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First data of age, condition, growth rate and diet of invasive *Neogobius melanostomus* (Pallas, 1814) in the Pomeranian Bay, Poland

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Abstract

Round goby (*Neogobius melanostomus* (Pallas, 1814)) is an invasive species in the Oder River. In this study, age of 147 fish was determined using scales and otoliths, and the Fraser-Lee back-calculation method was used for population structure and theoretical length growth rates with 3 mathematical models of growth: von Bertalanffy, Ford–Walford and 2nd degree polynomial. Fish condition was determined using Fulton, Le Cren and Clark equations. Average total length and weight of fish was 162.00 mm and 83.00 g, respectively. Males were more abundant than females, representing 70% of the fish caught, and achieved greater total lengths and weights. Age 2+ dominated females and 3+ males age groups. Of the three mathematical models used to estimate fish growth, the 2nd degree polynomial model had the best fit to back-calculated lengths. Males had slightly higher growth rates than females in the first two years of life but comparable in subsequent years. The diet consisted of various benthic organisms that varied with fish age. The most frequently occurring food component was *Dreissena polymorpha*, which accounted for approximately 70% in the diet of fish with a body length greater than 191 mm.

Key words: *diet, fish alien species, Gobidae, growth rate, Pomeranian Bay, population structure*

INTRODUCTION

In recent years, round goby (*Neogobius melanostomus* (Pallas, 1814)) has rapidly expanded its range into Europe [JURAJDA *et al*. 2005; OJAVEER 2006; VAN BEEK 2006] and North America [CORKUM *et al*. 2004]. Shipping, geopolitical changes since the Second World War, and the Balkan conflict of the 1990s and early 2000s are confirmed as important factors in the rapid expansion of Gobiid species from the Black Sea [ROCHE *et al*. 2013]. In addition, many studies indicate that the high tolerance to a wide range of environmental conditions, aggressive behaviour, early sexual maturity and high fecundity, and the possibility of spawning multiple times a year can ensure round goby survival and expansion from sites where goby has been introduced [LAVRINCIKOVA, KOVAC 2007; ROCHE *et al*. 2013; STAMMLER, CORKUM 2005].

In 1990, this species was collected in the catchment area of the Baltic Sea, in the Gulf of Gdańsk (Poland) [SKÓRA, STOLARSKI 1993] for the first time, and in subsequent years it was also collected from nearby waters: Puck Bay, the Vistula Lagoon, and the Vistula River [KUCZYŃSKI 1995; SAPOTA 2004]. At the beginning of the twenty-first century, this species was seen in the northern and eastern parts of the Baltic Sea [CZERNIEJEWSKI, BRYSIEWICZ 2018; OJAVEER 2006].

The Oder River is one of the most important transboundary rivers in the Baltic region whose river basin is under intensive urban development and agricultural use, exposed to flooding, and intensive shipping. Pomeranian Bay is mainly influenced by wind-induced mixing and large-scale currents in Baltic Sea. The Szczecin Lagoon, on the other hand, is primarily influenced by the discharge of the Odra River into the Lagoon. The large area (687 km^2) and shallow depth (average 3.8 m) of the Lagoon are two key elements of the Odra estuary region that is subdivided into the “Kleines Haff”, located mainly on German territory, and the “Wielki Zalew” on Polish territory. The Wielki Zalew covers about 60% of the lagoon area and volume [SCHERNEWSKI 2008].

In the Odra estuary, juvenile stages of round goby were caught for the first time in 2003 in the Pomeranian Bay. In the German part of the Szczecin Lagoon adults have been caught since 2006 [WINKLER 2006], and in the Polish part of the Szczecin Lagoon since 2009 [CZUGAŁA, WOŹNICZKA 2010]. Currently, round goby is established in the Odra River (up to Schwedt, about 120 km upstream from the Pomeranian Bay). The gobies were, most likely, introduced via ballast water from the Baltic or North Sea harbours (e.g., Hel, Gdynia), because their first occurrences have taken place in ports (unpublished angler’s reports). Colonisation of Odra River by the round goby started from the Pomeranian Bay, where upstream migration was observed. The invasion spread seems to mirror the sequence recorded for Vistula River [SCHOMAKER, WOLTER 2014]. According to SAPOTA [2004], the population of round gobies in the Vistula estuary rapidly increased in abundance, spread to nearby locations, and stabilized in following years. Despite numerous scientific articles on this species published in recent years, the environmental variability and diversity of adaptive traits, their role and importance in the Pomeranian Bay ecosystem, population structure, and the growth rates in this basin are still unknown and may differ from the literature data.

