Master's thesis

Impacts of anthropogenic factors on fish community structure in Lebialem-Mone Forest Landscape of Cameroon

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Master's Degree Programme in
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ABSTRACT

Two sites of the Cross River within the Lebialem-Mone forest landscape of Cameroon were chosen, one of the sites faced with human activities (test site) and the other with no human pressure (control site). The lengths and weights of fish obtained from both sites were analyzed in SPSS. Fish communities living within these 2 sites were compared after collecting fish from them using gill nets within 2 months of sampling (September-October 2009). Questionnaires were distributed to the fishers to respond to questions related to their fishing practices. Each fish from a sample of 240 fishes obtained from both sites was identified with its length and weight recorded. Fishing pressure constitutes the main difference of these two sites with respect to the fish samples analyzed. Shannon index is also calculated for both sites to obtain the species diversity. The control site is comprised predominantly of large sized fish species while the test site is predominated by small sized fish species. Also, the control site has higher species diversity than the test site. Fishing and deforestation constitute the main factors affecting the fish communities on both sites as over 55 % of the river catchment in the test site has been deforested. However, fishing is the most dominant factor affecting the fishing community on this site due to the extremely high fishing pressure noticed. The survey carried out revealed that the fishers love to collect large size fish species. The total annual yield of fish obtained by the fisher population in this area is 167 633 kg within an area of about 8 hectares. The yield per unit effort (YPUE) is 14.5 kg of fish caught by each fisher per day.

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TIIVISTELMÄ

Cross River -joen kalayhteisöä tutkittiin koeverkkokalastuksella LebialemMone forest landscape -alueella Kamerunissa. Tutkimusalueita oli kaksi: ihmistoiminnan vaikutuksen (mm. kalastus, metsien hävittäminen) alainen koealue ja luonnontilainen kontrollialue (ei kalastusta). Kummallakin alueella tehtiin verkkokoekalastus solmuväliltään 30 mm verkolla syys-lokakuussa 2009. Kummallakin alueella kalastettiin 3 verkkovuorokautta kuukaudessa. Verkko koettiin päivittäin ja jokaisesta saaliista otettiin 20 kalan satunnaisotos, yhteensä 120 kalaa/alue. Kaloista määritettiin laji, kokonaispituus ja tuoremassa. Luonnontilaisen kontrollialueen saalis koostui suurikokoiseksi kasvavista lajeista, mutta ihmistoiminannan vaikutuksen alaisen koealan saalis koostui pienikokoisista lajeista. Luonnonvaraisen kontrollialueen saaliin lajimäärä ja diversiteetti-indeksi olivat koealuetta suurempia. Koealueen kalastajille tehtiin kirjallinen lomaketiedustelu, jonka perusteella n. 8 ha pyyntialueen vuotuinen kokonaissaalis oli n. 168 tonnia ja kalastajakohtainen päiväsaalis 14,5 kg. Kalastajat pyrkivät pyytämään suureksikasvavia lajeja. Alueiden kalayhteisöjen erot ovat todennäköisesti seurausta siitä, että koealueen kalastus oli intensiivistä ja suureksi kasvavia lajeja valikoivaa mutta kontrollialueella ei kalastettu ollenkaan.

Contents

1. INTRODUCTION

According to Heywood and Watson (1995), there has been serious threat to aquatic ecosystems in African freshwater fish species including pollution, euthrophication, indiscriminate fishing and overfishing. Fishing results in the selective removal of large fish species or individuals thus resulting in a decrease in the abundance of most vulnerable species (Bianchi et al. 2000). These overfished species are usually top consumers of higher energy or trophic levels along the food chain. The resultant effect of this is a change in the fish biomass, species composition and size structure of the impacted site. A major factor affecting the organization and structure of fish communities has been associated to the fishing or removal of larger species having the highest commercial value (Hall 1999). This resultant effect of fishing renders the over exploitation or high exploitation of a majority of fish stocks the world over. Pinnegar et al. (2002) pointed out that overfishing result in the fish assemblage being dominated by fast-growing small species usually prey species comprising of lower biomasses and short life spans.

Increased sedimentation and siltation in lakes have been noticed due to erosion resulting from the clearing of vast areas of land within the African Great Lakes Region (Alabaster 1981). This increased sedimentation has increased turbidity and reduced light penetration thus affecting the rate of photosynthesis and can lead to algal succession. The introduction of exotic fish species had also been a common practice in African freshwater systems (EAFFRO 1964). For example, in order to stimulate the commercial fishery, four exotic tilapiines were introduced into Lake Victoria in the 1950s when a decline of two indigenous Tilapia species from the commercial catch was noticed. In addition, a huge predaceous fish, the Nile perch (*Lates niloticus*) from the Nile River, was also introduced to improve fishing and to convert the abundant haplochromine biomass into table fish. This action instead stimulated mass extinction of native fish which constituted an important part of the entire Lake ecosystem due to predation by the Nile perch and competition for food, habitat and other abiotic substances by the tilapiines (Kaufman 1989). Also, there was a resultant decrease in the number of fish species in Lake Naiyasha due to the introduction of an exotic species, black bass (*Micropterus salmoides*) into the Lake (Siddiqui 1977).

Threats to aquatic ecosystems could be observed along the Cross River within the Lebialem-Mone Forest landscape of Cameroon thus giving the basis for this study. Fishing activity in the Cross River is usually high from October to December after the wet season when the river is emptying. At this period, a huge multitude of juvenile fish that hatched during the rains and used flooded areas and streams as nursery grounds are caught by the fishers with the common use of fish fences, traps, cast nets and cross-over nets. Juveniles that have not had the chance to reproduce are also fished during this period (James et al. 2003).

Agricultural activities observed around the Cross River include vegetation clearing, deforestation and bush fires in preparation for the cultivation of various crops. Some pesticides, fertilizers and other agricultural chemicals are applied to the farms. According to Bugenyi (1987), these agricultural activities result to extreme changes in the drainage of the basin whereas the chemicals applied to farms eventually end up in the water system.

