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Fish Distribution and Abundance in the Upper Awash River, West Shewa, Ethiopia

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Abstract

The study was conducted to assess the impact of agricultural and industrial wastes on the distribution and relative abundance of fish along the upper Awash River Basin. Fishes were collected using electrofishing apparatus from three sampling sites along the river representing different levels of anthropogenic impacts on the river. A total of 1912 fish belonging to five species were collected from all sampling sites. Nearly 73.43% of the fish were collected from the pool as compared with that of rifle habitat. Fish abundance varied significantly ($p<0.05$) between the sampling sites. Generally, diversity of fish and abundance declined drastically from the less impacted site towards the downstream sites S_2 and S_3 indicating the impact of agricultural and industrial effluents on the fish fauna of the river Awash.

Keywords: *Garraquadrimaculata, Garadembecha,* pool, Riffle

Introduction

Physical, biological and chemical characteristics determine the fish diversity of rivers (Kuehne, 1962; Barila et al, 1981). Human population growth puts pressure on physical alteration, nutrient addition from agricultural activities and industrial pollution of rivers (Whiles et al, 2000; Chu & Karr, 2001).Freshwater habitat alteration through either pollution or deforestation of river bank causes species extinction (Thomas, 1994; Lévêque et al., 2008). Environmental modification of aquatic ecosystems in particular dam construction causes change in hydrology, sedimentation, blockage of fish migration and connectivity among ecosystems (Brooker, 1981; Benke,1990; Quinn & Kwak, 2003).Irrigation channelization and hydroelectric dams has adverse effects on freshwater fauna and flora (Roberts, 1993).

In Ethiopia, irrigation schemes have been implemented by diverting and damming rivers in different parts of the country. The potential impacts of these projects on the diversity and distribution of fresh water fish is poorly documented. Environmental degradation rate caused by intensive and frequent farming, deforestation, overgrazing, irrigation and pollution are believed to be high in Ethiopia (Gebremariam, 2002). This degradation had a direct impact on decrease in fish fauna and biodiversity in the different drainage basins. Awash River, one of the largest river in the country. Information on the status of fish abundance and diversity difference due to agricultural activity, grazing by cattle, irrigation and industrial pollution is not available in

the upper section of the river. Golubstov and Mina (2002) reported that the basin is inhabited by 11 fish species. Fast human population growth and unsafe disposal of industrial and urban waste cause river water deterioration and a threat for ichthyofauna extinction. Thus, the main objective of this study was to assess the impact of anthropogenic activities on the diversity and abundance of fish fauna along the upper section of river Awash.

Materials and Methods

The study area

Awash River is one of the most important river basins in Ethiopia. The river rises from high plateau of Chilimo forest near Ginchi town. It is located at an altitude of 1500 m.a.s.l. River Awash flows along the rift valley and drains into Lake Gammary in Afar regional state. The river has a total length of 1200 km and catchment area of 112 700 km^2. This study covers the upper part of the river where agricultural activities such as cattle grazing, deforestation, and discharge of industrial waste cause major threats to the river ecology.

Collection of fish samples

Fish samples were collected from three selected sampling sites along the upper RiverAwash using a back pack electrofishing unit (Model Bh234, Honda, inc., Germany, direct current, output range =200V). The reference site, S1 is relatively pristine, with forest canopy cover located in the upper part of the river. Station2 is located above the bridge and immediately downstream of the first sampling site. This station surrounded by agricultural land, deforestation in the buffer zone and water abstraction is going on. Station3 is located across the bridge about one kilometer below the paper mill factory. In this location, people use the river for bathing, washing, grazing, and has no vegetation cover in the buffer zone. The site is highly populated and waste water from paper mill enters the river above this site.

