Scientific Papers. Series D. Animal Science. Vol. LXV, No. 1, 2022
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

LENGTH-WEIGHT RELATIONSHIPS OF THE MONKEY GOBY (*NEOGOBIUS FLUVIATILIS*, PALLAS, 1814) FROM THE SOMEȘ RIVER CATCHMENT

George-Cătălin MUNTEAN, Călin LAȚIU, Paul UIUIU, Radu CONSTANTINESCU, Vioara MIREȘAN, Tudor PĂPUC, Daniel COCAN

Faculty of Animal Science and Biotechnologies, University of Agricultural Sciences and Veterinary Medicine, 3-5 Calea Mănăștur Street, Cluj-Napoca, Cluj County, 400372, Romania

Corresponding author email: tudor.papuc@usamvcluj.ro

Abstract

The monkey goby (Neogobius fluviatilis) is a species present in the ichthyofauna of Romania, which naturally inhabits the seaside area, the mouths of the Danube, the Danube, and the Danube tributaries lower sections. The species currently expands its range across the European continent, and it is now inhabiting new aquatic environments, including the Someș River catchment, in the Transylvania region of Romania. The purpose of this study is to analyse the biometric aspects regarding the Neogobius fluviatilis populations from the Someș River catchment. Specimens of Neogobius fluviatilis were collected from 9 locations situated on the main course of the Someș River and from a lake built on a small river from the Someș catchment, the Țaga Lake. The collected specimens were preserved, and morphometric analysis was conducted in the laboratory with the following biometric aspects being analysed: length classes distribution and the length-weight relationships (LWR), such as the Fulton condition factor (K) and the allometric growth. In the present research work, we managed to obtain important information regarding the biometric aspects of the monkey goby (Neogobius fluviatilis) population from the Someș River catchment.

Key words*: Fulton, ichthyology, morphometry.*

INTRODUCTION

The monkey goby (*Neogobius fluviatilis*) is a native species from the ichthyofauna of Romania, native to the aquatic habitats found along the Danube (Kirin et al., 2013). *Neogobius fluviatilis* has a high degree of adaptability, that tolerates both freshwater ecosystems and brackish or saltwater ecosystems and easily adapts to new environments (Bănărescu, 1964; Cocan & Mireșan, 2018).

Species from the Gobiidae family currently expand their ranges across the European continent, and their expansion must be documented by scientists (Roche et al., 2013). These species made their way across the European continent due to the anthropic intervention of connecting interior navigable paths, which helps the fish to actively migrate, and they are also transported in the water tanks of commercial vessels, thus passively migrating (Ahnelt et al., 1998).

Neogobius fluviatilis reached parts of the European continent (Dutch Rhine) it had never inhabited by actively migrating through channels that connect different river systems (Kessel et al., 2009).

Gobiid species also expand their range in the river catchments they naturally inhabit by populating river sections that are at a higher altitude than the sections where they were naturally present, and this is considered to be an effect of climate change and that increasing annual temperatures provide suitable environments for *Neogobius fluviatilis* in new places (Harka & Bíró, 2007).

The species presence in the Someș River (Transylvania, Romania) was first documented by Cocan et al. (2014), along with another gobiid species, the racer goby (*Babka gymnotrachelus*).

For the species to reach the Someș River, it had to populate the Danube sector above Orșova, where Bănărescu makes the upmost mention of *Neogobius fluviatilis* on the Danube in 1964. By anthropic means, the species reached the Tisa River, which receives the waters of the Someș River on the territory of Hungary and from there to make its way up the Someș River to the central region of Transylvania. This study aimed to assess the biometric aspects of the population of *Neogobius fluviatilis* across different locations in the Someș River catchment.

MATERIALS AND METHODS

The sampling of *Neogobius fluviatilis* specimens from the Someș River catchment took place between 2014 and 2018 and all the laboratory work and data analysis was done from 2018 to 2021. Sampling stations were determined in such manner that as many possible aquatic habitats across the Someș River catchment to be explored and in as many regions as possible. 10 stations were situated on the course of the main river in the vicinity of the following settlements: Aciua, Benesat, Cărășeu, Cetan, Cuciulat, Letca, Mica, Năpradea, Oar, Valea Groșilor. One station was determined on the Țaga Lake, an artificial lake situated on a secondary tributary of the Someș River, the Fizeș River. The coordinates of the sampling stations are presented in Table 1. For each sampling location, the water depth was measured where captures occurred. Water flow was evaluated as stagnant, low, moderate, or fast and turbidity was evaluated as low, moderate, or high. The substrate was described as well.

