LENGTH-WEIGHT RELATIONSHIP AND CONDITION OF THREE GOBY SPECIES IN THE DANUBE RIVER NEAR SLANKAMEN (SERBIA)

JASMINA KRPO-ĆETKOVIĆ, MAJA PRICA*, SRĐAN SUBOTIĆ*, MIROSLAV NIKČEVIĆ**, BRANISLAV MIĆKOVIĆ***

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Length-weight relationship and condition of 37 individuals of the monkey goby (*Neogobius fluviatilis*), 115 individuals of the round goby (*N. melanostomus*), and 40 individuals of the racer goby (*Babka gymnotrachelus*), caught in July and October 2011 in the Danube River near Slankamen (1216.02 rkm), were analyzed, as well as the relative abundance of each species sample associated with particular sediment types. The average length (± S.D.) of the sampled individuals was 8.76 ± 2.05 cm for the monkey goby, 7.52 ± 1.50 cm for the round goby, and 7.08 ± 0.94 cm for the racer goby. The average weight (± S.D.) of the sampled individuals was 5.49 ± 4.55 g for the monkey goby, 5.84 ± 3.68 g for the round goby, and 3.62 ± 1.78 g for the racer goby. The regression coefficient of the length-weight relationship was $b > 3$ for each species, which indicates a positive allometric growth. The highest average value of Fulton's condition factor was observed for the round goby (K = 1.2), followed by the racer goby (K = 1.0), and the lowest for the monkey goby (K = 0.7). The highest occurrence of the monkey goby was on the sandy bottom, of the round goby on silty-coarse pebble bottom, and of the racer goby on pebble bottom.

Keywords: length-weight relationship, Fulton's condition factor, allometric growth, bottom type, large river

INTRODUCTION

Ponto-Caspian gobiid species have increased their ranges along European river systems over the past several decades (KORNIS et al. 2012). While the round goby (*Neogobius melanostomus*) expansion was well documented, due to invasion of the Great Lakes of North America, the monkey goby (*Neogobius fluviatilis*) and the racer goby (*Babka gymnotrachelus*) expansions were less studied (ROCHE et al. 2013). Part of the invasion success of these species is their tolerance for wide spectrum of environmental factors and high phenotypic variability (REID and ORLOVA 2002). Non-native species could exert dominance within local fish communities (BORCHERDING et al. 2011) and may have an important role in food webs (KAKAREKO et al. 2005).

The aim of this study was to determine the length-weight relationship of three invasive goby species, their condition factor, as well as the relative abundance of each species sample associated with particular bottom type in the Danube River near Slankamen (Serbia).

MATERIALS AND METHODS

Thirty-seven specimens of the monkey goby (*N. fluviatilis*), 115 specimens of the round goby (*N. melanostomus*), and 40 specimens of the of racer goby (*B. gymnotrachelus*) were caught by angling in the Danube River near Slankamen (1216.02 river kilometer), Serbia. Angling was done with a casting rod, using housefly (*Musca domestica*) larvae as a bait. Immediately after capture, fish were unhooked and the bait removed before swallowing to eliminate its influence on the fish weight and condition factor. The first sample (n = 40) was collected in July 2011 from pebble substrate, the second sample (n = 106) was collected in October 2011 from substrate that mostly consisted of silt (85 %) and coarse pebbles (15 %), and the third sample (n = 46) was collected in October 2011 from sandy substrate. The total length (to the nearest 0.1 cm) and weight (to the nearest 0.01 g) were measured for each individual. The occurrence of sampled goby species on different bottom types was estimated as the percentage of each species within each bottom type.

