The population of *Carassius gibelio* (Bloch, 1782) and its parasites in Madatapa Lake (South Georgia)

Japoshvili B.[1]; Mumladze L.[1, 2, 3*]; Murvanidze L.[1]

Received: April 2015 Accepted: December 2015

Abstract

Gibel carp is a very successful invasive fish species in the waters of Georgian inland and the only fish species in Lake Madatapa. However, almost nothing is known about its biology and morpho-ecological peculiarities at the national level and even the distribution data is not documented. For the first time, we studied the population characteristics of gibel carp in Lake Madatapa (South Georgia) with the aim to reveal the extent of its morphological variability, sex ratio, length-weight relationship and its parasitic community. We showed that the gibel carp population in Madatapa Lake has typical morphological characteristics. The sex ratio is significantly female biased (1/1.8) and the length-weight relationship is within the published margins. The gibel carp population is under the heavy parasitic load, but only two parasitic species (one cestoda and the other digenean species) affect the fishes. Within the framework of the obtained results, we discussed future research needs concerning the gibel carp in the lake.

Keywords: Gibel carp, Madatapa, Sex ratio, Length-weight relationship

[DOR: 20.1001.1.15622916.2017.16.2.24.7]

1- Institute of Zoology, Ilia State University, Cholokashvili ave. 3/5, 0165, Tbilisi, Georgia.
2- Institute of Ecology, Ilia State University, Cholokashvili ave. 3/5, 0165, Tbilisi, Georgia.
3- Invertebrate Research Centre (IRC), 26, Agladze Str. 0119, Tbilisi, Georgia.
***** Corresponding author's Email: lmumladze@gmail.com

Introduction

Lake Madatapa is an eutrophic lake located in Javakheti plateau (Southern Georgia) at 2108 m a.s.l. and is the part of the Javakheti Protected Areas since 2011 (Fig. 1). The lake is naturally volcanic in origin with a surface area of 8.8 km^2 and a maximum depth of 1.7 m. The lake is historically known to be free of fish species which is believed to be a result of severe winter conditions. Indeed the lake is completely frozen during January (Apkhazava, 1975). After the mid 90s the gibel carp (*Carassius gibelio*, Bloch, 1782) firstly appeared there. However the exact date and the source of invasion of gibel carp in the lake is unknown and currently untraceable.

While gibel carp is the most common species in Georgia, very limited data is available on its biology, ecology and even distribution as well as its ecological impacts and economic importance in the region. The species is extensively studied in many countries and it is proved that the species is extremely tolerant to the variable environmental conditions (e.g. De Boeck *et al.*, 2004; Nilsson and Renshaw, 2004). This makes gibel carp a very successful invader in all kinds of inland waters (Lusková *et al*., 2010) and it is considered as a strong competitor to other fish species and has strong impacts on the invaded habitats (Paulovits *et al*., 1998; Gaygusuz *et al*., 2007; Perdikaris *et al*., 2012; Tarkan *et al*., 2012). However, in some cases the species could also be an important addition to water ecosystems. For example, after the arrival of gibel carp, Lake Madatapa gained significant importance for the local community as a fish source. Furthermore the appearance of gibel carp in the lake resulted also in the appearance of pelicans (*Pelicanus* spp.) (Gavashelish. However there is no source of information on where the population characteristics of gibel carp was studied or what effects of it are seen in Georgian water ecosystems, although having such information is important for the management of water ecosystems and invasive fish species.

Figure 1: A view of Lake Madatapa in early autumn.

[DOR: 20.1001.1.15622916.2017.16.2.24.7]

Within the framework of our ongoing project (with the aim of studying various hydrobiological properties of major lakes of Javakheti plateau) we reported the preliminary results of the study of gibel carp population in Lake Madatapa in order to provide basic information useful for future work. Lake Madatapa while harboring only one fish species could provide new insights into its population dynamics from an evolutionary perspective. Specifically we intended to explore the morphological characteristics, sex ratio and length-weight relationship (LWR) of the gibel carp population in the lake as well as to identify its parasitic species community and their prevalence.

