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Feeding biology of the African catfish *Clarias gariepinus* (Burchell) in some of Ethiopian Lakes: A review

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Abstract
The investigations on feeding biology of the African Catfish *Clarias gariepinus* (Burchell) in some of Ethiopian Lakes have indicated that omnivorous feeder. Zooplankton, insects, fish preys, detritus, phytoplankton and macrophytes were the most important food items in the diet. The animal origins were the most important food items in most water bodies. However, plant origins were probably accidentally ingested. Seasonal variation in the diet composition of the fish was observed. Insects, zooplankton and fish preys were preferred foods during the dry season. Detritus, zooplankton, insects and macrophytes were mostly consumed during the wet season. The fish showed different size based dietary shifts in all water bodies with it increases in size. The small sized fish fed mainly on insects, fish prey and zooplankton. While, the larger fish consumed more zooplankton and fish prey. Generally, the feeding biology of fish is depending on prey availability, season, habitat differences and size of the fish, aspects that might warrant for further study in view of aquaculture applications as well as in their natural aquatic ecology.

Keywords: *Clarias gariepinus***,** feeding biology, ethiopia, omnivorous

1. Introduction
The African catfish (*Clarias gariepinus*) is widely distributed in Africa freshwater and Middle East (Clay, 1979; Viveen *et al*., 1986; Spataru *et al*., 1987) [14, 37, 32]. In Ethiopia, it is widely distributed almost in all water bodies such as in the rift valley, Abay, Awash, Baro-Akobo, Omo-Gibe, Tekeze and Wabishebele-Genale basins (Awoke, 2015; Golubtsov and Mina, 2003) [7, 21]. It also contributes to the Ethiopian capture fisheries (Reyntjens and Wudneh, 1998) [31]. The study of food and feeding habits of freshwater fish species is an issue of continuous research. This is because it makes up a basis for the development of a successful management program on fish capture and culture (Shalloof and Khalifa, 2009) [33]. Moreover, studies on natural feeding of fish enable to identify the trophic relationships present in aquatic ecosystems, identifying feeding composition, structure and stability of food webs in the ecosystem (Adeyemi, 2009; Otieno *et al.*, 2014) [2, 29]. The information is also vital for management of the fish in the controlled environment and for formulation of the appropriate dietary given for the fish in aquaculture (Adeyemi, 2009) [2]. Therefore, understanding of its food and feeding habits is a key factor to successful and sustainable fish culture in a controlled environment (Shalloof and Khalifa, 2009) [33].

The African Catfish is an opportunistic and omnivorous feeder ingesting a wide variety of food items such as algae, macrophytes, zooplankton, insects, fish prey, detritus, Amphibians and sand grains (Abera, 2007; Admasu *et al.*, 2015; Dadebo, 2000; 2009) [1, 4, 16-17]. The diet composition may vary within season and spatial conditions of the environments (Houlihan *et al.*, 2001) [22]. In the same way, the diet composition may also vary depends upon the fish size, maturity, and habitat differences (Kamal *et al.*, 2010) [23]. Various authors have studied the food and feeding habits of African catfish in Ethiopian water bodies (Alemayehu, 2009; Admasu *et al*., 2015; Dadebo *et al*., 2014; Dadebo, 2009; Dadebo, 2000; Teka, 2001; Tugie and Taye, 2004) [4-5, 16-18, 35-36] reported that the African catfish feed on a variety of foods based on the environment in which they live. However, there is no compiled information on the food and feeding habit of African catfish in different water bodies, which give the general perception on feeding biology of the fish in the country. Therefore, this review paper is aimed to recapitulate the food and feeding habits of the African catfish *Clarias gariepinus* in some of Ethiopian Lakes.

2. Materials and Methods

A range of literature sources were used for this review including journal articles, books and book chapters, workshop proceedings, FAO reports, bulletins, legal documents, and unpublished reports including PhD dissertations. The documents were collected from University libraries and Ethiopian Ministry of Livestock and fishery, from individual researchers and from the Internet data bases.

