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PIARACTUS BRACHYPOMUS (CHARACIFORMES, SERRASALMIDAE) – AN INCIDENTAL ALIEN SPECIES IN POLISH AND WORLD WATERS?

PIARACTUS BRACHYPOMUS (CHARACIFORMES, SERRASALMIDAE) – SPORADYCZNIE WYSTĘPUJĄCY GATUNEK OBCY W WODACH POLSKI I ŚWIATA?

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Streszczenie. W pracy przedstawiono charakterystykę biologiczną pięciu osobników pirapitingi *Piaractus brachypomus* (15,3–37,0 cm długości całkowitej) złowionych w północno-zachodniej Polsce (w Zalewie Szczecińskim, jeziorze Dąbie, w kanale z wodą zrzutową z Elektrowni Dolna Odra w Szczecinie) w latach 2002–2010 podczas połowów rekreacyjnych i komercyjnych. Dodatkowo przedstawiono udokumentowane przypadki złowienia *P. brachypomus* przez wędkarzy w różnych akwenach na terenie Polski (w jeziorach, stawach, zbiornikach zaporowych, rzekach i zalewach) w okresie od 2001 do września 2015 roku. Złowione ryby miały długość całkowitą 17,0–49,0 cm. Wszystkie osobniki zostały wypuszczone do zbiorników wodnych przez akwarystów. Przedstawiono i przedyskutowano również występowanie przedstawicieli tego gatunku poza naturalnym zasięgiem (czyli zlewni Amazonki i Orinoko) w Europie i na świecie, w tym złowienie żywego osobnika w Morzu Bałtyckim. Ocenę sukcesu ewentualnej inwazji w wodach Polski przeprowadzono na pirapitingach z hodowli akwarystycznej. Doświadczenia laboratoryjne wykazały, że dolna granica tolerancji termicznej tego gatunku wyniosła 11,2°C, zatem prawdopodobieństwo przezimowania w polskich wodach należy uznać za bardzo niewielkie, nawet w podgrzanych wodach kanałów zrzutowych Elektrowni. Jednak postępujący proces globalnego ocieplenia może zwiększyć rozsiedlenie *P. brachypomus* z uwagi na możliwość zimowania i rozrodu w miejscach nierodzimego występowania, co zwiększy również zagrożenie przenoszenia pasożytów przez ryby z tego gatunku.

Key words: pirapitinga, Polish waters, thermal tolerance, nonindigenous occurrences, alien species, biological invasions.
Słowa kluczowe: pirania pirapitinga, wody Polski, tolerancja termiczna, nierodzime występowanie, gatunki obce, inwazje biologiczne.

INTRODUCTION

Major sources of alien fish invasions include, among others, the aquarium trade, live fish markets, and ballast water discharges (Sapota and Skóra 2005; Więcaszek et al. 2009). In the last 800 years, 35 alien fish species have been introduced, mainly intentionally, in Polish inland

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waters. To date, 26 fish species have been reported as naturalized, acclimatized, or casual (nine species considered invasive). It means that 34% of fish fauna in Poland are non-indigenous species. The majority originate from North America, eastern Asia and Siberia, or different regions of Europe. More than 65% of all introductions have occurred in the last 60 years (Grabowska et al. 2010).

Pirapitinga *Piaractus brachypomus* (Cuvier 1818) is a tropical fish native to the Amazon and Orinoco river basins. It is highly valued as an aquaculture species, and it is considered to be one of the most significant and prized species in the aquarium trade (Jégu 2003). Generally, representatives of the genus *Piaractus* are economically important and have high culture potential in South and North America and recently in Asia (Ferreira et al. 1996).

Since 2001, some reports of single specimens of *P. brachypomus* have been noted in Polish waters (Boeger et al. 2002, Witkowski and Grabowska 2012). Since the early 1990s in Poland, *P. brachypomus* have been sold in Poland in pet shops as small individuals (ca 8 cm of total length) and customers have not been informed that fish growth was not inhibited by the tank size. The growth rate of this species is high (Ma et al. 2003), and it is likely that "oversized" individuals have been released into the wild because very few home fish keepers could cope with fishes attaining sizes of 80 cm. Since 2014 the trade of *P. brachypomus* in Poland has been restricted by the Ministry of Environment, because it has been considered an alien species with a potentially negative impact on the native environment (Rozporządzenie Ministra Środowiska 2011).

