Finding of nile tilapia *Oreochromis niloticus* (Cichliformes: Cichlidae) in Georgia, the South Caucasus

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Abstract. Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) is a fish from the family Cichlidae, native to Sub-Saharan Africa. Nile tilapia is one of the most cultured freshwater fish species worldwide and because of its commercial value and well-developed aquaculture technologies, it has been introduced to many countries. Nile tilapia also has become invasive in areas of suitable climate when escaped from aquaculture facilities to the wild. Georgia is the country in the Ponto-Caspian region situated on the southern slopes of the Great Caucasus eastwards from the Black Sea coast. Due to its very variable landscape, the climate of Georgia fluctuates from cold mountainous to humid subtropical type. Here we present the finding of *Oreochromis niloticus* in freshwaters of eastern Georgia for the first time, with the discussion of risk assessment with the climate suitability for potential establishment.

Keywords: caucasus; climate; non-native species; risk assessment

1. Introduction

The introduction of non-native species is a global problem. Some introduced species cause negative effects on native organisms and cause their decline [1, 2]. Aquaculture is one of the pathways of new fish species introductions [3, 4].

Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) is a cichlid fish, native to tropical and subtropical regions of the African continent and the Nile River [5]. Nile tilapia is the most cultured species worldwide from all tilapiine fishes [6]. Because of its commercial value and well-developed aquaculture technologies, it has been introduced in many countries. Due to the species ability of fast growth, paternal care, age, and size at maturity, this species has become successful invaders outside its native range and have become invasive in several countries such as Brazil [7] and the USA [8].

Nile tilapia was found in Turkey by Mert & Cicek [9], which was supposed to be its maximum northern distribution in the Mediterranean area. Authors, however, emphasized that the confirmation of this species establishment was needed [9]. Later, Nile tilapia was included in the checklist of the freshwater fishes of Turkey [10]. A few years later, Nile tilapia appeared in local anglers caught in a small village in neighboring Georgia.

Georgia is a country located in the South of the Great Caucasus Mountains eastwards from the Black Sea coast, and this area is included in global biodiversity hotspots [11]. The region is characterized by
different altitude landscapes that facilitated the climate variability from cold mountainous to humid subtropical type [12]. In total, 119 freshwater fish species can be found in the South Caucasian region (Georgia, Armenia, and Azerbaijan), with seven endemic species [13].

Here we present the finding of Nile tilapia in freshwaters of Eastern Georgia for the first time, with the discussion of climate suitability for the species establishment and associated risks in the area.

2. Material and methods
In the summer of 2019, a tilapia (*Oreochromis* sp.) fish appeared in local anglers caught in a small village Mshvidobani (Lagodekhi region) in Eastern Georgia. The territory of the Lagodekhi municipality is characterized by a mild humid climate with hot summers and mildly cold winters. The average annual humidity of the air is 72%, the annual sum of precipitation is 1004 mm. The annual summer temperature is 12.6°C. The coldest month (January) has an average temperature of 0.9°C. The hottest period of the year is July-August with an average temperature of 24.1°C (http://www.lagodekhi.gov.ge).

In a small river, Baisubniskhevi (GPS coordinates N41.7634466 E46.1304388, the Kura River drainage) the local angler caught 10 individuals of the tilapia species with the fishing rod and put the photograph on the forum for identification on 29 September 2019. The record of the angler's catch was found on the fishermen forum (https://bit.ly/3lKSasu). The river, where the tilapia fish was found is used to supply the fish pond and fish farms in the area. From the bridge, down the river, south-west, in around 100 m, there are two ponds where a small aquaculture facility is located. Outflow from the ponds flows to the Baisubniskhevi River. The study area is shown in figure 1.

![Figure 1. The south-east of the Mshvidobani Village: the Baisubniskhevi River, the bridge, and the aquaculture ponds.](image)

Identification of caught individuals was done using the available picture (figure 2). We took morphological characters, which we were able to measure from the photograph and compared to the identification key [5]. We used the following characters: the number of scales in the lateral line and the presence of vertical spines on the caudal fin.
Figure 2. *Oreochromis niloticus* caught in the Baisubniskhevi River near village Mshvidobiani, Lagodekhi region (Georgia) on 23.09.2019. (c) Sportfishing.ge/forum.