* University of Belgrade, Faculty of Biology, Studentski trg 16, 11000 Belgrade, Serbia, e.mail: jkrpo@bio.bg.ac.rs, maja_oxford@yahoo.com, ssubotic@bio.bg.ac.rs

**University of Belgrade, Institute for Multidisciplinary Research, Kneza Višeslava 1, 1030 Belgrade, Serbia, e-mail: mvnikcevic@imsi.rs, baneklej@imsi.rsr

The length-weight relationships were estimated using the standard allometric equation:

$$W = a\,L^{b} \quad (1),$$

where W is the total body weight (g), L the total body length (cm), and *a* and *b* are the coefficients of regression between W and L. Weight-at-length curves were generated using the Simply Growth software (©PISCES Conservation Ltd, 2002). The Fulton's condition factor was calculated using the following equation (RICKER 1975):

$$K = \frac{W}{L^3}100 \quad (2).$$

RESULTS

A relatively broad range of lengths and weights was observed for all three species (**Tab. 1**). A span of nine 1-cm length classes was sampled for *N. fluviatilis* and *N. melanostomus*, and of six 1-cm length classes for *B. gymnotrachelus*.

The largest number of *N. fluviatilis* individuals were in the length class of 7 cm, of *N. melanostomus* in the length class of 8 cm, and of *B. gymnotrachelus* in the length class of 6 cm (**Fig. 1**).

The regression coefficient *b* of the length-weight relationship was $b > 3$ for each species. The highest *b* value was observed for *N. melanostomus*, and the lowest for *B. gymnotrachelus* (**Fig. 2**).

The highest average value of the Fulton's condition factor was observed for *N. melanostomus* ($K = 1.18$), followed by *B. gymnotrachelus* ($K = 0.97$), and the lowest for *N. fluviatilis* ($K = 0.67$) (**Fig. 3**).

Each of the sampled goby species showed the highest occurrence on a particular bottom type. The largest number of *N. fluviatilis* individuals were found on sandy bottom, while that of *N. melanostomus* on the silty bottom with coarse pebbles, and that of *B. gymnotrachelus* on the pebble bottom (**Tab. 2**).

DISCUSSION

Length-weight relationship of a fish varies between waterbodies, size ranges, growth stanzas, sexes, reproductive phases, and seasons (SAFRAN 1992, FROESE 2006), and to avoid bias, comparisons should be considered accurate only if calculations were done on samples that cover a similar size range.

Sampled individuals of the monkey goby from the Danube River had a higher value of the length-weight regression coefficient *b* (3.24) in comparison with specimens from its native range in Manyas Lake in Anatolia (2.98) (SASI and BERBER 2010). The authors suggest that such a low value of *b* is due to the lake being eutrophic and shallow, loaded with organic waste. In 16 streams in the same region of Turkey, ILHAN et al. (2012) found that the value is $b = 3.13$, and this is still lower than our estimate. On the other hand, SASI and BERBER (2010) observed a considerably higher value of the Fulton's condition factor ($K = 1.26$) then the value for the monkey goby from our study ($K = 0.67$); however, the mean body weight of the fish in their sample was higher (24.58 g) than in the sample from the Danube (17.45 g) for the same span of lengths, and that could be the reason for the higher value of *K* in this lake. The average *K* value of the monkey goby from the Sava River in Croatia was somewhat higher than in the Danube River ($K = 0.88$ for the specimens from the Sava River and $K = 0.94$ for specimens from its tributaries) (JAKOVLIĆ et al. 2015), but still lower than in its native range in Turkey.

Sampled individuals of the round goby in our study have a higher *b* value ($b = 3.41$) than TARKAN et al. (2006) reported for this species in NW Turkey (2.87–3.28, average $b = 3.10$), and PHILLIPS et al. (2003) for six tributary streams of Lake Erie in Pennsylvania ($b = 3.10$). Males and females of the round goby caught in the Gulf of Gdansk (SKORA and RZEZNIK 2001) have similar regression coefficients ($b = 2.96$ for males, $b = 3.00$ for females), and they are both lower than in our study. The round go-

Species	Pebble		Silt with coarse pebbles		Sand	
	n	%	*n*	%	*n*	%
N. fluviatilis	3	8	0	0	34	74
N. melanostomus	8	20	98	92	9	20
B. gymnotrachelus	29	73	8	8	3	7
Total	40	100	106	100	46	100

Tab. 1 Length (in cm) and weight (in g) of sampled goby species.

