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Shifts in the food of Nile perch (*Lates niloticus*) in Lake Victoria

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Abstract

The study investigated diet of Nile perch in Lake Victoria and compared results with past data from the same lake in order to analyse diet shifts over time. Fish samples (2020) were collected by seining and trawling from 2012 to 2016. In overall, *Caridina nilotica* (59%) was the dominant food item in the diet, while *Rastrineobola argentea* (5%) contributed the least. The diet of Nile perch of 1 cm was copepods, cladocerans and rotifers. The diet changed to only copepods and cladocerans at 2 cm. The proportion of the relatively large calanoids increased with Nile perch size in 1988/89, comprising between 35 and 80% of the diet of fishes of 3–4 cm. Nile perch of 6–25 cm TL fed more on *C. nilotica* in 2012/2016, compared to 1988/1989 and 2006/08. Haplochromines were fed on more in 2006/2008 than in 2012/2016 by Nile perch of 6–30 cm TL as fish size increased. The frequencies of occurrence of *R. argentea* in the diet were highest in 1988/1989, and lowest in 2006/2008, for fish size of up to 30 cm TL. The proportion of Odonata in the diet of size class 16–20 and 21–30 cm TL were highest in 2012/2016 and 1988/1989, respectively. Thus, shifts in Nile perch diet was observed from zooplankton to *C. nilotica*, then to haplochromines and finally to fish prey as size increased. Nile perch preferred haplochromines with C. nilotica as the substitute food. Cannibalism was observed to have decreased, only being evidenced in Nile perch above 35 cm TL, which could actually have a positive impact on the Nile perch fishery. The information on shifts in diet of Nile perch in Lake Victoria is of considerable ecological importance.

KEYWORDS

Lake Victoria, Lates niloticus, shift, diet

1 | INTRODUCTION

Nile perch (*Lates niloticus*) was introduced into Lake Victoria during 1954 and 1963 to create a recreational fishery and convert the large biomass of the indigenous haplochromines cichlids into a more valuable commodity (Pringle, 2005). Before its introduction, it is reported the lake had a multispecies fishery comprised of over 500 endemic fish species, including tilapine, haplochromine, *Bagrus*, *Clarias*, *Synodontis*, *Schilbe*, *Protopterus* and *Labeo* (Ogutu-Ohwayo, 1990). Most of these species have declined, however, because of predation by Nile perch and increasing fishing pressures, among other causes (Yongo, Outa, Kito, & Matsushita, 2017). Haplochromine cichlids were previously the main prey of the introduced Nile perch in Lake Victoria (Balirwa, 2007; Njiru, Waithaka, Muchiri, van Knaap, & Cowx, 2005). After the decline of the haplochromine stocks at the end of the 1980s, however, Nile perch shifted to the shrimp *C. nilotica* and, to a lesser degree, to its own young and Dagaa (*Rastrineobola argentea*), as well as juvenile tilapines as primary food sources (Katunzi, Van Densen, Wanik, & Witte, 2006; Kishe-Machumu, Witte, Wanink, & Katunzi, 2012; Nkalubo, Chapman, & Muyodi, 2014; Outa, Yongo,

& Jameslast, 2017). Recent studies, however, indicated a resurgence of some native fishes in Lake Victoria coincident with heavy fishing pressure on Nile perch, especially haplochromine cichlids that are again the major prey of Nile perch (Budeba & Cowx, 2007; Ngupula & Mlaponi, 2010). Nile perch is the most commercially important fish species in Lake Victoria. However, it currently faces problems of overexploitation, water pollution and other stresses (Ogello, Obiero, & Munguti, 2013; Yongo, Agembe, Outa, & Owili, 2018). Illegal fishing gears and methods in the shallow zones of the lake have attributed to growth overfishing, resulting in depletion of the stock since few mature individuals have a chance to grow and replenish stocks (Mkumbo, 2002). Nile perch plays an important role in top-down control and biomass conversion (Ogutu-Ohwayo, 2004). Thus, its loss or reduction from the lake can adversely affect the ecosystem stability. With ecological changes occurring in the lake, it is likely that Nile perch has changed its feeding habits to utilize food items that were hitherto not on its prey list. Accordingly, the present study investigated the Nile perch diet in Lake Victoria, comparing the results with past data from the lake in order to gain insight on its diet shifts over time.