Fig 1. The types of impact and physical alteration of the river

Each sampling site was divided into two habitat units' pool (deep, slow moving water) and riffle (shallow, moderate flow and high turbulent water) (Hawkins et al., 1993). In each sampling site two runs of electrofishing were conducted with time interval of 30-35 minutes each. Fishing was made from down to the upper river direction in pool and riffle water habitat types. Electrofishing and capturing of the fish were done using a hand net with frame width of 35*25cm and mesh size of 200 mm with 2 m handler.All fish sampled were recorded according to their habitat unit separately. After sampling, fish were identified to species level; standard length (SL) and total weight (TW) were measured to the nearest millimeter and gram, respectively. After taking the morphometric data on the river bank, most fish were released back to the river; whereas the remaining fish were preserved in alcohol and transported to the laboratory for further analysis. The fishing area was calculated by sketching the sampling stretch and length measurements using natural reference points. The relationship between fish abundance and width, depth, dominant substrate types of the sites and water velocity were examined. Water quality parameters such as water temperature (T), dissolved oxygen (DO), specific conductivity and pH were measured *in situ* using a multi-portable probe (Model HQ40D, HACH instruments).

Results

Water quality parameters

There was no significant difference in physico-chemical parameters including temperature, dissolved oxygen, pH among site. However, there was a general increase in water temperature from upstream to downstream (Table1). Conductivity ranged from 230 to 428µS/cm between sampling sites. The conductivity below the paper mill factory (S_3) was significantly higher that the upper site $S_1$and middle site S_2 ($P<0.05$).

Table 1. Mean value of physico-chemical parameters in each sampling site

Sampling sites	Temperature (°C)	pH	DO (mg/L)	Conductivity (µS/cm)
Reference site(S_1)	19.5	8.5	8.6	340
Above the bridge(S_2)	25	8.5	8.5	413
Below the paper mill (S_3)	28	7.98	6.45	428

General Habitat characteristics

There was considerable variation in river depth between sampling sites (Table 2). However, there was no significant difference ($P>0.05$) between upper and lower part of the segments. But there was variation in depth between Riffle and Pool units of all sampling sites. Depth is greater in Pool habitat in general. The river width varied significantly among sites ($P<0.05$) downstream sites (S_2& S_3) being wider than reference site S_1.The reference site S_1 is much narrower than the lower sites (S_2 & S_3).Variation was observed in the substrate type and composition of each site. The reference site was dominated by fine sediment, gravel and rock while, the lower segment is dominated by fine sediments, rocks and macrophytes (Table 2).

Table 2. Habitat variables measured in upper Awash River

Habitat Variables	Reference		Above the bridge		Below paper mill
	Riffle	Pool	Riffle	Pool	Pool
Depth (m)	0.2	0.4	0.05	0.4	0.5
Width (m)	2	2	1.5	3	4
Velocity (m/s)	-	-	0.2	0.1	0.1
Secchi depth (m)	Maximum	Maximum	0.05	0.3	0.4
Substrate composition (%)					
Fine sediment	70	70	8	-	85
Gravel	20	20	85	-	-
Rock	10	10	5	-	10
Macrophytes	-	-	2	-	5
Fish density (N/m^2)	4		13		1

Fish species diversity and abundance

A total of 1912 fish specimen belonging to five species of the family Cyprinidae were collected from the three sampling sites. The five fish species were *Garra quadrimaculata (Rüppell 1836),Garra dembecha, Garra hitriceps, large* and *small barbus species*. *Garra quadrimaculata (Rüppell 1836)* was the most dominant fish species collected from site S_1 (781) followed by *G.dembecha(306)*. *Gara dembecha* was the most dominant species in site S_3 (below the paper mill) which was represented by 101 individuals (Table 3). Among the five species, *G.hitriceps* was the least abundant as only11 individuals were caught above the bridge in the pool habitat. Relatively more number of fish species was captured from S_2 which is located above the bridge.

