

Review

Breeding seasons of some commercially important fishes in Ethiopia: Implications for fish management

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Fishing during periods close to spawning (breeding) season results in a decline in fish population. Identifying the breeding season of each fish species is important for conservation and aquaculture development. Published and unpublished sources of data were used to prepare this review manuscript. Based on the review process, it is possible to observe that the breeding season of fish occurred all year round. Although, the intensive or peak breeding period occurred uni-annual or bi-annual and also it is different from the fish species as well as the nature of water bodies. The peak breeding seasons of the African catfish *Clarias gariepinus* was observed from (March-June), (April, June-July), (April-July) and (February-March) in Lakes Chamo, Babogaya, Tana and Hawassa, respectively. The intensive spawning season of the Nile tilapia *Oreochromis niloticus* was appeared at (January and July), (September, March-April and August), (September, April-August), (January-March and July-September) in Fincha Reservoir, Lakes Beseka, Babogaya and Hawassa, respectively. The common carp *Cyprinus carpio* was breed intensively during (March and June), (February and April) in Fincha and Tropical Amerti Reservoir respectively. The crucian carp *Carassius carassius* was reproduced from (March-July, August and October) in Melka-Wakena Reservoir. The breeding behavior of the *Labeobarbus* fish species was observed from (July-October) in the Tana and Blue Nile basin. The breeding condition of fishes in Ethiopian water bodies has been associated with the rainfall and periodicity where the abundance of food items present in water bodies. Generally, the close season of the fish (spawning) depending on physiological and environmental factors attributes that effective management is very important during breeding seasons to sustain fish resources for food security in the country as well as further study is needed why the fish mostly breed in rainy time.

Key words: Breeding season, environmental factors, Ethiopia, fishes, lakes, reservoir, physiological factors.

INTRODUCTION

Fecundity is a biological process among fish populations and can be defined as, the number of ripe eggs that are released prior to spawning as noted by Admassu et al. (2015). Fish reproduction has been associated with habitat differences, fish species type, differences in body condition and growth. Fish species having poor body

condition tend to have slower fecundity compared to those in better body condition (Dadebo and Mengistou, 2011; Admassu et al., 2015). Furthermore, fecundity is related to fish size (length, weight) and gonad weight (Admassu et al., 2015). Similarly, different factors determine the season of fish breeding. For instance, fish

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in tropical inland water bodies breed all-year round (Admassu et al., 2015). Generally, many fish species have one peak (intense) breeding period in a year, while others have two peaks (Tadesse, 1997; Admassu, 1996; Dadebo, 2000). Environmental factors are key determinants of spawning season in aquaculture as well as in natural aquatic environment. Accordingly, for fish species in the tropics, rainfall associated factors such as fluctuations in water level, seasonal flooding play significant role for the timing of intensive breeding (Admassu et al., 2015). Furthermore, Kolding et al. (1992) and Dadebo (2000) have documented that the peak spawning season of fish is during rainy season where there is a rich source of food supplied by flood from the terrestrial origin. Reproductive biology of each fish species is critical for the conservation and fish resource management. For this reason, considerable studies were conducted in Ethiopian water bodies for fishery resources management and conservation (Abera, 2012; Admassu et al., 2015; Ameha et al., 2006; Dadebo, 2000; Dabebo et al., 2011; Degefu et al., 2012; Gebremedhin et al., 2014; Hailu, 2013; Hirpo, 2012, 2013). Fishes are important source of omega-3 fatty acid and it is required to support an ever increasing human population particularly in Ethiopia. Aquatic resources like fish can alleviate poverty while providing food security for the populace. The Nile tilapia, *Oreochromis niloticus*, African catfish *Clarias gariepinus*, *Labeobarbus* species, *Barbus* species, the common carp *Cyprinus carpio* and the crucian carp *Carassius carassius* are the most commercially important fishes in Ethiopian water bodies. Besides this, the trend of fish demand has increased rapidly in a certain year back (Temesgen and Getahun, 2016). Therefore, understanding of the breeding and fecundity of the aforementioned commercially important fishes can provide basic knowledge for the proper management of the fish resources. However, no compiled information is available for these key important fish species in water bodies of Ethiopia. Therefore, the major objective of this review paper was aimed at identifying the intensive (peak) breeding season of selected commercially viable fishes in Ethiopian water bodies for better exploitation of fish resources.

