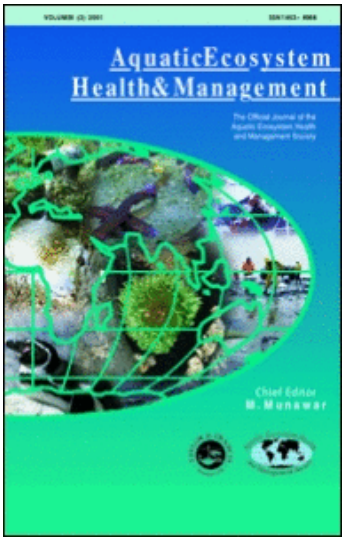

Aquatic Ecosystem Health & Management
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713393886

Some observations on the spawning season of *Barbus amphigramma* in Lake Naivasha, Kenya

G. M. Mutia[a]; M. J. Ntiba[a]; K. M. Mavuti[a]; G. Omondi[a]
[a] School of Biological Sciences, University of Nairobi, Nairobi, Kenya

Online publication date: 09 June 2010

To cite this Article Mutia, G. M. , Ntiba, M. J. , Mavuti, K. M. and Omondi, G.(2010) 'Some observations on the spawning season of *Barbus amphigramma* in Lake Naivasha, Kenya', Aquatic Ecosystem Health & Management, 13: 2, 214 — 221
To link to this Article: DOI: 10.1080/14634988.2010.481240
URL: http://dx.doi.org/10.1080/14634988.2010.481240

Taylor & Francis
Taylor & Francis Group

Some observations on the spawning season of *Barbus amphigramma* in Lake Naivasha, Kenya

G. M. Mutia, M. J. Ntiba,* K. M. Mavuti and G. Omondi
School of Biological Sciences, University of Nairobi, P.O. Box 30197-00100 Nairobi, Kenya.
**Corresponding author: mjntiba@uonbi.ac.ke*

The objective of the study was to investigate some aspects of the breeding patterns of the cyprinid Barbus amphigramma *in Lake Naivasha. The study was carried out from February to October, 2003. Fishing was done with the use of gillnets of mesh size 0.5 inch to 3 inch and a beach seine of mesh size 1 inch. Six gonad maturity stages have been described visually, based on morphological features, and validated by histological features of the ovary, as well as examination of the oocyte diameter. Females dominate the population at all sizes classes.* Barbus amphigramma *spawns all year round, but with discernible peaks in March, July and October. The peaks in March and October correspond with the beginning of the long and short rains, respectively, in Kenya.*

Keywords: breeding patterns, gonadosomatic index, sex ratio, fecundity, gonad maturation, oocyte development

Introduction

Barbus amphigramma appeared in the lake in the early 1980's (Harper, 1984). It is the only fish species in Lake Naivasha which has been described as a natural invader, being a small riverine fish which migrated down to the lake from the River Malewa. Although *B. amphigramma* does not frequently feature in the fish markets around the lake, its exploitation forms a minor subsistence activity of the local fishing community.

Ecologically, *B. amphigramma* has been reported to be one of the food items for the macro-predator species *Micropterus salmoides* in Lake Naivasha (Aloo, University of Nairobi, Kenya, unpublished). It was under exploitation and of high commercial value in the mid 1980's with records showing that in 1985, 60.0 tonnes of *B. amphigramma* were landed, followed by 62.9 tonnes in 1986 (Anonymous, 1987). However, the catch decreased significantly in 1987 to 26.1 tonnes. Only a small number of fish was caught in 1989 (Anonymous, 1989). There have been no records on its exploitation thereafter, or any detailed ecological study describing its biology and interaction with the abiotic and biotic factors in Lake Naivasha (Figure 1). This gap in the lack of knowledge and data, for nearly twenty years, stimulated the interest of the present study in Lake Naivasha, situated in the Great Rift Valley, Kenya. The study was carried out from February to October, 2003.

