Vol. 45 No. 2 1988

ISSN: 0006-3207

BIOLOGICAL CONSERVATION

Editor

Eric Duffey

ELSEVIER APPLIED SCIENCE

Biological Conservation **45** (1988) 93–108

A Comparative Survey of the Fish Communities of Two Nigerian Headwater Streams in Relation to Man-Made Perturbations

O. M. Udoidiong

Department of Zoology and Fisheries, University of Cross River State, PMB 1017, Uyo, Nigeria

(Received 23 June 1987; revised version received 19 October 1987; accepted 19 November 1987)

ABSTRACT

Small streams in southeastern Nigeria support a rich and varied freshwater fish fauna, but scientific reports on them are lacking. Two headwater (first-order) streams and their fish assemblages were surveyed in this locality, and the results indicate high similarity in fish species composition, but differences in other community parameters. Whereas three species were dominant and fourteen rare in the Udom stream, four species (three different) were dominant and fifteen rare in the Nung Oku stream, in contrast to the report of Lotrich (1973) that first-order streams have a fish community composed of one rare and one common species. The effects of land use and irrational exploitation on these streams are discussed and the need for conservation stressed. The results indicate that our small inland waters are sensitive to man-made perturbations.

INTRODUCTION

The numerous streams in southeastern Nigeria support a rich and varied freshwater fish fauna; but neither these streams nor their species assemblages have been studied, except for the work of Reid (1983) which was taxonomic rather than ecological. Available literature on the occurrence, distribution, and ecology of fishes in small West African streams is

Biol. Conserv. 0006-3207/88/$03·50

fragmentary (e.g. Lelek, 1968; Loiselle, 1969, 1971; Sydenham, 1975; Whyte, 1975), and important fish species that could be threatened may thus escape detection.

This paper describes aspects of the ecology of the fish communities of two Nigerian headwater streams, highlights the effects of land use on these streams, and stresses the need for their conservation in Nigeria. Although preliminary, the study serves as a starting point for future investigations in this area where ecological information on streams is lacking. The zonal approach (Odum, 1975) was followed in which discrete communities are recognised, classified, and listed as a check-list of community types. Aspects of the structural approach of Lotrich (1973) are also reflected in this study.

STUDY AREAS

The study was carried out on the Udom and Nung Oku streams, located in different local government areas (LGA) and draining into different rivers in Cross River State, Nigeria. However, both streams belong to the same ichthyogeographical zone—Cross River Basin Zone (Sydenham, 1977).

Udom stream

Locally known as 'Idim Udom' (A on Fig. 1), the stream is located in Ikono LGA (5° 30′ N; 7° 80′ E) and forms one of the headwaters of Ikpa River. The 300 m stretch sampled is in Ekpene Ediene Ikot Antia, a village located 17 km east of Ikot Ekpene (5° 20′ N; 7° 70′ E), and about 1 km from the old Ikot Ekpene–Itu road. Initially the stream originated from a hill (Obot Atan) opposite Archibong Memorial Grammar School, Ukpom; but this source has apparently dried up. For about 0·5 km from the source, the stream channel has become dry land and the water now seeps through at a different point. The dry valley is colonised by many terrestrial species, notably the trees *Raphia hookeri* and *Musanga smithii*; *Musa* spp. were introduced by man. The aquatic macrophytes of the littoral zone are dominated by *Nymphaea* spp., while the banks support *R. hookeri*, *Elaies guineensis* and the christmas bush *Alchornea cordifolia*, whose canopies shade substantial portions of the channel. In some areas small swamps abound, with *R. hookeri* being the dominant tree. Decaying and decayed pieces of *R. hookeri* make the surrounding water peaty. These habitats appear to be particularly favourable for rivulins (see below). Transparency is slightly reduced in these habitats and the muddy bottom is only seen with difficulty, in contrast to the easily visible sandy bottom of the lotic portions. The mean values of some physico-chemical variables are shown in Table 1.

