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GOBIIDS OF THE DNIPRODZERZHYNSK RESERVOIR (DNIEPER RIVER, UKRAINE): DISTRIBUTION AND HABITAT PREFERENCES

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Background. The Dniprodzerzhynsk reservoir is one of six reservoirs built on the Dnieper River, which currently supports important commercial and recreational fisheries. To date, there are no published data on the reservoir's non-commercial fish species, among which gobies are considered to be the most abundant and important species. The goal of this work was to contribute to general knowledge on local gobiid fauna, focusing on their mesohabitat preferences.

Materials and methods. Sampling in the Dniprodzerzhynsk reservoir was conducted during late August of 2011 and 2012 within the framework of routine annual juvenile fish surveys in the Dnieper reservoirs. Fish were collected at sampling sites located along the reservoir shoreline using a beach seine made of mill sieving gauze (1 mm mesh size). Mesohabitat features were recorded at each beach seine haul site, and included maximum depth, substrate type, and vegetation density. These data were used to identify fish mesohabitat preferences with the aid of Ivlev's electivity index.

Results. Seven gobiid species were collected: western tubenose goby, *Proterorhinus semilunaris* (Heckel, 1837); knout goby, *Mesogobius batrachocephalus* (Pallas, 1814); Pontian monkey goby, *Neogobius fluviatilis* (Pallas, 1814); round goby, *N. melanostomus* (Pallas, 1814); racer goby, *Babka gymnotrachelus* (Kessler, 1857); Pontian bighead goby, *Ponticola kessleri* (Günter, 1861); and ratan goby, *Ponticola ratan* (von Nordmann, 1840). Ratan goby was recorded for the first time from this reservoir. Most frequently encountered were monkey goby (76.27%), followed by western tubenose goby (32.20%), racer goby (31.36%), round goby (14.41%), bighead goby (10.17%), while knout and ratan gobies were the most rare (each accounting for 1.69%). All gobiids showed preferences for certain mesohabitat features such as bottom substrate and aquatic vegetation density.

Conclusion. The gobiid fauna of the reservoir is rich and is dominated by monkey goby. The occurrence of ratan goby, an estuarine and marine species that adapted to freshwater conditions, is an evidence for ongoing Ponto-Caspian gobiid invasion to the Dnieper reservoirs.

Keywords: Gobies, alien species, *Proterorhinus*, *Neogobius*, *Ponticola*, *Babka*, *Mesogobius*

INTRODUCTION

Gobies represent a large polymorphic family (Gobiidae), which includes up to 2000 mostly marine species, distributed worldwide, which are most diverse in shallow tropical coastal waters. They are generally small benthic fishes inhabiting marine and brackish waters and few are found in pure freshwater (Kalinina 1976, Kottelat and Freyhof 2007).

Gobiids of the Ponto-Caspian region currently attract considerable attention of ecologists and fisheries biologists due to successful invasion by several members of the group (round, monkey, bighead, racer, and tubenose gobies) of water bodies situated outside of their native range. These species are invasive in both Europe (upper and middle Danube, North and Baltic Sea basins) (Jurajda et al. 2005, Sapota and Skóra 2005, van Kessel et al. 2009, Czugała and Woźniczka 2010) and North America (Laurentian Great Lakes) (Ricciardi and MacIsaac 2000, Neilson and Stepien 2009) where they have undergone rapid range expansion since their introduction in the 1990s (Charlebois et al. 2001). Their spread has been attributed to a combination of factors such as ballast water introductions, bait transfers, hull transfers, and natural population expansions (Cepkin et al. 1992, Marsden et al. 1996). Invasive goby species cause significant changes in the composition and abundance of benthic invertebrates (Barton et al. 2005), decline of native fishes (French and Jude 2001, Corkum et al. 2004), and increased energy transfer to piscivorous fish (Johnson et al. 2005).

Thirteen (Vasil'eva 2003) to fifteen (Movčan 2012) gobiid species have been reported from the Dnieper River, three of which occur only in the Dnieper-Bug Lagoon and

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two reports are considered doubtful (Movčan 2012). Nine species are currently known from the Dnipropetrovsk region, which partially covers Dnieper and Dniprodzerzhynsk reservoirs: Black-Sea tadpole goby, *Benthophilus nudus* Berg, 1898; beardless tadpole goby, *Benthophiloides brauneri* Beling et Iljin, 1927; longtail dwarf goby, *Knipowitschia longicaudata* (Kessler, 1877); western tubenose goby, *Proterorhinus semilunaris* (Heckel, 1837); knout goby, *Mesogobius batrachocephalus* (Pallas, 1814); Pontian monkey goby, *Neogobius fluviatilis* (Pallas, 1814); round goby, *N. melanostomus* (Pallas, 1814); racer goby, *Babka gymnotrachelus* (Kessler, 1857); and Pontian bighead goby, *Ponticola kessleri* (Günter, 1861) (see Bulahov et al. 2008). Gobies of the Dnieper reservoirs do not have commercial value, but are recreationally fished and are also an important prey for piscivorous fishes (Smirnov 1986, Drobot et al. 2003, Bulahov et al. 2008, Dìdenko and Gurbìk 2012).

