

Original scientific article
Received: 2009-04-22

UDC 597.556.333.1:591.9(282.249.1)

FRESHWATER GOBIES IN THE ADRIATIC DRAINAGE BASIN OF THE WESTERN BALKANS

Radek ŠANDA

Department of Zoology, National Museum, CZ-115 79 Prague, Václavské náměstí 68, Czech Republic

E-mail: RSanda@seznam.cz

Marcelo KOVAČIĆ

Rijeka Natural History Museum, HR-51000 Rijeka, Lorenzov prolaz 1, Croatia

ABSTRACT

The knowledge of the west Balkan freshwater gobies in the Adriatic drainage basin is still poor and insufficient for their adequate and effective conservation. New data on geographical and ecological distribution of freshwater gobies in the Adriatic drainage basin of the West Balkans are provided. A considerable extension of the known range in this area is demonstrated for Knipowitschia caucasica, Padogobius bonelli and Pomatoschistus canestrinii. For the first time, Knipowitschia radovici and Knipowitschia croatica have been reported from the River Neretva catchment in Bosnia and Herzegovina. The find of K. radovici is, so far, the second known record of this species. Pomatoschistus montenegrensis is reported from Albania for the first time.

Key words: Gobiidae, geographic distribution, ecological distribution, Adriatic drainage, Western Balkans

GHIOZZI D'ACQUA DOLCE NEL BACINO IDROGRAFICO ADRIATICO DEI BALCANI OCCIDENTALI

SINTESI

La conoscenza dei ghiozzi d'acqua dolce dei Balcani occidentali nel bacino idrografico Adriatico è ancor sempre scarsa ed insufficiente per una conservazione adeguata ed effettiva di tali specie. L'articolo fornisce nuovi data sulla distribuzione geografica ed ecologica dei ghiozzi d'acqua dolce nel bacino idrografico Adriatico dei Balcani occidentali. Viene dimostrata un'estensione considerevole della distribuzione fino ad oggi nota per le specie Knipowitschia caucasica, Padogobius bonelli e Pomatoschistus canestrinii. Viene inoltre riportata per la prima volta la presenza di Knipowitschia radovici e Knipowitschia croatica nel fiume Neretva, in Bosnia ed Erzegovina. Per K. radovici si tratta inoltre della seconda segnalazione in assoluto. Pomatoschistus montenegrensis viene segnalato per la prima volta in Albania.

Parole chiave: Gobiidae, distribuzione geografica, distribuzione ecologica, bacino idrografico Adriatico, Balcani occidentali

INTRODUCTION

The knowledge on the west Balkan freshwater gobies in the Adriatic drainage basin has been extended considerably in the recent years. Four new species have been described (Kovačić, 2005a; Kovačić & Šanda, 2007; Miller & Šanda, 2008; Miller, *in press*), and new data on morphology, ecology and distribution of already known species published (Kovačić & Pallaoro, 2003; Kovačić, 2005b). So far, eight freshwater gobies have been recorded for this area. This includes *Knipowitschia mrakovcici* Miller, 2009 from the River Krka, a species known since 1989, but described only recently (Mrakovčić *et al.*, 1994; Miller, 2009). Most of these species are endemic, restricted to small isolated freshwater habitats and vulnerable to human threats. However, the knowledge on their taxonomy, geographical and ecological distribution, as well as on their life histories and present human-induced threats is far from the level that could enable their effective conservation and could prevent species extinction. The aim of this paper is to provide information on the extended geographical and ecological distribution of the West Balkan freshwater gobiid species, based on the positive identification of our material, as well as of the published data, and on the published information on the deposition of the collected material.

MATERIAL AND METHODS

Fishes were collected by electrofishing or by hand net during scuba-diving. The examined material is deposited in the National Museum Prague (NMP) and in the Rijeka Natural History Museum (Prirodoslovni muzej Rijeka – PMR). The data on all used material are listed for each species in the Results section.

The identification was carried out using identification keys and the so far published species descriptions (Miller, 2003, 2004; Kovačić, 2005a; Kovačić & Šanda, 2007; Miller & Šanda, 2008). The head lateral line system was checked using a binocular. When necessary, the specimens were stained in 2% KMnO₄ solution for 20 s and 0.3% H₂SO₄ solution for 20 s, which allowed a better examination of sensory papillae rows. The diagnoses are a minimum combination of characters that positively identify researched specimens among the European and Ponto-Caspian gobiid species (Miller, 2003, 2004; Kovačić, 2005a; Kovačić & Šanda, 2007; Miller & Šanda, 2008). Morphometric and meristic methods follow Miller (1988). The meristic abbreviations: A, anal fin; C, caudal fin; D, dorsal fins; P, pectoral fin; V, pelvic disc; LL, scales in lateral series; TR, scales in transverse series. The terminology of lateral-line system follows Sanzo (1911), Economidis & Miller (1990) and Miller (2004).

The published data on gobiid species are considered to have a positive identification when the following criteria have been met: the specimens are deposited in collections, or the published description contains enough morphological data for a positive identification. All other published data were cited separately and discussed in the remarks. The information on the ecological distribution was based on the published data and our data from the new records.

