STUDIES ON SOME ASPECTS OF THE BIOLOGY OF THE CATFISH *Bagrus docmac* Forsk (PISCES: BAGRIDAE) IN LAKE CHAMO, ETHIOPIA

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ABSTRACT

Some aspects of the feeding, reproduction, condition and length weight relationship of the catfish, *Bagrus docmac* were studied from February 1995 - February 1996 in Lake Chamo, Ethiopia. A total of 534 fish samples ranging in size from 33.1-99.1 cm fork length (FL) and 500-17400 g in weight were investigated. The length-weight relationship for *B. docmac* was expressed by: $TW = 0.0054FL^{3.24}$. The Clark's condition factor was calculated for both sexes separately. The mean monthly condition values of the males ranged from 0.436 ± 0.011 to 0.489 ± 0.014 while that of the females ranged from 0.449 ± 0.011 to 0.489 ± 0.012.

The diet of *B. docmac* was composed of insects, aquatic snails and different fish species. Insects were identified as larvae, nymphs and adults. The identified prey fish species were *Synodontis schall*, *Labeo horii*, *Oreochromis niloticus*, *Barbus* sp. and *Hydrocynus forskhalii*. Some unidentified fish remains were found due to partial digestion. Small *B. docmac* (< 40 cm fork length) ingested more insects than fish. The large fish was found to be piscivorous, and fish constituted more than 98% of the diet by weight. *S. schall* was the most important prey fish, and occurred more than 81% of all food items of *B. docmac*. The *S. schall* (prey) and the *B. docmac* (predator) length ratio ranged between 1:2 and 1:6.

Sex ratio (male to female) of *B.docmac* was 1:1.07 in the total sample, and not significantly different from 1:1 (X^2 = 10.9;

$p > 0.05$). Among various length classes sex ratio was significant only in fish ≥ 80 cm fork length ($X^2 = 5.18$; $p > 0.05$). Males mature at a smaller size than females. The size at 50% maturity of the males was found to be 68.0 cm fork length while that of the females was 68.6 cm fork length.

An extended breeding period from February-August with spawning peak in May was observed for both males and females. Pulses in breeding activity occurred in the rainy seasons of the lake region.

The estimated number of eggs in the ovary was ranged from 94442-615674. The ripe ovaries contained from 989-2100 eggs per gram of wet weight with the mean number of 1474 eggs/g of ovary. Fecundity was positively related with fork length ($r^2 = 0.64$, $p < 0.05$), body weight ($r^2 = 0.72$, $p < 0.05$) and gonad weight ($r^2 = 0.90$, $p < 0.05$).

1. INTRODUCTION

Catfish, the name generally given to the fishes of the order Siluriformes, are a large and diversified group of fishes that are widely distributed throughout the world. The bagrid catfish (Bagridae) are widely distributed in Asian and African freshwaters. According to Lowe-McConnell (1987), about 100 species of bagrid catfish are found in African freshwaters. Bagrids such as *Chrysichthys* sp. are found in the rivers of West Africa and Zaire and in Lake Tanganyika. *Auchenoglanis* bagrids are more abundant in equatorial West Africa (Lowe-McConnell, 1987). Ajayi (1987) reported the occurrence of *Bagrus* species with other bagrids in Lake Kainji, Nigeria. Lowe-McConnell (1987) pointed out the presence of *Bagrus docmac* (Forskhal) in the inshore demersal zone over hard substrates and rocky areas of Lake Turkana. She also observed *B. bayad* in the deeper water of the lake. Bagrids in Africa are widely distributed occurring in the basins of the Gambia, Nile, Chad, Niger, Senegal and Volta (Golubtsov *et al.*, 1995).

During the exploratory survey of Lake Victoria, Bergstrand and Cordone (1971) documented that *B. docmac* was the most widely spread siluriform fish. They indicated that *B. docmac* comprised approximately 7% of the total fish biomass of the lake.

In Ethiopia, the surveys made so far indicate the occurrence of *B. docmac* (local name: "Karkaro") in the two Southern Rift Valley lakes, Abaya and Chamo (Shibru Tedla, 1973; Ethiopian

Mapping Authority, 1988). In addition *B. docmac* is found in Gambella region (Golubtsov *et al.*, 1995) and Tekeze Valley (Elias Dadebo, Pers. Comm.).

The food and feeding habits of *B. docmac* were investigated by several workers (Corbet, 1961; Elder, 1960; 1962; Motwani, 1970; Chilvers and Gee, 1974; Royce, 1984; Lowe-McConnell, 1987; Okach and Dadzie, 1988; Khallaf and Authman, 1992). Lowe-McConnell (1987) observed that, the feeding behaviour of *B. docmac* varies with the size of the fish. The changes in diet and prey size with the growth of *B. docmac* and *B. bayad* have also been documented by Khallaf and Authman (1992).

Mostly, *Bagrus* spp. are predatory bottom-feeders and feed on invertebrates and\or on other fish. Corbet (1961) pointed out that *B. docmac* is a major predator in waters of Victoria basin, depending almost entirely on the Haplochromine cichlids. In addition, Gee and Gilbert (1967) and Bergstrand and Cordone (1971) showed that *Haplochromis* was the most important prey of *B. docmac* in Lake Victoria. Chilvers and Gee (1974) reported the feeding similarities between *B. docmac* and Nile perch, *Lates niloticus*. Accordingly, both species feed predominantly on invertebrates when young but shift to piscivorous feeding habits as adults. However, *B. docmac* and *L. niloticus* are mutually exclusive in their bathymetric distributions and they also have different preferences for water temperature and conductivity (Okach and Dadzie, 1988).

The reproductive adaptation of *B. docmac* has been studied by some authors (Elder, 1960; McKaye and Oliver, 1980; Rinne and Wanjala, 1983; Dadzie and Okach, 1989). Available information shows that *B. docmac* moves into shallow water to spawn where it makes a nest on a sandy bottom against a rock. Migration among the other bagrid catfish populations from the deeper areas to the shallow inshore waters to spawn has also been reported by some authors (Corbet, 1961; Lock, 1975). According to Lowe-McConnell (1987) *B. docmac* females grow to a larger size than the males. The males stay on the breeding grounds for longer periods while guarding the eggs and young (McKaye and Oliver, 1980).

With the everincreasing need for various sources of protein to meet the world's expanding population, a comprehensive fish resource management as well as wise and efficient utilization of existing fisheries are of utmost importance. The management of fish resource needs a substantial body of scientific information. The important part of such information base is the knowledge of finding out what kinds of fish are present and understanding the rate at which the fish grow and reproduce. In addition, the size at which the fish spawn, the maturation rates they exhibit and the feeding patterns are well of considerable importance (Lowe McConnell, 1987). Thus more attention has to be given to fisheries research that aim at obtaining information on basic biology of desirable fish species, such as *B. docmac*.

The catfish are of special importance as food fish, because they have few bones in their flesh. The commercial importance of the catfish have been pointed out by some workers (Royce, 1984; Payne, 1986; Elias Dadebo, 1988). The bagrid catfish *B. docmac* is one of the main fish supporting important fisheries in lakes and rivers. It was mentioned that the catfish *B. docmac* and *Clarias mossambicus* were the two important fish species in fishermen's catches and a major food source for the human population around Lake Victoria region (Benda, 1979). Marten (1979) also suggested the importance of fishing *Bagrus* in Lake Victoria.

B. docmac is one of the main commercially important fish species in Ethiopia. It is a highly regarded and valuable fish. It has very few intramuscular bones, and accepted as valuable food fish. Therefore it is of considerable importance in the fisheries of Lakes Chamo and Abaya.

Inspite of its importance, no published information is available on the biology of this fish in Ethiopia. In the present account, a study of the various aspects of the biology of *B. docmac* has been conducted in Lake Chamo. The objectives of this work were:

1. To study the food and feeding habit of *B. docmac* in Lake Chamo.
2. To determine the maturation, breeding period and fecundity of the fish.
3. To assess the length-weight relationship and condition factor of the fish.

The study may provide some basic information for further investigation of *B. docmac* in the country. Particularly, the information on feeding and breeding would be desirable to a better understanding of the ecology of the fish in the lake. The results obtained from this study may also provide information which guides the proper utilization and management of the fish in Lake Chamo.

2. DESCRIPTION OF THE STUDY AREA

Lake Chamo lies within the Ethiopian part of the great African Rift Valley. The Rift Valley lakes of Ethiopia are found in the southern half of the country where there are seven major and permanent natural lakes that vary in size and depth (Fig.1). The recent geological history of the lakes has been reviewed by Grove *et al.* (1975). The lakes of the main Ethiopian Rift System lie in three separate internal drainage basins (Zinabu G/Mariam and Elias Dadebo, 1989; Elizabeth Kebede *et al.*, 1994). In the north is the Ziway-Shalla basin, further south is the Awassa-Shallo complex and finally the Abaya-Chamo lakes drainage system. The Abaya-Chamo lakes are part of a much larger drainage basin which includes Lakes Chew Bahir (formerly Lake Stephanie) and Turkana (Von Damm and Edmond, 1984).

Lake Chamo is the most southern of the Ethiopian Rift Valley lakes, about 530 km south of Addis Ababa. It lies at an altitude of 1233 m and has a surface area of approximately 551 km^2 and a maximum depth of 13 m (Amha Belay and Wood, 1982; Green and Seyoum Mengestou, 1991). The Abaya-Chamo basin comprises most of the floor of the Rift Valley below 1500 m altitude, and between latitudes 5°30'N and 6°30'N and longitudes 36°30'E and 38°30'E (Makin *et al.*, 1975). Lake Chamo lies within the less intensely faulted basin, and to the east of the lake rises the remarkable precambrian block of the Amaro Mountains (Mohr, 1962). Lake Chamo is fed principally by Kulfo River entering from the north.

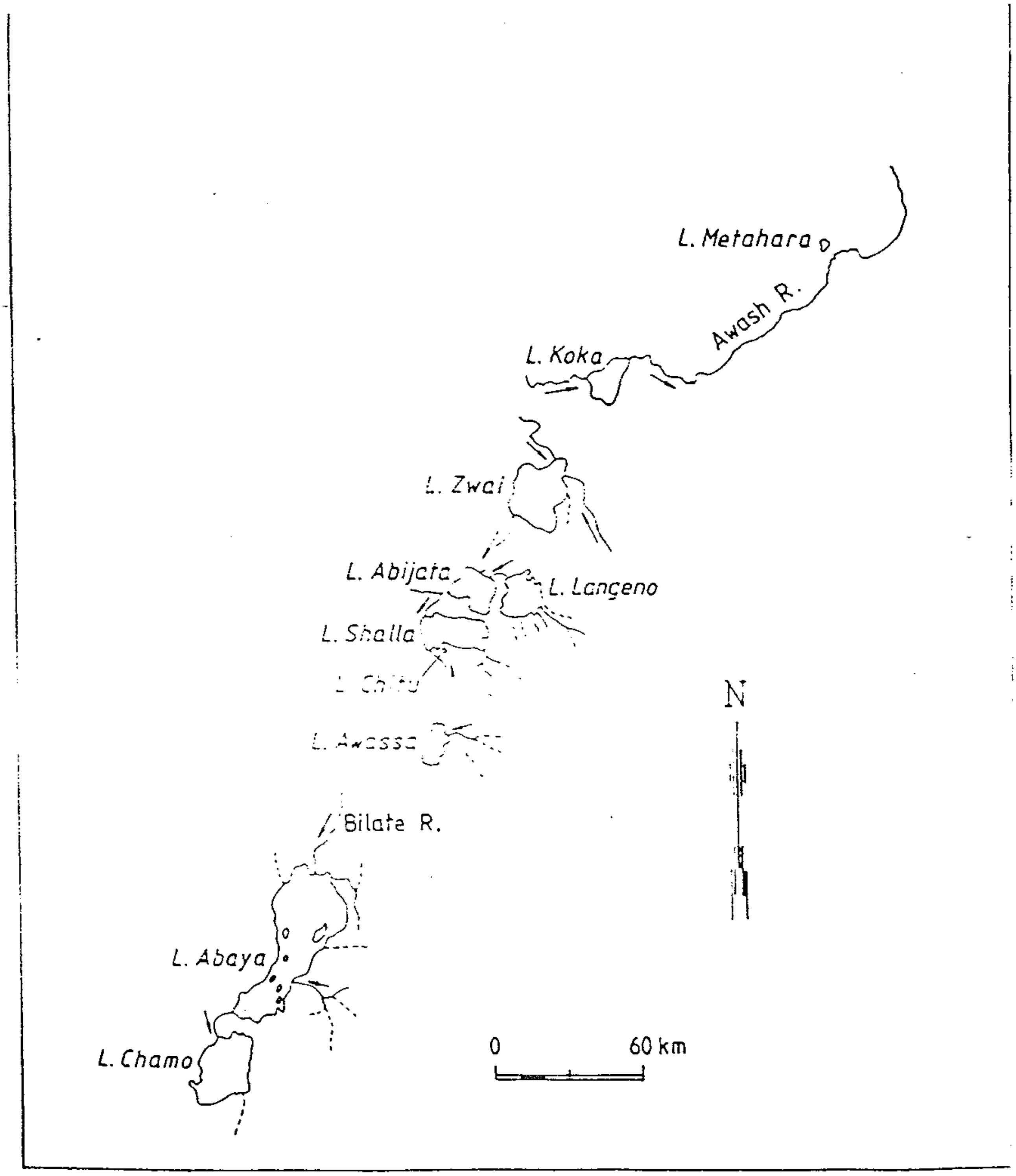


Fig. 1. Location of Lake Chamo in relation to the other Rift Valley Lakes of Ethiopia (source: Elizabeth Kebede *et al.*, 1994).

