Diversity, distribution and abundance of fish species in upper Awash River Basin, West Showa Zone, Ethiopia

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Abstract: This study examined the diversity, distribution and abundance of fish species in Upper Awash River, Ethiopia was assessed. Five sampling sites were selected along the gradient of the river. Fish sampling was carried out using Frame net of 3-mm stretched mesh size from February through April, 2018. There was a considerable variation in river depth and width at all sites. A total of 3018 fish categorized under three species belonging to the Family Cyprinidae, namely, Garra quadrimaculata, Garra dembeensis and Labeobarbus beso were identified. Garra quadrimaculata was numerically the most dominant species in all sampling sites. Perhaps, there was no fish specimen caught from S-I. Similarly, the highest and lowest number of G. dembeensis was collected from S-V (42.73%) and S-II (2.51%), respectively. The composition of L. beso was higher at S-IV (49.1%), but no L. beso collected from S-I and S-II. High number of fish was caught from the pool parts at all sites. Shannon diversity index (H') varied between 0.14 and 0.80, and evenness index (J') varied from 0.2 to 1.7, but H' and J' of S-I were zero due to the absence of species in the area. Based on Shannon index, the upper Awash River was categorized as an impacted river. Therefore, effective management of the river is very imperative for sustainable utilization of fish resources.

Subjects: Zoology; Marine & Aquatic Science; Marine Biology; Biodiversity & Conservation; Ecology - Environment Studies

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PUBLIC INTEREST STATEMENT

Fish and shellfish are one of the aquatic resources with excellent protein content, and it is highly contributing to the food security. These diversities are, however, highly threatened by natural and human factors. Ethiopia is one of the tropical countries richest in diversified fish species. However, the resources are not well exploited and the contribution of fishes in food security is not significant. Particularly, the role of aquaculture is at its infant stage. This is due to the limited scientific information on the available diversities and their biology characteristics. It is from this background that this study is tried to investigate the diversity, distribution and abundance of fish species in the Upper Awash River basin. The finding revealed that the diversity, distribution and abundance of the fish species is highly influenced by anthropogenic and natural factors in this basin, and this information is a guarantee for using the fish stocks in aquaculture.
Keywords: Abundance; Diversity; Ethiopia; Fish; Upper Awash Basin

1. Introduction

Rivers and streams show signs of surprising phenomena with physical, cultural and psychological expression in life of human beings; they bring life and death, civilization and devastation, opportunity and risks and also used as shelter and feeding opportunities for a wide range of organisms like fish, insects, plants, mollusks, birds and mammals (Anderson et al., 2019). They carry water from the mountains to the sea, fueling the water cycle coupling land, ocean and the atmosphere (Karr, 1999). They are also the most suitable media to clean, disperse, transport and dispose of wastes from domestic and industries, drainages and irrigation to the water bodies, and change the appearance and quality of water bodies (Meybeck et al., 1996). However, river systems throughout the world have been disturbed by a wide variety of anthropogenic activities particularly large rivers have been subjected to dramatic physical alterations which ultimately reduced the diversity and abundance of riverine fish assemblages (Madejczyk et al., 1998).

Ethiopia is endowed with numerous water bodies including lakes, rivers, reservoirs and some wetlands. It has about 7334 km² of major lakes and reservoirs, and 8065 km length of rivers within the limits of Ethiopia (Tesfaye & Wolff, 2014). Although Ethiopia is presently separated from both East African and South Arabian mountains (Tudorancea et al., 1999), two main biogeography units called Nilo-Sudan and East Coast ichthyofaunal provinces are in contact to this region (Vijverberg et al., 2012). This made the freshwater fish fauna of Ethiopia to have a mixture of Nilo-Sudanic, East African and endemic fish forms (Getahun, 2005). Nilo Sudanic form which includes the genera of Alestes, Bagrus, Barilius, Citharinus, Hydrocynus, Hyperopisus, Laboe, Malapterurus and Mormyrus is the highly dominant fish in BaroAkobo Basin followed by Webi-Shebele and Omo-Gibe basins (Golubtsov et al., 1995).