RESULTS

Knipowitschia caucasica (Berg, 1916)

Material examined. 10 specimens, PMR VP1113, River Zrmanja, Jankovića buk, Dalmatia, Croatia, 44° 12'10.3" N, 15°43'17.2" E, 18 October 2002; 10 specimens, PMR VP1114, River Zrmanja, between Obrovac and the river mouth, Dalmatia, Croatia, 44°13'1.2" N, 15°38'30.5" E, 18 October 2002; 10 specimens, PMR VP1119, River Krka, Žurići, Dalmatia, Croatia, 43°49' 12.4" N, 15°56'11.7" E, 7 May 2003; 1 specimen, PMR VP1289, Desansko lake, drainage of the River Neretva, Dalmatia, Croatia, 43°3'4.8" N, 17°31'4.8" E, 22 June 2004; 1 specimen, PMR VP1390, mouth of the River Raša, Istria, Croatia, 45°4'25.6" N, 14°2'0.5" E, 23 May 2005; 1 specimen, PMR VP1399, mouth of the River Raša, Istria, Croatia, 45°2'57.2" N, 14°2'56.2" E, 22 September 2005; 1 specimen, PMR VP1400, mouth of the River Raša, Istria, Croatia, 45°3'37.7" N, 14°2'34" E, 22 September 2005; 1 specimen, PMR VP1985, Privlaka, near Zadar, Dalmatia, Croatia, 44°16'37.6" N, 15°7'41. 3" E, 26 April 2008.

Diagnosis. (1) sensory papillae with suborbital row *a*, (2) interorbit without two or more transverse rows of papillae, (3) the anterior oculoscapular and preopercular canals present, (4) coloration not uniformly black above, (5) the posterior oculoscapular canal present at least in a part of the population, (6) the scales beginning anteriorly from the rear end of D1 at least in a part of the population.

Distribution. (Fig. 1) Published data: Dinjiška on Pag Island, River Karišnica flowing into Karinsko Sea, Karinsko Sea, Vransko Lake, Pirovac in Pirovački Bay, Prokljansko Lake in Krka River basin, River Jadro in Morinj Bay near Šibenik, River Pantan near Trogir, River Cetina near Omiš, all in Croatia (Kovačić & Pallaoro, 2003).

New data: the mouth of the River Raša on Istria, Privlaka near Zadar, River Zrmanja between Obrovac and its mouth to the sea and in Jankovića buk, River Krka in Žurići, Desansko Lake in the River Neretva catchment, all in Croatia. The knowledge about the range of *K. caucasica* in the Adriatic Sea basin was considerably extended. Previously published data delimit the known area of occurrence to the northern and cen-

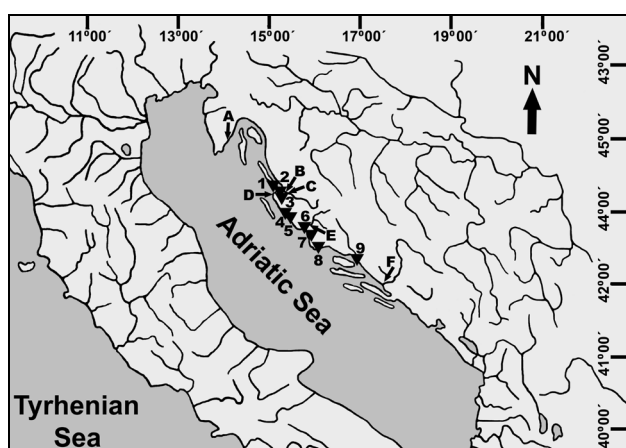


Fig. 1: The occurrence of *Knipowitschia caucasica* in the Adriatic drainage basin of the Western Balkans. ▼ indicates published records (Kovačić & Pallaoro, 2003): 1 – Dinjiška on Pag Island; 2 – Karinsko Sea; 3 – River Karišnica; 4 – Vransko Lake; 5 – Pirovac in Pirovački Bay; 6 – Prokljansko Lake; 7 – River Jadro in Morinj Bay; 8 – River Pantan; 9 – River Cetina. New records are indicated by arrows: A – mouth of the River Raša; B – River Zrmanja between Obrovac and mouth to the sea; C – River Zrmanja in Jankovića buk; D – Privlaka; E – River Krka in Žurići; F – Desansko Lake.

Sl. 1: Pojavljanje vrste *Knipowitschia caucasica* v Jadranskom povodju zahodnega Balkana. ▼ ponazarja objavljene podatke (Kovačić & Pallaoro, 2003): 1 – Dinjiška na otoku Pagu; 2 – Karinsko morje; 3 – Reka Karišnica; 4 – Vransko jezero; 5 – Pirovac v Pirovačkom zalivu; 6 – Prokljansko jezero; 7 – Reka Jadro pri Morinjskem zalivu; 8 – Reka Pantan; 9 – Reka Cetina. Novi podatki so označeni s puščicami: A – ustje reke Raše; B – Reka Zrmanja med Obrovcem in njenim ustjem v morje; C – Reka Zrmanja pri Jankovića buku; D – Privlaka; E – Reka Krka pri Žurićih; F – Desansko jezero.

tral Dalmatia, from the southern coast of the Island Pag to the River Cetina catchment (Kovačić & Pallaoro, 2003). An intensive research revealed presence of this species in the River Neretva catchment and in the waters of the Istrian peninsula, as well as in several new places within the previously known range.

Ecological distribution. Euryhaline species, found in brackish running to slowly running waters: mouths of rivers, springs by the sea, small lagoons or tidal pools, sea-influenced parts of rivers. Found in places with highly variable bottom: mud, sand, gravel or boulders, bare or covered with algae or *Zostera* spp.

Remarks. The range of *K. caucasica* is very large, including brackish coastal waters of the Caspian, Black, Aegean, the eastern Ionian (Miller *et al.*, 2004) and the eastern Adriatic Seas (Kovačić & Pallaoro, 2003). There

is a considerable hiatus in the distribution of *K. caucasica* from the River Neretva estuary to the River Acheloos in Greece. Some authors suggest that the Adriatic basin is inhabited by *K. pannizae* (Economidis & Miller, 1990; Miller *et al.*, 2004; Kottelat & Freyhof, 2007). Recognizing the described high variability in morphological characters of the Adriatic populations of *K. caucasica* (Kovačić & Pallaoro, 2003), it is not always possible to positively distinguish between *K. caucasica* and *K. pannizae*. Further investigations, including detailed morphological and molecular analyses, are necessary to solve this problem. However, the studied populations of the Adriatic *K. caucasica* clearly differ from the published description of *K. pannizae* (Miller, 1972) (see diagnosis).