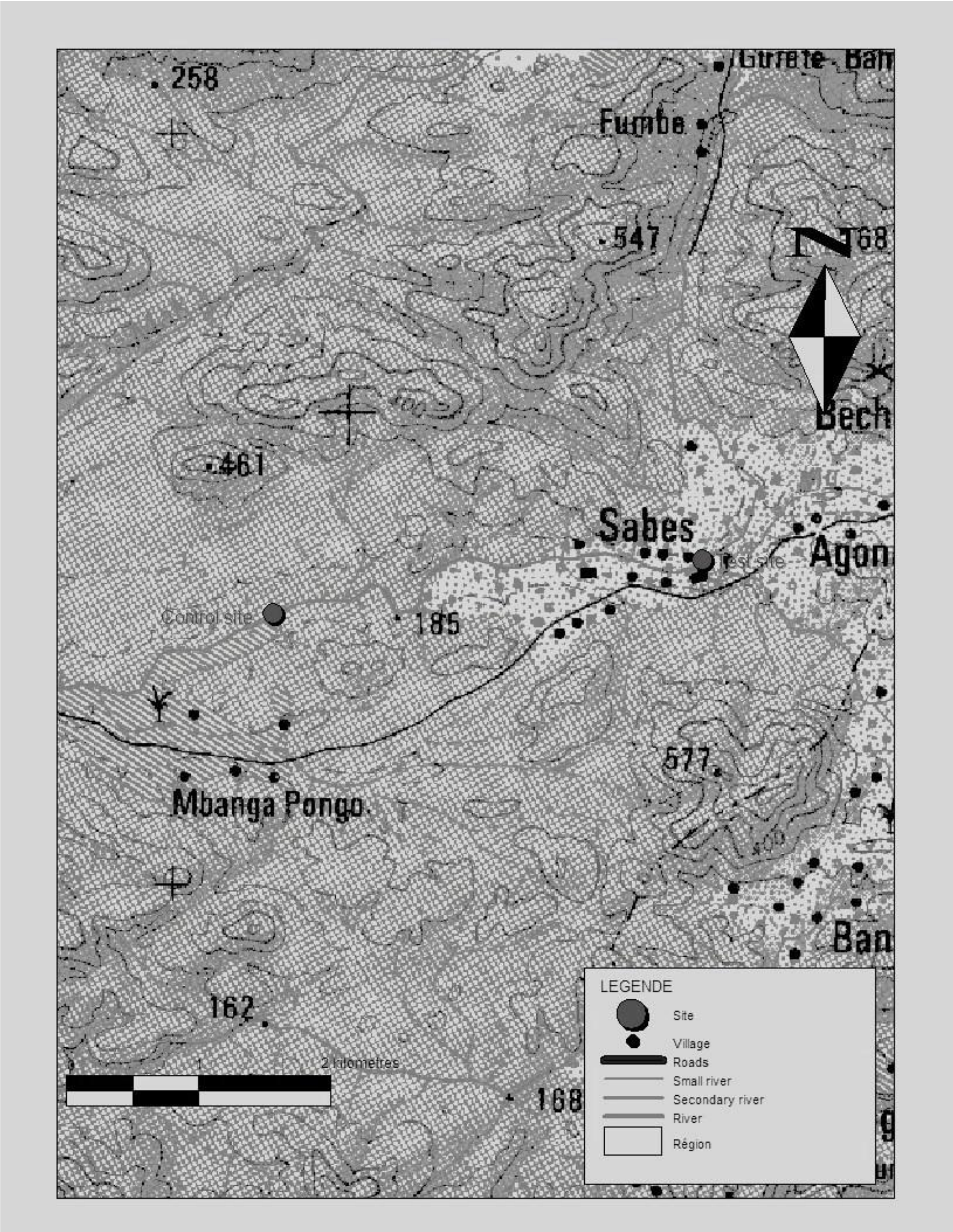
The aim of this study is to elucidate the effects of anthropogenic factors specifically fishing on the aquatic ecosystem of the Cross River. These effects will be limited to the community structure and species composition of fish in the selected area. This study therefore aims at testing or finding out how anthropogenic factors have affected the structure and abundance of fish in this area, comparable with a site with no anthropogenic effects or pressure. The aim of the questionnaire survey undertaken is to investigate the fishing practices employed by the fishers. The main hypothesis tested in this study is that, analysis of fish community is expected to show a difference in fish composition (species composition and size composition) between the test site with high human impacts and the control site with no human impacts. Fish community structure and species composition is expected to greatly vary between the test site and the control site.

This study attempts to improve the knowledge on whether fish community or species diversity changes significantly with the presence of human impacts. The findings of this study may help in assessment programmes of fish communities in human disturbed aquatic ecosystems.

2. MATERIALS AND METHODS

2.1. Study Sites

This study was conducted in the River Manyu (Cross River) within the Lebialem-Mone forest landscape in the South West Region of Cameroon (Figure 1). Two sites were chosen along the Sabes village-stretch of the Upper Cross River with a distance of over 10 km from each other; one of the sites at the lower part of the Cross River is a natural site with no human impacts (control site) while the other site at the upper part of the Cross River is faced with high human impacts including fishing and farming by the local community (test site). These two sites are identical in current velocity, width and depth. There is also identical natural vegetation at both sites in terms of species composition. This vegetation is denser in the control site than in the test site where some significant deforestation has taken place for crop cultivation. Fishing is rarely done in the control site and observed farms are far away from the site. This region was selected on consultation with a local NGO called the Environment and Rural Development Foundation (ERUDEF) carrying out conservation activities in the entire region and the GIS-unit of the Ministry of Forestry and Wildlife. According to ERUDEF and the GIS-unit, Sabes is noted for its high fishing activity in the Lebialem-Mone Forest Landscape. Also, the Cross River passes quite close to residents of this region. The whole Cross River is composed of over 166 fish species, from 15 orders, 42 families and 97 genera (Teugels et al. 1992). The Cross River has its origin about 200-300 m above sea level along the western slopes of the Cameroonian highlands of the Bamenda-Nkongsamba elevation towards Tinto. The Cross River has a length of over 600 km and an area of about 70,000 km^2 (Teugels et al. 1992). About two thirds of the basin lies within Nigeria and it is called the Lower Cross River whereas one third of the basin called the Upper Cross River lies within Cameroon. The Upper Cross River is characteristic of rapids and waterfalls (Reid 1989, Teugels et al. 1992).



Source: GIS-Unit, PSMNR SWR-Cameroon

Figure 1: Topographic map of Lebialem-Mone Forest-Landscape, Cameroon showing the Control and Test sites.

2.2. Fish monitoring

Two straight line gill nets were set, one on the test site (site with high human activity) and the other on the control site (site with no human activity). Nets of mesh-sizes from knot to knot of 30 mm were used and each of the nets had a length of 10 m and height of 2 m (Figure 2). The nets were set from the banks extending inwards into the water depth. The nets in both the test and the control sites were monitored on a daily basis and sampled six times each on a weekly basis (i.e. ones a week); in September and October (3 times each month). A total of 240 individuals were sampled by selecting randomly from the total fish catch each sample day; 120 from the test site and 120 from the control site. A total of 40 fish samples were collected each sample day, 20 from the control site and 20 from the test site to obtain the length (cm) and weight (g) of each sample and to identify each species by its common name and its scientific name. This smaller sample size was chosen to obtain an equal sample in the control and test sites since fish catch in the test site was usually small. After the fish were removed from the nets during each sample day, the nets were reset back on the site. The total length (cm) and weight (g) of each fish in the sample obtained from the nets each sample day were recorded using a ruler and a scale balance respectively. The site specific estimates of the length (cm) and weight (g) distribution of the catches were constructed by pooling the length and weight data from different samples (Figure 4 and Figure 5 respectively). Fish samples obtained from each net were also identified both by their local names or common names used by the local population and their scientific names (genus and species). The types of fish, quantity and species composition in the two sites was thus obtained, giving the general distribution of fish species in the area. A comparison was done for the species composition and abundance obtained from the fishing nets in the test and control sites. Statistical analysis of the fish sizes (lengths and weights) obtained both in the test site and control site was done using the Mann-Whitney U-test analysis. Mann-Whitney U-test was also done for statistical analysis of the lengths and weights of fish common in the control and test sites. The diversity index (Shannon index) of the fish community obtained in the control and test sites was calculated.

