Oceanologia (2015) 57, 280–287

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/oceano

ORIGINAL RESEARCH ARTICLE

Changes in the parasite communities as one of the potential causes of decline in abundance of the three-spined sticklebacks in the Puck Bay

Jolanta Morozińska-Gogol *

Institute of Health Sciences, Pomeranian University in Słupsk, Słupsk, Poland

Received 24 November 2014; received in revised form 4 February 2015; accepted 24 March 2015
Available online 10 April 2015

KEYWORDS
Parasites;
Three-spined stickleback;
Puck Bay;
Baltic Sea

Summary In the past, the Puck Bay was a very important area for freshwater and marine ichthyofauna. Due to anthropogenic degradation of the environment, especially eutrophication, commercially important fish species have lost spawning grounds and their distribution and abundance fell significantly. A sharp increase in the number of *Gasterosteus aculeatus* was recorded since the mid-seventies of the twentieth century. Sticklebacks had become the dominant species and were distributed evenly in the coastal waters. But now, the numbers of sticklebacks are decreasing. In this paper, the parasite community of the three-spined sticklebacks was studied. The values of parasitological indices are counted and compared with previous data. Possible consequences of the harboured parasites for body condition, fecundity and changes in host behaviour are described. Also the other possible reasons for the current reduction in the number of sticklebacks in the Puck Bay are analyzed.

* Correspondence to: Institute of Health Sciences, Pomeranian University in Słupsk, ul. Bohaterów Westerplatte 64, 76-200 Słupsk, Poland. Tel.: +48 59 84 05 910; fax: +48 59 84 05 916.
E-mail address: morgo@onet.eu.
Peer review under the responsibility of Institute of Oceanology of the Polish Academy of Sciences.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.oceano.2015.03.001

1. Introduction

Fish from the family Gasterosteidae are distributed worldwide in the Northern Hemisphere and they inhabit freshwater, brackish water and inshore zones of the sea (Wootton, 1976). They are short-living fishes, about 2—4 years (DeFaveri and Merilä, 2013; Voight, 2007). Because of its worldwide distribution, occurrence in various habitats, omnivorous nature and a central position in the food web, three-spined stickleback *Gasterosteus aculeatus* (Linnaeus, 1758) is a very popular model host in ecological parasitology (Barber, 2013).

Parasites are a very important component of biocenosis and good indicators of the environmental changes and ecosystem health (Hudson et al., 2006; Marcogliese, 2002). Some species of parasites play a vital role in the regulation of the abundance of hosts by affecting their growth, fertility and behaviour (Marcogliese, 2004; Pojmańska and Niewiadomska, 2010). They may also change the host's colouration making them easier to be seen and easier to be caught by the other hosts (Pojmańska and Niewiadomska, 2010).

Among the parasites of *G. aculeatus* we found generalists as well as specialists. Some of them can contribute to the reduction of sticklebacks population, e.g., *Schistocephalus solidus* inter alia affect their fertility (Heins and Baker, 2008), *Diplostomum* spp. reduced vision and can lead to blindness (Valtonen and Gibson, 1997; Voutilainen et al., 2009) and *Thersitina gasterostei* reduced respiration (Rokicki, 1994).

Barber (2013) reported that 155 parasites, including 120 metazoans, were recorded from the three-spined sticklebacks worldwide. From Euroasia region 86 metazoan species of parasites were known (Poulin et al., 2011). In Poland, totally 51 species of parasites, including one alien species *Anguillicola crassus* Kuwahara, Niimi & Itagaki, 1974, have been noted (Morozińska-Gogol, 2006).