***Knipowitschia croatica* Mrakovčić, Kerovec, Misić, Schneider, 1996**

Material examined. 10 specimens, PMR VP1599, River Matica, Polje Rastoka, Croatia, 43°12'29.5" N, 17°23'57.6" E, 14 October 2006; 10 specimens, PMR VP1613, River Matica, Polje Rastoka, Croatia, 43°12'51.1" N, 17°25'14.9" E, 19 October 2006; 27 specimens, NMP P6V 85605-85610, 85613-85627, 85628-85633, channel in Hutovo Blato wetland, Bosnia and Herzegovina, 43°03'51.5" N, 17°45'18.8" E, 23 July 2004, 13 July 2006 and 24 September 2008; 2 specimens, NMP P6V 85611-85612, River Trebižat above Kravica waterfalls, Bosnia and Herzegovina, 43°9'38.5" N, 17°36'45.1" E, 22 July 2004; 3 specimens, NMP P6V 84588-84590, River Trebižat in Teskera, Bosnia and Herzegovina, 43°11'0.9" N, 17°31'21" E, 14 July 2006.

Diagnosis. (1) sensory papillae with suborbital row *a*, reaching anteriorly at least below anterior edge of pupil, (2) head canals absent, (3) interorbit without multiple transverse rows of papillae, (4) body squamation reduced to axillar patch, (5) D1 modally VI, (6) A 1/8.

Distribution. (Fig. 2) Published data: River Matica in karst field Polje Jezero, Bačina Lakes, Modro oko Lake, River Norin, all in Croatia (Mrakovčić *et al.*, 1996).

New data: karst field Polje Rastoka, Croatia; channel in Hutovo Blato wetland, River Trebižat above Kravica waterfalls, River Trebižat in Teskera, all in Bosnia and Herzegovina. The occurrence of *K. croatica* is reported for the first time from several localities in Bosnia and Herzegovina, as well as from the karst field Rastoka in Croatia. The known distribution area covers the lower River Neretva basin up to the town of Čapljina and karst fields Jezero and Rastoka. To be able to confirm the presence of *K. croatica* in the River Neretva upstream of Čapljina and in its inflow Bregava, as well as in the River Trebižat upstream of village Teskera, further investigation is required.

Ecological distribution. Oligotrophic karst waters, both slowly running and stagnant. In fresh and slightly

population, (5) coloration without numerous small, but intense black spots in males.

Distribution. (Fig. 2) Published data: known only from its type locality, the River Norin, an inflow of the River Neretva in Croatia (Kovačić, 2005a).

New data: It was found for the first time in Bosnia and Herzegovina, in a channel in Hutovo Blato wetland in the River Neretva catchment. This place is located only 10 km aerial distance from the type locality.

Ecological distribution. Found only in oligotrophic karst freshwaters, both in running and almost stagnant. Juveniles were found in littoral areas with vegetation, together with *K. croatica*, whereas adults were collected in deep water in the flow. The bottom in the flow was made of gravel, changing to mud laterally in the case of the River Norin, while it was composed of fine sediment covered amply with woody debris in the case of the channel in Hutovo Blato. This species tolerates temperatures of up to at least 24°C.

Remarks. Vuković (1977) published information on the presence of several gobies (*Padogobius panizzai*, *Pomatoschistus canestrini*, *P. microps* – the names are given exactly in the form used in the original publication) in the lower Neretva in Bosnia and Herzegovina. This work could partially refer to this species. Glamuzina *et al.* (2008) and Dulčić *et al.* (2008) referred to the presence of undescribed *Knipowitschia* species found in lakes Svitava and Deran in Hutovo Blato wetland, Bosnia and Herzegovina. Their *Knipowitschia* sp. is most probably *K. radovici*. The distribution of *K. radovici* in the lower River Neretva catchment needs further investigation.

Padogobius bonelli (Bonaparte, 1846)

Material examined. 10 specimens, PMR VP1052, Stream Dobarnica, Dalmatia, River Zrmanja catchment, Croatia, 44°12'0" N, 15°46'12" E, 17 October 2002; 4 specimens, PMR VP1053, River Zrmanja, Ogari, Croatia, 44°11'34" N, 15°47'22" E, 17 October 2002; 7 specimens, PMR VP1054, River Zrmanja, Kaštel Žegarski, Croatia, 44°9'38" N, 15°51'15" E, 16 October 2002; 10 specimens, PMR VP1116, River Zrmanja, Berberi buk, Dalmatia, Croatia, 44°11'46" N, 15°46'6" E, 17 October 2002; 8 specimens, PMR VP1406, River Mirna, Sv. Ivan, Buzet, Istria, Croatia, 45°23'54.6" N, 13°58'47.2" E, 19 September 2005; 10 specimens, PMR VP1408, River Mirna, Motovun, Istria, Croatia, 45°20'47.5" N, 13°49'44" E, 20 September 2005; 2 specimens, PMR VP1409, River Mirna, between Veliki Mluni and Mali Mluni, Istria, Croatia, 45°23'33.9" N, 13°54'45.5" E, 20 September 2005; 10 specimens, PMR VP1407, Stream Račički, Mirna drainage, Istria, Croatia, 45°21'42.7" N, 13°51'19.2" E, 23 September 2005; 1 specimen, PMR VP1988, lower part of the River Ričica, 44°23'12.7" N, 15°44'58.1" E, Lika, Croatia, 28 June 2008.

Diagnosis. (1) sensory papillae without suborbital

row a, (2) scales normal, (3) no free pectoral rays, (4) anterior nostril not elongate beyond upper lip, (5) no scales on anterior nape, (6) head canals absent.

Distribution. (Fig. 3) Published data: Occurrence of *P. bonelli* (under the name *P. martensii*) was reported from the lower River Zrmanja catchment and the lower Krka catchment (near Krka–Čikola waterfalls), all in Croatia (Bianco & Miller, 1990).