Figure 2. Gill net used with a *Labeo sp.* entangled in it.

2.3. Questionnaire survey

Questionnaires (Appendix 1) were distributed to the fishers of this region to elucidate modalities and practices. The total fisher population in the area is about 67 people. This estimated fisher population was obtained from the local fishers' organization in the area. These questionnaires were distributed on a sample with preference given to those who were readily available at the time of the survey. Some of the fishers who could not easily read the questions had the questions asked to them verbally and their responses filled on the corresponding questionnaire. A total of 50 questionnaires giving a representative sample of the fisher population in the area were distributed, 45 of which were filled and returned by the fishers (representing 67.5 % of the fisher population using the site) within a period of 10 days. Fishers had to respond to questions concerning their fishing activities. The yearly fish yield and the total number of days per year spent by each fisher for fishing are obtained. This will give us some information about the extent of fishing or fishing pressure on the site.

2.4. Survey of anthropogenic activities

There was a visual survey on the anthropogenic factors in the area. This was done by visually looking at the human activities carried out around this test site and recording the activities. Local inhabitants were interviewed with respect to the activities they undertake around this site. Common human activities which were investigated and recorded include farming, deforestation and fishing.

3. RESULTS

Fish species that were obtained and sampled in the area included 14 species; *Mormyrus tapirus*, *Mormyrus rume*, *Tilapia zilli*, *Tilapia galilaea*, *Tilapia nilodica*, *Labeo batesii*, *Labeo pseudocoubie*, *Channa obscura*, *Alestes nurse*, *Alestes macrolepidotus*, *Hepsetus odoe*, *Barbus bynni occidentalis*, *Auchenoglanis occidentalis* and *Heterobranchus bidosalis*. In the control site with no human pressures, the fish catch consisted of 13 species; *Labeo batesii*, *Labeo pseudocoubie*, *Mormyrus tapirus*, *Mormyrus rume*, *Channa obscura*, *Hepsetus odoe*, *Alestes macrolepidotus*, *Alestes nurse*, *Barbus bynni occidentalis*, *Auchenoglanis occidentalis*, *Tilapia zilli*, *Tilapia nilodica* and *Heterobranchus bidosalis* with *Labeo spp*. being the highest number of fish caught constituting 26 % of the total catch (Figure 3). Fish species like the *Mormyrus* spp., *Channa obscura*, *Hepsetus odoe*, *Alestes spp*., *Auchenoglanis occidentalis* and *Heterobranchus bidosalis* which constituted 40 % of the catch in the control site were not recorded in the test site.

In the test site with high human pressure, fish catch consisted of 5 species; *Tilapia zilli*, *Tilapia nilodica*, *Tilapia galilaea*, *Labeo batesii* and *Barbus bynni occidentalis* with *Tilapia zilli* and *Tilapia nilodica* being the highest constituting 44 % and 30 % of the total catch respectively (Figure 3).

The diversity index (Shannon index) for the control site is H=2.29 while for the test site, it is H=1.24.

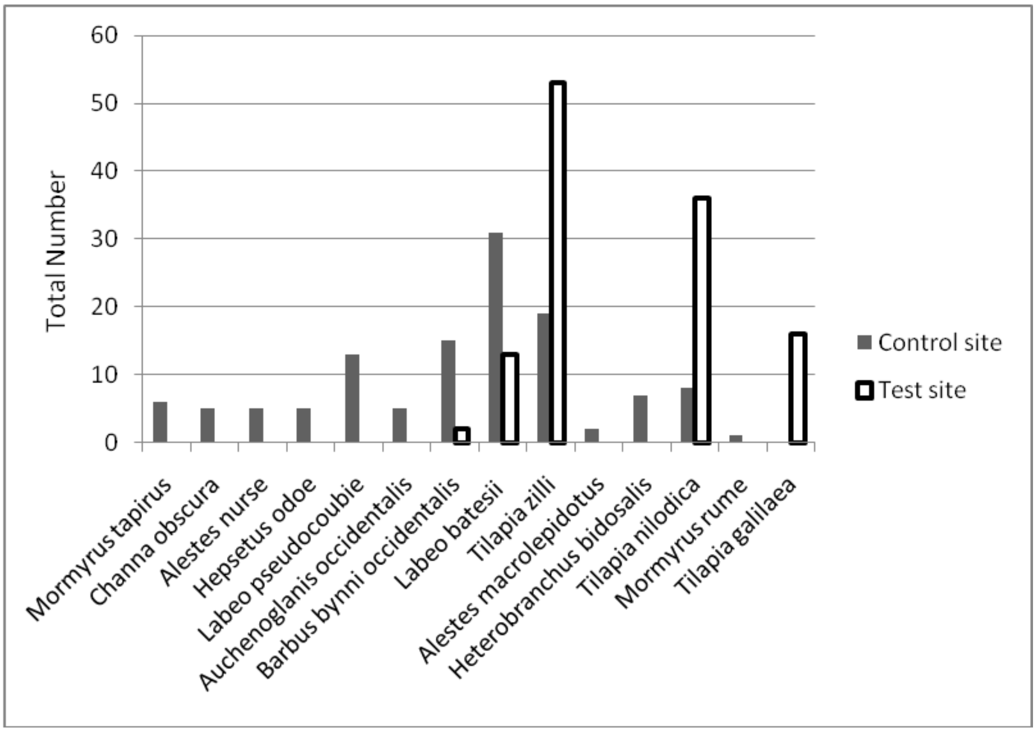


Figure 3. The proportion of different species (240 fishes) in the catch obtained from the control and test sites in the Cross River within the Lebialem-Mone Forest Landscape of Cameroon in 2 months of sampling (September-October 2009).

There is a significant difference in length (Fig. 4) and weight (Fig. 5) of fish obtained in the control and test sites (Mann-Whitney U, $p<0.001$ for both length and weight). Fish obtained in the test site were predominantly smaller in size while large size fishes were predominantly obtained in the control site.