Only two goby species, western tubenose goby and Pontian monkey goby, historically inhabited the Dnieper River reach currently covered by the Dniprodzerzhynsk Reservoir before impoundment (Suhojvan and Vâtčanina 1989). Four new gobiids were recorded in this reservoir in the 1980s almost 20 years after its establishment: Black-Sea tadpole goby, racer goby, round goby, and bighead goby (Suhojvan and Vâtčanina 1989). However, no recent information on gobiid fauna is available for this body of water. There are also very limited data on habitat preferences of some goby species (especially recent invaders) in other Dnieper reservoirs. At the same time, rich fauna of gobiids of these reservoirs allows studying habitat partitioning between them that may be important for management of their populations in other water bodies.

Thus, the goal of this work was to extend the general knowledge on gobiid fauna of the Dniprodzerzhynsk Reservoir and their general ecology via evaluation of composition, distribution, relative densities, and habitat use of gobies in the littoral zone of the reservoir.

MATERIALS AND METHODS

Study area. The Dniprodzerzhynsk Reservoir is the second smallest reservoir after the Dnieper Reservoir in the cascade of six Dnieper reservoirs, and was created within 1963–1965. The water body covers an area of 567 km^2 (Denisova et al. 1989) and is located partially on the territory of Dnipropetrovsk, Poltava, and Kirovograd Oblasts (regions) of Ukraine. It has a length of 114 km, maximum width of 20 km, average depth of 4.3 m, and maximum depth of 16 m (Denisova et al. 1989). The area with depths less than 1 m composes 17% of its total area, while the total area of shallow waters with depth less than 2 m is 31% (Grinževs′kij 1998).

Data collection. Sampling in the Dniprodzerzhynsk Reservoir was conducted in late August 2011 and late August 2012 within the framework of routine annual juvenile fish surveys in the Dnieper reservoirs. In total, 67 sites at 9 locations (Kremenchuk, Ps'ol River mouth, Keleberda, Deriivka, Mishurin Rog, Svitlogorske and Vorskla River mouth, Dnieper–Donbas canal inlet, Verkhn'odniprvs'k, Auly), which had been selected and used in previous years as control sampling sites for juvenile commercial fish monitoring program, were sampled (from 4 to 11 sites per location depending on availability of hauling areas) (Fig. 1). The majority of sites were sampled twice in both 2011 and 2012. Geographical coordinates of each sampling site were registered using a GPS receiver (Garmin Dakota 10).

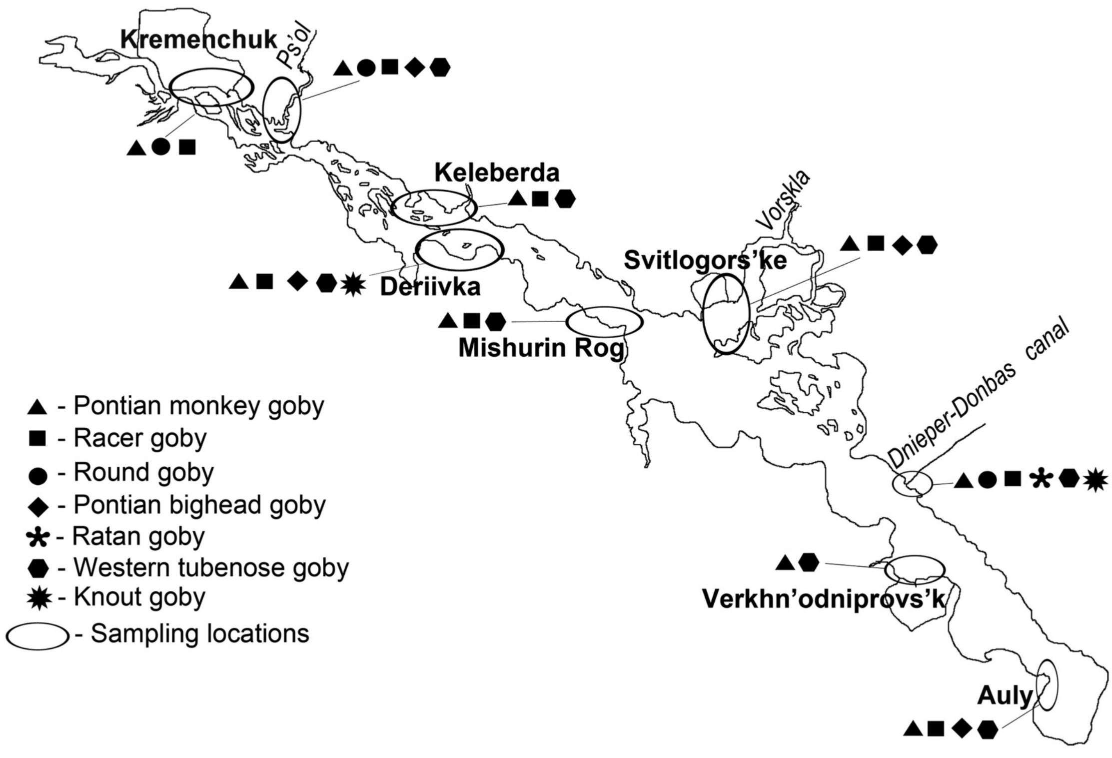

Fig. 1. Locations of goby catches in the Dniprodzerzhynsk Reservoir

Fish were collected using a beach seine made of the mill sieve gauze (10 m long × 1 m high with 1.0 mm bar mesh size). The area of seine hauls depended on the water depth and bank steepness and ranged from approximately 10 to 100 m^2, which was measured visually using the seine length as a reference. On some sites, fish were additionally sampled by angling. Fish were usually processed in the field (species identification, counting, length and weight measurements). Standard length (SL) and weight were determined, to the nearest 1.0 mm and 0.01 g, respectively, using a ruler and an electronic balance.