2 | MATERIALS AND METHODS

Fish samples were caught by seining and trawling from sampling sites between 34°13′ and 34°52′E and 0°4′ and 0°32′S, representing the Kenyan waters of Lake Victoria during the wet and dry periods of 2012/16. The fish (2020) for stomach content analysis ranged between 1.0 and 74.5 cm TL. Only juveniles (100) of up to 5 cm TL were preserved in buffered 10% formalin for laboratory analysis using an inverted microscope (×100) and keys of Jung (2004), while the other sizes were investigated in the field. The stomach contents were analysed using a modified point method according to Hynes (1950), as reviewed by Hyslop (1980). Each stomach was awarded an index of fullness from 0 to 20. An empty stomach scored 0, while stomachs that were a quarter, half, three-quarters and completely full scoring 5, 10, 15 and 20, respectively. The contents of each stomach were emptied into a Petri dish, with the different food items identified and sorted into categories using a stereo microscope. Each category was assigned a number of points proportional to the estimated contribution. The importance of each food category was expressed as a percentage by dividing the total points awarded to all food types into the number of points awarded to the food type in question. Stomach contents for each 5 cm length class were assessed separately to determine diet shifts.

3 | RESULTS

Out of the 2020 fish analysed during 2012/2016, 1,382 (68%) had stomachs with food items, while 638 (32%) were empty. In overall, diet of Nile perch consisted primarily of *Caridina nilotica*, haplochromines, *R. argentea*, unidentified fish and other prey items in varied proportions, with *C. nilotica* (59%) and *R. argentea* (5%) contributing the highest and lowest, respectively (Figure 1a). By comparing with results of 2014/2015, *C. nilotica* (44%) and tilapia (8%) contributed the highest and lowest proportions, respectively (Figure 1b). Results for diet shifts in relation to the fish size are presented in Figure 2. Zooplankton was only observed in the diet of fish in the length class 1–5 cm TL (20%), while *C. nilotica* was the dominant food item in the diets of almost all size classes, although it decreased with increasing fish sizes. Fish prey was an important food item as the Nile perch increased in size, with cannibalism only evidenced from size classes above 35 cm TL. Zooplanktivorous Nile perch (<5 cm TL) collected in 2012/16 consumed copepods, cladocerans and rotifers, while they fed only on calanoids and cyclopoids in 1988 (Table 1). In the 2012/2016 study, the diet of fishes of 1 cm was copepods, cladocerans and rotifers. The diet changed to copepods and cladocerans only when the fish reached 2 cm. The proportion of the relatively large calanoids increased in 1988/1989 with Nile perch size, making up between 35 and 80% of the diet of fishes of 3–4 cm. Comparisons of the frequency of occurrence of prey items in the Nile perch diet for the data collected during 1988/1989, 2006/2008 and 2012–2016 are summarized in Figure 3. Nile perch of 6–25 cm TL in 2012/2016 fed more on *C. nilotica* compared to 1988/1989 and 2006/2008 (Figure 3a). The occurrence of *C. nilotica* in the diet of Nile perch

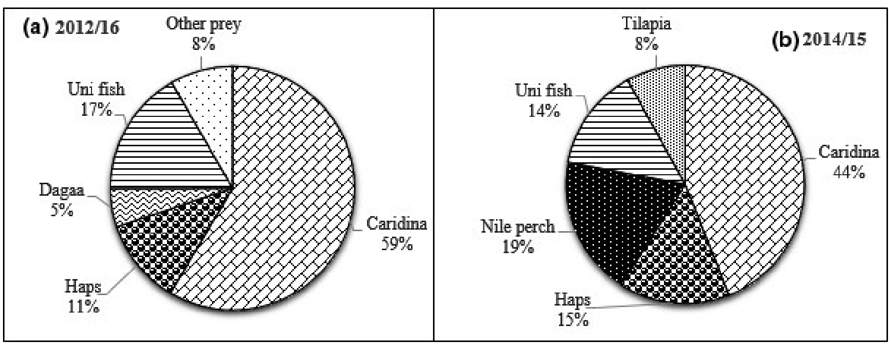

FIGURE 1 Contribution of major food items in overall diet of *Lates niloticus* from Lake Victoria. Source: this study (2012/2016), 2014/2015 (Outa et al., 2017). (Haps, haplochromines; Uni fish, unidentified fish)

