88.9% of all of the total copepods, and 73.7% of the species; they were present at 15 springs (copepods were not collected at AAS1, LGD1, PIA1, SAN1, Tab. 1), with a high abundance at some of the stations. All harpacticoids belonged to the family

Tab. 2. List and total number of copepod taxa collected in the present study (column A: number of individuals), and records from other studies in Alpine and pre-Alpine spring systems (column B: Mezzanotte & Sambugar, 2004; column C: Crema *et al*., 1996; column D: Stoch 2006; column E: Stoch 1993, 2003; column F: Stoch 1998b; G: Stoch & Tomasin 2002) and in the central Apennines (column H, Maiella Massif: Di Lorenzo *et al*. 2003; column I, Gran Sasso-Monti della Laga Massif: Pesce *et al*. 1995; Pesce 1996; Galassi 1997; Galassi & De Laurentiis 1997a, b; D'Ambrosio *et al*. 2003; Fiasca *et al*. 2004). The ecological characteristics of each taxon are reported in column J (ss = stygoxene; sf = stygophile; sb = stygobiont). Species endemic for Italy are marked with an asterisk.

[1] According to Mirabdullayev & Defaye (2002, 2004), who re-examined the material of the *A. robustus* species complex, only records from waterbodies in Scandinavia, Canada and northern regions of the U.S.A. can be attributed to the nominal species. Records of *A. robustus* from Eurasia (Scandinavia excluded) belong to *A. trajani* or to *A. einslei* Mirabdullayev & Defaye 2004.

	A	B	C	D	E	F	G	H	I	J
Harpacticoida										
Attheyella (Attheyella) crassa (G.O. Sars, 1863)	1	+	+	+			+	+	+	ss
A. *(A.) wierzejskii* (Mrázek, 1893)			+	+	+	+				ss
A. (Brehmiella) paranaphtalica Pesce & Galassi, 1988								+	+	sf
Bryocamptus (*Arcticocamptus*) *abnobensis* (Kiefer, 1929)										ss
B. (A.) alpestris (Vogt, 1845)	1			+						ss
B. (A.) cuspidatus (Schmeil, 1893)	52		+	+		+				ss
B. (A.) rhaeticus (Schmeil, 1893)			+	+	+	+				ss
B. (A.) vandouwei (Kessler, 1914)										ss
B. (Bryocamptus) minutus (Claus, 1863)									+	ss
B. (B.) pygmaeus (G.O. Sars, 1863)	82		+	+	+	+	+	+	+	ss
B. (Limocamptus) echinatus (Mrázek, 1893)	3	+	+	+	+	+		+	+	sf
B. (Rheocamptus) tatrensis (Minkiewicz, 1916)	16	+	+	+	+	+	+			ss
B. (R.) typhlops (Mràzek, 1893)								+	+	sf
B. (R.) zschokkei (Schmeil, 1893)	187	+	+	+		+		+	+	ss
Ceuthonectes serbicus Chappuis, 1924		+					+			sb
Echinocamptus pilosus (Van Douwe, 1911)					+					sf
Elaphoidella cvetkae Petrovski, 1893					+				+	sb
E. mabelae Galassi & Pesce, 1991									+*	sb
E. elaphoides (Chappuis, 1923/24)								+		sb
E. gracilis (G.O. Sars, 1863)									+	ss
E. phreatica (Chappuis, 1925)					+					sf
E. pseudophreatica (Chappuis, 1928)	1						+			sb

(continued)

Tab. 2. Continuation.