The less important feeders are the Sile and Sego Rivers from the west. Lake Chamo is connected by a broad channel to the Sagan River which rises close to the southeastern corner of Lake Abaya. Beadle (1981) suggests that Lake Chamo discharges into the Sagan River in periods of flood. At present time, the water level of the lake is lower than that of the outlet channel, thus Lake Chamo has no obvious surface outlet currently.

The climatic condition of the Lake Chamo region consists of one dry and one rainy season per year (Daniel Gemetchu, 1977). The data collected from the local meteorological station of Northern Omo Agricultural Development Enterprise shows that the rainy months are contiguously distributed from March to October (Fig.2). The annual amount of rainfall ranges from 600 to 1000 mm. Currently, there is a reduction in water level of the lake as compared to the level reported by Daniel Gemetchu(1977). The mean monthly maximum and minimum air temperatures of the area are given in Fig.3 for six years (from 1990 to 1995) and compared to that of the average monthly maximum and minimum air temperature of the sampling year, 1995. The existing average air temperature of the lake region is higher than that of the previous records (Fig.3)

The physical features and chemical composition of the lake are indicated in Tables 1 and 2, respectively. There is a significant human activities around the lake, particularly the increased use of irrigation, tree cutting and burning.

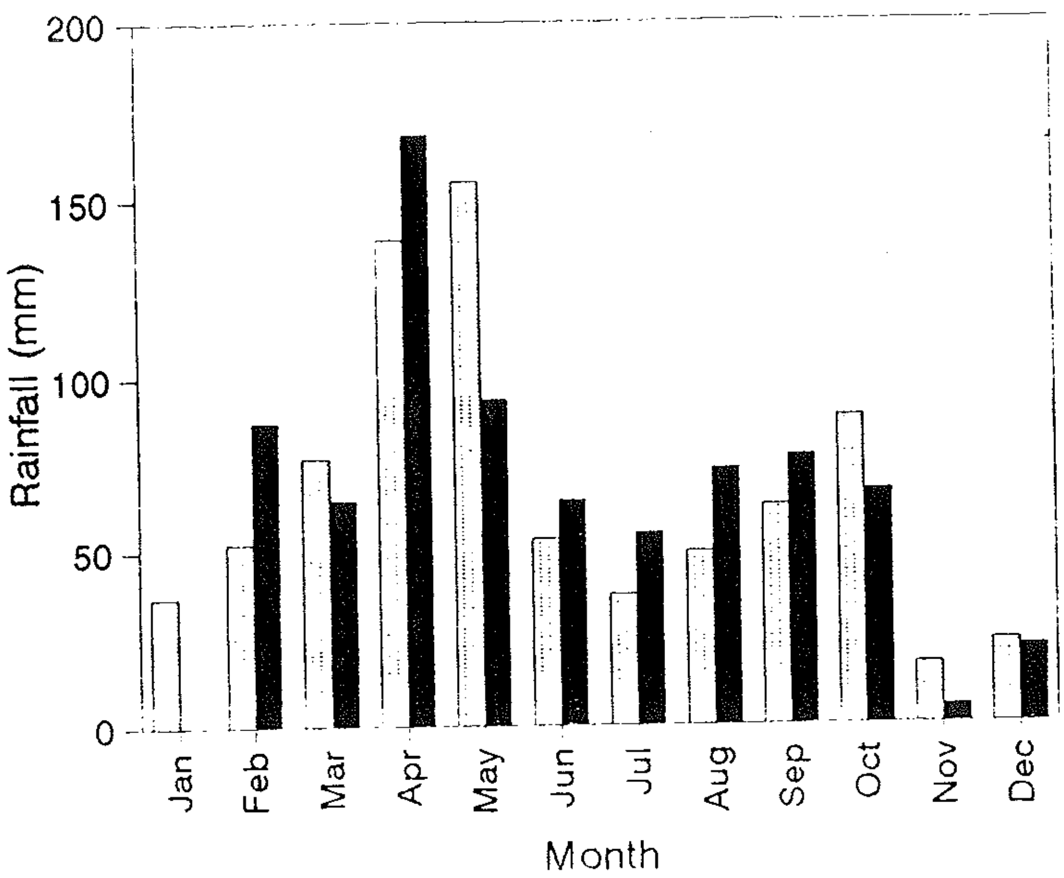


Fig. 2. Seasonal variation in rainfall (mm) for the Lake Chamo region. Mean monthly rainfall from 1990-1995 (open bars) and the total monthly rainfall for 1995 (closed bars) are indicated separately.

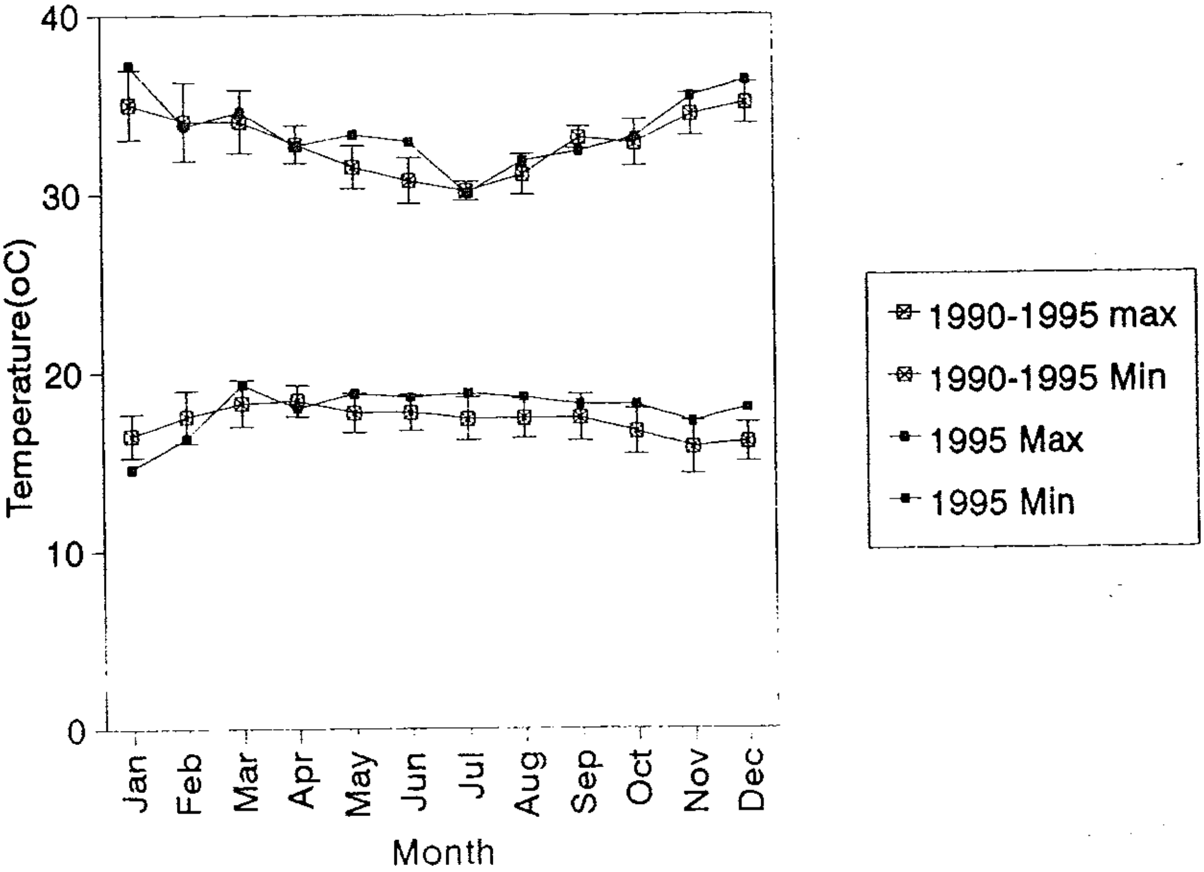


Fig. 3. Seasonal variation in the maximum and minimum air temperature °C of the Lake Chamo region. The mean monthly maximum and minimum air temperature for the period between 1990-1995 and the average maximum and minimum air temperature for 1995 are indicated separately.

Based on previous works (Amha Belay and Wood, 1982; Wood and Talling, 1988), the level of nutrients and chlorophyll a values suggest that Lake Chamo is a highly productive lake. The study of limnological aspects of an algal bloom on this lake by Amha Belay and Wood (1982) shows that different phytoplankton species dominate at different depths and sites of the lake. The major groups of phytoplankton of the lake are *Tribonema*, *Synedra*, *Anabaenopsis*, *Chroococcus* and *Microcystis* species. It is interesting to note that algal blooms and fish kills have been more common in this lake since the time when they were first reported by Amha Belay and Wood (1982).

According to Green and Seyoum Mengestou (1991) the dominant rotifer of the lake is *Brachionous angularis* Gosse. The cladocerans of Lake Chamo include *Moina micrura*, *Ceriodaphnia cornuta* and *Daphnia magna*, of which *Moina micrura* is highly abundant (Seyoum Mengestou, Pers. Comm.). The known copepods of the lake are *Mesocyclops ogunnus* Onabamiro and *Thermocyclops decipiens* Kiefer (Defaye, 1988). The major benthic groups in Lake Chamo are oligochaetes, gastropods, ostracods, chironomoids and the hemipterans (Tudorancea *et al*., 1989).

Lake Chamo is mainly shallow, with rich marginal vegetation composed of *Typha phragmites* and *Juncus* species as well as tall water side grasses such as *Loudetia phragmitodes* and *Sesbiana* sp. (FAO, 1992). The most important woody plant in the western riverine shore of the lake is *Aeschynomene elaphroxylon* (local name; "Sokee"), from which the fishermen construct their fishing rafts.

The ichthyofauna of Lake Chamo (Table 3) is similar to that of the neighbouring lake Abaya, and both have a more diverse fish fauna than the other Rift Valley lakes of the country. The fish species of these lakes represent the Soudanian fish fauna, fish species found in the Nile system (Beadle, 1981). He believes that Lakes Abaya, Chamo, Chew Bahir and Turkana were connected, and that Lake Turkana overflowed into the Nile giving a free passage for the Soudanian fauna up into Lakes Abaya and Chamo.

Currently, six fish species are of great economic importance and support a flourishing commercial fishery in Lake Chamo. These are *Lates niloticus, Bagrus docmac, Oreochromis niloticus, Labeo horii, Clarias gariepinus* and *Barbus* sp., with decreasing order of importance. The small catfish, *Synodontis schall*, is very abundant but is not of direct economic importance at present. *Labeo horii* is also economically important, because it provides food for the crocodile farm situated close to the Arba Minch town.

According to FAO (1992), the potential sustainable yield of Lake Chamo ranges between 3 and 5.5 thousand tons/year. The estimated current catch for the year 1994-1995 from this lake is 1814 tons (Lake Fisberies Development Project,1995).
All fishermen in Lake Chamo are using wooden rafts("Ogolo") constructed from *Aeschynomene elaphroxylon*. Herrmann (1993) mentions that gillnets have introduced to this lake in 1988. At the moment, gillnetting is the major type of fishery. Mostly, the catfish are traped by hooks and longlines.

Information on water birds at Lake Chamo is sparse. However, white pelican (*Pelecanus onocrotalus*), pink-backed pelican (*Pelecanus rufescens*), herons, long-tailed cormorant (*Phalacrocorax africanus*), darters (*Anhinga rufa*) and Storks are common around the lake. In addition, a large colonies of *Leptoptilos crumeniferus* and small numbers of yellow-billed stroks (*Ibis ibis*) are supported in the forest near the lake.