BaroAkobo Basin is the richest in fish diversity, which could be attributed to the presence of diverse and rich habitats, and the past and present connection with other systems (east and central Africa) (Getahun, 2002). In other way, endemcity seems to be highest in AbayBasin (most of them are in Lake Tana due to flock L. barbus and Garra) followed by Ethiopian Rift Valley lakes and Awash Drainage Basins (Golubtsov & Mina, 2003).

Fishes of the high mountains torrential streams are largely Cyprinidae, which adapted to live in the swiftly flowing floodwaters that occur seasonally (Getahun & Stiassny, 1998). Two genera of fishes (Barbus spp. and Garra spp.) dominated the fish fauna of the highland streams. It has been indicated that fish species diversity decreases with an increase in altitude (Golubtsov & Mina, 2003). Elevation, water temperature and the stream size are the important factors for explaining the longitudinal patterns of fish distribution (Brunger et al., 2005). Virtually, all studies of longitudinal changes in fish fauna have focused solely on the patterns of fish species richness, and absence or presence of fish species. However, the study of relative abundance and distribution can provide more insight into the factors that affect the structures of fish species (Hubbel, 2001). Moreover, the species relative abundance and distributions vary in relation to faunal isolation, speciation rates, community size and size of regional fauna (Hubbel, 2001; Magurran, 2005).

Many of the drainage basins of Ethiopia, especially the rivers, are not exhaustively explored. In addition, knowledge on diversity, population structure and distribution of fish species in these drainage basins has been poorly known (Getahun, 2005). Relatively a large number of small, medium and even large rivers have not been well studied including the present study area on its fish composition in relation to its volume. Information on the available habitats both in quality and quantity can perhaps be obtained based on our knowledge on this information. The composition of fish species related to the scope of water volume should be thus fully known for the management and sustainability of the resources. Similarly, very limited studies have been conducted on fish species in the upper Awash Basin. This study was, therefore, initiated to fill the knowledge gap on assessing the diversity, distribution and abundance of fish species in Upper Awash River Basin, Western Shoa Zone, Ethiopia.
2. **Materials and methods**

2.1. **Description of the study area**

The study was conducted at the Upper Awash River Basin in Dandi District, which is located 75 km away from the capital Addis Ababa toward the west direction in West Shoa Zonal Administration, Oromia Regional State, Ethiopia. Dandi District has a total area of 109,729 ha with an altitudinal range from 2000-3200 m a.s.l. It has a tropical climate condition. The mean temperature and rainfall of the area is 16.5°C and 1409.5 mm, respectively (Dandi District RDO, 2010, unpubl. data). The rainfall distribution is bimodal: a short rainy season from March to April and the main rain season from June to September with mean annual rainfall of 1100 mm.

The district is well known for its richest water resources like Awash River and Dandi Lake. Awash River Basin covers a catchment area of 110,000 km² and serves as home for 10.5 million people. Based on physical and socio-economic factors, Awash Basin is divided into Upland (all lands above 1500 m a.s.l.), Upper Valley, Middle (area between 1500 m and 1000 m a.s.l.), Lower Valley (area between 1000 m and 500 m a.s.l.) and Eastern Catchment (closed sub-basin between 2500 m and 1000 m a.s.l.). The river is perennial, the water level and flow rate decline drastically during the dry season. The discharge fluctuates concurrently with the rainfall intensity. The maximum volume of the river is in the months from July to September; it reaches its peak in August (16.3 m/s) and lowest in December (0.16 m/s). Catchment of the river is entirely used for mixed agricultural activities (Shawul et al., 2019).

2.2. **Study design and sample site selection**

Preliminary survey was made in December, 2017, in order to have the topography and anthropogenic activities information in the basin for sample site selection. Based on physical, chemical, biological and land-use information obtained during the observation, five sampling stations were selected for primary data collection. The sampling stations were selected along the longitudinal zonation of the river and designated as: Station I (Galessa), Station II (Arera), Station III (Anjory), Station IV (Walgata) and Station V (Osale). Sampling stations were classified following the rapid bioassessment protocol criteria (Barbour et al., 1999) based on major stressor around the river.