The objective of the paper was to present the biological characteristics of five pirapitinga individuals caught in Polish water bodies, with the age, diet and gonad development studies, and to evaluate the potential for over winter survival of this species under natural conditions. This was done by determining the lower thermal limits of this species, i.e. temperature that did not allow the fish to maintain its normal activity. Additionally, well-documented *P. brachypomus* records in other Polish waters are presented.

MATERIALS AND METHODS

Analyses were performed on five individuals collected from Polish water basins: two individuals from the warm effluent channel of the Pomorzany Power Plant in Szczecin (captured by recreational anglers), one individual from lake Dąbie (Fig. 1), and two individuals from the Szczecin Lagoon, captured by commercial fishers (Fig. 2). Fish measured 15.3–37.0 cm in length and 65.5–1169 g in weight (Table1). Age of fish was determined by scale-reading. Additionally, the stomach contents and gonads' development stage were examined.

Both the Pomorzany Power Plant and lake Dąbie, are situated within Szczecin town area. The temperature of the water of the Pomorzany Power Plant channel ranges from 7.5°C in the winter to 29°C in the summer, while in Lake Dąbie the range is 2–25°C. The Szczecin Lagoon is situated in the Oder estuary, and shared by Germany and Poland. It is separated from the Pomeranian Bay of the Baltic Sea by the islands of Usedom and Wolin. Between April and October, the temperature of surface and near bottom water fell within the range from about 5.4 to 22.9°C (Poleszczuk and Piesik 2000). The annual average water temperature is 11°C. The average salinity is between 0.5 and 2 PSU (Schiewer 2008).

Fig. 1. Specimens of pirapitinga *P. brachypomus* examined in this study (above: one from the warm power plant channel, below: one from the Lake Dąbie)
Ryc. 1. Osobniki *P. brachypomus* poddane badaniom (powyżej: osobnik z kanału zrzutowego Elektrowni, poniżej: osobnik z jeziora Dąbie)

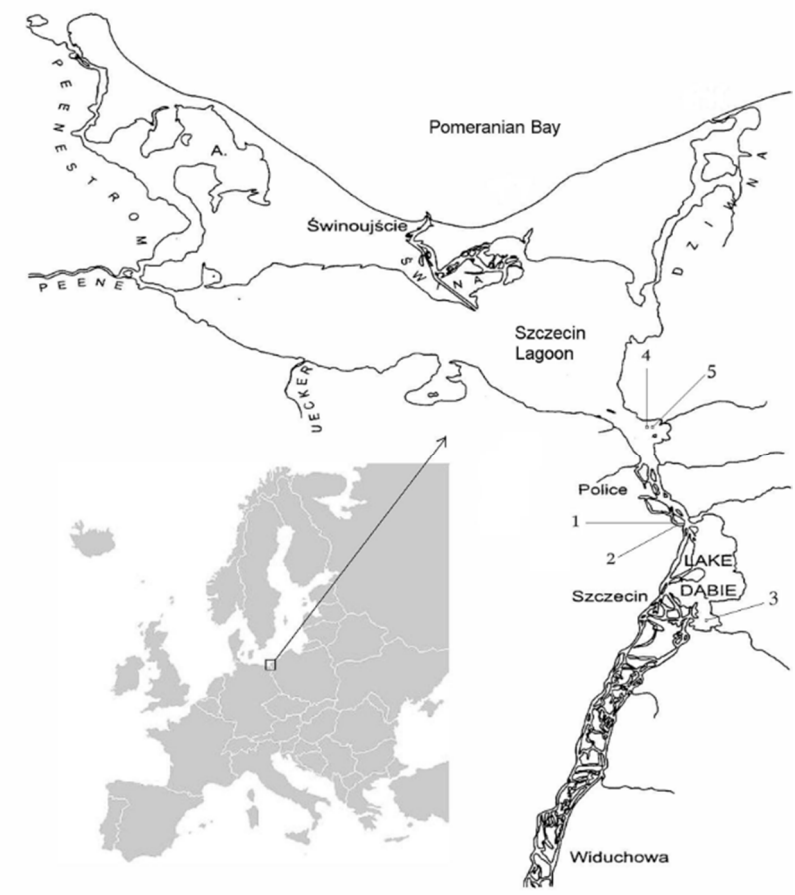

Fig. 2. Location of wild-caught specimens of pirapitinga *P. brachypomus*, captured in West Pomeranian region, Poland
Ryc. 2. Miejsca złowienia osobników *P. brachypomus* w rejonie Pomorza Zachodniego (Polska)