The species richness also varied between sites and habitat units of the river. In reference site (S_1), pool and riffle habitat 133 and 2 fishes were captured respectively. Above the bridge (S_2), 1153 and 506 specimens were captured from pool and riffle respectively. In the highly polluted site below the paper mill 118 individuals were collected from the pool habitat but no fish was found in the riffle. Overall, 73.43 % of the fish were captured in the pool and the rest 26.57% were caught in the riffle. In the pool habitat unit, fish abundance was significantly correlated with depth, velocity and substrate types (Table.2). The highest density of fish was captured above the bridge in S_2 (130,000 fish/ha) and the lowest in site S_3which is located below paper mill factory (10,000 fish/ha). The fish abundance was highest in site S_2 with 5 fish species including *Garra hitriceps* which did not exist in other sampling sites. In S_1 and below paper mill S_3, only three fish species were caught. Drastic change in fish abundance was recorded below the paper mill factory where domestic and industrial effluents are discharged directly to the river. Fish abundance in Awash River is significantly higher ($P<0.05$) in site S_2both in riffle and pool than site S_1 and site S_3 (Figure. 3).There wasn't significant difference ($P>0.05$) in fish abundance between sampling site $S_1$and sampling site S_3.

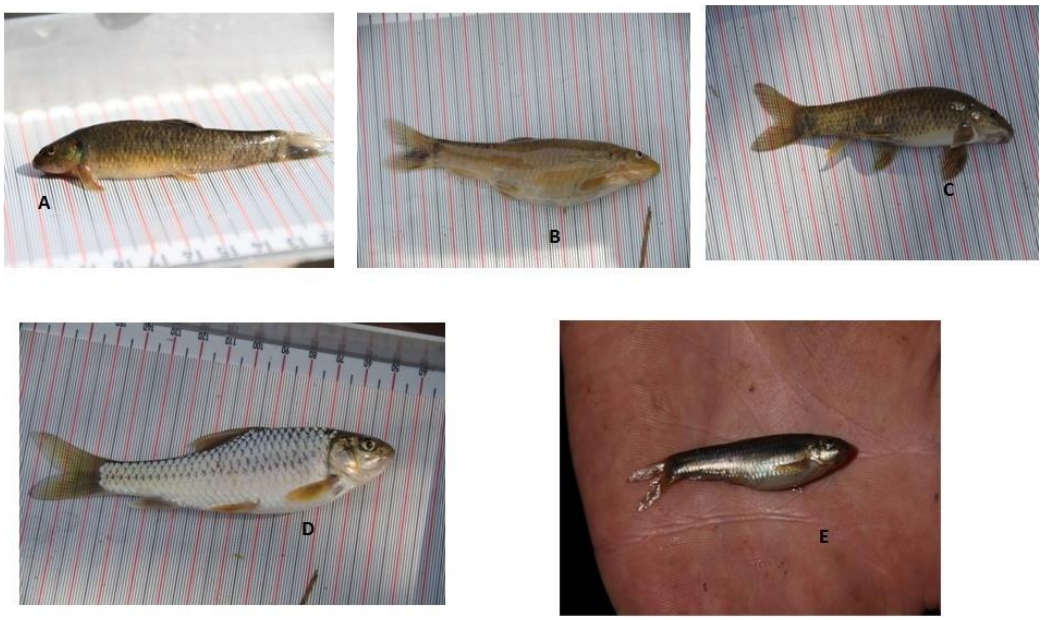

Fig 2. Fish species caught in upper Awash River, **A**, *Garradembecha*, **B,** *Garra species*, **C,** *Garraquadrimaculata*, **D**, *Large Barbus*, **E,** *Small Barbus*

Table 3. Percentage and relative abundance of fish species in pool and riffle habitat

Fish species	Reference site-S1		Above the bridge		Below the paper mill	Total	Abundance %
	Pool	Riffle	Pool	Riffle	Pool		
Garraquadrimaculata	100	0	781	309	0	1190	62.24
Garradembecha	30	2	306	173	101	612	32
Garrahitriceps	0	0	11	0	0	11	0.575
Large barbus	0	0	13	14	1	28	1.46
Small barbus	3	0	42	10	16	71	3.71
Total abundance	**133**	**2**	**1153**	**506**	**118**	**1912**	**100**