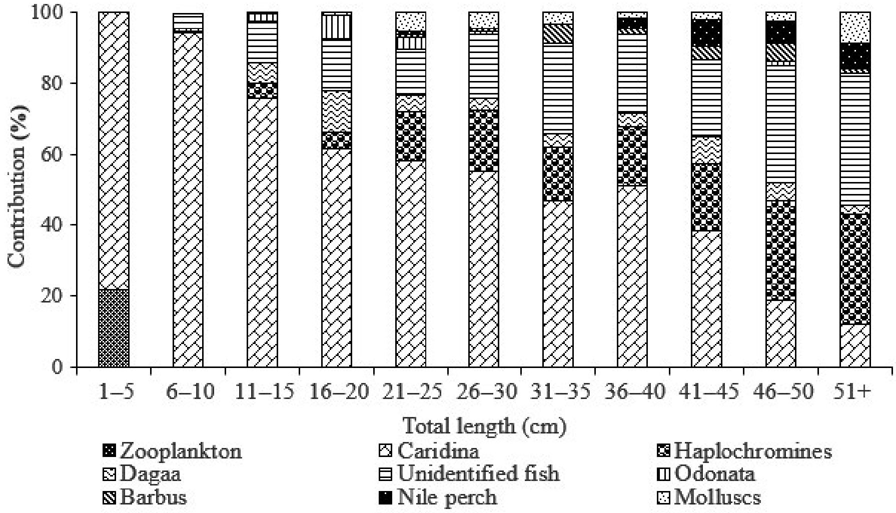

FIGURE 2 Food of *Lates niloticus* of different lengths from Lake Victoria, Kenya 2012/2016

TABLE 1 Percentage composition of zooplankton in the diet of small Nile perch in 2012–2016 and 1988/1989 (Katunzi et al., 2006)

Prey items	Copepods	Cladocerans	Rotifers	Calanoids	Cyclopoids
Nile perch (1 cm)	33.9	58.9 (0)	7.4	0 (8.1)	0 (91.9)
Nile perch (2 cm)	43.8	56.2 (0)	0	0 (8.1)	0 (91.8)
Nile perch (3 cm)	0	0 (0)	0	0 (35.9)	0 (64.0)
Nile perch (4 cm)	0	0 (0)	0	0 (80.2)	0 (19.8)

Note. Values in brackets are derived from Katunzi et al. (2006) (1988/1989).

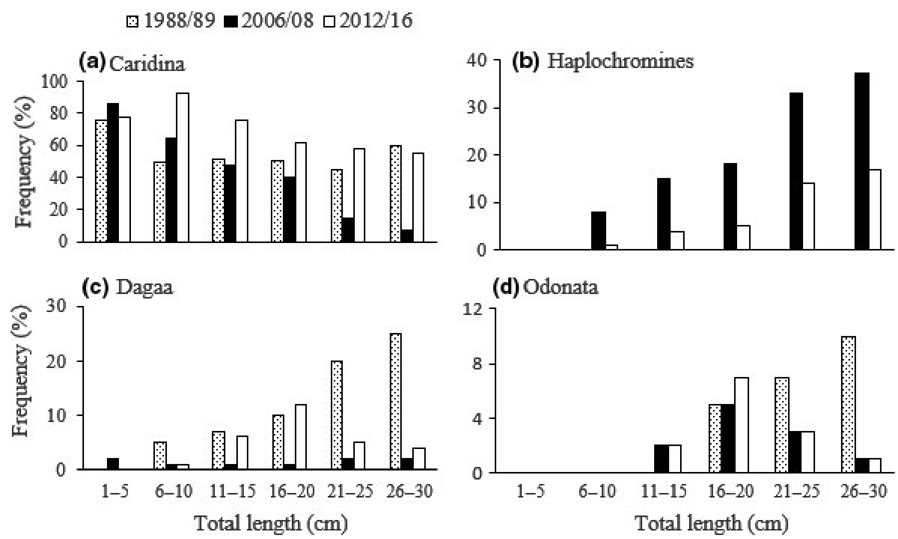

FIGURE 3 Frequency of occurrence of the main prey items of Nile perch up to 30 cm TL in 1988/1989 (Katunzi et al., 2006), 2006/2008 (Kishe-Machumu et al., 2012) and 2012/2016 (this study)