New data: It was found in the River Zrmanja considerably further upstream from the previously published locality. It was also found in several places within the River Mirna catchment in Istrian peninsula. Furthermore, it was found in the River Ričica, belonging to the River Lika catchment, where it had been most probably introduced. The presented data confirmed the previously supposed presence in the River Mirna basin (see remarks) and extended the knowledge about the species' occurrence in the River Zrmanja basin.

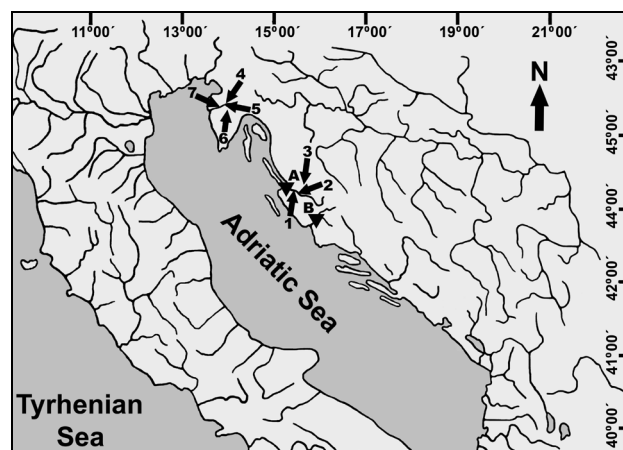


Fig. 3: The occurrence of *Padogobius bonelli* in the Adriatic drainage basin of the Western Balkans. ▼ indicates published records (Bianco & Miller, 1990): A – lower part of the River Zrmanja; B – River Krka near Krka–Čikola waterfalls. New records are indicated by arrows: 1 – closely located places in the River Zrmanja drainage (River Dobarnica, Ogari and Berberi buk); 2 – River Zrmanja in Kaštel Žegarski; 3 – River Ričica, Lika drainage; 4 to 7 – River Mirna drainage (4 – Buzet; 5 – between Veliki Mluni and Mali Mluni; 6 – Račički Stream; 7 – Motovun).

Sl. 3: Pojavljanje vrste *Padogobius bonelli* v jadranskem povodju zahodnega Balkana. ▼ ponazarja objavljene podatke (Bianco & Miller, 1990): A – spodnji tok reke Zrmanje; B – Reka Krka pri slapovih Krka–Čikola. Novi podatki so označeni s puščicami: 1 – lokacije v povodju reke Zrmanje (reka Dobarnica, Ogari in Berberi buk); 2 – Reka Zrmanja pri Kaštelu Žegarskem; 3 – Reka Ričica, povodje Like; 4 to 7 – Povodje reke Mirne (4 – Buzet; 5 – med Velikimi Mluni in Malimi Mluni; 6 – Potok Račički; 7 – Motovun).

Ecological distribution. Freshwater species, present mainly in running waters of rivers and springs. Bottom: bare pebbles, boulders, bedrock or with scattered vegetation. Exceptional was its discovery in the muddy, slowly running water of the River Ričica in the Lika catchment.

Remarks. Several gobiid species were reported for the River Mirna in the various species lists published for Istria or Croatia in general: *Padogobius martensii*, *Knipowitschia pannizai*, *P. panizzae* (Leiner & Povž, 1993, 1994; Mrakovčić *et al.*, 1994; Leiner *et al.*, 1995). We believe that all these finds refer to the population of *P. bonelli* from the Mirna River. The presence of this species in the River Ričica, the Lika catchment, is probably a result of introduction or of a passive transference with water taken by the system of the reversible hydroelectric power plant Obrovac.

Pomatoschistus canestrinii (Ninni, 1883)

Material examined. 1 specimen, PMR VP1290, River Norin, Vid, catchment of the River Neretva, Dalmatia, Croatia, 43°4'52.8" N, 17°37'54.8" E, 24 June 2004; 5 specimens, PMR VP1291, Desansko Lake, catchment of the River Neretva, Dalmatia, Croatia, 43°3'4.8" N, 17°31'4.8" E, 22 June 2004; 7 specimens, PMR VP1292, Modro oko, catchment of the River Neretva, Dalmatia, Croatia, 43°3'26.7" N, 17°30'37" E, 21 June 2004; 10 specimens, PMR VP1293, Kutli Lake, catchment of the River Neretva, Dalmatia, Croatia, 42°57'1.9" N, 17°36'47.7" E, 22 June 2004; 1 specimen, PMR VP1294, River Neretva, near Bijeli vir, Dalmatia, Croatia, 43°0'27.7" N, 17°38'59.4" E, 22 June 2004; 10 specimens, PMR VP1374, mouth of the River Mirna, Istria, Croatia, 45°19'24.7" N, 13°36'14.4" E, 25 May 2005; 10 specimens, PMR VP1384, mouth of the River Raša, Istria, Croatia, 45°13'3.6" N, 14°3'43.2" E, 23 May 2005; 6 specimens, PMR VP1402, River Raša, near Kunj, Istria, Croatia, 45°4'30.9" N, 14°2'4.5" E, 22 September 2005; 7 specimens, PMR VP1405, River Mirna, near Sv. Dionizije, 45°20'7.6" N, 13°39'9.6" E, 20 September 2005.

Diagnosis. (1) sensory papillae with suborbital row *a*, (2) interorbit without two or more transverse rows of papillae, (3) squamation never reduced just to axillar patch, (4) the anterior oculoscapular canal always present, the preopercular and posterior oculoscapular head canals of variable occurrence, (5) coloration with numerous small, but intense black spots in males.

Distribution. (Fig. 4) Published data: Occurrence of *P. canestrinii* was reported from the lower River Zrmanja catchment up to village Nadvoda, the lower River Krka up to Skradinski buk, the rivers Jadro and Žrnovnica near Split, the lowermost part of the River Cetina and Bačinska Lakes in the River Neretva catchment, all in Croatia (Kovačić, 2005b).

