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Fish biodiversity, distribution and abundance in Iyabe-Riana river, South West Kenya

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Abstract
Studies were conducted to establish the distribution, abundance and biodiversity of fish in the Iyabe-Riana River, during the period April-September 2019. Fish samples were obtained from five sampling locations using electro-fisher Samos 1000 producing 75V. Physico-chemical parameters were measured using a YSI hydro lab model 650 MDS. Fish were identified up to genera and where possible up to species level. ANOVA was used to determine significant spatial and temporal differences of fish distribution. The relationship between physico-chemical parameters and fish abundance was determined using Pearson correlation. Shannon-Weiner, Simpson, Margalef and Hill formulae were used to calculate biodiversity, dominance, Richness and evenness indices respectively. Total number of fish decreased from upstream towards downstream. The mean fish catch per hour ranged from 35 ± 18 to 150 ± 67. Analysis of variance showed significant spatial differences in catch rate ($p > 0.05$). Fish abundance was positively correlated with dissolved oxygen concentration while it was negatively correlated with turbidity, total suspended solids and total dissolved solids. Biodiversity, richness and evenness indices were generally higher than in the main River Kuja. Poor water quality observed, affected fish distribution as well as the short-term weather variations. It is concluded that pollution due to anthropogenic activities, short term weather variations and nature of habitat determined fish distribution, abundance and biodiversity.

Keywords: biodiversity, fish abundance, fish distribution, Iyabe-Riana river, lake Victoria basin

1. Introduction
Globally, rapid decline in biological diversity is caused by habitat loss and environmental degradation, Vyas *et al*. [12]. Degradation threatens survival of fish in smaller rivers whose fish fauna has been little studied. In this study, we explore fish distribution and biodiversity of Iyabe-Riana River, a tributary of River Kuja, which drains in to Lake Victoria. In the lake's basin, located in South West Kenya, riverine habitats are under increasing degradation due to high population density and associated agricultural and urbanization activities.

Distribution of fish is important in knowing where they live and provide an opportunity to study and understand their dynamics. Fish biodiversity refers to species richness, abundance and their phylogenetic diversity, Negi and Sheetal [7]. It is used as a measure of the health of a biological system, Mohammed *et al*. [6] and Mace *et al*. [5].

Abundance and diversity of fish species in lacustrine and riverine habitats in Kenya have been declining due to introduction of alien species: the Nile perch and Tilapine species, overfishing and habitat degradation. Within Lake Victoria basin, the main lake, before the 1950s, had 14 groups of fish species. Which have been reduced to three groups: the indigenous *Rastrineobola argentea*, *Lates niloticus* and Tilapine species Oguto Ohwayo [9]. Earlier studies on larger rivers have indicated the presence of fish species which no longer occur in the lake. Whereas there have been some efforts to study fish distribution and biodiversity in major rivers flowing in to Lake Victoria, there have been limited studies in their smaller tributaries. This study focused on the distribution and biodiversity of fish in a tributary of River Kuja- the Iyabe-Riana River with the objective of formulating management measures that can be used for conservation of the riverine fisheries resources.

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2. Materials and Methods
2.1 Study area
The Iyabe -Riana river originates from Igego hills, in the Lake Victoria basin and is located between longitude 34.144E and latitude 1.22^{0}S (Fig. 1). The river basin's altitude ranges from 1100-2050 M above sea level. The area experiences high rainfall of 2000 mm per year and an annual temperature range of 10.1 °C- 30.4 °C with a mean of 22.4 °C. The river has a length of 110 km and covers a catchment area of 6900 km^2. The river basin catchment is dominated by farming activities. Cash crops in the area include sugarcane, coffee and tea while subsistence crops are maize, bananas and vegetables. Kisii town is the major town in the catchment. Other town centers include Kerina, Iyabe and Rodi Kopany. Anthropogenic activities carried out in these centres could impact negatively on its aquatic ecosystems.