MATERIALS AND METHODS

147 round goby specimens were fished by six commercial fishing trawls from July to October 2018 in the Pomeranian Bay (Fig. 1). The study material was collected as bycatch during monitoring surveys focusing on commercial fish species. The survey was carried out in Pomeranian Bay from the commercial vessel with trawls (mesh size of 10–20 mm), at depth 10–12.5 m, over the sandy bottom. Total length (*TL*) and standard length (*SL*) of the fish were measured using electronic callipers with precision of 0.1 mm, and all fish were weighed (total weight, *TW*, in g) on an Axis 2000 electronic balance to the nearest 0.1 g. Gender was determined by examination of the urogenital papilla [CHARLEBOIS *et al*. 1997].

Using the measured lengths and weights, the length structure and length-weight relationship were determined [RICKER 1975]. Age was estimated from according to the method proposed by GUMUS and KURT [2009]. Right and

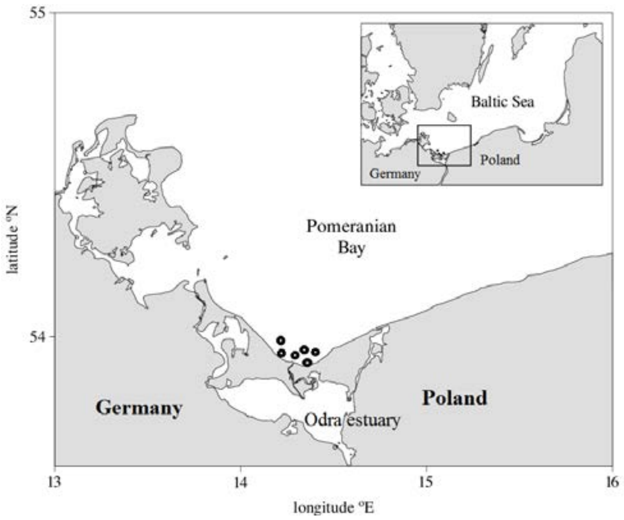

Fig. 1. Sampling site locations in the Pomeranian Bay; source: own elaboration

left sagittal otoliths from each individual were placed in black plastic trays and soaked in 95% ethanol for approximately 5 min. Otoliths were then viewed under a microscope equipped with a camera and digitized using the Nicon Application. Fish lengths were calculated using the back-calculation method of Fraser-Lee [GRULA *et al*. 2012]. The calculated lengths at age, were subsequently used for the calculation of mathematical growth models: von Bertalanffy, Ford–Walford and 2nd degree polynomial [SZYPUŁA *et al.* 2001]. Three growth models were used to select the most accurate equation to determine the length growth rate in this study, since in previous studies of this species growth was characterized only with the von Bertalanffy growth model. Fish condition factors were determined using three formulas:

- Fulton

$$K = 100W \cdot TL^{-3} \quad (1)$$

Where: W = individual weight (g), TL (mm)

- Clark

$$K_C = 100W_2 \cdot TL^{-3} \quad (2)$$

Where W_2 = individual weight of gutted fish (g), TL (mm)

- Le Cren

$$K_L = 100W \cdot TL^{-b} \quad (3)$$

Where W = individual weight (g), b = the allometry coefficient related to the form of the individuals’ growth) [LE CREN 1951; RITTERBUSCH-NAUWERCK 1995].

Fulton and Clark formulas are the most popular in the literature to determine the condition of fish, but when fish increase less in weight than predicted by increase in length or vice versa, Le Cren formula determines the condition factor most accurately [LE CREN 1951; RICKER 1975].

The diet composition was evaluated by analysing the contents of digestive tracts dissected from all individuals and preserved in 80% ethanol. Quantitative and qualitative gut content analysis included the identification of prey organisms to species, genus or higher taxa and enumeration of prey items under the light microscope at a magnification of 100×. This method for the stomach content analysis was implemented because the food was digested to varying degrees. Often it was not possible to assign the food items to a particular species or genus, and consequently the identification of these components was narrowed to a higher taxon. Food composition was determined using the following methods: the relative contribution of each prey item to the total number of all prey in the stomachs of each fish (%*N*), frequency of their occurrence (%*F*), and the percentage of total stomach contents in all examined fish consisting of that prey.