during 2006/2008 declined as the fish increased in size, unlike the other periods. Haplochromines were fed on more in 2006/2008 than in 2012/2016 by Nile perch of 6–30 cm TL as the size increased (Figure 3b). The frequencies of occurrence of *R. argentea* in Nile perch stomachs were highest in 1988/89, and lowest in 2006/2008, for fish size of up to 30 cm TL (Figure 3c). Moreover, for Nile perch ranging from 6 to 30 cm TL, the frequency of occurrence of *R. argentea* in 1988/1989 increased with Nile perch size, although this was not the case in 2006/2008 and 2012/2016. The proportion of Odonata in the diet of Nile perch of size class 16–20 cm TL and 21–30 cm TL were highest in 2012/2016 and 1988/1989, respectively (Figure 3d).

4 | DISCUSSION

The diet of Nile perch collected during 2012/16 was dominated by *C. nilotica* (59%), with little contributions from haplochromines, *R. argentea* and other fish prey (Figure 1). The results agree with those of Outa et al. (2017) who also reported dominance of *C. nilotica* (44%)

in the diet of Nile perch collected from the Nyanza Gulf of Lake Victoria during 2014/2015. These observations suggest *C. nilotica* is the preferred prey item of Nile perch in the absence of haplochromines cichlids, indicating the shift from haplochromines to *C. nilotica* as the main prey was attributable to the decline of the haplochromines. Analysis of stomachs in relation to fish size indicated shifts in diet at three levels from zooplankton to *C. nilotica*, then to fish prey, including haplochromines, and juvenile Nile perch with increasing fish size. Zooplankton was only present in the stomach of young fish in the length class 1–5 cm TL (Figure 2). As the diet changes require morphological and physiological features that are not yet well developed in young fish, they can easily digest zooplankton, which also satisfy their demand for protein (Yongo et al., 2016). The contribution of *C. nilotica* in the diet declined progressively from Nile perch of 1–5 cm TL up to 51+ cm TL because the adult fish were increasingly feeding on other prey items, including haplochromines, *R. argentea*, juvenile Nile perch, molluscs, insects and *Barbus*. The results of this study (2012/2016) for Nile perch of up to 30 cm TL were comparable with the findings of Katunzi et al., 2006 in 1988/1989 and those of Kishe-Machumu et al. (2012) in 2006/2008 (Figure 3). Nile perch of 6 to 25 cm TL fed more frequently on *C. nilotica* in 2012/2016, compared to 1988/1989 and 2006/2008 (Figure 3a), which could indicate that *C. nilotica* is the most available prey item for Nile perch in the Kenyan side of the lake following the decline of haplochromines cichlids. Although the frequency of occurrence of *C. nilotica* in the diet of Nile perch of up to 30 cm TL did not exhibit a trend across size classes in 1988/1989, a negative trend observed in 2006/2008 and 2012/2016 could be attributed to a resurgence of haplochromines in the lake, as evidenced by the positive trend in the occurrence of haplochromines in the diet during the same periods (Figure 3b). The contribution of *R. argentea* and Odonata to the diet of Nile perch has been remarkably reduced because of a continued preference for *C. nilotica* and haplochromines (Figure 3c, d).

5 | CONCLUSION

Nile perch is a predator, feeding mainly on *C. nilotica*, haplochromines and other fish, as well as its own young. The shifts in its diet was observed at three distinct levels, with fish sizes below 5 cm TL feeding only on zooplankton, fish above 5 cm TL shifting to *C. nilotica*, and then finally selecting fish as the main diet. Cannibalism was observed to have been reduced, only being evident in Nile perch above 35 cm TL, which could actually have a positive impact on the Nile perch fishery.

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