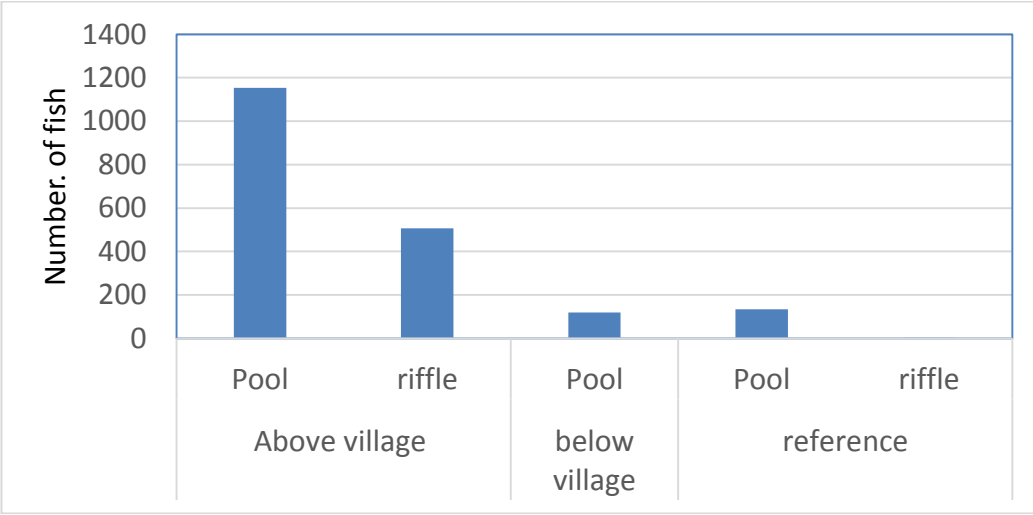

Fig 3. Total number of fishes captured in pool and riffle habitats at the three sites

Length frequency distribution of fishes

The length frequency distribution of *G. quadrimaculata* collected from in upper Awash River is shown in Figure. 4). Length frequency distribution showed significant difference between sites ($p<0.05$). Length of *G. quadrimaculata* in river Awash ranged from 24 to 123 mm. Length class between 39 to 43 mm was the most frequent in the river (Figure 3). On the other hand, length classes less than 34 mm and higher than 48 mm was the least abundant.