Materials and methods

During the September of 2014 we sampled the gibel carp population in Lake Madatapa (N41.18°, E43.78°), using two gill nets with 18 and 24 mm mesh size (each net of 100 m long and 1.5 m height). Nets were installed in the evening and checked early the next morning to avoid sample loss by birds (gulls and ducks). Weight (to the nearest 0.01 g) and total length (to the nearest 0.1 mm) were measured in the field and all individuals were transported to the laboratory for further investigation.

Age was determined by inspecting the scales under the microscope and the sex was determined by the visual checking of gonads. Number of gill rakers and lateral line scales were counted and all live individuals (34) were also inspected for parasites. Fish were initially examined externally for ectoparasites and then gills, eyes and other internal organs were checked with common necropsy and parasitological methods (Stoskopf, 1993). Parasites were identified using the keys of Bykhovskaya-Pavlovskaya *et al*. (1964).

After the checking for outliers, log transformed power function ($W=aL^b$) was applied to account the LWR (Froese, 2006). To detect possible differences between males and females in LWR we applied multiple regression analyses with the sex as a dummy variable including sex-length interaction terms. Data transformation and regressions were performed using IBM SPSS software package (IBM corp.).

Results

In total 141 gibel carp specimens were caught in Lake Madatapa with an average weight 37.5 g (SD = 53, range [13.3-471.7]) and length of 12.5 cm (SD= 2.9, range [9.4 - 30]). The number of lateral line scales varied between 29 and 31 and the number of gill rakers varied between 36 and 47. The overall length-weight relationship falls within the margins of published sources (e.g. Froese and Pauly, 2014). There were no significant differences (i.e. interaction term is not significant after multiple regression - $p>0.05$) between the regression coefficients for males and females and the slope (b) does not

[DOR: 20.1001.1.15622916.2017.16.2.24.7]

differ significantly from 3 (Table 1). Out of 141 fished specimens, sex was determined for only 105 specimens (the gonads of remaining specimens were either strongly damaged by the parasites or were not developed) and the sex ratio was significantly female biased (1/1.8, χ^2=8, p<0.01). There are no size or weight differences between males and females (t=0.6, df=103, p<0.05 for both cases).

Out of 34 specimens from Lake Madatapa, 31 (91%) were infected with one or two parasites. The plerocercoids of cestoda (*Ligula intestinalis* L., 1758) had highest prevalence (75%), whereas only 38% of studied fishes were infected with metacercariae of digenean trematode (*Diplostomum spathaceum* Rud, 1819). Both parasites were detected in only nine specimens (27%). Cestodes were found in five females, whereas sex was not determined for the other eight specimens. Of the 29 specimens infected with *L. intestinalis*, 24 (83%) had completely degenerated gonads. From the remaining five specimens, for whom the sex was determined, only one was male. Out of the three specimens without parasites, two were females and one was male.

Discussion

Only few published sources addressing the occurrence of *Carassius* spp. in Georgia resulted in confusing knowledge of species identity and their distribution (reviewed in Japoshvili *et al*., 2013). During the last 25 years, *Carassius* sp. invaded most of the inland waters of Georgia and it was commonly accepted that the species was *C. carassius* (L). However recent studies (Japoshvili *et al*., 2004; Japoshvili *et al*., 2013) showed that the gibel carp is probable the only invasive *Carassius* carp in the waters of Georgian inland with doubtful occurrence of *C. carassius* in extreme western Georgia (Kessler, 1877-1878 cited in Elanidze, 1983). The studied population of gibel carp from Lake Madatapa has also typical morphological characteristics reported elsewhere (Kottelat and Freyhof, 2007) hence confirms our previous findings (Japoshvili *et al*., 2013).

Table 1: Regression statistics of length-weight relationships of gibel carp population in Madatapa Lake.