A large population of hippopotamus (*Hippopotamus amphibius*), Nile monitor (*Varnus niloticus*) and Nile crocodiles (*Crocodilus niloticus*) are also found in Lake Chamo.

Table 1. Some morphometric features of Lake Chamo

Characteristics	Values
Latitude	5°50'N (d)
Longitude	37°35'E (d)
Altitude	1233 m (c)
Surface area	551 km^2 (c)
Catchment area	2210 km^2 (a)
Length	36 km (b)
Width	23 km (b)
Perimeter	118 km (b)
Max. depth	13 m (e)
Secchi depth	65 cm (a)

(a) Elizabeth Kebede *et al.*, 1994

(b) FAO, 1992

(c) Wood and Talling, 1988

(d) Makin *et al.*, 1975

(e) Welcomme, 1972

Table 2. The chemical composition of Lake Chamo

Chemical features	Mean values
pH	8.90 (a)
Chlorophyll a	89 μgl^{-1} (a)
Salinity	1.099 gl^{-1} (c)
Conductivity (K_{20})	1000 μScm^{-1} (c)
Calcium (Ca^{2+})	0.35 $meql^{-1}$ (b)
Magnesium (Mg^{2+})	0.70 $meql^{-1}$ (b)
Sodium (Na^{+})	12.61 $meql^{-1}$ (b)
Potassium (K^{+})	0.78 $meql^{-1}$ (b)
Chloride (Cl^{-})	2.02 $meql^{-1}$ (b)
Sulfate (SO_4^{2-})	1.10 $meql^{-1}$ (b)
Carbonate-bicarbonate (CO_3 HCO_3)	12.25 $meql^{-1}$ (b)
Total cations	11.9 $meql^{-1}$ (a)
Total anions	11.7 $meql^{-1}$ (a)

(a) Amha Belay and Wood, 1982

(b) Elizabeth Kebede *et al.*, 1994

(c) Wood and Talling, 1988

Table 3. A list of Major Fish Species found in Lake Chamo

Family	Species	Common name
Mormyridae	*Mormyrus caschive*	Elephant snout fish
Charcidae	*Hydrocynus forskalii*	Tigerfish
Cyprinidae	*Barbus bynni*	Barbus
	Barbus sp.	"
	Labeo horii	Labeo
	Labeo niloticus	"
Bagridae	*Bagrus docmac*	Catfish
Clariidae	*Clarias gariepinus*	"
Mochokidae	*Synodontis schall*	"
Schilbeidae	*Schilbe* sp	"
Cyprinodontidae	*Aplocheilchthys* sp.	Minnow
Centropomidae	*Lates niloticus*	Nile perch
Cichlidae	*Oreochromis niloticus*	Tilapia

3. MATERIALS AND METHODS

3.1. Sampling and Measurements

B. docmac were collected over a thirteen months period between February 1995 and February 1996 using stationary longlines at three different sites of the lake; Desset, Bedena and Bolle (Fig.4). In addition, beach seines and small hook and line gear were used to obtain a wider range of fish size. The commercial gillnet catch was also sampled. However, sampling methods other than the stationary longlines were usually not successful. Five pieces of stationary longlines, each with 100 similar sized hooks and 200 m long were used. The hooks were numbered from 1 to 5 in decreasing order of size. The hooks were baited usually with *S. schall* and were set on surface of the water during the afternoon and lifted in the following morning. Monthly sampling was done for 5 days on the lake.

The fork length (FL) and standard length (SL) of all individual samples were immediately measured to the nearest 0.1 cm. The total weight (TW) and eviscerated weight (EVW) of individuals under 1000 grams were weighed to the nearest gram whereas those between 1000 and 2000 grams were weighed to the nearest 5 grams. Fish over 2000 grams were weighed to the nearest 50 grams. All fish were dissected and the stomach inspected for its contents. The entire content of the stomach was removed and preserved in 5% formaldehyde solution. The sex of each fish was identified by inspecting its gonads. The maturity stages of the gonads were assessed by visual examination based on a five point maturity scale (Holden and Raitt, 1974) (Table 4).

Ripe ovaries were removed, weighed to the nearest 0.1 g, and preserved in a modified Gilson's fluid: 100 ml 60% ethanol + 880 ml water + 15 ml 80% nitric acid + 18 ml glacial acetic acid + 20 g mercuric chloride (Simpson, 1951). In order to assist penetration by the preservative, the ovaries were split longitudinally and turned inside out (Bagenal and Braum, 1978). Then samples were transported to Addis Ababa for laboratory examination.

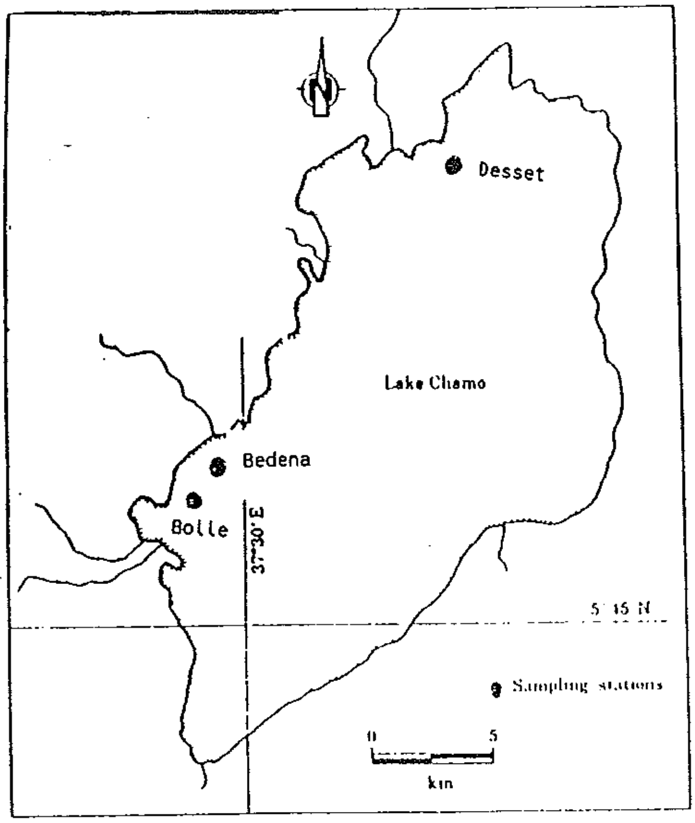


Fig. 4. Map of Lake Chamo showing sampling stations (source: Getachew Tefera, 1993).

Table 4. A five point maturity scale (Holden and Raitt, 1974).

Stage	Description
I Immature	Ovaries and testis are about 1/3 length of the body cavity. Ovaries pinkish, translucent; testes whitish. Ova not visible to the naked eye.
II Maturing virgin recovering spent	Ovary and testis about 1/2 length of body cavity.Ovary pinkish, translucent; testes whitish, more or less symmetrical. Ova not visible to naked eye.
III Ripening	Ovary and testis are about 2/3 length of body cavity. Ovary pinkish yellow with granular appearance; testes whitish to creamy. No translucent ova visible.
IV Ripe	Ovary and testis from 2/3 to full length of body cavity. Ovary orange-pinkish colour with conspicuous superficial blood vessels, large transparent, ripe ova visible. Testes whitish creamy, soft.
V Spent	Ovary and testis shrunken to about 1/2 length of body cavity. Walls loose. Ovary may contain remnants of disintegrating opaque and ripe ova, darkened or translucent. Testes blood shot and flabby

3.2. Determination of length-weight relationship and Condition factor

FL and TW were used to calculate length-weight relationship. The length-weight relationship was calculated by using the method of LeCren (1951): $TW = aFL^b$, where TW is in g, FL in cm, a is intercept and b is slope. Length composition of the sample used in this study was determined after classifying the data into seven FL groups of 10 cm width.

Clark's condition factor (K') was used to study seasonal and sex based variation in the well-being of *B. docmac*. The body weight without gonad and stomach i.e., eviscerated weight (EVW) and the fork length of the fish were used to determine the condition factor. K' values of the individual fish were calculated using the method of Bagenal and Tesch (1978): $K' = 100EVW/FL^b$. Monthly condition values of male and female fish were then determined. The K' values were statistically tested by using ANOVA, and means compared using Tukey's and Sheffe's multiple comparison methods (Zar, 1984) to determine if the values varied between sexes and between months.

3.3. Determination of Food and Feeding habits

The food items were identified and quantitatively analyzed using the following methods.

3.3.1. *Frequency of occurrence*

The number of stomach samples containing one or more individuals of each food category was expressed as a percentage of all stomachs containing food (Windell and Bowen, 1978). This method records the number of stomachs in which a given food item occurred irrespective of its size or abundance. The proportion of fish that fed on certain food items was then calculated.

3.3.2. *Percent composition by number*

The number of individuals of a given food type that were found in all stomach samples examined was expressed as a percentage of the total number of individuals counted in all food categories (Crisp *et al.*, 1978; Hyslop, 1980; Bowen, 1983). The relative abundance of each food item in the diet was then estimated.

3.3.3. *Percent composition by weight*

The weight of food items in each food type was expressed as a percentage of the total weight of ingested food in the stomach contents analyzed (Bowen, 1983). If the prey fish were only slightly digested, they were weighed directly. If prey were partially digested, the method of "reconstructed weights" (Pearre, 1980) was used to estimate their weight at ingestion. In this procedure,the length of the indigestible hard part, i.e., the dorsal spine of the most important prey fish (*S. schall*) was measured. Weight of prey was then estimated from the relationship between the length of the dorsal spine and the weight of the prey that was established from prey specimens collected from the lake. Other fish prey were weighed and the weight before ingestion was estimated according to the degree of digestion. The weight of invertebrate prey were obtained from the average weight of invertebrate prey collected from the lake.

3.4. Determination of Fish size- Food habit relationship

Percent composition by number and by weight data were arbitrarily classified into six fish length groups. The relative importance of each food item for fish belonging to each length class was then determined using Fagade and Olaniyan (1972) method. Variation in food habit with fish size was then studied.

3.5. Determination of Prey and Predator relationship

This part of the study was concentrated on the relationship between *B. docmac* size and the size of the most important prey fish, i.e., *S. schall*. The FL of the prey was determined variously depending on the degree of digestion. If the prey was digested slightly (i.e. FL was not affected), then its FL was measured directly. On the other hand, the FL of a digested prey was indirectly estimated using a relationship that was established between size of an indigestible body part (i.e., dorsal spine) and FL of the prey sampled from the water (Ajayi, 1987).

3.6. Reproductive Biology.

3.6.1. *Determination of Sex ratio, breeding season and size of maturation*

Sex ratio (male to female) was determined for various size classes of fish. Chi-square test was done to identify the significance differences in sex ratio. To determine breeding season, the number of fish at gonad stages IV and V, i.e. breeding individuals, was determined for each sampling occasion. The percentage frequency of breeding fish was then plotted by months. The time of year when the frequency was high was then taken as the peak breeding season of the fish. The size at which 50% of the fish were mature was also determined according to Beverton and Holt (1957).

3.6.2. *Estimation of Fecundity*

Ripe eggs were liberated from the ovaries that were preserved in Gilson's fluid. Then, the eggs were separated from the ovarian tissue by washing through a series of sieves. Fecundity, the total number of ripe ova just prior to spawning (Bagenal and Brawm, 1978) was estimated by the gravimetric method (Kipling and Frost, 1969). Three 1 g sub-samples were taken from each fish and the average number of eggs per 1 g weight of eggs was determined. Then, the average number per 1 g was related to the total weight of all eggs to estimate fecundity of each fish. The relationships between fecundity and fish size (i.e., FL and TW), and fecundity and gonad weight were determined using least squares regression analysis (Sokal and Rohlf, 1981).

4. RESULTS

4.1 Length-Weight Relationship and Condition factor

A total of 534 fish were sampled during the period February 1995 to February 1996. The samples ranged from 33.1 to 99.1 cm in fork length (FL) and from 500 to 17400 g in total weight. The length composition and sample size of the fish grouped into 10 cm FL are indicated in Fig. 5. Length-weight relationship was curvilinear (Fig. 6) and statistically significant (r^2 = 0.89, $p < 0.05$). The regression equation fitted to the data was as follows: $TW = 0.0054 \times FL^{3.24}$.

