THESIS

submitted for the Degree of

DOCTOR OF PHILOSOPHY

Faculty of Science

University of Cape Town

1960

F. H. TALBOT, B.Sc. (Rand), M.Sc. (U.C.T.)

PART 1

The fishes of the genus Lutianus of the East African Coast.

PART 2

Notes on the biology of the Lutjanidae (Pisces) of the East African Coast with special reference to L. bohar (Forskal).

From the ANNALS AND MAGAZINE OF NATURAL HISTORY
Ser. 12, vol. x, p. 241, *April*, 1957.

THE FISHES OF THE GENUS LUTIANUS OF THE EAST AFRICAN COAST.

By F. H. TALBOT,
East African Marine Fisheries Research Organization, Zanzibar.

[Plates IV—XII]

INTRODUCTION.

While investigating the biology of the economically important members of the genus Lutianus on the East African coastline, difficulty was experienced with the identification and the nomenclature of the group using existing literature. It was essential that adequate descriptions of the species of the genus should be available before their biology could be investigated. Routine work of the East African Marine Fisheries Research Organization has produced over 1,000 specimens for study. The Organization's vessel, the M.V. " Research ", has collected by hand-lines, multiple trolling lines, gill nets, deep lines and basket traps over the six hundred mile coastline of Kenya, Tanganyika and Zanzibar Protectorate, i.e. from Lat. 1° 30″ S. to 10° 30″ S. This material forms the basis of the present paper.

Underwater observations with and without a Seibe-Gorman aqualung down to seven fathoms have been made on a number of coral reefs. In this way some knowledge of the habits of certain species of the genus has been acquired, and some species rarely taken by normal fishing methods were discovered to be common. Specimens of these have been collected by spear guns. Where notes of habits of a species have been made they have been appended under the heading " Ecological note ".

Of the thirteen species of the genus found in the area, all (except the very small *L. ehrenbergi*) pass through the local markets and are considered good eating, and seven are important food fishes. Economically the genus ranks as one of the three most important groups of bottom Teleosts ; the others being the Epinephelids and the genus Lethrinus.

Measurements are based on an average of six specimens over the widest size range available.

Definition of terms.

Depth : The greatest depth of the body.

Eye : The greatest diameter of the fleshy orbit.

Head : The distance from the anterior end of the fish with mouth closed to the posterior end of the gill cover.

Interorbital distance : The shortest fleshy interorbital distance.

Length : This is measured excluding the caudal fin (body length, standard length), unless otherwise stated.

Lateral line count : Counts have been made to the end of the caudal peduncle (figures in brackets) and to the last of the lateral line scales on the caudal fin sheath (figures not in brackets).

Pectoral : Measured from the axil to the distal end of the longest ray.

Proportions : Where proportions vary directly with size the variation from the largest to the smallest fish in the size range is indicated by (l) and (s) behind the figures, and vice versa.

Snout : The snout is measured from the tip of the snout excluding the lips to the nearest point on the rim of the fleshy orbit.

Sub-orbital distance : The shortest distance between the fleshy orbital rim and the maxillary groove.

Key to the Genus *Lutianus*.

I. Scales above lateral line run parallel to dorsal profile, at least under the spinous dorsal.		
A. Distinct black lateral line spot	*ehrenbergi*	2
B. No lateral line spot, silvery red	*argentimaculatus*	4
II. Scales above lateral line run obliquely upwards to dorsal profile.		
A. Blue longitudinal lines on body.		
(i) Four wide blue lines, black lateral line spot present or absent	*kasmira*	5
(ii) Five or more thin blue lines, some joining anteriorly, black lateral line spot present or absent	*duodecimlineatus*	6
B. Body red or silvery red, with or without additional distinctive markings, no lateral line spot.		
(i) Dorsal spines X.		
(*a*) Scale rows run obliquely upward above and below the lateral line. In adults, head markedly concave dorsally in profile, and upper caudal lobe distinctly rounded and larger than ventral lobe. Deep preopercular notch	*gibbus*	7
(*b*) Scale rows run parallel to body axis below the lateral line. Head convex or straight dorsally in profile. Two silvery spots on side which may be absent in large fish. Preopercular notch shallow or absent	*bohar*	8
(ii) Dorsal spines XI.		
(*a*) Anterior nostril midway between eye and snout. Colour markings distinct in young (see Plate VIII A). Preopercular notch shallow	*sanguineus*	10
(*b*) Anterior nostril much nearer snout than eye. Colour markings distinct in young (see Plate IX B). Large adults develop a deep preopercular notch, and a long finger-like interopercular knob	*sebae*	11
C. Distinct black lateral line spot, no longitudinal blue lines, body yellow or orange.		
(i) Second anal spine shorter than snout. Vomerine teeth in a V with no elongate posterior projection	*monostigma*	12
(ii) Second anal spine longer than snout. Vomerine teeth in an arrowhead shape usually with an elongate posterior projection	*fulviflamma*	13
D. Wavy blue lines on head, pale spots on body, chalky lateral line spot, lost in large fish	*rivulatus*	15
E. Longitudinal yellow or fawn lines parallel to scale rows.		
(i) Dorsal spines XI. suborbital distance into eye two or more. No preopercular notch	*lineolatus*	16
(ii) Dorsal spines X, dorsal black sub-marginally with a fine white rim, suborbital distance into eye less than two Moderate to deep preopercular notch	*vaigiensis*	16