LITERATURE REVIEW

Different literatures and data sources were collected from university libraries and Ethiopian Ministry of Livestock and Fishery, from individual researchers, and from the internet databases from July, 2018 to November, 2018. Other sources that were also employed included journal articles, books and book chapters, workshop proceedings, FAO reports, bulletins, legal documents, and unpublished reports. Estimation of breeding season of fishes involved the use of visual examination or five point gonad maturity stages developed by Holden and Raitt (1974) and seven

point maturity stages for *Labeobarbus* fish species developed by Nagelkerke (1997). The maturity stages of the gonad scales show that the stage of development of gonads was also based on their sizes and the space they occupied in the body cavity of fish (Holden and Raitt, 1974; Nagelkerke, 1997). Following this precedence, gonad maturity stages are classified as immature (I), recovering spent or developing virgin (II), ripening (III), ripe (IV) and spent (V). Gonad maturity stages of the *Labeobarbus* fish species were given a seven level stage (I-VII) as shown in Table 1. Therefore, the breeding seasons of fishes were estimated from the percentages of fish with ripe gonads obtained each month (Ameha et al., 2006; Dadebo et al., 2011; Dadebo, 2000). However, ripe gonads were observed throughout the year. However, breeding season was considered as the period of the year in which relatively higher proportions of fishes were in breeding condition (Dadebo et al., 2011).

BREEDING SEASONS OF SOME COMMERCIALY IMPORTANT FISHES IN ETHIOPIAN WATER BODIES

Breeding seasons of the African catfish *C. gariepinus* (Burchell, 1822)

The African catfish is widely distributed in almost all freshwater systems of Ethiopia such as the Nile (Baro-Akobo), Omo-Turkana, Blue Nile (Abay), Atbara-Tekeze, Rift Valley, Wabishebelle and Juba drainage basins (Golubtsov and Darkov, 2008). The African catfish, *C. gariepinus*, is the second most commercially important fish species that contributes about 20% of the total catch per year in Ethiopian water bodies (Tesfaye and Wolff, 2014).

The breeding season of *C. gariepinus* was determined with respect to the number of ripe gonads sampled from Ethiopian water bodies in each month. A study made in Lake Chamo showed that most of the catfish breed between March and June where females possessed (70-91.3%) ripe gonads while males had (75-86.8%) ripe gonads as noted by Dadebo et al. (2011). The intensive breeding season was linked to rainfall which caused water levels to increase (in some cases leading to flooding) and conductivity to decline; this phenomenon might also triggers a positive spawning stimulus of *C. gariepinus* (Wudineh, 1998; Dadebo, 2000). According to the investigator, August-December was associated with fish with very low proportion of ripe gonads where males and females had 10.8-20.0 and 7.7-24.1% ripe gonads, respectively in Lake Chamo (Dadebo et al., 2011).

Similarly, in Lake Babogaya the peak breeding season of the African catfish was between April and July for both sexes; however, the majority of the fish had an extended spawning season between February and September (Admassu et al., 2015).

The intensive breeding (spawning) time of the species

Table 1. Gonad maturity stages of fishes and their descriptions (Bagenal and Braum, 1978; Nagelkerke, 1997).

