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Length-weight relationship and reproduction of fishes in Gilgel Abay, Andassa, Jemma and Koga Rivers, Blue Nile, Amhara region, Ethiopia

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Abstract
Length-weight relationship, frequency distribution and reproduction of fishes in Gilgel Abay, Andassa, Jemma and Koga Rivers were studied by using gillnets and monofilaments of different mesh sizes, cast nets, hook and lines. Fish species identification was done by using literature and specimen deposited in the laboratory. Totally, 1106 fish specimens were collected from four Rivers. Three families and thirteen species of fishes were identified four Rivers. *Labeobarbus intermedius, Varicorhinus beso, L. nedgia* and *Clarias gariepinus* were the most dominant fish species found in both rivers. Length-weight relationship of *L. intermedius, V. beso, L. nedgia* and *C. gariepinus* were curvilinear and statically significant ($p<0.001$). There was significant difference in Fulton condition factor for the dominant fish species between Andassa and Gilgel Abay Rivers. Absolute fecundity of *L. intermedius, L. nedgia* and *V. beso* was linearly related to total length, total weight and gonad weight. Four seasons detail data should be collected to have clear understanding on the reproductive biology of fishes. Labeobarbus intermedius and V. beso were the first and second most abundant fish species that had a total length ranged from 16 to 53.5 and 22 to 54.5 cm at Andassa River and 19 to 48- 18.6 to 35.1 cm at Gilgel Abay River, respectively. *Labeobarbus nedgia* was the third most abundant species that had a total length ranged from 23.4 to 52.9 and 18.5 to 48 cm at Andassa and Gilgel Abay Rivers, respectively. The fourth most abundant fish species was *C. gariepinus* with a total length ranged from 28 to 66.5 and 22 to 58.5 cm in Andassa and Gilgel Abay Rivers, respectively.

Keywords: Length-weight relationship, length frequency distribution, fecundity, condition factor and sex ratio

Introduction
Ethiopia is a land locked country that depends on the inland waters for the supply of fish as a cheap sources of animal protein. It has a number of lakes and rivers with substantial quantity of fish stocks. The total area of the lakes and reservoirs stands at about7000-8000km^2 and the important rivers stretch over 7000km in the country [1]

Sustainable utilization of the aquatic resources, particularly the fishery resources is necessary so as to support the increasing Ethiopian human population through inexpensive source of animal protein [1]. Specimen of fish species were identified to species level using taxonomic key as indicated in [2] and [3] Picture of fish specimens was taken for each species. Immediately after capture, a gentle pressure was applied on the abdomen to check whether spermiation or ovulation has occurred or not. Then, total length and fork length were measured to the nearest 1 cm using measuring board and total weight of all specimens of fish was measured to the nearest 0.1 cm using sensitive balance. After dissection, gonadal maturity of each fish specimen was identified, using a five point of maturity scale [1]. Gonad weight was measured to the nearest 0.1 g using sensitive beam balance. From specimen of matured females (fish at stage IV) egg sack was measured and preserved with 4% formalin for fecundity estimation. After taking the entire necessary information, individual specimens were preserved with 4% formalin and put in plastic jar and was transported to laboratory for further identification and measurement.

Knowledge on length-weight relationship and some biological aspect of fish species of Ethiopia is poorly known. Relatively a large number of small, medium and even some large rivers have not been well studied and explored. Study on these rivers is a critical issue to be deal to fill such gaps. Gilgel Abay is the major river flowing into Lake Tana and Andasa River is a tributary of Blue Nile River. In so far as research finding is concerned, no report is found for both rivers. In general, no attention has been given for fish diversity, abundance and economic importance in Abay and Andassa Rivers. Andassa River is found in West Gojjam Administrative Zone (Bahir Dar Zuria Woreda and Mecha Woreda) and it is a perennial tributary of Blue Nile River. The river had high water volume during rainy season due to high runoff and sediment accumulation from the upstream. Gilgel Abay River originates from the highland area of Sekela Woreda (Gash Abay town) in West Gojjam Zone. Gilgel Abay is a natural geographical boundary that separates Debub Achefer and Mecha Woreda. Jemma and koga rivers start mountain amedamit and tributary of Gilgel Abay.

Materials and Methods

Description of the study area

Andassa River is found in West Gojjam Administrative Zone and it is a perennial tributary of Blue Nile River (Fig 1). The river arises from Mount Adama. The river has high water volume during rainy season due to high runoff and sediment accumulation from the highlands. Gilgel Abay River originates from the highland area of Sekela Woreda (Gashi Abay town) in West Gojjam Zone. Gilgel Abay is a natural geographical boundary that separates Debub Achefer and Mecha Woreda.