The sampling design involve five sampling stations S1-S5. The latter were geo-referenced using Magellan global positioning system model 78s. These were sampled once every month for a period of three months during April, May and August 2019 (dry months) and another three months, June, July and September 2019 (wet months). Physico-chemical Parameters temperature, pH, conductivity, DO, turbidity, and TDS were measured using a Multi-parameter YSI hydro lab model 650 MDS. TSS was estimated as the difference between pre- weighed Whatman GFC filter of pore size 0.45 microns and that of same type of filter paper through which 200ml of sample water had been filtered and then dried to constant weight in an oven at 100°C APHA (2014). Fishing was done during the day for 30 minutes at each sampling station between 8:00 and 14:00 hours using an electro-fisher, Samos 1000 generator producing a current of 75V. Fish were collected using a scoop net, placed in an ice-box and transported to the laboratory where they were sorted, counted and identified to species level.

Shannon-Weiner diversity index was estimated using the formula:

$$H = -\sum_{i=I}^{S} p_i \ln(p_i)$$

Simpson diversity index was estimated using the formula:
Simpson index of diversity = 1-D

$$D = \sum_{i=I}^{s} Pi^2$$

Shannon's equitability index (E_H) was estimated to determine evenness of fish species using formula:

$$E_H = \frac{H}{\ln S}$$

Where:
pi is the proportion of individuals calculated as abundance of individual species divided by total number of individuals in the community sampled, In is the natural log, Σ is the sum of all calculation, S is the number of species, H is the Shannon index of diversity, D is Simpson index.

Species richness, that is, the number of species in a community was used to indicate the level of biodiversity at different sampling stations.

3. Results
The spatial distribution of fish in the Iyabe-Riana River indicated a higher diversity of non-cichlid fish species than in Lake Victoria into which the river drains via the lower River Kuja. Most of the fish species present were more abundant in the river and did not occur in the main lake except, *Clarias gariepinus*, *Labeo victorianus*, *haplochromines* and *Afromastercemblus frenatus* which despite this occur in higher numbers in the river than in the lake.

Seven families having 13 species were identified except haplochromines which could not be identified up to species level (Table 1). Four species had a wide percentage occurrence of 100%: *L. altianalis, E. neumayeri, C. theodorae,* and *A. frenatus.*

Seven species had a percentage occurrence of above 50%. *L. victorianus* listed in the IUCN red list had a percentage occurrence of 20%, while other species with least occurrence were: *G. affinis,* haplochromines, *T. zilii,* and *E. paludinosus.*

Four species namely; *L. altianalis, Chiloglanus sp., Leptoglanus sp.,* and *A. frenatus* were most abundant with a combined percentage occurrence of 68.9%. The least abundant species constituted of *E. paludinosus, T. zillii,* haplochromines, *L. victorianus* and *C. gariepinus.* Hence the four most abundant species had both high percentage occurrence and composition respectively compared to the rest.

The total number of fish caught at each sampling station ranged from 13-714 with a mean of 53± 37 (SD), showing there was a high variance in the number of fish among the sampling stations, (Table 2). Two tailed analysis of variance depicted a significant difference of fish numbers among the sampling stations, [F (4, 25) = 3.436, *p* = 0.023]. Tukey test grouped the stations in to two. First was Koluoch bridge, Etureti and Enamba, the second group was Etureti, Enamba bridge, Getare and Bara nne.

The fish species: *L. altianalis, E. neumayeri, C. theodorae, Leptoglanis sp., E. kerstenii, and A. frenatus,* were distributed throughout the sampling stations, while other species showed paucity in their distribution with no catches at some of the sampling stations. Species such as *E. palludinosus* and *Haplochromines* showed an increasing trend of catches downstream, while other species showed a decreasing trend in catches downstream.