After two months, on 29 November 2019, we visited the locality where the angler’s coughed the tilapia fish. We interviewed local inhabitants and applied electro-fishing with device EFGI 650. We sampled in shallow waters, at a maximum 70 cm depth, with an effective radius of 1m and 100-volt strength at the Baisubniskhevi River close to the Mshvidobiani village. The starting point was at the bridge (N41.763548 E46.130234) upstream northeast in the transect of 100 m length, and we also sampled the channels that are the outflow of aquaculture facilities.

We used the program Climatch v1.0 (Bureau of Rural Sciences) to test the climate suitability of the tilapia’s native range, Source Area (SFA) versus Georgia, Target Area (TA). Five variables including annual mean temperature, the temperature of coldest and warmest months, and temperature of coldest and warmest quarters were used for the test. The test gives a final score from 1-10, meaning that the SA and TA climate are matching if the result scores are more than 7. Any less score indicates no suitability of climate between SA and TA [14].

3. Results

We were not able to catch fish during electrofishing. Nevertheless, the unavailability of the specimen we could still distinguish the species from the photograph (figure 2) as Nile tilapia (*Oreochromis niloticus*) according to the number of scales from lateral lines which were 33 and the most distinguishable character for *O. niloticus*, presence of vertical stripes on the caudal fin.

We interviewed the son of the owner of the aquaculture facility and fishponds (that is 100 meters far away down from the bridge) because the owner himself was unavailable. His son considered the picture of tilapia as a Prussian carp (*Carassius gibelio*) and he said that they have many Prussian carps in the pond. In the end, it was quite unclear if they have this fish there. However, after interviewing locals, they admit that they have caught tilapia fish several times from the bridge and from the channel which supplies the river with water.

We compared Nile tilapias native area (SA) tropical and subtropical regions of the African continent and the Nile River to its introduced area (TA) Georgia. The result of Climate analysis identified the TA as a not suitable climate for the Nile tilapias distribution (figure 3). The maximum similarity value between SA and TA within the whole of Georgia was 5 in the Abkhazia Region (northwest of Georgia, the Black Sea Basin), where minimum temperatures in winter vary between 4-6 °C.
4. Discussion
The fish found in the Lagodekhi region was identified as Nile tilapia, however without having the voucher specimen. The obtained morphological characteristics observed in a photograph perfectly matched those presented by Trewavas [5]. Nile tilapia is the most commonly distributed cichlid fish outside of its native range due to its trade value [6]. Aquaculture is also most likely the reason for this species' appearance in the Lagodekhi region. This fish likely escaped from nearby fish farms that are just 100 meters far away from where the fish was spotted. To track the exact place and time of Nile tilapias introduction in the area was impossible since the owner of the facility was not able to communicate with us and it was not possible to confirm the information that we got from locals.

Even if the Climate analysis did not confirm the environmental suitability for the Nile tilapia in Georgia, the risk of this species establishment still exists. For example, Nile tilapia was not considered to be established in temperate environments in the US, since it was believed that the species could not survive the winter. However, the study done by Grammer et al. [15] proved its successful establishment in temperate Mississippi (Southeastern Mississippi, the Pascagoula River). Although the extended temperatures range for Nile tilapia is 8-42 °C [16], it was found to be well adapting to the outflows of the aquaculture farms, where water is warmer (so-called thermal refugia), which then could have led to survival and establishment of Nile tilapia in temperate regions in the USA [17].

Global climate change is believed to be the factor of some non-native species to become invasive, it was hypothesized that climate change might alert the mechanisms of transportation and introduction of non-native species as commercial and recreational activities will increase the propagule pressure of non-native species [18, 19]. In the view of global climate change the probability of species establishment and spreading is increasing as the fish enter the open waters. We suggest observing the locality if the fish is likely to overcome the temperature barriers over the winter period and establish a viable population.