Table 1. Someș River catchment *Neogobius fluviatilis* sampling stations coordinates

Sampling station	Coordinates
Aciua	47°68'42.6"N, 23°38'59.5"E
Benesat	47°41'52.7"N, 23°31'19.8"E
Cărășeu	47°75'71.5"N, 23°10'88.2"E
Cetan	47°11'59.1"N, 23°46'15.5"E
Cuciulat	47°18'34.2"N, 23°25'03.0"E
Letca	47°20'08.1"N, 23°28'23.5"E
Mica	47°14'81.1"N, 23°91'37.3"E
Năpradea	47°30'20.4"N, 23°27'14.1"E
Oar	47°81'23.1"N, 22°73'30.0"E
Țaga Lake	46°55'08.0"N, 24°04'48.9"E
Valea Groșilor	47°14'45.8"N, 23°43'32.2"E

Specimens were caught using angling techniques, such as float fishing and bottom fishing. Housefly larvae (*Musca domestica*) and red wigglers (*Eisenia fetida*) were the most successful baits, but the *Neogobius fluviatilis* specimens also responded to baits such as bread flakes, sweetcorn, or grasshoppers (*Tettigonia* sp.). Baits were fished on the bottom or near it, because *Neogobius fluviatilis* is a demersal species.

A total of 237 specimens of *Neogobius fluviatilis* were captured in this research. From each location the following number of specimens was captured: 27 at Aciua station, 14 at Benesat station, 16 at Cărășeu, 5 at Cetan, 43 at Cuciulat, 47 at Letca, 7 at Mica, 10 at Năpradea, 8 at Oar, 53 at Țaga Lake and 7 at Valea Groșilor.

The samples were immediately stored in recipients with formalin solution, so they could be properly stored for the laboratory analysis. Laboratory analysis of the specimens was conducted at the Ichthyology Laboratory from the Faculty of Animal Science and Biotechnologies, at the University of Agricultural Sciences and Veterinary Medicine, in Cluj-Napoca.

For each specimen a meristic determination was condoned, to prove that it belongs to the *Neogobius fluviatilis* species. The sex of the analyzed specimens was determined according to the instructions of Oțel (2007) and the male to female ratio in each sampling location was determined.

Gravimetric determinations were done using the Dune Compact DCT 5000 weighing scale and a Petri dish was used to set the tare of the scale. The total length (TL) of the fish was measured using a digital caliper or a ruler.

Information obtained in the laboratory was tabulated and analyzed using the Microsoft Office 365 Excel software (www.microsoft.com). The distribution of sexes and the following biometric aspects were analyzed: length classes distribution and length-weight relationships (LWR) such as the Fulton condition factor (K) and allometric growth.

The Fulton condition factor is a useful tool in assessing the individual condition of fish (Ricker, 1975) and for this study, we used the formula from Cocan & Mireșan (2015), as follows:

$$K = \frac{W \cdot 100}{TL^3}$$

where:
K – Fulton condition factor
W – weight (g)
TL – total length (cm)

Regarding the allometric growth we used the formula from Cocan and Mireșan (2015), as follows:

$$\boldsymbol{W = aTL^b}$$

where:
W – weight (g)
TL – total length (cm)
a – constant
b – slope

RESULTS AND DISCUSSIONS

Habitat conditions

Habitual conditions for each sampling station are presented in Table 2. Since we encounter *Neogobius fluviatilis* in such varied conditions, we can assume that the species is highly adaptable to new environmental conditions and that the Someș catchment suits the general requirements of the species.

Table 2. Habitual conditions from each sampling station

Sampling station	Depths (m)	Water flow	Turbidity	Substrate
Aciua	0.2-0.4	stagnant	high	sand and clay
Benesat	1-1.5	moderate	low	rocks
Cărășeu	0.2-0.5	fast	moderate	sand
Cetan	2	fast	low	sand
Cuciulat	0.7	moderate	moderate	rocks
Letca	0.5	moderate	moderate	sand and clay
Mica	0.5-1	fast	high	clay
Năpradea	0.3-1.2	moderate	low	rocks
Oar	0.2-0.5	moderate	low	sand and clay
Țaga Lake	0.4	stagnant	moderate	muddy
Valea Groșilor	0.4	low	high	sand and clay

Distribution of sexes across sampling stations

The work of Oțel (2007) describes that the male of *Neogobius fluviatilis* has a higher second dorsal fin than the first dorsal fin, thus we can distinguish between males and females. We identified 143 males and 94 females. The proportions between males and females varied at the sampling locations.