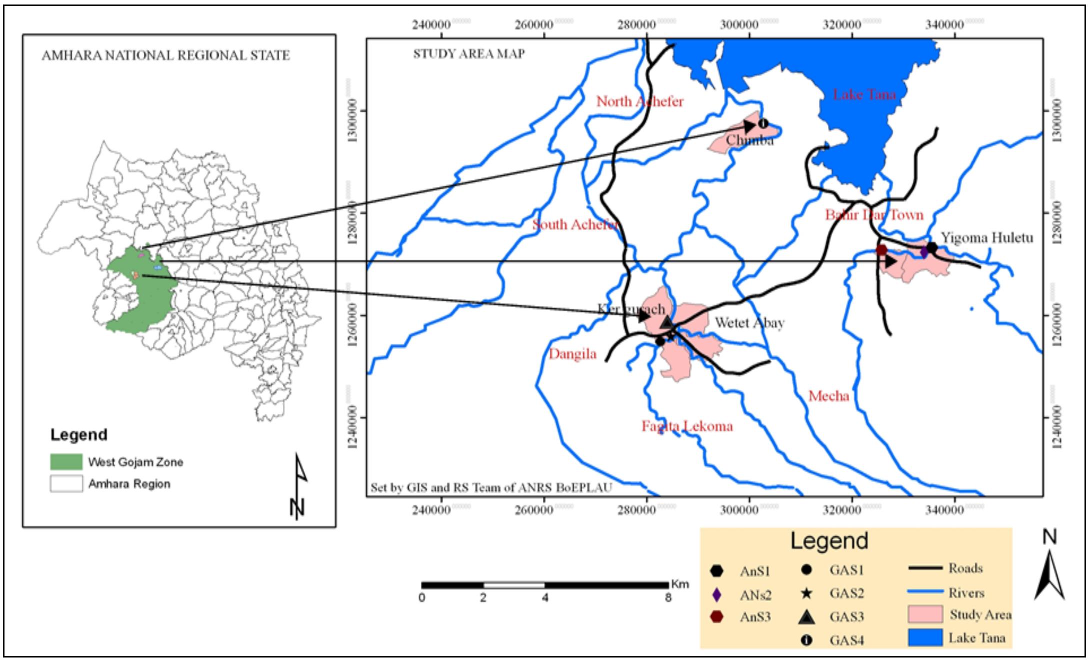


Fig 1: Map of the study area and sampling sites at Andassa and Gilgel Abay Rivers.
(Source: Amhara Research Institute GIS team at Bahir Dar)

Site selection and sampling

Reconnaissance survey was conducted to fix the sampling sites. Field survey was conducted in a number of sub-areas along Andassa and Gilgel Abay Rivers. Three and four sampling sites were selected from Andassa and Gilgel Abay Rivers, respectively. Selection criteria were the nature and velocity of the flowing rivers, suitability for fishing/net setting, and accessibility of the site (Fig1).

Length-weight relationship

The relationship between total length and total weight of most dominant fish was calculated using power function as in (5) as follows:

$TW = aTL^b$

Where, TW – total weight (g)
TL- total length (cm)
a-intercept of regression line
b-slope of regression line

Condition Factor (Fulton's factor)

The well-beingness of each dominant species was studied by using Fulton condition factor (6). Fulton condition factor (%) was calculated as

$$FCF = \frac{TW}{TL^b} X100$$

Where, TW- Total weight in gram (g) and TL- Total length in centimeters (cm)

Fecundity

Fecundity is the number of eggs in ovary before spawning. Fecundity was determined by total counting method or gravimetrically [7] by weighing all the eggs from each ovary of gravid fish species (gonad maturity stage IV).Three sub-samples of 1 g eggs were taken from different parts of ovary and counted and the average was calculated. Then, total number of eggs per ovary was calculated by extrapolation from the mean. The relative fecundity was calculated by dividing the number of eggs per fish weight. The relationship of fecundity with total length, total weight, and ovary weight was determined through the following relationship (6).

$F = TL^b$, $F = aTW^b$, $F = aGW^b$

Where, F= Fecundity, TL = Total Length (cm), TW = Total Weight (g), GW = Gonad Weight (g), a = constant and b = exponent

Data analysis

Data was analyzed using SPSS version 16 and Excel of windows 2003/2007 for ANOVA (comparison of means). Regression, Chi-square test (to test sex ratio) and some descriptive statistics were used.

Results and Discussions

Survey data results in study area

All respondents were Orthodox and their educational level was basic education. All fishermen eat fish meat in average 15 kg per year which is highly greater than whole people.Fish meat source the study area was four rivers (Jemma, Koga, Andassa and Gilgel Abay) and preferable species was oreochromis niloticus. In the study area the fish resource decline year to year due to this reason price of fish highly upgrading. Fishing activities done by local materials including toxic plants, no one worries about fish resources and fishing done throughout the year but preferable season was September to November.

Table 1: Identified fish species in four rivers

Gilgel Abbay	Andassa	Jemma	Koga
L. intermedius	*L. intermedius*	*L. intermedius*	*L. intermedius*
V. beso	*V. beso*	*V. beso*	*V. beso*
L. nedgia	*L. nedgia*	*L. nedgia*	*L. nedgia*
C. gariepinus	*C. gariepinus*	*C. gariepinus*	*C. gariepinus*
L. brevicephalus	*L. brevicephalus*	*L. brevicephalus*	*L. brevicephalus*
L. acutrostris	*L. megastoma*		
L. tsanesis	*L. surkis*		
L. macrophytalamus			
L. trutiformis			
O. niloticus			

Length frequency distribution of the most dominant fish species

The length frequency distribution of the most dominant fish species for each river is indicated below (Fig 2 and 3). *Labeobarbus intermedius* and *V. beso* were the first and second most abundant fish species that had a total length ranging from 16 to 53.5 and 22 to 54.5 cm at Andassa River and 19 to 48 and 18.6 to 35.1 cm at Gilgel Abay River, respectively. *Labeobarbus nedgia* was the third most abundant species that had a total length ranging from 23.4 to 52.9 and 18.5 to 48 cm at Andassa and Gilgel Abay Rivers, respectively. The fourth most abundant fish species was *C. gariepinus* with a total length ranging from 28 to 66.5 and 22 to 58.5 cm in Andassa and Gilgel Abay Rivers, respectively.