Mean ± SE Clark's condition factor of *B. docmac* in Lake Chamo ranged from 0.449 ± 0.011 to 0.489 ± 0.012 for females and from 0.436 ± 0.011 to 0.489 ± 0.014 for males. The smallest condition values for females and males were in July 1995 and February 1996, respectively. The largest condition values were recorded in February 1996 for females, and in January 1996 for males. The values did not vary significantly (ANOVA, $F = 4.77$ $p = 0.03$) between sexes. The month by sex interaction term in the ANOVA was also insignificant suggesting a similar seasonal fluctuation pattern in conditions of both males and females (Fig. 6). ANOVA test showed a significant variation in condition factors among months (Table 5). However, multiple comparison tests (i.e., Tukey and Sheffe test) could not differentiate variation in condition of the fish among months (Table 6). Fig. 8 shows the condition of the fish plotted against the FL. The values remained almost constant with increase of the FL.

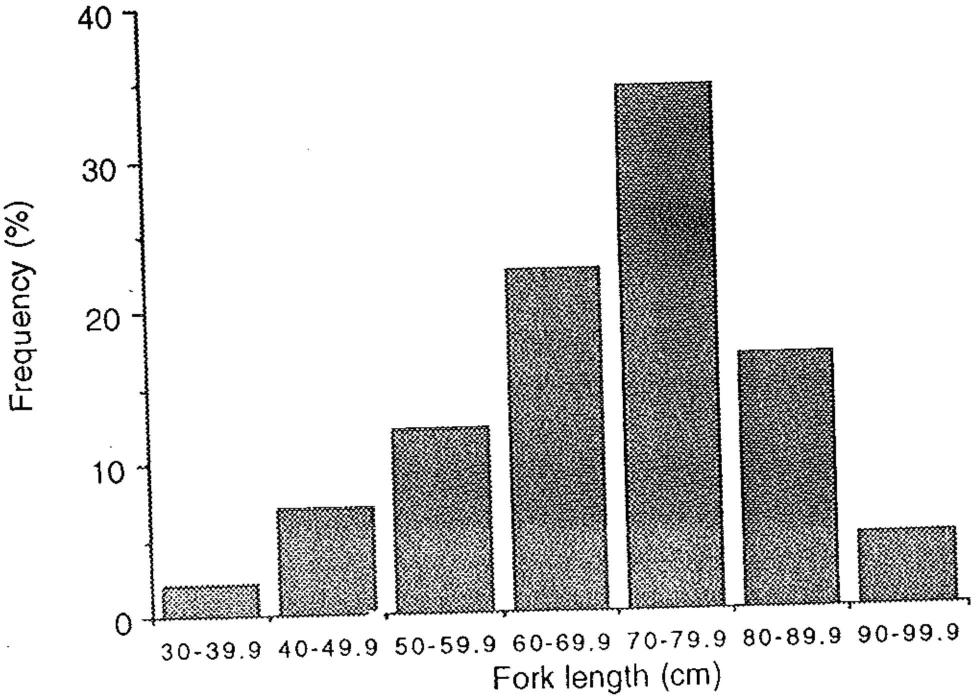


Fig.5. Length composition and sample size of *B.docmac* grouped in 10 cm FL.

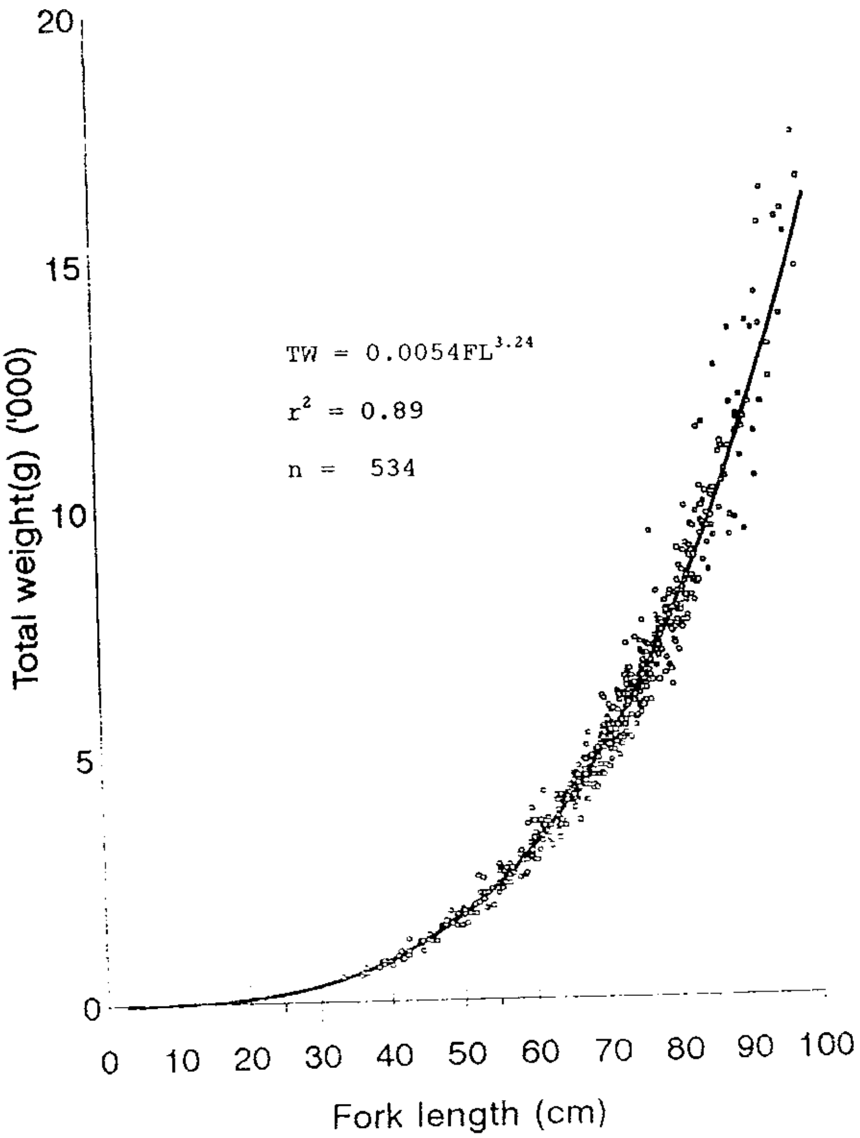


Fig. 6. The length-weight relationship of *B. docmac* in Lake Chamo.

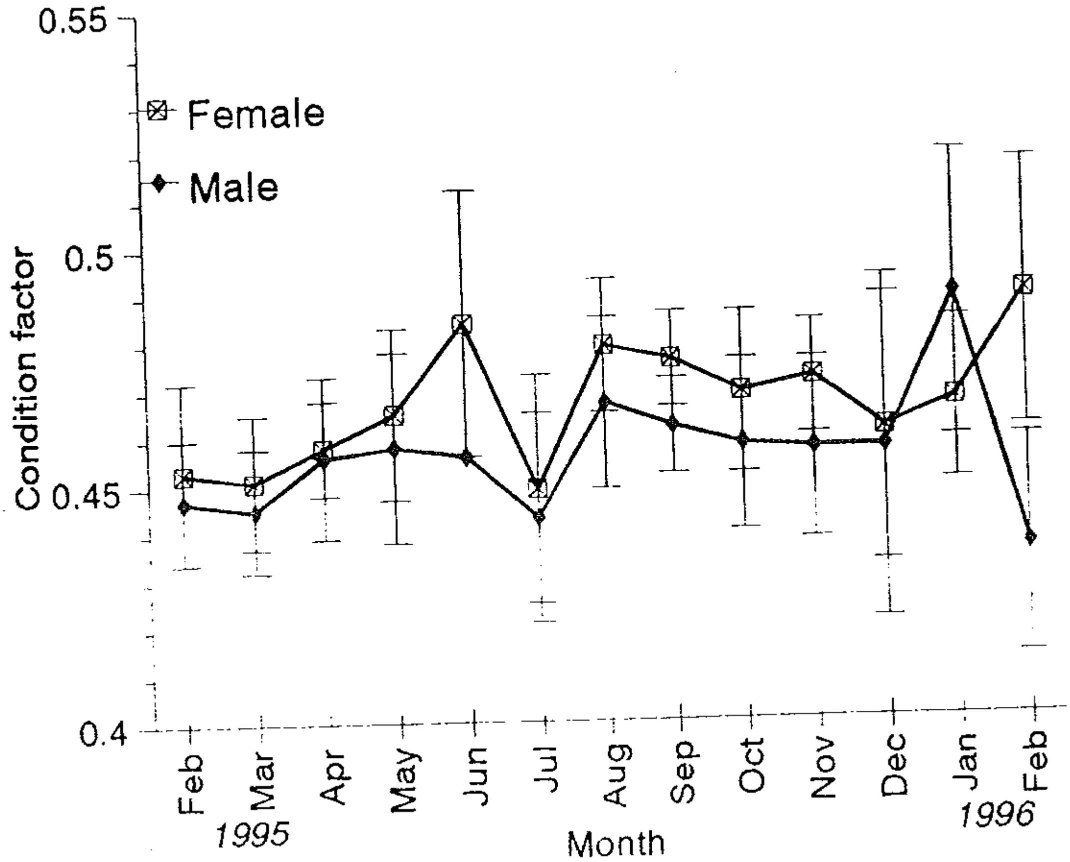


Fig. 7. The mean monthly Clark's condition factor of *Bagrus docmac* in Lake Chamo. The values for different months are plotted separately for males and females. The 95% confidence intervals are indicated.

Table 5. Results of two-way ANOVA to determine significant differences in fish condition factor.

	d.f	F value	probability
Month	10	2.73	0.003
Sex	1	4.77	0.03
Month X Sex	10	0.752	0.675

Table 6. Results of multiple comparison test to determine significant differences in condition factor between months

	Tukey test	Sheffe test
Critical value	q = 4.552	S = 4.30
Calculated value	all q < 4.552	S = 2.36
p value	p < 0.05	p < 0.05

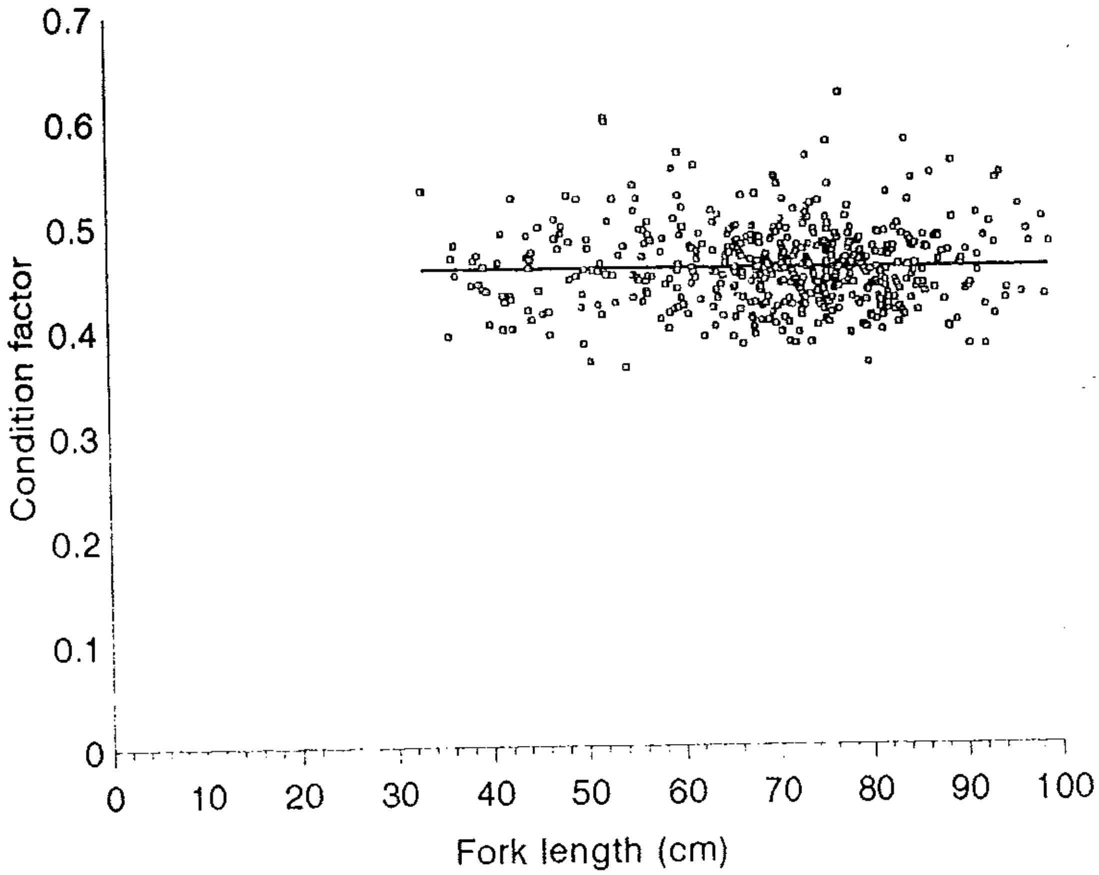


Fig. 8. The relationship between Clark's condition factor and fork length of *B. docmac*.

