

FOOD AND SIZE COMPOSITION OF *EPINEPHELUS CHLOROSTIGMA*
(VALENCIENNES, 1828) PISCES: SERRANIDAE IN SOME COASTAL
AREAS OF THE ETHIOPIAN RED SEA WITH NOTES ON THE TAXONOMY
AND DISTRIBUTION OF THE FAMILY

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ABSTRACT

Eight fishing trips were made from June, 1986 to April, 1987 and fishes were caught using hook and line. Out of the 392 stomachs of *Epinephelus chlorostigma*, (Valenciennes, 1828) examined for food, 197 (50.26%) of them were found empty. The food organisms found in the stomach were mainly fish of the family Atherinidae and Pomacentridae. Crustaceans and Gastropods were also important as secondary foods especially in smaller size groups. Eggs were also found in a considerable number of stomachs.

There appeared to be no difference in the quality as well as quantity of the food of *E. chlorostigma* among the different sampling sites. This can be attributed to the absence of big differences in physical, chemical and biological factors among the sites. On the other hand high percentages of empty stomachs during the winter months were accounted to the relatively bad weather condition prevailing during this period.

There was an obvious relation between the size of the species concerned and the type of prey consumed, the larger size groups showing preference to fishes and the smaller to crustaceans and gastropods.

The total lengths of *E. chlorostigma* ranged from 20 to 52 cm with a mean length of 35.7cm. The size distribution was found to be affected by depth since larger fishes of the species tend to inhabit greater depths than their younger counterparts.

Length-weight relationship was established for *E. chlorostigma* as $W=0.051L^{2.593}$ with a regression coefficient, $r=0.906$. A rapid linear increment of length with weight was observed upto a certain size (36cm) and beyond that, gain in weight tends to replace gain in length.

Notes on the taxonomic characters and distribution of eight species of Serranidae were given. Out of the observed areas, most species were found on the eastern side of Hermil Island

1. INTRODUCTION

The Sea, which yields approximately 12 percent of the animal protein consumed by the world population (Reseck, 1980), is an abode for a multitude of living and non-living resources. The Red Sea, which is not an exception to the above, had been a place of inquisitiveness for many researchers starting from the eighteenth century. They laid major substantiality into the collection and identification of its flora and fauna, the vital concern being on fish. Actually works done in its physical, chemical and geological aspects were also not insignificant (Drake and Girdler, 1964; Ekman, 1967; Whitemann, 1968; Lowell and Genik, 1972).

Identifications of fishes, though sporadic, have been made at different times from collections made mainly at Massawa, Assab and the Dahlak Islands. But neither the individual works nor a combination of them is comprehensive and circumstantial. Furthermore, no major consideration was given to the biological study of these fishes. It has one obvious reason. The scientists did not stay here for a long time to make such studies since they were foreigners.

Out of the roughly 100 fish families so far documented only a few are economically important as food fish. The Serranidae are one and a commonly occurring family that forms an important portion of the marine shore fauna in tropical and sub-tropical areas.

Epinephelus chlorostigma (Valenciennes, 1828) Pisces:

Serranidae is an economically important species of the family found in many areas of the Ethiopian Red Sea. Despite its abundance and importance, there has not been any study of its biology. Thus this theses project was designed to study:

- a) the food
- b) the size composition and
- c) length-weight relationship of *E. chlorostigma*.

with some regards to the taxonomical characters and geographical distribution of related species of the family.

The study was not undertaken without critical problems. Two of these are important and worth-mentioning.

1) As a result of the impracticality for a single individual to competently cover the necessary areas of science which are related to the problems of the sea, most of the research carried out in this field involves an interdisciplinary approach by a team of specialists who combine the results of their special field of work in solving problems. The problem exerted on the study by the absence of such a team was manifested especially in the analysis of the food of *E. chlorostigma*. An expert's eye could have helped much in the identification to lower levels of the partly digested prey found in the stomach.

2) The other problem was related to the collection of data on board fishing vessels. The many aspects of the problem include:

a) the Hobson's choice one has in the selection of fishing (sampling) sites.

b) the waste of time (for a single trip takes a week in the average, most of which is spent on the going and coming back trips).

c) the constraints in space, food and others.

1.1 Literature Review

1.1.1 Characteristics of the Serranidae

Although there are some basic old works, in which one can hardly find, readily accessible later piece on the taxonomic description of serranid fishes include those of Fowler (1907) with regard to the Pacific region; Rivas (1964), Smith (1971) and Johnson and Keener (1984) of the Western Atlantic species; Morghans (1965) of the East African species; Bauchot, Desoutter and Randall (1984) of the National Museum of Natural History of Paris.

Aspects of the taxonomy of Red Sea serranids were also included in the works of Fischelson (1964); Ben-Tuvia (1968); Clark, Ben-Tuvia and Steinitz (1968); Botros (1971); Grofit (1971); Bayoumi (1977); Randall and Ben-Tuvia (1983); Chakraborty (1984) and Fischer and Bianchi (1984).

Smith (1965) stated classification of the family Serranidae as unsatisfactory, largely because the serranids and their allies are generalized perciform fishes and the assignment of genera to this complex is often based on the absence of basic similarities. Furthermore, Smith (1971) added that because of the great number of species and because many of them reach large size and consequently are poorly represented in collections, the classification remains unsatisfactory.

Gosline (1966) having analyzed works of the previous authors, put Serranidae as a somewhat specialized offshoot

of the basal percoid stock. He arranged the groups removed from the Serranidae of older author, (Fowler, 1907), into two categories in addition to the Grammistidae. One is made up of apparently specialized fishes of dubious affinities - the Callanthionae, Ostracoberycinae, Centro-genysinae and the Pseudochroms. The other category is formed by the Aeropomatinae, Doderleiminae, Malakichthynae, Macullochellinae, Polyprioninae and Niphoninae which are provisionally considered as a single separate family of basal percoid fishes - the Percichthyidae.

According to descriptions given by Smith (1971) and Fischer and Bianchi (1984), the body of Serranidae is robust or somewhat compressed, oblong oval to rather elongate. The number of dorsal spines varies from 8 to 15; usually there are 3 anal spines. The lateral line is single and complete and does not extend onto the tail. There are two nostrils on each side, the posterior of which is sometimes enlarged. The mouth is large, protractile and the maxilla is exposed for most or all of its length. The premaxilla has a dorsal posterior process lying internal to the shaft of the maxilla. There are two or three opercular spines but the upper edge of opercle is free. The colour is variable with patterns of light or dark stripes, spots, vertical or diagonal bars, or nearly plain.

Our knowledge of the fishery biology of serranids and other coral reef fishes stems primarily from three major studies: those of Bardach in Bermuda (Bardach, 1958); Randall

in the U.S. Virgin Islands (Randall and Brock, 1960); Munro and co-workers in Jamaica (Thompson and Munro, 1978; Munro, 1982).

Twelve genera of the family Serranidae were recorded by Fischer and Bianchi (1984) as fishes of the Western Indian Ocean and the Red Sea (Fishing area 51). Out of these, 6 genera containing 22 species were described by Randall and Ben-Tuvia (1983) as groupers of the Red Sea. These genera are *Epinephelus*, *Amyperodon*, *Cephalopholis*, *Plectropomus* and *Variola*.

Epinephelus is the most common genus within the groupers of the Red Sea. The name *Epinephelus* came from the Greek word meaning clouded over, in allusion to the membrane believed to cover the eye of *Epinephelus ruber*.

Twelve species of the genus were listed as fauna of the Red Sea of which *E. chlorostigma* is a recurrent species in the Ethiopian Red Sea. Literature on the biology of *E. chlorostigma* was not apparently obtained except the taxonomic aspect and that one in press (Moussac, 1986). But the many vernal contributions on the different aspects of related species of the genus *Epinephelus* were of paramount importance as a source of background information for the present work.

A profile of feeding biology of *Epinephelus* sp. was depicted by Teng, Chua and Lim (1978); Goldstein and Lange (1982); Chua and Teng (1982); Takede and Kurata (1984); Baddar (1984b) and Martins (1985) while Barans and Holliday (1983) and Baddar (1984a) gave an expose of the practical technique for assessing grouper stocks.

Reproductive biology and population parameters were delineated by such works as Diophode and Naik (1975); Brusle and Prunus (1981); Teng et al. (1982); Bouain and Siau (1983); Vadiya (1984a and b) and Moore and Labisky (1984), while their physiology and biochemistry were reviewed by Woo and Wu (1982 and 1984); Ng et al. (1984); Ng, Tam and Woo (1985) and Vernouk and Abbad el Andaloussi (1986).

Moreover, distribution and abundance of *Epinephelus* species were discussed by Sundberg and Richards (1985); Shipp, Tyler and Jones (1986) and Clarke (1986) while their relationship with parasites was discoursed upon by Tareen, Yamani and Hadi (1980); Zhukov (1983); Madhavi and Manumantha (1983); Rahim et al. (1985); Foo, Ho and Lam (1986); Hussey (1986) and Ahmad (1986).