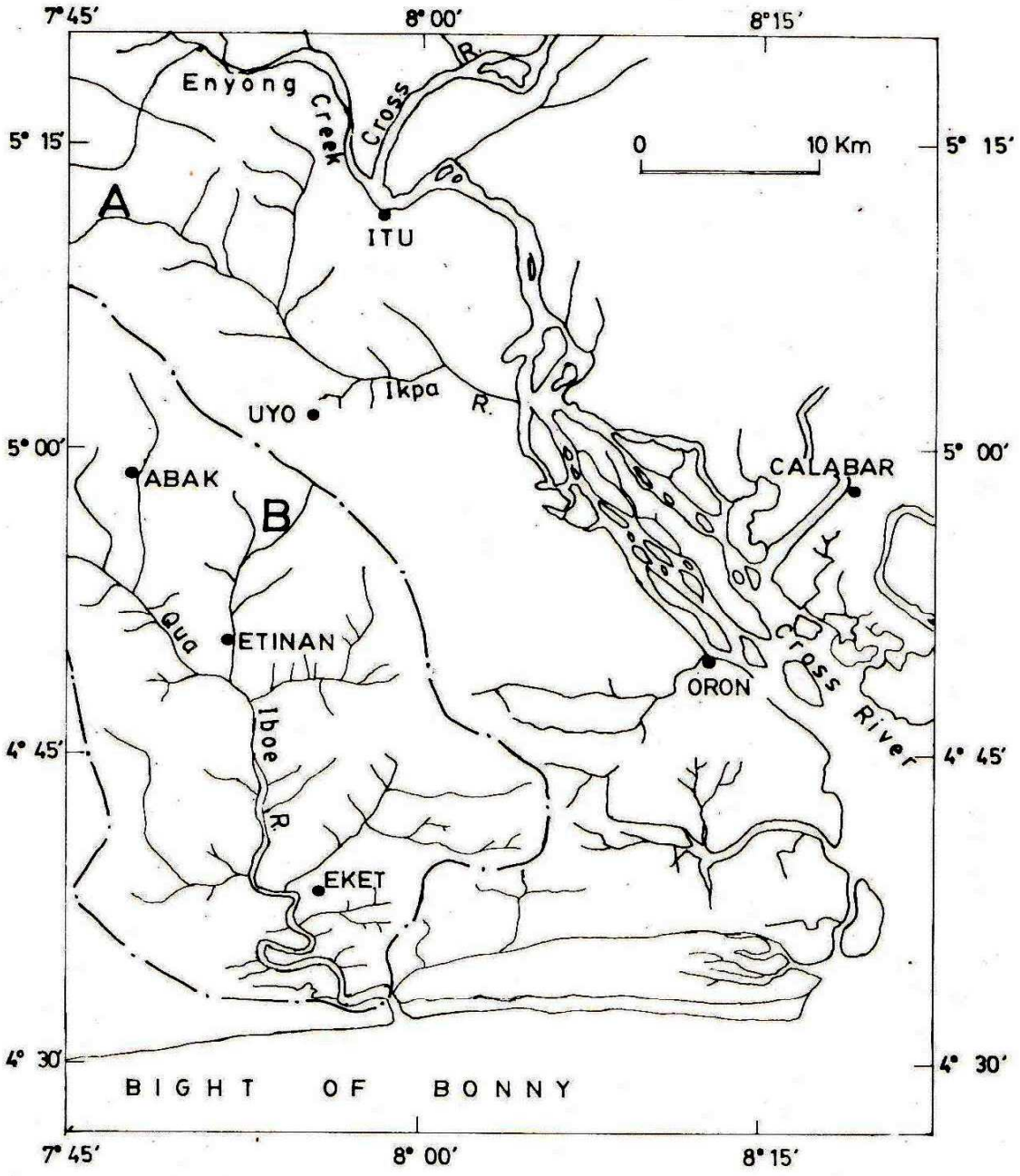

Fig. 1. Map of parts of the Cross River and Qua Iboe River systems showing the streams (A and B) surveyed. –·–·– Limit of Qua Iboe River Basin.

Nung Oku stream

This stream is locally known as 'Idim Nung Oku'. The stretch sampled is located in Nung Oku village, Ibesikpo in Uyo LGA (5° 01′ N; 7° 56′ E) (B, Fig. 1). The stream, which contains black water (suggesting the presence of humic substances), originates from a low hill opposite Lutheran High School, Obot Idim. Information received from villagers indicates that a few decades ago the water used to accommodate large dug-out canoes (pirogue) employed both for fishing and transportation of palm produce to beaches on

TABLE 1
Water Quality Data of the Udom and Nung Oku Streams

Parameters	*Udom stream*			*n*	*Nung Oku stream*			*n*
Type of water	Clear				Black			
Depth								
Pool	0·381 (0·24–0·54)			6	0·753 (0·60–1·0)			6
Riffle	0·545 (0·24–0·72)			6	0·346 (0·20–0·50)			6
Width								
Pool	4·75 (4·1–6·0)			6	5·33 (3·0–6·5)			6
Riffle	3·516 (2·3–5·0)			6	0·423 (0·34–0·50)			6
	Dec.	*Jan.*	*Feb.*	$\bar{x}$	*Dec.*	*Jan.*	*Feb.*	$\bar{x}$
Current velocity ($m\,s^{-1}$)	0·24	0·15	0·32	0·236	0·035	0·018	0·026	0·0263
Suspended particles ($g\,litre^{-1}$)	0·05	0·02	0·03	0·033	0·31	0·16	0·24	0·236
pH	6·5	6·0	6·2	6·23	6·2	5·5	5·1	5·6
Water temperature (°C)	26·5	26·5	25·0	26·0	29·5	28·4	26·2	28·03
Air temperature (°C)	28·0	28·5	30·2	28·9	32·5	29·5	31·0	31·0
Free carbon dioxide ($mg\,litre^{-1}$)	5·4	5·1	4·6	5·03	17·4	16·2	19·0	17·53
Dissolved oxygen ($mg\,litre^{-1}$)	6·2	6·1	5·8	6·03	3·6	5·1	4·4	4·36
Total alkalinity ($mg\,litre^{-1}$)	5·5	5·0	4·5	5·0	14·5	13·3	14·2	14·0

Figures outside and within parentheses refer to averages and ranges respectively.

the Qua Iboe river into which it flows. The stream has now dried up almost to extinction, leaving along its course some relatively large pools joined by very thin strings of slow-flowing water. Due to this drying-up, much of the channel has given way to dry land colonised by terrestrial plants notably the herb *Costa afer*.