Lutianus ehrenbergi (Peters). (Pl. IV A.)

Mesoprion Ehrenbergi Peters (1869) ; *Lutjanus ehrenbergi* Weber & De Beaufort (1936) ; non. *L. ehrenbergi* Blegvad (1944).

Description.

Standard lengths 44 to 98 mm.

Proportions : head 2·2 (s)–2·5 (l) ; depth 2·4 (s)–2·7 (l) ; pectoral 3·2 (l)–3·6 (s) ; all in body length. Eye 3·6 (l)–4·0 (s) ; inter-orbital

4·1 (l)–5·0 (s). Snout 3·6 (l)–4·0 (s) ; all in head length. Sub-orbital into eye 2·7 (l)–5·0 (s).

Dorsal fin count X (XI), 12 to 13 ; anal fin count III 8 (9).

Lateral line count 50 to 53 (45 to 48). Five rows of cheek scales. Six rows of scales from lateral line to mid-dorsal spines. Scales on head start behind vertical through hind end of eye. Scale rows run parallel to the body axis below the lateral line.

Pre-opercular flange serrate, finely on the vertical limb, and coarsely on the horizontal limb. Notch indistinct in the juvenile, and small but distinct in the adult. Small inter-opercular knob present.

Weak rows of conical incisors in both jaws, with the upper anterior teeth slightly enlarged to form weak canines. Thin bands of villiform vomerine teeth in a V with no posterior projection. Palatine teeth similar to the vomerine, in a small band. Lingual teeth present or absent.

Colour in formaline olive above and pale below with a yellowish tinge. Fins hyaline. Caudal pale yellow. Soft dorsal with a faint dusky tip. Large distinct lateral spot black in life and fading to brown on preservation, covering nine lateral line scales below the posterior spinous and anterior soft dorsal, more above than below the lateral line, covering three scale rows above and two below the lateral line. Faint darker spots on each scale result in pale brown longitudinal lines. In life a few golden bars are present along the body.

Maximum size seen in East Africa, 98 mm.

Ecological note. Taken from mangrove pools on Zanzibar Island. Not common, and never seen underwater about coral reefs.

Distribution. Red Sea ; East African Coast ; Indo-Pacific Region as far east as the Solomon Islands.

Note. This species seems to be closely allied to *L. johni* (Bloch), and neither Smith (1953), Barnard (1927) nor Sauvage (1891) record it from East Africa Peters (1869) and Klunzinger (1870) describe it from the Red Sea. The E.A.M.F.R.O. specimens, although close to Day's descriptions of *L. johni*, differ from them in a number of points. In his description he mentions the soft dorsal being higher than the spinous. In these fish the spinous is very much higher than the soft dorsal. This point is specifically mentioned in Peters' original description of *L. ehrenbergi*. Day mentions that in two-and-a-half inch specimens of *L. johni* a strong denticulation is present in the lower limb of the preopercle, a remnant of a large spine in post-larval fish. Two-and-a-half inch *L. ehrenbergi* in the E.A.M.F.R.O. collection lack this spine. He also mentions the dorsal spines decreasing in height to the last, whereas in *L. ehrenbergi* the penultimate spine is always shorter than the ultimate. Weber and De Beaufort (1936) mention as an additional difference the absence of occipital scaling in the latter. The species also vary in size. *L. ehrenbergi* is a small species, and matures at a small size. Two of the E.A.M.F.R.O. specimens are fully mature females at 75 mm. This species is not recorded over 270 mm. in length. *L. johni* reaches nearly

a metre in length (Weber and De Beaufort) and, if an analogy can be drawn with other large Lutianids about whose biology something is known, it must mature at about 300 mm. *L. johni* has not been taken in the area.