Materials and Methods

Fleets of gillnets, each with a depth of 1.5 m, a length of 45 m and mesh sizes ranging from 0.5 to 3 inches, were used for fishing. The nets were set overnight parallel to the shore at each of the sampling stations (Figure 1) for 12 hours and examined the following morning. The catch was sorted and identified. *B. amphigramma* specimens (1247

Aquatic Ecosystem Health & Management, 13(2):214–221, 2010. Copyright © 2010 AEHMS. ISSN: 1463-4988 print / 1539-4077 online
DOI: 10.1080/14634988.2010.481240

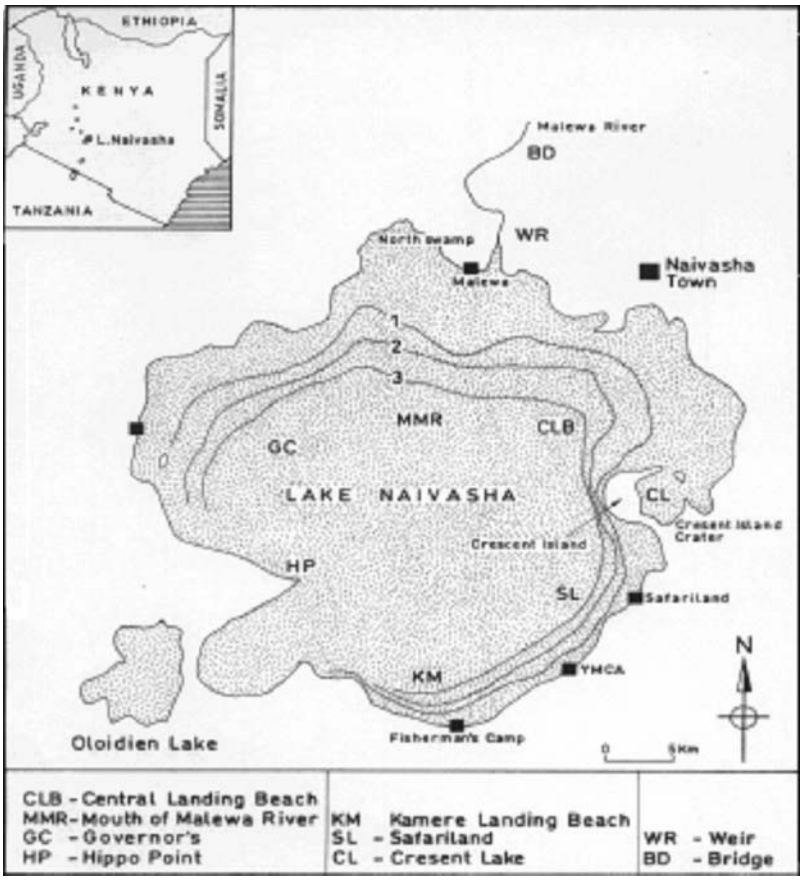

Figure 1. Map of study area in Lake Naivasha showing depth contours and samplings stations (Modified in 2006 from Hickley et al., 2002).

caught) were weighed to the nearest gram on a top loading electrical balance and their total length measured on a fish measuring board to the nearest mm. They were then dissected, sex determined and the ovary was assigned a maturity stage following a gonad maturation staging scheme described by Ntiba (University of Nairobi, Nairobi, Kenya, unpublished) and Ntiba and Jaccarini (1990). Each gonad was weighed to the nearest 0.001 g on an Ohaus Adventurer analytical balance. Gonadosomatic index (GSI) was calculated from the expression: GSI = WO/(WF-WO) × 100, as described by Hickling (1970) and Ntiba and Jaccarini (1990), and where WO is weight of ovary and WF is the weight of fish. From one of the lobes of the ovary, a portion from the anterior, mid and posterior was cut, rinsed in physiological solution and preserved in Bouin's fixative for a minimum period of 24 hours, then rinsed in 50% alcohol and preserved in 70 % alcohol. This material was then dehydrated in a series of graded alcohols, cleared in xylene and impregnated in molten wax at 58–60°C (Steedman, 1960). The impregnated material was embedded in a block of wax, mounted on a microtome and cut into sections of 5–10 μm. The sections were mounted on slides and stained using haematoxylin and eosin (H and E) staining technique. The slides were then examined under a standard microscope, and fitted with a micrometer in the eye piece to study the internal appearance of the ovaries at different stages of maturity. Standard statistical tests (Snedecor and Cochran, 1989) were carried out.