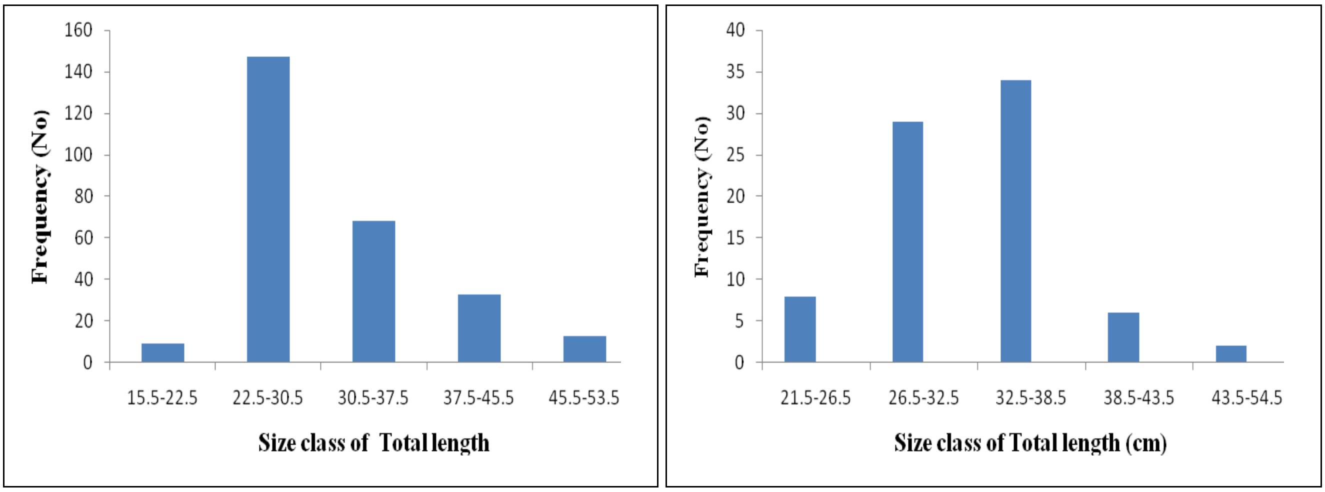
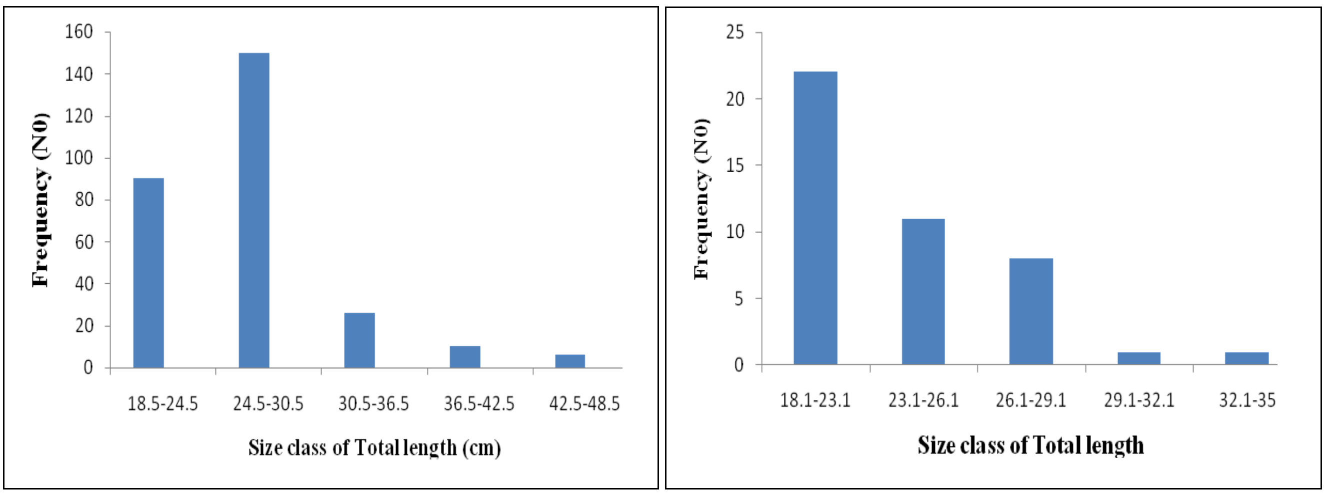


Fig 2: Length frequency distribution of *L. intermedius, V. beso, L. nedgia* and *C. gariepinus* in Andassa River (N = 270, 79, 36 and 51), respectively