Mesohabitat features within each beach seine haul site (maximum depth, substrate type, and vegetation density) were recorded. Maximum bottom depth was measured to the nearest 5 cm using a 1.5 m rod placed onto the substrate in the deepest part of the seine hauling area (usually the farthest part from the shore). The substrate was assessed visually and categorized as: sand (35 sites); muddy sand (40 sites); mud (8 sites); clay (5 sites); stones—including all hard substrates such as gravel, rocks, concrete (5 sites); sand + stones: sand or muddy sand with inclusion of hard substrates such as gravel or rocks (13 sites); sand + shells grounds: specific shoreline mesohabitat, where deeper sand or muddy sand changes to shallower ground covered by a layer of dead Gastropoda shells (mainly *Viviparus* sp.) (7 sites). Aquatic vegetation density was assessed visually and categorized as: absent (no vegetation) (28 sites); sparse (isolated aquatic plants) (23 sites); medium (multiple groups of aquatic plants covering less than 50% of the bottom surface) (30 sites); dense (more than 50% of the bottom surface is covered with aquatic vegetation) (35 sites). Aquatic plants included submerged ones, those with floating leaves, and emergent species.

Data analysis. The distribution of each gobiid species was characterized by its frequency of occurrence (FO) calculated as the percentage of total samples containing a certain species. Fish relative density for every site was calculated as the catch-per-unit-effort (CPUE = number of fish caught per 100 m^2 of a seine haul). Data were log transformed to satisfy the assumptions of normality. The mean values of non-transformed data are reported in tables.

Relations between gobiid CPUE and maximum depth of the sampling site were examined using linear regression. CPUE values were log transformed before analysis to normalize them.

A one-way analysis of variance (ANOVA) was performed on the data to test for difference among the mean number of fish caught (CPUE) on different substrates and vegetation densities and to identify which of these factors had greater effect on gobiid distribution. A multiple comparisons procedure (Tukey–Kramer) was used in the case of significant difference to compare all possible pairs of mean CPUE of gobiids caught on different substrates and vegetation densities. ANOVA and Tukey–Kramer test were performed at the significance level of a = 0.05.

Substrate type and vegetation density preferences of gobiids were evaluated using Ivlev's electivity index:

$$E_i = (r_{ij} - n_j) \cdot (r_{ij} + n_j)^{-1}$$

where: r_{ij} is the percentage of captured individuals (per 100 m^2) of species i in habitat j and n_j is the percentage of habitat j sampled (Ivlev 1961, Smokorowski et al. 2008). Values around zero indicate no preference, –1 mean total avoidance, and 1 indicate complete preference. I this study, value from –0.10 to 0.10 were considered as absence of preference or avoidance, values higher than 0.50 or lower than –0.50 as strong preference or avoidance, respectively, and all other values as some preference or avoidance.

When performing statistical analysis and calculating Ivlev's electivity index, fish were separated into adults and/or sub-adults (fish with adult appearance) and fry (Koblickaâ 1981). The same sites sampled in both 2011 and 2012 were treated separately. Fish captured by angling and species represented by less than 10 individuals were not included in the statistical analysis.

Statistical calculations were performed with JMP IN 4 (SAS Institute Inc.).

RESULTS

Altogether, 1219 specimens of gobies were caught by beach seine in 2011 and 2665 in 2012 (7.5% and 19.0% of total catch by number, respectively). Fifty-five specimens were caught by angling gears, and one was accidentally caught in a Petersen dredge near Auly when sampling benthos from the depth of 6 m.

In total, seven gobiid species were captured: western tubenose goby; Pontian monkey goby; round goby; Pontian bighead goby; racer goby; ratan goby, *Ponticola ratan* (von Nordmann, 1840); and knout goby. No gobies were caught at 5 sites of 67 (for both years). Highest gobiid diversity was observed in locations with the highest mesohabitat diversity such as the Ps'ol River mouth and the Dnieper–Donbas canal inlet (4 mesohabitat types at each location), while Verkhn'odniprvs'k beach, where only two gobiid species were caught, was characterized by only two mesohabitat types.

Monkey goby was the most frequent species, followed by tubenose goby and racer goby (Table 1, Fig. 1). The least frequently observed species were knout goby and ratan goby, which were both caught only at two sampling sites located, however, at two different locations in the case of the first species and one location in the case of the second species. Monkey-, round-, knout-, and ratan gobies were caught with beach seine and with angling gears. The goby caught with the Petersen dredge was one specimen of racer goby on the zebra mussel bed. The majority of species were recorded both as fry and sub-adult or adult individuals but bighead-, knout-, and ratan gobies were represented only by adults in the material sampled.