Student *t*-tests were used to test for significant differences between males and females in observed and back-calculated lengths, weights, and condition factors using SYSTAT 12 statistical program. Length-weight relationships were determined in Statistica 10.0. The parameters *a* and *b* were estimated by linear regression on the Log-transformed ($\log_{10}$) equation $\log(W) = \log(a) + b \log(L)$. The significance of the regressions was assessed by ANOVA, and the *b*-value for each species was tested by *t*-test to verify that it was significantly different from the predictions for isometric growth ($b = 3$).

RESULTS

LENGTH AND WEIGHT

The length and weight of round goby caught in the Pomeranian Bay ranged from 89 to 220 mm (mean ± *SD* = 152 ± 42 mm) and from 10.10 to 193.30 g (mean ± *SD* = 76.10 ± 44 g). The most numerous size length classes were 161.00 to 180.00 mm (30%) and 141.00 to 160.00 mm (29%). The lowest numbers of fish were found in the following classes: 81.00 to 100.00 mm (2%), 101.00 to 120.00 mm (2%) and in the class of 201.00 to 220.00 mm (5%). Among the 147 caught fishes, males dominated, representing 70% of the fishes (103), while females accounted for 30% (44). The highest number of males (32% of all males) fell within size class 161.00–180.00 mm, and 34% of all females were assigned to the 141.00–160.00 mm size class (Fig. 2) The ranges of females' length and weight were from 100.00 to 198.00 mm and from 20.20 to 157.50 g respectively, while males ranged from 89.00 to 220.00 mm and from 10.10 to 193.30 g. The females had significantly lower average total lengths (respectively 148.50 ± 22 mm and 169.00 ± 23 mm; *t*-test value: –4.735; $p < 0.001$) and weights (62.30 ± 30.40 g; and 92.10 ± 38.30 g; $p < 0.001$, $t = -5.017$) than males.

CONDITION FACTOR

The weight of fish is exponentially related to their length. Based on the slope (*b*) of the relation one can determine whether the growth of a fish species is isometric ($b = 3$), negative allometric ($b < 3$, a fish increases less in weight than predicted by its increase in length), and positive allometric ($b > 3$, a fish increases more in weight than predicted by its increase in length). The relationships between total length (*TL*) and weight (*TW*) of round goby are shown as equation for females:

$W = 0.000008TL^{3.1572}$ ($SE(b) = 0.139$; $R^2 = 0.9248$)

and males:

$W = 0.000006TL^{3.2131}$ ($SE(b) = 0.087$; $R^2 = 0.9316$)

Where: *SE* = standard error; R^2 = determination coefficient.

The value of the exponent *b* in both males and females reached above 3, indicating a positive allometric growth for both sexes. Females had higher Fulton and Clark condition factors (Tab. 1).

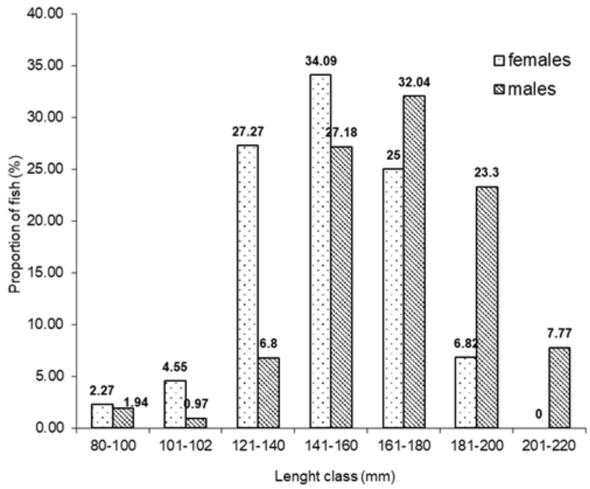

Fig. 2. Length distribution of round goby (*Neogobius melanostomus*) females and males from the Pomeranian Bay (Odra River estuary); source: own study

Table 1. The values of round goby (*Neogobius melanostomus*) condition factors (mean ± *SD*) from the Pomeranian Bay

Method	Value of factor condition for			*t*-value
	pooled fish	males	females	
Fulton (*K*)	1.79±0.23	1.76±0.24^{ns}	1.81±0.23^{ns}	1.194^{ns}
Clark (K_C)	1.56±0.24	1.48±0.30*	1.60±0.20*	2.702**
Le Cren (K_L)	0.67±0.12	0.80±0,11**	0.61±0.75**	12.465***

Explanations: *SD* = standard deviation, ^{ns} = not significant, * significant at $p > 0.05$, ** significant at $p < 0.01$, *** significant at $p < 0.001$.
Source: own study.