1.1.2 Habitat of the Serranids

Serranid fish, especially the grouper species, are ubiquitous in warm waters and form an important actual or potential food source for man where they occur (Moerlean, 1963). These fishes are normally widely dispersed, solitary that patrol a home range (Smith, 1972), but no active defense of the territory has been recorded (Smith, 1971).

It is not only because they resort to grazing on the coral that serranids inhabit reefs (Marshall, 1965), but they also get shelter from it. Since most serranids are secretive, they occupy crevices, ledges and caves in wrecks and reefs. That is why the geographical variation in coral reefs greatly affects the distribution of these species (Meadows and Campbell, 1978).

All fish of the genus *Epinephelus* belong to the Neritic zone in the pelagic environment which is spreading over the continental shelf, extending offshore to a depth of about 200 meters (Lagler et al., 1977), but they actually dominate in the shallower waters (FAO/UNDP, 1981). The neritic zone is well lighted but has seasonal variation in light as well as temperature, salinity, dissolved oxygen, nutrients, wave actions, current and its biota.

Concealment through disruptive coloration is observed in some groupers. These fishes are known to undergo colour variations of three types (Lagler et al., 1977): instantaneous - under nervous control; bathymetric - correlated with the environment; and xanthic - a yellow colour phase under genetic control. Many of them show luminescence resulting from the presence of luminous bacteria living on fishes in a symbiotic relationship.

1.1.3 Food of the Serranids

The finding and consumption of food is governed by physical constraints as well as behaviour (Bond, 1979). Some fishes are so extremely specialized physically that the food selection is limited and feeding behaviour is usually specific. On the other hand, species with generalized structure can be rather flexible in feeding behaviour, and can exploit a wide range of resources. The latter is valid for the serranids. The groupers are unspecialized carnivores feeding mainly on fishes and crustaceans (Randall and Brock, 1960).

A fish's functional morphology can often indicate the kinds of food it eats and, perhaps just as importantly, the kinds it is unable to eat. Carnivorous fishes have teeth well-developed to seize, hold and tear and gill rakers modified to grasp, retain, rasp and crush prey (Weatherley, 1972). There is a true flask-like stomach and a short intestine, elastic and thick-walled. Although most serranids have cardiform jaw-teeth which are numerous short, fine and pointed, the food is generally engulfed whole (Thompson and Munro, 1978).

Mostly the fishes do not continuously seek food every hour of the day. Usually there is a definite period (or periods) during the day when feeding activity reaches a peak. Some species are nocturnal, feeding only or mainly at night; others are diurnal, feeding in the bright of day only. Twilight or crepuscular feeding is a common periodicity; fishes on this rhythm feed once or twice a day in dimlight.

Serranids feed both by day and by night but are more active at dawn and at dusk. These fishes apparently wander considerably in search of food, and depend largely on their sense of smell. A well baited trap attracts them from distance. During spawning very few groupers' stomach contained food.

1.1.4 Sex and Reproduction of the Serranids

The sex of groupers cannot be determined with any degree of certainty by macroscopic examination unless they are in an active, ripe or early spent state. Two types of sex are evident:

1) Protogynous hermaphroditism (non-functional type) in which the seminal and ovarian parts in the gonads do not function simultaneously. The ovarian part mostly developed at early ages, the male part remaining inactive. After some cycles of spawning the oocytes are resorbed, the seminal part then developing (protogyny). It occurs in species that live in waters with unstable condition and restricted food base.

2) Synchronous hermaphroditism (functional type) in which they have ripe ovaries and testes at the same time, but usually spawn with one or more other individuals, alternately taking the role of male and female.

Most species of Serranidae exhibit protogynous hermaphroditism while some are synchronous hermaphrodites, some even capable of self-fertilization (Bond, 1979). The weight of ripe gonads relative to the total weight of the fish is small. There is no coupling during spawning of groupers and fertilization is external. The eggs and larvae are presumed to be pelagic (Ukawa and Mito, 1966).

It is often reported by fishermen that groupers gather in large schools at certain times of the year, although they are mostly solitary. This schooling is spawning aggregation. Spawning aggregation undoubtedly have adaptive value by assuring that large numbers of gametes are released in the same area at the same time, thus enhancing the chances of fertilization.

1.1.5 Toxicity in Serranids

Fish of the family Serranidae are most often implicated in ciguatera (a particular ichthyosarcotoxism caused by eating various marine fishes of tropical and non-tropical areas) together with fish of the family Muraenidae, Sphyraenidae, Lutjanidae and Carangidae. Ciguatera type of fish poisoning was also reported by Lagler and co-workers as fatal to about 7 percent of the humans who eat the flesh of the fishes (Lagler et al., 1977).

The common groupers cited by Randall (1958) as toxic were *Plectropomus leopardus*, *Variola louti*, *Cephalopholis argus*, *Epinephelus elongatus*, *E. hexagonatus* and *E. merra*.

2. INVESTIGATION AREA

2.1 The Red Sea Environment

The Red Sea extends for about 2000kms from the strait of Bab-el-Mandeb to the Gulf of Suez and Aqaba and has a surface area of 440,000km², a mean depth of 524m, and a maximum depth of 2,920m (UNESCO, 1976). Part of this is the Ethiopian Red Sea in which its coast extends along some 926km from Ras Kassar (N 18°03', E 37°35'; approximately) in the north to Ras Dumiera (N12°45', E 43°07'; approximately) in the South (Ben-Yami, 1964).

In the southern Red Sea, winds are controlled by the monsoon system of the Arabian Sea (Newmann and McGill, 1962; Halim 1969). In winter, surface water flows with the wind from the Gulf of Aden into the Red Sea while in summer with northerly winds, the circulation pattern reverses.

The highest salinity in the world, for open waters, occurs in the Red Sea (Russel and Yonge, 1975). There is a progressive increase in surface salinity from 36.5% in the south to 40.5% in the north which results in a progressive increase in surface density northwards.

There is evidence of an oxygen minimum (about 0.5ml O₂l⁻¹) at 400m depth in the southern Red Sea. This may result from the degradation of organic matters produced in the euphotic zone. The total phosphorus maximum occurs at the same depth as the oxygen minimum.

Although the Red Sea arose as an arm of the Mediterranean Sea, receiving at the very beginning its biota from that sea, these biota soon became mixed with the Indo-Pacific

elements in the pliocene period (Botros, 1971). The Mediterranean elements constituted an important ingredient of the Red Sea biota, but only as long as open connection existed between these two seas.

2.2 Sampling Sites

The sampling localities were in the Ethiopian Red Sea within the operation sphere of the local fishermen of Massawa ("Semhar" cooperative). It is within a range of $39^{\circ}35'N$ to $40^{\circ}30'N$ longitude and $15^{\circ}40'E$ to $16^{\circ}35'E$ latitude.

The sampling sites were named after the adjacent islands. Their location on the chart and approximate depth of the surrounding fishing area were given in table 5. They are numbered 1 upto 6 in Fig. 1.

