Journal of Threatened Taxa

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

COMMUNICATION

ECOLOGY OF THE CRITICALLY ENDANGERED SINGIDIA TILAPIA (TELEOSTEI: CICHLIDAE: *OREOCHROMIS ESCULENTUS*) OF LAKE KAYANJA, UGANDA AND ITS CONSERVATION IMPLICATIONS

Richard Olwa, Herbert Nakiyende, Elias Muhumuza, Samuel Bassa, Anthony Taabu-Munyaho & Winnie Nkalubo

26 July 2020 | Vol. 12 | No. 10 | Pages: 16251–16256
DOI: 10.11609/jott.5700.12.10.16251-16256

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 July 2020 | 12(10): 16251–16256

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

DOI: https://doi.org/10.11609/jott.5700.12.10.16251-16256

#5700 | Received 14 January 2020 | Final received 16 June 2020 | Finally accepted 19 June 2020

Ecology of the Critically Endangered Singidia Tilapia (Teleostei: Cichlidae: *Oreochromis esculentus*) of lake Kayanja, Uganda and its conservation implications

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Abstract: Singidia Tilapia *Oreochromis esculentus* is a Critically Endangered native tilapia fish species endemic to lakes Victoria and Kyoga basins of East Africa, however, it disappeared from these main lakes due to overfishing, environmental degradation and predation by the introduced Nile Perch *Lates niloticus*. Remnant populations of this fish species is now restricted to satellite lakes including Lake Kayanja of the Victoria basin. This study provides updated information about the population abundance, critical habitat, threats and diet of Singidia Tilapia to inform conservation decisions to revive its populations in the wild. Fish data collection and mapping of nursery and breeding habitats of Singidia Tilapia on Lake Kayanja was conducted between February 2016 and October 2017. In all the areas mapped and sampled, Singidia Tilapia (with a size range of 11–27 cm TL) was the most abundant (43%) relative to exotic Nile Tilapia *Oreochromis niloticus* (21%) and Redbelly Tilapia *Coptodon zillii* (36%). The emergence of introduced (exotic) tilapias like Nile Tilapia recorded in this study could be attributed to cage fish farming being carried out in this Lake. The diet of *Oreochromis esculentus* consisted mainly of detritus (60.8 %), plant materials (27.7%) and blue-green algae (5.5%). Destruction of critical habitats and presence of introduced fish species were noted as the major threats to this fish and its habitats. The generated information could contribute to guiding stakeholders to undertake appropriate actions to conserve this threatened fish species and its habitats.

Keywords: Africa, conservation, Cichlid fishes, recovery, threatened fishes.

Editor: Neelesh Dahanukar, IISER, Pune, India. **Date of publication:** 26 July 2020 (online & print)

Citation: Olwa, R., H. Nakiyende, E. Muhumuza, S. Bassa, A. Taabu-Munyaho & W. Nkalubo (2020). Ecology of the Critically Endangered Singidia Tilapia (Teleostei: Cichlidae: *Oreochromis esculentus*) of lake Kayanja, Uganda and its conservation implications. *Journal of Threatened Taxa* 12(10): 16251–16256. https://doi.org/10.11609/jott.5700.12.10.16251-16256

Funding: This study was carried out with financial support from The Rufford Small Grants Foundation, The Pro Natura Foundation Japan and The Mohamed Bin Zayed Species Conservation Fund.

Competing interests: The authors declare no competing interests.

For **Author details** & **Author contribution** see end of this article.

Acknowledgements: Our outmost credits go to The Pro Natura Foundation Japan, Rufford Small Grant Foundation, and The Mohamed Bin Zayed Species Conservation Fund for providing financial support for this study. Appreciations to associate professor Yasuaki Sato of Osaka Sangyo University, Japan for his guidance, advise, and support which made this study successful. We convey our gratitude to government representatives particularly district fisheries officer and assistant fisheries officer of Masaka for their guidance, technical support and participation in data collection and mobilization of local communities. Appreciation goes to the National Fisheries Resources Research Institute of Uganda for allowing time for Richard Olwa, Herbert Nakiyende, Bassa Sammuel, and Elias Muhumuza to be away from office duty to collect data, write, and review this article. We are grateful for the contribution of Dr. Winnie Nkalubo and Dr. Anthony Taabu-Munyaho of National Fisheries Resources Research Institute for their technical guidance, support, and valuable inputs. Thanks to the lake Kayanja communities, especially the fishermen and local leaders, for sacrificing their valuable time in implementing the activities of the project.