The temporal distribution of fish was analyzed by grouping catches for dry and wet months separately, (Tables 3 and 4). During the six months' study period, April, May and August 2019, were dry contrary to what is always observed. The amount of rainfall received in these dry months was much lower and was compared to that received in wet months; June, July and September 2019), (Figs. 2 and 3).

This can be attributed to climate change since the months April, May and August are always wet in the South-western Kenya. The total number of fish caught during the dry season was 1049 while that of the wet season was 519. The total number of fish caught during dry months ranged from 190-480 with a mean of 349 ±236 (SD). *E. nyanzae* was absent from the catches. Other species: *L. altianalis, E. neumayeri, C. theodorae and C. somereni,* were present throughout the dry period, while *Leptoglanis sp., E. kerstenii and L. victorianus showed paucity in their distribution. Three species E. paludinosus, T. zillii* and *haplochromines* were caught only once during the dry season (Table 3).

The total number of fish caught during wet months ranged from 158-208 with a mean of 173±58 (SD).

Three fish species: *E. kerstenii, G. somereni.*, and *E. palludinosu*s were absent from the catches (Table 4) and were different from those, which were absent, during the dry months. Three other fish species namely, *T. zillii, E. nyanzae* and *haplochromines* were caught only once. All the other species were present in the catches throughout the wet months.

The correlation between physico-chemical parameters and fish abundance (Table 5) at the different sampling stations shows a strong positive correlation with dissolved oxygen concentration ($R^2= 0.395$) indicating that the more the amount of oxygen in the water, the higher the fish abundance. Alternatively, fish abundance showed strong negative correlations with TSS ($R^2= - 0.701$), TDS ($R^2= -0.707$) and turbidity ($R^2=- 0.588$- these parameters did not favor occurrence of high fish densities.

3.1 Biodiversity indices
Fish biodiversity indices of the Iyabe –Riana River are presented in (Table 6). Both Shannon-Weiner and Simpsons biodiversity indices were highest sampling station S1. This station is located furthest upstream. Changes in diversity, richness and evenness indices were consistent downstream showing a general decrease in biodiversity downstream. The sampling station S5 which was furthest downstream had the lowest richness but had the highest evenness indices.

4. Discussion and Conclusion
Dominance of fish fauna in Iyabe-Riana River by indigenous omnivorous and detrivorous fish species is attributed to lack of vicious piscivores. Predatory fishes in the river namely; *C. gariepinus, Gambusia sp*., and *A. frenatus* are not obligate piscivores feeding on among other things in vertebrate fish and detritus. The latter are not widely distributed in the river and occur in low densities. Lack of obligatory piscivores in the complex riverine environment can be attributed to their poor adaptability in which the nature of the habitat makes it difficult for them to capture prey. Dominance of the omnivores and detritivores can be attributed to the fact that they are better adapted to the more complexly structured riverine habitat than piscivorous species.

In lacustrine Lake Victoria, absence of omnivores and detritivores has been attributed to predominance of obligate piscivore *Lates niloticus* and to some extent presence of other predators such as *Cynodontis sp., Schilibe intermedious* and *Bagarus docmak,* Witte *et al*. [11].

The Iyabe –Riana River is a small tributary of river Kuja which drains in to Lake Victoria at a short distance of about 7km from their confluence. Normally such small rivers in the Lake Victoria basin have not been thought to have any significant quantities of fish; as a result, little fishing takes place in them. However, this study surprisingly revealed high densities and diversity of fish in the river. Characteristically there was absence of planktivorous fish species as opposed to the main Lake Victoria where the planktivorous Cyprinid-dagaa- *Ratrineobola argentea* dominate. This is attributed to the well-known fact that riverine habitat has low plankton production which is the source of food for planktivorous species, and further, dagaa prefers more less turbulent habitats found in the main lake.

Coupled with the fact that most of the riverine fish   species are endangered or threatened, there is need therefore to take measures to protect them from impacts of anthropogenic activities that negatively affect their habitat.