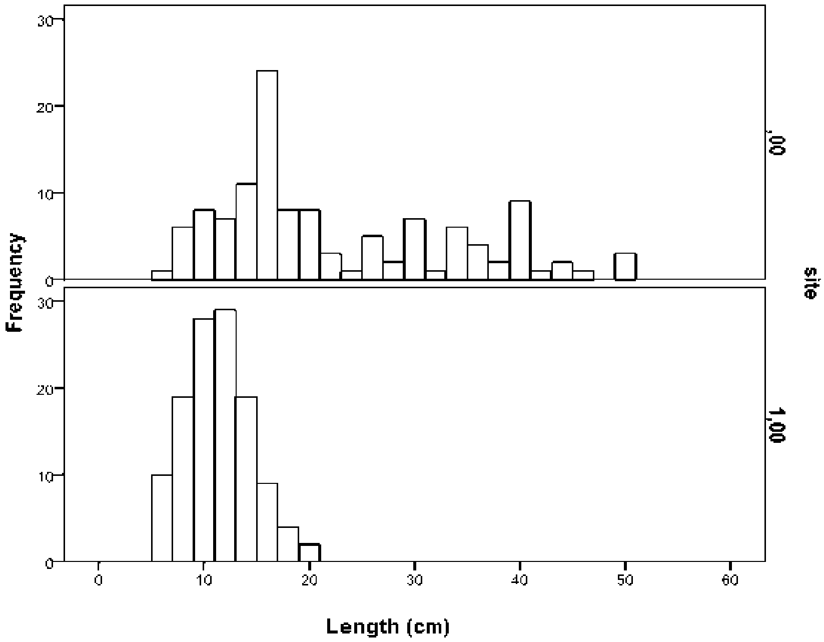


Figure 4. The length distribution of fish samples (120 individuals each) obtained in the control site (0) and test site (1) in the Lebialem-Mone Forest Landscape of Cameroon within 2 months of sampling (September-October 2009).

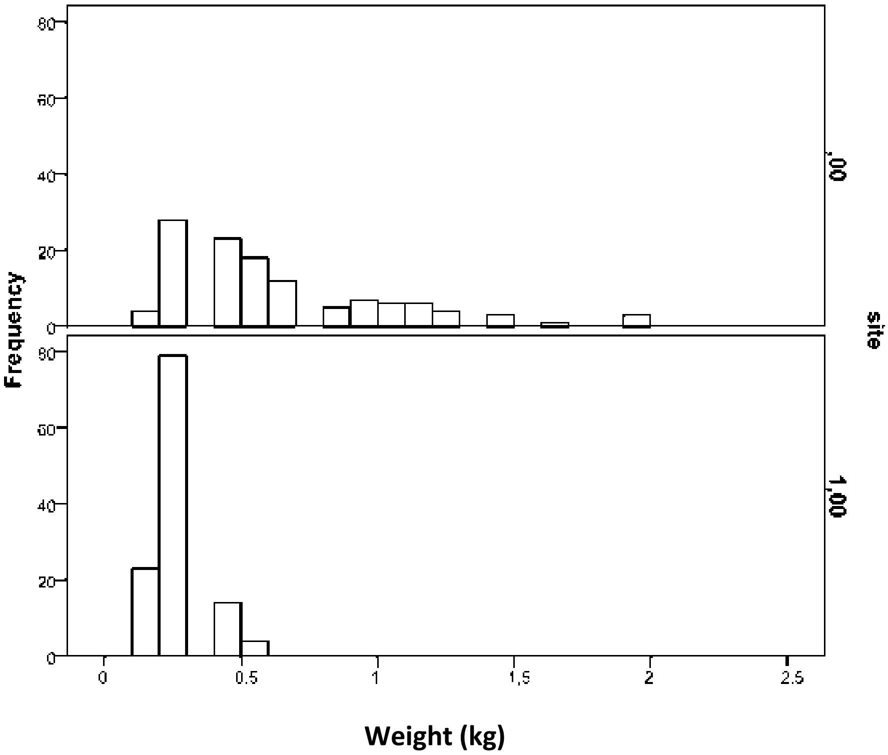


Figure 5. The weight distribution of fish samples (120 individuals each) obtained in the control site (0) and test site (1) in the Lebialem-Mone Forest Landscape of Cameroon within 2 months of study (September-October 2009).

There is no significant difference in length (Fig. 6) and weight (Fig. 7) of *Barbus bynni occidentalis* obtained in the control and test sites (Mann-Whitney U, p=0.8 for both length and weight).

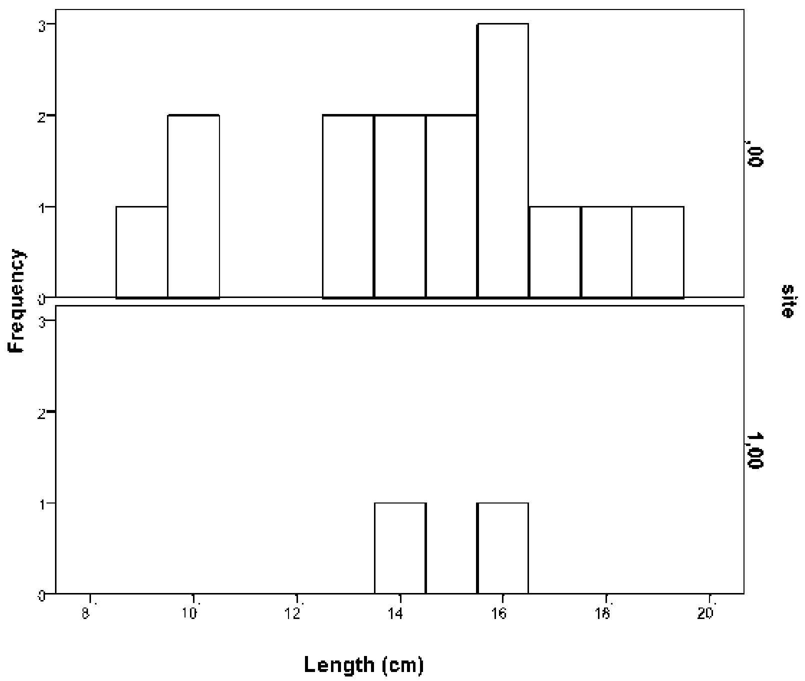


Figure 6. The length distribution of *Barbus bynni occidentalis* obtained in the control site (0) with a sample of 15 individuals and test site (1) with a sample of 2 individuals in Lebialem-Mone Forest Landscape of Cameroon during 2 months of study (September-October 2009).