Lutianus argentimaculatus (Forskal). (Pl. IV B, V A.)

Sciaena argentimaculata Forskal (1775); *Lutianus argentimaculatus* Day (1878–1888); *Lutianus gembra* Barnard (1927); *Lutianus argentimaculatus* Fowler (1928); *Lutianus argentimaculatus* Weber & De Beaufort (1936); *Lutianus argentimaculatus* Smith (1949).

Description.

Standard lengths 104 to 865 mm.

Proportions: head 2·5–2·8; depth 2·6 (s)–3·2 (l); pectoral 3·4–3·7; all in body length. Eye 4·5 (s)–6·4 (l); inter-orbital 5·1–5·4; snout 2·8 (l)–3·2 (s); all in head length. Sub-orbital distance into eye 0·7 (l)–1·3 (s).

Dorsal fin count X (unusually XI) 13 to 14. Anal fin count III 8.

Lateral line scales 48 to 53 (44 to 56). Seven to eight rows of cheek scales. Scales on head start above posterior third of eye in young specimens and as far back as above the free pre-opercular edge in large adults. Scale rows above lateral line parallel to dorsal profile anteriorly, rising obliquely below the posterior end of the soft dorsal. Scale rows below lateral line parallel to the body axis.

Pre-opercle flange serrate above and in notch. with coarse, widely separated serrations below. Notch weak. No distinct interopercular knob.

Moderate conical incisors in upper jaw, with one anterior pair enlarged to form strong back-curving canines. Lower jaw with a strong row of outer canines. Villiform vomerine teeth in an arrow head, usually with a backward projection. Granular palatine teeth present in oval patch. Small patch of lingual teeth usually present.

Juvenile coloration in formalin rust red above to silver below. Pectoral fins orange, dark-tipped. Dorsal hyaline, with the spinous part dark-tipped. Anal hyaline, with the first two rays dusky. In life a wavy blue line is present on head below eye.

Adults (formalin preserved) reddish brown above to silver below. Scaly bases of unpaired fins have an orange tinge. Unpaired fins and pelvics dusky, pectorals hyaline.

Maximum size seen in East Africa up to about one metre body length.

Ecological note. Common on the Tanganyika, Kenya and Zanzibar coasts in relatively sheltered waters. Never seen under water on the exposed eastern coral reefs subject to strong wave action, but common inside the shelter of the fringing reefs in depths of two to seven fathoms, and in estuaries, mangrove inlets, and in the sheltered waters of the Zanzibar and Mafia channels. Juveniles have been taken in mangrove pools on Zanzibar Island, down to 104 mm. in length.

This species is usually seen in slowly moving shoals in water of five to seven fathoms, with about five to thirty fish per shoal. Solitary individuals, usually from six to twenty lb in weight are often seen under and about coral rock shelter.

Distribution. Natal ; Red Sea ; Indo-Pacific region as far east as the Tuamotu Archipelago and Christmas Island.

Lutianus kasmira (Forskal). (Pl. V B.)

Sciaena kasmira Forskal (1775) ; *Lutianus bengalensis* Day (1878–1888) ; *Diacope bengalensis* Sauvage (1891) ; *Lutianus kasmira* Barnard (1927) ; *Lutianus kasmira* Weber & De Beaufort (1936) ; *Lutianus kasmira* Randall (1955).

Description.

Standard lengths 170 to 190 mm.

Proportions : head 2·5–2·8 ; depth 2·8–2·9 ; pectoral 3·3–3·6 ; all in body length. Eye 4·0–4·1 ; inter-orbital 4·3–4·7 ; snout 3·0 ; all in head length. Sub-orbital distance into eye 1·6–1·8.

Dorsal fin count X (XII in Malindi specimen, see below) 14, anal fin count III 8.

