

Nutritional and economic potential of *Clarias liocephalus* for rural populations of South Western Uganda

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ABSTRACT

Southwestern Uganda is one of the densely populated and nutritionally insecure regions in Uganda. The motivation behind this study was to explore the potential of *Clarias liocephalus*, a small wetland fish species common in the area, as source of nutritious food and supplementary income to the nutritionally and economically strained communities in the region. Although this fish has been part of the diet in some rural households in Uganda, information on its nutritional prowess and potential to address rural malnutrition and boost household income is still scanty. Macronutrients crude protein, crude fat, moisture, ash and mineral calcium and selected micronutrients, i.e., iron, zinc and manganese of *C. liocephalus* carcasses were analysed following AOAC standard methods. The general views of the fishers and users on the economic attributes of *C. liocephalus* in the region were also broadly evaluated. Results on the nutritional value (presented on wet weight basis) show *C. liocephalus* as a high protein-low fat fish (15.2 ± 0.191 and 0.301 ± 0.031 , respectively); offering a nutritional advantage to protein deficient and fat controlling diets in the community. It is also a key source of essential micronutrients highly desired in human nutrition (Calcium 715.225; Zn 2.080; Fe 5.370 and Mn 0.151). The high iron content is an important remedy against nutritional anaemia which is especially common in poor households in the study region. The community attaches several attributes to this fish in the diet but the quick money obtained from immature fish sold as bait has steadily diminished it from people's tables. We advocate for inclusion of this fish in peoples diets and recommend management intervention to limit the trade in immature *C. liocephalus*. We recommend further investigation into the wider nutritional profile and domestication trials of *C. liocephalus*.

Keywords: *Clarias liocephalus*, fish, malnutrition, micronutrients, Uganda, wetland

RÉSUMÉ

Le sud-ouest de l'Ouganda est l'une des régions à forte densité de population et à insécurité nutritionnelle de l'Ouganda. La motivation de cette étude était d'explorer le potentiel de *Clarias liocephalus*, une petite espèce de poisson des zones humides, commune dans la région, en tant que source d'aliments nutritifs et de revenus supplémentaires pour les communautés souffrant de difficultés nutritionnelles et économiques dans la région. Bien que ce poisson fasse partie du régime alimentaire de certains ménages ruraux en Ouganda, les informations sur son potentiel nutritionnel et sa contribution dans la lutte contre la malnutrition rurale et l'augmentation des revenus des ménages sont encore

rare. Les macronutriments de protéines brutes, de matières grasses brutes, d'humidité, de cendres et de calcium minéral et certains micronutriments, à savoir le fer, le zinc et le manganèse des carcasses de *C. liocephalus*, ont été analysés selon les méthodes standard de l'AOAC. Les opinions générales des pêcheurs et des utilisateurs sur les caractéristiques économiques de *C. liocephalus* dans la région ont également largement été évaluées. Les résultats sur la valeur nutritionnelle (présentés sur la base du poids humide) montrent que *C. liocephalus* est un poisson riche en protéines et faible en gras ($15,2 \pm 0,191$ et $0,301 \pm 0,031$, respectivement); offrant un avantage nutritionnel aux régimes pauvres en protéines et contrôlant les graisses dans la communauté. C'est également une source clé de micronutriments essentiels très recherchés dans la nutrition humaine (calcium 715.225; Zn 2.080; Fe 5.370 et Mn 0.151). La teneur élevée en fer est un remède important contre l'anémie nutritionnelle qui est particulièrement courante dans les ménages pauvres de la région d'étude. La communauté attache plusieurs attributs à ce poisson dans l'alimentation, mais les recettes rapides obtenues à partir de poisson immature vendu comme appât ont diminué. Nous plaçons pour l'inclusion de ce poisson dans l'alimentation des populations et recommandons une intervention de gestion pour limiter le commerce de *C. liocephalus* immature. Nous recommandons une étude plus approfondie du profil nutritionnel plus large et des essais de domestication de *C. liocephalus*.