Gonad stage	Testes	Ovaries
I	Immature, impossible to distinguish females from males. Gonads are a pair of transparent strings running along the body cavity.	Immature, impossible to distinguish females from males. Gonads are a pair of transparent strings running along the body cavity.
II	Unambiguously male, very small testes, white-reddish, not lobed, tube-shaped strings. (recovery spent or developing virgin)	Unambiguously female, very small ovaries, tube-shaped and reddish, eggs not visible (recovery spent or developing virgin)
III	Larger testes, white-reddish, somewhat lobed starting to flatten sideways (Ripening).	Ovary somewhat larger and starting to flatten sideways, eggs visible, but very small (Ripening).
IV	Large testes, white-reddish, lobed, flattened sideways (Ripe).	Large ovary flattened sideways and almost covering body cavity wall, eggs yellowish (Ripe).
V	Large, white testes, some milt runs out when testis is cut (for <i>Labeobarbus</i> species). *This stage is marked as spent for other fish species	Large and full ovary, completely covering body cavity wall, yellowish eggs run out when ovary is cut (for <i>Labeobarbus</i> species). *This stage is marked as spent for the other fish species
VI	Large white testes, running, large amount of milt runs out when testis is cut	Running, yellow eggs can be extruded by putting pressure on the abdomen
VII	Spent, empty testes, reddish and wrinkled	Spent, wrinkled ovary, reddish, containing a few yellow eggs

in this lake it was associated with rainfall seasons of the year. The surroundings of Lake Babogaya have two rainy seasons in a year from February to April little rains and through June to September heavy rains (Admassu et al., 2015). The fish also breeds intensively at April, as well as occurred in June-July than in April. In Lake Tana, the spawning season of *C. gariepinus* ranged between April and July (Ameha et al., 2006). According to Ameha (2006) and Tweddle (1978) the river mouths serve as sites for the breeding as this fish migrates to nearby floodplains during rainy time for the purpose of reproduction. Moreover, Payne (1986) stated that mature *C. gariepinus* migrates into flowing rivers prior to spawning into the flood water or flood plains during heavy rainy season.

However, from August to November most of the fish had spent gonads whilst between December and March majority of the fish gonads identified were in the recovering state. In Lake Hawassa, the peak breeding time of the African catfish is from February to March (Dadebo, 2000). In Lake Hawassa the breeding condition of *C. gariepinus* is associated with the environmental factors like rainfall and temperature. During February and June, rainfall was the highest around Lake Hawassa, and the maximum air temperature was low and this resulted in peak breeding condition of this fish species.

Breeding seasons of the Nile tilapia *O. niloticus* (Linnaeus, 1758)

The Nile tilapia is the most commercially viable fish species according to the report of Tesfaye and Wolff (2014). The species contributes more than 49% of the total annual landing in the country (Ethiopia). *O. niloticus* is widely distributed in Abay, Awash, Baro-Akobo, Omo-Gibe, Tekeze, rift valley and highland lakes and Wabishebele-Genale drainage basins as well as in manmade reservoirs (Awoke, 2015; Golubtsov and Mina, 2003). The Nile tilapia spawns throughout the year but, the intensive (peak) breeding occurs once or twice a year. For instance, in Fincha Reservoir the intensive breeding season of the Nile tilapia was from January to July (Degefu et al., 2012). This is probably due to the sub-humid type of climate of the reservoir which has an annual rainfall of 1824 mm and average of monthly air temperature is 15 to 18°C that provides conducive environment for fish reproduction (Mesfin et al., 1988).

In Lake Beseka, the peak spawning season of the same fish species started from, March-April and August-September (Hirpo, 2013). Similarly, in Lake Babogaya from September, April-August months were considered as the intensive breeding rhythm of the Nile tilapia (Hirpo, 2013). However, in Lake Hawassa two peak (intensive)

breeding seasons of the Nile tilapia were identified including January-March and July-September (Admassu, 1996). The occurrence of intensive breeding activity during January-March indicated that in relation with increase of solar radiation and sunshine that triggers phytoplankton production while July-September was linked to heavy rainfall. The peak breeding activities of fish species is also associated with rainfall in Lakes Beseka, Babogaya, and Hawassa. Moreover, according to Tadesse (1997) the peak breeding period of fish species in tropical waters are related to light intensity, temperature, rainfall and water level or seasonal flooding. The presences of sufficient foods in the aquatic environments are also important for the breeding condition of fish (Tadesse, 1997).