3. Feeding Biology of the African Catfish in some of Ethiopian Lakes

3.1 Food and feeding habits of the African cat fish

Many authors have reported that African catfish feed on a variety of food items including phytoplankton, zooplankton, insects, detritus, macrophytes, fish parts, gastropods and nematodes (Admasu *et al*., 2015; Dadebo *et al*., 2014; Dadebo, 2000; 2009; Alemayehu, 2009) [4-5,16-18]. However, in terms of prey importance, the foods of animal origins were the most consumed food items by the fish in all of the water bodies. For instance, studies carried out in some water bodies of Ethiopia in Lake Babogaya (Admasu *et al*., 2015) [4], Lake Chamo (Dadebo, 2009) [17], Lake Hawassa (Dadebo, 2000) [16], Lake Koka (Dadebo *et al*., 2014) [18] and Lake Hayq (Alemayehu, 2009) [5] indicated that insects, fish prey, zooplankton, detritus and macrophytes were the most consumed food items by African catfish. Insects were the most important food items followed by macrophytes and zooplankton occurred in (82%), (60%) and (60%) respectively in Lake Babogaya (Admasu *et al*., 2015) [4]. However, zooplankton were the most preferred food items followed by detritus and insects occurred in (75.4%), (33.7%) and (27.2%) respectively in Lake Chamo (Dadebo, 2009) [17]. Similarly, zooplankton were the most important food items followed by insects, fish preys and macrophytes occurred in (60%), (46%), (26%) and (24%) respectively in Lake Hayq (Alemayehu, 2009) [5]. According to Dadebo (2009) [17] *C. gariepinus* possess long, numerous and compact gill rakers to filter large amount of zooplankton such morphological adaptation important to shift from one kind of feeding habit to the other depends on the availability of food items in the lake as well as zooplankton production depends on water productivity and temperature. However, in Lake Hawassa, fish prey were far the most important food items in the diet of *C. gariepinus* occurred in (81.7%) followed by macrophytes (24.7%) and insects (24.7%) in the lake (Dadebo, 2000) [16]. Because of the fish has morphological adaptation for piscivorous feeding habit like big mouth, marginal and pharyngeal teeth, tough and muscular stomach with high acidity and short intestine as well as high availability of *Oreochromis niltocus* as fish prey and the absence of top predator (piscivory) (Dadebo, 2009) [17]. In Lake Koka, detritus, insects, zooplankton, macrophytes and fish prey were the most consumed in the diet of the fish occurred in (79.6%), (63.6%), (56.2%), (63%) and (>20%) respectively (Dadebo *et al*., 2014) [18] (Fig. 1). However, studies showed that the ingestion of detritus, macrophytes, algae, sand particles and benthic food items indicated the ability of the species to possess benthic habitats and accidentally ingested while the fish was searching other prey organisms those are attached with the macrophyte vegetations and the bottom of the sediment (Corbet, 1961; Admasu *et al*., 2015; Abera, 2007; Admassu and Dadebo, 1997) [15, 4, 1, 3]. Because, detritus considered as under low nutritional value (Bagenal and Braum, 1978; Bowen, 1979) [9, 13]. Moreover, studies noted that in lotic and lentic water systems have considered that an increased consumption of detritus is a prime response to a decline of higher value primary food resources (Bowen, 1979; King *et al*., 2003) [13, 24]. The contributions of other food items were low throughout the water bodies (Fig. 1). This indicates the changing of food items composition in the diet of African catfish based on the diet composition in the lakes, which may varies depending on environmental condition, season (water level) and habitat differences of the lakes.

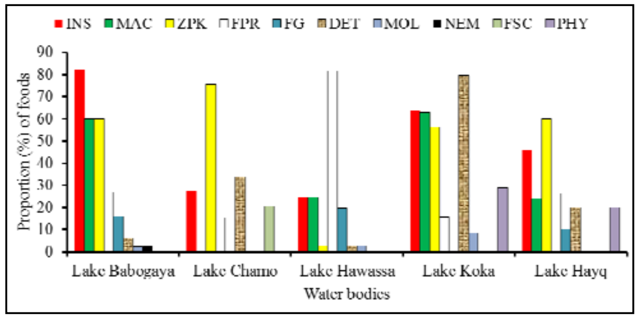

Fig 1: Frequency occurrence (%) of different food items in the diet of *C. gariepinus* from some of the Ethiopian freshwater systems (MAC- Macrophytes, DET-Detritus, INS-Insects, PHY-Phytoplankton, FSC-Fish scales, FPR-fish prey, FG-Fish egg, NEM-Nematods, MOL- Molluscs and ZPK-Zooplankton)