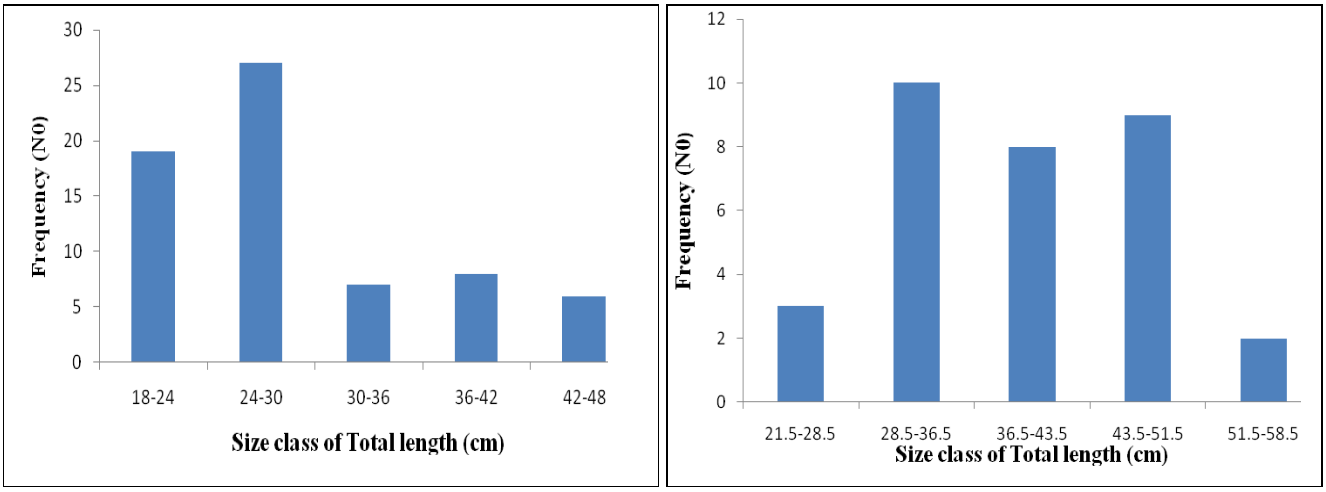


Fig 3: Length frequency distribution of *L. intermedius, V. beso, L. nedgia* and *C. gariepinus* in Gilgel Abay River (N=282, 42, 67 and 32), respectively.

Some biological aspect of dominant species

Length-weight relationship

The relation between total length and total weight for dominant fish, *L. intermedius*, *V. beso*, *L. nedgia* and *C. gariepinus* were curvilinear and showed significant variation (p<0.001) at Andassa and Gilgel Abay Rivers (Table 2 and 3).

Table 2: Length-weight relationship of the dominant fish species in Andassa River.

Species	Regression equation	TW (Mean ±SD)	TL (Mean ±SD)	R^2	N	Sig.
L. intermedius	$TW=0.0084TL^{3.0}$	300.18±218.34	31.13±6.76	0.96	270	0.000***
V. beso	$TW=0.007TL^{3.1}$	421.69±172.59	32.92±4.63	0.95	79	0.000***
L. nedgia	$TW=0.0061TL^{3.1}$	567.25±320.25	38.37±7.49	0.97	36	0.000***
C. gariepinus	$TW=0.0463TL^{2.4}$	461.21±234.66	42.68±8.39	0.74	51	0.000***

Note *** very highly significant (p<0.001)

Table 3: Length-weight relationship of the dominant fish species in Gilgel Abay River.

Species	Regression equation	TW (Mean ±SD)	TL (Mean ±SD)	R^2	N	Sig
L. intermedius	$TW=0.0074TL^{3.1}$	196.6+143.05	27.46+4.74	0.93	282	0.000***
V. beso	$TW=0.0213TL^{2.8}$	149.59+63.29	23.99 +.30	0.94	42	0.000***
L. nedgia	$TW=0.00TL^{3.3}$	273.96+251.72	29.3+7.37	0.89	67	0.000***
C. gariepinus	$TW=0.025TL^{2.6}$	430.03+25.36	38.48+8.59	0.96	32	0.000***

Note *** very highly significant (p<0.001)

Fulton condition factor (FCF)

Fulton condition factor of *Labeobarbus intermedius* in Andassa River (0.87±0.144) was lower than Gilgel Abay River (0.89±0.23) (Table 4 and 5).

Table 4: Mean of Fulton condition factor of the dominant species for both rivers.

Fishes	Andassa River (Mean ± SD)	Gilgel Abay River (Mean ± SD)
L. intermedius	0.81±0.144	0.89±0.23
V. beso	1.33±1.55	1.0±0.2
L. nedgia	0.84±0.113	0.86±0.14
C. gariepinus	0.51±0.147	0.95±1.14

Table 5: Fulton condition factor of the dominant species in dry and wet seasons at Andassa and Gilgel Abay Rivers.

Fish species	Andassa Mean		Gilgel Abay Mean		Andassa SD		Gilgel Abay SD		Significance	
	Wet	Dry	Wet	Dry	Wet	dry	Wet	Dry	wet	dry
L. intermedius	0.84	0.88	0.88	0.9	0.12	0.16	0.24	0.23	0.084	0.006**
V. beso	0.88	1.35	0.98	1.12	0.20	1.5	0.20	0.10	0.004**	0.663ns
L. nedgia	0.84	0.91	0.88	0.84	0.11	0.09	0.10	0.18	0.261	0.083
C. gariepinus	0.59	0.55	1.12	0.74	0.04	0.17	1.14	0.28	0.179	0.006**

Note *significant deference, **highly significant (p<0.001) and ns (non-significant p>0.05).