2.2.1. **Station I (S-I)**

This site is located at upper Awash River at the base of Galessa Stream where there is less human settlement and other activities and few domestic animals sometimes grazing in the area. There is natural vegetation around the station. The Galessa Stream is located in the Gare Arere peasant association in Chilimo forest. Activities such as grazing and deforestation are not common and water is comparatively less polluted in this area. The site is considered as a reference site.

2.2.2. **Station II (Arera)**

This is located at the confluent point of Arera and Warabbostreams, which are found in the Gare Arere peasant association. At this station, there are some natural vegetation and scattered eucalyptus trees, which are planted at the river bank. There is a scattered human settlement nearby and natural and artificial forest. Activities such as agriculture, grazing and bathing are common in this site. This site is relatively less impacted as compared with the remaining three stations.

2.2.3. **Station III (Anjory)**

This is located in Arere Kure peasant association, at the back of China camp close to Ginchi town below the point where Kerensa Stream joins Awash River. This site is totally surrounded by grazing lands. The structural habitat of the river is dominated by mesolithic and macrolithal stones at riffle, and by sand and mud at the pool area of the site. Anthropogenic activities such as farming and grazing, cattle watering, bathing, car and washing are common practices in the area. This area is highly impacted as compared to S-I and S-II.
2.2.4. Station IV (Walgata)
This is located below the paper mill Wamara Saqo peasant association, below the town and is polluted by the effluent discharged from the paper mill industry and from Ginchi town. The area is highly covered with immense agricultural activities and no vegetation coverage at the river bank. Anthropogenic activities such as farming and grazing, herbicide spraying, washing clothes, cars and bathing are also common activities and the site is considered as highly impacted. The structural habitat of the river is dominated by mesolithal at riffle; and sand and mud at pool parts of the site.

2.2.5. Station V (Osole)
This is located one to two km away from the fourth site, which is totally surrounded by agricultural activities. It was characterized by high human settlement from the right side and Ginchi town from the left side.

Finally, geographic position and altitude of the study stations were measured using Global Position System (GPS 76S) in order to demarcate the study stations (Table 1 and Figure 1).

3. Collection and analysis of physico-chemical parameters
At each sampling site, water samples were collected on a monthly basis for a period of three consecutive months (February 2018 through April, 2018). The water samples were collected between 11:00 and 12:00 am to avoid the effect of diurnal variations. The procedure described in APHA (1998) was followed for the collection of water samples. The parameters, like temperature, pH and conductivity, were measured in situ using digital probes. The major nutrients like

| Sampling stations | Altitude mean (m) | Width mean (m) | Depth mean (m) | Coordinate X (Longitude) | Y (Latitude) | (%) Fine sediment | % Gravel | % Rock | % Macrophytas |
|-------------------|------------------|---------------|---------------|--------------------------|--------------|------------------|---------|-------|---------------|
| S-I               | 2475             | 1.2           | 0.16          | 04° 81'55.0"            | 10° 04'562" | 30               | 15      | 45    | 10            |
| S-II              | 2346             | 2             | 0.45          | 04° 48'11.0"            | 10° 02'362" | 40               | 17      | 35    | 8             |
| S-III             | 2252             | 2.5           | 0.87          | 04° 08'56.0"            | 09° 99'333" | 70               | 4       | 15    | 11            |
| S-IV              | 2200             | 2.4           | 1.2           | 04° 63'45.0"            | 09° 96'336" | 75               | 2       | 15    | 10            |
| S-V               | 2176             | 2.6           | 1.15          | 04° 74'67.0"            | 09° 95'341" | 60               | 25      | 5     | 10            |

S = indicates sampling station

![Figure 1. Map of the study area showing the sampling stations in Upper Awash River.](image-url)
Nitrate and Total Phosphorus were also analyzed at Ambo University, chemistry laboratory using spectrophotometer (AOAC, 1998). Habitat characteristics were assessed visually, and then width, depth and length of the selected pools and riffles were measured by plastic 100 m.