Throughout its length, except for portions traversed by roads and intensively used for domestic purposes, the stream is shaded by a canopy of *R. hookeri* (but the degree of shading is less than that in the Udom stream). The immediate banks and dried portions of the channel have numerous aquatic and terrestrial plants, including *Vossia* and *Nymphaea* spp., *Ipomoea involucrata* and *Cynodon plectostackyon*. A large reserve of gravel on the banks is commercially exploited. The stream bed is muddy, except at portions that come under human influence. The shallow nature of the water allows radiation down to the muddy bottom. Mean values for the measured physico-chemical variables are given in Table 1.

MATERIALS AND METHODS

Sampling

A longer stretch (468 m) was sampled in the Nung Oku stream in view of its smaller size in order to make the areas of water sampled in both streams approximately comparable. Both lotic and lentic portions (now to be described as 'riffles' and 'pools') were sampled in each stream for three months from December 1984 to February 1985 inclusive, on a fortnightly basis. The two collections per month were pooled.

Four sampling methods were used. First, fishes were collected with set nets (4 × 2 m; 3 cm stretched mesh) used exclusively in the open water. Secondly, local, non-return valve traps, 'Ikpa' were employed, as described by Reed (1967), Holden & Reed (1972) and Essien (1981). The nets and traps were always set at dusk and inspected at dawn. Thirdly, local baskets of fine mesh were used. In this case, collecting was by active manual operation lasting for 3 hours per sampling occasion in the littoral zone. Mormyrids and rivulins were mostly caught by this method. Lastly, hook and line fishing lasting for 2 hours per sampling trip was employed. However, this yielded poor results. Specimens were preserved immediately after capture in 10% formalin and taken to the laboratory for identification and length measurements. Every aspect of the materials and sampling was synchronised, except sampling days.

Indices of species structure in the two streams were computed. Species

diversity was calculated using the Shannon index of general diversity (H), designated as:

$$H = -\sum\left(\frac{n_i}{N}\right)\log\left(\frac{n_i}{N}\right)$$

where n_i = number of individuals of each species; N = total number of individuals of all species. In order to enable direct comparison of the two fish communities, H was scaled as:

$$\frac{H}{\log_e S} \quad \text{(see Odum, 1975)}$$

where H = Shannon index; S = number of species. In this approach, 1 is the maximum diversity and zero the minimum.

The estimated value of 'H' above was used to calculate the McArthur–Terborgh species equitability index E (a measure of evenness of distribution of species abundances), given as:

$$E = \frac{{}_eH}{S} \quad \text{(Peck \& Forsyth, 1982)}$$

where e is the base of natural logarithm; H = Shannon index; S = number of species. A completely uniform distribution would give E = 1.

The Simpson index, designated as:

$$D = \sum\left(\frac{n_i}{N}\right)^2$$

was used as an index of dominance (Odum, 1975). A maximum value of 1 is obtained when there is only 1 species (complete dominance), and values approaching zero are obtained when there are numerous species, each a very small fraction of the total (no dominance).

Finally, sample similarity was examined using the formula:

$$S = \frac{2C}{A + B} \quad \text{(Odum, 1971)}$$

where S = similarity; A = number of species in stream A; B = number of species in stream B, and C = number of species occurring in both streams. This index ranges from 0–1·0 to quantify the range from no similarity to complete similarity, and is a simple measure based on species presence only (Krebs, 1978).

RESULTS

Species composition

The qualitative composition of fishes in both streams is illustrated in Table 2. Seventeen species representing ten families were recorded in the Udom while 19 species from 11 families were caught in the Nung Oku, making a total of 23 species representing 12 families. Of these, 13 species were common to both streams. Four of the ten uncommon species occurred in the Udom stream and the remaining six were recorded only in the Nung Oku stream.