Fulton condition factor of *Labeobarbus intermedius* in Andassa River (0.87±0.144) was lower than Gilgel Abay River (0.89±0.23). Therefore, *L. intermedius* was in better condition in Gilgel Abay River than Andassa River. In this study, the mean Fulton condition factor value obtained (Andassa River = 0.81 and Gilgel Abay River = 0.89) for *L. intermedius* was greater than the one reported by [8]. However, it was less than from other reports [9, 10]. Fulton condition factor of *L. intermedius* at Gilgel Abay River was greater than the one reported by [11] at the head of Blue Nile River but it was lower at Andassa River. There was no significant difference in Fulton condition factor between males and females for *L. intermedius*, *L. nedgia and V. beso* (p<0.05). Fulton condition factor of *V. beso*, *L. nedgia* and *C. gariepinus* were 1.33±01.55, 0.84±0.113, 0.51±0.0.147 and 1.02± 0.0.2, 0.86±0.14, 0.95±1.14 in Andassa and Gilgel Abay Rivers, respectively. In this study, the Fulton condition factor of *V. beso* and *C. gariepinus* at Andassa River was greater than the one reported by [11] at the head of Blue Nile River but it was lower for Gilgel Abay River. Fulton condition factor of *V. beso*, *L. nedgia* and *C. gariepinus* were higher in Andassa than Gilgel Abay River. There was no significant difference in Fulton condition factor between female and male in all dominant fish species except *C. gariepinus* in Andassa River (Table 4).

Sex ratio

From the total number of 1106 fishes collected from both Rivers during the study period, 9 (0.96%) specimens were unsexed, and 1097 specimens (99.04%) were sexed. Among these, 681 (73.23%) and 249 (26.77%) were females and males, respectively. Generally, females were numerous than males. The chi-square test showed significance difference between females and males of *L. intermedius*, *L. nedgia*, *L. crassibarbis*, *L. brevicephalus* and *V. beso* and non-significant difference for *C. gariepinus* at Andassa and Gilgel Abay Rivers (Table 6 and 7).

Table 6: Number of females, males and corresponding sex ratios (data pooled from all sites) at Andassa River.

Fish Species	Female	Male	F : M	χ^2	Significance
L. intermedius	197	72	1:0.37	59.2 4	0.000***
V. beso	62	17	1:0.27	25.36	0.000***
L. nedgia	30	6	1:0.2	16	0.000***
C. gariepinus	31	20	1:0.65	1.59	0.123 ns
L. crassibarbis	16	1	1:0.1	10.89	0.000***
L. brevicephalus	17	3	1:0.18	8.5	0.005**
L. surkis	0	2	-	-	-

Note: ** highly significant (P<0.05), *** (very highly significant, (P<0.001) and ns (non-significant, p>0.05)

Table 7: Number of females, males and corresponding sex ratios (data pooled from all sites) at Gilgel Abay River.

Fish Species	Female	Male	F:M	χ^2	Significance
L. intermedius	206	76	1:0.34	59.93	0.000***
V. beso	34	7	1:0.37	17.78	0.000***
L. nedgia	47	20	1:0.43	10.88	0.000***
C. *gariepinus*	14	17	1:0.82	0.29	0.59 ns
L. brevicephalus	22	6	1:0.27	9.143	0.000***
L. crassiburbis	1	0			
L. tsanesis	1	0			
L .truttiformis	0	1			
L. macrophytalamus	0	1			
O. niloticus	1	0			
L. acuctirostris	2	0			

Note: *** (very highly significant, P<0.001) and ns (non significant, P>0.05)

In the present study sex ratio of the dominant fish species were statically significant except *C. gariepinus* in both Rivers (p<0.05). The imbalance of female to male ratio at both Rivers might be related to different biological mechanisms such as different maturity rate, different mortality rates and different migratory rates between the male and female [12].