Lateral line scales 56 (49 to 51) ; number of scales from the lateral line to the mid-dorsal spines seven. Seven to eight rows of cheek scales. Scales on head begin above middle to anterior third of eye, with the temporal region therefore scaly. One or two rows of scales on the sub-opercle. Scale rows run obliquely upward to the dorsal profile above the lateral line, and below it run parallel to the body axis.

Pre-opercular flange finely serrate above and just below the pre-opercular notch, which is deep and smooth. Lower curve of the free pre-opercular edge coarsely serrate. A large, often sharp, inter-opercular knob present, fitting into the notch.

Teeth of the typical Lutianid pattern, with the outer conical incisors weak, sharp, and needle-like. Two to three pairs of teeth slightly enlarged anteriorly to form weak canines. Outer row of teeth in the lower jaw moderate, only slightly enlarged half way down jaw. Villiform teeth in a band inside upper jaw, and in a small patch on either side of the symphysis in the lower jaw. Villiform vomerine teeth set in a V with no posterior projection. Similar palatine teeth set in a thin band. No lingual teeth.

Colour in formalin pale yellow, with brighter yellow about head, scaly fin sheathes, and operculum. Fins hyaline to yellow, with the dorsal strongly black tipped. Four distinct longitudinal lines, pale blue-grey, dark edged. Uppermost line from nape to ninth dorsal spine ; second from upper border of orbit to sixth or seventh soft dorsal ray ; third from upper end of free preopercular edge to last dorsal ray ; fourth from snout under eye to caudal peduncle. A distinct black lateral line spot present between the second and third longitudinal lines, below the first few soft dorsal rays, and mostly above the lateral line. In life under water this lateral line spot is often seen as a pale patch or is absent,

suggesting active chromatophores as found in *L. bohar*. A wide black bar from snout to eye is also distinct underwater.

Maximum size seen in East Africa 190 mm.

Ecological Note. Occasionally seen in large shoals on the outer exposed edges of coral reefs, often in conjunction with shoals of *L. fulviflamma*. Taken in local basket traps, but not a common food fish. This species does not seem to frequent the mangrove swamp areas, nor the inside of the fringing reefs, but is a species of clear water and active coral growth areas. One specimen has been taken from the research vessel in fifty fathoms off Malindi (Kenya). This deep water specimen, however, differs in a number of ways from the shallow water specimens in the E.A.M.F.R.O collection, and is described below. Schultz notes that off the Marshall and Mariana Islands *L. kasmira* is " very abundant " down to a hundred feet.

Malindi specimen. Dorsal fin count XII 13, anal fin count III 8. There is more scaling on the head, with 18 rows of cheek scales as compared with eight to ten, the scaling continuing further forward on the head, forward of the eye to below the posterior nostril. The black lateral line spot is absent.

Distribution. Natal ; East Coast of Africa ; Madagascar ; Indo-Pacific region to Tahiti.

Lutianus duodecimlineatus (C.V.). (Pl. VI A.)

Diacope duodecimlineata Cuvier & Valenciennes (1830), ? *Diacope duodecimlineata* Sauvage (1891), *Lutianus duodecimlineatus* Barnard (1927), *Lutianus duodecimlineatus* Fowler (1934), *Lutianus duodecimlineatus* Smith (1953).

Description.

Description based on one specimen of 150 mm. standard length.

Proportions : head 2·5 ; depth 2·5 ; pectoral 3·3 ; all in body length. Eye 3·7 ; inter-orbital 3·9 ; snout 3·1 ; all in head length. Sub-orbital into eye 1·4.

Dorsal fin count XI 13. Anal III 8.

Lateral line scales 54 (49). Seven scales from lateral line to mid-dorsal spines. Twelve rows of cheek scales. Scales on head begin above the front border of eye. Two rows of scales on sub-opercle. Scale rows on body run obliquely upward to dorsal profile above lateral line, below lateral line they are parallel to body axis.

Free pre-opercular edge finely serrate above and just below notch, which is deep and smooth. Lower limb of pre-opercle coarsely serrate. Inter-opercular knob distinct and pointed.

Both jaws with a weak outer row of conical incisors, slightly enlarged to form weak canines anteriorly in the upper jaw. Villiform bands inside the incisors, in the lower jaw anteriorly only. Sharp villiform vomerine teeth in a V without backward projection. A small band of villiform palatine teeth present. Tongue smooth.