It is evident from this study that low densities of fish occurred at sampling stations where water quality was poor as indicated by the negative correlation between fish numbers and turbidity, TSS and TDS. This can be attributed to pollution and other anthropogenic inputs such as silt, agricultural effluents containing nutrients and urban effluents mainly containing domestic water. Studies by Basavaranja [3] on the biodiversity and abundance of fish in Anjanapura reservoir in India, indicated similar findings. The river drains a high potential agricultural catchment predominated by cultivation of tea, coffee, sugarcane and subsistence crops. In addition, some major urban centers such as Suneka, Kisii and Rodi kopany provide urban effluent to the river, which results to poor water quality. On the converse, sampling locations with good water quality were rich in both diversity and quantity of fish. This is the reason why there were higher fish densities and biodiversity upstream the Iyabe-Riana River as opposed to the more polluted downstream. Negi and Mamgain [7] demonstrated that physical habitat variables play a key role in the distribution of fish in a river and habitat alteration brought a threat to fresh water fish fauna.

In this study, only one method of fishing- electro-fishing was employed. The method is thought to work better in the riverine habitat due to shallow depth of water. However, in some parts of the river where the habitat is complex such as in the riverine wetland and estuarine habitats, the method may not be suited for sampling since it may not be effective in catching fish in high depths and large volumes of water. There is therefore need to employ other methods of fishing such as cast nets, fish traps, gill nets and long lines to obtain data which can be used to confirm observations made in this study.

It was observed that fish catches were higher during the dry months than during the wet ones. During the wet period, floods have been observed to dislodge riverine vegetation and to carry large amount of silt, which covers both the river and its riparian zone, thereby destroying fragile fish habitats such as breeding, nursery and feeding grounds as well as hideout refugia, Stoddard *et al*. [10]. There is need to carry out long term studies that will help understand the effect of weather or climatic changes on fish in the riverine habitats. Results of this study can be compared with those of Orina [8] on ecosystem integrity of River Kuja in South west Kenya and that of Basavaranja [3] on fish diversity and abundance in Anjanapura reservoir in Kamataka state, India, who established that the higher the diversity, richness and evenness indices the higher the variety and abundance of fish. In this study, the indices for the Iyabe-Riana River were generally higher than those of the main River Kuja in to which it drains (Table 7).

This can be explained by the observation that the main River Kuja is more perturbed by anthropogenic activities than Iyabe-Riana River. It can therefore be noted that some small rivers in Lake Victoria basin can contain large numbers and considerable biodiversity, richness and evenness of indigenous fish species. Since most of these are potamodromous, their survival in the lake is not guaranteed due to the fact that the predatory Nile perch and other similar species have been able to drive these species in to virtual extinction. Overfishing in the river mouth is known to have led to decline of some major riverine fisheries. It can

therefore be concluded the threats to the diversity, distribution and abundance of fish of Iyabe-Riana River include; Pollution originating from anthropogenic perturbations in the riverine habitats, predation and climatic changes and to a lesser extent in the lower ridges of the river, intense overfishing and predation by major piscivores in the river.

Table 1: Percentage occurrence and composition of fish in the Iyabe- Riana River in South west Kenya.

Family	No. of species	Fish taxon	Total	% composition	% Occurence	IUCN status
Cyprinidae	6	*Labeobarbus altianalis*	714	45.5	100	LC
		L. victorianus	18	1.1	20	CR
		Enteromius paludinosus	14	0.9	3.3	LC
		Enteromius kerstenii	40	2.6	33.3	LC
		Enteromius neumayeri	126	8.0	100	LC
		Enteromius nyanzae	19	1.2	10	LC
Clariidae	2	*Clarias theodorae*	63	4.0	100	LC
		C. gariepinus	25	1.6	66.7	LC
Mochokidae	1	*Chiloglanis* sp.	242	15.4	80	LC
Amphiliidae	1	*Leptoglanus* sp.	199	12.7	83.3	LC
Poeciliidae	1	*Gambusia affinis*	35	2.2	20	LC
Mastercemlidae	1	*A. frenatus*	138	8.8	100	LC
Cichlidae	2	*Haplochromines*	18	1.1	20	-
		Tilapia zillii	13	0.8	13.3	-

Table 2: Spatial distribution of fish species by numbers in Iyabe-Riana River, South west Kenya.