Table 1. Characteristics of *P. brachypomus* individuals caught in area of Szczecin
Tabela 1. Charakterystyka osobników *P. brachypomus* złowionych w rejonie Szczecina

	Date of fish capture Data złowienia ryby	Type of water body Rodzaj zbiornika wodnego	Area of capture Region	Method of capture Metoda połowu	Total length Długość całkowita TL [cm]	Weight Masa [g]
1.	20 June 20 czerwca 2002	power plant cooling water canal kanał zrzutowy elektrowni	Szczecin town – miasto	by recreational angler wędka	37.0	990.0
2.	20 June 20 czerwca 2002	power plant cooling water canal kanał zrzutowy elektrowni	Szczecin town – miasto	by recreational angler wędka	37.0	1169.0
3.	16 September 16 września 2002	lake jezioro	Lake – jezioro Dąbie Szczecin town – miasto	professional fish catch – fyke net połowy komercyjne sieci mieroże	31.8	688.3
4.	15 June 15 czerwca 2005	lagoon zalew	Szczecin Lagoon Zalew Szczeciński Stepnica village – – miejscowość	professional fish catch – roach fyke net połowy komercyjne sieci mieroże (płociowe)	15.3	65.5
5.	6 June 6 czerwca 2010	lagoon zalew	Szczecin Lagoon Zalew Szczeciński Stepnica village – – miejscowość	professional fish catch – roach fyke net połowy komercyjne sieci mieroże (płociowe)	23.6	263.3

Studies of the lower limits of thermal tolerance were performed on nine individuals weighing from 1380 to 1620 g (39.9–42.3 cm TL). The fish were obtained from aquarium culture. For a period of seven days prior to the experiment, the fish were acclimatized to a temperature of 24.5°C (corresponding to the ambient water temperature) in a thermo-regulated aquarium with a volume of 120 dm³, in well-aerated tap water. The water temperature was lowered using a cooling system equipped with a thermostat. The experiment was carried out in May/June in the lab room, well-lit by two large windows, 3.6 m by 1.8 m, without any artificial light. Each fish was kept separately. They were not fed during the experiment. Observations during the lowering of water temperature indicated that at a temperature of 24.5°C (the beginning of the experiment) the respiration rhythm of the fish was about 33 to 35 breaths per minute. The experiment was based on slowly lowering the water temperature (0.7°C per day) and observing the behavior of the fish. After the minimal temperature was reached (i.e. when fish could not maintain normal activity), water cooling was discontinued and the water was gradually re-warmed.

Moreover, the catalog of records was established, based on accurate photographic documentation of fish captured, with detailed description of localization of capture, length, and in some cases – weight of the individuals described.

RESULTS

The stomachs of five fish studied (caught in the wild) were empty, with the exception of one specimen (from the warm effluent channel of the Pomorzany Power Plant), where the asp *Aspius aspius* (L., 1758) scales were noted along with a fragment of a plastic aquarium plant, which indicates that this specimen was of aquarium origin.

The scales of *P. brachypomus* were small and cycloid with a smooth caudal margin. The age determined from scales ranged from 6+ to 11+. Four specimens of pirapitinga caught in the wild in June including three individuals from the warm effluent channel and one from the Szczecin Lagoon were in good condition, while one individual collected on September 19 in Lake Dąbie, with a water temperature of 14.8ºC, had a slightly deformed body shape. Although its weight was almost the same as that of specimens from aquariums used in the experiment, it was in a very poor condition, and it died after five days in a laboratory tank.

In the laboratory experiment on nine specimens of *P. brachypomus* (obtained from aquarium culture), lowering the water temperature did not affect respiratory rhythm of the studied individuals. The first, distinct locomotive change (a short-term imbalance) was noted when the water temperature decreased below 13.0ºC (on day 16 of the experiment). The temperatures of the loss of balance of studied fish were different for groups of fish, and occurred at 12.8 (three fishes), 12.1 (one fish), 11.6 (four fishes), and 11.2ºC (one fish) – Fig. 3.