AGE STRUCTURE

Age 2+ and 3+ dominated of the studied fish. Within the 2+ class there were more females (48.15%) than males (42.71%) while in the 3+ class males (43.75%) were slightly more abundant than females (40.74%) within this population. Also, fish from classes 1+, 4+, and 5+ were present at lower frequencies. (Fig. 3).

GROWTH RATES

Table 2 shows the length growth rates of round goby (von Bertalanffy, Ford-Walford, and the 2nd degree polynomial mathematical models of fish growth, as determined by back-calculation readings of Fraser-Lee. The largest annual increases in length were recorded in the first three years of round goby life. While males had a slightly higher growth rate compared females in the first two years of life, in subsequent years the lengths were similar.

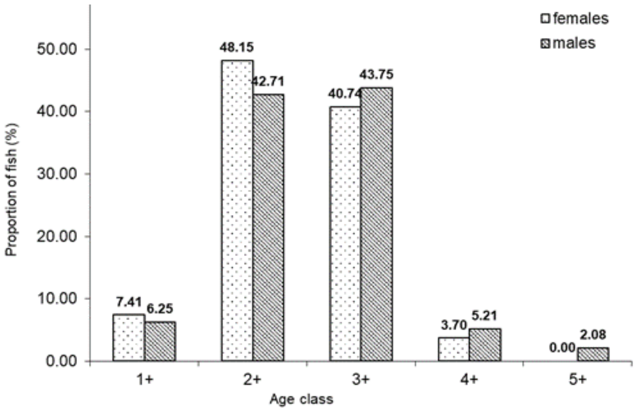

Fig. 3 Age distribution of round goby (*Neogobius melanostomus*) females and males from the Pomeranian Bay (the Oder River estuary); source: own study

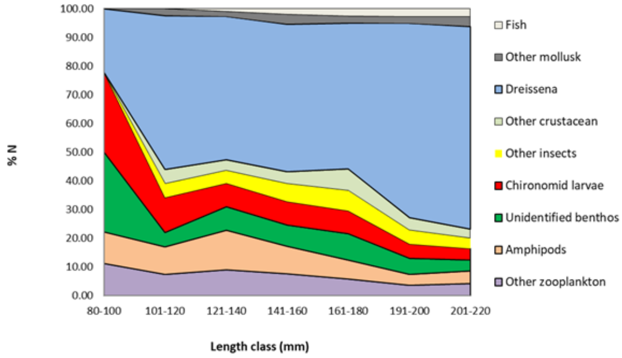

Fig. 4. The numerical diet composition (%*N*) by taxa of examined length classes in the round goby (*Neogobius melanostomus*) from the Pomeranian Bay (Oder River estuary); source: own study

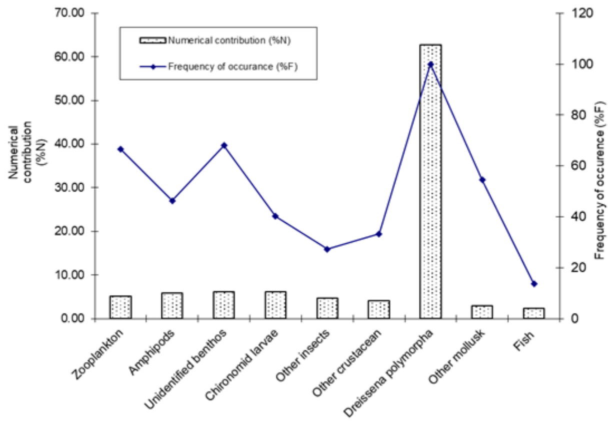

Fig. 5. Numerical contribution (%N) and frequency of occurrence (%F) of the food components of round goby (*Neogobius melanostomus*) from the Pomeranian Bay (Oder River estuary); source: own study

Table 2. Male and female round goby (*Neogobius melanostomus*) length (mm) at age calculated with three mathematical models of growth

Age (years)	Length acc. to the method			
	back-calculation	von Bertalanffy	Ford-Walford	2nd degree polynomial
Male				
1	48.80	61.60	53.00	51.30
2	93.90	108.80	94.60	95.30
3	133.60	144.10	127.30	130.30
4	156.10	170.40	153.10	156.20
5	172.40	190.00	173.30	173.10
Female				
1	50.00	66.90	52.40	51.20
2	92.80	119.80	94.80	95.20
3	135.30	159.20	129.20	130.90
4	156.60	188.60	156.90	158.40

Source: own study.