Mots-clés: *Clarias liocephalus*, poisson, malnutrition, micronutriments, Ouganda, zone humide

INTRODUCTION

Poor nutrition perpetuates the cycle of poverty and malnutrition. Fish is important in improving human nutrition, contributing to productivity, economic development, and poverty reduction through improved physical and mental capacity and reduction of morbidity and mortality. This is so because fish provides valuable nutrients that are easily assimilated and is a source of some key micronutrients like iron and zinc. Micronutrient malnutrition, also known as hidden hunger, is common in society's vulnerable section (women and children) especially in the developing countries (FAO, 2018). Although the global consumption of fish continues to increase globally; the per capita supply for direct human consumption remains below required protein needs (Tacon and Metian, 2009), especially in developing countries. This is partly attributed to the growing human population, receding fish stocks as well as over dependence on large conventional fish species and neglect of small less known ones. Less information on the nutritional prowess of

small fishes exists and this includes for *Clarias liocephalus*, also a small fish whose body length rarely goes beyond 20 cm (Yatuha *et al.*, 2013).

The potential of *C. liocephalus* to address rural malnutrition and boost household income formed the basis of this study bearing in mind the receding wetland habitat in the study area and the nutritional insecurity in the specific region of study (NEMA, 2014). Although the rural communities in Uganda have had *C. liocephalus* in their diet and even, without scientific proof, have attached several attributes to this fish, the findings of this study present a justified basis to sustainably manage the fishery of *C. liocephalus* currently threatened with overfishing (Yatuha *et al.*, 2013) and habitat loss (NEMA, 2014). The recent proliferating trade in immature *C. liocephalus* as live bait in the Nile perch fishery could likely compromise its dietary contribution because trading in immature *C. liocephalus* is more appealing since it fetches money faster. With possible threats of overfishing facing *C. liocephalus* populations in the region, there

was need to undertake studies to explore and understand the value of this fish.

Bearing in mind the receding wetland habitat and the increasing number of vendors engaged in immature *C. liocephalus* bait market in southwestern Uganda, the overall aim of this study was to gather information on the nutritional and economic potential of *C. liocephalus* to guide management on sustainable utilization and conservation of the fishery.

MATERIALS AND METHODS

Source of samples for nutrient analysis. Live samples of *Clarias liocephalus* were bought from fishermen of Kigambira wetland in Lake Mburo National park and kept in a holding tank at Mbarara Zonal Agricultural Research and Development Institute (MbaZARDI). Samples for nutrient analysis were processed immediately after capture while the mineral nutrient analysis was done later using the fish that remained held in the tank.

Processing nutrient profile of *Clarias liocephalus*. The nutrient profile of *C. liocephalus* was obtained through proximate analysis following standard procedures. Fresh juvenile and adult male and female specimen were washed, and minced to obtain a homogeneous consistency. Crude protein, crude fat, moisture, and ash contents were determined on both mature and juvenile *C. liocephalus* specimen while mineral micronutrients Zinc, Iron, Manganese and Calcium were determined only for adult male and female specimens which were available at the time of the analysis. The macronutrient analyses (except calcium) were done in Mbarara University of Science and Technology Pharmacy laboratory and the mineral analyses at Uganda Industrial Research Institute (UIRI) laboratories in Kampala.

Macronutrient analysis. Crude protein, crude fat, moisture and ash content of the fish samples were determined following the Association

of Official Analytical Chemistry (AOAC) 2000 standard methods. Crude protein was determined by the Kjeldahl's method (Sink *et al.*, 2010), using the value of 6.25 as the conversion factor of total nitrogen to protein, crude lipid by the Bligh and Dyer procedure, moisture by the oven dry method at 100°C until constant weights were obtained and ash by incineration in a muffle furnace at 550°C for 12 hrs.

Mineral micronutrient determination.

Fish samples for mineral quantification were prepared following the procedures described by AOAC (1995). Approximately 3 g of each sample (fresh raw) were placed in crucibles in a cool muffle furnace, and ignited for 5 hours at 550° C, the ash was cooled and digested in 20% HCl, filtered and diluted to 100 ml volume with Potassium chloride solution. The samples were then analysed for mineral contents of calcium (Ca) iron (Fe), zinc (Zn) and manganese (Mn) using the Atomic Absorption Spectrophotometry (1996, Perkin-Elmer Corporation) method.