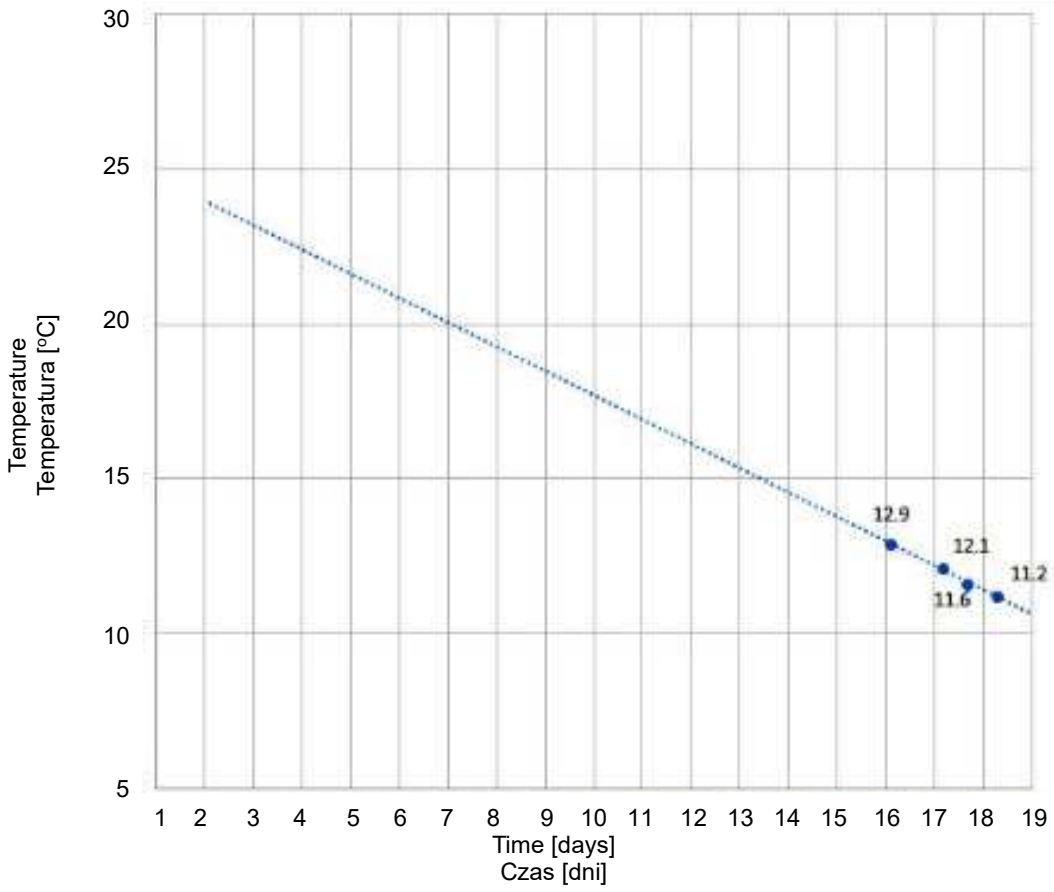

Fig. 3. Thermal limits of *P. brachypomus* during the lowering the water temperature
Ryc. 3. Granice tolerancji termicznej *P. brachypomus* podczas obniżania temperatury wody

The fish sank to the tank bottom and ceased to react to mechanical stimuli, but the respiration rates did not change. It was confirmed that the fish regained their balance at a temperature of about 13.5°C and resumed reacting to stimuli.

All of five specimens studied from open waters had immature gonads.

Seventeen well-documented *P. brachypomus* records in Polish water basins (warm effluent reservoirs, lakes, ponds, rivers and lagoons) were noted from 2001 to July 2015. They were caught from June to October each year, mainly in the heated water reservoir of power plants (Fig. 4). The individuals in reports had a total length range of 17.0–49.0 cm TL and weight range to 3000 g. They were all captured by the recreational anglers (Table 2).