INTRODUCTION

Singidia Tilapia *Oreochromis esculentus* is a Critically Endangered indigenous tilapiine cichlid (Twongo et al. 2006), endemic to lakes Victoria and Kyoga basins of eastern Africa (Nagayi-Yawe et al. 2006). This fish species has suffered a large reduction in extent of occurrence and is now restricted to a few refuge impoundments and satellite lakes such as Kayanja of the Victoria basins (Balirwa et al. 2000; Ogutu-Ohwayo & Balirwa 2006). Many researchers have documented factors attributing to the decline in the populations of Singidia Tilapia including the aggressive competition for food, spawning, and nursery grounds with introduced Nile Tilapia *Oreochromis niloticus*, predatory actions of Nile Perch (Mwanja et al. 2012), and environmental degradation like pollution, habitat modification, fragmentation & loss (Balirwa et al. 2003;Dudgeon et al. 2006; Ogutu-Ohwayo & Balirwa 2006; Chapman et al. 2008; Njiru et al. 2008; Lowe-McConnell 2009). Since this species was assessed and published as Critically Endangered (Twongo et al. 2006), no active research has been carried out to learn more about its distribution patterns and population status, therefore, additional research was needed to provide updated information and data about the feeding behavior, population status, threats to its critical habitat and distribution to inform conservation actions to halt the extinction of this species in the wild.

METHODS AND MATERIALS

The study was implemented on Lake Kayanja, one of the satellite lakes of Lake Victoria basin. It is geographically located at 0.283^{0}S & 31.867^{0}E (Figure 1). This Lake is administratively found in the sub-county of Bukakata, Masaka District in the central region of Uganda and lying west of lake Victoria. The habitats of lake Kayanja are dominated by wetlands and riverine forests which provide structural heterogeneity for fish to escape from predators, and thus having special significance for conservation of lake Victoria's fauna. A reconnaissance survey was conducted to identify the sampling sites within the lake based on indigenous knowledge of fishermen and key habitat characteristics including lake depth, vegetation cover, and human activities in the vicinity. Three sites namely; Kawunguli, Kasanje, and Bugiri were selected for fish surveys to collect primary data on Singidia Tilapia.

Collection of fish data

Fish surveys were conducted at pre-selected experimental sites for collection of primary fish data. Experimental gill-netting and electro-fishing techniques (Image 1 and 2) were used to collect fish samples. At each site, three fleets of graded multi-filament gill nets of mesh sizes ranging from 25.4–139.7 mm at an interval of 12.7mm and sizes 152.4–203 mm at 25.4mm intervals. The fleets were set parallel to the lake shoreline towards open water in the evening (17.00–18.00 h) and retrieved at dawn (05.00–06.00 h) the following morning. At each study site, geographical coordinates were recorded using a Global Positioning System (GPS). At the shallow inshore areas of each site, fish populations were sampled using a pulsed electro-fisher with an eight-watt generator and two anodes (Amisah & Cowx 2000). Two 30-minute runs were made at each site at an interval of 15 minutes to allow processing of the catch and recovery of conditions for fish re-occupancy. All the fish caught were measured for total and standard lengths (TL and SL) in centimeters, and identified to species level according to Greenwood (1966) guidelines. A total of 45 fish stomachs of Singidia Tilapia, Nile Tilapia, and *Coptodon zillii* indicating presence of any food were dissected out, contents evaluated and preserved in 5% formalin solution in separate numbered bottles for further analysis in the laboratory. The analysis of gut contents of preserved stomachs followed procedures reviewed by Elliott & Bagenal (1979). After rinsing the preserved stomachs with tap water and blotting off the excess water, the contents of each stomach to be analyzed were emptied into a petri-dish. Binocular (x10-80) and compound (x600) microscopes were used to identify the contents. At the lower magnification, large food items, such as, insects, fish or their remains were identified and quantification was based on the point's method (Hynes 1950). All the collected data were analyzed using excel spreadsheet to determine relative population abundance, percent composition of the diet. ArcGIS was used to generate distribution maps and critical habitats of Singidia Tilapia.