4. Collection of fish samples
Fish samples were collected monthly between February and April, 2018 from each site (pools and riffles) using frame net mesh size of 3 mm with total area of 4.6 m². This frame net was pulled by two persons from each side of the net end from downstream to upstream to collect fish from the pool of each station. To collect fish from riffle, a frame net was fixed at the downstream of the selected riffle of each site held by two persons and the third person disturb the fish from upstream of that riffle chasing the fish towards the fixed frame net. The collected fish samples were preserved in 5% formalin and identified to the family and species level in Biology laboratory, Ambo University with the help of standard reference keys (Habteselassie, 2012). The fish samples were measured for their total length and total weight using measuring board and sensitive balance, to the nearest to 0.1 cm and 0.1 gm, respectively.

5. Determination of species composition
The relative abundance of fish species was calculated as:

\[
\text{Relative Abundance of spp.} = \frac{\text{Number of specimens of particular species}}{\text{Total number of specimens of all species}} \times 100
\]

The dominance was also expressed as the percentage of corresponding species in the total number of individuals captured during the whole study period. Fish diversity indices were calculated as per standard method (Shannon & Weaver, 1963), which explains both variety and abundance of fish species (Næsje et al., 2004). This was calculated as:

\[
H' = \sum_{i=1}^{n} \left( \frac{n_i}{N} \right) \left( \log_2 \left( \frac{n_i}{N} \right) \right)
\]

\(H'\) = Shannon-Wiener indices of fish diversity, \(n_i\) = Total number of individuals of a species and \(N\) = Total number of individuals of all species.

In addition, Evenness (\(J'\)) for Shannon diversity index (\(H'\)) was calculated from equation:

\[
J = \frac{H'}{H} = \frac{H}{\log S}, \text{ Where:}
\]

\(S\) = number of species (spp. richness)

\(H'\) = maximum value of Shannon index

\(J\) = Evenness based on Shannon index

Dominance (\(D2\)) for the most abundant species was also calculated as:

\[
D2 = \sum_{i=1}^{2} pi
\]

where \(pi\) is the proportion of the total sample represented by the \(i\)th species (Kwak & Peterson, 2007).

6. Data analysis
The data collected were stored in MS Excel 2010; a variety of subjects were analyzed by combining quantitative and qualitative data analysis techniques. Descriptive statistics was used to summarize and analyze the collected data. SPSS version 21 was used to do descriptive and inferential analysis.
One-way ANOVA was used to assess the physico-chemical parameters and general habitat difference among the study sites.

7. Results

7.1. Physico-Chemical Parameters

The physico-chemical parameters of the five sampling sites of the upper Awash River Basin are presented in Table 2. The pH of water samples ranged between 8.2 and 8.8 with the mean pH of 8.7. The minimum mean pH of the water (8.5 ± 0.465) was recorded at S-I Site and the maximum mean pH was recorded at S-III (8.8 ± 0.7) and S-V (8.8 ± 0.4). The dissolved oxygen content of the water samples was found in the range of 6.7 to 9.4 mg/L. The higher mean dissolved oxygen content was recorded at S-V (8.4 ± 1.0 mg/L) and the lowest mean value was observed at S-II (7.4 ± 0.7) and S-III (7.4 ± 0.841 mg/L), respectively. The water temperature also varied between 11.8 and 24.6°C. The maximum and minimum mean water temperature was recorded at S-V (23.4 ± 1.0°C) and S-I (12.7 ± 0.6°C), respectively. The electrical conductivity of the water samples also ranged between 169.1 and 496.4 µS/cm. The mean electrical conductivity also increased downstream with the lowest mean value recorded at S-I (187.7 ± 1.8 µS/cm) and the highest value recorded at S-V (495.4 ± 1.0 µS/cm). The nitrate content was also found in the range of 0.1 to 0.9 mg/L. Mean nitrate content was highest in S-III (0.8 ± 0.04 mg/L) and lowest at S-I (0.1 ± 0.02 mg/L). The phosphorus content was between 0.04 and 0.6 mg/L. The highest mean total phosphorus content was recorded at S-III (0.3 ± 0.4 mg/L) and the least content was measured at S-I and S-II, respectively. Except for water temperature and electrical conductivity (p < 0.05), the results did not show a significant difference of water parameters among the study sites (p > 0.05).