DIET COMPOSITION

Crustaceans and molluscs were most important in the studied round gobies' diet. Among crustaceans, marine isopods (*Idotea balthica*) were most commonly eaten while amphipods from the family Gammaridae were only consumed sporadically. The largest group consisted of molluscs (Gastropoda), mainly zebra mussles (*Dreissena polymorpha*), and less frequently cockle (*Cardium edule*), baltic clam (*Macoma baltica*), and blue mussel (*Mytilus edulis*). In addition, Chironomidae larvae were important prey for small round goby (<15 cm). Remains of young fish, mostly otoliths and scales from fish of the genus *Neogobius*, were also observed among the food items. The food composition changed with fish size; smaller fish diets were dominated by benthos (33%), specifically Chironomidae larvae (25%), and in the largest fish (191.00–200.00 and 201.00–220.00 mm), *D. polymorpha* accounted for about 70% of food intake (Fig. 4).

D. polymorpha was the most frequent component of the round goby diet from the Pomeranian Bay and was found in all examined fish stomachs (100%). Benthos and zooplankton were also frequently consumed, especially in the first years of life. Similarly, in the case of a numerical contribution of individual prey items, *D. polymorpha* also had the largest share (63%) – Figure 5.

DISCUSSION

The maximum length that the round goby reaches in the Pomeranian Bay in this study is 220 mm, with males reaching greater lengths than the females. These values are similar to those obtained for the non-indigenous round goby population inhabiting the Danube River basin [GRULA *et al*. 2012; POLAČIK *et al*. 2008] and the waters of North America [CHARLEBOIS *et al*. 1997], but are definitely lower, especially for males, than values obtained for the round goby in its natural range [BERG *et al.* 1949]. Moreover, within each of these waters, males grew faster than females and were longer at any given age despite the fact that they have a shorter life cycle [BERG *et. al*. 1949] and reach sexual maturity later. The overview of the species that have successfully colonized Polish waters shows that their success is seen in taxa, in which natural selection favours high reproduction, the so-called r- strategists, or generalists [PIANKA 1970]. Moreover, these species, in addition to high fertility, are typically characterized by small body size, short developmental cycles, high ecological plasticity, and low stress sensitivity. All these characteristics can be assigned to invasive species [ANDRZEJEWSKA *et. al*. 2011]. It is important to note that these non-indigenous populations attain reduced maximum length compared to the native populations. For example, non-indigenous round goby populations reach a maximum body length (*SL*) of 153 mm in Slovakia, 150 mm in Austria, and 160 mm in Hungary [GRULA *et al*. 2012; POLAČIK *et al*. 2008] while in the waters of their natural range, the body length reaches up to 250 mm [BERG 1949]. It is not likely that the smaller fish size is due to the shorter life cycle of individuals within the non-indigenous populations since in both native and colonized waters round goby reaches 5 to 6 years of age [BERG *et. al*. 1949; SOKOLOWSKA, FEY 2011]. Likewise, in the Pomeranian Bay, 5-year-old fish were observed despite the evident dominance of 2- and 3-year-old fish.

This variation in the maximum achieved length may be a form of adaptation to the new environments. According to KONEČNÁ *et al*. [2014] abiotic conditions may be more, less or equally "suitable" in novel areas than those at the site of origin and affect round goby biological characteristics and their expansion into new habitats. Moreover, the novel biotic conditions, such as loss of natural predators and/or competitors, low density of conspecifics and/or difference in food resources are likely to favour altricial strategies, at least in the early phase of an invasion [GRABOWSKA *et al*. 2011; KONEČNÁ *et al*. 2014]. However, individuals in a populations residing in fresh water typically have a smaller maximum length and slower growth (Tab. 3), compared to the populations inhabiting saline waters [CORKUM *et al*. 2004]. Laboratory tests conducted by KARSIOTIS *et al*. [2012] showed that the highest round goby growth rates were reached by fish grown in 5–15 ppt salinity, with the highest survival rates observed in water with a salinity of 20 ppt. Euryhaline characteristics of this species, combined with a wide range of thermal tolerance (from –1 to + 30°C) and high fertility [CORKUM *et al*. 1998; MOSKAL'KOVA 1989], allow this invasive fish to colonize new areas, including estuaries.