Relative abundance

Figure 2 illustrates the relative abundance of the fishes in the Udom and Nung Oku streams. The comparison shows that in the former the

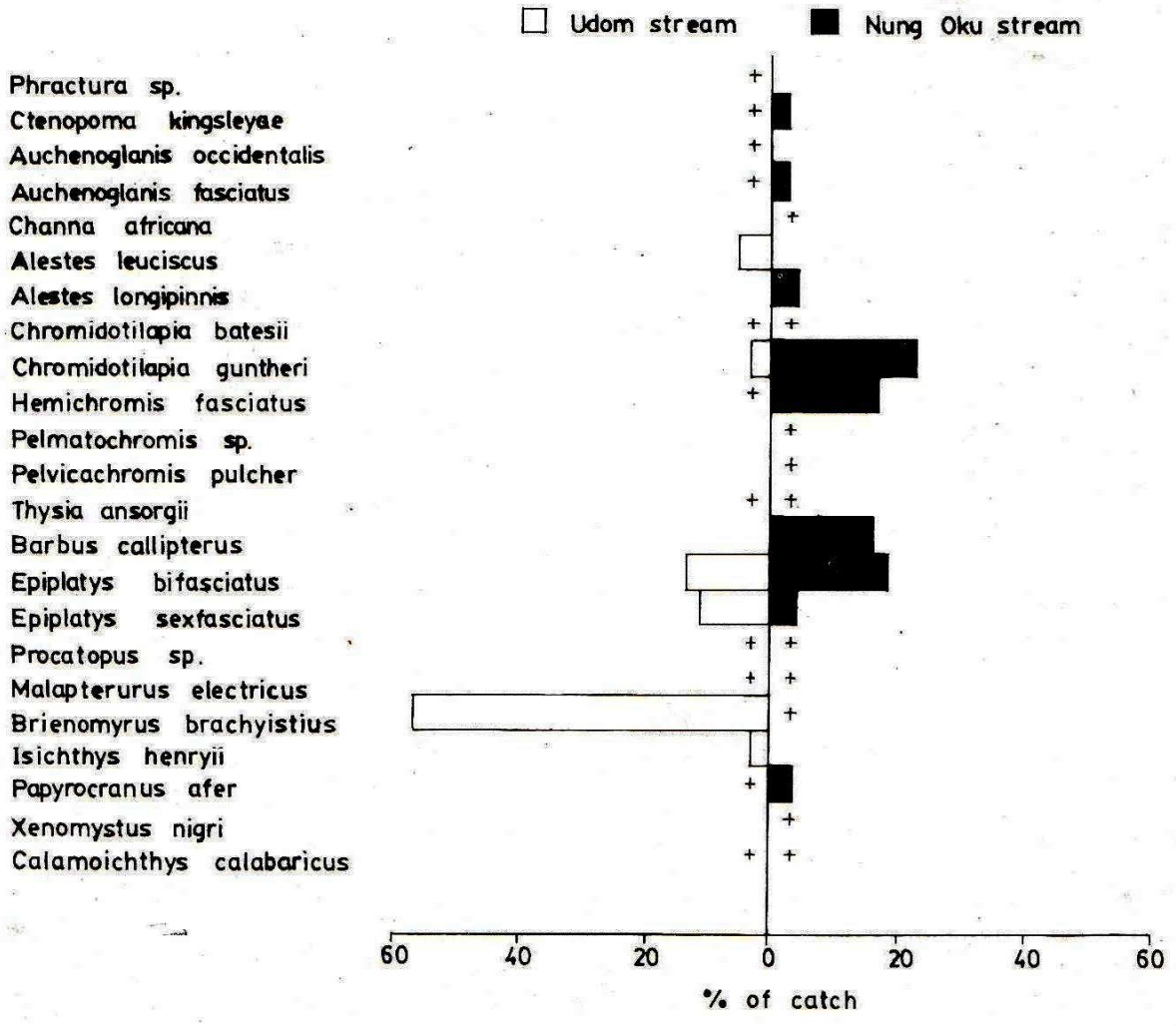

Fig. 2. Relative abundance of fishes recorded in Udom and Nung Oku streams. +, Species contributing less than 2·6% of the catch in each stream.

TABLE 2
Summary of Data on Fishes Captured in Udom and Nung Oku Streams

Family/Species	*Udom stream*			*Nung Oku stream*		
	n	*%n*	$\bar{x}$ *Length (cm)*	*n*	*%n*	$\bar{x}$ *Length (cm)*
Amphilidae						
Phractura sp.	2	0·6	4·6	—	—	—
Anabantidae						
Ctenopoma kingsleyae	2	0·6	6·6	7	2·6	10·3
Bagridae						
Auchenoglanis fasciatus	1	0·3	11·0	7	2·6	12·5
A. occidentalis	2	0·6	5·8	—	—	—
Channidae						
Channa africana	—	—	—	1	0·4	17·7
Characidae						
Alestes leuciscus	17	4·8	5·7	—	—	—
A. longipinnis	—	—	—	10	3·7	7·3
Cichlidae						
Chromidotilapia batesii	4	1·1	5·6	1	0·4	7·0
C. guntheri	13	3·7	5·5	65	23·9	9·2
Hemichromis fasciatus	1	0·3	7·0	47	17·3	6·8
Thysia ansorgii	3	0·9	5·4	5	1·8	8·9
Pelvicachromis pulcher	—	—	—	1	0·4	8·6
Pelmatochromis sp.	—	—	—	1	0·4	11·0
Cyprinidae						
Barbus callipterus	—	—	—	45	16·6	5·7
Cyprinodontidae						
Epiplatys bifasciatus	47	13·4	1·7	50	18·5	2·3
E. sexfasciatus	39	11·1	3·9	11	4·1	3·9
Procatopus sp.	6	1·7	3·2	3	1·1	3·3
Malapteruridae						
Malapterurus electricus	1	0·3	11·2	2	0·7	12·6
Mormyridae						
Brienomyrus brachyistius	198	56·6	5·8	2	0·7	13·6
Isichthys henryii	11	3·1	8·1	—	—	—
Notopteridae						
Papyrocranus afer	2	0·6	13·8	9	3·3	17·7
Xenomystus nigri	—	—	—	3	1·1	11·7
Polypteridae						
Calamoichthys calabaricus	1	0·3	26·6	1	0·4	26·0