7.2. General habitat characteristics of the river

There was a considerable variation in river depth between the sampling stations. The result showed a significant difference in water depth among the riffle and pool units of all sampling sites (p < 0.05), but no significant difference observed between the upper and lower part of the river segments (p > 0.05). The river width also varied significantly among the stations (p < 0.05), where the down parts of the river (S-III, S-IV and S-V) were wider than the upstream stations (S-I and S-II). The reference station, S-I is much narrower than any of the other lower stations. There was also altitude, substrate type and substrate composition variation between the study sites. The reference and less impacted stations (S-I and S-II) were predominated by rocks, fine sediments and gravels, whereas the down parts of the river (S-III, S-IV and S-V) were dominated by fine sediments, rocks and macrophytes (Table 1).

| Parameters | S-I | S-II | S-III | S-IV | S-V |
|------------|-----|------|-------|------|-----|
| pH         | 8.5 (8.2, 8.5, 9.0) | 8.7 (8.4, 8.7, 9.2) | 8.8 (8.2, 8.8, 9.5) | 8.7 (8.4, 8.7, 9.3) | 8.8 (8.5, 8.8, 9.3) |
| DO (mg/L)  | 7.7 (7.6, 7.7, 7.8) | 7.4 (6.7, 7.4, 7.9) | 7.4 (6.7, 7.4, 8.3) | 7.5 (6.8, 7.5, 7.9) | 8.4 (7.6, 8.4, 9.4) |
| Temp. (°C) | 12.7 (11.8, 12.7, 12.8) | 13.7 (12.8, 13.7, 14.2) | 21.3 (21.8, 23.1, 24.0) | 22.7 (22.3, 22.7, 23.0) | 23.4 (22.5, 23.4, 24.6) |
| EC (µS/cm) | 187.7 (169.1, 187.7, 172.7) | 334.7 (312.3, 334.7, 368.3) | 375.5 (371.0, 375.5, 379.3) | 478.4 (469.8, 478.4, 483.5) | 495.4 (494.4, 495.4, 496.4) |
| N-NO₃ (mg/L) | 0.1 (0.1, 0.1, 0.1) | 0.4 (0.3, 0.4, 0.6) | 0.8 (0.8, 0.8, 0.9) | 0.4 (0.1, 0.4, 0.5) | 0.4 (0.4, 0.4, 0.5) |
| T-p (mg/L)  | 0.1 (0.04, 0.1, 0.1) | 0.1 (0.04, 0.1, 0.1) | 0.3 (0.1, 0.3, 0.6) | 0.1 (0.1, 0.1, 0.2) | 0.075 (0.1, 0.075, 0.2) |

N-NO₃ = Nitrate, DO = Dissolved oxygen, T-P = Total phosphorus, EC = Electrical conductivity, x ± SD = Mean ± standard deviation, S = study site
7.3. Diversity and relative abundance of fish species
A total of 3018 fish samples belonging to three species under the family Cyprinidae were identified from the upper Awash River Basin. Garra quadrimaculata (Rüppell 1836) (55.70%) were the most dominant fish species in the study area followed by Garra dembeensis (Rüppell 1836) (39.63%). In general, there is no fish collected from S-I (Galessa) Site (Table 3; Figure 2).

7.4. Distribution and relative abundance of fish species
The total number of fishes caught in the present study varied between the sampling sites. Except for S-I, fish samples were caught from all other four sites (S-II, S-III, S-IV and S-V). High numbers of G. quadrimaculata were collected from S-V Site (34.86%) followed by S-III (29.63%) and Site-IV 24.63%, respectively. Similarly, high numbers of G. dembeensis were collected from S-V (42.73%) followed by S-IV (29.68%), whereas the least number were collected from S-II (2.51%). In other ways, there was high number of L. beso was collected from S-IV (49.1%) followed by S-III (33.3%), but there is no L. beso collected from S-I and S-II (Table 2). Generally, the total number of fish caught increased downstream up to S-III, declined at S-IV, and then increased at Station-V. The total fish specimens were collected from the fifth site (Table 4).