Species	Total body length (cm)			Weight (g)		
	Min	Max	Mean ± S.D.	Min	Max	Mean ± S.D.
N. fluviatilis	5.4	13.6	8.8 ± 2.1	0.98	17.45	5.49 ± 4.55
N. melanostomus	3.5	11.4	7.5 ± 1.5	0.38	19.07	5.84 ± 3.68
B. gymnotrachelus	5.8	10.2	7.1 ± 0.9	1.63	10.70	3.62 ± 1.78

Tab. 2 Occurrence of sampled goby species on different bottom types.

by from the Sava River in Croatia has a similar value of *b* (3.38) and almost identical value of the Fulton's condition factor (*K* = 1.17) (PIRIA et al. 2011) as individuals from the Danube River (*K* = 1.18).

The racer goby caught in its native range in the Marmara region in Turkey (TARKAN et al. 2006) had a higher value of the length-weight regression coefficient (*b* = 3.32), in comparison with our results (*b* = 3.05). GRABOWSKA (2005) observed differences in length-weight relationship between males and females of the racer goby in a reservoir of the Vistula River in Poland; the value of *b* in our study is lower than the value for males (*b* = 3.23), but higher than the value for females (*b* = 2.83).

High values of the of the exponent *b* in LW relationship equation, observed for all three species of gobies in the Danube, indirectly indicates their high successfulness in adapting to new habitats (PIRIA et al. 2011). GRULA et al. 2012 observed that the growth of freshly established Ponto-Caspian gobies was negative allometric, while the growth of the longer established individuals is positive allometric, suggesting a shift in resource allocation towards somatic growth, which corresponds to a more specialized life-history typical for native populations.

ERÖS et al. (2005) have observed the highest densities of the monkey goby over sandy bottoms, which is in line with our results. The same was reported by PIRIA et al. (2011) and JAKOVLIĆ et al. (2015) for monkey gobies from the Sava River in Croatia. Monkey goby is the only species of Ponto-Caspian gobiid species for which a positive correlation is established between the relative density and the increasing proportion of fine substrata in the Danube River in Hungary (ERÖS et al. 2005), and it is known to bury itself into sandy substrata to avoid potential predators (HOLČIK et al. 2003).

Round gobies from the Danube River were most abundant on a combination of silt and coarse pebble bottom. The preference for a combination substrate of stone-clay was observed by ZAREV et al. (2013) in 12 tributaries of the Danube in Bulgaria, and for combination of sand and stones by DIDENKO (2013) in the Dniprodzerzhynsk Reservoir in Ukraine. RAY and CORKUM (2001), PHILLIPS et al. (2003), ERÖS et al. (2005), and JURAJDA et al. (2005) suggest that round goby occurs more often on

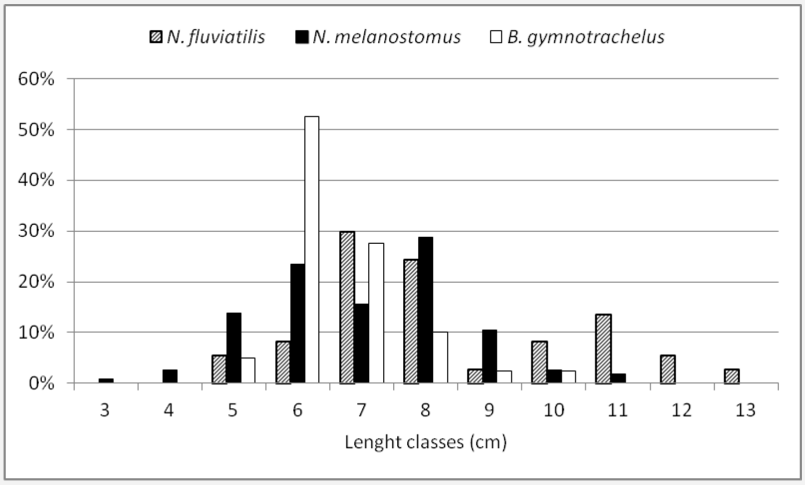

Fig. 1 Length frequency distribution of sampled goby species.