Monkey goby was the most abundant species, followed by racer goby and tubenose goby, while knout and ratan gobies were the least abundant (Table 1). Maximum CPUE values were observed for tubenose goby, if both juvenile and adult fish are included. Monkey goby, however, showed the highest maximum CPUE values of adults.

No association between fish relative density and maximum depth (meters) on the sampling site was found except for round goby, which showed some slight positive relation:

$$y = 16.84(\pm 6.69\ \text{SE})x - 7.0088(\pm 6.13\ \text{SE})$$
$$n = 109;\ r^2 = 0.06;\ P = 0.0133$$

Highest densities of sub-adult and adult gobies were observed on sand, followed by mud, muddy sand, and sand + shells, as well as on sparse vegetation density and on sites without vegetation, while gobiid fry was most abundant on clay substrate (but this was mainly due to high density of monkey goby fry) and dense and medium vegetation densities (Figs. 2 and 3). Significant differences in the number of fish caught on different substrates were observed only for fry and sub-adult/adult monkey goby, fry and sub-adult/adult round gobies (ANOVA, Tables 2 and 3). As for the vegetation densities, significant differences were observed only for fry and sub-adult/adult tubenose goby, adult bighead goby and adult racer goby (ANOVA, Tables 2 and 3).

Tukey–Kramer procedure showed significant differences in the number of fish caught only between clay and such substrates as sand, muddy sand, sand + shells, and stones for fry and between sand and stones for sub-adult/adult monkey goby; between dense vegetation and others vegetation types for both fry and sub-adult/adult tubenose goby; between sites without vegetation and

Table 1

Selected indices of gobiid fishes captured in August 2011 and August 2012 from the littoral zone of the Dniprodzerzhynsk Reservoir, Ukraine

Fish species	FO [%]	CPUE FA	CPUE A	Max CPUE FA	Max CPUE A	Mean SL [mm]	Mean *W* [g]
Proterorhinus semilunaris	32.2	15.38	5.69	504.00	53.33	31.7 ± 0.9	0.62 ± 0.07
Neogobius fluviatilis	76.27	60.97	28.33	430.00	375.00	51.5 ± 1.1	1.97 ± 0.46
Neogobius melanostomus	14.41	6.93	5.73	188.57	182.86	50.3 ± 3.5	2.57 ± 0.95
Babka gymnotrachelus	31.36	17.01	8.33	312.00	312.00	38.2 ± 1.4	1.02 ± 0.12
Ponticola kessleri	10.17	1.02	1.02	30.00	30.00	53.5 ± 2.6	2.94 ± 1.05
Ponticola ratan	1.69	0.03	0.03	1.82	1.82	—	—
Mesogobius batrachocephalus	1.69	0.07	0.07	4.00	4.00	—	—

FO = frequency of occurrence, CPUE = catch-per-unit-effort [fish per 100 m^2]. FA = combined mean values for fry and adult fish, A = combined mean values for only for sub-adult and adult fish, SL = standard length, SE = standard error, *W* = weight; SL and *W* values are mean ± SE; calculated only for the most abundant species (sub-adult and adult fish).

Table 2

Analysis of variance (ANOVA) for the effect of substrate type and vegetation density on catch-per-unit-effort (CPUE) values of adult gobiid fishes from the Dniprodzerzhynsk Reservoir, Ukraine

Fish species	Substrate (df = 6; 106)			Vegetation density (df = 3; 109)		
	MS	*F*	*P*	MS	*F*	*P*
Proterorhinus semilunaris	3.26	2.02	0.0693	8.09	5.31	**0.0019**
Neogobius fluviatilis	7.70	2.69	**0.0181**	5.70	1.87	0.1392
Neogobius melanostomus	6.33	5.70	**<0.0001**	1.31	0.94	0.4249
Babka gymnotrachelus	3.31	1.95	0.0798	6.63	4.01	**0.0095**
Ponticola kessleri	0.71	1.59	0.1572	1.68	3.93	**0.0105**

df = degrees of freedom, MS = mean square, *F* = *F*-ratio, *P* = significance level; Bold font denotes significant difference (α < 0.05).

Table 3

Analysis of variance (ANOVA) for the effect of substrate type and vegetation density on catch-per-unit-effort (CPUE) values of gobiid fry from the Dniprodzerzhynsk Reservoir, Ukraine

Fish species	Substrate (df = 6; 106)			Vegetation density (df = 3; 109)		
	MS	*F*	*P*	MS	*F*	*P*
Proterorhinus semilunaris	2.04	1.25	0.2894	7.14	4.73	**0.0039**
Neogobius fluviatilis	10.28	3.20	**0.0063**	9.11	2.63	0.0538
Neogobius melanostomus	1.09	3.25	**0.0057**	0.54	1.47	0.2273
Babka gymnotrachelus	1.16	0.78	0.5903	1.18	0.79	0.4996

df = degrees of freedom, MS = mean square, *F* = *F*-ratio, *P* = significance level; Bold font denotes significant difference (α < 0.05).

dense vegetation for sub-adult/adult racer goby; between stone substrate and sand, muddy sand, sand + shells, clay for adult round goby and between sand + stones and other substrates for fry round goby; between sparse vegetation and dense and absent vegetation for sub-adult/adult bighead goby (Figs. 2 and 3).