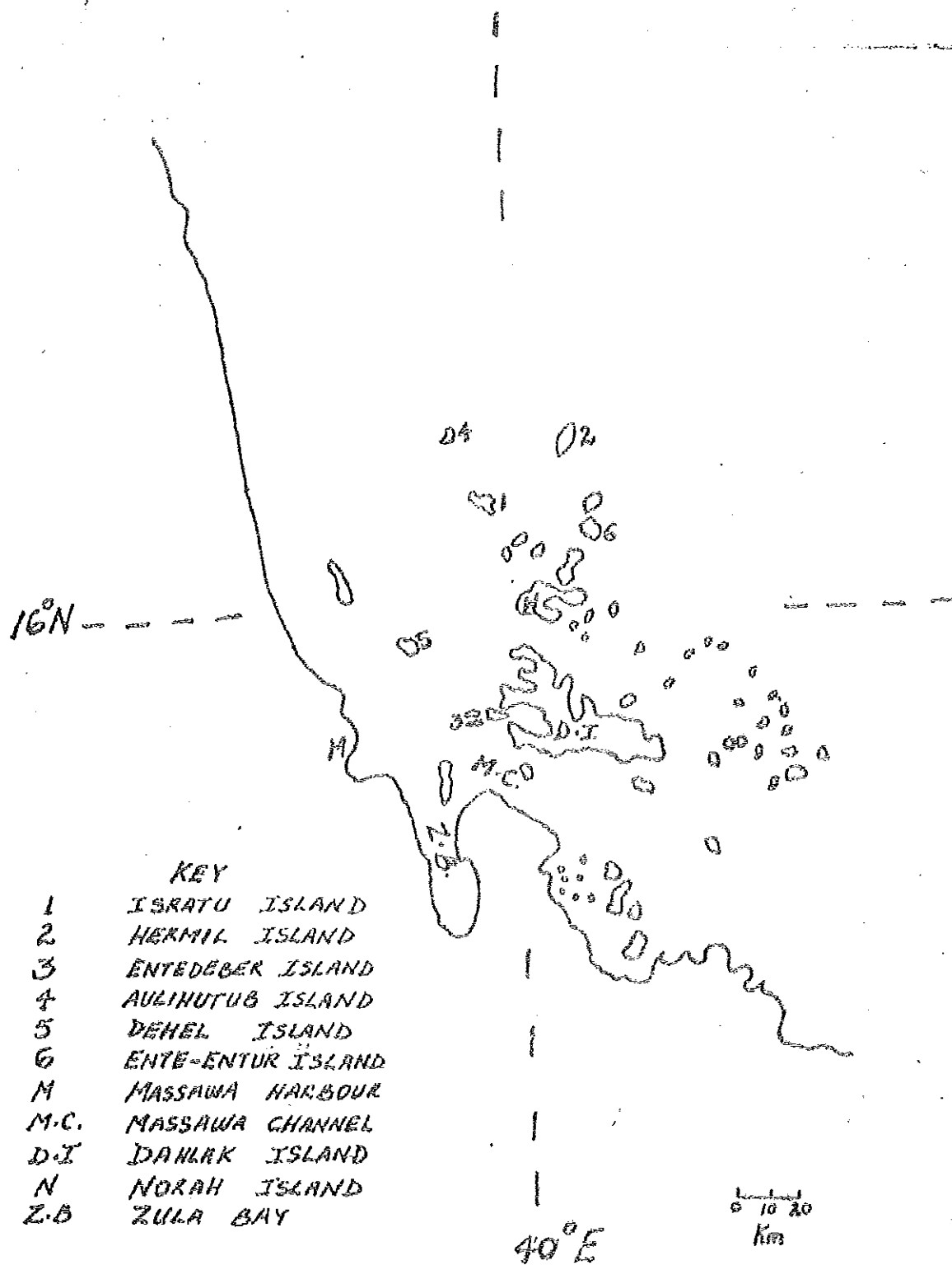


FIG 1 THE ETHIOPIAN PART OF THE RED SEA

3. MATERIALS AND METHODS

Eight sampling trips were made with the local-fishermen of Massawa ("Semhar" cooperative) and the Naval Force fishing team. Each fishing trip took 5-10 days. Samples were taken from June, 1986 to April, 1987 except September, October and February.

The boat used in most of the trips, "Wabe", is a glass fibre boat (Viksund) with a maximum length and width of 9.55 and 3.20 meters respectively. It has an engine of 33 horsepower.

Fish were caught using handline with a baited hook (Kridtjonsson, 1959 and Shaheen, 1977). A nylon fishing line of 100m length with a lead weight of about 500g was used by each fisherman. The line was a monofilament with a diameter and strength of 1.3mm and 140lbs respectively. The hook used was hook number 5.

3.1 Sampling Procedure

After the fishes were caught and landed on deck, the following procedures were done for *Epinephelus chlorostigma*.

a) Total length (T.L) was measured from the tip of the protruding lower jaw to the tip of the upper lobe of the caudal fin held in a natural position.

Total length was recorded according to that agreed by the International Council for the Exploration of the Sea (ICES) and the International Commission for the North West Atlantic Fisheries (ICNAF) sampling meeting, 1965 (FAO, 1981). Concordantly, the unit of measurement was 1cm.

A measuring tape (fibre glass, 20m), which has an advantage over a measuring board in its levity and portability was used to take the measurements. When measuring a fish, its mouth was closed and since the fish shrinks rapidly on dying, it was measured while it was fresh and wet, i.e. as near to the relaxed live condition as possible.

Length measurements were noted in serial order as the fishes were measured. Later they were retabulated as a frequency distribution.

b) Weight was taken using a triple beam balance model 700 (capacity 2610 grams).

c) Gut was removed and preserved in plastic bottles with 5% formalin for further investigation of the content in the laboratory.

Other fishes presumed to be within the family Serranidae, by looking at the apparent and palpable common characters (the presence of opercular spines, 3 anal spines, and characteristic coloration), were kept in ice box for further species level identification.

Air and water temperature was measured throughout the study period using a simple thermometer. The depth of the fishing area was approximately estimated with the fishing line.

The chart (no. 62120) of the Red Sea, was used to locate exactly the fishing areas and the routes.

3.2 Laboratory Work

In the laboratory the outside of the gut was cleaned of adherent fat and mesenteries, and then each section was cut open and the contents taken out. The stomach, i.e. that part of the alimentary canal between the oesophagus and the pyloric sphincter, was examined with regard to food and its contents were assessed both qualitatively and quantitatively.

In such a way, a study has been made of the stomachs of 392 specimens whose total lengths ranged from 20 to 52cm. The contents were qualitatively identified to the lowest level possible. In most cases the food was found partly digested, difficult to identify, and it was collected under major groups.

Quantitatively the data were analyzed with two methods, by a point system which takes into account the abundance and volume of the food organisms, and by the frequency of occurrence of each organism.

The points were given according to Frost (1977), i.e. the stomach was opened and described, according to the amount of food it contained, as full, $\frac{3}{4}$ full, $\frac{1}{2}$ full, quarter full, less than quarter full, or trace and according to the degree of fullness was allotted 100, 75, 50, 25, 12 or 6 points respectively. The contents were then put into a petridish and the relative amount of each category present was estimated visually and given points. This is a modification of Swynnerton and Worthington (1940) and Hynes (1950), point method.

In the frequency of occurrence method (Hynes, 1950), the number of fishes in which each food item occurs was given as percentage of the number of fishes which contained food. The two methods were later applied by a number of authors (Fagade, 1971; Dipper, Bridges and Menz, 1977; Jacob and Nair, 1982; Matallans, 1982).

Morphometric, meristic and measurement data, given in appendix 4, were recorded for fishes brought for confirmatory identifications. Such identifications to species level were made using the key of Randall and Ben-Tuvia (1983) and the FAO species identification sheets for fishing area 51 (Fischer and Bianchi, 1984).

4) RESULTS AND DISCUSSION

4.1 Food of *E. chlorostigma*

392 stomachs were examined and 50.26% of them were found empty (Table 1) and some of these stomachs were found everted when taken out which might have been due to pressure changes (Munro, 1976). Furthermore, the majority of the food organisms found in the stomach were already partly digested and it was difficult to identify them to lower levels and hence qualitative analysis and computation of percentages of food items were made with major groups or families depending on the completeness of the prey and the extent of digestion. Food organisms were identified consulting Marshall and Williams (1972); Humfrey (1975); Barnes (1980) and Fischer and Bianchi (1984).

The food organisms found in the stomach of *E. chlorostigma* are given in Table 2. The relative importance of these food organisms was determined by quantitative analysis using both the frequency of occurrence and points method (Table 3). The data obtained from both points and frequency of occurrence methods were expressed in percentages. The percentages were based on the number of fish which contained food, not on the total examined. The degree of similarity between results obtained using the two methods was computed using the non-parametric Spearman-Rank Correlation Coefficient (Snedecor and Cochran, 1980). Accordingly all the food categories were used for all correlation computations to allow a standardization of comparisons. The correlation coefficient value, 0.771 is significant at the $P=0.1$ level. This method was also applied by Gunn and Milward (1985) while studying

TABLE 1. Number of Empty Stomachs with the Total Number of Fishes Examined

	1986					1987			TOTAL
	JUNE	JULY	AUG.	NOV.	DEC.	JAN.	MAR.	APR	
TOTAL NUMBER OF FISH EXAMINED	35	27	32	43	60	50	80	65	392
NUMBER OF EMPTY STOMACH	12	8	12	24	39	31	47	24	197
% OF EMPTY STOMACH	34.29	29.63	37.5	55.81	65	62	58.75	36.92	50.26

Table 2. Food Items Found in the Stomach of *E. chlorostigma*

FOOD ITEMS	ORDER	SUB-ORDER	FAMILY/GROUP
TELEOST FISHES	MUGILIFORMES	ATHERINOIDAE	ATHERINIDAE
	PERCIFORMES	PERCOIDEI	POMACENTRIDAE
CRUSTACEANS	DECAPODA	REPTANTIA	BRACHYURA
	DECAPODA	NATANTIA	PENAEID SHRIMP
GASTROPODS	NEOGASTROPODA	MURICACEA	MURICIDAE
	NEOGASTROPODA	CONACEA	CONIDAE
EGGS OF FISH	UNIDENTIFIED	UNIDENTIFIED	UNIDENTIFIED

TABLE 3. Food Items of *E. chlorostigma* by Frequency of Occurrence (F) and Points (P) Methods.