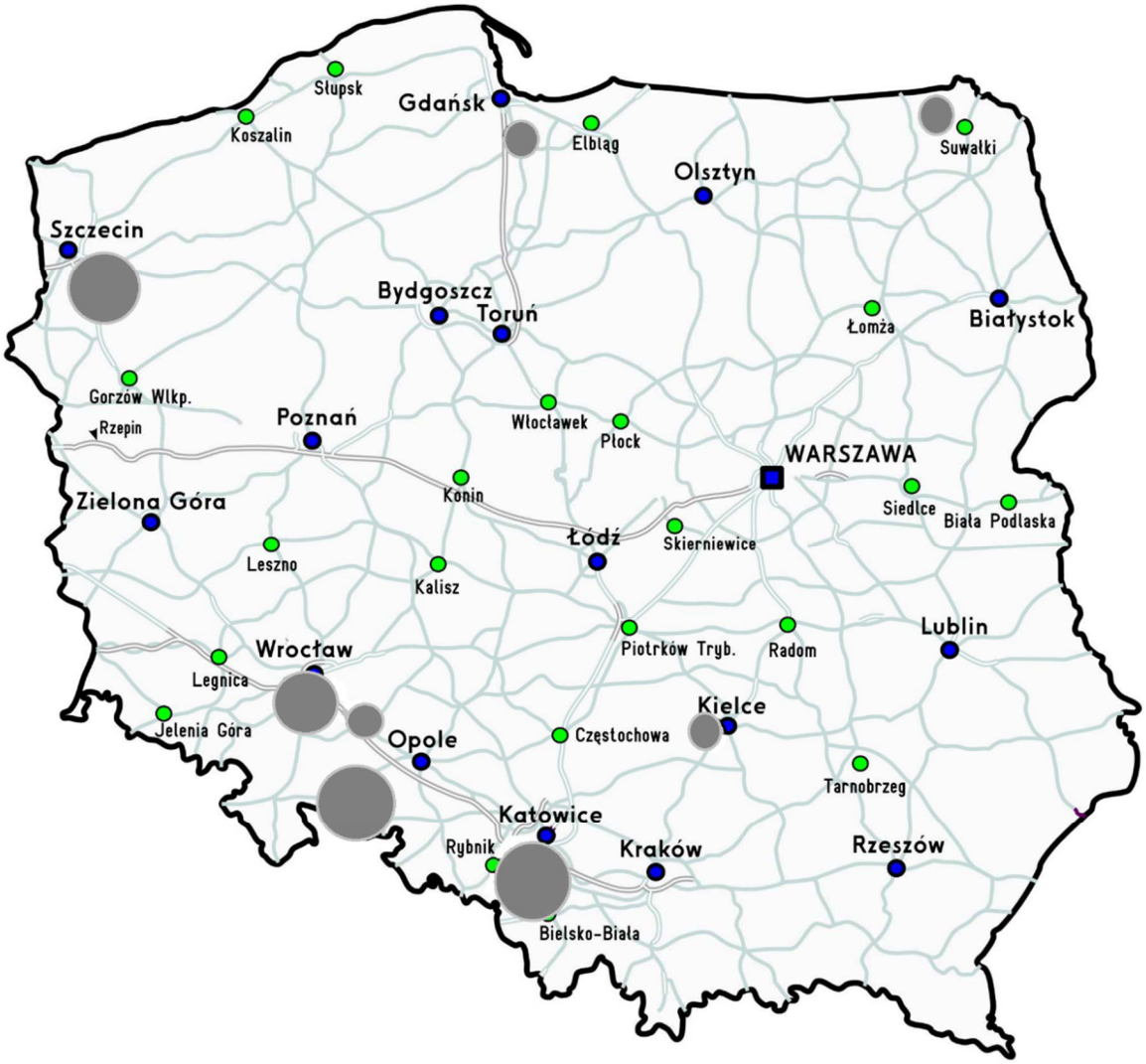

Fig. 4. Localization of well-documented pirapitinga records in open waters in Poland (the diameter of characters depends on the specimens number)
Ryc. 4. Lokalizacja udokumentowanych połowów *P. brachypomus* w wodach otwartych Polski (średnica oznaczeń zależna od liczby osobników)