Economic attributes. A general impression on the economic value of *C. liocephalus* in the community was obtained from the resource users using simple interviews and direct observations. Data on the economic attributes were obtained from Buteraniro trading centre in Ntungamo district. This site was selected because it is one of the largest *C. liocephalus* bait markets in the area. To get a general picture on how much immature fish enters Buteraniro bait market, the site was visited once every month for three months and two hours per visit were dedicated to observe the fish deliveries. Information on the economic attributes of adult *C. liocephalus* sold out as food was gathered from fish vendors in Mbarara central market in Mbarara town centre and Rwebikoona market one of the suburbs of Mbarara town. It was only in these two markets where *C. liocephalus* was sold dry for human consumption.

Data analysis

Descriptive methods were majorly used to analyze the data using Microsoft Excel spreadsheets and SPSS Inc. 17 (IBM Corp) statistical packages.

RESULTS AND DISCUSSION

Macronutrient profile. The results on the macronutrient composition of *C. liocephalus* are summarized in Table 1. *Clarias liocephalus* is a high protein low lipid fish. High protein low-lipid fishes have between 15%-20% protein and less than 5% fat. This implies that *C. liocephalus* has a lower fat content per unit protein compared to other animal protein sources like fatty fish, beef, pork etc. It therefore offers a nutritional advantage for people in need of fat controlling diets as well as protein deficient sections of society. *Clarias liocephalus* is normally dried before it is eaten (Fig. 1), and there is evidence that drying influences proximate composition by concentrating the nutrients, especially protein, almost six fold (Egbal *et al.*, 2010), this shows that the nutritive value of the species could be much higher than what we obtained in this study. This offers an advantage to the resource constrained rural consumers since the cost of *C. liocephalus* is still more affordable compared to other fish species on the market. It is also a call to resource managers to protect the now vulnerable wetland habitat where the species thrives for boosting the nutrition of the community in the area and beyond.

The fat content results of this fish seem to be

much lower than what is reported in other clariids like *C. lazera* and *C. gariepinus* (Egbal *et al.*, 2010). This could be attributed to several factors, for example, the samples used in this study were eviscerated, and it could be possible that intact species have higher lipid content since gonads in gravid specimen usually are covered by fat reserves. Since *C. liocephalus* is eaten whole with all the viscera and gonads intact, it follows that the value in the fish eaten by the community could be richer than what was found in this study.

The high ash content in both the juvenile and mature specimen is an indication that the species is potentially rich in minerals. Ash, which is an inorganic residue that remains after the organic matter is burnt off, is a measure of the mineral content of a food.

Although there was no statistically significant difference ($p>0.05$), the results indicate that mature *C. liocephalus* has higher protein and lipid content compared to immature specimens; while immature specimens registered a higher moisture and ash content compared to the mature specimens. This implies that immature harvested fish may not offer the full nutritional package that is desirable in human diet. Therefore, there is need for harvesting guidelines in the *C. liocephalus* fishery.

Micronutrient profile. The micronutrients in *C. liocephalus* as summarized in Table 2 show the species as a key source of essential

Table 1. Proximate composition of mature and immature *C. liocephalus* fish samples obtained from Kigambira wetland in Lake Mburo National park South Western Uganda

Parameter	Adult	Juvenile
	Mean \pm se	Mean \pm se
% Crude Protein	15.58 \pm .191	13.95 \pm .667
% Fat	0.301 \pm .031	0.126 \pm .027
% Ash	2.97 \pm .046	3.27 \pm .286
% Moisture	76.385 \pm .59	79.94 \pm .366

[NB: Results are means of triplicate determined on wet weight basis]



Figure 1. Mature *C. liocephalus* (smoked and staked for sale as food) from Kigambira wetland in Lake Mburo National park

micronutrients highly desired in human nutrition, with mature males having slightly higher values than female (Fig. 2).