3.2 Seasonal variation in the diet composition of African catfish

High water levels are designated as resource rich, while low water levels have poor resources in trophic dynamics mainly in lentic ecosystems (Balcombe *et al.*, 2014) [10]. The availability of food is dynamic throughout the year in tropics due to the seasonality of foods availability and the feeding habit of fish also changes on the seasonal bases (Ballesteros *et al.*, 2009) [11]. In Ethiopian water bodies, many authors have also reported the seasonal variation of food types and their proportion in the diet of African catfish. For instance, insects (>80%), fish preys and zooplankton (>60%) were the most preferred food items during the dry and wet seasons and their proportion is almost similar except fish prey (56.67%) which was high in wet season in the diet of the African catfish in Lake Babogaya (Admasu *et al*., 2015) [4]. Nile tilapia was the most preyed fish by *C. gariepinus* in the lake. During the dry season, zooplankton (81.8%), insects (75.6%), detritus (66.1%), phytoplankton (59.4%), macrophytes (45.5%) and fish prey (38.8%) were important food items in the diet of the fish in Lake Koka (Dadebo *et al*., 2014) [18]. *Labeobarbus intermedius* was the most preyed fish in the diet of African cat fish in the lake. During the wet season the proportions of food items were varied. For instance, detritus (92.5%), macrophytes (79.8%), insects (52.6%), zooplankton (32.4%) and fish prey (32.4%) were also important foods in the lake. The high abundance of macrophytes and detritus in the diet of African catfish in wet season is associated with rainfall season of Ethiopia. Fish movements to shallow parts of the lake for reproduction could explain the increase of ingested macrophytes in the wet season. They stay there for a long period by feeding on macrophytes and vegetation in the wet season (Tefera, 1993) [34]. The high dietary proportion of detritus in the diet of the fish in wet season might also have emerged from plant materials flooding in during the rainy season (Worie and Getahun, 2015) [39]. The highest proportion of zooplankton during the wet season may also associate with the period of low water temperature and flooding time. Low water temperature is a prerequisite condition to the hatching of zooplankton in natural water (Mergeay *et al.*, 2006) [25]. In addition, the seasonal flooding can contribute to high zooplankton population in the water through bringing nutrients from the environment, and help in mixing autochthonous nutrients amongst the different strata of lake, which trigger the increasing of phytoplankton production and consequently zooplankton productivity (Okogwu, 2010) [28].

In Lake Hayq, insects (56.8%), zooplankton (49.6%), fish preys (31.6) were preferred by the fish during the dry season. While, during the wet season zooplankton (78%) and insects (45%) were the most important food items and their proportion is different compared to the dry season (Alemayehu, 2009) [5] (Fig. 2). This is due to low water temperature is a prerequisite condition to the hatching of zooplankton in natural water during summer (Dadebo, 2009; Mergeay *et al.*, 2006) [17, 25]. The phytoplankton composition in the diet of fish was declined during the wet season in Lake Koka and Hayq this is associated with the high flooding from the catchment area, which can caused fluctuation in water level and increase turbidity (Njiru *et al.*, 2004) [27]. Turbidity of water decreases the penetration of sunlight and affects the growth and abundance of phytoplankton (Paaijmans *et al.*, 2008) [30]. In conclusion, studies indicated that the feeding habit of the tropical fishes is depends on the resource accessibility in the environment, which determines the choices and feeding preferences of fish based on their trophic niches or foraging areas (Ahrens *et al.* 2012; da Silva *et al.*, 2014) [6, 19].

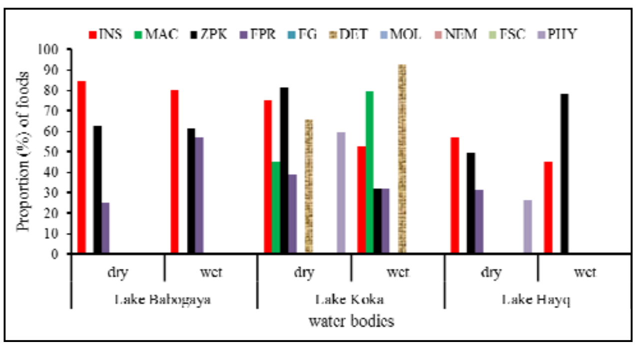

Fig 2: Frequency occurrence (%) of different food items in the diet of *C. gariepinus during* the dry and wet seasons in some of the Ethiopian freshwater systems (MAC- Macrophytes, DET-Detritus, INS-Insects, PHY-Phytoplankton, FSC-Fish scales, FPR-fish prey, FG-Fish egg, NEM-Nematods, MOL- Molluscs and ZPK-Zooplankton)