Results

Sex ratio

The monthly variations in sex ratio of the *B. amphigramma* are shown in Table 1. The χ^2 value was calculated to be 20.342; df. = 8, $p < 0.5$ shows that in this population females formed a bigger portion of the fish sampled meaning that the sex ratio is

Table 1. Monthly variation in sex ratios (df = degrees of freedom, x^2 = Chi-square, M and F = numbers of males and females, respectively).

Month	Females	Males	Total	Ratio F:M	Degree of Freedom (df)	Chi (χ^2)
February	83	39	122	2.1:1	1	2.230
March	101	45	146	2.2:1	1	3.670
April	112	49	161	2.3:1	1	4.520
May	95	83	178	1.1:1	1	4.920
June	88	69	157	1.3:1	1	1.940
July	83	67	150	1.2:1	1	2.380
August	98	69	167	1.4:1	1	0.540
September	104	64	168	1.6:1	1	0.014
October	113	65	178	1.7:1	1	0.128
Total	877	550	1427	1.6:1	8	20.342

$\chi^2 = 20.342, df = 8, p < 0.05$

significantly different from the expected 1:1 ratio ($p < 0.05$).

Maturity stages and the breeding cycle

The scheme of Gonad maturation is given in Table 2.

Figure 2 shows the gonad weight relative to body weight at each maturity stage for males and females. These plots more or less confirm the gross morphological criteria used in determining the maturity stages in *B. amphigramma* by visual inspection.

The weights of the testes and ovaries as a percentage of body weight exclusive of gonads, calculated on a monthly basis, are plotted in Figure 3.

These results show that while there is no congruency in changes of the gonad relative to body

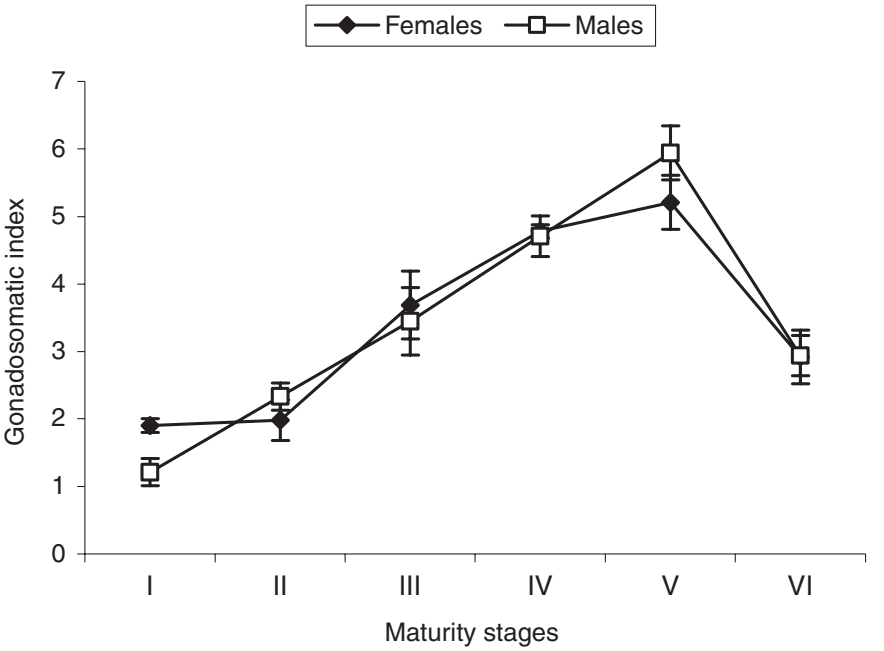

Figure 2. The mean gonadosomatic index of females and male *B. amphigramma* at various maturity stages.

Table 2. Description of the maturity stages of *B. amphigramma* gonads based on modified gonad maturity schemes from Ntiba and Jaccarini (1990).