4.2 Food and Feeding habits

From the total number of fish caught during the period of investigation, 280 (52.4%) contained food in their stomachs. The diet of *B. docmac* in Lake Chamo was composed of insects, molluscs, and different fish species (Table 7). Insects were identified as young stages (larvae and nymphs) and adults belonging to four sub-groups. Shells of aquatic snails (i.e. Gastropoda) were found in the gut of some specimens. Fish were found in the gut of most specimens. The identified fish species in the gut of *B. docmac* were *H. forskhalii*, *Barbus* sp., *L. horii*, *O. niloticus* and *S. schall*. However some were partially digested and unidentifiable.

All the four sub-groups of insects were grouped to one food category (i.e., Insects) for further analysis. Generally, eight categories of food items were identified in the diet of *B. docmac* (five fish groups, two invertebrates (i.e., insects and molluscs), and unidentified fish remains).

Although there were different food categories in the diet of *B. docmac*, some food items were found to be more important than others. Generally, among the fish groups, *S. schall and L. horii* were found to be the major food items. Similarly, insects were the major food items among invertebrates. Based on the frequency of occurrence method, the main items in descending order of importance were *S. schall* (81.1%), insects (20%) and *L. horii* (17.1%) (Fig. 9).

Table 7. Food items identified in the gut of *B. docmac* from Lake Chamo.

Insecta
Chironomidae larvae
Odonata nymph
Coleoptera
Hemiptera
Mollusca
Gastropoda
Pisces
Synodontis schall
Labeo horii
Oreochromis niloticus
Barbus sp.
Hydrocynus forskhalii
Unidentified fish remains

A similar order of importance of the major items was also found based on numerical analysis and gravimetric analysis except that insects were less important in the case of gravimetric method (Fig. 9). The minor food items combined constituted 17.5% by occurrence method, 10.9% by each of numerical and gravimetric methods.

Among food categories of *B. docmac*, it is evident that *S. schall* contributed most of the amount and bulk of the food. The weight of partially digested *S. schall* was estimated by using the equation derived from dorsal spine length vs body weight: Log_{10} TWs = $-3.6 + 3.36Log_{10}$SPL, ($r^2 = 0.77$, $p < 0.05$, $n = 81$) (Fig.10) where TWs is total weight of *S. schall* and SpL is dorsal spine length. A total of 281 (63%) *S. schall* weighing 23.68 kg (69.2%) were recorded in comparison with all other food items combined.

4.3. **Food in Relation to Size of** *B. docmac*

The composition of the diet of *B. docmac* was found to vary with its size (Figs 11 a and b). The most evident result is that the importance of invertebrates (particularly insects) decreased whereas that of fish increased with increase in the length of *B. docmac*. Numerically, invertebrates were 43.8% of the diet for *B. docmac* between 30.0 and 39.9 cm FL, but they were less than 2.5% of the food of fish $\geq$ 80.0 cm FL (Fig. 11a). Based on the gravimetric method, invertebrates

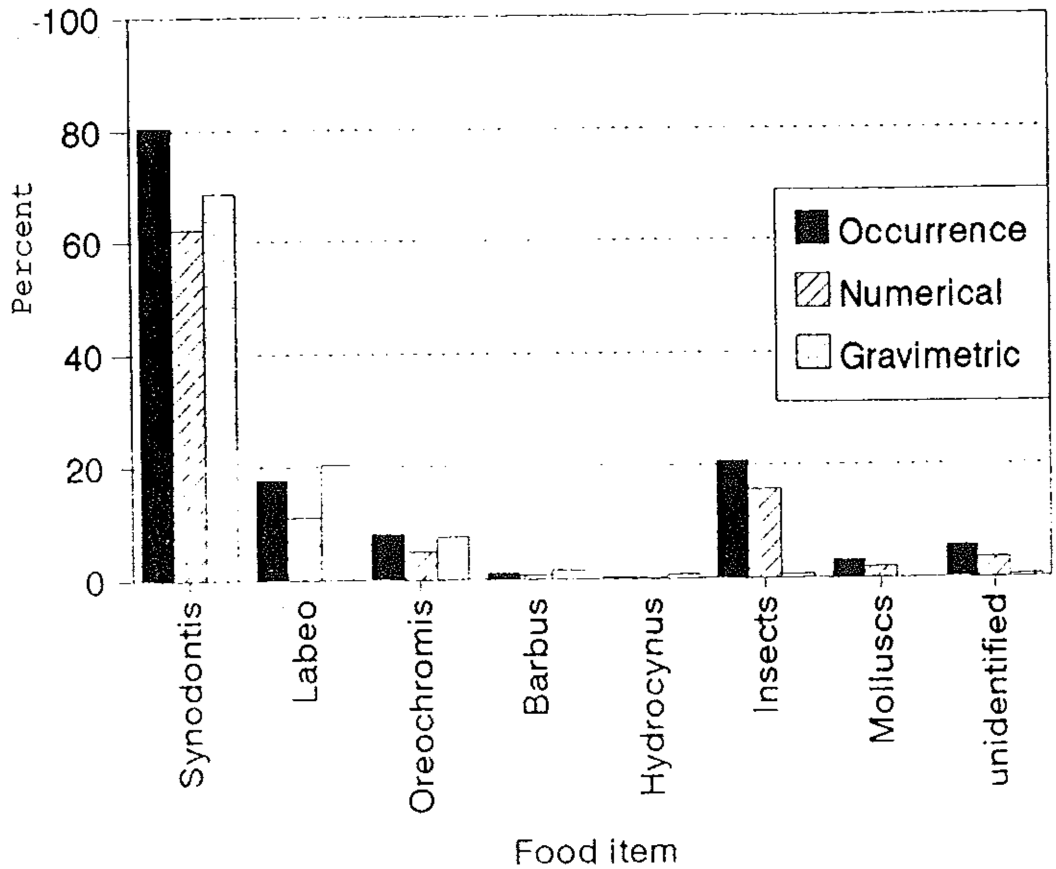


Fig. 9. Relative importance of various food items to the diet of *B. docmac* in Lake Chamo determined using the occurrence, numerical and gravimetric methods.

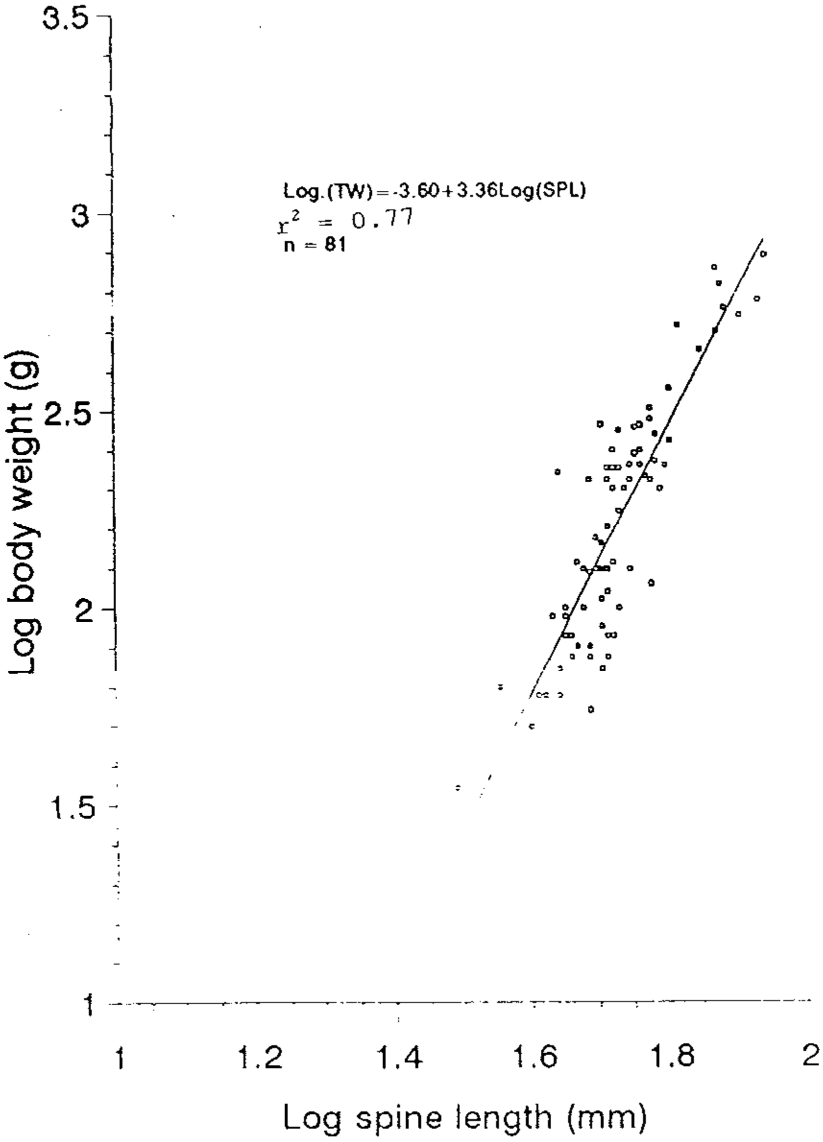


Fig. 10. The relationship between Log_{10} (dorsal spine length) and Log_{10}(body weight) of *S. schall* in Lake Chamo. The equation shown in the figure was used to reconstruct the weight of *S. schall* ingested by *B. docmac*.

were 4.4% by weight of the food of *B. docmac* between 30.0 and 39.9 cm FL. This value decreased to < 0.1% for *B. docmac* ≥ 80 cm FL (Fig. 11b). In contrast, fish prey contributed 56.2% by number and 95.6% by weight for *B. docmac* between 30.0 and 39.9 cm FL. However, the contribution of fish prey increased upto 97.6% by number and 99.9% by weight for *B. docmac* ≥ 80.0 cm FL. In comparison to the other fish prey, it is evident that *S. schall* showed increasing number and weight in the diet of *B. docmac* with increasing FL (Fig. 11a). The relative numerical value of *S. schall* increased from 25% in 30-39.9 cm length group to 76.6% in the larger size groups. Similarly, the relative weight was 39% in 30 - 39.9 cm FL and increased up to 82.1% in larger length groups (Fig. 11b).

There was some similarity between the trends for *L. horii* and tilapia (Fig.11). Both these prey fish exhibited increased importance with increase in predator size up to 50 cm, beyond which their importance declined. Two fish species, *Barbus* sp. and *H. forskhalii* were encountered in the stomachs of larger specimens (>65 cm). Out of 280 fish containing food, *Barbus* sp. were recorded from the stomachs of three individuals that were 65.6 cm, 73.0 cm and 73.5 cm FL, respectively. Only one *H. forskhalii* was found in the stomach of *B. docmac* which was 80.2 cm FL.

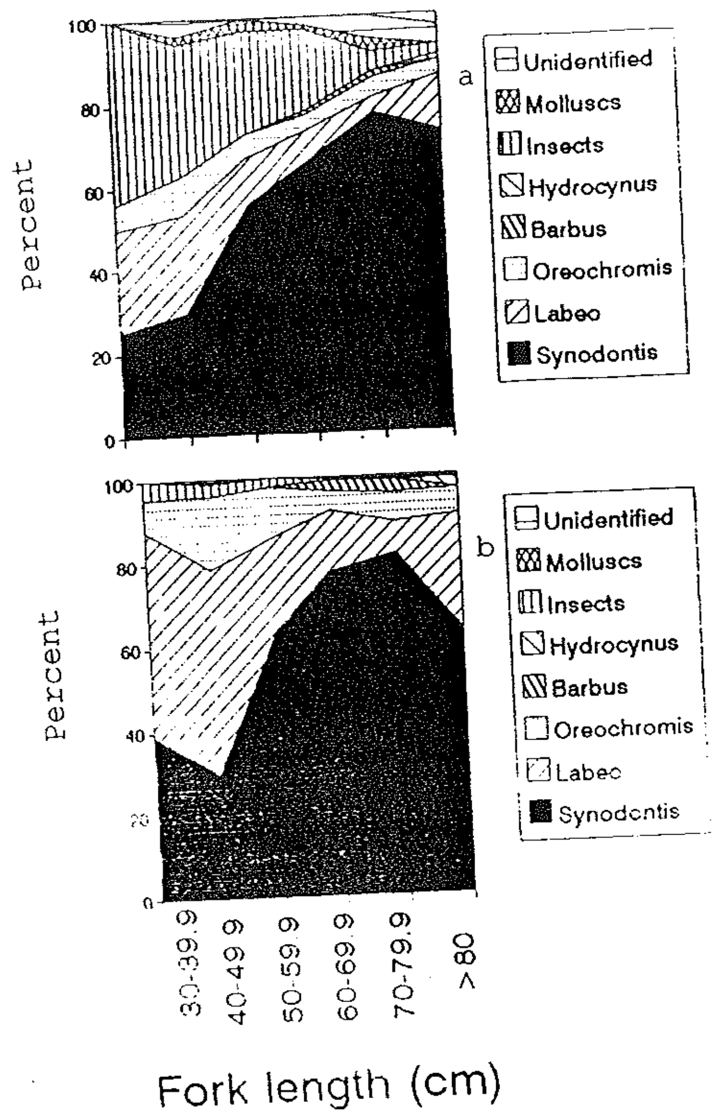


Fig. 11. Composition of the diet of various length groups of *B. docmac* in Lake Chamo determined using numerical (a) and gravimetric (b) methods.