Breeding seasons of the common carp *C. carpio* and crucian carp *C. carassius* (Linnaeus, 1758)

The common carp *C. carpio* (L.) was introduced to Ethiopia in 1936 for aquaculture development (Welcome, 1988 as cited in Hailu, 2013). It has been introduced in different water bodies of Ethiopia including manmade and natural lakes to maximize fish yield to alleviate hunger in the country (Tedla and Haile-Meskel, 1981). The exotic fish species *C. carpio* and the crucian carp *C. carassius* are commercially important fishes. However, they collectively contribute about 2% of the total annual catch in Ethiopia (Tesfaye and Wolff, 2014). The common carp can reproduce any time of the year. The study conducted in Fincha Reservoir by Degefu et al. (2012) revealed that the peak breeding season of common carp was March and June (Degefu et al., 2012). However, in tropical Amerti Reservoir the intense spawning season of the same fish species was February and April (Hailu, 2013). The intensive breeding season of *C. carassius* occurred two times a year during March-July and also from August to October while some of the fish will breed year round in Melka-Wakena Reservoir (Abera, 2012). The intensive breeding season of the common carp and the crucian carp in the two Reservoirs (Fincha and Amerti) was also associated with the rainy season (Abera, 2012). Rainfall stimulates spawning by creating safe environment for better growth and survival of fish (Abera, 2012). Nutrient loading of the reservoir leads to increased primary production.

Breeding seasons of the *Labeobarbus* fish species

Labeobarbus fish species contributed a total of about 8% of the total commercial catch in Ethiopian water bodies (Tesfaye and Wolff, 2014). The *Labeobarbus* fish species is widely distributed in Ethiopian river drainage basins including Abay, Awash, Baro-Akobo, Ayisha, Wabishebbelle, Tekeze, Omo-Gibe, Ogaden, Mereb-Gash

and Genale-Dawa, and in Highland and rift valley lakes of Ethiopia (Awoke, 2015; Golubtsov and Mina, 2003). Gonado somatic index is the ratio of gonad weight as a proportion of the total body weight (Gebremedhin et al., 2012). The highest mean gonad-somatic index (GSI) in fish population had been used as a measure of determining the breeding season, showing the approach of intense breeding season. In line of this, *Labeobarbus brevicephalus*, *Labeobarbus intermedius*, *Labeobarbus nedgia* and *Labeobarbus tsanensis* migrant fish species breed intensively from August-October in Lake Tana to Arno-Garno River, Lake Tana sub-basin (Gebremedhin et al., 2012).

The cause of migration of the fishes in tropics within the breeding season could be initiated by rainfall and water level variations (Lowe-McConnell, 1975). The aggregation of the *Labeobarbus* species at the river mouths were associated with rainy season to spawn in Lake Tana (Nagelkerke and Sibbing, 1996; de Graaf et al., 2005). For instance, *L. intermedius*, *L. brevicephalus*, *L. nedgia* and *L. tsanensis* were aggregated at the river mouth of Arno-Garno River from July through to October. To this end, the investigator pointed out that the aggregated *Labeobarbus* spp. at the river mouth were those that had gonad stages of IV and V and this is the implication of migration for spawning purposes during heavy rain season (Gebremedhin et al., 2012). Consequently, most of the *Labeobarbus* spp. that spawn at the upstream of the Arno-Garno Rivers also had gonads at stage VI. Comparably, *L. intermedius*, *L. nedgia* and *L. brevicephalus* of male fish species had peaking breeding season in September while the intense spawning time occurred in September and August for female *L. nedgia* and *L. intermedius* fish species. However, female *L. brevicephalus* had a peak in October in the tributaries of Lake Tana, namely, Qimon, Guanta, Shini, Chibirna Rivers (Teshome et al., 2015). Based on this the fish species such as *L. intermedius*, *L. brevicephalus*, *Labeobarbus macrophthalmus*, *Labeobarbus platydorsus*, *Labeobarbus truttiformis*, *L. tsanensis*, *Labeobarbus surkis*, *Labeobarbus gorgorensis*, *Labeobarbus crassibarbis* and *L. nedgia* had peak breeding season which occurred from August-October in the tributaries of Lake Tana including Zabzi, Kilty, Gilgel Abay and Jemma Rivers as reported by Mequanint et al. (2014).