At the Cetan sampling station, only females were captured, at Oar station, there was an equal number of males and females, but in the rest of the sampling locations males were more numerous at 8 stations, and only at one station both sexes were present, but there were more females captured.

Table 3 displays how many specimens of each sex were captured at each sampling station and the percentage of males and females.

In general, the number of males at each station was higher than the number of females, except Letca station, where the number of females was slightly higher, and at Cetan station, where no males were captured.

Table 3. Distribution of sexes across sampling stations

Sampling station	Males	Females	♂%	♀%
Aciua	16	11	59.25	40.75
Benesat	12	2	85.72	14.28
Cărășeu	13	3	81.25	18.75
Cetan	0	5	0	100
Cuciulat	25	18	58.13	41.87
Letca	21	26	44.68	55.32
Mica	5	2	71.42	28.52
Năpradea	7	3	70	30
Oar	4	4	50	50
Țaga Lake	36	17	67.92	32.08
Valea Groșilor	4	3	57.14	42.86
TOTAL	143	94	60.33	39.67

Length classes distribution

Specimens with similar lengths can be classified by this aspect and the number of length classes present and how numerous they provide valuable information about the population from a particular place. For this analysis, we adapted the model presented by Jkrpo-Ćetković et al.

(2018), in which he attributes a specimen to a length class based on how many centimeters the specimen has, such as a fish of 7.1 cm belongs to the length class 7, and we classified specimens by their total length, like in the following example: if a specimen has a total length of 2.5 cm, then it belongs to the class of "2-3" because it is longer than 2 cm and shorter than 3 cm.

A total of 10 length classes were identified. The smallest number of length classes identified was at the sampling station of Oar, where only two length classes were accounted for, "8-9" and "9-10". The biggest number of length classes we identified in the Țaga Lake, a total of 9 classes, all between class "4-5" and "11-12", which shows that *Neogobius fluviatilis* dwells well in lentic habitats and this could pose a threat for lacustrine ecosystems that this species ends up inhabiting. The smallest class was class "4-5" and the biggest class was class "13-14". The results of the length classes analysis are presented in Table 4.

Length-weight relationships

Length-weight relationships give us insight into a fish population based on the lengths and weights of the specimens across the population. In determining the Fulton condition factor (K) and the allometric growth we used the total length and weight of specimens. The minimums, maximums, and means with standard deviations (SD) of the lengths and weights of the captured specimens from the sampling stations are presented in Table 5.

Table 4. Distribution of length classes across sampling stations

Length class	Aciua	Benesat	Cărășeu	Cetan	Cuciulat	Letca	Mica	Năpradea	Oar	Țaga	Valea Groșilor
4-5										1	
5-6	2					5	1			4	
6-7	2	2		1	2	9		3		17	
7-8	7	3	4	2	6	8	3	3		15	
8-9	9	6	6	1	12	8	2	1	3	10	
9-10	5	3	6		14	7			5	2	2
10-11	1			1	9	8	1			1	
11-12	1					2		3		2	2
12-13										1	2
13-14											1

Table 5. Total lengths and weights overview across sampling stations

	Total length (cm)			Weight (g)		
Station	Minimum	Maximum	Mean±SD	Minimum	Maximum	Mean±SD
Aciua	5.63	11.73	8.19±1.17	2	16	6.03±3.21
Benesat	6.88	9.66	8.25±0.84	2	8	5.07±2.01
Cărășeu	7.32	9.92	8.64±0.76	4	12	7.31±2.62
Cetan	6.82	10.36	8.36±1.47	3.09	12.11	6.45±3.66
Cuciulat	6.05	10.96	9.10±1.11	1.85	13.35	8.08±3.06
Letca	5.28	11.2	8.23±1.76	1.43	18.32	6.75±4.71
Mica	5.84	10.89	8.26±1.53	2	17	6.85±4.91
Năpradea	6.14	11.46	8.41±2.12	2	18	6.8±6.4
Oar	8.47	9.79	9.21±0.5	6	11	9.25±2.18
Țaga Lake	4.88	12.47	7.49±1.51	1	21.44	4.66±3.67
Valea Groșilor	9.71	13.65	11.65±1.44	9.37	28.60	18.87±7.47

Fulton condition factor (K)

Fulton's condition factor value describes a good physical condition of the fish if the value is above 1 and a poorer condition if the value is below 1.