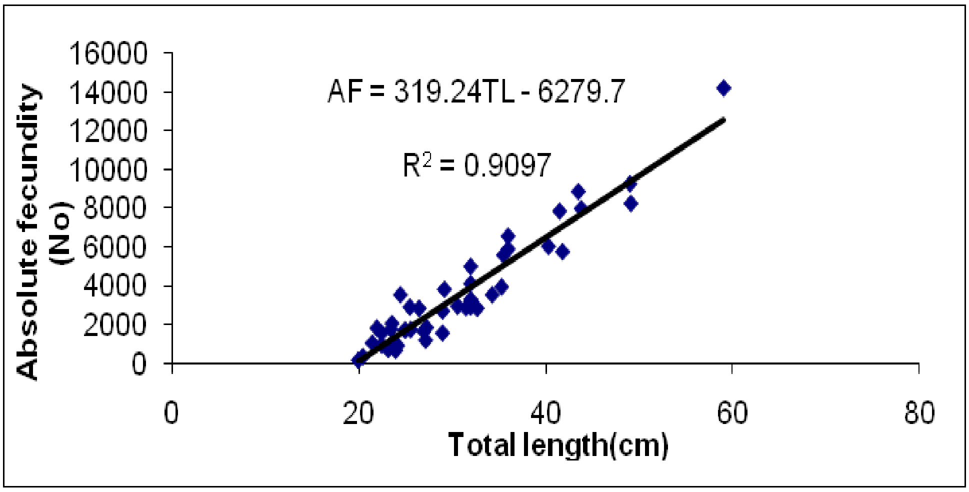
Fecundity

The absolute fecundity (AF) of *L. intermedius*. *L. nedgia* and *V. beso* ranged from 347 to 14158, 926 to 14750 and 1075 to 24653 eggs with average fecundity of 3595, 5529 and 510, respectively (Table 7). The relationship between AF with TL, TW and GW of *L. intermedius*, *L. nedgia* and *V. beso* were linear. In general, absolute fecundity of the three dominant fish species was strongly positively correlated with total length, total weight and gonad weight (Fig 4-6). The information about fecundity of large barbus fish species in Africa is scarce [13]. There was few data on the fecundity of large barbus [15, 14] studied fecundity of large barbus of Lake Tana and its tributary. The absolute fecundity of *L. brevicephalus* and *L. truttiformis* ranged from 1284 to 4563 and 1732 to 8134 eggs, respectively in Lake Tana [15]. The absolute fecundity of *L. brevicephalus* and *L. truttiformis* ranged from 1284 to 4563 and 1732 to 8134 eggs, respectively in Dirma and Megech Rivers [16]

Table 8: Absolute fecundity relation to TL, TW, GW of the dominant fish species both Andassa and Gilgel Abay Rivers

Fish	Total length(cm)	Total weight (gm)	Gonad-weight(g)	AF in number
L. intermedius				
Mean	30.93	314.28	13.26	3595
SD	8.7	219.1	10.19	2895
Minimum	20	89	1	347
Maximum	59	890	48	14158
V. beso				
Mean	33.37	357.22	25.53	5529

SD	6.15	238.23	39	7354
Minimum	26	122.4	6	1075
Maximum	45	884.3	28	24653
L. nedegia				
Mean	33.34	503.22	15.4	510
SD	12.48	496.98	12.95	5332
Minimum	21	96.2	0.4	926
Maximum	52	1310.7	35.8	14750



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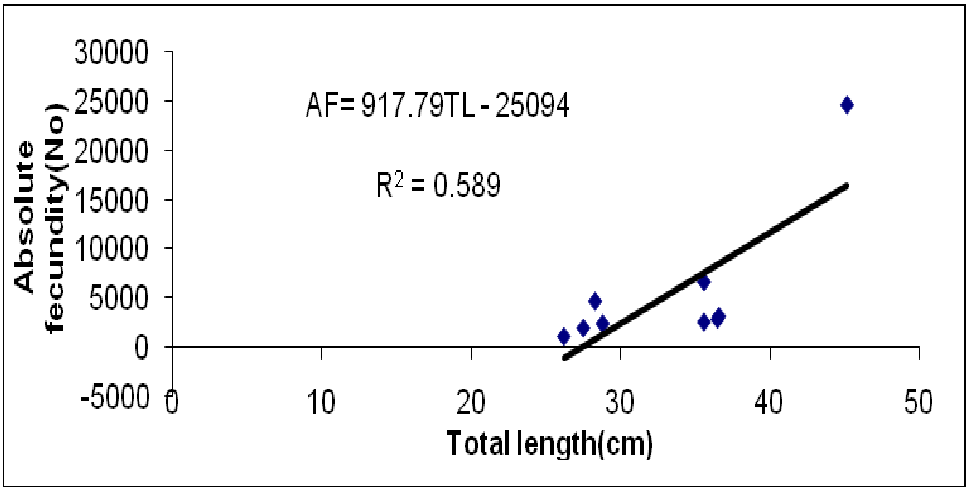