The growth rates of round goby are typical of the short-lived fish species, a fast increase in length during the first years of life and a significant decline in growth thereafter. However, the rates of growth may be also influenced by changes in the diet composition [GRULA *et al*. 2012]. The round goby is an omnivore [BRANDNER *et al*. 2013a; 2013b], at a length of 6–11 cm their food preferences change from small insects and crustaceans to mussels that later dominate diet of this fish [BARTON *et al*. 2005; CAMPBELL *et al*. 2009; FRENCH, JUDE 2001]. In round goby caught in the Pomeranian Bay a similar phenomenon of gradual specialization of the consumed food was noted. Round goby in the basic fed mainly on *D. polymorpha*, however the participation of individual dietary components varies with the growth of individuals. Up to a length of 80 mm, amphipods dominated the benthos fraction, while after reaching the length of 85–90 mm round goby preferred *D. polymorpha*, which accounted for 70% of all food in the class length from 201 to 220 mm. Likewise, in the natural range waters of the of this species, Mollusca are an important component of the diet accounting for 86% of the stomach contents from the Sea of Azov [GRULA *et al*. 2012] and 90% in Ponto-Caspian habitats such as the Bug estuary, while crustaceans (gammarids and chelicorophiids), chironomids, annelids and fishes are of low importance [PINCHUK *et al*. 2003]. In areas colonized by invasive *D. polymorpha*, both in the North American Laurentian Great Lakes [KORNIS *et al*. 2012] as well as in the Baltic coastal zones [KARLSON *et al*. 2007, own data], round goby primarily consume *Dreissena* sp. GHEDOTTI *et al*. [1995] reported that consumption of mussels by one individual of this species may exceed 100 per day. The diet of round goby in the Pomeranian Bay also consisted largely of benthic macroinvertebrates, and consumption of young fish was very low. A number of field studies have also observed low consumption of juveniles of this fish [FRENCH, JUDE 2001; VASEK *et al*. 2014]. These results indicate that invading gobies are likely to impact native fish fauna through competitive effects rather than through direct predation on juvenile fish. Because the round goby in the studied population from the Pomeranian Bay had a large proportion of *D. polymorpha* in their diet, it can be presumed that this species may become a potential competitor for flounder (*Platichthys flesus*) in this region as the mussels are their main food component. However, round goby may not be a threat to the development of other fish species because, with the exception of round goby scales,

Table 3. Length at age data of round goby (*Neogobius melanostomus*) in various waterbodies

Location		Max. standard length (mm)	Standard length *SL* at age (mm)						Max. age	Source
			1	2	3	4	5	6		
Pomeranian Bay	male	220	49	94	134	156	172	–	5	this study
	female	198	50	93	135	157	–	–	4	
Gulf of Gdańsk		187	–	94	125	133	144	175	6	SOKOLOWSKA and FEY [2011]
		220	96	132	157	177	195	–	5	WANDZEL [2000; 2003]
		190	54	108	144	159	–	–	4	SAPOTA [2004; 2005]
Vistula Lagoon		193	81	126	157	–	–	–	3	SAPOTA [2005]
Danube River		98	42	77	93	–	–	–	3	SIMONOVIC *et al.* [1998; 2001]
Kuibyshev Reservoir		146	77	105	119	146	–	–	4	SHEMONAEV and KIRILENKO [2009]
Caspian Sea		160	63	67	81	85	–	–	4	NIKOLSKI [1954]
Sea of Azov		250	110	–	–	140	–	–	4	BERG *et al.* [1949]
Sea of Azov		140	84	88	95	–	–	–	3	APANASENKO [1973]
Black Sea, Cremea		150	54	78	88	114	–	–	4	APANASENKO [1973]
Black Sea, Tiligul Lagoon		110	69	80	87	–	–	–	3	APANASENKO [1973]
Upper Detroit River		112	58	65	83	–	–	–	3	MACINNIS and CORKUM [2000]
Lake Erie, Pensylvania		112	68	80	94	–	–	–	–	PHILLIPS *et al.* [2003]

Source: own study and own elaboration based on literature.

the analysed digestive tracts did not contain eggs or scales of other fish species.