4.4 Prey and Predator Relationship

S. schall was evidently the most important prey of *B. docmac* in lake Chamo (Fig. 9 and Fig. 11). Therefore prey size and predator size relation was analyzed only for *S. schall*. The FL of *S. schall* was estimated using FLs Vs dorsal spine length (Fig. 12) which was described by:

FLs = -2.924 + 0.458 SpL ($r^2 = 0.89$, $p < 0.05$), where FLs is fork length of *S. schall* and SpL is dorsal spine length.

The length of *S. schall* that were ingested by *B. docmac* ranged from 9.0 to 23.2 cm. The length of *B. docmac* that had consumed *S. schall* was between 36.1 and 98.4 cm. Hence, the overall prey/predator size ratio ranged from 1:2 to 1:6. However, most prey/predator ratios were found to lie between 1:3 and 1:5 (Fig. 13). This indicates that *B. docmac* mostly feeds on *S. schall* that are between 20.0 and 33.3% of its length. It is evident that prey/predator length relationship varied with the length of *B. docmac* (Fig. 13). Thus, the ratio was 1:2 for most *B. docmac* below 40.0 cm FL, and between 1:3 and 1:4 for most *B. docmac* between 40.0 and 55.0 cm FL, which increased to 1:4 and 1:5 for larger *B. docmac*

In terms of prey size,almost all of *S. schall* prey were found to be below 45% and above 15% of the length of *B. docmac*. The maximum absolute size of *S. schall* eaten showed a fairly linear increase up to 23.2 cm FL with increase in predator size up to 85 cm FL. Beyond this it decreased with increasing predator length.

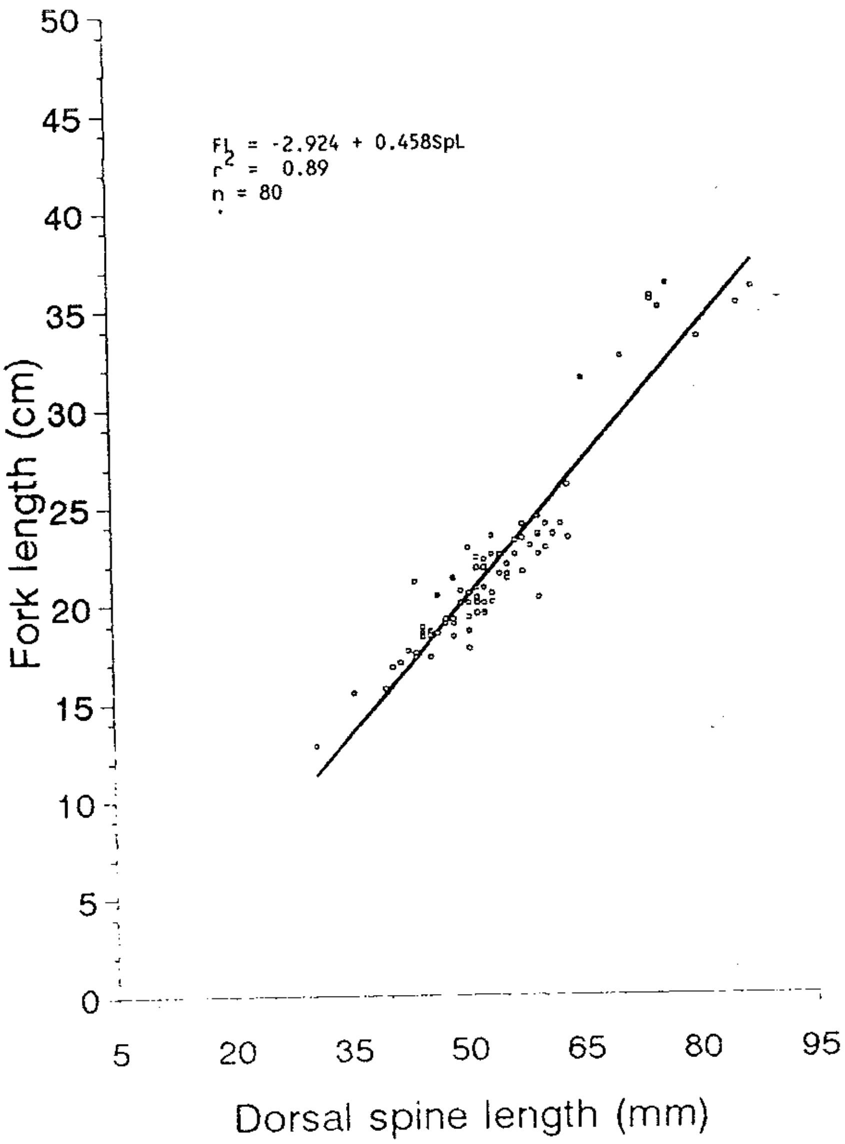


Fig. 12. Dorsal spine length Vs fork length relationship of *S. schall* in Lake Chamo. The regression equation presented in the figure was used to estimate fork length of *S. schall* prey from spine length collected from the gut of *B. docmac*.

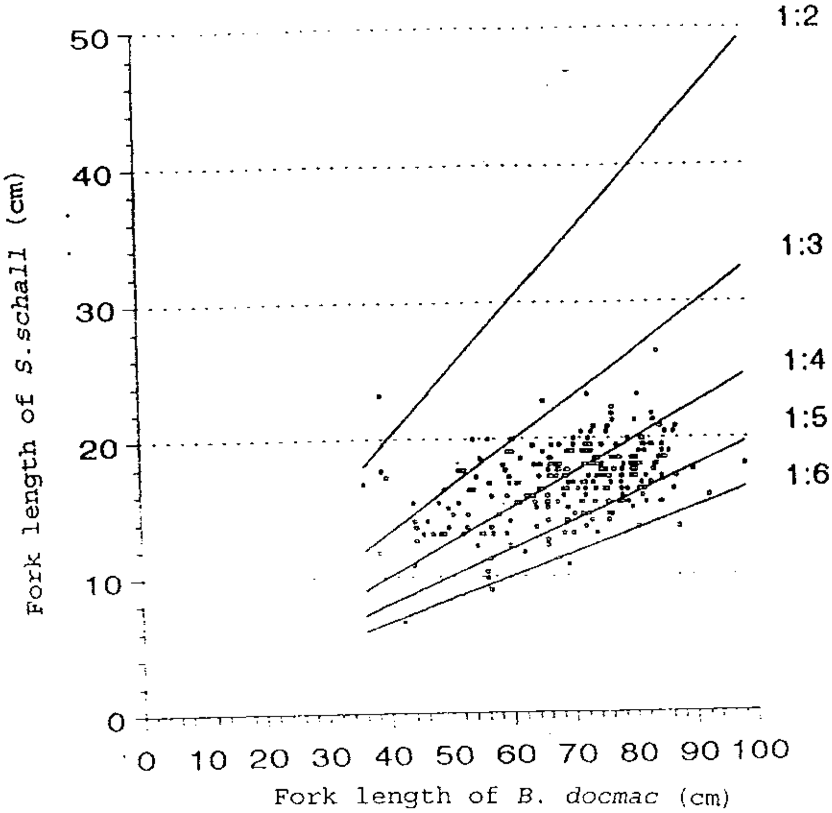


Fig. 13. Prey (*S. schall*) size and predator (*B. docmac*) size relationship in lake Chamo. The lines for 1:2, 1:3, 1:4, 1:5 and 1:6 prey : predator ratio are indicated.

4.5. Reproductive Biology.

4.5.1. *Sex ratio*

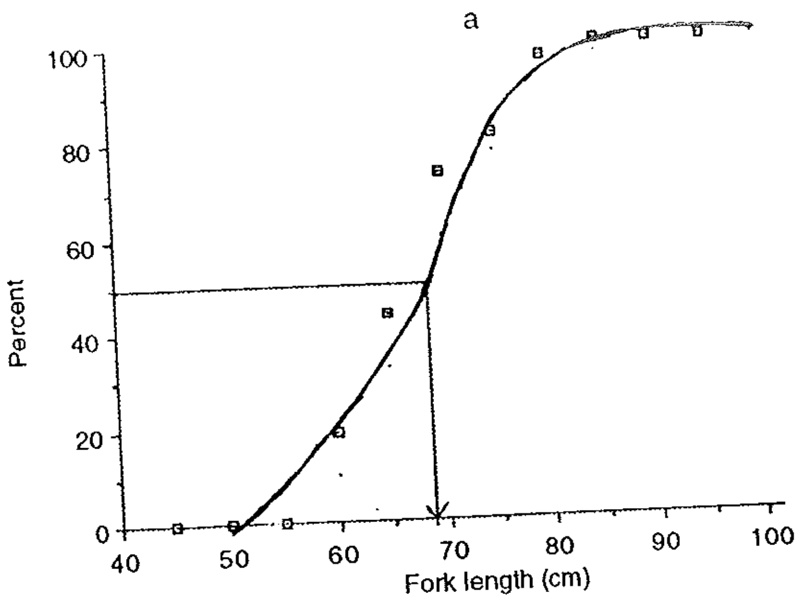
Of 534 individuals of *B. docmac* examined, 258 (48.3%) were males and 276 (51.7%) were females. The total ratio of males to females was 1:1.07 (Table 8) which did not deviate significantly from the hypothetical ratio of 1:1 ($p>0.05$). Sex ratio was also calculated after grouping the data into various length classes. There was a significant variation in sex ratio only in fish $\geq$ 80 cm FL in which females were dominant. Females appeared to grow a larger size than the males, because 62.3% of fish that were $\geq$ 80 cm FL were females. The largest female caught was 99.1 cm FL (= 16.5 kg) and the heaviest was 17.4 kg (FL = 98.4 cm). In contrast, the largest male caught was 91.5 cm FL and 12.0 kg. Eventhough females were more numerous the pattern of increase in their weight was more or less similar to that of males except during the ripe periods (i.e. with large ovaries).

4.5.2. *Length at maturity*

Males mature at smaller size than females. The smallest mature female was 60.2 cm FL and all females above 85 cm FL were mature. The smallest mature male was 51.0 cm but most males of more than 80.0 cm FL were mature. The proportion of mature male and female *B. docmac* of 5 cm FL intervals are shown in Fig. 14. The size of 50% maturity estimated from the figures were between 67.5 cm and 70.0 cm FL for both males and females. As shown in the Figs 14a and b, the actual size of 50% maturity of the females was found to be 68.6 cm, while that of the males was 68.0 cm FL.

Table 8. Number of male and female, and sex ratio (male : female) of *B. docmac* of various fork length (FL) groups caught from Lake Chamo between February 1995 and February 1996.