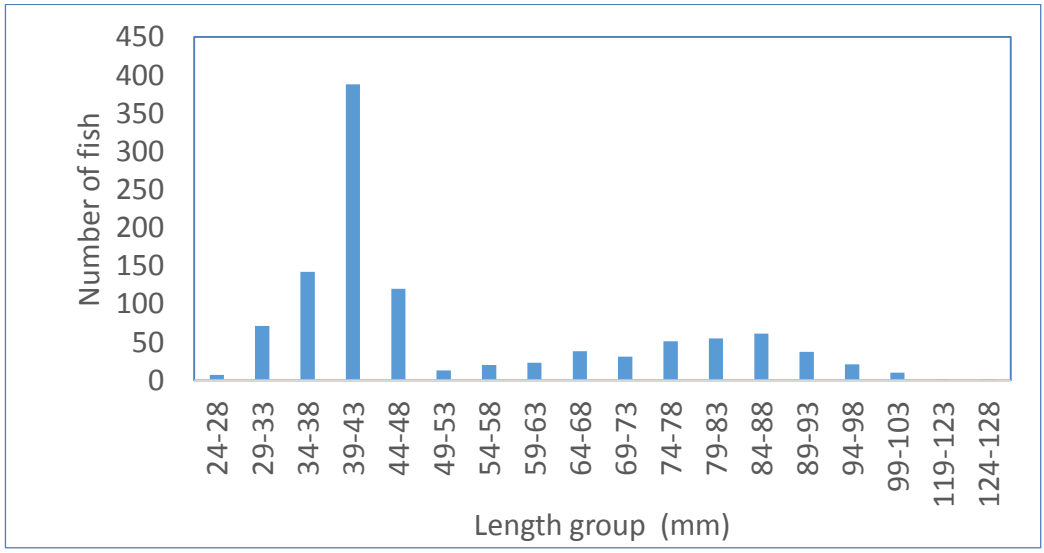

Figure.4. Length frequency distribution of *G.quadrimaculata*in upper Awash River

Discussion

Physico-chemical parameters were not significantly different among sites. However, conductivity was significantly higher at sampling site (S_3) below paper mill. This could be due to the higher concentration of ions coming from domestic and industrial pollution.

Ethiopian rift valley is home to about 30 different fish species (Golubstov and Mina, 2003). Awash River basin contributes 11 species (Golubstov, et al., 2002; Golubstov and Mina, 2003). However, in the present study, Cyprinidae was the only family inhabiting in the upper part of the river. The species richness of upper Awash River is very low compared to species richness reported by Golubstov and Mina, (2003). The species richness increased from upstream to down river system (Nikolsky, 1937; 1963). According to Golubstov & Mina (2003) in Ethiopia altitude difference is the main determinant factor affecting fish community structure in major river basins. Unlike the previous reports, fish species diversity did not increase in down the river. For example, the upper most forest covered site $S_1$was inhabited by three species, the agricultural impacted site S_2wasinhabited by five species and below the paper mill factory site $S_3$was inhabited by three species but all sampling sites were located at the same altitude.

This implies that fish species diversity in the study sites is mainly influenced by water volume, pollution and associated habitat modification of the river. Drastic change of fish species composition and abundance were observed in the polluted site of the study (pollution from the Ginchi town and paper mill factory). Fish assemblage response is revealed by different species impacted by environmental disturbance (Ward and Stanford, 1989).

According to Pegg and Taylor (2007) the composition and diversity of fish community in the stream was determined by biotic and abiotic factors. However, abundance of *G. quadrimaculata* at all study sites indicates that this species is more tolerant to agricultural activities, water abstraction, laundering and pollution. The genus *Garra* is distributed throughout Asia and Africa but 60% of the African species exist in Ethiopia and most of them are endemic (Menon 1964; Boulenger, 1902; 1907; 1909-1916; Krysanov and Golubtsov, 1992). *Garra* are highly resistant fish that live in hard flow and slightly polluted rivers and streams like Kebena and Akaki River (Abebe Getahun and Melanie, 1998). *G.hitriceps* was less abundant at all sites which might be site specific or non-availability of favored food.

In river continuum concept, there is ichthyomass increase along the gradient of rivers. Generally small ichthyofauna was expected in small streams and increase downstream (Vannote et al., 1980). Upper river water quality was good however, the

abundance and fish diversity was less in site S_1 which indicates volume of water is the main determinant for fish community assemblage. The lower diversity and biomass of fish species at upper stream influenced by stream order and networks whereas downstream where below factory S_3 could be the impact of industrial and domestic wastes which are discharged directly to the river. Earlier studies indicated that fish assemblage is influenced by stream order, network position and uncontrolled wastes to the river (Huet 1956; Kuehne 1962; Shedon1986; Lotrich 1973; Rahel and Hubert, 1991).

Most of the fish were collected from pool habitat units, this could be the lentic zone used as refuge for ichthyofauna because it provides more stable environment due to its depth, velocity and water volume. On the other hand, in riffle habitats where less water volume and less available food resources restrict the fish species richness. It is recognized that riffle habitat support less species diversity than pool habitats as result of change in water temperature, high flow velocity, turbidity, allochthonous nutrient inputs and food resources availability.

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