	A	B	C	D	E	F	G	H	I	J
E. plutonis Chappuis, 1938									+*	sb
Epactophanes richardi Mrázek, 1894	46		+		+				+	sf
Hypocamptus brehmi (Van Douwe, 1922)	3			+					+	ss
Maraenobiotus vejdovskyi Mrázek, 1893	1									sf
Maraenobiotus vejdovskyi truncatus Gurney, 1932	4									sf
M. zschokkei Kreis, 1920				+						sf
Moraria alpina Stoch, 1998				+		+				sf
M. poppei (Mrázek, 1893)	3	+		+	+	+	+	+	+	sf
M. stankovitchi Chappuis, 1924	1				+		+	+		sf
M. cf. *brevipes* (G.O. Sars, 1863)			+							sf
Nitocra hibernica (Brady, 1880)									+	ss
Nitocrella kunzi Galassi & De Laurentiis, 1997								+*	+*	sb
N. pescei Galassi & De Laurentiis, 1997									+*	sb
N. psammophila Chappuis, 1954							+			sb
Paracamptus schmeili (Mràzek, 1893)		+							+	ss
Parapseudoleptomesochra italica Pesce & Petkovski, 1980									+	sb
Parastenocaris lorenzae Pesce, Galassi & Cottarelli, 1995									+*	sb
P. glacialis Noodt, 1952									+	sb
P. crenobia Galassi, 1997								+*		sb
Pseudectinosoma reductum Galassi & De Laurentiis, 1997									+*	sb
Simplicaris lethaea Galassi & De Laurentiis, 2004									+*	sb
Cyclopoida										
Acanthocyclops agamus Kiefer, 1938								+*		sb
A. hispanicus Kiefer, 1937						+				ss
A. kieferi (Chappuis, 1925)							+			sb
A. robustus (G.O. Sars, 1863) (1)							+			ss
A. vernalis (Fischer, 1853)			+							ss
A. aff. trajani	4									ss
Diacyclops bisetosus (Rehberg, 1880)	21									ss
D. clandestinus (Kiefer, 1926)									+	sb
D. hypnicola (Gurney, 1927)									+	sf
D. paolae Pesce & Galassi, 1987		+						+	+	sb
D. paralanguidoides Pesce & Galassi, 1987								+	+	sb
D. ruffoi Kiefer, 1981							+			sb
Ectocyclops phaleratus (Koch, 1838)									+	ss
Eucylops serrulatus (Fischer, 1851)	1		+	+		+	+		+	ss
E. gr. *subterraneus* (Graeter, 1907)									+	sb
Graeteriella unisetigera (Graeter, 1908)				+						sb
Macrocyclops albidus (Jurine, 1820)							+		+	ss
M. fuscus (Jurine, 1820)				+					+	ss
Megacyclops viridis (Jurine, 1820)	3								+	ss
Microcyclops varicans (G.O. Sars, 1863)									+	ss
Paracyclops fimbriatus (Fischer, 1853)			+		+			+	+	ss
P. imminutus Kiefer, 1929	5	+		+	+	+	+			ss
Speocyclops demetiensis (Scourfield, 1932)					+					sb
S. infernus (Kiefer, 1930)							+			sb
S. troglodytes (Chappuis, 1923)					+					sb
Tropocyclops prasinus (Fischer, 1866)									+	ss
Number of taxa	**19**	**9**	**13**	**17**	**16**	**11**	**15**	**15**	**36**	

Canthocamptidae. This includes harpacticoids which live in continental waters, from the Arctic to the Antarctic. and those which inhabit most types of water bodies and wetlands. They are most commonly found in the lacustrine meiobenthos. The family contains today more than 700 species, 500 of which are ascribed to the complex *Attheyella-Elaphoidella-Bryocamptus* (Pesce 1999-2007). Species of the latter genus are dominant in the studied springs.

Two groups of species characterised the harpacticoid assemblages, a condition already reported by Stoch (2006) for South Tyrol springs. The first group includes species which are considered rheophile, but not crenophile; they are ubiquitary species (*Attheyella crassa*, *Bryocamptus* (*Rheocamptus*) *pygmaeus*, *B. (R.) zschokkei*, *B. (R.) tatrensis*, *B.* (*Limocamptus*) *echinatus*, *Epactophanes richardi*) or species living in mosses (*Moraria poppei*) (Stoch 2000-2005). A second group is represented by cold-stenothermic species, reported from mountain systems in the Alps (Cottarelli *et al.* 2002), at times with boreal-Alpine disjunct distribution, which followed the Quaternary glacial retreat, and survived at high elevation or in cold refugia. These are the species belonging to the genera *Bryocamptus* (*Articocamptus*), *Hypocamptus*, and *Maraenobiotus*. The subgenus *Articocamptus* is represented overall by 23 species, four of which are present in Italy at high elevation in the Alpine area, and as a glacial relict in the Apennines (a record of *A. (B.) cuspidatus* (Galassi 1997) and one of *B. (A.) rhaeticus* (Pesce 1996), both from the Gran Sasso in the central Apennines) (Tab. 2). The two species collected in northern Apenninic springs, *B. (A.) alpestris* and *B. (A.) cuspidatus*, have been recorded from springs in Trentino and South Tyrol (Crema *et al.* 1996; Stoch 1998b, 2006; Cantonati *et al.* in prep.). The genus *Hypocamptus* is present in Italy with three species. *Hypocamptus paradoxus* had been collected so far at high elevation (>2000 m a.s.l., see Stoch 2000-2005) in periglacial lakes, and in hyporheic habitat of Alpine streams (Cottarelli *et al.* 2002). *Hypocamptus brehmi*, collected also in springs in South Tyrol (Stoch 2006), is known as a glacial relict in the Apennines. The two species of *Maraenobiotus*, *M. vejdovskyi* and *M.* v. *truncatus*, are reported from high elevations, typically from crenal and epirhithral habitats (Stoch 2000-2005).