	Testes	Ovary	Ovary
Maturity	External features	External features	Histological features
Stage 1 Immature virgins	Long, slender and thread like translucent structures occupying 33% of the abdominal cavity.	Long, slender and thread like structures, red in color and occupying 33% of the abdominal cavity	Largest oocytes have a maximum diameter of 25 μm. Many oocytes have small nucleus relative to the size of the thick staining cytoplasm. Ovary wall is 53 μm thick
Stage 2a Developing virgins	Ribbon like structures slightly bigger than 1, grayish-whitish in color and occupy 50% of the abdominal cavity.	Firm and ribbon like slight increase in size, pink in color and occupy 50% of the abdominal cavity, oocytes are discernable.	Largest oocytes have maximum diameter of 54 μm. large circular nucleus. Oocytes have no definite shape. ovary wall is 85 μm thick
Stage 2b Recovering	Same as those in 2a but slightly bigger and firmer.	Same as those in 2a but softer and plump to the touch	Same as stage 2a except for the many residual atretic oocytes.
Stage 3 Maturing	Broad and thick, dark white color blood vessels visible externally and milt oozes out from cut surface. Occupying 70% of the abdominal surface.	Broad and thick occupying 70% of the abdominal cavity red or reddish brown. Blood vessels visible externallyand. oocytes visible though ovary wall.	Largest oocytes have a diameter of 91 μm. Many oocytes with cytoplasmic vacuoles present. Oocytes are contained in well organized ovigerous lamellae, and ovary wall is 200 μm.
Stage 4 Ripe	Further increase in size occupying 90% of the abdominal cavity. White in color. Milt oozes out on slight pressure.	Distended and occupying 90% of the abdominal cavity Blood vessel disappearing and oocytes can be seen clearly through the ovary wall.	Largest oocyte has a diameter of 109 μm. Many oocytes with cytoplasmic vacuoles still present. Largest oocytes are filled with eosinophilic yolk granules. Ovigerous lamellae present but some disappearing.
Stage 5 Running	Fully distended occupying almost all the abdominal cavity exudes milt on slight pressure.	Fully distended with granular surface occupying all of the abdominal cavity	Largest oocytes have a maximum diameter of 121 μm. Many oocytes have thickly staining yolk granules. Some late oocytes have oil globules in the cytoplasm.

(Continued on next page)

Table 2. Description of the maturity stages of *B. amphigramma* gonads based on modified gonad maturity schemes from Ntiba and Jaccarini (1990). *(Continued)*

	Testes	Ovary	Ovary
Maturity	External features	External features	Histological features
Stage 6 Spent	Shrunken and flaccid, walls are harder and wrinkled. No milt oozes out on pressure and blood vessels are visible externally.	Ovary is not fully empty. Residual oocytes present. Flaccid and red in color. Ovary wall is thick.	Largest oocytes have a maximum diameter of 95 μm. Smaller oocytes have thickly stained cytoplasm. Numerous blood vessels at the periphery of the residual oocytes. Post ovulatory follicles present.

weight between the males and females the GSI values remain relatively high and mostly above 2. This alludes to the fact that this fish spawns all year round with probable peaks in March, July and October.

Seasonal occurrence of maturity stages

The percentage monthly occurrence of maturity stages in females alone is shown in Figure 4. All stages (stage I and VI) were present albeit in varying proportions throughout the study which is characteristic of a fish that spawns round the year. The peak spawning periods probably are preceded by a peak in the numbers of stage V ovaries in March, May, August and October. Spent fish are proportionally very low in catches probably because individual fish are multiple spawners carrying batches of oocytes at different stages of development.