Acknowledgments
We would like to thank a user on Sportfishing.ge named Levanika, for his post and information regarding fish existence in the area. We thank the Department of Zoology and Fisheries (Czech University of Life Sciences, Prague) for financing the field trip and the Institute of Zoology (Ilia State University) for providing fishing gear.
References

[1] Gallardo B and Aldridge D C 2013 Priority setting for invasive species management: risk assessment of Ponto-Caspian invasive species into Great Britain. *Ecol. Appl.* **23** 352

[2] Ricciardi A 2003 Predicting the impacts of an introduced species from its invasion history: An empirical approach applied to zebra mussel invasions. *Freshw. Biol.* **48** 972

[3] Cook E J, Ashton G, Campbell M, Coullts A, Gollasch S, Hewitt C, Liu H, Minchin D, Ruiz G and Shucksmith R 2008 Non-native aquaculture species release Implications for aquatic ecosystems. In: *Aquaculture in the Ecosystem* (Dordrecht: Springer) chapter 5 pp. 155–184

[4] Gozlan R E 2010 The cost of non-native aquatic species introductions in Spain: Fact or fiction? *Aquat Invasions* **5** 231

[5] Trewavas E 1983 *Tilapiine Fishes of the Genera Sarotherodon, Oreochromis and Danakilia*. British Museum (Natural History)

[6] Food and Agriculture Organisation 2019 Cultured aquatic species information programme. *Oreochromis niloticus* (Linnaeus, 1758). Available from: http://www.fao.org/fishery/culturedspecies/Oreochromis_niloticus/en

[7] Britton J R and Orsi M L 2012 Non-native fish in aquaculture and sport fishing in Brazil: economic benefits versus risks to fish diversity in the upper River Paraná Basin *Rev. Fish Biol. Fish.* **22** 555

[8] Zambrano L, Martínez-Meyer E, Menezes N and Peterson A T 2006 Invasive potential of common carp (*Cyprinus carpio*) and Nile tilapia (*Oreochromis niloticus*) in American freshwater systems. *Can J Fish Aquat Sci* **63** 1903

[9] Mert R and Çiçek E 2010 Range expansion of introduced tilapia species (*Oreochromis niloticus*, L. 1758, Cichlidae) in Turkey. *J. Anim. Vet. Adv.* **9** 1753

[10] Çiçek E, Birecikligil S S and Fricke R 2015 Freshwater fishes of Turkey: a revised and updated annotated checklist. *Biharean Biol.* **9** 141

[11] Mittermeier R, Gil P, Hoffman M, Pilgrim J, Brooks T, Mittermeier C, Lamoreux J, Da Fonseca, G and Saligmann P 2004. *Hotspots Revisited* (Mexico City: Cemex)

[12] Zazanashvili N, Sanadiradze G, Buhknikashvili A, Kandaurov A and Tarkhnishvili D 2004 Caucasus. In: Mittermeier R, Gil P, Hoffman M, Pilgrim J, Brooks T, Mittermeier C, Lamoreux J, Da Fonseca G, and Saligmann P. (Eds), *Hotspots Revised*. (Mexico City: Cemex) pp. 148–152

[13] Kuljanishvili T, Epitashvili G, Freyhof J, Japoshvili B, Kalous L, Levin B, Mustafayev N, Ibrahimov S, Pipoyan S and Mumladze L 2020 Checklist of the freshwater fishes of Armenia, Azerbaijan and Georgia. *J Appl. Ichthyol.* **36** 501

[14] Kalous L, Patoka J and Kopecký O 2015 European hub for invaders: Risk assessment of freshwater aquarium fishes exported from the Czech Republic. *Acta Ichthyol Piscat* **45** 239

[15] Grammer G L, Slack W T, Peterson M S and Dugo M A 2012 Nile tilapia *Oreochromis niloticus* (Linnaeus, 1758) establishment in temperate Mississippi, USA: Multi-year survival confirmed by otolith ages. *Aquat. Invasions* **7** 367

[16] Philippart J C and Ruwet J C 1982 Ecology and distribution of tilapias. In the biology and culture of tilapias. *ICLARM Conference Proceedings* **7** 15

[17] Peterson M S, Slack W T and Woodley C M 2005 The occurrence of non-indigenous nile tilapia, *Oreochromis niloticus* (Linnaeus) in coastal Mississippi, USA: Ties to aquaculture and thermal effluent. *Wetlands* **25** 112

[18] Hellmann J J, Byers J E, Bierwagen BG and Dukes J S 2008 Five potential consequences of climate change for invasive species. *Conserv. Biol.* **22** 534

[19] Rahel F J and Olden J D 2008 Assessing the effects of climate change on aquatic invasive species. *Conserv. Biol.* **22** 521