Among the harpacticoids, the only stygobiont taxon collected is *Elaphoidella pseudophreatica*, which probably reaches the springs from the phreatic waters; it has been reported as widely distributed in pre-Alpine caves (Stoch & Tomasin 2002), and with few records in the central Apennines (Stoch 2000-2005).

Cyclopoid assemblages were represented by crenoxenes (*Acanthocyclops* aff. *trajani*, *Eucyclops serrulatus*, *Megacyclops viridis*, and *Diacyclops bisetosus*), which are ubiquitous and widespread in ponds and lakes of the study area (Moroni & Bellavere 2001), or rheophilic species, such as *Paracyclops imminutus*, whose reduced antennules and flattened body represent adaptation to life in running waters.

Mosses were the richest habitat; copepods collected there represent 63% of the copepod total (274 harpacticoids and 21 cyclopoids). All taxa of cyclopoids and harpacticoids were collected there, except *Bryocamptus* (*Limocamptus*) *echinatus*, *E. pseudophreatica* and *Moraria stanchovitchi*. Taxa exclusive of this habitat (i.e., not collected with the traps) were the harpacticoids *B. (R.) tatrensis*, *B. (A.) alpestris*, *M. vejdovski*, *M. vejdovskyi truncatus*, *M. poppei*, *E. richardi*, *A. crassa* and the cyclopoid *E. serrulatus*. Most of the harpacticoid species collected in mosses are commonly reported from muscicolous habitats, or are widely distributed in other freshwater habitats.

The copepod taxocoenosis of the investigated springs in the "Parco dei Cento Laghi" has strong affinities with those recorded in Alpine and pre-Alpine systems, with low numbers of stygobiont and/or endemic taxa. On the other hand, the central Apennines host a very diverse copepod fauna, with high numbers of endemisms (Tab. 2). According to Stoch (2003), the lack of stygobiont species recorded in the Alpine springs, which are located at high elevation, can be attributed to the effects of the Quaternary glaciations. In fact, stygobiont (typical and exclusive of groundwater systems) copepods were not able to re-colonize these areas in the post-glacial period, due to their reduced dispersal abilities (Crema *et al.* 1996), whereas surface species, which are crenophile and crenoxene, have been able to re-colonize spring habitats (Stoch 1998b). This hypothesis is confirmed by the lack of endemic, stygobiont taxa, which were collected in the central Apennines (Tab. 2) and are an ancient, relict taxa of marine (e.g., *Pseudoectinosoma*) and freshwater origin (e.g., species belonging to the genera *Parastenocaris*, *Simplicaris*, *Elaphoidella*, *Nitocrella*, *Diacyclops*) (D'Ambrosio *et al.* 2003).

Thirteen ostracod taxa in four families and six genera were collected (Tab. 3). *Psychrodromus olivaceus* was by far the most numerous species, although it was found in only two springs (BIA1 and CIR2). As for the other two congeners, *P. fontinalis* and *P.* cf. *betharrami*, they prefers springs, ponds fed by springs, and different types of groundwater (Baltanás *et al.* 1993; Meisch 2000). Other widely distributed taxa showing similar habitat preferences and high tolerance are *Cryptocandona vavrai*, *Potamocypris fulva*, and *P. pallida* (Dole-Olivier 1998; Meisch 2000; George & Martens 2002). Some genera found in pre-Alpine and Alpine spring systems (*Cavernocypris*, *Cyclocypris*, *Cypria*, *Eucypris*, *Fabaeformiscandona*, and *Scottia*, the latter a genus of semi-terrestrial species) were not collected in the present study; on the other hand, *Pseudocandona* and *Pseudolimnocythere* were exclusive of the northern Apennines (Tab. 3). There is not enough data presently available for a faunistic comparison with spring assemblages of other Apenninic areas.

Tab. 3. List and total number of ostracod taxa collected in the present study (column A: number of individuals) and in other studies in Alpine and pre-Alpine spring systems (column B: Crema *et al*., 1996; column C: D'Alberto & Sambugar 1998; column D: Mezzanotte & Sambugar 2004; column E: Meisch 2006).