Table 2. Localization of well-documented pirapitinga *P. brachypomus* records in open waters in Poland (excluding described in this paper – Fig. 2)
Tabela 2. Wykaz lokalizacji udokumentowanych połowów *P. brachypomus* w wodach otwartych Polski (bez lokalizacji podanych w niniejszej pracy – ryc. 2)

	Date of fish capture (by recreational anglers) Data złowienia ryby (przez wędkarza)	Type of water body Rodzaj zbiornika wodnego	Area Region	Length – Długość/ /weight – masa
1.	July – lipiec 2001	lake jezioro	Kamienne (Suwalszczyzna region)	no data brak danych
2.	7 August 7 sierpnia 2002	pond staw	town Wrocław miasto Wrocław	26.6 cm
3.	22 August 22 sierpnia 2002	pond staw	town Wrocław miasto Wrocław	31.8 cm
4.	16 November 16 listopada 2002	pond staw	Jelcz-Laskowice (near town Wrocław) (koło miasta Wrocławia)	37.0 cm/810 g
5., 6., 7.	September wrzesień 2004	lake jezioro	Miedwie (near town – koło miasta Stargard)	30.0 cm, 31.0 cm, 32.0 cm
8.	July – lipiec 2006	heated water reservoir of power plant zbiornik elektrowni (wody podgrzane)	Rybnik Reservoir (near Rybnik power plant) Zbiornik Rybnicki (koło Elektrowni Rybnik)	30.0 cm
9.	15 August 15 sierpnia 2006	heated water reservoir of power plant zbiornik elektrowni (wody podgrzane)	Rybnik Reservoir (near Rybnik Power Plant) Zbiornik Rybnicki (koło Elektrowni Rybnik)	42.0 cm/2000 g
10.	25 October 25 października 2006	heated water reservoir of power plant zbiornik elektrowni (wody podgrzane)	Rybnik Reservoir (near Rybnik Power Plant) Zbiornik Rybnicki (koło Elektrowni Rybnik)	48.0 cm/2200 g
11.	June – czerwiec 2010	river rzeka	Wierzyca, town – miasto Starogard Gdański	20.0 cm
12, 13	1 August 1 sierpnia 2010	river rzeka	Nysa Kłodzka, town – miasto Nysa	31.0 cm, 34.0 cm
14.	27 August 27 sierpnia 2010	river rzeka	Nysa Kłodzka, town – miasto Nysa	30.0 cm
15.	15 October 15 października 2010	heated water reservoir of power plant zbiornik elektrowni (wody podgrzane)	Rybnik Reservoir (near Rybnik Power Plant) Zbiornik Rybnicki (koło Elektrowni Rybnik)	49.0 cm /3000 g
16.	12 July 12 lipca 2012	dam reservoir zbiornik zaporowy	Umer Reservoir, town Kielce Zbiornik Umer, miasto Kielce	17.0 cm
17.	30 September 30 września 2015	lake jezioro	Jeziorak, town – miasto Iława	39.5 cm

DISCUSSION

Species that become established in areas outside their natural range are known as alien species. They do not pose a significant risk and many are even beneficial. In comparison, invasive alien species (IAS) are those species introduced by human activities outside their natural past or present distribution that threaten the environment, economy or society, including human health. According to the IUCN, after habitat loss, IAS are the second most

significant threat to biodiversity. They may become predators, competitors, parasites, hybridizers or diseases of native and domesticated animals. *Piaractes brachypomus* is considered either an alien species or IAS, dependent on the area of non-native occurrence; it is an alien species in the temperate zone, but it becomes IAS in the subtropical or tropical regions, where over-wintering and breeding success is possible (Minister of the Environment of Canada 2012).

Piaractus brachypomus have been introduced in the world as a commercial alien species, as escapees from aquaculture or released by aquarists. The first published record in central Europe, was in June 2002 in Poland (Boeger et al. 2002). However first unpublished record of individual of *P. brachypomus* was noted in July 2001. Sightings of *P. brachypomus* were widely publicized by local media as the occurrence of the red-bellied piranha *Pygocentrus nattereri* Kner, 1858, dangerous for humans. However, the comprehensive morphometric procedures and comparisons of morphological and anatomical characters with those reported in Géry et al. (1987), Jégu (2003) and Hensel (2004) indicated that specimens caught in Polish waters belong to the species *P. brachypomus*.