Table 3. Diversity of fish species in Upper Awash River Basin

| Species            | Family       | Number | Percentage (%) |
|--------------------|--------------|--------|----------------|
| G. quadrimaculata  | Cyprinidae   | 1681   | 55.7           |
| G. dembeensis      | Cyprinidae   | 1196   | 39.63          |
| L. beso            | Cyprinidae   | 141    | 4.67           |
| Total              |              | 3018   | 100            |

Table 4. Diversity and relative abundance of fish species in all sites of Upper Awash River

| Species            | Stations             | S-I (Galessa) | S-II (Arera) | S-III (Anjory) | S-IV (Walgata) | S-V (Osole) | Total |
|--------------------|----------------------|---------------|--------------|----------------|----------------|-------------|-------|
|                    | No.                  | %             | No.          | %             | No.            | %           | No.   | %     |
| G. quadrimaculata  | _                    | 180           | 85.71        | 498           | 58.92          | 414         | 49.66 | 589   | 52.17 |
|                    |                      |               |              |               |                |             |       |       | 1681  | 55.7  |
| G. dembeensis      | _                    | 30            | 14.29        | 300           | 35.50          | 355         | 42.57 | 511   | 45.26 |
|                    |                      |               |              |               |                |             |       |       | 1196  | 39.63 |
| L. beso            | _                    | 0             | 5.58         | 47            | 7.77           | 29          | 2.57  | 141   | 4.67  |
| Total              | _                    | 210           | 100          | 845           | 100            | 834         | 100   | 1129  | 100   |

S-I, S-II, S-III, S-IV and S-V indicates sampling site.
7.5. Fish composition by habitat type

The number of fish samples collected from pool and riffle parts of the river has shown a considerable variation among the study sites. In general, a high number of fishes were caught from the pool parts at all the study sites (Figure 3).

7.6. Fish diversity indices

Comparisons between the study sites showed a variation in Shannon diversity indices (H'). H' was zero for Galesso Stream (S-I), since there was no fish caught from the base of the stream up to the confluence of Arera and Werabo. Shannon diversity index was calculated starting from S-II to S-V. From the calculated Shannon diversity index, the value of H' was highest at S-IV (Walgata) (0.80) and the least was at S-III and S-V, whose values were equal (0.14). Except for S-I and S-II, whose species richness was 0 and 2, respectively, the other three sites (Anjory, Walgata and Osole) showed similar species richness (3 species each). Evenness of fish species in all four sites was also calculated based on Shannon's diversity index. Lower the value of the calculated evenness index, the less the evenness of the species is in that habitat. Based on this, S-IV was relatively more even than the other three stations, which showed similarity in evenness of fish species (Table 5).

8. Discussion

8.1. Physico-chemical parameters of the water

Physico-chemical parameters recorded in this study indicated slightly a good quality of water at upper Awash River, which is similar with the earlier reports made in different rivers in Ethiopia (Gebremariam, 2002; Kebede et al., 1994). Variation between stations was not significantly

| Table 5. Species diversity index and richness in present stations of upper Awash River |
|---------------------------------|----------------|----------------|----------------|----------------|----------------|
| Species                        | Sampling Stations | No. of Family  | No. of species | Shannon’s H | Evenness (J') |
|                                | S-I (Galessa) | S-II (Arera) | S-III (Anjory) | S-IV (Walgata) | S-V(Osole) |
| No. of Family | 0   | 1.00 | 1.00 | 1.00 | 1.00 |
| No. of species | 0   | 2.00 | 3.00 | 3.00 | 3.00 |
| Shannon’s H | 0   | 0.27 | 0.14 | 0.80 | 0.14 |
| Evenness (J’) | 0   | 0.90 | 0.30 | 1.70 | 0.30 |

S-I, S-II, S-III, S-IV and S-V indicates the sampling sites.
different (p > 0.05) except for conductivity, which was highest in lower sites. This could be associated with the degree of anthropogenic activities in some parts of the lower area (Elifu & Leta, 2018).