Knout goby was caught on muddy sand and stones (gravel). As for ratan goby, it was caught on sand + stones (beach seine) and gravel (angling) substrate.

All analysed gobiids showed preferences for substrate types and/or vegetation densities (Tables 4 and 5). Sub-adult and adult monkey goby preferred sand substrate and absent or sparse vegetation but avoided other substrates and dense vegetation. Fry monkey goby showed the highest preference for clay, some preference for sand + shells and mud, and dense and medium vegetation; however, they strongly avoided stones and in somewhat less degree sand + stones and sand as well as sparse or absent vegetation. Sub-adult and adult tubenose goby preferred mud and muddy sand substrates and dense vegetation, but avoided stones and sparse or absent vegetation. Fry tubenose goby showed highest preference for muddy sand and dense vegetation and avoidance for other substrate types and vegetation densities. Sub-adult and adult bighead goby preferred sand + shells, clay and sand + stones and completely avoided stones, mud, and areas with no vegetation. Sub-adult and adult racer goby slightly preferred sand and muddy sand substrates and strongly preferred sparse and in less degree dense vegetation, but avoided other substrates and vegetation densities. Its fry preferred only muddy sand and sand as well as sparse and medium vegetation. Sub-adult and adult round goby preferred stones and had some preference for mud and sand + stones and areas where vegetation was absent. They avoided clay and sand + shells, while fry preferred sand + stones. Fry round goby showed the highest preference only for sand + stones and some preference for absent and sparse vegetation.

Among sampled locations, the highest species diversity was recorded in the Ps'ol River mouth and near the Dnieper-Donbas canal inlet (6 species); the lowest was near Verkhn'odniprvs'k (2 species). In most samples, tubenose goby, monkey goby, round goby, and racer goby were represented by several specimens: 8.0; 13.9; 9.1; and 5.6 specimens, respectively (average number of fish in one sample, only adult fish, samples without these species are excluded), while bighead goby, knout goby, and ratan goby were represented usually by one specimen: 1.6; 1.0; and 1.0 specimen, respectively.