In Poland, after June 2002 there were also some reports of *P. brachypomus* catches from different regions; to date, this fish has been reported sporadically. According to Nowak et al. (2008) all of these specimens were definitely released into the wild by aquarists.

Piaractus brachypomus is probably not able to survive the Polish winter season, because the optimal temperature range for this species is 23–30°C (Shafland et al. 2008). The laboratory experiment conducted in this study showed that the lower limit of thermal tolerance (understood as an equivalent to normal function) was 11.2°C. According to Lovshin (1995) and Logan et al. (1996), the species stops feeding between temperatures of 16–18°C, with death ensuing at 11–13°C. This makes it impossible for this species to overwinter in the Polish waters even if their thermal regime is heavily transformed by man. Since it is a tropical species, it is not considered to be a threat in temperate climates. The only areas where it could survive locally and maintain populations would be in naturally warm springs or power plant effluent channels with minimum temperatures of 11–12°C (Čaleta et. al. 2011). In Slovak waters, for example, one population of guppy *Poecilia reticulata* Peters, 1859 has been established in hot springs (Koščo et al. 2010).

This experiment conducted in the present paper indicated that *P. brachypomus* does not tolerate water temperatures below 13°C. During the winter, temperatures in open water bodies in Poland are significantly lower, while the lowest temperatures in warm water effluent (Pomorzany Power Plant channel) are a little beneath the lower tolerance limit of *P. brachypomus* (7.5–10°C).

The "Rybnik" water reservoir, where was the most records of *P. brachypomus* individuals (in July-October), has been characterized from the thermal viewpoint as a hydro-engineering facility that constitutes an integral element of a technological sequence used for surface cooling of the cooling waters from the "Rybnik" Power Plant. In the course of flow through the reservoir, the initial temperature of the discharged water i.e. approximately 20–35°C drops to 6–25°C by the dam area. The temperature range of 6–25°C may be assumed as typical for this reservoir from the viewpoint of its impact on the receptor i.e. the Ruda river below the

"Rybnik" reservoir. In the yearly cycle, the temperatures of the reservoir's water are higher by 3.3–8.2°C than the typical temperatures of waters of the Śląskie Voievodeship area. The most clear difference can be seen for the months January–July (8.2–7.3°C) – Kostecki (2005).

However, it should be taken under consideration, that the progressive process of global warming may enlarge the distribution of nonindigenous occurrences of *P. brachypomus*, with more effective overwintering and breeding.

The species is primarily herbivorous, but it has powerful teeth that can inflict severe bites. It consumes nuts, fruits, seeds, and sometimes insects (Robins et al. 1991). In present study, only one of five individuals studied (37.0 cm TL), had a scales of *A. aspius* in its stomach. According to Correa et al. (2015), the diet assessments are important tools to depict the ecological function of alien species introduced into novel ecosystem and possible direct and indirect ecological effects. The diet analysis of *P. brachypomus*, introduced into the Sepik-Ramu River Basin (Papua New Guinea) nearly two decades ago, showed that in contrast to native populations in South America, that feed mainly on terrestrial plants and invertebrates, it was mainly composed of fish remains and aquatic plants, while terrestrial plants were frequently consumed but in relatively smaller amounts. These findings show that this species has an inherently plastic diet that can be adjusted when displaced to a novel geographic area. While trophic plasticity increases the likelihood of a species to establish breeding populations after its introduction, it also reduces our ability to predict negative effects on native species.

Outside of its natural distribution range, incidental finds of individual pirapitinga have been recorded in Europe in Slovakia (Hensel 2004), Spain (Leunda 2010), and Croatia (Čaleta et al. 2011). A live pirapitinga 21.5 cm in length was caught by a fisherman in the Øresund Sound of the Baltic Sea, on August 4, 2013, in a fyke net, at 1 m depth (salinity ca 13 psu) (H. Carl, Statens Naturhistoriske Museum, København, Denmark, personal communication). All these individuals are assumed to have been released by aquarists. However, in Croatia unofficial information indicates that the high water levels in the Drava River and its tributaries in spring 2010 led to the flooding of pirapitinga ponds in Hungary that swept the fish into the river (Čaleta et al. 2011). On the Iberian Peninsula along with *P. nattereri*, *P. brachypomus* was recognized as a non-native species that was not successfully established in this new area of distribution; a non-native fish species is considered successful when it is known to reproduce in the wild (Copp et al. 2005). *Piaractus brachypomus* was considered there as a carnivorous species that occupied more than one of sub-region. It was found to be extremely tolerant and capable of living in systems with poor water quality, identified as an intercontinental species, with the lowest prior invasion success (Ribeiro et al. 2008).