The mean dissolved oxygen content recorded in all sites (8.07 mg/L) was higher than the minimum requirements for fish survival and normal functioning under the natural systems (5 mg/L) (Franklin, 2013). The recorded pH was slightly alkaline, but it is still within the optimum range for survival of fish (6.5–8.2) (Campbell & Wildberger, 1992). The temperature recorded also falls within the WHO recommendation for normal functioning of aquatic life (12–25°C) (Edition, 2011). Perhaps, it was lower than the temperature reported from Guder River (23.2 to 25.6°C) (Garomsa, 2017). This might be attributed to the difference of data collection time (morning, versus afternoon) (EPA (U.S. Environmental Protection Agency), 2003).

The mean electrical conductivity range recorded in all sites (187.65 ± 1.84 to 495.39 ± 1.02 μS/cm) was lower than the result reported from Guder River (326 ± 7.54 to 608.67 ± 168.62 μS/cm) (Garomsa, 2017), Modjo River (910 ± 186.6 μS/cm) (Sitotaw, 2006), Debis River (922 ± 12.29 μS/cm) (Urge et al., 2017) and Lake Haya (900.6 μS/cm) (Alemayehu, 2009). This variation might be attributed to the extent of effluents dumped directly into the rivers from domestic and industrial wastes (Tesfaye, 2010). The highest mean electrical conductivity recorded at S-IV and S-V might also be associated with the effluent discharged from the paper mill industry and mining practices close to the sampling sites. It is also within the WHO recommendation for electrical conductivity for aquatic organisms survival (400 μS/cm) (WHO, 2008).

The highest mean values of nitrates and phosphorus recorded at S-III could be associated with the high number of animals commonly grazing around the sites. These animals deposit their dung either directly into the water or nearby the fields, which is easily washed into the river. The deposition of nitrate and phosphate rich animal’s dung in turn increases the level of these nutrients in the river water (Tesfaye, 2010). However, the value of nitrate recorded in all sites was still below the maximum limit (5 mg/ L) for aquatic fauna (Chapman & Kimstoch, 1996), the total phosphorus was, however, slightly higher than the maximum permissible limit in the water (0.005 to 0.02 mg/ L) (EPA (U.S. Environmental Protection Agency), 2003). The result of nitrate and phosphorus obtained in this study was lower than the report made from Debris River (1.965 mg/ L and 7.89 mg/L, respectively) (Urge et al., 2017). This could be associated with the extent of nutrients inputs from the surrounding area (Guignard et al., 2017).

8.2. Relative Abundance and Diversity of Fish

Over 78 Garra species have been so far described from Asia and Africa (Zhang, 2005), of which 17 are in Africa and 11 of them are from Ethiopia41. According to Stiasny and Getahun (2007), they are adapted to live in slow flowing and less polluted streams. In this study, a total of 3018 fish specimens belonging to three species of the family Cyprinidae were caught from all four sample sites, excluding Station-I. Compared with the previous report from the middle Awash River (five Cyprinidae species) (Abebe, 2016), the number of fish species caught in the present study was relatively lower (only three species). The species richness increased from upstream to downstream which is also confirmed in the finding of Wubie et al. (2017). According to Golubtsov and Mina (2003), altitude difference is the main determinant factor that affects the fish community structure in most river basins in Ethiopia.

The results obtained in this study also revealed the marked difference in diversity, abundance, and distribution of fish species among the sampling sites. These differences appeared to be related primarily to the habitat conditions and secondarily to the influence of environmental factors such as human-induced pollutants, natural topography of the area and relative tolerance of the fish fauna to the sites (Hashemi et al., 2015). Even though the upper site S-1 in Gellewa stream possesses good water quality, there was no fish caught from the area. This may be mainly linked with the low water volume, narrow width of the stream which is not easy for free movement of fishes (Bruno et al., 2013)
and mean temperature of the site (which was not greater than 12.687 ± 0.552°C), consequently not preferable for tropical fishes to survive and reproduce (Eric, 2011). In addition, there are large stones before the confluence of Arera and Werabo on the way up to Galessso Stream which may block the fish from migrating upstream. According to Hubbel (2001), the geographical barriers like forests, stones and bridges could be the reason for limiting the movement of fish in the water. Previous investigators also reported that fish assemblage can be affected by stream order, network position and uncontrolled waste disposal to the river (Rahel & Hubert, 1991).