Fish sp.	Bara nne	Getare	Enamba bridge	Etureti	Koluoch bridge	Total	Mean	SD	Range	Confidence Level (95%)
L. altianalis	222	216	132	102	42	714	142.8	76.76718	42-222	95.31904
E. neumayeri	42	24	30	18	12	126	25.2	11.54123	12-42	14.33033
C. theodorae	18	15	12	12	6	63	12.6	4.449719	6-18	5.525056
Chiloglanis sp. somereni.	68	66	72	36	0	242	48.4	30.60719	0-72	38.00384
Leptoglanis sp.	30	60	67	36	6	199	39.8	24.49898	6-67	30.4195
E. kersteni	12	9	7	6	6	40	8	2.54951	6-12	3.165634
A. frenatus	42	42	6	24	24	138	27.6	15.05988	6-42	18.69931
Gambusia sp.	13	12	10	0	0	35	7	6.480741	0-13	8.046902
L. victorianus	0	0	0	6	12	18	3.6	5.366563	0-12	6.663468
E. paludinosus	0	0	0	0	8	6	14	2.8	3.898718	0-8	4.840897
C. gariepinus	8	0	6	5	6	25	5	3	0-8	3.724992
E. nyanzae	9	0	6	4	0	19	3.8	3.898718	0-9	4.840897
T. zillii	7	6	0	0	0	13	2.6	3.577709	0-7	4.442312
Haplochromines	0	5	0	7	6	18	3.6	3.361547	0-7	4.173912

Table 3: Temporal fish distribution in the Iyabe- Riana River during the dry months

Fish species.	APRIL	MAY	AUGUST	Mean	SD	Range	Confidence level (95%)
L.altianalis	251	80	100	143.66	93.4898	80-251	233.2414
E. neumayeri	30	45	2	25.6667	21.8251	2-45	54.2165
C. theodorae	8	6	1	5.0000	3.6056	1-8	8.9567
C. somereni.	61	84	38	61.0000	23.0000	38-84	57.1352
Leptoglanis sp.	67	120	0	62.3333	60.1360	0-120	149.3860
E. kersteni	9	7	0	5.3333	4.7258	0-9	11.7396
A. frenatus	28	18	40	28.6667	11.0151	18-40	27.3632
G. affinis.	16	11	0	9.0000	8.1854	0-16	20.3335
L. victorianus	6	4	0	3.3333	3.0551	0-6	7.5892
E. paludinisus	0	3	0	1.0000	1.7321	0-3	4.3027
C. gariepinus	4	1	3	2.6667	1.5275	1-4	3.7946
B. nyanzae	0	0	0	0	0	0-0	0
T. zillii	0	0	2	0.6667	1.1547	0-2	2.8684
Haplochromines	0	0	4	1.3333	2.3094	0-4	5.7369
Total	480	379	190	349.66	235.7616	104141	586.6639

Table 4: Temporal fish distribution in the Iyabe- Riana River during the wet months

Fish sp.	June	July	September	Mean	SD	Range	Confidence level (95%)
L. altianalis	115	92	78	95.0000	18.6815	78-115	46.4075
E. neumayeri	21	6	17	14.6667	7.7675	6-21	19.2954
C. theodorae	20	6	5	10.3333	8.3865	5-20	20.8332
C. somereni.	24	21	9	18.0000	7.9373	9-24	19.7172
Leptoglanis sp.	2	3	3	2.6667	0.5774	2-3	1.4342
E. kersteni	0	0	0	0	0	0-0	0
M. frenatus	25	22	27	24.6667	2.5166	22-27	6.2516
G. affinis.	0	0	0	0	0	0-0	0