				Regression statistics				
	n	**Length range (cm)**	**Weight range (g)**	***a***	**95% CI for *a***	***b***	**95% CI for *b***	r^2
Male	38	10.1 - 27.5	14 - 310.5	-1.73	-1.99 - (-1.47)	2.93	2.69 - 3.17	0.95
Female	67	9.9 - 30	15 - 471.7	-1.79	-2.02 - (-1.56)	2.99	2.79 - 3.2	0.93
All	141	9.4 - 30	13.3 - 471.7	-1.8	-1.95 - (-1.61)	2.98	2.82 - 3.13	0.93

[DOR: 20.1001.1.15622916.2017.16.2.24.7]

Populations of gibel carp are normally female biased and sometimes only females are represented (Tsoumani *et al*., 2006). However, the pattern varies greatly with the geographic region (reviwed in Liasko *et al*., 2011). In mixed populations, the proportion of males also varies greatly and seldom approaches 50 percent (Vetemaa *et al*., 2005; Liasko *et al*., 2011). While the gibel carp could reproduce gynogenetically with the help of other cyprinid fishes (Deinhardt, 2013), the gonohoristic mode of reproduction is ascribed to various factors such as parasitic load ("Red Queen" hypothesis (Jaenike, 1978; Lively, 2010; Vergara *et al.*, 2014)) or severe environmental conditions (Liasko *et al*., 2011). Indeed the gibel carp in Lake Madatafa faces apparently severe environmental conditions as well as heavy parasitic loads. High prevalence of cestoda and trematoda parasites in the studied gibel carp population also supports the "Red Queen" hypothesis. On the other hand, gibel carp is the only fish in Lake Madatapa existing at least during the last 20 years and the survival of the population ultimately depends on the existence of conspecific males. This alone explains the high proportion of males in the system. There is no empirical study showing how the sexuality is maintained in a single species (with gynogenetic mode of reproduction) system however we do not yet know whether the population also includes triploid gynogenetic females. If this is the case, then the population may face to extinction threats under a simple population dynamic model (Smith, 1978; Doncaster *et al*., 2000). Hence the Madatapa Lake provides an excellent natural laboratory to disentangle the effects of different factors on the population structure and dynamics of gibel carp.

Acknowledgments

We would like to thank Ani Bikashvili, Marina Gioshvili, Giorgi Nozadze, members of the group of Parasitology of the Institute of Zoology and the staff of Javakheti Protected Areas for their help in field and laboratory work. The study was supported be the Shota Rustaveli National Scientific Foundation (Grant: FR/479/7-130/13).

References

Apkhazava, I., 1975. Lakes of Georgia. Mestniereba, Tbilisi, 180 p. (In Russian).

Bykhovskaya-Pavlovskaya, I.E., Gussev, A.V., Dubinina, M.N., Izyumova, N.A., Smirnova, T.S., Sokolovskaya, A.L., Schtein, G.A., Shulman, S.S. and Epshtein, V.M., 1964. Key to parasites of freshwater fish of the USSR. Israel Program for Scientific Translations, Jerusalem, 919P.

De Boeck, G., Meeus, W., De Coen, W. and Blust, R., 2004. Tissue-specific Cu bioaccumulation patterns and differences in sensitivity to waterborne Cu in three freshwater fish: Rainbow trout (*Oncorhynchus*

[DOR: 20.1001.1.15622916.2017.16.2.24.7]

mykiss), common carp (*Cyprinus carpio*), and gibel carp (*Carassius auratus gibelio*). *Aquatic Toxicology*, 70, 179–188. doi:10.1016/j.aquatox.2004.07.001

Deinhardt, M., 2013. The invasive potential of prussian carp in Finland under the light of a novel semi-clonal reproductive mechanism. MSc Dissertation, University of Jyväskylä, Finland, 73P.

Doncaster, C. P., Pound, G. E. and Cox, S. J., 2000. The ecological cost of sex. *Nature*, 404, 281–285. doi:10.1038/35005078

Elanidze, P. F., 1983. Fishes of lakes and rivers of Georgia. Metsniereba, Tbilisi, 320P.

Froese, B. R., 2006. Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22, 241–253. doi: 10.1111/j. 1439-0426.2006.00805.x

Froese, R. and Pauly, D., 2014. FishBase. Avaialable at: www.fishbase.org.

Gaygusuz, Ö., Tarkan, A. S. and Gaygusuz, Ç. G., 2007. Changes in the fish community of the Ömerli Reservoir (Turkey) following the introduction of non-native gibel carp *Carassius gibelio* (Bloch, 1782) and other human impacts. *Aquatic Invasions*, 2, 117–120. doi: 10.3391/ai.2007.2.2.6.

IBM Corp. Released 2012. IBM SPSS statistics for windows, Version 21.0. NY: IBM Corp., Armonk.