mormyrids comprised approximately 60·0% of the total catch, with *Brienomyrus brachyistius* as the most abundant (94·7%), and also the most abundant species of all fish (56·6%). In the Udom stream the cichlids constituted 5·9% of the catch. Conversely, in the Nung Oku, the cichlids constituted 44·3%. Although *C. guntheri* was the most abundant species, it contributed only approximately 24·0% of the total catch and 54·2% of the cichlids. The only mormyrid, *B. brachyistius*, provided only 1·0% of the total catch. The cyprinodonts came second in numbers in each stream, constituting 26·3% in the Udom stream and 23·6% in the Nung Oku. Whereas 14 species each formed less than 5·0% of the catch in Udom, 15 species did so in the Nung Oku, and were all considered rare.

Community parameters

The Shannon index of diversity was 1·556 for the Udom fishes, giving a scaled value of 0·5492, while for Nung Oku fishes it was 2·148, with a scaled value of 0·7294, indicating a higher species diversity for the latter. Computations indicate equitability $E = 0{\cdot}279$ for the Udom stream and 0·451 for the Nung Oku, indicating an uneven distribution of species abundances. However, Nung Oku has a relatively more even distribution of species abundances than the Udom. A value of 0·3559 (35·6%) was obtained as the index of dominance for the Udom stream fishes, and 0·1554 (15·5%) for the Nung Oku stream fishes. Thus, dominance is stronger in the Udom than in the Nung Oku. An index of 0·72 was obtained as the measure of sample similarity, portraying the two streams to be highly similar in their species composition.

Size composition

The size frequency distribution for species that showed some degree of size variation and numbers ≥ 30 are shown in Figs 3–5 inclusive, and comparisons made where appropriate. There is a pronounced similarity in the size composition (standard length, SL) of *Epiplatys bifasciatus* and *E. sexfasciatus* in the Udom stream (Figs. 3a and b, respectively), with fewer juveniles but more adults. Conversely, there were more juveniles of *E. bifasciatus* than adults in the Nung Oku stream (Fig. 3c). Separation as juveniles and adults was arbitrary, individuals less than 20·0 mm being regarded as juveniles and those greater than 20·0 mm as adults.

Barbus callipterus occurred only in the Nung Oku stream and the size distribution is shown in Fig. 3(d). Since representatives of the lower length groups were found with eggs, they consisted mostly of adults. Figure 4(a) shows the size distribution for *B. brachyistius* in the Udom stream, and Fig. 5