The smallest male (♂) mean value for the Fulton condition factor occurred at Benesat station with a value of 0.85±0.11 and the highest mean value for males Fulton condition factor occurred at Oar, with a value of 1.21±0.04. The smallest female (♀) mean value for the Fulton condition factor occurred at Benesat station with a value of 0.84±0.32 and the highest mean value for females Fulton condition factor occurred at Oar, with a value of 1.08±0.09. These results show that in the Benesat river section the population of *Neogobius fluviatilis* is not doing as well as in other river sectors. The Oar River section displays the highest values of the Fulton condition factor for both sexes, and we can underline the fact that this river section suits very well the needs of the species. The Fulton condition value for the Țaga Lake shows a mean value for males of 0.95±0.07 and a mean value for females of 0.96±0.11, values close to 1, which describe an almost good condition, but it looks more like the species is still adapting to the lacustrine environment. Regarding the other sampling sites, the Fulton condition factor value varies around the value of 1, which means that *Neogobius fluviatilis* finds the environmental conditions of the Someș catchment quite suitable. Table 6 presents the overview regarding the Fulton condition factor (K) from all the sampling stations.

Table 6. Fulton condition factor (K) and allometric growth for all sampling stations

Sampling station	Sex	K mean±SD	LWR equation	Growth type
Aciua	♂	0.92±0.1	$W = 0.0063Lt^{3.2004}$	Allometric (+)
	♀	1.05±0.11	$W = 0.0095Lt^{3.0462}$	Isometric
Benesat	♂	0.85±0.11	$W = 0.0013Lt^{3.8728}$	Allometric (+)
	♀	0.84±0.32	$W = 2E\text{-}05\ Lt^{5.8057}$	Allometric (+)
Cărășeu	♂	1.09±0.1	$W = 0.0017\ Lt^{3.8582}$	Allometric (+)
	♀	1.05±0.02	$W = 0.013\ Lt^{2.9007}$	Allometric (-)
Cetan	♂	N/A	N/A	N/A
	♀	1.01±0.07	$W = 0.0071\ Lt^{3.1669}$	Allometric (+)
Cuciulat	♂	1.04±0.07	$W = 0.0047\ Lt^{3.357}$	Allometric (+)
	♀	0.96±0.08	$W = 0.0038\ Lt^{3.4354}$	Allometric (+)
Letca	♂	1.05±0.12	$W = 0.0039\ Lt^{3.4591}$	Allometric (+)
	♀	0.98±0.07	$W = 0.0065\ Lt^{3.2018}$	Allometric (+)
Mica	♂	1.1±0.16	$W = 0.0018\ Lt^{3.8446}$	Allometric (+)
	♀	0.92±0.1	$W = 2.6034\ Lt^{0.6196}$	Allometric (-)
Năpradea	♂	0.87±0.23	$W = 0.5311\ Lt^{0.2655}$	Allometric (-)
	♀	0.86±0.15	$W = 0.0469\ Lt^{2.1218}$	Allometric (-)
Oar	♂	1.21±0.04	$W = 0.0862\ Lt^{2.1323}$	Allometric (-)
	♀	1.08±0.09	$W = 0.0001\ Lt^{5.0302}$	Allometric (+)
Țaga Lake	♂	0.95±0.07	$W = 0.006\ Lt^{3.2346}$	Allometric (+)
	♀	0.96±0.11	$W = 0.0086\ Lt^{3.0547}$	Isometric
Valea Groșilor	♂	1.18±0.21	$W = 0.0103\ Lt^{3.0528}$	Isometric
	♀	1.06±0.06	$W = 0.0063\ Lt^{3.2241}$	Allometric (+)

Allometric growth

The study of allometry in fish lets us see with what intensity they grow in length and weight, which is stronger, or if they are equal. Allometric growth is exponential, and it is determined by the value of the slope (b) from the equation, which represents the allometric condition factor (Mogodan et al., 2021). $b=3$ or close to 3 means an isometric growth (weight and length grow with the same intensity), $b>3$ means a positive allometric growth (weight grows with higher intensity), $b<3$ means a negative allometric growth (length grows with higher intensity).

Table 6 displays the growth equation for each sex, from all sampling sites, and based on the generated equation and the value of the slope (b), we obtain the value of the allometric condition factor, from which we assessed the growth type for males and females throughout the research.

CONCLUSIONS

The biometric aspects analysis of the monkey goby (*Neogobius fluviatilis*) from the Someș River catchment shows a good adaptation of the species to this new range. Our analysis shows overall a good situation for the population throughout the studied areas and regarding the allometric growth. Length-class analysis and Fulton condition factor (K) analysis point out the effectiveness of the species to adapt to lacustrine environments, where they can pose a threat to destabilize lentic environments and can also affect aquaculture activities.

ACKNOWLEDGEMENTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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