Colour (preserved in formalin) pale yellow, with five dark (blue in life) lines on body ; upper most from head behind upper edge of eye to seventh dorsal spine ; second from upper edge of opercle to last dorsal spine ;

Lutianus bohar (Forskal). (Pl. VII A, B.)

Sciaena bohar Forskal (1775); *Mesoprion bohar* Gunther (1859); *Lutianus bohar* Day (1878–1888); *L. bohar* Barnard (1927); *L. bohar* Smith (1953); *L. gibbus* Smith (in part) (1953); *L. bohar* Schultz (1953); *L. bohar* Randall (1955).

Description.

Standard lengths 87 to 590 mm.

Proportions: depth 2·3 (s)–3·0 (l); head 2·6 (s)–2·8 (l); pectoral 3·2–3·6; all in body length. Eye 3·8 (s)–6·1 (l); inter-orbital 3·6 (l)–4·3 (s); snout 2·2 (l)–3·4 (s); all in head length. Sub-orbital into eye 0·7 (l)–2·3 (s).

Dorsal fin count X (rarely XI) 14. Anal fin count III 8 (rarely 9).

Lateral line scales 54 to 58 (48 to 50). Eight scales from the lateral line to the mid dorsal spines. Seven to eight oblique rows of cheek scales. Scales on occiput start above the posterior half of the eye. Scale rows ascend obliquely to the dorsal profile, above the lateral line under both soft and spinous dorsal fins. Scales below the lateral line run parallel to the body axis.

Pre-opercular flange serrate, finely above and coarsely below the notch, which is small, usually distinct, but sometimes wide and indistinct, always without serrations, never deep and narrow. The inter-opercular knob is a small smooth bony point facing upward and outward. Both knob and notch are faint or absent in the juvenile.

Outer strong row of conical incisors in the upper jaw, with one enlarged fanglike pair of canines anteriorly. A band of fine villiform teeth lies inside the caniniform row. Strong outer row of conical incisors in the lower jaw, with three or four pairs enlarged half way along the jaw to form strong canines. A fine villiform band lies inside the incisors anterior to the canines only Vomerine teeth fine, sharp, and backward pointing, in a V without posterior projection. Granular palatine teeth present in an elongate patch. Granular teeth present on tongue.

Colour in formalin or post mortem deep red above, shading to silver below. Two silvery spots on flanks, the anterior spot below the last four dorsal spines and the posterior pair under the last six dorsal rays, and meeting across the caudal peduncle. These spots are very distinct and large in the young, but in the adult become relatively smaller and less conspicuous, and are able to appear and disappear within short time intervals, presumably due to active chromatophores. In very large adults they may be completely absent. Eye orange-red. Spinous dorsal red, white fringed. Caudal red, fringed with white at the tips of the caudal lobes. Pectorals, upper half red, lower white, and dark brown in axils. Pelvic spine and first ray creamy white, remainder black anteriorly to pink posteriorly. Anal black anteriorly, red posteriorly.

Largest specimen seen, 20 pounds weight, 640 mm.

Ecological Note. *L. bohar* is commonly taken by handline on the outer, exposed reef edges, over bottoms with strong coral growth giving much shelter. In this type of habitat it can be found in depths from four to twelve fathoms. During underwater observation it has also often been

seen inside the fringing reefs in five fathoms of water, near breaks in the fringing reef. Solitary juveniles of six inches are sometimes seen in shallow and more sheltered water and are occasionally caught by fine meshed local arrow-head traps.

L. bohar swims in small loose shoals of three to twelve fish continually on the move over and about coral shelter.

Distribution. East African Coast from the Red Sea to Natal ; Indo-Pacific region as far east as the Tuamotu Archipelago and the Marquesas Islands.

Note. Smith (1953) plates under the name *L. gibbus* a large fish of about 750 mm., lacking the concave head, deeply forked tail, and deep pre-opercular notch of that species. This seems to be a typical large *L. bohar*, with its very robust body, and no margaritaceous flank patches.

Lutianus sanguineus (C.V.). (Pl. VIII A, B ; IX A.)