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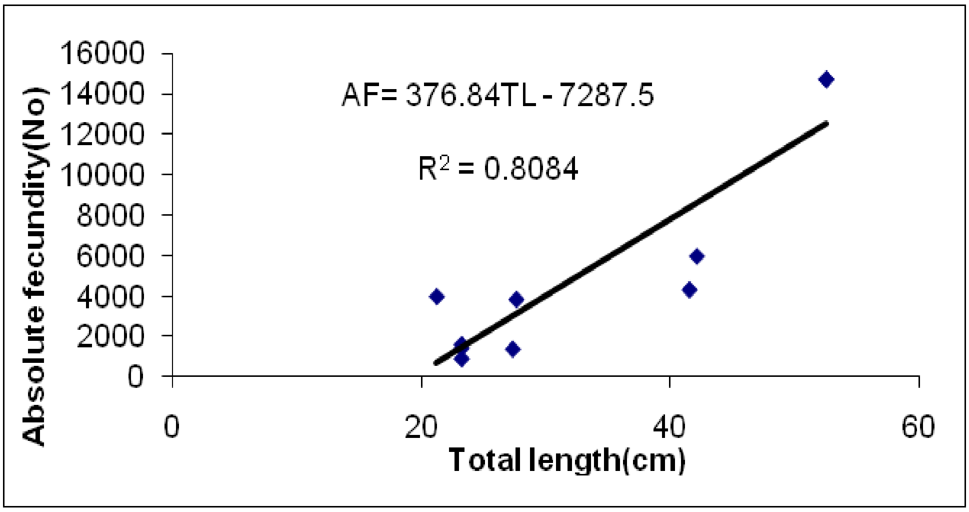
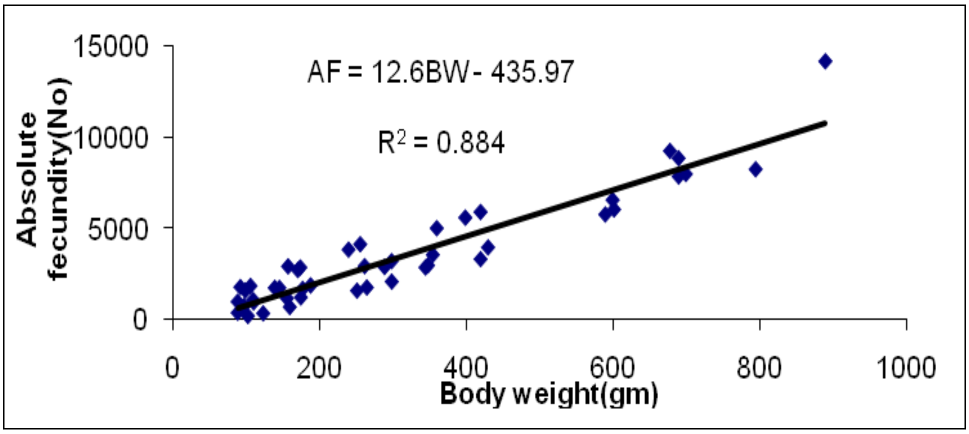


C

Fig 4: Absolute fecundity in relation to total length for *L. intermedius* (A), *V. beso* (B) and *L. nedgia* (C).



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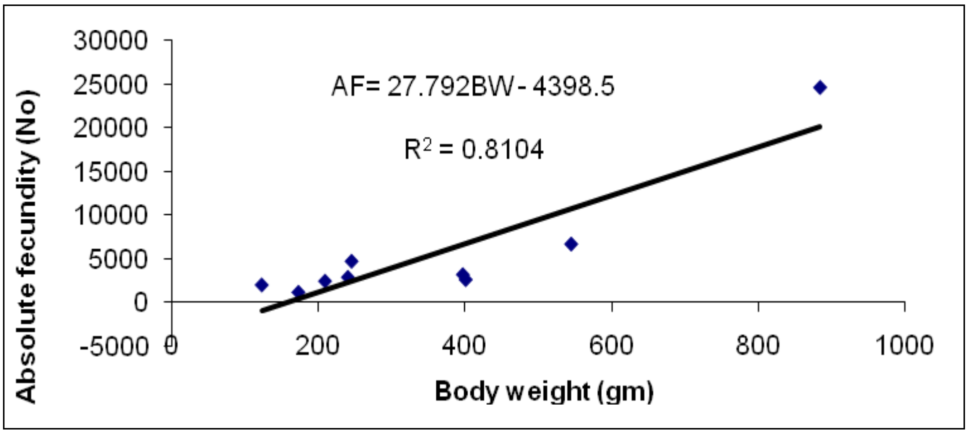

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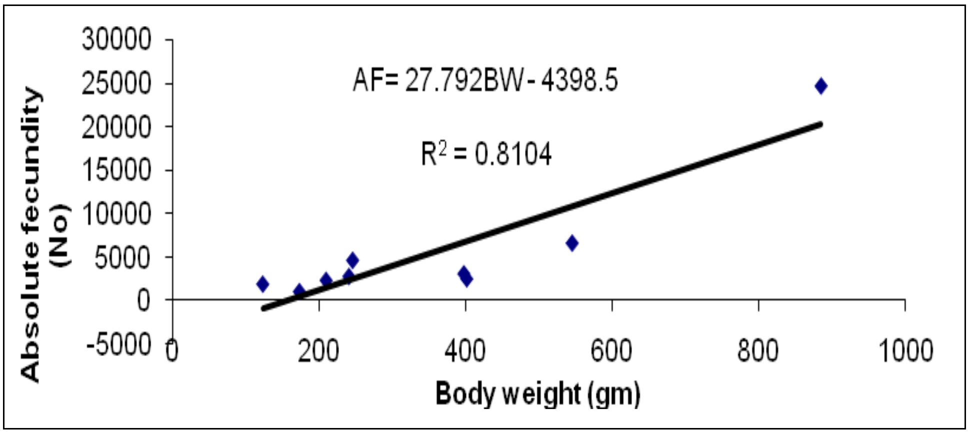
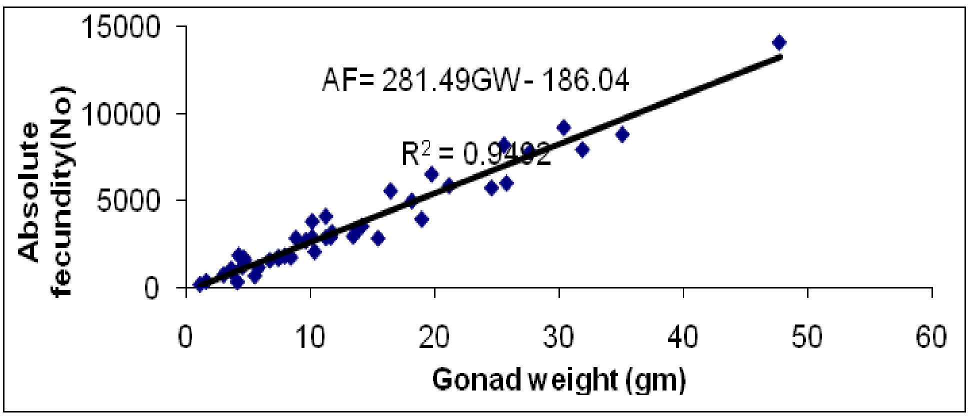