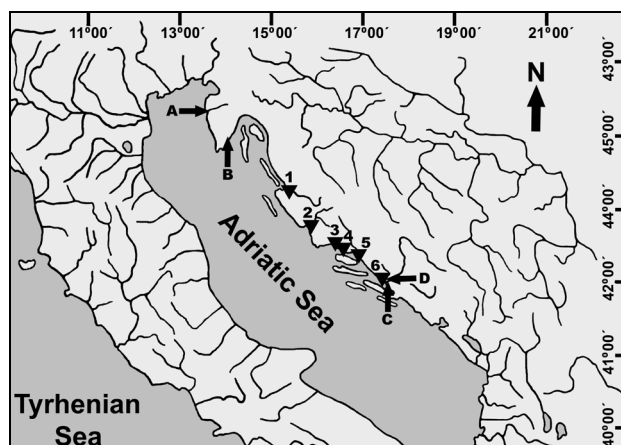


Fig. 4: The occurrence of *Pomatoschistus canestrinii* in the Adriatic drainage basin of the Western Balkans. ▼ indicates published records (Kovačić, 2005b): 1 – lower part of the River Zrmanja; 2 – lower part of the River Krka; 3 – River Jadro; 4 – River Žrnovnica; 5 – lowermost part of the River Cetina; 6 – Bačinska Lakes. New records are indicated by arrows: A – River Mirna (mouth to the sea and in Sv. Dionizije); B – River Raša (mouth to the sea and in Kunj); C and D – localities in the lower River Neretva drainage (C – River Neretva near Bijeli Vir and Kutli Lake; D – River Norin, lakes Desansko and Modro oko).

Sl. 4: Pojavljanje vrste *Pomatoschistus canestrinii* v Jadranskem povodju zahodnega Balkana. ▼ ponazarja objavljene podatke (Kovačić, 2005b): 1 – spodnji tok reke Zrmanje; 2 – spodnji tok reke Krke; 3 – Reka Jadro; 4 – Reka Žrnovnica; 5 – skrajni spodnji tok reke Cetina; 6 – Bačinska jezera. Novi podatki so označeni s puščicami: A – reka Mirna (ustje pri kraju Sv. Dionizije); B – reka Raša (ustje v morje in pri Kunju); C in D – lokalitete v povodju reke Neretve (C – reka Neretva pri Bijelem Viru in jezero Kutli; D – reka Norin, Desansko jezero in jezero Modro oko).

New data: It was found at several localities within the lower River Neretva catchment in Croatia (River Norin, River Neretva near Bijeli Vir, lakes Desansko, Modro oko and Kutli) and in the rivers Mirna and Raša on the Istrian peninsula. This considerably extends the knowledge about the occurrence of this species in the studied area.

Ecological distribution. Brackish (river mouths, sea-influenced parts of rivers and lakes) to freshwater parts of rivers separated from the sea by cascades; stagnant to running waters. Bottom highly variable: mud, coarse sand, gravel / pebbles, coarse sand between large rocks, boulders, mud / boulders, bare or with scattered vegetation.

Remarks. Vuković (1977) mentioned a presence of *P. canestrinii* in the lower River Neretva catchment in Bos-

nia and Herzegovina. However, there have been no reliable records of this species from this area so far. Further investigation is necessary to confirm the occurrence of *P. canestrinii* in the lower River Neretva catchment in Bosnia and Herzegovina.

Pomatoschistus montenegrensis Miller & Šanda, 2008

Material examined. 8 specimens, NMP P6V 81669-81676, River Buna, Muriqan, Albania, 23 August 2004, 41°59'59.5" N, 19°23'09.5" E.

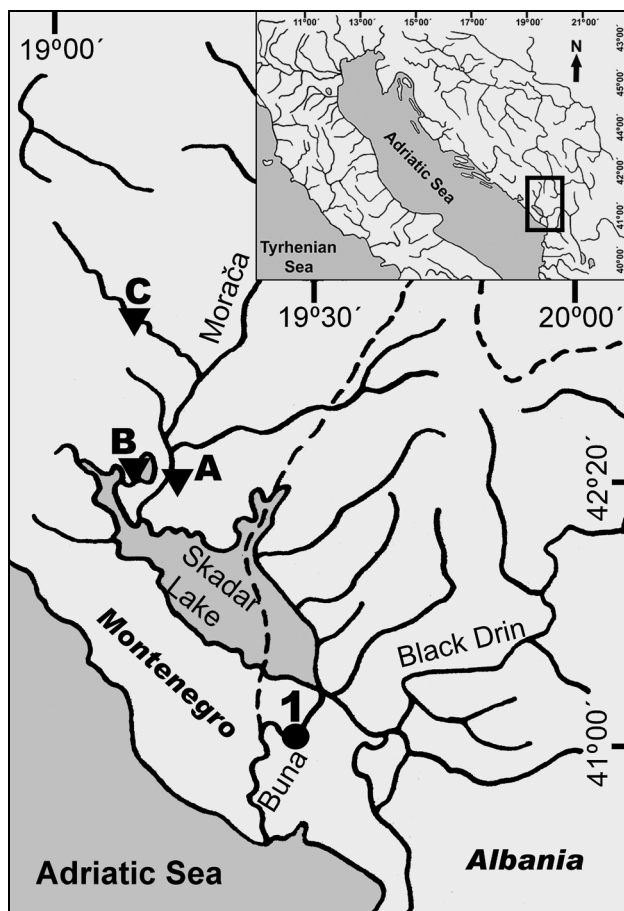


Fig. 5: The occurrence of *Pomatoschistus montenegrensis* in the Adriatic drainage basin of the Western Balkans. ▼ indicates published records: A – Morača River in Golubovci; B – Malo Blato Lake; C – River Zeta in Spuž. New record in the River Buna in Albania is marked by ● and number 1.