	A	B	C	D	E
Candona candida (O.F. Müller, 1776)					+
C. gr. *neglecta* Sars, 1887	2				
C. neglecta Sars, 1887	4	+		+	+
C. cf. *lindneri* Petkovski, 1969	2				
Cavernocypris subterranea (Wolf, 1920)		+	+		+
Cryptocandona vavrai Kaufmann, 1900	1	+			
Cyclocypris helocrenica Fuhrmann & Pietrzeniuk, 1990		+			
C. ovum (Jurine, 1820)					+
Cypria ophthalmica (Jurine, 1820)		+			
C. ophthalmica (Jurine, 1820) forma *lacustris*					+
Eucypris pigra (Fischer, 1851)		+			+
Fabaeformiscandona sp.				+	
F. brevicornis (Klie, 1925)					+
F. tyrolensis (Löffler, 1963)					+
Potamocypris fallax Fox, 1967		+			+
P. fulva (Brady, 1868)	3	+	+		+
P. pallida Alm, 1914	4	+			+
P. zschokkei (Kaufmann, 1900)		+			+
Pseudocandona albicans (Brady, 1864)		+			+
P. cf. *albicans* (Brady, 1864)	1				
P. cf. *marchica* (Hartwig, 1899)	5				
P. rostrata (Brady & Norman, 1889)	2				
Pseudolimnocythere cf. *hypogea* Klie, 1938	1				
Psychrodromus betharrami Baltanás *et al*., 1993		+		+	+
P. cf. *betharrami* Baltanás *et al*., 1993	5				
P. fontinalis (Wolf, 1920)	2				+
P. olivaceus (Brady & Norman, 1889)	84			+	+
Scottia pseudobrowniana Kempf, 1971					+
Unidentified Cyprididae		+			
Number of taxa	**13**	**13**	**2**	**4**	**17**

A female specimen of the genus *Pseudolimnocythere*, belonging to the Loxoconchidae, a family mostly represented by brackish and marine species, was collected in CIR2. It shows affinities with *P. hypogea*, an endemic, stygobiont species of Apulia (southern Italy) found in anchialine caves and also in freshwater and brackish wells (Pesce & Pagliani 1999; Karanovic & Pesce 2001). The only other recent representative of the genus is *P. hartmanni* from subterranean waters of Greece (Danielopol 1979). One fossil species, *P. hainburgensis*, was described for the Miocene of the Vienna Basin (Danielopol *et al*. 1991, 2007). The record from the northern Apennines is likely to represent a lineage originated from marine interstitial ancestors. Although its specific status remains to be unambiguously confirmed by the collection and the study of additional material, it permits to extend the known geographical distribution of the genus *Pseudolimnocythere*. To this regard, it must be mentioned that abundant material attributable to this genus has been recently collected in another area of the northern Apennines (Secchia Valley), namely in the Poiano karst springs, which are associated with Triassic evaporites (Stoch *et al*. 2008, in press).

The use of different sampling techniques (mosses and traps) allowed for collecting samples representative of the local microcrustacean fauna. In particular, harpacticoids were abundant in mosses and ostracods in traps; cyclopoids were relatively rare, without significant differences between the two methods. The three most abundant harpacticoid species, all belonging to the genus *Bryocamptus*, were evenly recorded from both moss and trap samples. The drift tubes yielded only three copepod specimens: one of the stygobiont *E.*

pseudophreatica, one of the eustygophilic *Moraria stankovitchi*, reported primarily as stygobiont but collected also in springs (Stoch & Tomasin 2002), and one of *D. bisetosus*, a surface cyclopoid species that is also frequently found in groundwater habitats (e.g., Moldovan *et al*. 2001; Malard *et al*. 2003; Masciopinto *et al*. 2006).

The rare occurrence of most of the copepod and ostracod taxa and the overall scarcity of data, due to only one season of sampling, did not allow for the detection of any clear pattern in the distribution of the spring microcrustaceans in relation to different environmental variables (altitude, watershed, lithology, degree of disturbance).

In conclusion, the high diversity recorded in the investigated springs underlines the importance of these fragile habitats, which are rarely considered in traditional ecological research. Mountain springs are increasingly threatened by direct and indirect impacts, such as changes in hydrological cycles, water pollution, and physical alteration of the habitat structure. The reduction of anthropic impacts on these ecosystems will hopefully become a priority in conservation and restoration projects, especially in protected areas.

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