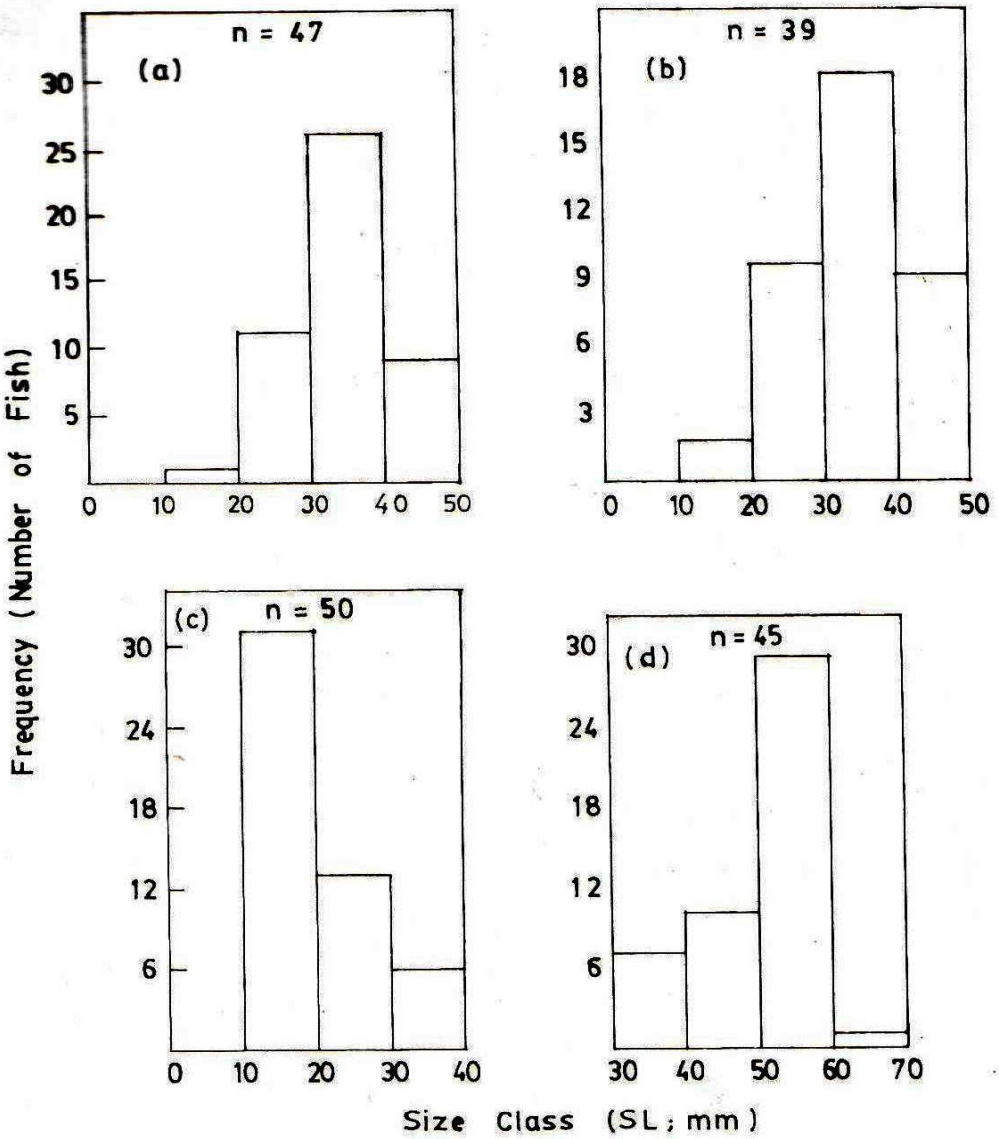

Fig. 3. Size frequency distribution for (a) *Epiplatys bifasciatus* and (b) *E. sexfasciatus*, both from the Udom stream; (c) *E. bifasciatus* and (d)*Barbus callipterus* from Nung Oku stream.

that for *C. guntheri* in the Nung Oku stream. There is a suggestion of a bimodal distribution in their size distribution, and the mean values of the modal length groups were compared using Student's *t*-test ($P < 0{\cdot}01$). Examination of the gonads revealed that sexual dimorphism was responsible for the size differences, males being smaller than females. Due to a paucity of individuals, the complete profile for the size distribution of *H. fasciatus* in the Nung Oku stream cannot be depicted (Fig. 4b). However, apart from the 30–40 mm SL size group, gravid females were represented in each of the length groups except 30–40 mm, indicating that a significant proportion of the specimens was adult.

For the 13 species common to both streams, Table 2 reveals that except for *H. fasciatus*, *E. sexfasciatus* and *Calamoichthys calabaricus*, the mean SL values of fishes from the Nung Oku stream were greater than those from the