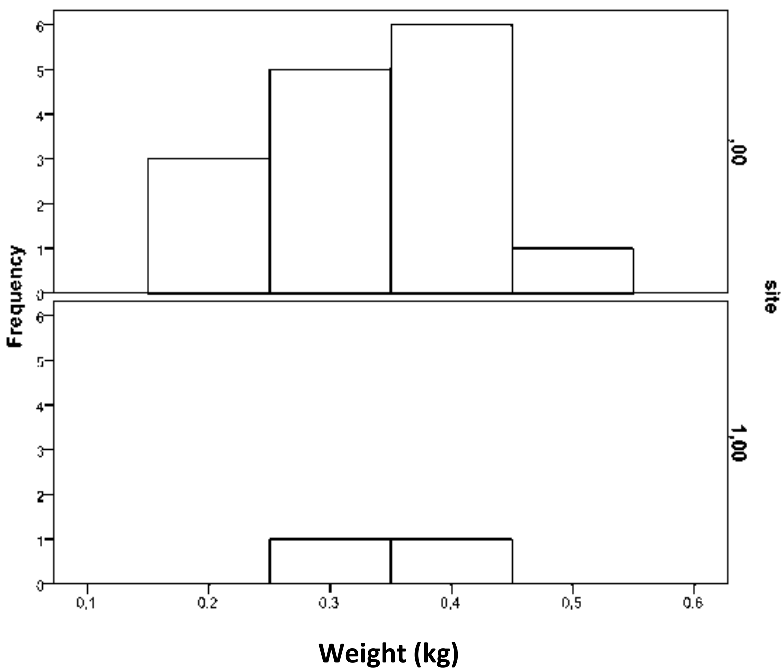


Figure 7. The weight distribution of *Barbus bynni occidentalis* obtained in the control site (0) with a sample of 15 individuals and test site (1) with a sample of 2 individuals in Lebialem-Mone Forest Landscape of Cameroon during 2 months of study (September-October 2009).

There is a significant difference in length (Fig. 8) and weight (Fig. 9) of *Labeo batesii* obtained in the test and control sites (Mann-Whitney U, p= 0.001 and p< 0.001 for weight). The test site consists mostly of small size fish while the control site consists mostly of bigger fish.

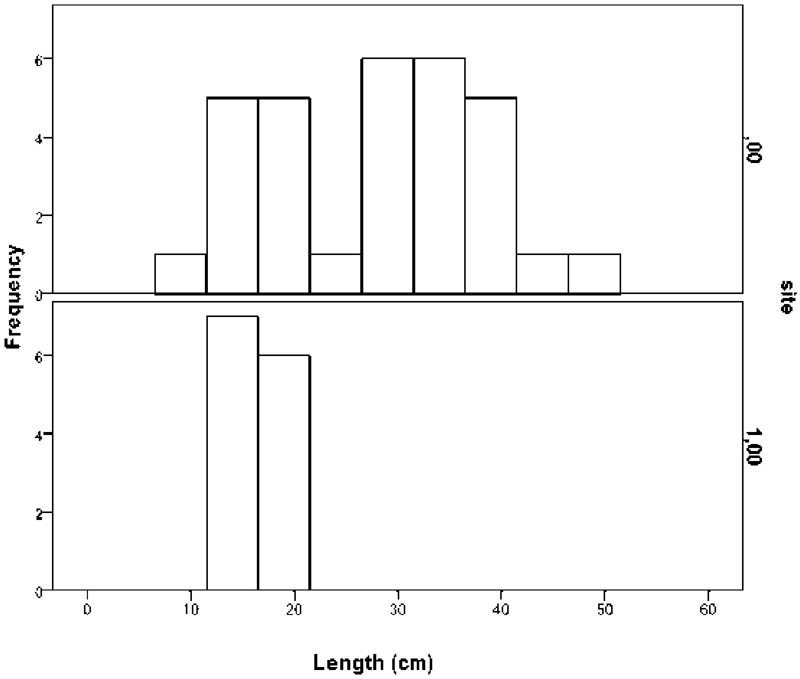


Figure 8. The length distribution of *Labeo batesii* obtained in the control site (0) with a sample of 31 individuals and test site (1) with a sample of 13 individuals in Lebialem-Mone Forest Landscape of Cameroon during 2 months of study (September-October 2009).

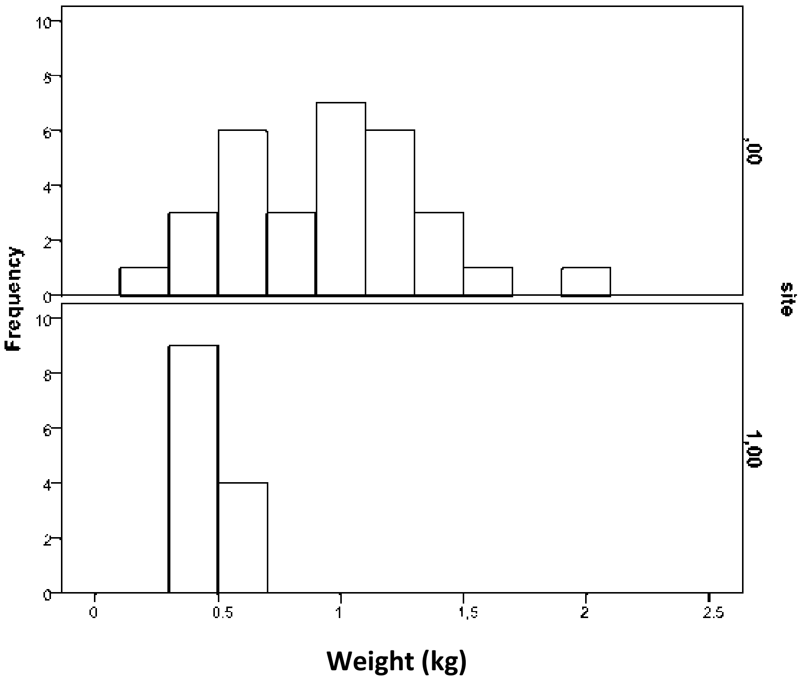


Figure 9. The weight distribution of *Labeo batesii* obtained in the control site (0) with a sample of 31 individuals and test site (1) with a sample of 13 individuals in Lebialem-Mone Forest Landscape of Cameroon during 2 months of sampling (September-October 2009).

There is a significant difference in lengths (Fig. 10) and weights (Fig. 11) of *Tilapia nilodica* obtained in the control and test sites (Mann-Whitney U, $p < 0.001$ for both length and weight). Fish are smaller in size in the test site.