*Garra quadriraculata* was highly abundant at all sampling sites and this indicates that the species can tolerate the pollution of water, environmental factors like low or high temperature, conductivity, pH and others. The study indicates that genus *Garra* is found distributed throughout Asia and Africa, but 60% of the African species exist in Ethiopia and most of them are endemic (Krysanov & Golubtsov, 1992). According to Stiassny and Getahun (2007), *Garra* spp. are highly resistant fish that live in hard flow and slightly polluted rivers. However, S-IV which is located below the paper mill industry had low total fish caught and biomass though it has higher volume of water at pool habitat in comparison with S-III. This shows that the discharges dumped to this site are seriously affecting the fish population, which could also affect the survival and growth of fish species in the river (Bukola et al., 2015).

Most of the fish species were collected from pool habitats, which could be related to the suitability of pool habitat for fish to survive well because of its depth, low velocity and high water volume. Similarly, Wubie et al. (2017) stated that riffle habitat supports less species diversity than pool habitats as result of change in water temperature, high flow velocity, turbidity, allochthonous nutrient inputs and food resources availability. On the other hand, during the dry season when flow of the water is low or volume of the water is low, the fish is trapped in very small shallow pools that causes stress on fish and make them very visible to the predators, and only very tolerant fish species such as Cyprinidae and Claridae can survive in seasonal and swiftly flowing rivers (Ahn et al., 2019). In correlation to this, S-II has less volume of pool habitat, which stresses the fish and exposes them to predators. This may be why only tolerant species like *G. quadriraculata* and *G. dembeensis* were caught in the upper sites.

The Shannon diversity index was highest in S-IV and lowest in S-III and S-V, respectively. Even though the number of fish species is only two in S-II, the diversity index was the second largest, which is attributed to the evenness of fish species in this site (Muchlisin & Siti-Azizah, 2009). The diversity indices at all sampling sites were relatively low due to the occurrence of few numbers of species in the area. Generally, $H'$ is the value that combines species diversity and evenness, where >3.99 is considered as non-impacted; 3.00–3.99 slightly impacted; 2.00–2.99 moderately impacted and <2.00, severely impacted (Namin & Spurny, 2004). Based on this category, the Upper Awash River Basin is categorized as a severely impacted river. The evenness index ($J'$) values also ranged between 0.3 and 1.7, revealing that the distribution of fish species at the sampling sites was not even (Jost, 2010).

9. Conclusion and recommendation
The present study reveals that though there is no significant variation in physico-chemical parameters among the study sites, there is an indication of water pollution in some sites, which might cause the variation in species distribution. The diversity of fish species in the present study is also low compared to other highland rivers, which could be associated with river ecology, water chemistry and temperature. The observation of *Garra* species in the river indicates the ability of the fish to adapt in small volume and polluted river water. The difference in fish composition among the study sites is also indicative of the habitat variation among the study sites. This calls for an effective management of the river for sustainable conservation and utilization of its resources in the future.
Acknowledgements
The authors would like to acknowledge Ambo University for the financial and logistics support. We would also like to thank the co-workers involved in data collection. In addition, we are very grateful for stakeholders in different administrative positions of Danji District and the local community who helped in the success of the research project.

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Disclosure statement
The authors declared that we have no conflict of interest.

Funding
This work was supported by Ambo University.

Citation information
Cite this article as: Diversity, distribution and abundance of fish species in upper Awash River Basin, West Showa Zone, Ethiopia, Bacha Temesgen, Zenebe Tadesse & Mathewos Temesgen, Cogent Food & Agriculture (2021), 7: 1974181.

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