Outside of Europe, *P. brachypomus* has been introduced into Peru, Columbia, Cuba, Malaysia, Indonesia, China, Taiwan, Papua New-Guinea, and the Canadian Province of Ontario (Hensel 2004). It is common in the open waters of 16 states of the United States, not only because of aquarium releases but the fish farms escapes as well, but it has thus far failed to establish any known reproducing populations (Nico et al. 2015). In some countries, it has become a valuable food source, for example in southern China. It has spread throughout inland waters thanks to its rapid growth, high reproduction ability, and the availability of food (Ma et al. 2003). It was also recently been introduced as a commercial alien species into India (illegally) via Bangladesh (Choudhury et al. 2013) and in Bengal (Barua and Chakraborty 2011).

In Malaysia, it came from Brazil, possibly through Taiwan. The genetic composition of the stock is dubious, and it has possibly already been subjected to inbreeding (Coates 1997). It began attacking other fishes in the rivers, when their main food, insects, became scarce. There are also reports of it attacking humans. It also causes ecological imbalance by preying on endemic fish species and their eggs and fry (Dau 2001).

Examinations of the patterns and characteristics of both invaders and invasion processes improve our ability to predict the impact of new invaders (Marchetti et al. 2004). Another area of concern is the issue of parasites which are able to infect other host fish species. The gill arches of one specimen of pirapitinga from the warm water channel of Pomorzany Power Plant were infected with the *Mymarothecium viatorum*, a neotropical monogenoid parasite that was described as new to science (Boeger et al. 2002).

Although it is considered to be a potential pest in many countries, native populations in South America are facing increased stress from commercial fisheries, poaching and agriculture (Ramirez-Duarte et al. 2008).

CONCLUSIONS

All *Piaractus brachypomus* specimens recorded in Poland were undoubtedly released into the wild by aquarists. Attention should be focused on the possibility of novel pathogen transfer to native aquatic biota as an important aspect of regulating the aquarium fish trade.

Piaractus brachypomus is probably not able to survive the Polish winter season. The laboratory experiment showed that the lower limit of thermal tolerance (understood as an equivalent to normal function) for this species was 11.2°C. Since it is a tropical species, the only areas where it could survive locally and maintain populations in Poland are heated power plant effluent channels. However, the progressive process of global warming may enlarge the distribution of nonindigenous occurrences of *P. brachypomus*, with effective overwintering and breeding.

Piaractus brachypomus is recorded in the open waters of many countries in the world, not only because of aquarium releases but the fish farms escapes as well. In some countries, it has become a valuable food.

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Abstract. This paper presents the biological characteristics of five individuals of *Piaractus brachypomus* (15.3–37.0 cm TL) caught in north-western Poland (Szczecin Lagoon, lake Dąbie and Pomorzany Power Plant cooling water canal in Szczecin), in 2002–2010, by recreational anglers and commercial fishermen. Additionally, well documented records of *P. brachypomus* (17.0–49.0 cm TL) in different waters (lakes, ponds, dam reservoirs, rivers and lagoons) collected from 2001 to September 2015 by recreational fishers, are presented. All these individuals were released into the wild by aquarists. Nonindigenous occurrences in Europe and in the world outside the native range (the Amazon and Orinoco basins) of the species are also discussed, including a record of alive pirapitinga in the Baltic Sea. An evaluation of invasion risk in the environment in Poland, based on the thermal tolerance of the specimens studied, is included. The laboratory experiment showed that the lower limit of thermal tolerance was 11.2°C, therefore the potential for over winter survival in Polish waters is extremely low, even in the warm-water canals of power plants. However, the progressive process of global warming may enlarge the distribution of nonindigenous occurrences of *P. brachypomus*, with more effective overwintering and breeding, with the possibility of novel pathogen transfer to native aquatic biota.