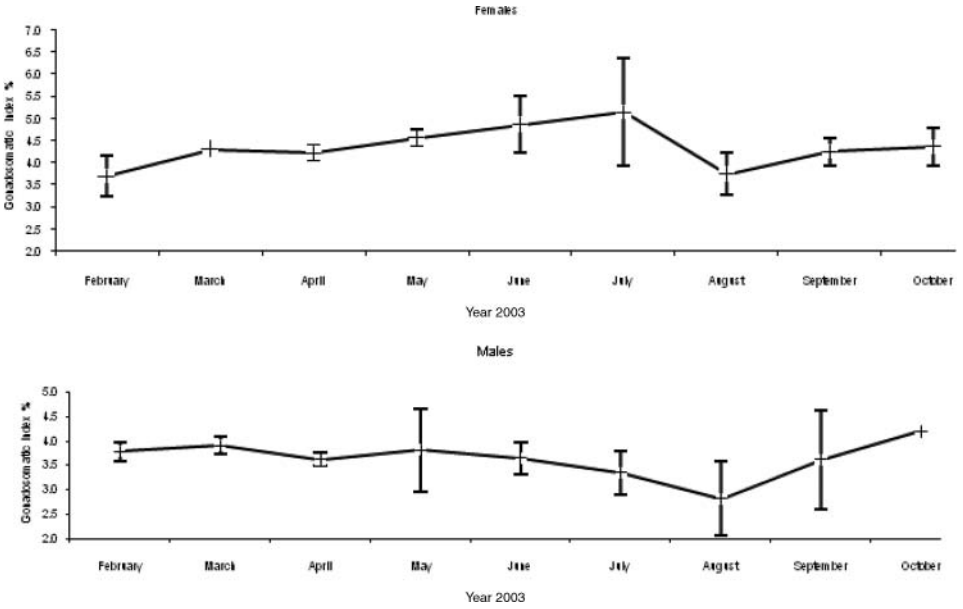

Figure 3. Monthly variation in gonadosomatic index of female (top) and male (bottom) *B. amphigramma* from Lake Naivasha in Feb–Oct 2003. Standard error of the mean (SEM).