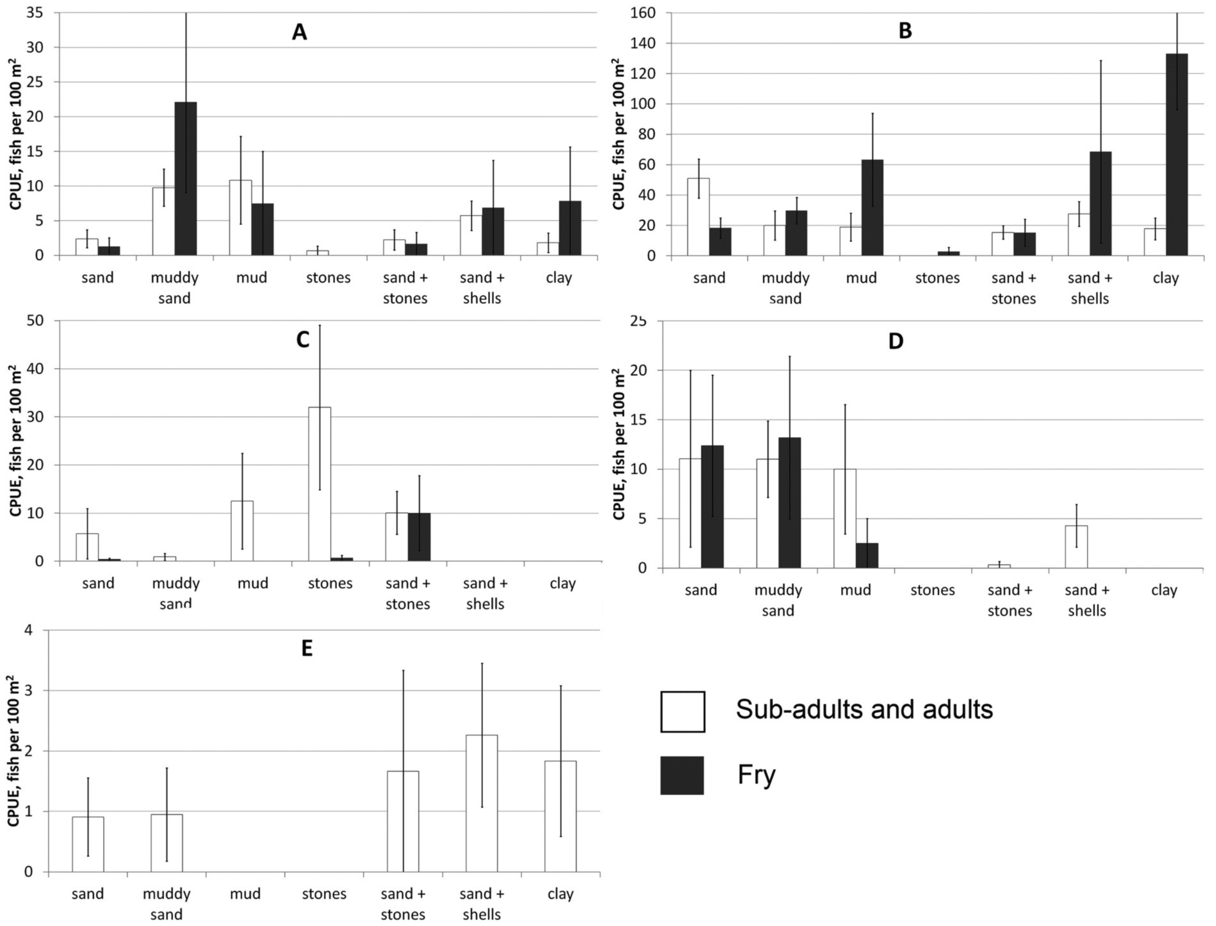

Fig. 2. Mean CPUE ± SE on different substrate types (for five most abundant gobiids): **A** western tubenose goby, *Proterorhinus semilunaris*; **B** Pontian monkey goby, *Neogobius fluviatilis*; **C** round goby, *N. melanostomus*; **D** racer goby, *Babka gymnotrachelus*; **E** Pontian bighead goby, *Ponticola kessleri*

DISCUSSION

This study confirmed presence of seven gobiid species in the Dniprodzerzhynsk Reservoir. Five are quite common for the Dnieper reservoirs: tubenose goby, monkey goby, round goby, bighead goby, and racer goby (Smirnov 1986, Bulahov et al. 2008). Knout goby is still rare in freshwaters (Kottelat and Freyhof 2007). It started penetrating upstream the Dnieper River from the Kakhovka Reservoir in the 1990s and was reported by anglers in the Dniprodzerzhynsk Reservoir (Bulahov et al. 2008).

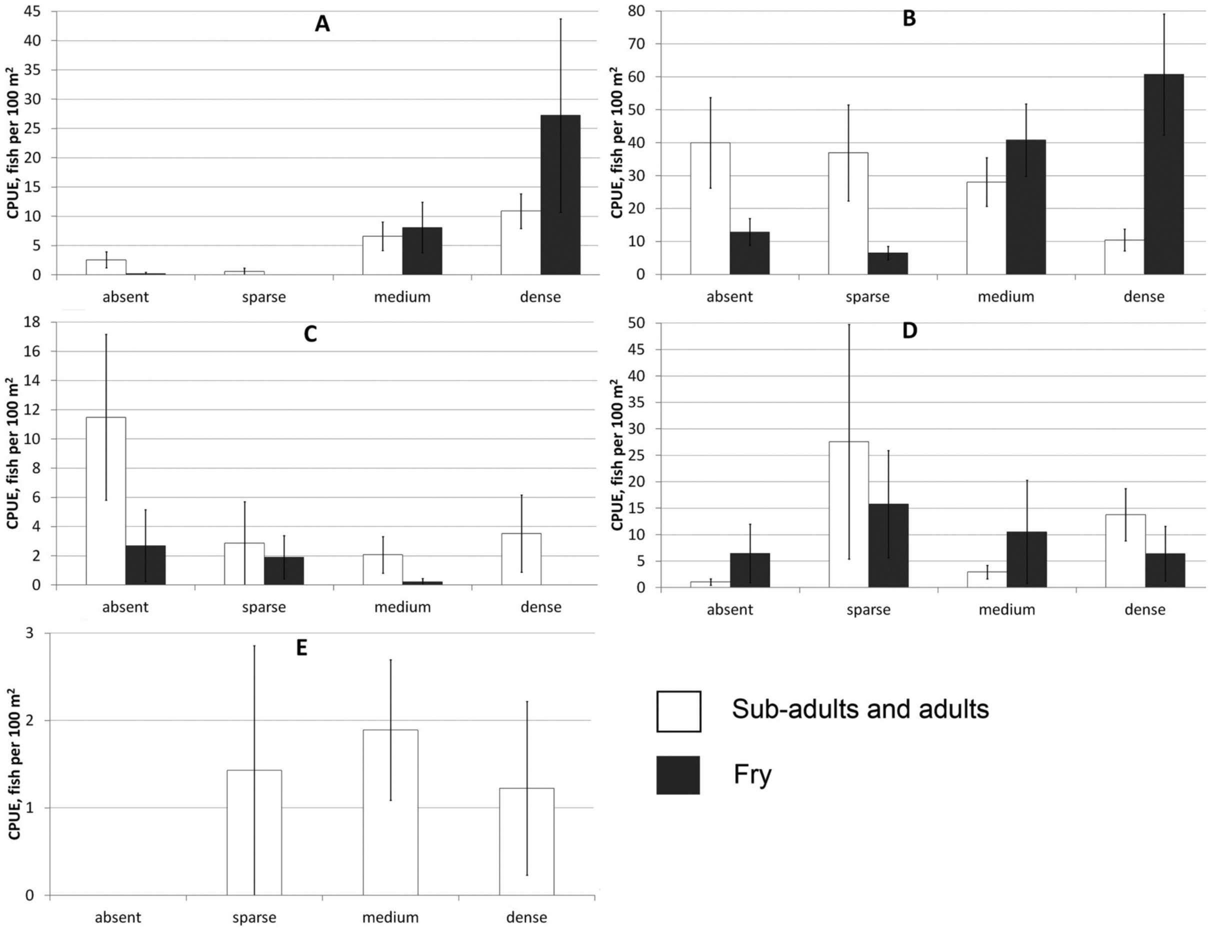

Fig. 3. Mean CPUE ± SE on different vegetation densities for five most abundant gobiids: **A** western tubenose goby, *Proterorhinus semilunaris*; **B** Pontian monkey goby, *Neogobius fluviatilis*; **C** round goby, *N. melanostomus*; **D** racer goby, *Babka gymnotrachelus*; **E** Pontian bighead goby, *Ponticola kessleri*