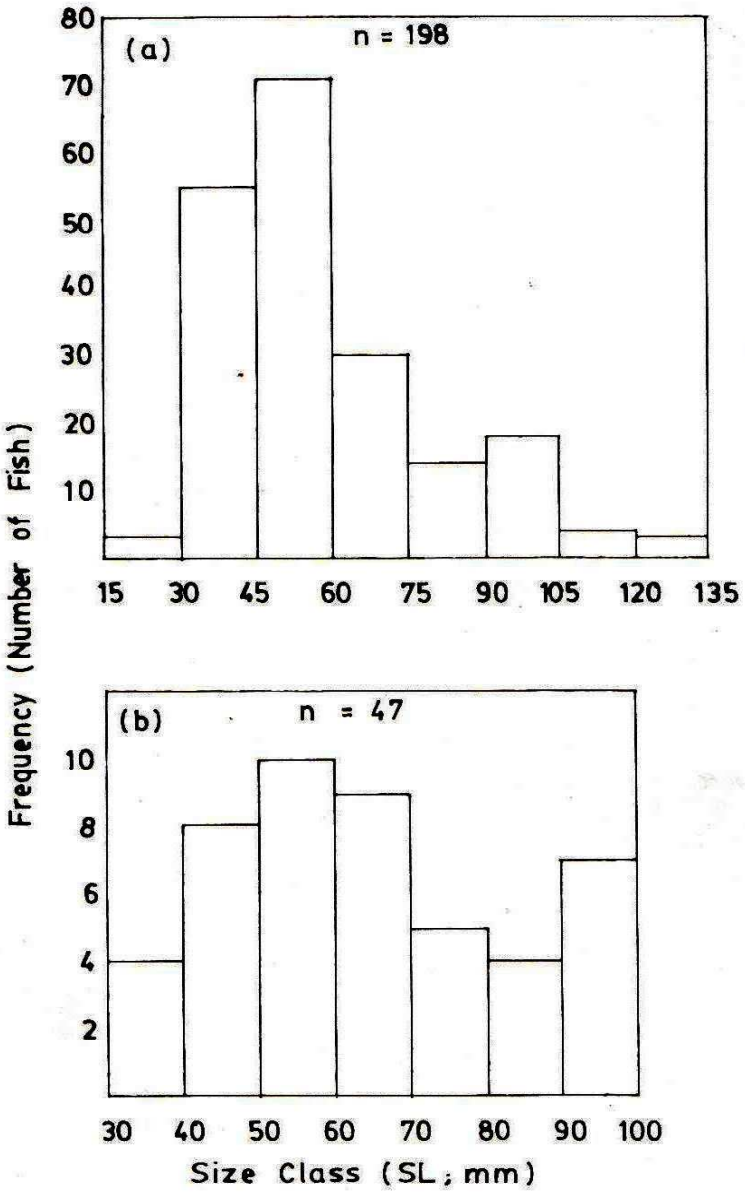

Fig. 4. Size frequency distribution for (a) *Brienomyrus brachyistius* from the Udom stream and (b) *Hemichromis fasciatus* from the Nung Oku stream.

Udom. After excluding species with one specimen from either or both streams, mean SL differences of the remaining eight species were compared using Student's *t*-test. In four cases $P < 0{\cdot}01$.

Spatial distribution

In the Udom stream this survey revealed that the pools were dominated by cyprinodonts in association with the shrimps *Desmocaris trispinosa* Aurivillus and *Macrobrachium dux* Lenz. Because of this highly skewed distribution, habitat separation has been omitted from the presentation. Conversely, an appreciable differential distribution was found among the species in the two habitats in the Nung Oku stream (Table 3), with 15 species

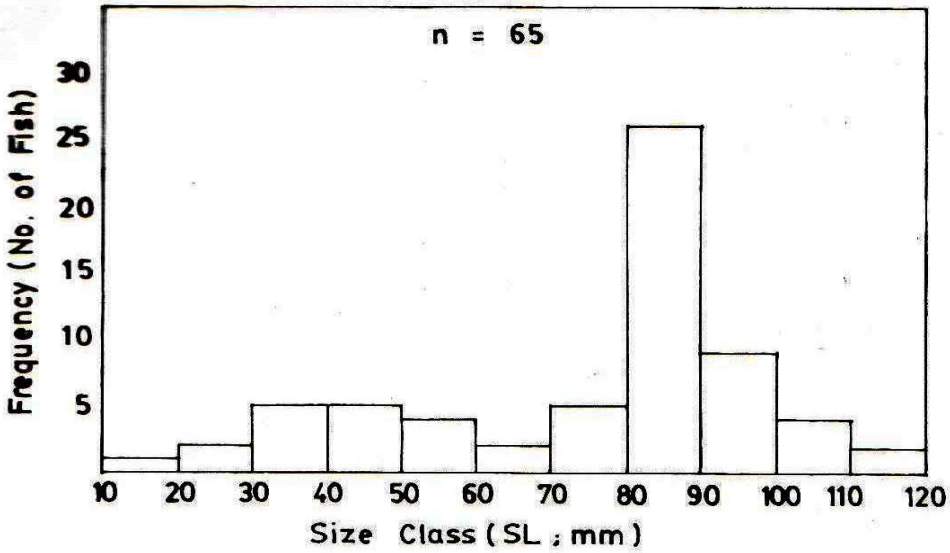

Fig. 5. Size frequency distribution for *Chromidotilapia guntheri* from the Nung Oku stream.

occurring in the pools and 13 in the riffles. Nine species were common to both habitats.

The Shannon index of diversity, H, was 0·859 in the pool, giving a scaled value of 0·3172; 0·813 in the riffle, with a scaled value of 0·3169. Equitability, E was 0·157 in the pool and 0·173 in the riffle. This therefore indicates that

TABLE 3
Relative Abundance of Fish from the Pool and Riffle of Nung Oku Stream

Species	*Pool*	%	*Riffle*	%
Ctenopoma kingsleyae	2	1·4	5	4·0
Auchenoglanis fasciatus	7	4·8	—	
Channa africana	1	0·7	—	
Alestes longipinnis	4	2·7	6	4·8
Chromidotilapia batesii	—		1	0·8
C. guntheri	29	19·7	36	29·0
Hemichromis fasciatus	31	21·0	16	13·0
Thysia ansorgii	2	1·4	3	2·4
Pelvicachromus pulcher	—		1	0·8
Pelmatochromis sp.	1	0·7	—	
Barbus callipterus	5	3·4	40	32·3
Epiplatys bifasciatus	48	32·6	2	1·6
E. sexfasciatus	3	2·0	8	6·5
Procatopus sp.	—		3	2·4
Malapterurus electricus	2	1·4	—	
Brienomyrus brachyistius	2	1·4	—	
Papyrocranus afer	7	4·8	2	1·6
Xenomystus nigri	3	2·0	—	
Calamoichthys calabaricus	—		1	0·8
	147	100	124	100

species diversity is equal in the two habitats, with a little difference in evenness of distribution of species abundances. A high similarity index of 0·64 was obtained for the species in the two habitats. The pool/riffle distribution given in Table 3 could be seasonal, since fishes are likely to be concentrated in pools during the dry season, apparently in relation to concentrations of food material. However, dominance was 0·1981 (19·8%) in the pool and 0·215 (21·5%) in the riffle, indicating a slightly stronger dominance in the latter. In the pool, *Epiplatys bifasciatus* was the most abundant species, followed by *H. fasciatus* and *C. guntheri.* In the riffle, *Barbus callipterus* dominated, closely followed by *C. guntheri* and *H. fasciatus.*