The species has high calcium content followed by iron and zinc. Globally today, more than two billion persons, particularly in the developing world, are deficient in essential micronutrients especially Fe and Zn (WHO, 2018) a very health-risking factor especially among society's vulnerable groups (children, expectant and breast-feeding mothers). *Clarias liocephalus* therefore presents a cheap and safe source of calcium for such groups. Adequate dietary calcium is required throughout life to prevent low bone mineral density, decrease risk of fragility fractures and osteoporosis at a mature age (Lilly *et al.*, 2017).

The Iron content in *C. liocephalus* is important

especially as a remedy in conditions of nutritional anaemia common in poor households where its deficiency is felt most. For example, in 2016, 53% of children aged between 6-59 months and 32 % of women aged between 15-49 in Uganda were anaemic (UDH, 2016). As noted by the Uganda demographic health survey in 2011 (UDH, 2016), iron supplementation is generally low in Uganda and mothers and children in central and southwestern Uganda (study region) had the lowest iron supplementation during the said survey. The fact that *C. liocephalus* can provide a natural source of iron is an opportunity that could be easily tapped basing on the findings of this study.

Nutritionally, the results of this study clearly indicated that *C. liocephalus*' nutritional attributes compare well with other common fish species in the area like *C. gariepinus* and

Oreochromis niloticus (Olopade *et al.*, 2016); and, according to the findings of Ayeloja *et al.* (2013) the species seems even nutritionally superior to the popular *O. niloticus*. From such findings, there is reason to advance *C. liocephalus* value chain through processing and packaging a healthy food product for infants and other nutritionally vulnerable persons.

Table 2. Mineral micronutrient composition of flesh samples of male and female *Clarias liocephalus* (mg/100g of wet weight) obtained from Kigambira wetland in Lake Mburo National park South Western Uganda

Micronutrient	Amount (mg/100g) Mean ± SE	Specimen Sex	Mean
Calcium (Ca)	712.78±8.559	Female	715.225
	717.67± 4.81	Male	
Zinc (Zn)	2.04±0.007	Female	2.080
	2.12 ± 0.027	Male	
Iron (Fe)	5.26± 0.052	Female	5.370
	5.48 ± 0.006	Male	
Manganese (Mn)	0.147±0.008	Female	0.151
	0.154± 0.001	Male	

[NB: Results are means of duplicate determined on wet weight basis]