Sl. 5: Pojavljanje vrste *Pomatoschistus montenegrensis* v Jadranskem povodju zahodnega Balkana. ▼ ponazarja objavljene podatke: A – Reka Morača pri Golubovcih; B – Jezero Malo Blato; C – Reka Zeta pri Spužu. Novi podatki iz reke Bune v Albaniji je označen z ● in št. 1.

Diagnosis. (1) sensory papillae with suborbital row *a*, (2) interorbit without two or more transverse rows of papillae, (3) squamation reduced to axillar patch, (4) presence of the anterior oculoscapular canal, and consistent loss of the preopercular and posterior oculoscapular head canals, (5) coloration with numerous small, but intense black spots in males.

Distribution. (Fig. 5) Published data: Found in the lower River Morača and its tributary, the River Zeta in southern Montenegro, and in a large natural channel that connects Malo Blato Lake with the main body of Skadar Lake (Miller & Šanda, 2008).

New data: This species is reported from Albania for the first time, where it was found in the River Buna in Muriqan. The distribution area most probably includes Skadar Lake, its inflows and its outflow, the River Buna.

Ecological distribution. Found in freshwaters, in shallows with a slow current or in pools remaining in gravel pits after river flooding. The bottom substrate was gravel, covered with fine sediment and overgrown by dense filamentous algae or fine sediment associated with macrophytes.

Remarks. The known distribution corresponds well with the previous records of freshwater gobies identified as *K. panizzae* in Skadar Lake (Ivanović, 1973; Marić, 1995) and the lower Morača (Marić, 1995). *P. montenegrensis* may well occur throughout the whole Ohrid-Drim-Skadar system. Although later authors do not mention gobies from Ohrid Lake or the River Drim, Vinciguerra (1933) noted a freshwater goby in Lake Ohrid. Further detailed investigation is necessary to identify the range of this species.

DISCUSSION

A careful determination of recently collected material from the area of the Adriatic catchment of the Western Balkans lead to a description of four new freshwater goby species during the last five years, including *K. mrakovcici* from the River Krka, which has been known since 1989, but was just recently described (Kovačić, 2005a; Kovačić & Šanda, 2007; Miller & Šanda, 2008; Miller, 2009). However, taxonomy of some species needs further investigation. The systematic status of *K. caucasica* and *K. pannizae* urgently requires a re-evaluation (Kovačić & Pallaoro, 2003). Is *K. caucasica* a widespread species in the area from the Adriatic to the Black Seas, does the Adriatic *K. pannizae* need a re-description, or are there even more than two euryhaline *Knipowitschia* species in this large area that includes several parts of the Mediterranean and the Black Seas? The relationships of the west Balkan gobies at a generic level are in some cases also questionable. Do *P. canestrinii* and *P. montenegrensis* constitute a monophyletic assemblage, which could differ from other *Pomatoschistus* species (Miller & Šanda, 2008)? Is *Knipowitschia*

monophyletic? What are the relationships of sand goby genera (*sensu* McKay & Miller, 1997) and species?

Despite the obvious progress in the knowledge of systematics, geographic distribution and habitat of most of the species remain poorly known. Data presented in this work show that freshwater gobies from the Adriatic drainage basin of the Western Balkans belong to two groups *i.e.*, euryhaline and strictly freshwater species. Euryhaline species, *K. caucasica* and *P. canestrinii*, are the most widespread freshwater gobies in the Adriatic drainage of the Western Balkans, occurring in suitable habitats throughout the whole area. Compared to *P. canestrinii*, *K. caucasica* was found at more localities, which indicates its higher ecological valence that allowed this species to disperse through marine conditions and to colonize even isolated brackish habitats (Fig. 1). *P. canestrinii* seems to be bound more strictly to areas with stable freshwater flow, e.g. larger rivers and non-drying up streams. The orientation of *P. canestrinii* towards the freshwater habitats is also suggested by its occurrence in purely freshwater sections of the river basins. On the other hand, *K. caucasica* was always found in at least slightly brackish habitats. The rest of the gobies from the Adriatic drainage of the Western Balkans, e.g. *K. croatica*, *K. radovici*, *P. bonelli* and *P. montenegrensis*, are freshwater species, only very rarely occurring in slightly brackish habitats. Also *K. mrakovcici* from the River Krka and *Knipowitschia montenegrina* Kovačić & Šanda, 2007, which are not presented in detail in this work, were found only in freshwaters (Mrakovčić *et al.*, 2006; Kovačić & Šanda, 2007; Miller, 2009).

The extension of the known geographic range was revealed for almost all the species of freshwater gobies from the Adriatic drainage basin of the Western Balkans. *P. canestrinii*, *K. caucasica* and *P. bonelli* were reliably documented for the first time in waters of the Istrian peninsula. Furthermore, *K. caucasica* was recorded for the first time from the River Neretva catchment and *P. bonelli* from the River Lika catchment, the former representing most probably an introduction. The remaining studied species were recorded from new localities within the basins, to which they are endemic. *P. montenegrensis* was recorded from the Skadar Lake basin in Albania, *K. radovici* and *K. croatica* from the River Neretva basin in Bosnia and Herzegovina. No new localities were recorded for *K. mrakovcici* from the River Krka basin and *K. montenegrina* from the Skadar Lake basin. *K. mrakovcici* is known from Visovačko Lake (Miller, 2009) and *K. montenegrina* from the River Morača in Montenegro (Kovačić & Šanda, 2007).