DISCUSSION

From a qualitative standpoint the two streams investigated have a rich fish fauna when compared with reports from other small African streams. For example, in Ghana, Lelek (1968) found only six species representing three families in the Ebo stream, and Whyte (1975) recorded 11 species representing five families from streams flowing into Lake Bosumtwi. In Nigeria, Sydenham (1975) recorded 13 species from 9 families in the Odo Ona stream. Of these, the families Hepsetidae and Mastacembelidae have not been recorded in the present study. Four species occur in the Udom, giving a similarity of 26·7%, whereas six species were common to Nung Oku stream, with a similarity of 37·5%. Welcomme (1969) reported six families comprising 17 species from the Kafunta stream-swamp system in Uganda, but none were recorded here, showing great dissimilarity in species composition.

The high similarity in species composition between the two streams in the present study agrees with Sydenham's (1977) report which indicates that they belong to the same (Cross River Basin) ichthyogeographical zone. However, there is a higher diversity, more even distribution of species abundances and a relatively lower concentration of dominance in the fish community of the Nung Oku compared with those of the Udom stream. Whereas the Udom is dominated by the mormyrids and cyprinodonts, the cichlids and cyprinodonts dominate in the Nung Oku. It appears that the rivulins preferentially inhabit lentic waters, while the peaty water in this habitat appears unfavourable for most of the other species.

The results do not agree with Lotrich's (1973) assertion that first-order streams have a fish community composed of one rare and one common species. If species with less than 5% contribution to the total catch in each stream are considered rare, then the Udom stream has 3 dominant species

and 14 rare species, whereas the Nung Oku has 4 and 15 respectively. Most of the species in the Nung Oku are benthophagous, showing strong preference for detritus, mud and chironomid larvae, whereas Udom stream fishes are mostly insectivorous and algivorous.

Effect of land use and unwise exploitation

The disappearance of the initial source of the Udom stream is clearly the result of uncontrolled cultivation of the adjoining hills right to the edge of the stream. The denuded hillsides easily erode during the rains and sand is deposited in the stream. In addition to obliterating the original source of the stream, the deposited sand has led to pronounced reduction in its width and depth. It is also believed that this size-reduction has resulted in the disappearance of some larger species which cannot tolerate shallow water. Colonisation of the dried portion by terrestrial plants emphasises the irreversible nature of the siltation.

Tahal Consultants (1982) report that the Ikono soil series is generally subjected to water erosion of varying degrees, and cautioned that, as the potential productivity of the area for agricultural development is slight, the land should be left undisturbed. It appears that either the Cross River State government, which received this report, has not notified the residents of this area of the warning, or the people have taken no heed.

The use of the unselective toxic chemical gammalin 20 for fishing has adversely affected the fishes in this stream, juvenile fish being particularly vulnerable.

The effect of eroded sand is much more pronounced in the Nung Oku stream. Much of the channel in the headwater sampled has been reduced to slow-flowing rivulets, leaving large areas completely taken over by terrestrial plants. The stream cannot regain its pristine condition and sooner or later it may become a series of small spring-fed pools. The clayey washings from the gravels and erosion of the exposed quarry banks has increased the suspended matter in the water, and reduced stream flow has caused silting of the stream bed. With the current rate of development in the area, more riparian vegetation will be removed and silt deposition will increase. The predominance of adults of *Barbus callipterus* and *Hemichromis fasciatus* in this stream is attributable to reduction in water volume.

Need for conservation

It appears that the government has shown little or no interest in the protection of small streams. This attitude probably derives from the erroneous belief that stream fishes and fisheries do not contribute

significantly, if at all, to the nation's economy. No laws seem to be enacted for the rational use of streams and their adjoining lands. Where, and if such laws exist, they have not been enforced. Small streams should be conserved because their waters are used by fish migrating upstream to spawn. In addition, the nature and size of food fisheries of streams, their value for research, gene pools and economic potential are yet to be established in this country. Aquarium fisheries sustained from streams could be capable of generating millions of Naira in foreign exchange. It is also important to conserve stream faunas, some with endemic communities together with representative biotopes, for their intrinsic value.

ACKNOWLEDGEMENTS

The author wishes to thank Mrs E. O. B. Umotong and Mrs A. E. Asuquo for field and laboratory assistance. My sincere thanks are due to Professor Lennart Hansson, Department of Wildlife Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden, and my colleague, Mr R. P. King, for their useful suggestions on an earlier draft of the paper.

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