Diacope sanguinea Cuvier & Valenciennes (1828) ; *Lutianus erythropterus* Day (1878–1888) ; *L. erythropterus* Barnard (1927) ; *L. sanguineus* Weber & De Beaufort (1936) ; ? *L. coccineus* Blegvad (1944) ; *L. sanguineus* Smith (1953).

Description.

Standard lengths 137 to 635 mm.

Proportions : depth 2·4 (s)–2·8 (l) ; head 2·4 (s)–2·9 (l) ; pectoral 3·3–3·7 ; all in body length. Eye 4·3 (s)–6·7 (l) ; inter-orbital 3·8 (l)–5·8 (s) ; snout 2·7 (l)–3·0 (s) ; all in head length. Sub-orbital into eye 0·6 (l)–1·09 (s).

Dorsal fin count XI 14. Anal fin count III 9 to 10.

Lateral line scales 56 to 59 (49 to 51). Eight scale rows from the lateral line to the mid-dorsal pines. Six to eight scale rows on cheek. A single row of inter-opercular scales. Scales on head begin behind vertical through posterior end of eye. Scale rows run obliquely upward above the lateral line, and parallel to the body axis or slightly upwards below the lateral line.

Pre-opercular flange finely serrate on the verticle limb above and through a shallow opercular notch. Small inconspicuous inter-opercular knob present.

Teeth very weak compared with most members of the genus, lacking the usually strong canines in the front of the upper jaw. Outer row of very weak conical incisors present in both jaws, a few slightly enlarged in the anterior part of the upper jaw. Inner bands of fine teeth in both jaws. Bristle-like vomerine teeth in a narrow V. Palatine teeth similar, in an oval patch. Lingual teeth absent.

Profile of head steep and straight in juveniles, but in adults a marked hump may develop directly above the eyes. In large specimens of 600 mm. this may be very marked, causing the head profile to become concave. (See Plate IX A.)

Colour of the adult (post mortem) a rich orange red with silver belly. Sometimes a brown bar down the occiput from the dorsal to the upper jaw, a remnant of the juvenile coloration. Eye pale red. Roof of mouth bright yellow, and yellow band inside teeth. Juvenile coloration distinct,

with yellow body colour and brown occipital band marked and broad including eye. Dusky saddle on the posterior caudal peduncle, preceded by a margaritaceous patch. Sides of body covered in distinct fine red-brown lines parallel with the axis of the body.

Grows to at least 50 lb., and nearly a metre in length.

Ecological Note. Taken on certain coral banks in the Mafia group at dusk and at night from the fisheries vessel by handline, in five to seven fathoms. Never taken during the day. Juveniles caught in traps among *Cymodocea* beds in shallow water in the Zanzibar Channel and taken from the E.A.M.F.R.O. fish ponds at Chukwani, a mangrove area. Large adults taken off the southern end of Zanzibar Island in deep water (about 40 fathoms) by local fishermen in the early months of the year.

Distribution. East African Coast from Natal to the Red Sea; Indo-Pacific as far east as Melanesia ; Japan.

Lutianus sebae (C. & V.). (Pl. IX B ; X A.)

Diacope Sebae Cuvier & Valenciennes (1828) ; *Genyoroge sebae* Gunther (1859) ; *Lutjanus sebae* Day (1878–1888) ; *Lutjanus sebae* Barnard (1927) ; *Lutjanus sebae* Smith (1953).

Description.

Standard lengths 165 to 670 mm.

Proportions : depth 2·1 (s)–2·4 (l) ; head 2·3–2·6 ; pectoral 2·9 ; all in body length. Eye 4·9 (s)–8·4 (l) ; inter-orbital 4·1–5·2 ; snout 2·3 (l)–2·6 (s) ; all in head length. Sub-orbital into eye 0·4 (l)–0·8 (s).

Dorsal fin count XI 15 to 16. Anal fin count III 10.

Lateral line scales 54 to 56 (49 to 50). Six to seven scales from the lateral line to the mid-dorsal spines. Seven to eight rows of cheek scales. Scales on head begin above the posterior third of eye, or behind it in large specimens. Inter-opercle scaled, with the scales usually embedded in large specimens. Scale rows run obliquely upwards above the lateral line, and almost parallel to the body axis below it.