FACTORS AFFECTING THE BREEDING CONDITION OF FISHES

Fish reproduction refers to the release of unfertilized eggs by the female fish. In turn, these eggs are fertilized by male fish as soon as possible. Normally, this process continues the whole year. However, most of the fish populations have their own peak or intense breeding season. Therefore, the spawning condition of the fish is

directly linked to various internal and external factors. The maturity of eggs and the breeding (spawning) season are governed by hormones, nutrition of the female and external (ecological) factors. Moreover, physiological factor like endocrine system (hormonal), fish stress, water quality, and ecological and environmental factors such as temperature, photoperiod, periodicity, water currents (tides), latitude, water depth, substrate type, hormonal influence and rain can affect the fish's migration, timing of reproduction, morphological changes, mobilization of energy reserves and courtship behavior (Pankhurst et al., 2011). Human impacts on spawning habitats are also other factors. Fishing activities at the reproduction nursery grounds has its own effect during the spawning period for the recruitment of number and quality of newly recruited fishes to the populations. Several species use spawning substrate to lay their eggs in the pelagic zone at this time they will be exposed to fishing gear. Other fish species lay their eggs on bottom of the sediment, deposit on the gravel, attach on the plant surface and bury the eggs into the substrate; at this time using proper fishing method is critical (Harriet et al., 2014).

FISHERIES MANAGEMENT IN RELATION TO THEIR SPAWNING SEASONS

Fisheries management is needed for proper utilization of fish resources in a specific aquatic ecosystem. However, fishermen did not consider the fate of the industry as they exploited the fisheries. In the Blue Nile Basin, during rainy season (July to October), *Labeobarbus* spp. is the most preferred fish by the fishermen because the fish species aggregate at the river mouths to travel the upstream of the tributary rivers for reproduction purposes; at this time they are highly vulnerable to fishing activities along the river (Gebremedhin et al., 2012). According to Skelton et al. (1991) pointed out that most of the African cyprinid fish population declines during their spawning season due to their high vulnerability to fishing activities by the fishermen.

In Lake Tana and the Blue Nile basin, the migratory *Labeobarbus* spp. are facing such problem and revealed drastic reduction of the fish stock to about 75%. This is attributable to the introduction of various gillnets for the last ten years (de Graaf et al., 2004). Fishing during the peak spawning season for each species in their respective water bodies should be banned or closed. Moreover, awareness should be created for the fisherman in relation to the intense breeding season of fish and continuous assessment of the fishermen around the breeding grounds is mandatory during commercial catch. Therefore, serious follow up and the whole participation of the different stakeholders are very urgent for lakes and rivers fishery management as well as development. Indeed, the government bodies both the federal and regional should create awareness on the

concerned body to sustain fishing activities.

Conclusions

The reproduction cycle of fish occurred throughout the year. However, most of the fish species have their own intensive or peak spawning season once or twice in a year. The breeding season of fish is correlated with physiological (hormones) and environmental such as water quality parameters and also ecological factors. Therefore, awareness creation of the stakeholder at the breeding ground is important for conservation fishery biology in the country.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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