	1986										1987						TOTAL	
	JUNE		JULY		AUGUST		NOVEMBER		DECEMBER		JANUARY		MARCH		APRIL			
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
FISH	56.52	59.27	57.90	44.97	45	46.72	68.42	67.77	52.33	49.81	47.37	65.57	42.42	47.42	39.02	46.07	49.23	51.50
BRACHYURA	26.09	20.79	36.84	29.56	35	29.51	26.32	14.62	19.05	13.48	15.79	12.30	21.21	24.06	19.51	20.41	24.10	21.26
MURICIDAE	4.35	4.21	15.79	14.78	10	12.30	5.26	6.65	9.52	8.99	5.26	4.92	12.12	8.69	17.07	15.17	10.77	10.04
CONIDAE	4.35	2.31	10.53	7.86	10	7.79	5.26	8.31	4.76	9.36	5.26	2.46	9.09	5.28	9.76	8.41	7.69	6.53
PENAEID SHRIMP	-	-	-	-	-	-	-	-	19.05	18.35	10.53	7.38	15.15	14.55	14.63	9.93	8.72	7.95
EGGS	26.09	12.92	15.79	2.83	15	3.69	15.79	2.66	-	-	15.79	7.38	-	-	-	-	9.23	2.72

The "main food" (Berg, 1979), i.e. the food item consistently present in fairly high concentration in the stomach at capture, was fish (49.23% by frequency and 51.41% by points method table 3). The predominant available food item (fish) seems to determine this preference in feeding habit. Allen (1941; cited by Weatherley, 1972) pointed out that when a feeding fish is beginning to select one particular type, the animal chosen will be the one which it sees at least fairly frequently.

Brachyurans and Shrimps, among the crustaceans inhabiting the coral environment, were also found as a favourite food of *E. chlorostigma*. Actually no published information was obtained on the food of *E. chlorostigma* inhabiting either Red Sea or other areas. But authors like Menzel (1960) and Randall and Brock (1960) described species within the genus *Epinephelus* as non-specialized carnivores depending mainly on fishes and crustaceans. Morghans (1965), after studying stomach contents of the East African species *Epinephelus Chewa*, reported the presence of fish remains and pieces of squids in the stomachs. Randall (1967); (cited by Munro, 1976) recorded specimens of *Mulloidichthys martinicus* (Teleost) from the stomachs of *E. guttatus* and specimens of *Pseudopenaeus maculatus* from the stomach of *E. straitus*.

Again, Randall and Ben-Tuvia (1983) in their work of the taxonomy of Red Sea groupers, reported remains of fishes from stomachs of *Aethaloperea rogga*; fishes and crustaceans from *Cephalopholis argus*; an apogonid fish from *C. oligosticta*; shrimp, crabs and fishes from *E. fasciatus*;

fish, brachyurans, crab and cephalopod from *E. fuccoguttatus*; crab and fish from *E. tauvina*; fish and crustaceans from the stomach of *Variola louti*.

The contribution of Gastropods to the food of *E. chlorostigma* is also important. Gastropods, as food of groupers, were apparently not reported in previous works. But their presence in the stomach of this species is not surprising since members of the genus *Epinephelus* are wide ranging opportunistic feeders and gastropods occupy a number of trophic levels in reef communities (Taylor and David, 1984). The increase in the composition of food and the lack of specialization of feeding habits appears to be a factor in the success of the species in invading separated geographic areas where preferred food may be absent.

Eggs were also found in the stomach of *E. chlorostigma*. These eggs would either be their own eaten due to overpopulation as fishes, when overpopulated, will eat many or all of their own eggs (Parker, 1958) or they might have taken advantage of the localized and abundant food provided by the shed ova of other spawners.

E. chlorostigma was found to be feeding in all months of the study period (table 3) which is common for most species of the tropical marine fish (Nikolskii, 1969).

The types of prey of *E. chlorostigma* from the different sampling sites appeared to be the same (Table 4). The difference in quantity among the sites was tested using the Kruskal-Wallis non-parametric method and the results were not significant at $P=0.2895$ for fish; $P=0.1265$ for Crustaceans and $P=0.1648$ for gastropods. This can be accounted to the

absence of big differences in physical, chemical and biological factors among the different sites.

On the other hand, high percentages of empty stomachs were recorded during winter months (Table 1). Some physical factors might be important in affecting acquisition of food by fish.

Wind appears to be a major factor in tropical waters where variation in water temperature is not high (minimum 27°C in winter and maximum 32.5°C in summer). Thus wind and consequently water turbulence is high in winter which reduces illumination and obstruct the visual acuity of the predator. This can negatively influence its food intake capacity. This is especially true in fishes like *Epinephelus* species that are adapted to live in clear waters. The negative effect of rough weather in the feeding intensity of fish had also been given by Dipper et al. (1977) when studying the feeding habits of *Labrus bergylta*.

The importance of the prey in relation to the size of the predator was examined using the Mann-Whitney non-parameters test. Fish prey becomes important in the diet with increase in the size of the predator (Table 5). The lower size groups show a pronounced preference for crustaceans and gastropods. So the type of food appears to be related to the length or age of the fish. The capacity of the predators to catch and ingest the prey can explain this relationship. Hyatt (1979; cited by Jacob and Nair, 1982)

TABLE 4. Food Items of *E. chlorostigma* and their Relative Importance from Different Sites of the Ethiopian Red Sea.

PREY	ISRATU		ENTEDEBER AULI-HUTUB				DEHEL		ENTE-ENTUR	
	F	P	F	P	F	P	F	P	F	P
FISH	56.52	59.27	45	46.72	68.42	67.77	47.37	65.57	42.42	47.42
BRACHYURA	26.09	20.79	35	29.51	26.32	14.62	15.79	12.30	21.21	24.06
MURICIDAE	4.35	4.21	10	12.30	5.26	6.65	5.26	4.92	12.12	8.69
CONIDAE	4.35	2.81	10	7.79	5.26	8.31	5.26	2.46	9.09	5.28
SHRIMP	-	-	-	-	-	-	10.53	7.38	15.15	14.55
EGGS	26.09	12.92	15	3.69	15.79	2.66	15.79	7.38	-	-

attributed such relation to the fact that any predator feeding visually possesses an upper limit in which it identifies the object as potential food and a lower limit in which it would detect and ingest it.

It appears that larger and older fishes inhabit relatively greater depths than their younger counterparts (Table 6). Thus with an increase in depth, there is a concomitant increase in the selection of prey fish as food. It is believed that the prey fish may be more abundant in the deeper waters.

TABLE 5. Quantitative Estimates (both frequency & point method) of Food of Large ($\geq 35\text{cm}$) and small ($< 35\text{cm}$) species of *E. chorostigma*

PREY	METHOD	MEAN \pm S.D.	MEAN \pm S.D.	P.VALUE*
		OF <i>E.chlorostigma</i> (n=8)	OF <i>E.chlorostigma</i> (n=8)	
FISH	FREQUENCY	73.5 \pm 13.97	21.67 \pm 12.32	P=0.001
	POINTS	75.32 \pm 12.91	23.37 \pm 15.12	P=0.001
CRUSTACEANS	FREQUENCY	10.80 \pm 7.55	46.53 \pm 20.52	P=0.001
	POINTS	9.86 \pm 7.40	35.88 \pm 14.50	P=0.001
GASTROPODS	FREQUENCY	8.37 \pm 8.08	27.18 \pm 10.96	P=0.004
	POINTS	7.68 \pm 6.58	27.34 \pm 7.41	P=0.001

* Mann-Whitney Test

TABLE 6. Size Distribution of *E. chlorostigma* with Depth

No. of Fish	Total Length(cm)	Weight(G)	Depth Range(m)
95	18 - 29	95 -365	5 - 20
185	30 - 41	275 -993	15 - 40
112	42 - 53	810 -1843	20 - 50

4.2 Size Composition of *E. chlorostigma*

The total lengths measured for *E. chlorostigma* were grouped into nine classes with an interval of 3cm. The sizes ranged from 20cm to 52 cm with a mean length of 35.7cm (Table 3).

Length distribution of samples obtained in different months and from different areas were compared in terms of mean length and range (appendix 2) in order to establish by visual inspection whether any major difference existed between such samples or not. As a result, the sampling frequencies were combined and they were treated as a unit irrespective of the actual location of the sampling stations. The little differences observed were simply due to the difference in the depth from which the samples were taken. The results of the combined sample frequencies are given in Fig. 2.

According to the combined result, three size groups could be assigned to the three peaks observed on the length frequency distribution, i.e. the 0 group fishes at 27.5 cm, the I group fishes at 35.5cm, and the II group fishes at 43.5cm. It seems unlikely that the size groups directly correspond to ages of the fishes as suggested by Peterson (1892; cited by FAO, 1981) and later on by Tanaka (1962). They used this method for indirectly estimating the age and growth of fishes especially those of tropical waters which live in a more or less uniform environment, and regular macroscopic changes do not always occur in their skeletal structures.

But later, Weatherley (1972) stated that it is difficult to separate modes representing age groups in a tropical water where there are several spawning and young fishes could enter the population throughout the year. However he admitted that sometimes due to environmental changes a particular spawning may be much more successful than usual and the progeny from such spawning may show as a mode in the length frequency distribution. The Peterson method has also been commented by Macdonald and Pitcher (1979) as the crudest and least reliable method.