FL (cm)	Male (M)	Female (F)	Total	Ratio (M : F)	X^2
30.0-39.9	4	8	12	1 : 2	1.1
40.0-49.9	17	20	37	1 : 1.18	0.1
50.0-59.9	38	27	65	1 : 0.71	2.7
60.0-69.9	65	55	120	1 : 0.85	1.8
70.0-79.9	91	95	186	1 : 1.04	0.02
≥80	43	71	114	1 : 1.65	5.18
Total	258	276	534	1 : 1.07	10.9
					($p > 0.05$)



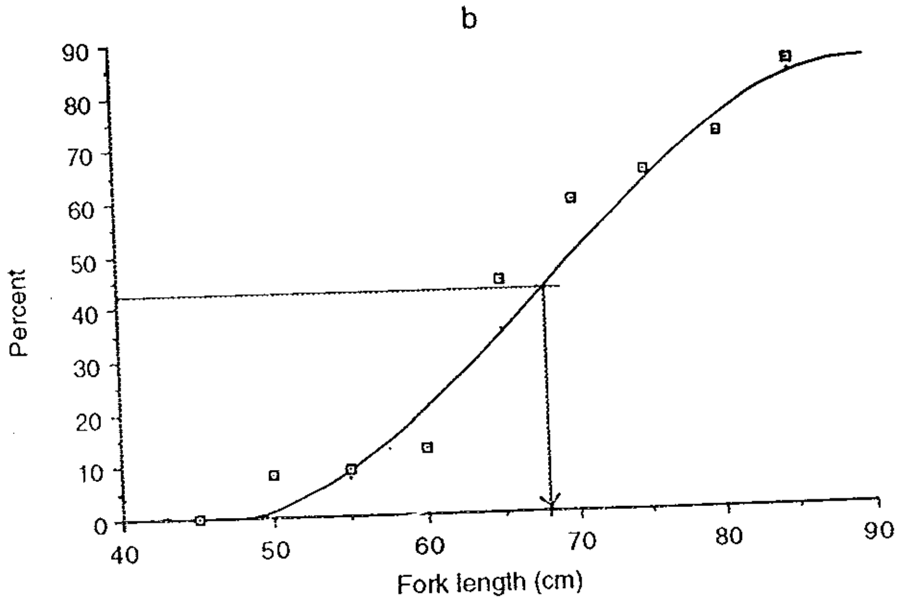


Fig. 14. The proportion of mature females (a) and males (b) *B. docmac* of 5 cm fork length intervals. The arrow shows the FL of 50% maturity.

4.5.3. *Breeding season*

Both females and males *B. docmac* that were in breeding condition were caught throughout the study period. However, their frequency varied with time of capture. Thus, most fish were in breeding condition during the period between February and August, the peak being in May (Figs 15a and b).

4.5.4. *Fecundity and size of eggs (ova)*

The diameter of ripe eggs of *B. docmac* was found to be between 0.66 mm and 1.50 mm. The mean ova diameter was 1.05 mm. The number of ova per gram of ovary weight ranged from 989 to 2100 with the mean number being 1474. The number of ripe ova in ovaries ranged from 94,442 in a fish that was 68.4 cm FL and 6.4 kg to 615,674 in a fish that was 94.0 cm FL and 16.3 kg.

Fecundity was found to be curvilinearly related to FL, but it was linearly related to both body weight and gonad weight (Fig. 16). The best fit equations to the relationships, respectively, were:

$$\text{Log } F = -1.15 + 3.395 \text{ Log } FL, \quad (r = 0.73;\ p<0.05),$$

$$\text{Log } F = 1.26 + 1.037 \text{ Log } TW, \quad (r = 0.75;\ p<0.05),$$

$$\text{Log } F = 2.974 + 1.027 \text{ Log } Gw, \quad (r = 0.95;\ p<0.05),$$

where, F is fecundity, FL in cm, TW in g, GW in g.

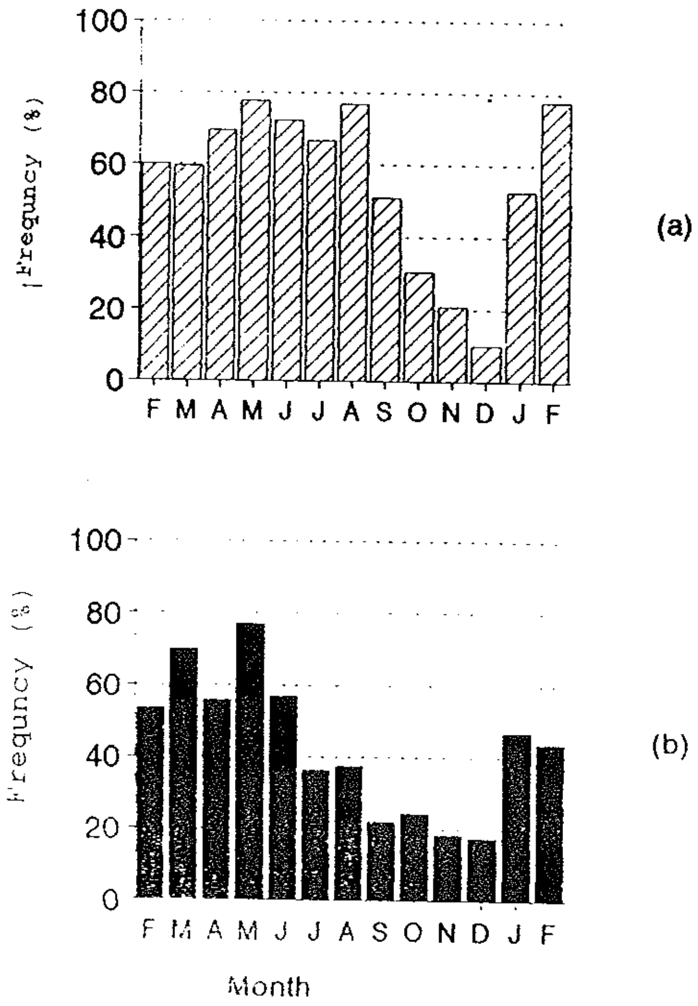


Fig. 15. Monthly frequency (%) of female (a) and male (b) *B. docmac* that were in breeding condition.

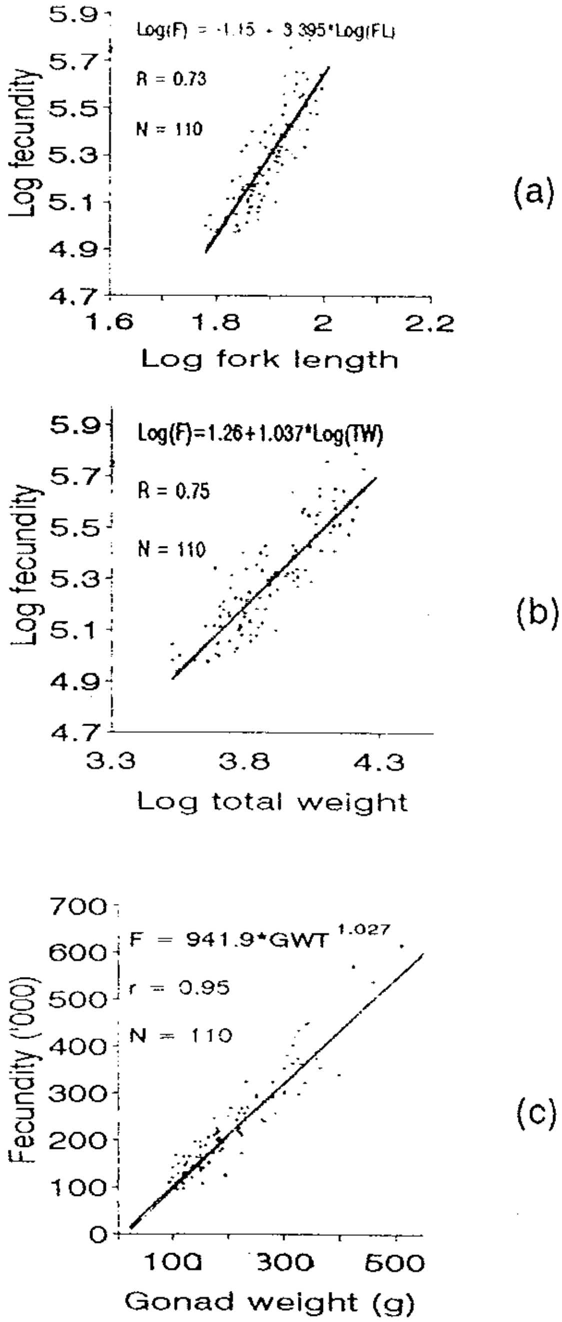


Fig. 16. The relationship between fecundity and fork length (a), body weight (b) and ovary weight (c) of *B. docmac* in Lake Chamo.

5. DISCUSSION

Specimens of small *B. docmac* could not be captured by the available capture method. The feeding places of the small *B. docmac* as stated by Lowe-McConnell (1987) is among rocks and stones feeding on lithophilous insects. Corbet (1961) reported that juveniles of *B. docmac* live in turbulent region of the Victoria Nile. He also observed the young *B. docmac* inhabiting the hard bottom littoral habitats of the lake. Such habitats can not be sampled by ordinary means. The study therefore limited to adult fish of relatively large size (> 30 cm FL), such as could be captured by hooks and stationary longlines.

The study showed that length and weight of *B. docmac* in Lake Chamo were curvilinearly related (Fig. 6). The value of b, which is 3.24, is different from 3, suggesting allometric growth in this fish (Bagenal and Tesch, 1978). Thus the fish becomes more rotund as it grows in length.

Rapid linear increment of length relative to weight was observed around 45 to 55 cm FL and beyond that, gain in weight tends to increase more than that in length. This might be related to the size of sexual maturity. This is in line with explanation given by Nikolsky (1969). He stated that before maturity, the main fraction of the food intake goes into protein growth. Thus, length increases before maturity, while afterwards most food goes to accumulating reserves, hence increasing weight relative to length.

The length composition and the sample size of *B. docmac* (Fig. 5), indicates that most of the fish caught were between 60 and 80 cm FL. Obviously, this length composition may not reveal the real population structure in the lake. The selectivity of the gear (hooks) could bring about such sample structure which was more concentrated within the limited length.

The largest *B. docmac* caught in this study was 99.1 cm FL for females and 91.5 cm FL for males. This appears to be larger than the maximum size of the same species reported by other workers (Corbet, 1961; Chilvers and Gee, 1974; Okach and Dadzie, 1988; Khallaf and Authman, 1992). The largest *B. docmac* caught from Lake Victoria, for instance was 75 cm total length (Okach and Dadzie, 1988). Lake Chamo is characterized by high temperature throughout the year (Getachew Tefera, 1993), and is a very productive lake (Amha Belay and Wood, 1982). In many fish species growth rates vary greatly with the available food and factors which affect its utilization such as temperature and overcrowding (Lowe-McConnell, 1987). Hence, conditions like high temperature and productivity of the water body may induce the production of available food for the fish growth.

Growth rates of *B. docmac* may also vary with change of diet, as observed by Okach and Dadzie (1988) in Lake Victoria. The decrease in the maximum length of *B. docmac* in Lake Victoria was related to the decline of the prey fish (*Haplochromis* sp.), that was caused by the introduction of Nile perch (Bergstrand and Cordone, 1971; Barel *et al.*, 1985). In addition, *B. docmac* was threatened with overfishing that caused a decline in the commercial catch of Lake Victoria (Okemwa, 1981). In contrast, the conditions of Lake Chamo might have allowed the fish to grow to its maximum size. If this is true, then the large *B. docmac* specimens caught in this study could be very old in age (Demeke Admassu, Pers. Comm).

The Clark's condition factor was used to comparison of the well being of *B. docmac* in Lake Chamo. Some basic reasons can be forwarded to explain the suitable use of this index. Obviously, the stomach content and the gonad weight of *B. docmac* (particularly the ripe females) were heavy. The condition factor of the fish is based on the assumption that the heavier fish of a given length is in a better condition (Anderson and Gutreuter, 1983). Clark's condition factor consists of the gutted weight divided by the fork length (Bagenal and Tesch, 1978).Thus it was reasonable to use Clark's condition factor in this study.

ANOVA declared the presence of significant difference in condition factor among the months. However, multiple comparison tests (i.e., Tukey and Sheffe) done to compare the condition factor of the fish in breeding and non breeding months could not indicate significant difference. Obviously, this suggests that Tukey and Sheffe tests were not as robust as the ANOVA test to indicate the presence of significant differences.

Condition values of males and females followed more or less the same trend throughout the year. As shown in Fig. 7, the rise in condition starting from March for two or three months presumably reflects that the body stores reserve energy which could be ready for the later active spawning period. The slight decline in condition starting from August until December might be interpreted as a decrease in anabolism of somatic tissue and an increase in the anabolism of gonad tissue to be matured in the later months. Mean monthly condition factor was low in July 1995 and February 1996. This might be due to the sampling errors or presumably due to the reduced feeding of the fish which can not be reasonably explained in this study.

As shown in Fig. 8, the condition factor remained constant with increase in length of the fish. This indicates lack of change in the condition factor as the fish grows longer. Shafi and Jasim (1982) also reported a similar result for the fish, *Aspicus varax* which they attributed to the carnivorous feeding habit of the fish. Similarly such stable values of condition could be related to the piscivorous nature of *B. docmac* fish, mainly depending on a single prey fish.