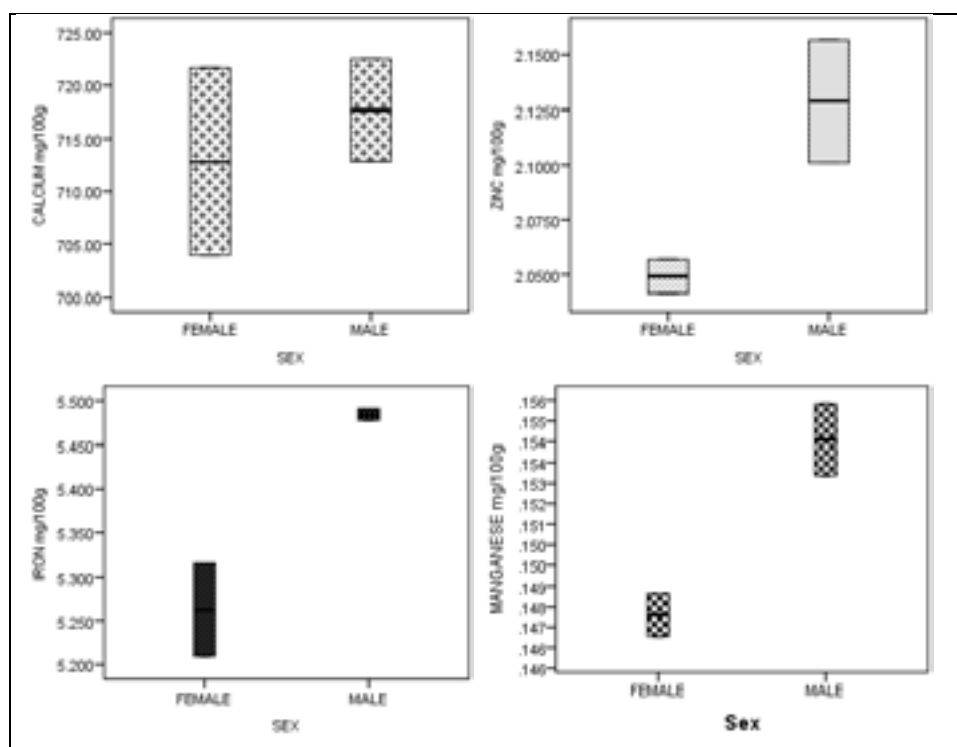


Figure 2. Micronutrient composition in adult male and female *C. liocephalus* from Kigambira wetland Lake Mburo National Park (2017)

Economic attributes. The cost of fish is presented as per fish but *C. liocephalus*, being a small fish, is normally sold in sets and the cost per set is based on the number and size of the fish. Adult fish (sold for consumption) are put on stakes and smoked before selling (Fig. 1), while the immature ones are sold live in sets of 10-12 fish. On average, the immature fish cost between 50-80 Ug shillings per fish and the mature fish 200-700 Ug shillings per fish. In Buteraniro bait market there were 10 individually owned bait selling stores equipped with water containers to hold and sustain the live fish. On average, 27000-30000 immature *C. liocephalus* were delivered at Buteraniro market in one hour. That is, in one hour, five motorbikes each carrying six jerrycans full of fish arrive at the market. Each jerrycan had 900-1000 live immature *C. liocephalus*; therefore each motorbike delivered 5400-6000 fish in one hour. On the other hand, information gathered from Mbarara central market indicate that only one woman and two old men were engaged in vending smoked *C. liocephalus* for food. The vendors in the immature *C. liocephalus* market contended that it was more lucrative since they sold the fish in bulk and were paid promptly. An added attraction to the *C. liocephalus* bait market was because there was no need for the costly post-harvest technologies since the fish was just kept in water. Water being cheaper than firewood in the area of study, the fishers preferred to sell immature bait than mature smoked adults. The bulk of immature *C. liocephalus* traded in just one outlet confirms the attractive but unsustainable economic viability of selling immature fish. There is a probable implication that *C. liocephalus* is indiscriminately and massively fished in the already diminishing wetland habitat in the region and this partly explains the scarcity of *C. liocephalus* in the diet of the people in the area. With such looming scarcity of the mature *C. liocephalus* for consumption and fewer people engaged in its value chain, deprivation

of a relatively cheap source of protein in the diet of the rural communities in the region is most likely. The use of some fish species for non-food purposes such as bait, and depriving them from being used for direct consumption, is well established globally (Tacon and Metian, 2009). As the global prices of fish species that are used for non-food purposes continues to increase (FAO, 2018), the poor who would wish to use the same fish for food cannot compete favorably. Indeed this study has verified that the market demand for *C. liocephalus* has substantially raised the price to the extent that fewer fish are processed for human food and they are more costly. This further pushes *C. liocephalus* away from the poor people's table. As malnutrition remains the number one killer in developing countries, particularly in sub Saharan Africa, (FAO, 2018), it is important to note the danger of exploiting *C. liocephalus* as bait. The most imminent danger of selling immature fish is over exploitation of the fish stock.

These results therefore present vital information for timely management intervention to guide use of *C. liocephalus* resource sustainably and to protect its natural habitat.

CONCLUSION

We conclude that *C. liocephalus* has potential to satisfy the diet demands of the nutritionally insecure sections of society in Southwestern Uganda. Although the fish is nutritious and can be purposively included in the diet of rural communities, the bait market, which fetches more income compared to the table fish, poses a threat to sustainable utilization of the fishery. We recommend that all concerned stakeholders note that the value of this small fish as fishing bait is not only unsustainable but also far less important compared to its nutritional contribution. A campaign to publicize the role of *C. liocephalus* in eradicating malnutrition in poor rural households and further research and investment into value addition by way of

processing and packaging the fish in affordable and high value forms are recommended.

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STATEMENT OF NO-CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this paper.

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