Furthermore, the selectivity of the gear used could bring about a population structure that lacks one or more of the age-size classes of the actual population for nearly all commercial fishing gear is selective.

Obviously, the length frequency distribution was affected by the depth from which the sample was taken and the fishing pressure. Since larger individuals of *E. chlorostigma* tend to inhabit greater depths than their younger counterparts, shallower depth samples were dominated by relatively smaller size groups. This was revealed by the size composition of the December sample where the smaller size groups were over-represented. This sample was taken from the relatively shallower depths of the eastern side of Hermil Island.

On the other hand, the monthly and the combined length distribution show that fish whose size were above average were more than those having a length below average. This is an evidence that there is no great fishing pressure upon the species in all the sampling sites since the presence of large and senile fishes is an indicative of very little fishing pressure in a very simple form of population dynamics (Cushing, 1968).

TABLE 7. Length Frequencies of *E.chlorostigma* from the Ethiopian Red Sea

TOTAL LENGTH (cm)	1986					1987				TOTAL
	JUNE	JULY	AUGUST	NOVEMBER	DECEMBER	JANUARY	MARCH	APRIL		
18-21	-	-	-	-	4	3	-	-	7	
22-25	2	3	2	2	10	4	1	5	29	
26-29	3	3	4	2	11	7	13	16	59	
30-33	3	4	4	2	14	9	13	4	53	
34-37	5	5	7	6	11	6	18	15	74	
38-41	5	4	3	9	4	11	15	7	58	
42-45	11	6	9	9	4	6	9	15	69	
46-49	5	2	3	12	2	4	10	3	41	
50-53	-	-	-	1	-	-	1	-	2	
TOTAL	35	27	32	43	60	50	80	65	392	

Abcissa = Total Length In cm

Ordinate = Frequency

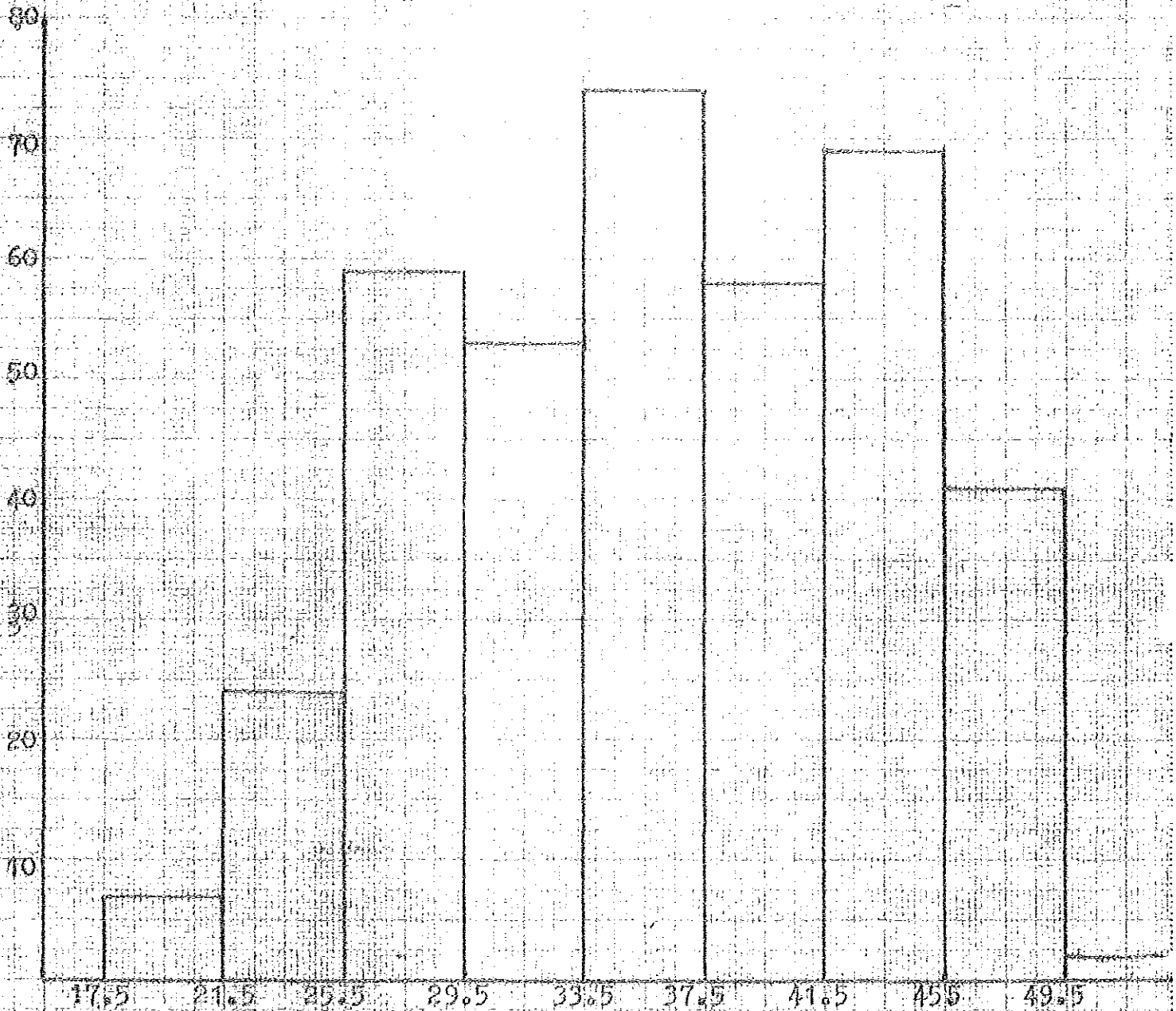


Fig. 2. Length Frequency Distribution of *Loinephelus chlorostigma* from the Ethiopian Red Sea.

4.3 Length-Weight Relationship

Length-weight relationship for *E. chlorostigma* was established by taking the logarithms of the equation $W=aL^b$ (Krumholz, 1949; Shepherd and Huish, 1978 and Grimes, 1978), where W =weight in grams; L =total length in centimeters; a = a constant and b =an exponent. The values of a and b were determined by the method of least squares from the available logarithmic data. Accordingly the relationship can be described by the equation:

$$W = 0.51L^{2.593}$$

The correlation coefficient (r) between length and weight of *E. chlorostigma* was found to be 0.906.

In the compilation of the length-weight data, the total lengths were placed in 3cm - classes with their corresponding frequencies as well as minimum, average and maximum weights (Table 4). The total lengths ranged from 20 to 52 cm while the weight varied from 95 to 1843g. The average lengths and weights were found to be 35.72cm and 617g respectively.

The plotting of the weight of the individual fishes against their respective lengths (Fig. 3) indicated that there is a curvilinear relationship between them. A rapid linear increment of length with weight was observed up to a certain size (around 36cm, which is near to the average total length) and beyond that, gain in weight tends to replace gain in length. This is in line with the explanation given by Nikolskii (1969). He stated that the main fraction of the food intake goes into protein growth before maturity. Thus length increases before maturity, while

afterwards most food goes to increasing the weight and to accumulating reserves. This rapid increase in mass during maturity seems to be an important adaptation leading to considerable increase in the fecundity of the population, since fecundity is more closely correlated with the body weight than with the length.

Eventhough such a curvilinear relationship did exist between length and weight of the fish examined, there was a considerable variation in the weight of fishes of a given length group. Furthermore, the heaviest fish of a given length group may be heavier than a fish in the next higher group. For instance, the heaviest fish in the 38-41cm class weighed 993g whereas fish grouped in 42-45cm class weighed as low as 810g (Table 4). Such differences can be attributed to sex, as a female with a ripe gonad weighs more than its counterpart having similar length; and stomach fullness for a well-distended individual weighs more than its hungry equivalent fellow mate.

ABSCISSA = TOTAL LENGTH (cm)

ORDINATE = WEIGHT (g)

1920

1620

1320

1020

720

420

120

18

24

30

36

42

48

FIG. 3. LENGTH-WEIGHT RELATIONSHIP FOR *Epinephelus chlorostigma*
EACH DOT REPRESENTS ONE FISH.

TABLE 8

The Relation Between Total Length and Weight

TOTAL LENGTH	NO.OF FISH	WEIGHT (G)		
		MINIMUM	AVERAGE	MAXIMUM
18-21	7	95	113.86	140
22-25	29	100	170.59	223
26-29	59	215	293.32	365
30-33	53	275	373.70	455
34-37	74	420	482.73	658
38-41	58	610	714.60	993
42-45	69	810	985	1180
46-49	41	936	1240.42	1450
50-53	2	1623	1733	1843

4.4 Notes on the Taxonomical Characteristics and
Distribution of the Serranidae

Of the 22 species of the family, described as to be found in the Red Sea as a whole, 8 species were found in the Ethiopian part of the Red Sea in this sampling survey.

While morphometric, meristic and mean measurements data of these 8 species of the family were given in appendix 4, results in their distribution and other additional features of each species are presented as follows. The format is adopted from Kotlyar (1984 and 1985).