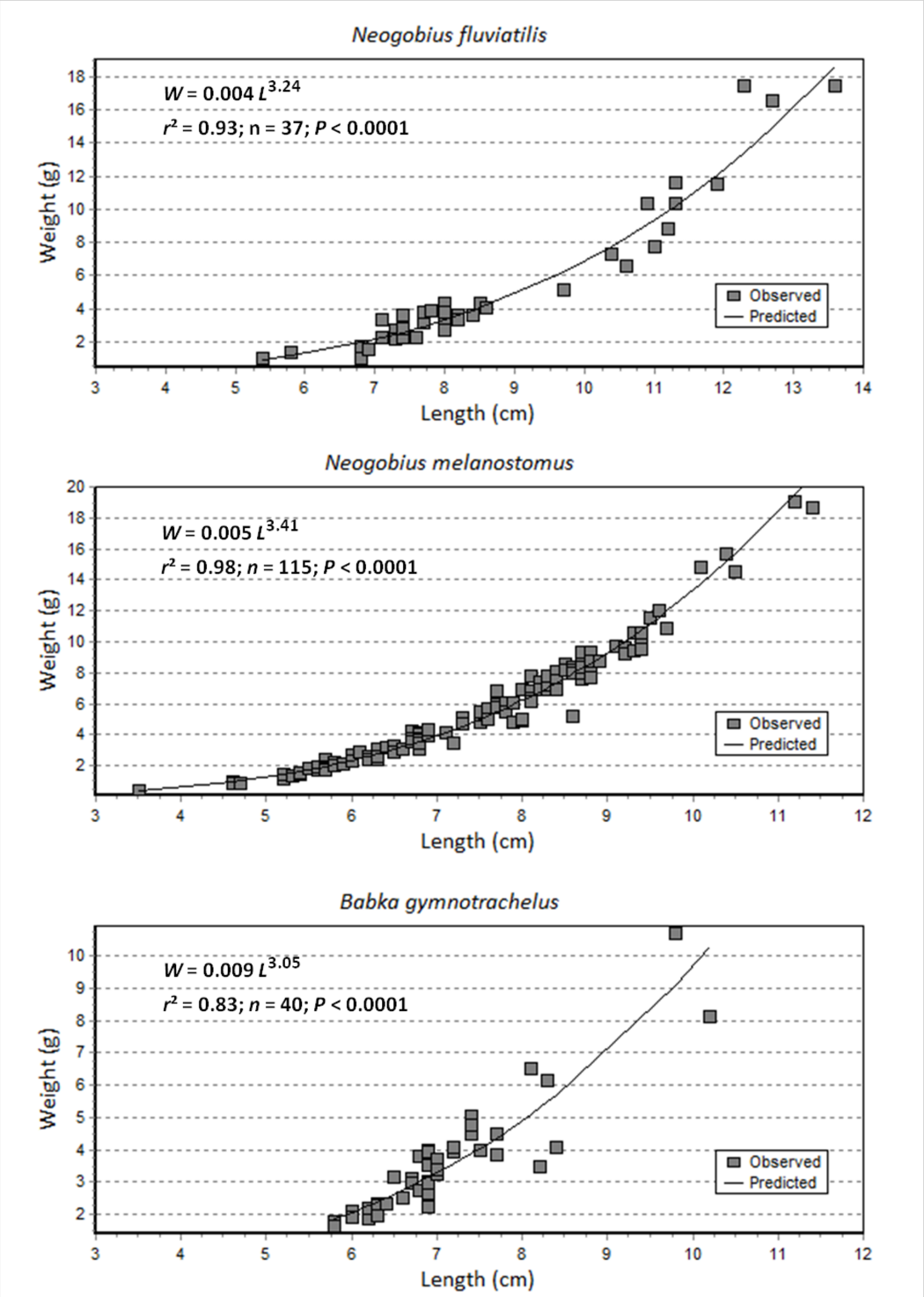

Fig. 2 Length-weight relationship of sampled goby species.