In large river basins in the Adriatic drainage basin of the Western Balkans, usually several gobies occur, par-

tially in sympatry. In the River Neretva basin, *K. caucasica*, *K. croatica*, *K. radovici* and *P. canestrinii* were found. In the River Krka basin, *K. mrakovcici*, *K. caucasica*, and *P. canestrinii* were found by the authors, and *P. bonelli* was reported by Bianco & Miller (1990). In the River Zrmanja basin, *K. caucasica*, *P. bonelli* and *P. canestrinii* were recorded. The same species were recorded in waters of the Istrian peninsula, though only *P. bonelli* and *P. canestrinii* in the same catchment (River Mirna). In the Skadar Lake basin, *P. montenegrensis* and *K. montenegrina* live in sympatry. Finally, in the River Cetina, *K. caucasica* and *P. canestrinii* were found. Further ecological studies are necessary to reveal the extent of range of the species and ecological overlaps between them. In most basins, two euryhaline and one or two freshwater species occur. Only freshwater species have up to now been found just in the Skadar Lake basin, whereas in the River Cetina only euryhaline species have been recorded. Furthermore, the endemism of strictly freshwater species, occurring (with the exception of *P. bonelli*) always in only one river basin, seems to be an interesting phenomenon. In general, evolution and dispersion of freshwater fishes are closely related to paleogeography and especially to the history of basin connections as a consequence of the geological development of landscapes (Bianco 1990; Bermingham & Martin, 1998). The differentiation within the freshwater gobies from the Western Balkan Adriatic drainage basin may have well resulted from the late Miocene to Quaternary hydrographic events in the Adriatic basin (Bianco & Miller, 1990; Miller, 1990; Miller & Šanda, 2008). Marine regressions led to connections of the previously isolated river basins (Bianco, 1990). Marshy conditions must have promoted the extension of the euryhaline lagoonal fauna along the coastline of the much shorter Adriatic basin, where the Meso-Adriatic Depression (Fossa Meso-Adriatica) remained a flooded basin that may have facilitated the dispersal of euryhaline fishes between catchments that are now separate (Bianco & Miller, 1990). Subsequent rise of the sea level, as a strong vicariant event, might have served to isolate estuarine and freshwater populations of freshwater gobies. To understand the biogeography and phylogenetic relationships of the freshwater gobies from the Adriatic drainage basin of the Western Balkans, further investigation is necessary, which would include incorporation of molecular techniques.

Finally, a good knowledge of the biology and ecology of the freshwater gobies of the Western Balkan Adriatic drainage basin, together with the identification of their population status and possible threats, will allow for efficient preparation of adequate national action plans.

ACKNOWLEDGEMENTS

We wish to thank the local authorities for enabling the field work. We are grateful to all who helped us with field sampling, especially to D. Radović, I.D. Grlica, J. Vukić, I. Bogut and I. Wilson. Special thanks are due to J. Vukić, who improved English in our manuscript. RŠ

was supported by the Fisheries Society of the British Isles (small research grant Diversity and Phylogenetic Relationships of Albanian Freshwater Gobies) and project DE06P04OMG008 of the Czech Ministry of Culture. MK was supported in part by the Ministry of Science, Education and Sports of the Republic of Croatia (Grants No. 119-1782739-1233 and 001-0013077-0844).

SLADKOVODNI GLAVAČI V JADRANSKEM POVODJU ZAHODNEGA BALKANA

Radek ŠANDA

Department of Zoology, National Museum, CZ-115 79 Prague, Václavské náměstí 68, Czech Republic
E-mail: RSanda@seznam.cz

Marcelo KOVAČIĆ

Prirodoslovni muzej Rijeka, HR-51000 Rijeka, Lorenzov prolaz 1, Hrvaška

POVZETEK

Naše znanje o zahodnobalkanskih sladkovodnih glavačih Jadranskega povodja je še vedno preskromno, da bi lahko poskrbeli za njihovo ustrezno in učinkovito zaščito. V članku avtorja navajata nove podatke o geografski in ekološki razširjenosti sladkovodnih glavačev v Jadranskem povodju zahodnega Balkana. Za vrste *Knipowitschia caucasica*, *Padogobius bonelli* in *Pomatoschistus canestrinii* sta ugotovila, da je njihov areal precej večji v obravnavanem območju od areala, znanega doslej. Prvič je bilo zabeleženo pojavljanje vrst *Knipowitschia radovici* in *Knipowitschia croatica* v povodju reke Neretve v Bosni in Hercegovini. Najdba *K. radovici* pa je doslej drugi znani zapis te vrste. Poročilo o pojavljanju glavača *Pomatoschistus montenegrensis* v Albaniji je prvo o tej vrsti iz tega dela Balkana.

Ključne besede: Gobiidae, geografska razširjenost, ekološka razširjenost, Jadransko povodje, zahodni Balkan

REFERENCES

Bermingham, E. & A. P. Martin (1998): Comparative mtDNA phylogeography of neotropical freshwater fishes: Testing shared history to infer the evolutionary landscape of lower Central America. *Mol. Ecol.*, 7, 499–517.
Bianco, P. G. (1990): Potential role of the paleohistory of the Mediterranean and Paratethys basins on the early dispersal of Mediterranean freshwater fishes. *Ichthyol. Explor. Freshw.*, 1, 167–184.
Bianco, P. G. & P. J. Miller (1990): Yugoslav and other records of the Italian freshwater goby, *Padogobius martensii*, and a character polarization in gobioid fishes. *J. Nat. Hist.*, 24, 1289–1302.
Dulčić, J., P. Tutman, B. Glamuzina, B. Skaramuca & H. Ahnelt (2008): Endemic gobies (Gobiidae) of the Hutovo blato wetland (Neretva River basin, Bosnia and Herzegovina) and their conservation status. In: Skaramuca, B. & J. Dulčić (eds.): *Zbornik radova znanstveno-naučnog*

skupa Ugrožene i endemske vrste riba u slivovima rijeka Neretve, Trebišnjice i Morače (Park prirode Hutovo blato, 14.–15. prosinca 2007). Sveučilište u Dubrovniku, The EastWest Institute, Dubrovnik, pp. 61–66.