Jaenike, J., 1978. A hypothesis to account for the maintenance of sex within populations. *Evolutionary Theory*, 94, 191–194.

Japoshvili, B., Ertan, O. and Diler, O., 2004. A study of morpho-ecological characters of *Carassius auratus* L. and *Carassius carassius* (L). *Proceedings of Institute of Zoology*, 12, 280–283.

Japoshvili, B., Mumladze, L. and Küçük, F., 2013. Invasive *Carassius* carp in Georgia: Current state of knowledge and future perspectives. *Current Zoology*, 59(**6**), 732-739.

Kottelat, M. and Freyhof, J., 2007. Handbook of European freshwater fishes. Publications Kottelat, Cornol, Switzerland, 646P.

Liasko, R., Koulish, A., Pogrebniak, A., Papiggioti, O., Taranenko, L. and Leonardos, I., 2011. Influence of environmental parameters on growth pattern and population structure of *Carassius auratus gibelio* in Eastern Ukraine. *Hydrobiologia*, 658, 317–328. doi: 10.1007/s10750-010-0502-6

Lively, C. M., 2010. A review of red queen models for the persistence of obligate sexual reproduction. *Journal of Heredity*, 101, 13–20. doi: 10.1093/jhered/esq010

Lusková, V., Lusk, S., Halačka, K., Vetešník, L., 2010. *Carassius auratus gibelio* - The most successful invasive fish in waters of the Czech Republic. *Rusian Journal of Biological Invasions*, 1(**3**), 176–

[DOR: 20.1001.1.15622916.2017.16.2.24.7]

180. doi: 10.1134/S2075111710030069

Nilsson, G. E. and Renshaw, G. M., 2004. Hypoxic survival strategies in two fishes: extreme anoxia tolerance in the North European crucian carp and natural hypoxic preconditioning in a coral-reef shark. *Journal of Experimental Biology*, 207, 3131–3139. doi: 10.1242/jeb.00979

Paulovits, G., Tatrai, I., Matyas, K., Korponai, J. and Kovats, N. 1998. Role of prussian carp (*Carassius-auratus Gibelio* (Bloch)) in the nutrient cycle of the kis-balaton reservoir. *International Review of Hydrobiology*, 83, 467–470.

Perdikaris, C., Ergolavou, A., Gouva, E., Nathanailides, C., Chantzaropoulos, A. and Paschos, I., 2012. *Carassius gibelio* in Greece: The dominant naturalised invader of freshwaters. *Reviews in Fish Biology and Fisheries*, 22(**1**), 17–27. doi: 10.1007/s11160-011-9216-8

Smith, J. M., 1978. The evolution of sex. Cambridge, Cambridge University Press, 222P.

Stoskopf, M. K., 1993. Fish medicine. Philadelphia, Saunders Company, 882P.

Tarkan, A.S., Gaygusuz, O., Gaygusuz, G.C., Saç, G. and Copp, G.H., 2012. Circumstantial evidence of gibel carp, *Carassius gibelio*, reproductive competition exerted on native fish species in a mesotrophic reservoir. *Fisheries Management and Ecology*, 19(**2**), 167–177. doi: 10.1111/j.1365-2400.2011.00839.x

Tsoumani, M., Liasko, R., Moutsaki, P., Kagalou, I. and Leonardos, I., 2006. Length-weight relationships of an invasive cyprinid fish (*Carassius gibelio*) from 12 Greek lakes in relation to their trophic states. *Journal of Applied Ichthyology*, 22(**4**), 281–284. doi: 10.1111/j.1439-0426.2006.00768.x

Vergara, D., Jokela, J. and Lively, C.M., 2014. Infection dynamics in coexisting sexual and asexual host populations: support for the red queen hypothesis. *American Naturalists*, 184(**S1**), S22–S30. http://dx.doi.org/10.5061/dryad.40d6h.

Vetemaa, M., Eschbaum, R., Albert, A. and Saat, T., 2005. Distribution, sex ratio and growth of *Carassius gibelio* (Bloch) in coastal and inland waters of Estonia (North-Eastern Baltic Sea). *Journal of Applied Ichthyology*, 21(**4**), 287–291. doi: 10.1111/j.1439-0426.2005.00680.x