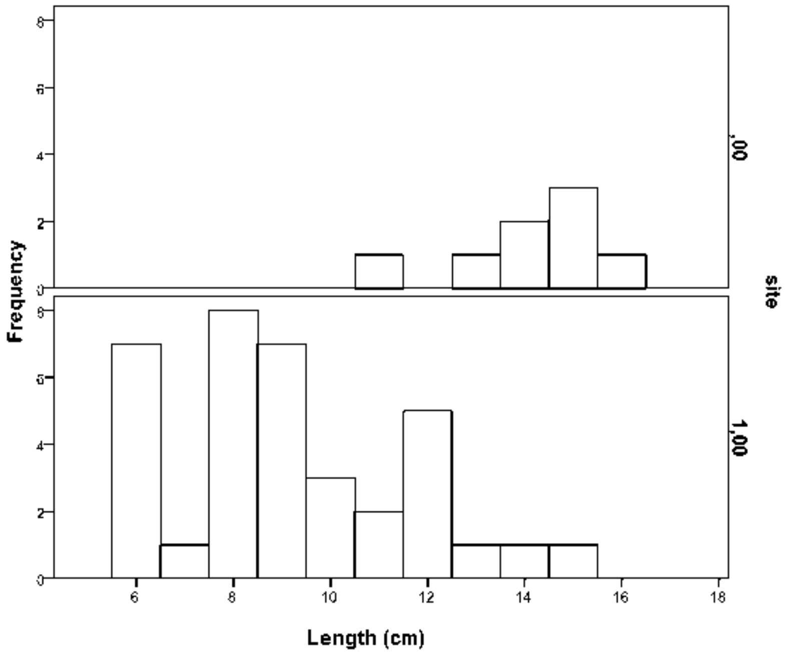


Figure 10. The length ditribution of *Tilapia nilodica* obtained in the control site (0) with a sample of 8 individuals and test site (1) with a sample of 36 individuals in Lebialem-Mone Forest Landscape of Cameroon during 2 months of sampling (September-October 2009).

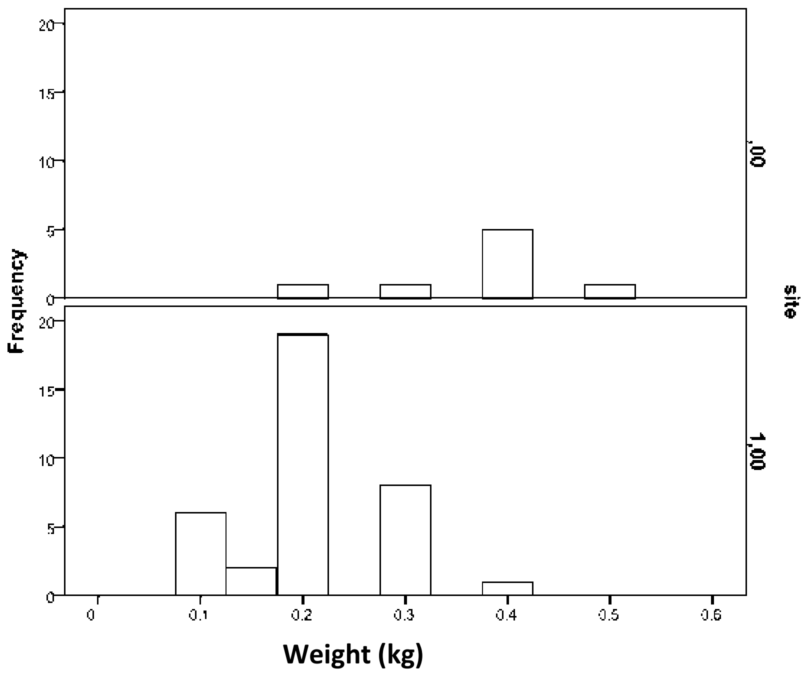


Figure 11. The weight distribution of *Tilapia nilodica* obtained in the control site (0) with a sample of 8 individuals and test site (1) with a sample of 36 individuals in Lebialem-Mone Forest Landscape of Cameroon during 2 months of sampling (September-October 2009).

There is no significant difference in lengths (Fig. 12) and weights (Fig. 13) of *Tilapia zilli* obtained in the control and test sites (Mann-Whitney U, p= 0.4 for length and p=0.9 for weight).

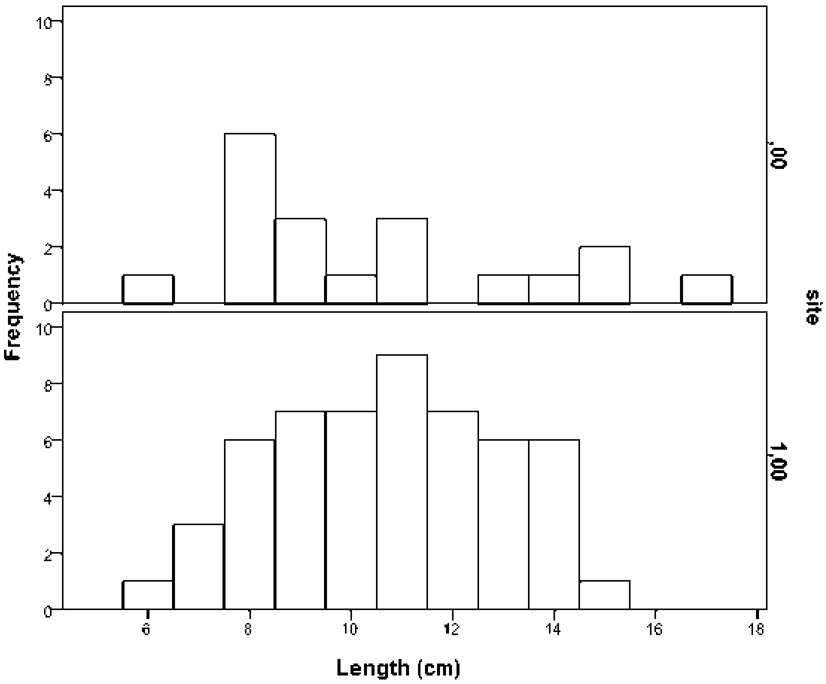


Figure 12. The length distribution of *Tilapia zilli* obtained in the control site (0) with a sample of 19 individuals and test site (1) with a sample of 53 individuals in Lebialem-Mone Forest Landscape of Cameroon during 2 months of study (September-October 2009).