Correspondingly to the SIMONOVIC *et al*. [2001] study that revealed molluscs were the preferred food for all round goby length classes, this study of the Pomeranian Bay population showed this preference as well. It is generally regarded that occurrence of *D. polymorpha*, whose contribution to the round goby's diet exceeds 50% in many waters, is a major factor assisting round goby in the colonization of new reservoirs [RAY, CORKUM 1997], a phenomenon called "ecological facilitation" [RICCIARDI 2001]. Abundant mussels in Pomeranian Bay also affect the high condition of round goby. Compared to the results the study on this species conducted by BRANDNER *et al*. [2013a] in the upper Danube River, round goby of the Pomeranian Bay achieved higher average Clark condition factors (from 1.39 to 1.41 in the Danube River and from 1.48 and 1.60 in the Pomeranian Bay, for females and males respectively) and a higher slope value of the length-weight regression (3.0 in the Danube River and 3.1572 and 3.2131 for females and males in the Pomeranian Bay respectively). This points to not only a higher condition of fish in the Pomeranian Bay, but also allometric weight gain in relation to the length for *N. melanostomus* in this basin.

Taking the above into consideration, and the fact that in the brackish waters of the Baltic Sea, both in the Gulf of Gdańsk [SOKOŁOWSKA, FEY 2011] and the Pomeranian Bay (own data), the round goby showed the largest and fastest-growing individuals, it can be concluded that this species found favourable conditions for growth and further expansion in this new area. According to BONISŁAWSKA *et al.* [2014], the percentage of round goby embryos surviving in fresh water is very high (90%), similar to that obtained in salt water, which indicates the possibility of successful reproduction in the presence of other favourable environmental conditions such as a suitable substrate for spawning of this non-native species in the Polish inland waterways. Ongoing research and observations indicate that even in the early ontogenetic stages, round goby is well adapted to very diverse environmental conditions, as evidenced by the high percentage of survival of larvae and the low percentage of losses in rearing fry.

In the case of biological invasions in Poland, the Carlton's theory [CARLTON 1996] applies in that most species do not disperse into new areas directly from their place of origin but from areas where they were intentionally or non-intentionally introduced. Usually, the invasions from such areas are natural migrations or species invasion. In most cases, colonization of Polish waters from areas where the species was intentionally or non-intentionally introduced had run through corridors, dictated by the linear or channelized spatial structure of habitats (e.g., certain shellfish and fish of the genus *Neogobius*). These types of waterways spread species not only dispersed by ships and other means such as ballast water, transported products and materials, but also by natural migration through these waters [BIJ DE VAATE *et al*. 2002; ROCHE *et al*. 2013]. Although, the successful introduction of the species may be sometimes preceded by a number of unsuccessful attempts [KREBS 1997]. It is worth noting that *N. melanostomus* also shows upstream river expansion in the Black Sea basin. According to SIMONOVIC *et al*. [1998], the first two fish of the species were found within former Yugoslavia in 1997 and 1998, 861 km from the mouth of the Danube River near Prahova. Two years later they were found in the Vienna region [WIESNER *et al*. 2000], and in 2001 near Wolfsthal and Krems [WIESNER 2003]. In 2003 round goby appeared in the Slovak part of the river [STRÁŇAI, ANDREJA 2004].

The presence of round goby in some tributaries of the Odra River [KESZKA *et al.* 2013] and its appearance as far as 120 km upstream from the Pomeranian Bay [SCHOMAKER, WOLTER 2014] confirms the similarity of round goby's rapid expansion scenario in the Odra estuary to the already colonized the Vistula River.

CONCLUSIONS

Round goby is undoubtedly a permanent component of the Baltic fish fauna. Population from the Pomeranian Bay is distinguished from other, especially native populations that they grow relatively quickly and lack older individuals, as in the Gulf of Gdańsk. It seems that the round goby is a generalist that exploits the favourable conditions in the Pomeranian Bay without the competition with native species in the main stem of the Odra River. The role goby will play in the future in the coastal zone of the Baltic Sea, will probably be the result of their biological predispositions and the scale of anthropogenic changes in the Baltic Sea environment.

It can be concluded that in the absence of adequate control and due to biological and ecological predispositions (e.g., euryhaline characteristics, opportunistic feeding, multiple and prolonged reproduction, and egg caring) *Neogobius melanostomus* will continue global expansion.

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