Mapping of critical habitats

A combination of scientific and indigenous knowledge was used to identify and map critical sites such as spawning and nursery grounds vital for the survival of Singidia Tilapia (Image 3) using the GPS. The criteria used to map these sites were based on known indicators such as presence of both mature (breeding) and young (immature/juvenile) Singidia fish, and characteristics of habitats such as shallow muddy bottom, presence

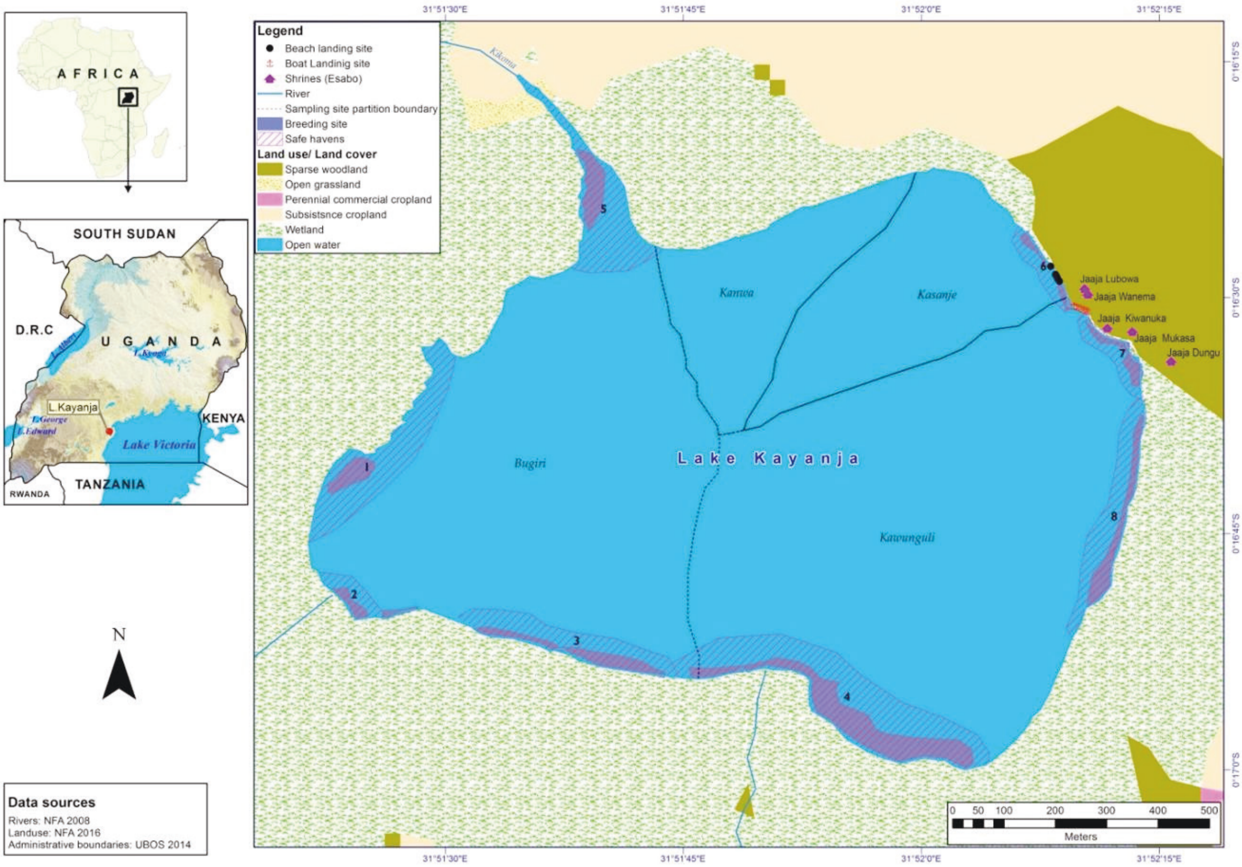


Figure 1. Breeding and nursery sites of Singidia Tilapia mapped on lake Kayanja.

Image 1. Experimental gill-netting in lake Kayanja.