Table 4

Ivlev's electivity indices for sub-adult/adult and fry of gobiid fishes from the Dniprodzerzhynsk Reservoir, Ukraine for different substrate types

Fish species	Stage	Substrate						
		Sand	Muddy sand	Mud	Stones	Sand + stones	Sand + shells	Clay
Proterorhinus semilunaris	A	–0.41	0.26	0.31	–0.79	–0.44	0.00	–0.48
	F	–0.77	0.39	–0.13	–1.00	–0.71	–0.17	–0.11
Neogobius fluviatilis	A	0.28	–0.17	–0.20	–1.00	–0.30	–0.01	–0.23
	F	–0.28	–0.05	0.32	–0.84	–0.36	0.36	0.61
Neogobius melanostomus	A	0.00	–0.73	0.37	0.70	0.27	–1.00	–1.00
	F	–0.54	–1.00	–1.00	–0.37	0.79	–1.00	–1.00
Babka gymnotrachelus	A	0.14	0.14	0.09	–1.00	–0.92	–0.32	–1.00
	F	0.18	0.21	0.21	–1.00	–1.00	–1.00	–1.00
Ponticola kessleri	A	–0.06	–0.03	–1.00	–1.00	0.24	0.38	0.29

A = sub-adult/adult, F = fry.

Ratan goby is not common for freshwater reservoirs. This is a mesohaline fish, which inhabits littoral zones in the Black Sea and western part of the Sea of Azov and avoids desalinated zones; however solitary individuals were observed in lower reaches of some rivers (South Bug) up to 90 km from the sea (Belìng 1927, Pinčuk 1964). Nevertheless, Pinčuk et al. (1985) indicated that a dwarf form of this species established an isolated viable population in the Kakhovka Reservoir; however, no information has been available since then. This gobiid is not listed among freshwater fish in the Handbook of European Freshwater Fishes (Kottelat and Freyhof 2007). Taking into account that ratan goby was caught in both 2011 and 2012 and was represented by several length groups, it seems that this species established a viable population in the Dniprodzerzhynsk Reservoir at least at one location close to the Dnieper–Donbas canal inlet near an abandoned berth, which was actively used for unloading construction materials during construction of the Dnieper–Donbas canal facilities in the late 1970s.

Establishment of knout and ratan gobies can mean that they can survive and reproduce in fresh water and that the invasion of the Dnieper reservoirs with Ponto-Caspian gobiids still continues. This invasion is due to construction of large reservoirs on the Dnieper River that changed hydrodynamics and created limnic ecosystems which have facilitated spread of rather poorly swimming species; and impaired natural soil hydrochemical barriers resulting in an increase of water mineralization (Slynko et al. 2011, Witkowski and Grabowska 2012). Among all recorded gobiids only two (tubenose and monkey gobies) are native to this part of the Dnieper River (Suhojvan and Vâtčanina 1989), while all others reached that body of water and established there after impoundment and thus can be considered invasive. Knout and ratan gobies are probably more recent invaders than bighead-, round-, and racer gobies. However, it is possible that ratan goby was brought to the reservoir earlier but remained unnoticed until now due to its limited distribution.

Other gobiids that may also occur in the Dniprodzerzhynsk Reservoir are Black-Sea tadpole goby and beardless tadpole goby, which are recorded for other Dnieper reservoirs (Bulahov et al. 2008). However, they stay at some distance from the shoreline on deeper bottoms (Smirnov 1986) and consequently could not be caught by beach seine.

Relative densities of gobiids in the Dniprodzerzhynsk Reservoir were consistent with or exceeded those in other Dnieper reservoirs (Table 1). For example, in some locations of the Kakhovka Reservoir, CPUE values can reach 15.3–22.1 fish per 100 m^2 for tubenose goby, 10–18 fish per 100 m^2 for round goby, and up to 39–58 fish per 100 m^2 for monkey goby (Bulahov et al. 2008).

It seems that the substrate type was the critical factor in determining abundance of monkey and round gobies, while vegetation density was more important for tubenose-, bighead-, and racer gobies (Table 2). It is necessary to note that not all biotopes can be sampled using the beach seine—the preferred ones being shallow beaches without submerged obstacles. Therefore, the obtained values may be biased and the obtained results are supposed to be valid only for these habitats. Sampling of all available littoral habitats of the reservoir (including very complex ones, i.e., featuring elements of hydrotechnical infrastructure or other elements, which cannot be sampled with beach seine) using other fishing techniques (e.g., electrofishing, which is prohibited in Ukraine) might possibly reveal different preferences.

The studied gobiids showed significant preferences for some mesohabitats. According to different authors (Smirnov 1986, Kottelat and Freyhof 2007, Bulahov et al. 2008), monkey goby inhabits almost all biotopes, but prefers sand and mud bottom, and avoids aquatic vegetation. The same was observed in the Dniprodzerzhynsk Reservoir, where this species inhabited various substrate types, but showed preference for sand substrate and absence of vegetation. However, its fry was more abundant on clay substrate and in dense vegetation.