3.3 Size based food and feeding habits of African catfish

Otieno *et al.* (2014) [29] noted that fish feed mainly on food items that can fit into their mouth and what their stomach can digest. As fish grow, the stomach becomes longer and their digestive system becomes more developed. However, the feeding rate relative to body weight decreases, whereas the absolute rate of food consumed increases (Wakil *et al.*, 2014) [39]. In most of the Ethiopian water bodies, the size based feeding study of African catfish showed the highly dominance animal origin foods in the diet by the smallest and larger fish but their proportion is different. For example, insects (>80%) and zooplankton (56%) were the most important foods preferred by 25-44 cm TL in Lake Babogaya (Admasu *et al.*, 2015) [4]. Similarly, insects (>70%), fish preys (>60%) and zooplankton (40%) were preferred by 20-30 cm TL in Lake Hayq (Alemayehu, 2009). Zooplankton (45.5%) and detritus (>40%) were the most important food items in size class 15-44.9 cm TL in Lake Chamo (Dadebo, 2009) [17] (Fig. 3). Generally, high proportions of insects were taken by the smallest sized fish in some of water bodies. This is because juvenile fish need high protein intake to support high growth rate and metabolism (Benavides *et al.*, 1994) [12]. Additionally, having a small stomach volume that cannot support big macrophytes and detritus loads and smallest fish live in shallow water where, high density of benthic macroinvertebrates this is another reason for juveniles feed on larval insects, detritus and zooplankton (Engdaw *et al.*, 2013) [20]. The proportion of insects and zooplankton were decreased with the fish size increases; while fish prey was increased with the fish size increases in Lake Babogaya (Admasu *et al*., 2015) [4] and the fish shifted from insectivore to pscivore. However, insects, fish preys and detritus almost null with the size of the fish increases; while the importance of zooplankton (>85%) was raised with the fish size increase in Lake Chamo (Dadebo, 2009) [17] (Fig. 3) and the fish shifted from omnivore to zooplanktivore. In Lake Hayq, zooplankton, fish preys and phytoplankton were increased with the size of the fish increases but the contribution of insects were decreased as the fish grows older (Alemayehu, 2009) [5] (fig. 3) and the fish shifted from insectivore to filter feeder and pscivore. The larger fish inhabits pelagic zone of the water for filter feeding rather than benthic organisms (Dadebo *et al*., 2014) [18]. Moreover, researchers pointed out that *C. gariepinus* showed size based diet shift because of the change in habitat use in different water bodies of Ethiopia (Abera, 2007; Admasu *et al*., 2015; Dadebo *et al*., 2014) [1, 4, 18].

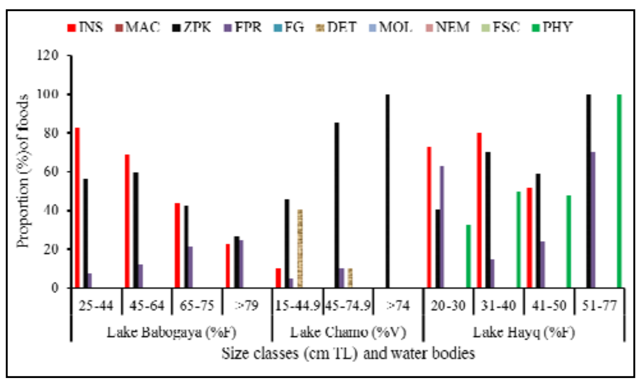

Fig 3: The mean volume (%V) and frequency occurrence (%O) of different food items in relation to fish size (cm TL) of *C. gariepinus* from some of the Ethiopian freshwater systems (MAC-Macrophytes, DET-Detritus, INS-Insects, PHY-Phytoplankton, OST-Ostracods, FSC-Fish scales, FG-Fish egg, NEM-Nematods, and ZPK-Zooplankton)

4. Conclusion

Clarias gariepinus found to be omnivorous in its feeding habits in all water bodies. The food items of animal were important while plant origins were ingested during pursing other prey organisms in the stomach contents of the fish. Notable seasonal variation was observed in the diet composition of *C. gariepinus* through water bodies of Ethiopia. In terms of size related variation the smallest fish ingested more insects while, the larger fish were mainly feds on zooplankton. The size related shifts in food items proportion of African catfish probably depend on physiological requirements, whereas the seasonal changes in dietary pattern might rather reflect the opportunistic feeding behavior of the species. Therefore, further study in the dietary aspect of the fish feeding habit and works on the further improvement and optimization protein rich feed is very important at aquaculture level.

5. Conflict of interest

The author declares that there is no conflict of interests.

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