4.4.1 *Epinephelus chlorostigma* (Valenciennes, 1828)-Fig.4

English name - Brown spotted grouper

Local name - "Tewina" (an Arabic word)

Short description - In addition to those features given in appendix 4, it has 49-53 lateral line scales, 26-30 pyloric caeca, angular anal fin and rounded pectoral fin. Inter-orbital space is slightly convex. Preopercle is serrate with enlarged serrae at the angle.

Colour when fresh - Whtish, the whole body covered with numerous roundish brown spots.

Colour when preserved - The spots become dark brown.

Comparative remark - The closely set small brown spots all over the body and the narrow white edge along rear margin of caudal fin.

Distribution - It was found in all the sampling places (Table 5) in depths ranging from 5 meters to 50 meters. Its distribution is related with the distribution of corals.

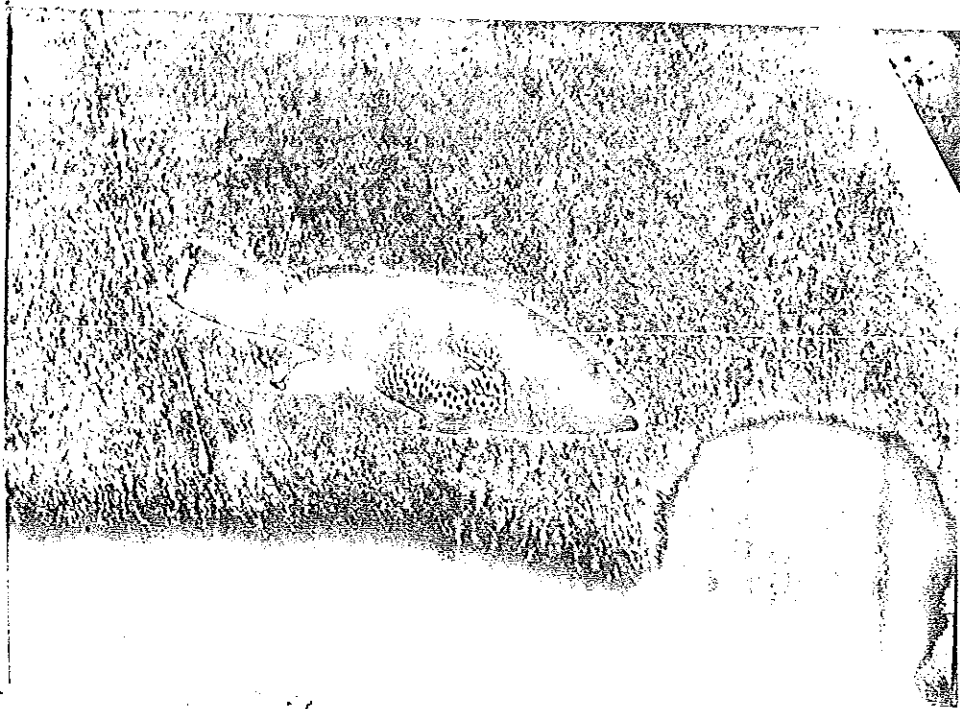


Fig. 4. - Epinephelus chlorostigma. (Valenciennes, 1828).

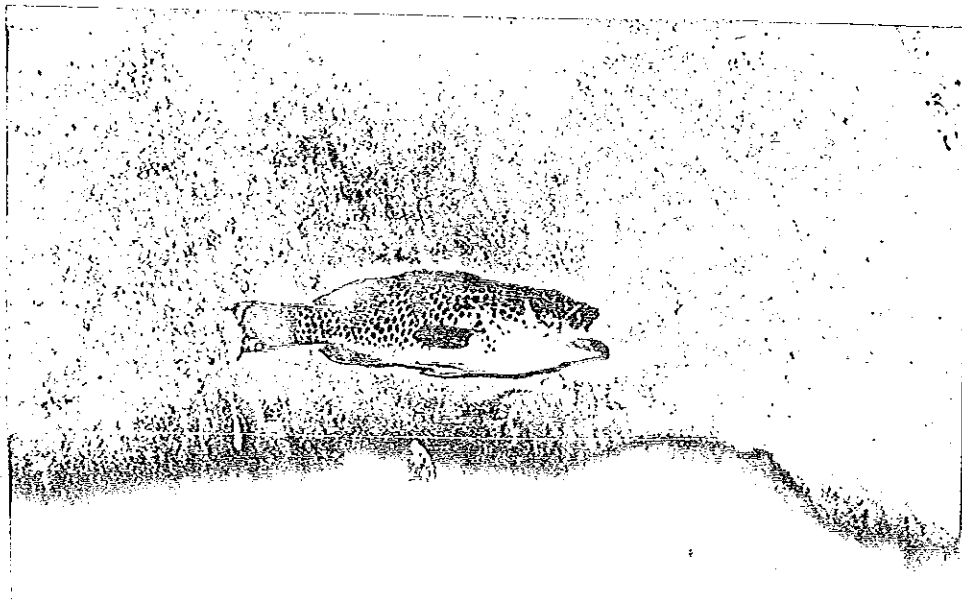


Fig. 5. Epinephelus areolatus (Forsskal, 1775)

4.4.2 *Epinephelus areolatus* (Forsskal, 1775)-Fig. 5.

English name - Arcolated grouper

Local name - "Chernia" (an Italian word)

Short description - In addition to those features given in appendix 4, it has 50 to 56 pored lateral line scales, 11 to 17 pyloric caeca, rounded pectoral fins, finely serrate posterior margin of preopercle. Inter-orbital space is slightly convex, eye is relatively large.

Colour when fresh - Whitish covered with numerous rounded brown spots, larger than those found on *E. chlorostigma*. Pectoral fins pale or with faint dark spots on rays.

Colour when preserved - The brown spots become brownish-yellow when kept for long.

Comparative remark - It is usually confused with *E. chlorostigma*. It differs in having larger spots, small number of pyloric caeca (11-17) and larger eye.

Distribution - It was found in the eastern side of Hermil Island in depths ranging from 20-40 meters. It is usually associated with corals.

4.4.3 *Epinephelus summana* (Forsskal, 1775)-Fig. 6

English name - Summan grouper

Local name - "Chernia"

Short description - In addition to those features given in appendix 4; it has 49-54 lateral line scales; finely serrate posterior margin of preopercle. Inter-orbital space is usually flat.

Colour when fresh - Generally brownish grey with pale blotches and numerous small white spots. Fins dark brown with small white spots.

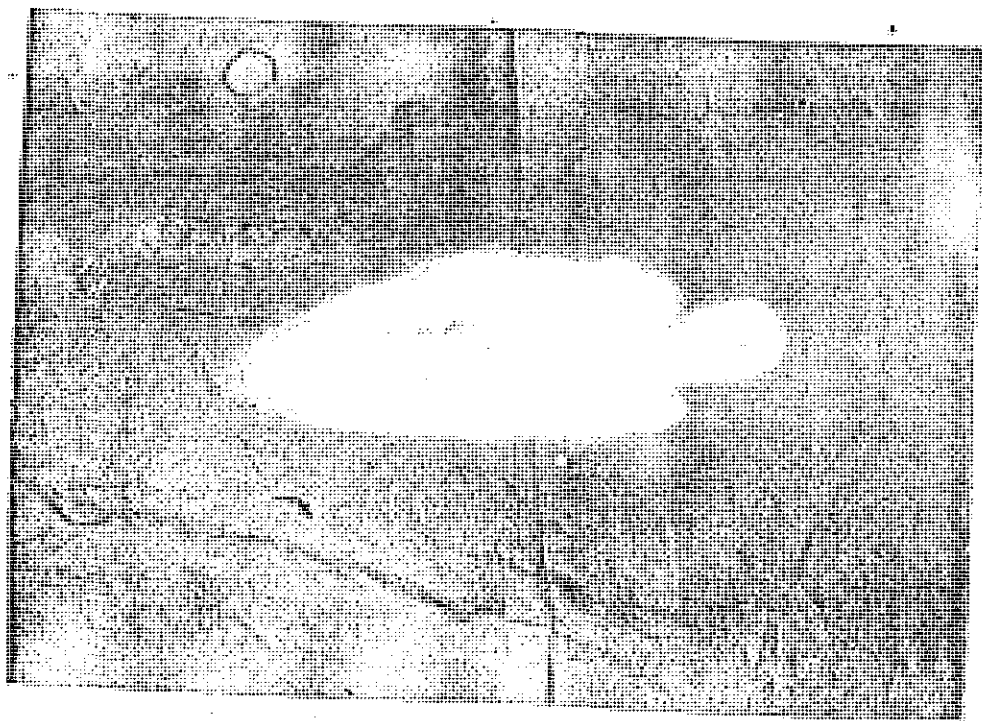


Fig. 6. Epinephelus summana (Forsskal, 1775)