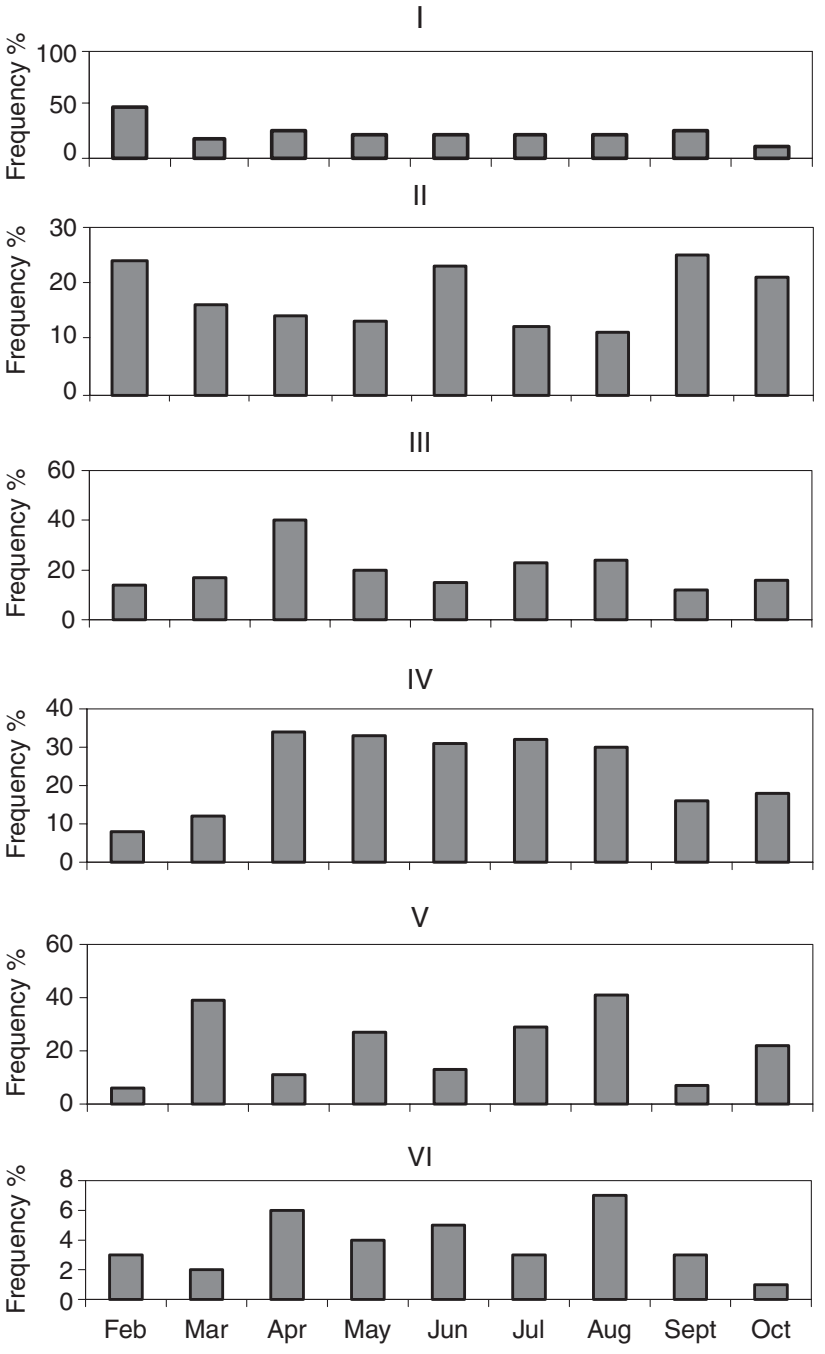

Figure 4. Monthly percentage occurrence of maturity stages of the female *B. amphigramma*

Discussion

The most important conclusion of this study is the clear demonstration that the population of *B. amphigramma* of Lake Naivasha, Kenya spawns throughout the year. The evidence for this is that morphologically ripe gonads occurred throughout the year. Additionally, gonadosomatic indices remained clearly high, mostly above 2, throughout the year, but also showed peaks during the wet

and in the dry season. This coincided with high levels of dissolved oxygen and low temperatures, which made the conditions suitable for spawning. Seemingly young juveniles were present throughout the sampling period, an indication of all year recruitment (Mutia, University of Nairobi, Kenya, unpublished). According to Manyala (1992) the cyprinid, *Rastrineobola argentea,* from Lake Victoria also breeds throughout the year with peaks in August and December-January. In Lake Kariba, Begg (1974) reported that breeding in *Limnothrissa miodon* takes place all year round, a fact supported by the presence of larvae, juveniles and ripe adults. Furthermore, Begg identified two breeding peaks that coincided with periods of increased nutrient availability; the first during the annual turnover (June–August) and then again when the tributary rivers are fast-flowing in January–March. Kenya experiences two rainy seasons during March–June and October-December, respectively. This study has showed that the breeding pattern of *B. amphigramma* is characterized by high (GSI value >2) gonad activity throughout the year. However, even if breeding takes place throughout the year, peak spawning activities occur in March, July and October. The two peaks in March and October coincide with the beginning of the short and the long rains in Kenya. It was of interest to note while fish with ripe ovaries (stage IV) occurred in the samples almost throughout the year fish with running ovaries (stage V) were found in all the stations sampled during the peak spawning time.

Rainy season spawning is well documented among other *Barbus* species in Africa. Gaigher (1976) found that spawning in *Barbus kimberleyensis,* in the Hardap Dam of South West Africa, coincided with peak seasonal rains. Several seasonally spawning *Barbus* have well-defined seasonal run up the rivers and streams to spawn at the start of or early into the rainy period. Payne (1975) found that *Barbus liberiensis* showed movement upstream and a single, discrete, breeding season coinciding with the early part of the rainy seasons.

In a small tributary stream of Lake Victoria near Jinja, Uganda, Welcomme (1979) reported well-defined seasonal migrations in *Barbus kersteinii*, *Barbus apleurogramma* and *Barbus paludinosus*. He classified these three species as potamodromus in that they depend on the river for breeding, early development and on the lake for survival of the adult fish. In Rivers Nzoia and Sondu, both tributaries of Lake Victoria in kenya, Whitehead (1959) reported that *Barbus altianalis, Barbus nummifer and Barbus doggetti* were anadromous, where their breeding coincided with seasonal flooding. However, he classified *B. apleurogramma* as non-anadromous since its adults and juveniles occurred in rivers, streams, swamps, as well as in the floodwater pools of Lake Victoria during the dry season. Furthermore, he also found they spawned amongst the grasses in one of the lakeside streams during the dry season. According to Sempeski and Gaudin, (1995) adults and juveniles of *B. apleurogramma* occur in the heavily vegetated swamps surrounding Lake Nabugabo in Uganda during both the dry and wet season. This probably suggests that the reproductive seasonality and migratory tendencies of the population(s) of this *Barbus* species could change depending on their geographical location and environment.