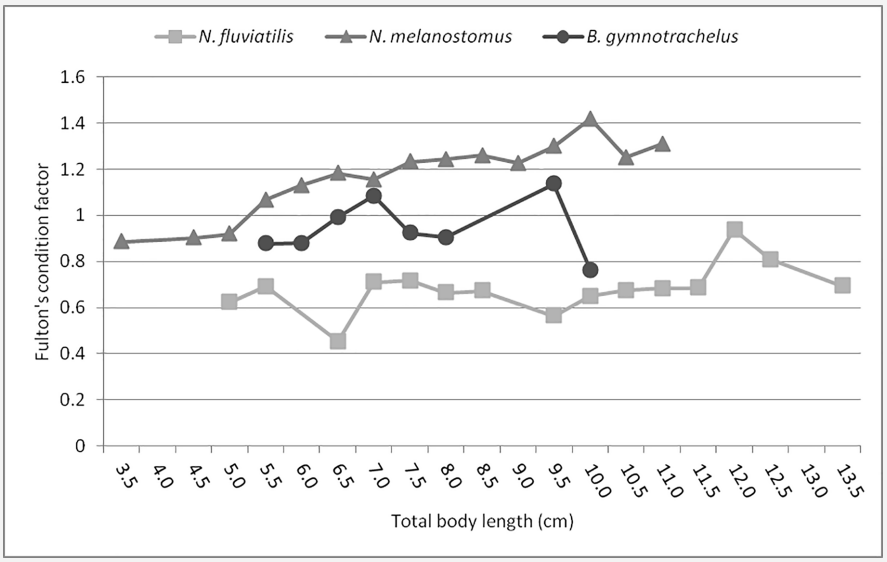

Fig. 3 Fulton's condition factor of sampled goby species.

gravel/rocky bottom, and JUDE (2001) observed the preference for cobble substrate where it can use the cover provided by interstitial spaces in rocky areas to hide from predators. CHARLEBOIS et al. (1997) mention that round goby occupies a variety of habitat types, including coarse gravel and sandy areas, which indicates its wide tolerance for various environmental conditions.

The data on bottom type preference of the racer goby outside its native range and its ability to colonise lotic environments are still scarce (KAKAREKO et al. 2016). DIDENKO (2013) observed a slight preference of the racer goby for sand and muddy substrate in the Dniprodzerzhynsk Reservoir in Ukraine, but concluded that vegetation density was a more important factor for this species than the substrate type. In 12 tributaries of the Danube River in Bulgaria, racer gobies were the most abundant on stone-clay bottom, and less abundant, but equally distributed, among stone-gravel, gravel, gravel-sand, gravel-silt, and silt bottoms (ZAREV et al. 2013). The relative abundance of the racer goby was high in downstream sections of the Strwiąż River in Poland with gravel/stony bottom and sand alluvia with mud layers along the banks where water flow was low to almost stagnant (GRABOWSKI et al. 2016). HAERTL et al. (2012) and KAKAREKO et al. (2016) observed that racer goby occurs on both soft and hard bottoms but usually outside the main river channel, in backwaters where water velocity is slower. KAKAREKO et al. (2016) also suggest that habitat plasticity of this species, which reflects in its ability to occupy suboptimal environments with less preferred hard substrata, facilitates its spreading into new areas.

There is still a lack of reliable data on biological and ecological characteristics of these three Ponto-Caspian gobiid species in Serbia, and this study would contribute to a better understanding of life-history and habitat selection comparisons. Further and more comprehensive studies that will serve in assessing the potential risks and impacts of these invasive species for native species and ecosystems in Serbia are necessary.

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