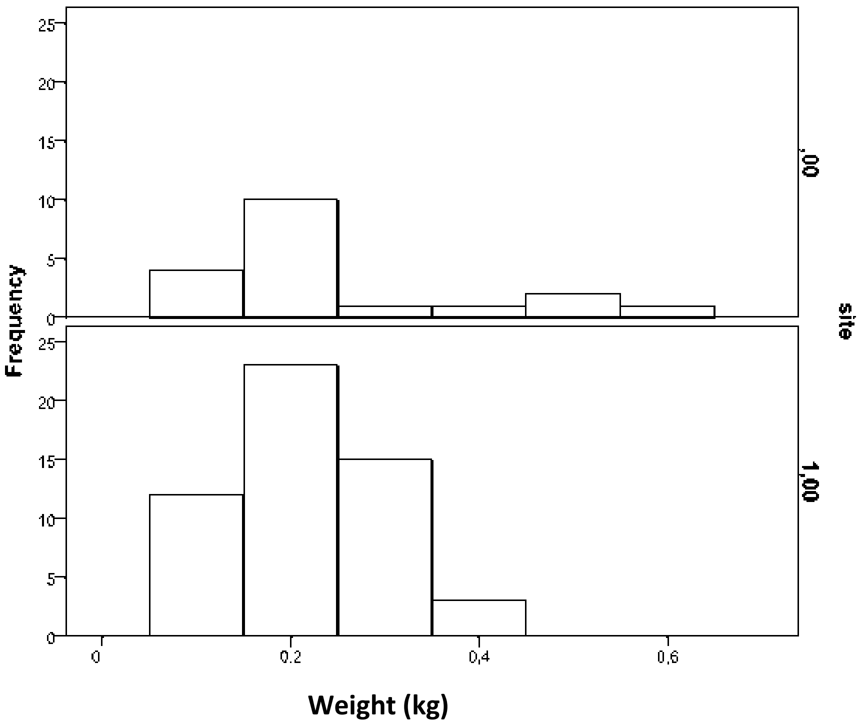


Figure 13. The weight distribution of *Tilapia zilli* obtained in the control site (0) with a sample of 19 individuals and test site (1) with a sample of 53 individuals in Lebialem-Mone Forest Landscape of Cameroon during 2 months of study (September-October 2009).

Fishers responded to different questions in the questionnaires relating to their fishing practices. Responding to what fishing methods they use, 100 % of the respondents indicated that they use gill nets and hooks while 20 % use trap boxes. No fisher uses chemicals for fishing. Responding to how often they go for fishing, 7 % of the fishers indicated that they go for fishing daily, twice a week (22 %), 3 times a week (33 %), 4 times a week (22 %), 5 times a week (7 %) and 6 times a week (2 %).

Responding to what type of fish the people collect every fishing event, 30 % of their catch constitutes *Tilapia spp., Labeo spp*. (30 %), *Barbus spp*., *Hepsetus odoe*, *Mormyrus spp*. and *Channa sp.* (40 %). Responding to which of the fish species the people like, 100 % of the respondents indicated *Labeo spp*., 80 % indicated *Channa sp.*, *Hepsetus odoe*, *Mormyrus spp*. and *Barbus spp*. while 13 % indicated *Tilapia spp*. Responding to which fish the people often buy, 100 % of the fishers indicated that the people often buy big sized fishes.

Responding to whether their fish catch has increased or decreased using the same fishing effort as before, all 100 % of respondents indicated that their fish catch has decreased. The fishers spend an average of three (3) days each week for fishing with an average yearly fish catch of 2 515 kg. 3 fishers spend up to 7 days each week for fishing (Fig. 14) having an annual fish yield of 22 568 kg of fish while 15 fishers spend 3 days each week for fishing. The total annual yield of fish obtained by the fisher population in this area is 168 505 kg within an area of about 8 hectares. The yield per unit effort (YPUE) is 14.5 kg of fish caught by each fisher per day. Each fisher spends an average of 173 days each year for fishing. The total fisher population spend 11 591 days each year for fishing.

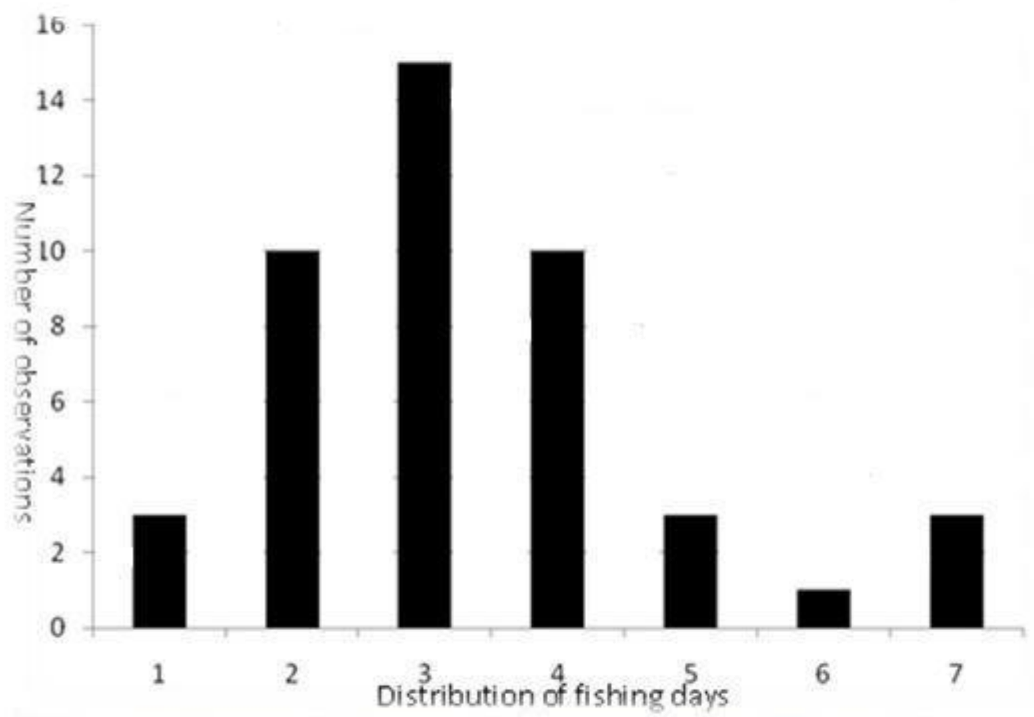


Figure 14. Results of the total number of days spent by fishers for fishing per week (distribution of fishing days) and the number of fishers fishing in each distribution (number of observations) in Lebialem-Mone forest landscape of Cameroon obtained via questionnaire survey within 2 months of study from September-October 2009.

Farms containing crops like plantains, bananas, palms, cocoa, coco yams, melon and other such food crops and cash crops were seen quite close to the river banks. Some of these farms contained water in them coming from flooded river banks. A local bridge made of cane rope was seen passing along the river from bank to bank on the test site. Deforestation was also observed to have been undertaken around the river catchment. These anthropogenic effects were not observed close to the control site.

4. DISCUSSION AND RECOMMENDATIONS

This study hypothesized that analysis of fish community is expected to show a significant difference in species composition and size composition between the test and control sites. The results obtained were as expected. In the results, it is glaring that the fish communities varied in the two sites as expected. The test site is composed predominantly of *Tilapia* species specifically *Tilapia zilli* and *Tilapia nilodica* (Fig. 3) which are small size species as expected with a significantly larger length and weight (Fig. 4 and 5). The number of species and Shannon index were much lower in the test site than in the control site. Furthermore, the typical fish sizes were much lower in the test site for several species occurring in both sites (Fig. 8 and 9). The dominance of *Tilapia spp*. indicates that the test site is made up predominantly of small sized fishes. These small sized species predominate in the test site probably because they are not major targets for fishing by the fishers and also due to the near absence of predators since they have been overexploited by the fishers. Usually, fishing strategies in ecosystems start by removing top predators, which modifies the assemblage structure resulting to the near depletion of such predators (Shin *et al*. 2005). This study was carried out partly during the wet season in September when a large number of juvenile fishes are hatched, and partly immediately after the rains in October when these juvenile fishes are ready for collection by the fishers (James *et al*. 2003). Large sized fishes are scarce in the test site due to overexploitation by the fishers as they love to collect it and it is most preferred by the consumers. Fishing results in alterations of the size structure of fish assemblages via direct effects, such as selection of more profitable bigger fish, as well as indirect effects that leads to the increase in smaller species (Justin *et al* 2009).