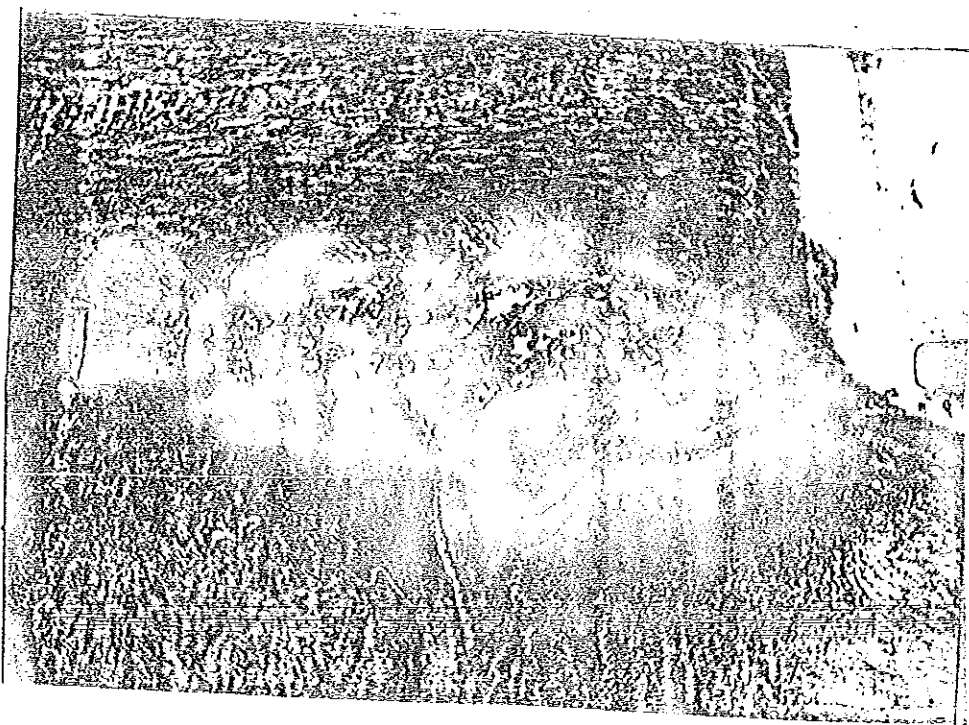


Fig. 7. Epinephelus malabaricus (Schneider, 1801)

Colour when preserved - It becomes generally brown with some distortion of the pale brown blotches.

Comparative remark - It has shorter pectoral and pelvic fins when compared to the same size specimens of other confusing species (*E. microdon*). The whitish spots on the body are also relatively larger.

Distribution - It was found around Entevedul and eastern side of Hermil Island in relatively shallower depths of 5-20 meters. This species appears to be confined to the Red Sea.

4.4.4 *Epinephelus malabaricus* (Schneider, 1801)-Fig. 7

English name - Malabar grouper

Local name - "Chernia"

Short description - In addition to those features given in appendix 4, it has 58-64 pored lateral line scales, finely serrate preopercle with a shallow notch, the serrae enlarged at the angle, smooth margins of sub-opercle and inter-opercle, 13 to 16 lower gill rakers.

Colour when fresh - Head and body generally greyish-brown covered with small dark brown spots. Five slightly oblique dark bars are found on the body. The last three of them are usually bifurcate ventrally, dark blotches on inter-opercle.

Colour when preserved - Greyish dark with indistinct bands. The blotches on inter-opercle were also lost.

Comparative remark - It has smaller number of pored lateral line scales and lower gill rakers when compared to the confusing species (*E. tauvina*).

Distribution - Found in all the sampling sites (Table 5) around coral areas in depths ranging from 20-40m. Large specimens reaching about 120cm were obtained from the eastern side of Hermil Island.

4.4.5 *Plectropomus maculatus* (Bloch, 1790)-Fig. 8

English name - Spotted coral-trout

Local name - "Cherinia Sudanese" (an Italian word)

Short description - In addition to those features given in appendix 4, it has 88-104 pored lateral line scales, naked inter-orbital space, finely serrate posterior margin of preopercle, slender and short dorsal spines.

Colour when fresh - Orange-red, with dark-edged blue spots, those on head and front part of body larger and more elongate.

Colour when preserved - There is no considerable change but the orange-red colour fades a little bit.

Comparative remark - Its typical orange-red colour and the naked inter-orbital region differentiates the species from confusing counterparts, e.g. *Plectropomus truncatus*.

Distribution - It was found in the eastern side of Hermil Island in depth ranging from 20 to 40 meters in coral areas.

4.4.6 *Plectropomus truncatus* Fowler and Bean, 1930-Fig. 9

English name - Square tail coral-trout

Local name - "Chernia Sudanese"

Short description - In addition to those features given in appendix 4, it has 88-105 pored lateral line scales, scaled and concave to flat inter-orbital space, poorly developed

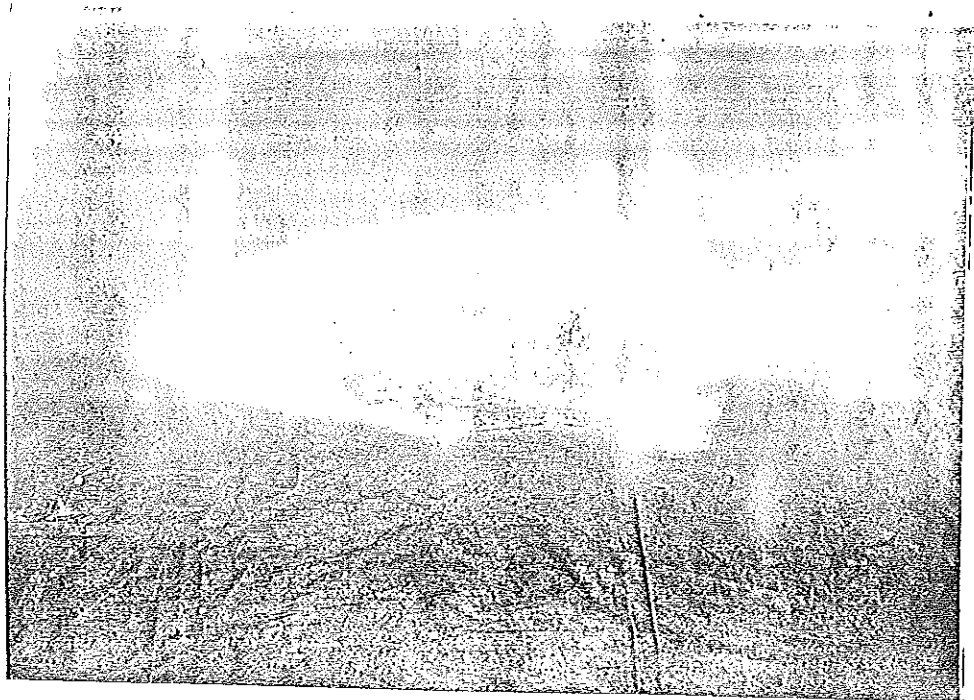


Fig. 8. Plectropomus maculatus (Bloch, 1790)

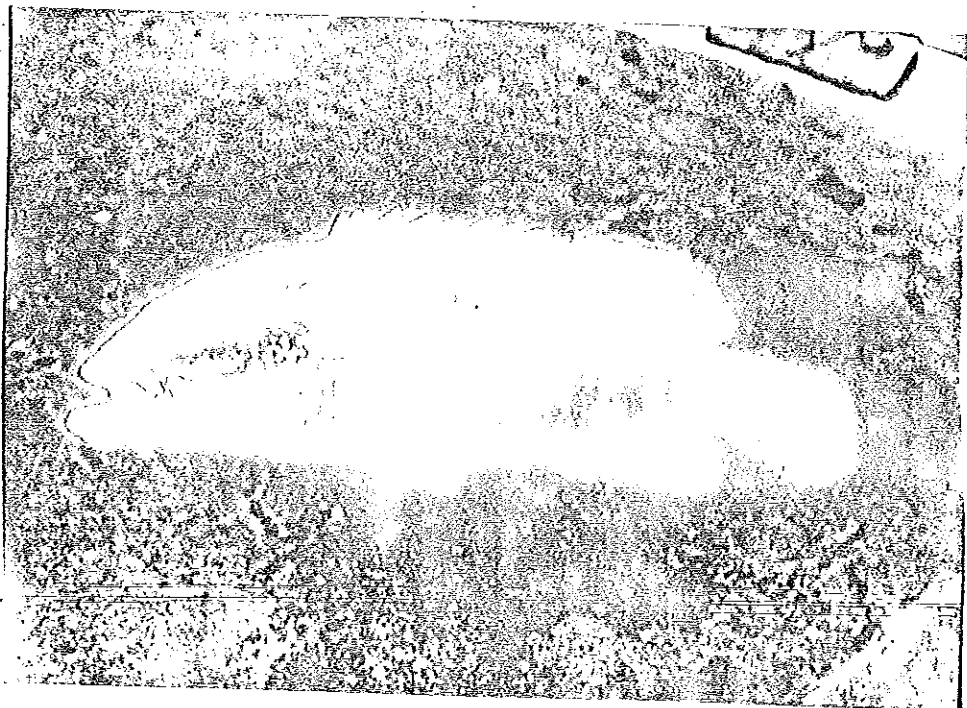


Fig. 9. Plectropomus truncatus Fowler and Bean, 1930

Colour when fresh - Orange brown with many blue spots throughout the body.