A significant increase in the number of the three-spined sticklebacks was recorded since the mid-seventies of the twentieth century. They became the dominant species and were distributed evenly and in large numbers in the coastal waters of the southern Baltic Sea, especially in the Puck Bay (Skóra, 1992, 1993). The next change in the composition of ichthyofauna of the Puck Bay was observed in the nineties, when the alien invasive species, the round goby *Neogobius melanostomus* (Pallas, 1811), appeared and spread rapidly (Sapota, 2004). Over the last few years, changes in the occurrence of *G. aculeatus* in the coastal waters are observed. Formerly sticklebacks occurred in large number in the Gdynia Marina and the fishing port in the Puck for the whole year. Presently, their abundance in these locations has significantly decreased. Reduction in the number of sticklebacks in these areas could be a result of changes in the abiotic and biotic elements of the environment, including relationships with other species, like competition, predation and parasitism.

The first information about parasites of stickleback from the Polish Coast was printed in 1883 by Girdwoyń, who described the plerocercoids *S. solidus*. Afterwards parasitofauna of *G. aculeatus* from the Polish coastal waters was studied in detail by Fidelus (1975), Morozińska-Gogol (1999, 2002) and also by Sulgostowska and Vojtkova (2005), when the sticklebacks were the dominant fish species in the habitat. More than 30 species of parasites of the sticklebacks were recorded from the entire Polish coastal waters, including lagoons, estuaries and coastal lakes (Morozińska-Gogol, 2006).

In this paper, the recent decline in the abundance of the three-spined sticklebacks in the Puck Bay is reported. Some of the parasites that infected sticklebacks caused health effects and induced changes in host behaviour. This research is carried out for a better understanding of the role of the parasite communities in the fluctuations in host abundance, their health and circulation of the parasites in the food web of the ecosystem of the Puck Bay.

2. Study area

The Puck Bay is the western part of the Gulf of Gdańsk. This reservoir is separated from the open sea by the Hel Peninsula. The border between the Puck Bay and the Gulf of Gdańsk is a line connecting the tip of the Hel Peninsula with Kamienna Góra — the hill in Gdynia. The sandbank, Rybitwia Mielizna, divides the Puck Bay into the inner and outer Puck Bay. The inner part is also called the Puck Lagoon. Both parts have different conditions. The outer eastern part connected with the Gulf of Gdańsk is deeper with higher salinity and lower summer temperature. The Puck Lagoon is a shallow semi-enclosed basin with less salinity and more susceptibility to changes in weather and strong anthropogenic pressure (Kruk-Dowgiałło and Szaniawska, 2008).

In the past this basin was inhabited by many species of freshwater, migratory and marine fish (Skóra, 1993). From the 1970s, adverse changes in the ecosystem structure because of increasing eutrophication and pollution were observed. Structure of ichthyofauna has changed, including the disappearance of many fish species and expansion of Gasterosteidae and also Gobiidae (Kruk-Dowgiałło and Szaniawska, 2008; Skóra, 1993). The biomass of the three-spined stickleback was 99% of all fish biomass in this basin in the 1990s (Skóra, 1993).

3. Material and methods

The three-spined sticklebacks were caught with a manual fishing lift net in two ports of the Puck Bay, in the Gdynia Marina (54°31′0″N, 18°33′12″E) situated in the outer Puck Bay and in the fishing port in Puck (54°43′22″N, 18°24′40″E) located in the Puck Lagoon. Fish were caught from the Gdynia in November 2012 and April 2013 and from the Puck in April and June 2013. In the remaining months fishing of the samples was unsuccessful.

Lateral plate morphs were determined, where *trachurus* is a fully plated form, *semiarmatus* is partially plated on the pectoral and caudal parts of the body, and *leiurus* is a low plated form (Bańbura and Bakker, 1995). Fish were weighed and measured. Sex of the sticklebacks was also determined. Fulton's condition factor (CF) was calculated with the formula: $CF = 10^5 \times W/L^3$ (Coop and Kovač, 2003), where W is fish weight in grams and L is total fish length in millimetres. If stickleback was infected with *S. solidus*, because of significant weight of the parasites, plerocercoids were removed before fish weighing. Statistical significance of the differences in CF between males and females as well as between infected and uninfected sticklebacks was tested with t-test.

Sticklebacks were examined for ectoparasites and endoparasites using the standard procedures of parasitological