L. victorianus	0	1	1	0.6667	0.5774	0-1	1.4342
E. paludinisus	0	0	0	0	0	0-0	0
C. gariepinus	1	2	0	1.0000	1.0000	0-2	2.4841
E. nyanzae	0	0	9	3.0000	5.1962	0-9	12.9080
T. zillii	0	0	1	0.3333	0.5774	0-1	1.4342
Haplochromines	0	0	8	2.6667	4.6188	0-8	11.4737
Total	208	153	158	173.0001	57.8366	175936	143.6733

Table 5: Correlation of the physic-chemical parameters with abundance of the Iyabe-Riana River.

	DO	*TSS*	*TDS*	*Temerature*	*Turbidity*	*Conductivity*	*pH*	*Abundance*
DO	1							
TSS	-0.52839	1						
TDS	-0.54557	0.968377	1					
Temperature	-0.28225	0.555312	0.512955	1				
Turbidity	0.121438	0.081874	0.094322	0.084298	1			
Conductivity	0.245705	-0.14991	-0.18887	0.231769	-0.22601	1		
pH	-0.04519	-0.15621	-0.11709	-0.25421	0.288095	-0.39065	1	
Abundance	0.395229	-0.70133	-0.70831	-0.29463	-0.58826	0.281746	0.019066	1

Table 6: Table of mean spatial diversity indices

Sites	Shannon	Simpson	Richness	Evenness
Bara nne	1.419921±.2777	.6790±.0911	6.50±2.258	.8007±.1231
Getare	1.282831±.2516	.6188±.0976	6.17±1.329	.7108±.0782
Enamba bridge	1.314009±.1725	.6556±.0739	5.67±1.211	.7642±.0458
Etureti	1.266390±.2070	.6276±.0915	5.83±1.835	.7419±.0965
Koluoch bridge	1.297678±.4004	.6675±.1111	4.83±1.941	.8754±.0809
Mean	1.316166±.2596	.6497±.0902	5.80±1.730	.7786±.1004
Total Mean Range	0.6931-1.9274	.4960-.8359	2-9	.5929-1.000

Table 7: comparison of biodiversity, Richness and Evenness indices for this study and other studies done elsewhere