Colour when preserved - It becomes dark brown with indistinct spot when kept for long.

Comparative remark - The concave nature of the inter-orbital space and the characteristic coloration when fresh distinguish this species from other confusing ones (e.g. *P. maculatus* and *P. leopardus*).

Distribution - It was found in the eastern part of Hermil Island in similiar areas and depths with *P. maculatus*.

4.4.7 *Variola louti* (Forsskal, 1775)- Fig. 10

English name - Moon tail sea bass

Local name - "Nagel" (an Arabic word)

Short description - In addition to those features given in appendix 4, it has 64 to 78 pored lateral line scales, finely serrate preopercle, moderately convex and naked inter-orbital space, very angular soft portion of dorsal fin, more angular soft portion of anal fin.

Colour when fresh - Body yellowish-brown with many pinkish small irregular spots and yellow margins on the median fins.

Colour when preserved - It becomes more brownish and the spots also loose their yellow colour.

Comparative remark - *Variola louti* is easily distinguished from *Variola albomarginata* (similiar species) by the presence of yellow margins in the rear end of its median fins.

Distribution - It was found abundantly in the eastern side of Hermil Island in depth ranging from 20 to 40 meters. It is highly associated with corals.

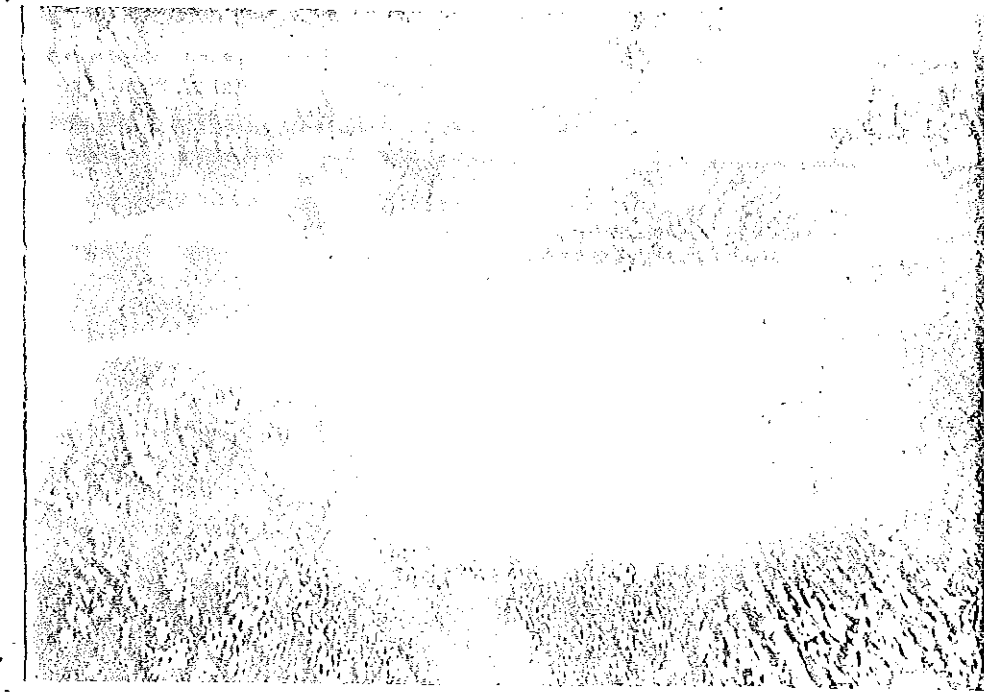


Fig. 10. Variola louti (Forsskal, 1775)

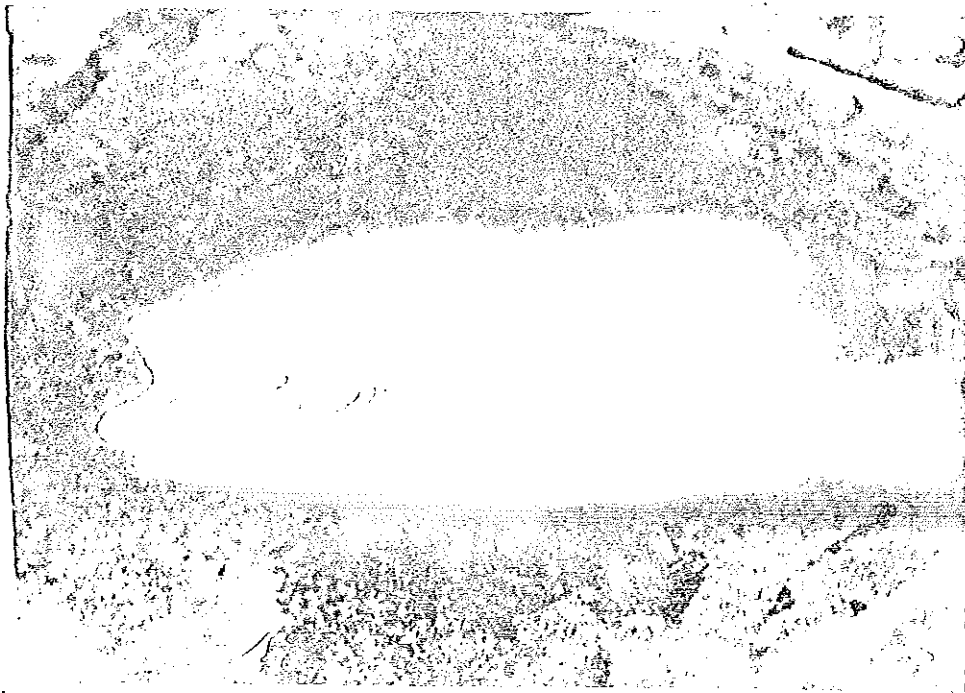


Fig. 11. Aethaloperca rogaa (Forsskal, 1775)

4.4.8 Aethaloperca rogae (Forsskal, 1775) - Fig. 11

English name - Red mouth grouper

Local name - "Abu-Ruman" (an Arabic word)

Short description - In addition to those features given in appendix 4, it has 48-55 pored lateral line scales, fully scaled head, convex inter-orbital space, finely serrate upper margin of preopercle and smooth lower margin. Soft portions of dorsal and anal fins are distinctly angular.

Colour when fresh - Dark-brown throughout the whole body.

Colour when preserved - It becomes dark black when preserved.

Comparative remark - It is distinctive from other species in the deeper body, steep shape of the back of the head, truncated caudal fin, angular soft portion of the dorsal and anal fin and dark characteristic coloration of the body.

Distribution - It was found around Ente-Entur Island and the eastern side of Hermil Island in depths ranging from 20 to 40 meters.

TABLE 9

Fishing Sites

Fishing Site	Fished Depth	Location	
		Longitude	Latitude
ISRATU ISLAND	15-25	39°50'E	16°15'N
HERMIL ISLAND	5-40	40°10'E	16°30'N
ENTEDEBER ISLAND	20-50	39°55'E	15°40'N
AULIHUTUB ISLAND	15-30	39°45'E	16°32'N
DEHEL ISLAND	20-40	39°37'E	15°52'N
ENTE-ENTHUR ISLAND	20-40	39°37'E	16°20'N

CONCLUSION AND RECOMMENDATION

The food of *E. chlorostigma* are fish, crustaceans, gastropods and eggs of fish. But it seems important to study the availability of the prey type in the niche to draw conclusive correlation between the importance of different prey types and their relative abundance. Moreover, the position of the species in the trophic pyramid appears to depend on its size.

The size distribution of *E. chlorostigma* is largely affected by depth, the larger size groups preferring greater depths. Apparently, there is no problem of fishing pressure on the species in the studied areas. Although extensive data on the stock assessment of *E. chlorostigma*, and other related species co-occurring in the studied areas are lacking, there seems to be no danger of overexploitation at this time if larger scales of fishing will have to be used.

The length-weight relationship for *E. chlorostigma* is $W=0.051L^{2.593}$ and this relation can be utilized for converting weight of fish to lengths of fish and vice-versa. Moreover, the data (appendix 6) can also be used converting weights of fish to number of fish.

Though eight species of the family Serranidae are presently recorded with their geographical distribution, future long term survey are needed to make the list as complete as possible.

Finally the use of fishery acoustics highly recommended in the fishing activities since it avoids the simple trial and error method, now being in use.

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APPENDIX 4

Selected characters of
Serranidae in the Ethio

NAME OF THE SPECIES

Epinephelus chlorostig

Epinephelus areolatus

Epinephelus summana

Epinephelus malabaricus

Plectropomus maculatus

Plectropomus truncatus

Variola louti

Aethaloperca rogaa