In the control site with no human pressure, *Labeo batesii* predominates constituting 26 % of the total catch indicating the dominance of large sized fishes in the control site. This corresponds to the results obtained by Justin *et al*. (2009), where Manantali Reservoir with little human impacts is composed of large- sized fish species such as *Lates niloticus, Mormyrus rume and Hydrocynus forskalii* while Selingue Resevoir with high human pressure is made up of small-sized species. The presence of the snake fish (*Channa obscura*), *Mormyrus tapirus* and *Hepsetus odoe* in the control site is a clear indication of the abundance of prey species and a fish community in natural state, the presence of flooded forest banks undoubtedly assist their “lay in wait and stealth” predation (Moriarty 1983). These predator species constitute 12 % of the total fish catch in the control site. The proportion of small-sized species was significantly lower in the control site probably due to the predatory effects of these predators on them. However, the control site has higher species diversity. This could be due to the calm and undisturbed nature of the site by humans and the presence of vegetation cover. Sediment characteristics, substratum heterogeneity and vegetal cover affect fish distribution via their influence on prey availability (Marchand 1993) and protection from predators (Blaber and Blaber 1980, Marshall and Elliott 1998). About 55 % of the test site has been deforested.

Although the catch per unit effort was not recorded systematically since only a random sample of the total catch was recorded, by visual judgement it could be concluded that it is 3 times higher in the control site, thus indicating much higher fish density there. These differences are in concordance with the expected and observed results in this study and it is as well in concordance with the results obtained by Benedict *et al*. (2009) in the Cross River of Nigeria were there was a higher species richness recorded for the river stretch with forest cover than in the deforested river stretch.

The 30 mm mesh size gillnets (from knot to knot) used for this study are large enough, thus preventing very minute or younger fish species from being caught. To improve on the sampling programme, gill nets with multiple mesh sizes are recommended for further studies on the fisheries in this region. This would be expected to provide a larger species diversity since both minute and larger fish species would be caught. Benedict *et al*. (2009) used gill nets with mesh sizes of 22 – 76 mm stretched mesh in a similar study carried out in the wetlands of the Nigerian Cross River. Also, the catch per unit effort (CPUE) should be recorded and mark-recapture done to record some information on fish migration. A longer period of time could be used (about 4 - 6 months) for further studies in this region to enable more fish samples obtained and to provide a more adequate and intense fisheries baseline survey of the area.

In this study, there is a significant variation in fish weights and lengths in the control and the test sites. This variation is not as a result of chemical pollution. According to Azmat *et al*. (2007), fish exhibit allometric growth when there is high chemical pollution (like fluoride ion) in water body. The impact of high concentration of fluoride alters the growth rate by impairing the weight and length of fish. According to Masoud *et al*. (2006) and Pinskwar *et al*. (2003), there was a ready accumulation of fluoride compound in fish with a particular affinity of Fluoride ion in bone tissue and thus contributing to contamination of the entire fish which may be attributed with retardation of growth rate of fish. Since in this present study, there is no significant chemical pollution on the site as the fishers avoid the use of chemicals, chemical pollution therefore has no significant effect on the fish, suggesting the influence of fishing. Fish poisoning using Gammalin 20 was widely practiced around the Cross River in the past. Cameroon law has now banned the use of chemical poisons (Reid 1989, Feu 2001).

The fishing effort on this site is very high as the total fisher population spends 11 591 days each year for fishing. The yield per unit effort (YPUE) of 14.5 kg of fish caught per fisher per day is very high compared to that obtained by Feu (2001) of 32 kg per fisher per month in the lower Cross River of Nigeria. However, the fishers indicated that their fish catch today has reduced greatly in comparison to the catch in the past using the same fishing effort indicating that their YPUE has as well reduced. There is therefore overfishing on this study site as the fish community and fish yield now consist predominantly of small size non valued species. Also, fishers now obtain a lower amount of desired and valued species in their catch in this study site. These fishers are thus unhappy with their annual catch and income today as the non valued fish species predominating their catch is less desired by the consumers. These therefore suggest a very high fishing pressure and overexploitation of fish on this site especially the large sized fish species as indicated by the fishers.

The variation in species diversity between the two sites could therefore be as a result of fishing and deforestation.

Fish serves as a major source of protein to many people the world over and particularly in Cameroon. Fish and other aquatic resources need to be sustainably managed in order not to compromise the needs of the future generation. In order to enhance sustainable management of fish in the Cross River, lots of measures could be undertaken.

Closed season could be introduced such that fishing is forbidden at given periods of the year especially during spawning seasons. This will help to protect young fish stock and enhance growth.

Limiting fishing effort especially the number of hours spent by each fisher for fishing and number of fishers will help give the opportunity for unexploited stock to recover and increase in number.

The types of fishing gears used should be monitored. Fishers should be prevented from using nets with very minute mesh sizes. This will help to control the size or species of fish caught.

Licensing should be introduced so that any individual without a fishing license will be prevented from fishing. This will help to reduce the number of participants in the fishery and as a means to recover some revenue from the fisheries.

Quotas should be introduced so that a given allowable catch should be set for each fisher. Quotas will directly limit the amount of fish taken from the stock.

Size limits should be set for the fish caught. This will reduce overfishing and ensure that immature individuals are not caught.

Taxes or tariffs should be imposed on anybody who goes for fishing without a fishing license and to those who exceed their fishing quotas.

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Appendix 1. Copy of questionnaire to fishers used for this study.

I am Ettagbor Hans, a student from the University of Jyväskylä in Finland. I am carrying out a research on the "Impacts of anthropogenic factors on fish community structure in Lebialem-Mone Forest landscape of Cameroon". This research is strictly for academic purpose. Your honest response to these questions will be highly solicited.

1) What type of fishing method (s) do you use?

a) Gill nets b) Hooks c) Chemicals d) Others……………………………………...

…………………………………………………………………………………………

2) How often do you go for fishing?

a) Daily b) Weekly c) Others………………………………………………………

3) What amount of fish do you collect every fishing event?

a) 1Kg b) 2Kg c) Others……………………………………………………….

4) What type of fish do you collect every fishing event?...

…………………………………………………………………………………………

5) Which of the fish species do people like?..

…………………………………………………………………………………………

6) Which fish do people buy often? Big or Small?..

7) Has your fish catch increased or decreased using the same fishing effort as before?....

…………………………………………………………………………………………