The significant difference in sex ratio could be attributed to several factors. First, there is a possibility of sex reversal where the males reverse their sex in response to changes in environmental parameters. Secondly, there is a possibility that there is higher male mortality probably attributed to greater reproductive investment. Thirdly, food supply could be a determining factor, where females predominate when food is abundant, while males predominate in oligotrophic environments (Nikolsky, 1963). A more detailed study could unravel the bias of the population towards females.

Conclusions

It is concluded that, although gonad recrudescence showed spawning peaks in March, July and October, several lines of evidence have indicated that *B. amphigramma* of Lake Naivasha, Kenya, spawns throughout the year. The spawning peaks in March and October are clearly associated with the onset of short and long rains, respectively, in Kenya. Finally, a more detailed study is certainly required to unravel the bias of the population in terms of sex ratio.

Acknowledgements

This study was supported through the Kenya-Belgium Inter-University Cooperation Programme (VLIR-IUC-UON) and University of Nairobi to

whom we are extremely grateful. We also wish to thank the Fisheries Department, Kenya and Lake Naivasha Riparian Association for being very supportive during the study. John Mutembei assisted dedicatedly in finalizing the draft paper.

References

Anonymous, 1987. Kenya Fisheries Department Annual Report.

Anonymous, 1989. Kenya Fisheries Department Annual Report.

Begg, G. W., 1974. Investigations into the biology and status of the Lake Tanganyika sardine, *Limnothrissa miodon* (Boulenger), in Lake Kariba, Rhodesia. Lake Kariba Fish. Res. Inst., Proj. Rept. 17.

Gaigher, I. G., 1976. The reproduction of *Barbus* cf. *kimberleyensis* (Pisces, Cyprinidae) in the Hardap Dam, South West Africa. Zool. Afr. 11, 97–110

Harper, D. M., 1984. Recent changes in the ecology of Lake Naivasha, Kenya. Limnol. 22, 1192–1197.

Hickling, C. F., 1970. A contribution to the natural history of the grey mullets (Pisces, Mugilidae) J. Mar. Biol. Asoc. UK 50, 609–633.

Hickley, P., Bailey, R., Harper, D. M., Kundu, R. Muchiri, S. M., 2002. The status and future of Lake Naivasha, Kenya. Hydrobiologia 488, 181–191.

Manyala, J. O., 1992. Growth, mortality and mesh size selection of Dagaa, *Rastrineobola argentea*, in the Winam Gulf of Lake Victoria (Kenya). MSc. Thesis. Univ. Nairobi.

Nikolsky, G. V., 1963. *The ecology of Fishes. 6th ed.* Academic Press, London.

Ntiba, M. J., Jaccarini, V., 1990. Gonad spawning maturation and times of *Siganus sutor* off the Kenya coast: Evidence for definite spawning seasons in a tropical fish. J. Fish Biol., 14, 329–342.

Payne, A. I., 1975. The reproductive cycle, condition and feeding in *Barbus liberiensis*, a tropical stream dwelling cyprinid. J. Zool. Lond. 174, 247–269.

Sempeski, P., Gaudin, P., 1995. Habitat selection by graying. Spawning habitats. J. Fish. Biol., 47, 256–265.

Snedecor, G. W., Cochran, W. G., 1989. *Statistical methods, 8th edition*. Iowa University Press, Ames, Iowa.

Steedman, H. F., 1960. *Section cutting in microscopy*. Blackwell Scientific, Oxford.

Welcomme, R. L., 1979. *Fisheries ecology of floodplain rivers*. Longman Group, London.

Whitehead, P. J. P., 1959. The anadromous fishes of Lake Victoria. Rev. Zool. Bot. Afr. 59, 329–363.