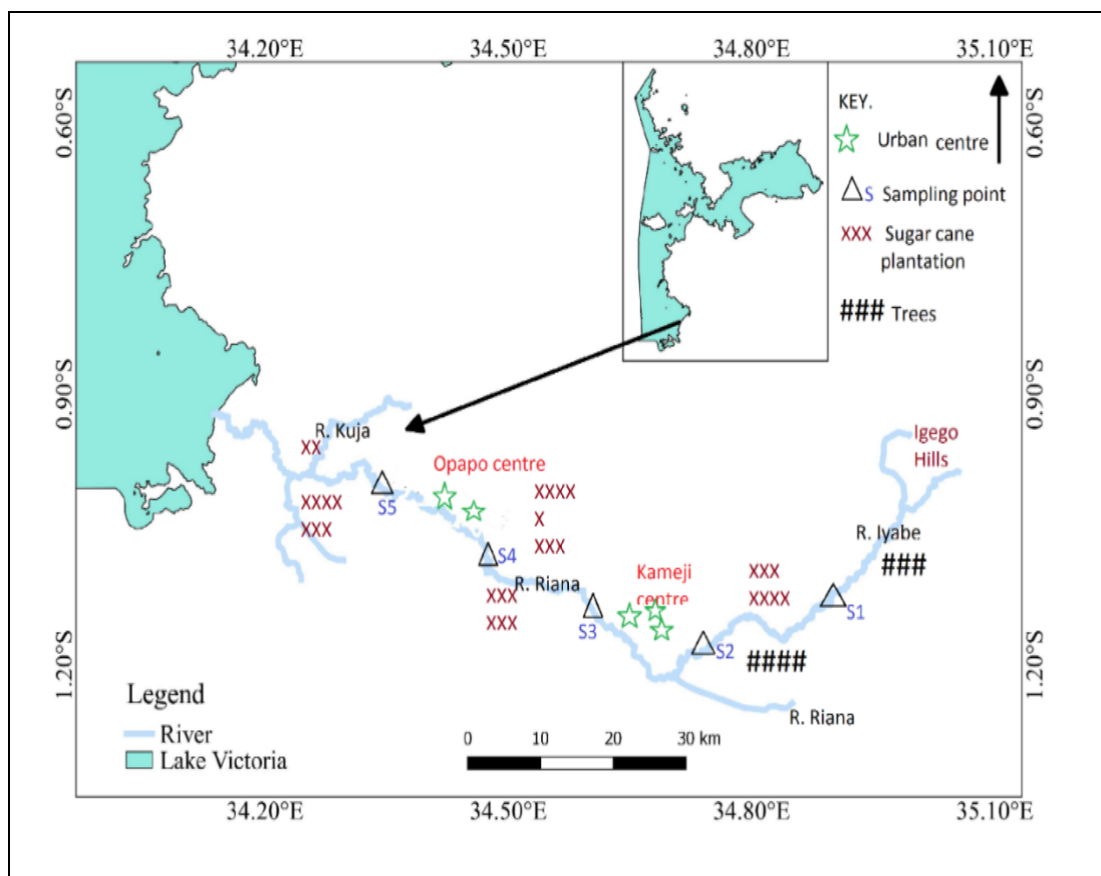| Author	Habitat	Shannon	Simpson	Richness	Evenness
This study, 2020	Iyabe-Riana River	0.69-1.92	0.50-0.83	2.0-9.0	0.59-1.00
Orina *et al*., 2017	River Kuja	0.20- 1.94	0.10 -0.82	2 – 13	0.24 - 0.95
Basavaranja *et al*., 2014	Anjanapura reservoir	2.4-3.0	0.89-0.95	1.48-2.4	0.6-0.9