Image 2. Electro-fisher being used to sample fish in lake Kayanja.

of breeding substrates like water lily, river inlets, and riverine forest preferred by of Singidia Tilapia

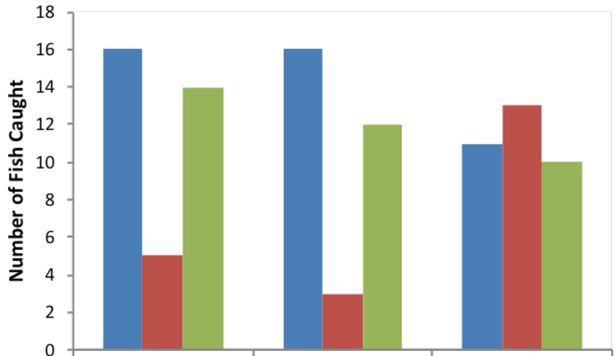
RESULTS AND DISCUSSION

Distribution and abundance of Singidia Tilapia

Singidia Tilapia was mostly found in areas identified and mapped as breeding and nursery areas (Figure 1; Image 4). A total of eight breeding sites of Singidia Tilapia were mapped in lake Kayanja (Figure 1). These critical sites are characterized by known indicators like shallow muddy bottoms, presence of waterweeds such as water lily, river inlets, and riverine forest. The surveys also revealed presence of introduced (exotic) tilapiines, i.e., Nile Tilapia *Oreochromis niloticus* and Redbelly Tilapia *Coptodon zillii*.

Population and abundance of Singidia tilapia

A total of 1,956 fish specimens representing 16 fish species were collected from the study area, of which 43 individuals were Singidia Tilapia, 21 were Nile Tilapia, and 36 were Redbelly Tilapia. Singidia Tilapia was the



	Bugiri	Kawunguli	Kasanje
Oreochromis esculentus	16	16	11
Oreochromis niloticus	5	3	13
Coptodon zillii	14	12	10

Figure 2. Population abundance of Singidia Tilapia and exotic fish species.

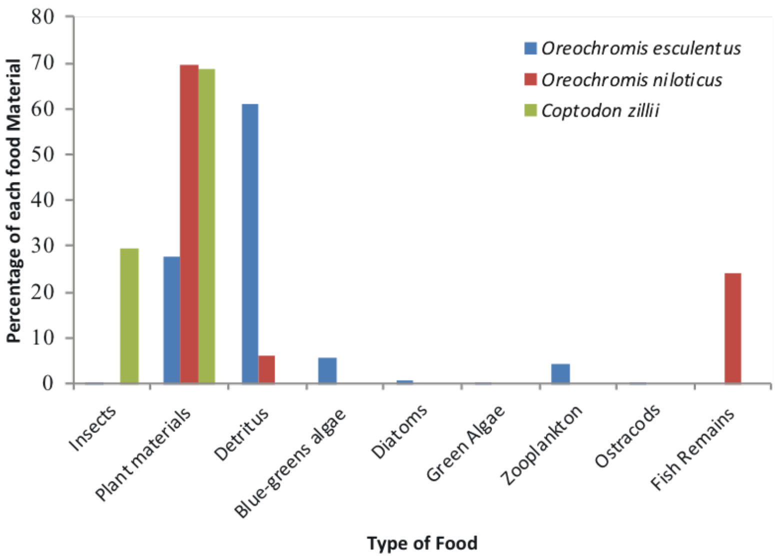


Figure 3. Prey of Singidia Tilapia and the introduced fish species.

most abundant (43%) relative to introduced (exotic) Nile Tilapia (21%) and Redbelly Tilapia (36%) in the study area. In terms of numbers, Singidia Tilapia was most abundant in Bugiri followed by Kawunguli sites, while Nile Tilapia was abundant in Kasanje (Figure 2). The variability in the distribution of Singidia Tilapia in lake Kayanja could be attributed mainly to habitat characteristics, for example, Kawunguli and Bugiri sites are dominated by shallow muddy bottom, breeding substrates like water lily, and river inlets which are preferred habitats for Singidia Tilapia. The high number of Nile Tilapia in Kasanje could be attributed to presence of the cage of Nile Tilapia in this area; we believed some of these Nile Tilapia fish must have escaped to the surrounding water from the cage.