Table 5

Ivlev's electivity indices for sub-adult/adult and fry (in brackets) gobiid fishes from the Dniprodzerzhynsk Reservoir, Ukraine for different vegetation densities

Fish species	Stage	Vegetation density			
		Absent	Sparse	Medium	Dense
Proterorhinus semilunaris	A	–0.38	–0.82	0.08	0.31
	F	–0.96	–1.00	–0.09	0.48
Neogobius fluviatilis	A	0.17	0.13	–0.01	–0.46
	F	–0.43	–0.67	0.11	0.30
Neogobius melanostomus	A	0.33	–0.33	–0.47	–0.24
	F	0.38	0.23	–0.69	–1.00
Babka gymnotrachelus	A	–0.78	0.54	–0.48	0.25
	F	–0.15	0.29	0.10	–0.15
Ponticola kessleri	A	–1.00	0.17	0.30	0.09

A = sub-adult/adult, F = fry.

Round goby, *Neogobius melanostomus*, which according to different authors prefers zones of productive shell beds on hard bottom and has an affinity for rocky substrates (Smirnov 1986, Ray and Corkum 2001, Erős et al. 2005, Kottelat and Freyhof 2007, Brownscombe and Fox 2012), showed preference for stone and sand + stone substrate and for absent vegetation. However, it was also collected on mud substrate at some sampling sites in the Ps'ol River, which is not typical for this species. Abundance of round goby also depended on the depth that was consistent with their distribution in lakes Huron and Michigan, where this fish was more abundant in deeper habitats than in shallower ones (Cooper et al. 2009).

Racer goby, *Babka gymnotrachelus*, prefers sand or mud bottoms and is typically found in well vegetated or highly complex habitats and often occupies zebra mussel beds (Smirnov 1986, Kottelat and Freyhof 2007). In the Dniprodzerzhynsk Reservoir, this species also showed preference for sand and muddy sand and vegetated substrates, however, with the highest preference for sparse vegetation. As for mud substrate, sub-adult/adult racer goby was almost indifferent to it, while its fry strongly avoided muddy bottoms.

Pontian bighead goby, *Ponticola kessleri*, according to different authors, inhabits different substrate types: stony (Smirnov 1986, Jurajda et al. 2005), muddy sand and clay covered substrates and rarely sand (Bănărescu 1964). In the Dniprodzerzhynsk Reservoir, this species was most abundant on sand + shells grounds and sand + stones substrate and less abundant on mud and stones. However, due to the fact that bighead goby is relatively rare in the Dnieper Reservoirs and relatively few individuals were caught, it is possible that it was not represented in all suitable mesohabitats.

Western tubenose goby, *Proterorhinus semilunaris*, in different water bodies was associated with various mesohabitats: dense vegetation and coarse rock (Kottelat and Freyhof 2007), muddy bottoms with aquatic vegetation (Smirnov 1986), rocky ripraps (Jude and DeBoe 1996), silted and sandy habitats (Gursoy Gaygusuz et al. 2010), medium-sized stones and habitats with large amounts of vegetation (Janáč et al. 2012). In the Dniprodzerzhynsk Reservoir, unlike the Morava River (Janáč et al. 2012) and the St. Clair River (Jude and DeBoe 1996) where this species preferred rocky substrates and avoided fine substrates such as silt and sand, it showed preference for mud, muddy sand and dense vegetation and strong avoidance of stones and sandy bottoms and sites with absent or low vegetation. Low abundances of tubenose goby observed on stony and sandy bottoms in the Dniprodzerzhynsk Reservoir may be related to the fact that these substrates usually are not covered with aquatic plants, which are probably more important for this species than substrate type. As for the preference for dense vegetation, it was indicated by all above-mentioned authors. Especially high abundances of tubenose goby were observed in the mouths of rivers flowing into the Dniprodzerzhynsk Reservoir (Ps'ol and Vorskla) and in small sheltered bays, which were characterized by slow water flow, mud bottoms, and high vegetation density.

Differing mesohabitat preference probably allows gobiids to reduce both interspecific and intraspecific competition and populate virtually all biotopes in the reservoir. When analysing electivity indices (Table 4), it can be seen that positive values within each substrate type are observed only for one or two species. For example, sandy bottoms without- or with sparse vegetation are occupied mainly by adult monkey goby, clay bottoms by fry monkey goby, mud and muddy sand with high vegetation density by tubenose goby, while muddy sand with sparse vegetation by racer goby, stones and sand + stones without vegetation by round goby, while sand + stones, sand + shells, and clay with medium vegetation by bighead goby. However, it remains unclear if the observed preferences are true for all examined gobiids, because some of them may be displaced from their more suitable mesohabitats by more competitive species. For instance, bighead goby in the Dniprodzerzhynsk Reservoir is much less abundant than many other gobiids that may be due to the fact that it invaded this water body after it had been already colonized by monkey goby and tubenose goby, while in the middle Danube River this species was the first invader among gobiids and currently it outnumbers monkey goby and racer goby, which penetrated here later (Kováč et al. 2009), but it appeared to be less successful than round goby (Kováč et al. 2009, Borcherding et al. 2013). However, this issue needs to be investigated further.

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