Fig 1: Map showing the sampling points on Iyabe-Riana River in the Lake Victoria basin, south west Kenya
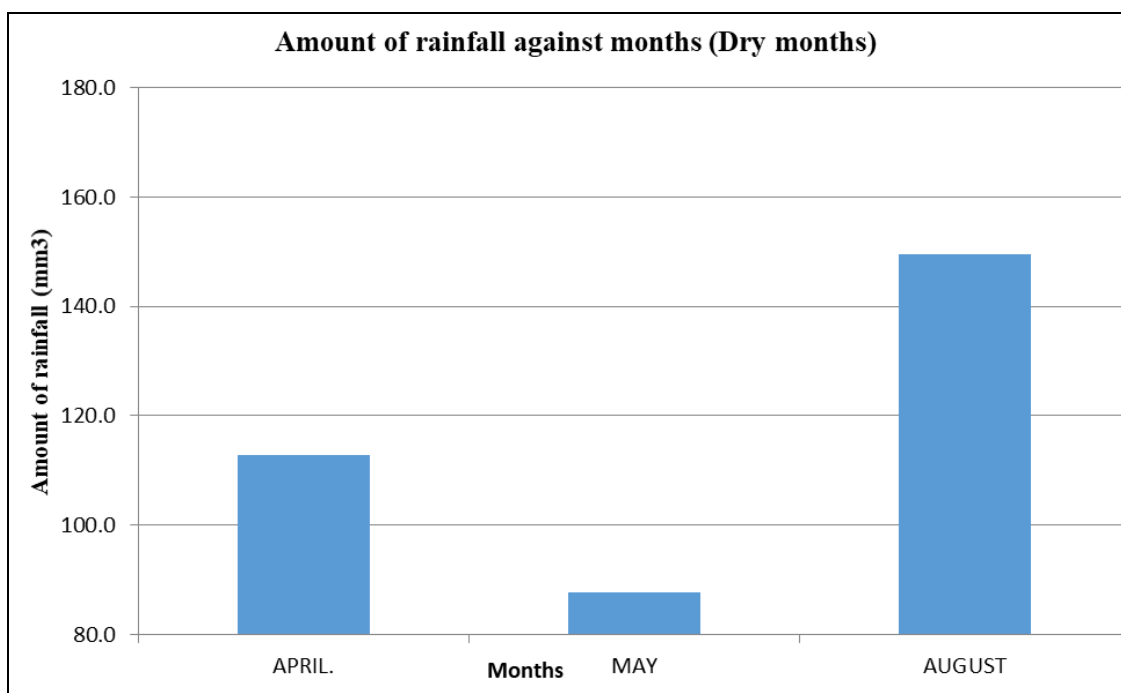
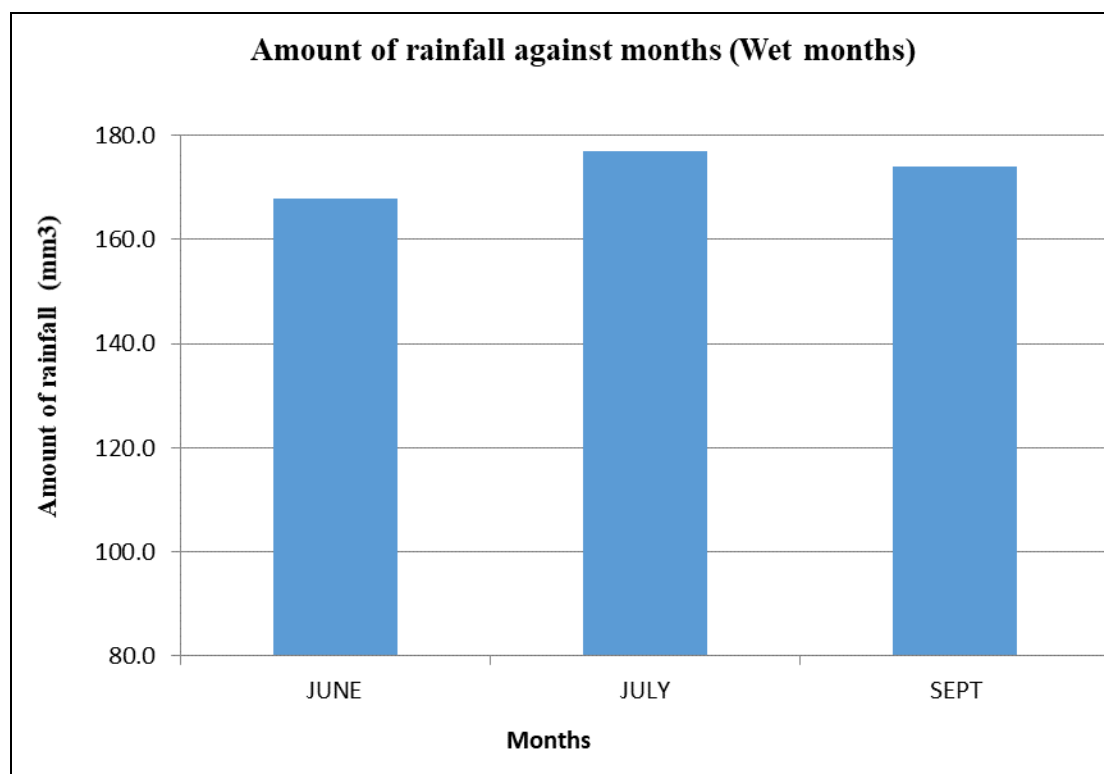**Fig 2:** Rainfall patterns for dry months, Kisii, Kenya 2019.

Fig 3: Rainfall patterns for wet months, Kisii, Kenya 2019.

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