Diet of Singidia Tilapia and the introduced fish species

A total of 45 fish stomachs of Singidia Tilapia, Nile Tilapia and Redbelly Tilapia were collected and analyzed to determine their feeding behaviors. The diet of Singidia Tilapia consisted of detritus (60.8%) followed by plant materials (27.7 %), blue-green algae (5.5 %), zooplanktons (4.5% and others (1.5%). The Nile Tilapia was feeding mainly on plant materials (69.5%) followed by fish remains (24.3%), and detritus (6.3%) (Figure 3). *Coptodon zillii* fed mainly on plant materials (68.7%) and insects (29.3%). Plant materials were the main diet for Nile Tilapia and *Coptodon zillii* while Singidia Tilapia fed mainly on detritus. *Coptodon zillii* fed more on insect remains than any of the targeted fish species. This finding complements on what other researchers have documented about the dietary requirement of native tilapias and introduced tilapias (Nagayi-Yawe et al. 2006; Mwanja et al. 2012; Ogutu-Ohwayo 1990; Lowe-McConnell 2009).

Image 3. Research team mapping breeding and nursery sites of Singidia Tilapias.

Image 4. Singidia Tilapia *Oreochromis esculentus*

Image 5. The cage for Nile Tilapia culture in lake Kayanja.

Image 6. Maize farm located at the shores of lake Kayanja.

The key threats to Singidia Tilapia fish species

This study revealed the transformation of lakeshore into farmlands and presence of introduced or exotic fish species were major threats that could jeopardize the ecological integrity of lake Kayanja and the conservation of endangered fishes in future. The following were some of the unwarranted activities being undertaken on lake Kayanja and its catchment areas

Cage fish farming of Nile tilapia in lake Kayanja (Image 5), which competes with Singidia Tilapia for food, spawning, and nursery ground.b)

Destruction of the buffer zones as result of cultivating crops up to the lake shores (Image 6), and increasing the chances of unused agro-chemicals such as fertilizers from farms to enter these lakes through surface runoffs, thus polluting the aquatic environment, in addition to burning of vegetation by fishermen.

Poor waste disposal and management due to the beach established for recreational, leisure, and special events and activities at the shores of lake Kayanja. Generally during and after such events, many contaminated polythene papers, non-biodegradable plastic bottles, and human wastes find their way into the lake, thus polluting the aquatic ecosystem.

CONCLUSIONS AND RECOMMENDATIONS

During the 19th and 20th centuries, Singidia Tilapia was one of the most abundant and important artisanal and commercial fish species in Uganda. It disappeared from the main lakes such as Victoria and Kyoga due to environmental degradation, predatory actions of the Nile Perch, and aggressive competition for food & space from introduced fishes particularly Nile Tilapia *Oreochromis niloticus*. Remnant populations of this fish species are now surviving in satellite lakes like Kayanja. This lake is, therefore, acting as functional refuge habitat for this

Critically Endangered fish and other aquatic resources that support the livelihoods of millions of people in Uganda. From this study, fish habitat modification, fragmentation and loss, and presence of introduced or exotic fish species were noted as the major threats that could jeopardize the ecological integrity of lake Kayanja to support the conservation of endangered fishes in future. The following recommendations need to be undertaken by all the relevant stakeholders to halt the risk of extinction of this fish species and other vital aquatic resources in lake Kayanja

Recommendations

a) Engagement of all stakeholders particularly government agencies and fishermen in best practices to abate, minimize, and mitigate threats to fish and their habitats in Uganda.

b) Proper management guidelines for satellite lakes to regulate and control development activities such as cage fish farming, agriculture within and around these lakes.

c) Development and implementation of strategic recovery plans to revive the population of Critically Endangered fishes including Singidia Tilapia in the wild.

d) Gazettement, monitoring, and protection of critical habitats for native tilapias not only in lake Kayanja, but also in other satellite lakes.

e) Promotion of fishing community involvement in the conservation and management of satellite lakes fisheries resources in Uganda.

f) Enhancement of public awareness about satellite lakes fisheries resources among all stakeholders to make them know the values and contribution of these resources to their wellbeing and livelihoods, as well as the actions they need to undertake to conserve and sustainably use these resources.

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Author contribution: RO, the principal investigator secured funds for this study, led the field team and participated in data collection, analysis and writing of this article. HN, EM and SB collected and analyzed data and wrote this article. WN provided technical advice, guidance and support to the field team to facilitate successful implementation of the study and writing of this manuscript. AT-M provided technical advice and reviewed this article.

Journal of Threatened Taxa

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PLATINUM OPEN ACCESS

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

July 2020 | Vol. 12 | No. 10 | Pages: 16195–16406
Date of Publication: 26 July 2020 (Online & Print)
DOI: 10.11609/jott.2020.12.10.16195-16406

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