C

Fig 5: Absolute fecundity in relation to total body weight for L. *intermedius (A)*, *V. beso* (B) and *L. nedgia* (C).



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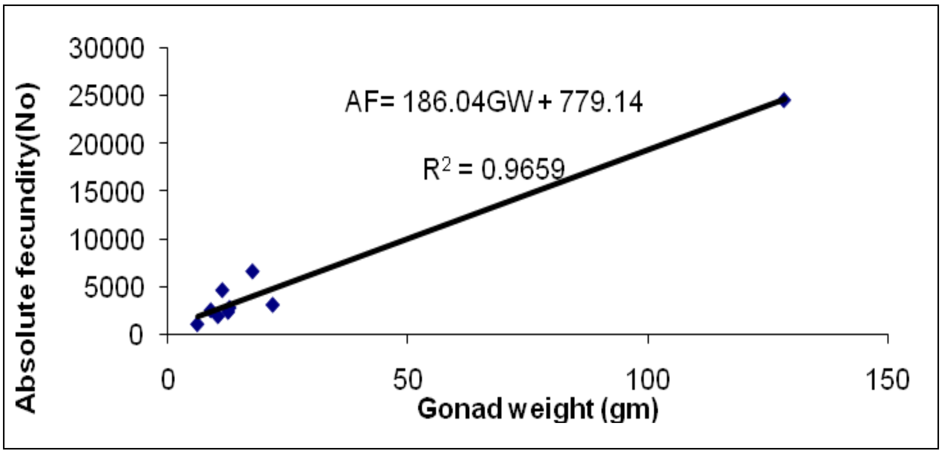

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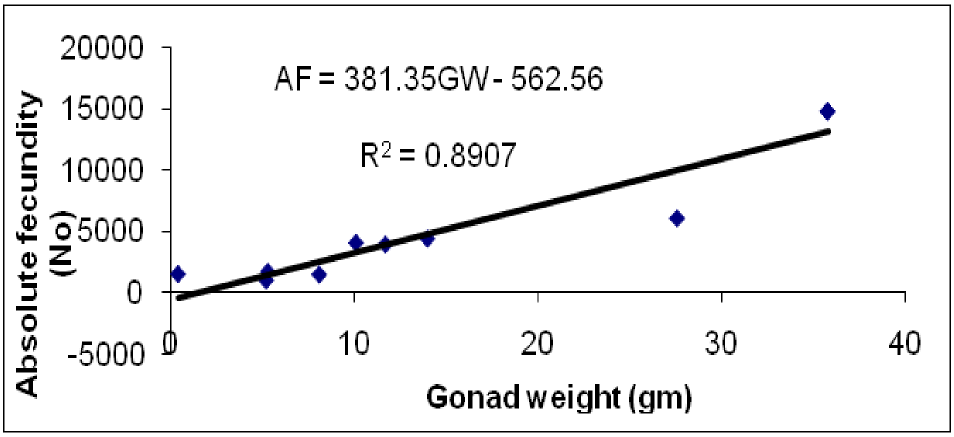

C

Fig 6: Absolute fecundity in relation to total gonad weight *L. intermedius* (A), *V. beso* (B) and *L. nedgia* (C).

Conclusion and Recommendation

Conclusion

- *Labeobarbus intermedius*, *V. beso*, *L. nedia* and *C. gariepinus* were the most dominant fish species in both rivers.
- From the total number of 939 fishes collected in Andassa and Gilgel Abay Rivers during the study period 9 (0.96%) specimens were unsexed, 930 fishes (99.04%) were sexed. Among the sexed 681 (73.23%) were females and 249 (26.77%) were males, implying a numerous females.
- From length-weight relationship, it can be stated that the two dominant fish species *L. intermedius* and *L. nedgia* showed nearly isometric growth in both Rivers but *C.gariepinus* showed negatively isometric growth.
- The chi-square test analysis showed that there was significant variation in sex ratio for most of the dominant fish species in both rivers ($p<0.001$).
- Fecundity showed linear relation with total length, total weight and gonad weight for *L. intermedius*, *V. beso* and *L. nedgia* with mean fecundity of 3595, 5529 and 510 eggs, respectively

Recommendations

- There should be a detail study on length-weight relationship and biology of fish species in the upper streams of both rivers.
- Four season detail data should be collected to have clear understanding on the reproductive biology of fishes.
- Clarias gariepinus the longest fish species both revers
- Further study is needed on those fishes with small catch rates.
- *Varicorhinus beso* could be taken as a good candidate for commercial fish production in the locality.

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