Economidis, P. S. & P. J. Miller (1990): Systematics of freshwater gobies from Greece. *J. Zool. Lond.*, 221, 125–170.

Glamuzina, B., J. Dulčić, E. Hasković, A. Ivanc, S. Mandić, D. Mrdak & B. Skaramuca (2008): Stanje ihtiofaune u slivovima rijeka Neretve, Trebišnjice i Morače tijekom ljetnih meseci 2007. godine. In: Skaramuca, B. & J. Dulčić (eds.): *Zbornik radova znanstveno-naučnog skupa Ugrožene i endemske vrste riba u slivovima rijeka Neretve, Trebišnjice i Morače* (Park prirode Hutovo blato, 14.–15. prosinca 2007). Sveučilište u Dubrovniku, The EastWest Institute, Dubrovnik, pp. 21–41.

Ivanović, B. M. (1973): Ichthyofauna of Skadar Lake. Montenegrin Institute of Biological and Medical Research, Podgorica Biological Station, Podgorica, 146 p.

- Kottelat, M. & J. Freyhof (2007):** Handbook of European freshwater fishes. Kottelat, Cornol and Freyhof, Berlin, 646 p.
- Kovačić, M. (2005a):** A new species of *Knipowitschia* (Gobiidae) from Dalmatia, Croatia. *Cybium*, 29(3), 275–280.
- Kovačić, M. (2005b):** Morphological variability of *Pomatoschistus canestrinii* (Gobiidae), with the reduction of squamation and head canals. *Cybium*, 29(4), 373–379.
- Kovačić, M. & A. Pallaoro (2003):** Is *Knipowitschia caucasica*-like form from the Adriatic Sea a new Goby species? Evidence from a morphological approach in the Eastern Adriatic Sea. *Cybium*, 27, 81–164.
- Kovačić, M. & R. Šanda (2007):** A new species of *Knipowitschia* (Perciformes: Gobiidae) from southern Montenegro. *J. Natl. Mus. (Prague), Nat. Hist. Ser.*, 176(5), 81–89.
- Leiner, S. & M. Povž (1993):** Sladkovodne ribe (Pisces) Istrskega polotoka. *Ichthyos*, 12, 23–34.
- Leiner, S. & M. Povž (1994):** The freshwater fishes of Istrian Peninsula. *Period. Biol.*, 96(4), 431–434.
- Leiner, S., M. Povž & M. Mrakovčić (1995):** Freshwater fish in Istrian Peninsula. *Annales, Ser. Hist. Nat.*, 5(1), 215–222.
- Marić, D. (1995):** Endemic fish species of Montenegro. *Biol. Conserv.*, 72(2), 187–194.
- McKay, S. I. & P. J. Miller (1997):** The affinities of European sand gobies (Teleostei: Gobiidae). *J. Nat. Hist.*, 31, 1457–1482.
- Miller, P. J. (1972):** Gobiid fishes of the Caspian genus *Knipowitschia* from the Adriatic Sea. *J. Mar. Biol. Ass. U.K.*, 52, 145–160.
- Miller, P. J. (1988):** New species of *Corcyrogobius*, *Thorogobius* and *Wheelerigobius* from West Africa (Teleostei: Gobiidae). *J. Nat. Hist.*, 22, 1245–1262.
- Miller, P. J. (1990):** The endurance of endemism: the Mediterranean freshwater gobies and their prospects for survival. *J. Fish Biol.*, 37 (Suppl. A), 145–156.
- Miller, P. J. (ed.) (2003):** The Freshwater Fishes of Europe, Vol. 8/I. Aula-Verlag, Wiebelsheim, 416 p.
- Miller, P. J. (ed.) (2004):** The Freshwater Fishes of Europe. Vol. 8/II. Aula-Verlag, Wiebelsheim, 478 pp.
- Miller, P. J. (2009):** A West Balkanian freshwater gobiid fish, *Knipowitschia mrakovcici* sp. nov. (Teleostei: Gobiidae). *J. Fish Biol.*, 74(7), 1499–1507.
- Miller, P. J. & R. Šanda (2008):** A new West Balkanian sand-goby (Teleostei: Gobiidae). *J. Fish Biol.*, 72(1), 259–270.
- Miller, P. J., E. D. Vasileva & A. N. Economou (2004):** *Knipowitschia caucasica* (Berg, 1916). In: Miller, P. J. (ed.): The Freshwater Fishes of Europe. Vol. 8/II. Aula – Verlag, Wiesbaden, pp. 343–364.
- Mrakovčić, M., D. Schneider & M. Kerovec (1994):** Freshwater gobies of Croatia. *Period. Biol.*, 96, 441–443.
- Mrakovčić, M., M. Kerovec, S. Mišetić & D. Schneider (1996):** Description of *Knipowitschia punctatissima croatica*, (Pisces: Gobiidae), a new freshwater goby from Dalmatia, Croatia. In: Kirchhofer, A. & D. Hefti (eds.): Conservation of Endangered Freshwater Fish in Europe. Birkhauser Verlag, Basel, pp. 311–319.
- Mrakovčić, M., A. Brigić, I. Buj, M. Čaleta, P. Mustafić & D. Zanella (2006):** Crvena knjiga slatkovodnih riba Hrvatske. Ministarstvo kulture, Državni zavod za zaštitu prirode, Zagreb.
- Sanzo, L. (1911):** Distribuzione delle papille cutanee (organi ciatiforme) e suo valore sistematico nei Gobi. *Mitt. Zool. Stat. Neapel*, 20, 249–328.
- Vinciguerra, D. (1933):** Pesci di Albania raccolti dal Dr. Pietro Parenzan nel 1930. *Ann. Mus. Civ. Stor. Nat. Genova*, 56, 303–310.
- Vuković, T. (1977):** Ribe Bosne i Hercegovine. Igkro Svetlost, Sarajevo.