The proportion of *B. docmac* individuals whose stomachs were empty was high (about 48%). Since the longline was set overnight, the fish might have regurgitated and/or might have digested their food before sampling. A high regurgitation rate has also been observed in *B. docmac* sampled from Lake Victoria (Corbet, 1961). Piscivorous fish in tropical lakes feed throughout the year, because the prevailing water temperature condition does not inhibit feeding activity (Longhurst, 1957;

Whitefield and Blaber, 1978). Thus the occurrence of large number of empty stomachs in this study is unlikely to suggest that the feeding activity of *B. docmac* in Lake Chamo is seasonally inhibited .

The food items in the diet of *B. docmac* analyzed by the three different methods showed different values. Insects, for example, comprised 20% of the diet of *B. docmac* when analyzed by frequency of occurrence, but only 0.67% when analyzed by weight (Fig. 9). Several workers have also suggested that the relative importance of food items can best be gauged by two or more methods used in conjunction (Hynes, 1950; Mann, 1973; Crisp *et al.*, 1978; Whitefield and Blaber, 1978; Hyslop, 1980). Thus consideration of only one method of stomach content analysis does not give a true impression of the importance of the food items.

Generally, *B. docmac* in Lake Chamo was found to be piscivorous, because *S. schall* was its most important prey. Different types of prey fish were reported to be the major food items of *B. docmac* in other places. Khallaf and Authman (1992) noted that tilapia composed more than 90% of the diet by number in the Nile canal of Egypt. *Haplochromis* spp were found to contribute over 90% by number of the total food of *B. docmac* in the Kenyan waters of Lake Victoria (Corbet, 1961; Chilvers, 1969; Chilvers and Gee, 1974; Okach and Dadzie, 1988). According to Ajayi (1987), *B. docmac* preyed heavily on the catfish, *Chrysichthys auratus* supplemented with tilapia spp. in Lake Kainji, Nigeria.

S. schall, L. horii and *O. niloticus* are all abundant in Lake Chamo, eventhough, the latter species was of less importance to the diet of *B. docmac*. *L. horii* was also not as equally importance as *S. schall* (Fig. 9). The vertical distribution of *B. docmac* and *S. schall* in the lake might be one factor for the preference, since both species are bottom dwellers (Ofari-Danson, 1992; Demeke Admassu, Pers. Comm.). Similar observations on food selection were made by Cyrus and Blaber (1983). Chilvers (1969) reported that the availability of different food items in the stomach of *B. docmac* varied with the degree of exposure of the area fished. Such an observation could not be confirmed in the present study. However, there is evidence to suggest that similar food items occurred in all of the sampling areas. In this regard food selection by *B. docmac* seems to depend upon the availability of food items and also the type of prey species. The shape of prey species, their behaviour pattern, warning systems or some other factors may influence the selection of suitable prey species.

At present, the vast population of *S. schall* in Lake Chamo is not exploited commercially. The presence of *B. docmac* may be considered as an asset, in that it provides a major link between man and the currently unexploited large stocks of *S. schall* in the lake.

Owing to partial digestion, it was not possible to identify all stomach contents with equal accuracy. Therefore "unidentified fish remains" was placed in the food categories. Since *S. schall* was identified in the largest amount, it is reasonable to assume that most of the unidentified fish remains were *S. schall*.

Aquatic snails and insects occurred in a considerable quantity. Some authors have reported that aquatic invertebrates play a secondary role in the diet of *B. docmac* (Corbet, 1961; Chilvers, 1969). *Barbus* sp. and *H. forskhalii* were of negligible importance in the samples studied, because they occurred in only 1.07% and 0.36%, respectively. It may suggest that these fish species may have been accidentally swallowed.

The diet composition of *B. docmac* appeared to vary with its size (Fig. 11). There was a general increase of fish in the stomachs while insects showed progressively declining importance with increase the size of *B. docmac*. Similarly, Okach and Dadzie (1988) found a positive correlation between the size of *B. docmac* and the occurrence of fish, and a negative correlation between the size of *B. docmac* and occurrence of insects in the stomach. Some other authors mention the importance of insects in the smaller sized *B. docmac* (Corbet, 1961; Munro, 1967; Lowe-McConnell, 1987). Due to the lack of smaller fish (< 33 cm FL), the present investigation can not confirm the clear ontogenetic changes in diet. However, the available data show that insects occur more within the smaller size ranges of *B. docmac*.

Prey/predator ratio in *B. docmac* varied with the length of predator (*B. docmac*) (Fig. 13). 80% of *S. schall* consumed by *B. docmac* that were between 30 and 39.9 cm FL were between 1:2

and 1:3 prey/predator ratio. But more than 68% of *S. schall* ingested by *B. docmac* that were ≥ 80 cm FL were between 1:4 and 1:5 prey/predator ratio. Evidently smaller *B. docmac* predators (30 - 39.9 cm FL) more commonly took relatively larger *S. schall*, while large *B. docmac* fed up on smaller prey in relation to their size. The prey/predator length ratio of large *B. docmac* (≥80 cm FL) was found to be between 1:4 and 1:6. It was observed that in the larger *B. docmac*, prey fish were not always wholly contained in the stomach, but the caudal peduncles often projected forwards into the buccal cavity. Such phenomenon was rare in small *B. docmac*. It may be deduced that the maximum volume to which the stomach can be distended, is relatively greater in small *B. docmac*. This may be due to the relatively larger coelomic space available for stomach expansion because of the absence of mature gonads and large quantities of fat. Chilvers and Gee (1974) and Olatunde (1979) suggested predator's gape, volume of the buccal cavity, stomach distension and prey length as the factors influencing prey/predator size ratio. In addition, Chilvers and Gee (1974) observed the more sluggish behaviour pattern of larger fish in aquaria. Therefore, it is of interest that the large sized *B. docmac* feed on a small sized *S. schall* which could be very susceptible to be preyed.

S. schall has a well developed antipredation defences. The triangle shape of erect spines which can be formed by locking mechanisms, makes it more difficult to be preyed by other predators. A Nile perch has been found dead with a *S. schall* jammed into its throat (Demeke Admassu and Zenebe Tadesse, Pers. Comm.). Nevertheless, the catfish *B. docmac* does manage to swallow it. Chilvers and Gee (1974) and Ajayi (1987) found that *B. docmac* swallowed it's prey head first. Such whole fish, head first ingestion, which was also observed in this investigation, seems advantageous, particularly to the process of manoeuvring the chocking of the dorsal and pectoral spines of *S. schall* during ingestion. *B. docmac* may be effective of catching its prey by face to face attack. In addition to this, the possession of numerous small prehensile teeth may avoid damage by the prey's pectoral and dorsal spines.

The overall one to one sex ratio of *B. docmac* was obtained in Lake Chamo. Such 1:1 sex ratio in *B. docmac* has also been reported from the Winam Gulf of Lake Victoria (Dadzie and Okach, 1989). The significant change in sex ratio within the larger size class ($\geq$ 80 cm FL) might be due to the length and weight of mature ovaries which increase with the size of females.

Male *B. docmac* matured at relatively smaller length (50 - 54.9 cm FL) than females (60 -64.9 cm FL) (Fig. 14). 50% of both males and females were mature at a length class of 65 - 69.9 cm. In Lake Victoria, male and female *B. docmac* were found to mature at lengths of 16 -20.9 cm, and 21 - 25.9 cm, respectively (Dadzie and Okach, 1989). This does not agree with the present investigation. The size at first sexual maturity of male and female *B. docmac* in Lake Victoria was reported by Rinne and Wanjala (1983) and Dadzie and Okach (1989) to be at a much smaller size than is currently the case in Lake Chamo. Lowering of maturation size in response to intensive fishing is known in other commercial species (Garrod and Horwood, 1984; Edwards, 1985). For instance, in Lake George (Uganda) the maturation size of tilapia (*O. niloticus*) was found to be lower following years of intensive fishing (Gwahaba, 1973). Maturation of fish may be affected by several physical and biological factors. According to Lowe-McConnell (1987), the size at which a fish species mature is partly genetically determined and partly modified by prevailing conditions. These may account for the discrepancies of maturation observed between the different localities.

Evidently, a considerable number of fish were found in breeding condition throughout the year (Fig. 15). This indicates that conditions are favourable for breeding throughout the year in the lake. Similarly, *B. docmac* displayed protracted spawning activity with at least half the population in spawning condition throughout the year in Lake Victoria (Lowe-McConnell, 1987). Nevertheless, in the present study, high proportion of breeding fish were observed during rainy months of the year (February - August). Similar observations were made on the other catfish, *Clarias mossambicus*, in Lake Awassa (Elias Dadebo, 1988). In contrast, different reports exist on the breeding season of *B. docmac* in other regions. In Lake Victoria, Elder (1960) reported a single breeding season, from February to March. Chilvers (1969) reported evidence for the existence of two breeding seasons , one in April and the other in November. Rinne and Wanjala (1983) found the breeding season to be from August to September. Dadzie and Okach (1989) indicated the main breeding period from September to February. Such equivocal reports could be due to the difference in environmental conditions of the areas which may affect the breeding of the fish.

The pattern of change in breeding seasons as observed presently is comparable to the mean monthly rainfall of the Lake Chamo region (Fig. 2). Air temperature (Fig. 3) shows little variation throughout the year like that of most lakes in the tropics (Hails and Abdullah, 1982; Aizam, 1986). It may therefore be inferred that the rainfall and the resulting increased water level might be the determinants in bringing about the relatively increased spawning activity of the fish in the wet season. Similar suggestions have been given for the catfish, *B. docmac* (Rinne and Wanjala, 1983; Dadzie and Okach, 1989), on the catfish, *Mystus vittatus* (Sudha and Shakuntala 1989) and on the cyprinid fish, *Labeo victoriannus* (Cadwalladr, 1965). In the wet season, continuous rainfall brings nutrients from the atmosphere (Khan *et al.*, 1990) and from the land by flooding (Sudha and Shakuntala, 1989). As a result, the increased food availability might be highly suitable for the juveniles and seems likely to be the cause in triggering breeding in *B. docmac*.

Egg diameter of *B. docmac* varied from 0.66 mm to 1.50 mm within different specimens and even between eggs from the same ovary. Such variations in the egg diameter were similarly reported for other tropical fish species (Greenwood, 1955; Clay, 1979; Halim and Gumaa, 1989). The wide interval of ova diameter may indicate the continuous maturation of eggs in the ovary.

In the present study, fecundity of *B. docmac* ranged from 94,442 to 615,674. Rinne and Wanjala (1983) and Dadzie and Okach (1989) estimated low values from 2000 to 88,000 and from 25,000 to 100,000 eggs, respectively, for the same species from Lake Victoria. The great variations of eggs produced by the individual fish was also demonstrated for a large number of other tropical fish species (Ogutu-Ohwayo, 1988; Halim and Gumaa, 1989; Khan *et al.*, 1990; Ofari-Danson, 1992). As was indicated in the result, *B. docmac* showed high fecundity. The high fecundity may enable the fish to adapt the harsh environment. In addition it may suggested that high fecundity offers the potential for rapid establishment in areas.

This study showed that fecundity was curvilinearly related to fork length ($FL^{3.395}$). Linear relationship between fecundity and body weight ($TW^{1.037}$) and gonad weight ($GW^{1.027}$) was also revealed. Previous workers reported the linear relationship of fecundity with length, body weight and gonad weight for *B. docmac* in Lake Victoria (Dadzie and Okach, 1989). The rapid increase in mass during maturity, seems to be an important adaptation leading to considerable increase in the fecundity of the fish, since fecundity is more closely correlated with the body weight than with the length.

6. CONCLUSIONS AND RECOMMENDATIONS

The length-weight relationship for *B. docmac* is $W = 0.0054FL^{3.24}$. This relation can be utilized for converting weight of fish to lengths of fish and vice-versa.

B. docmac is found to be carnivorous in its feeding habits and the foods constitutes fish, insects and aquatic snails. A catfish, *S. schall* is the most utilized prey in adults. The cyprinid fish, *L. horii* is also of considerable importance. Smaller sized *B. docmac* seems to be insectivorous. Since *S. schall* is not exploited at present, *B. docmac* serves as the major link between *S. schall* and man. Moreover, it seems important to study the biology of the prey fish in the lake to draw conclusive knowledge on the position of *B. docmac* in the trophic interaction of Lake Chamo.

Breeding of *B. docmac* starts at the beginning of the early rainy months of the lake region (February) and continues until August. The size at which 50% of the fish are mature is between 67.5 and 70 cm FL. The smallest mature female was 60.2 cm FL while the smallest mature male was 51.0 cm. *B. docmac* is highly fecund in Lake Chamo.

From management point of view, it is recommended that all fish under 67.5 cm FL should not be exploited from Lake Chamo.

Finally the use of suitable gears (i.e., hook size number 5) is highly recommended for fishing *B. docmac* from Lake Chamo.

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