Preopercle finely serrate in and above notch, coarsely below it. Large adults (600 mm. body length) lose all serration. In the young, notch shallow, with inter-opercular knob small and indistinct. Both the notch and the knob develop with age, and large specimens of 20 lb. and over develop a deep smooth notch, and a blunt, finger-like inter-opercular knob.

Canines never strongly developed. Incisors conical, in a single row in each jaw, weak and sharp in the young, short and sturdy in the adult. Inner band of villiform teeth present in the upper jaw, but reduced to a small patch on either side of the symphysis in the lower jaw. Thin band of sharp, short vomerine teeth in a wide V. Similar palatine teeth in a short band. Lingual teeth absent.

Body colour (formalin preserved) silver white, with three broad, red-brown bands ; the anterior from the occiput through the eye to the upper jaw, the second band from the third to fifth to the pelvic fin and anus, and the third curving from the last two dorsal spines to the bottom of the caudal peduncle, continuing out on the lower caudal lobe. Soft

dorsal and anal hyaline, black edged. Caudal hyaline with upper and lower caudal lobes black tipped. Pectorals hyaline, pelvics dusky.

With age the bands become paler, and the body colour a rich red. Large fishes show no trace of the three bands.

Grows to at least 60 lb. in East African waters.

Distribution. East coast of Africa from the Red Sea to Moçambique ; Indo-Pacific region as far east as Melanesia ; New South Wales.

Lutianus monostigma (Cuvier and Valenciennes). (Pl. X B.)

Mesoprion monostigma Cuvier & Valenciennes (1828) ; *Diacope monostigma* Klunzinger (1870) ; *Lutianus lioglossus* Day (1878–1888) ; *Lutianus monostigma* Schultz (1953).

Description.

Standard lengths 120 to 385 mm.

Proportions : depth 2·6–2·9 ; head 2·4 (s)–2·5 (l) ; pectoral 3·3–3·6 ; all in body length. Eye 4·2 (s)–5·2 (l) ; inter-orbital 5·0–5·8 ; snout 2·9 (l)–3·3 (s) ; all in head length. Sub-orbital into eye 0·8 (l)–1·3 (s).

Dorsal fin count X 12 to 13. Anal fin count III 8.

The anal and dorsal are weak spined and fairly low. Second anal spine always shorter than snout, and shorter than the third anal spine.

Lateral line scales 53 to 55 (47 to 48). Six scales from the lateral line to the mid-dorsal spines. Six rows of cheek scales. One row of inter-opercular scales. Scales on head begin above hind border of eye. Above the lateral line scale rows run obliquely upward under the dorsal fin, and below the lateral line are parallel to the body axis.

Pre-opercular flange finely and regularly serrate in juveniles, with wider serrations on the lower curve. Smooth in large adults. Notch a wide indistinct indentation, sometimes absent in adults. No inter-opercular knob.

Sharp conical incisors form the outer rows in both jaws. One large, fang-like pair of canines anteriorly in the upper jaw, and a few enlarged canines half way along the lower jaw. Vomerine teeth fine, in a V without a backward projection. Granular palatine teeth present in an elongate patch. Small patch of granular lingual teeth sometimes present.

Body colour (post mortem) grey, sometimes yellow, with faint darker lines following the scale rows. All fins yellow, the pelvics and anal a striking golden yellow. Eye silver. Distinct round black lateral line spot, more above than below the lateral line, relatively much smaller in adults and oval in shape.

Maximum size seen 385 mms. body length.

Ecological note. This species is only found about coral areas with much shelter. Unlike the closely allied *L. fulviflamma*, it is never seen in mangrove swamp and muddy creek areas. Adults are found about under large coral " rocks " in reef areas (Latham Island, Mafia Island, always close to shelter, and although a few may be found under one coral " rock " there is no clear shoaling behaviour, unlike *L. fulviflamma*. Juveniles are common about coral reefs in the Zanzibar Channel, in twos

and threes. Economically not an important fish in East Africa, being rarely caught by fishermen.

Distribution. Red Sea ; East African Coast ; Seychelles ; Madagascar ; Indo-Pacific region as far east as the Tuamotu Archipelago.

Note. This species is closely allied to *L. fulviflamma* (Forskal) (see below) and to *L. russelli* (Bleeker). It differs from the latter in having 12 to 13 soft dorsal rays, not 14 to 15, and six to six-and-a-half scales between the lateral line and the median dorsal spines, not seven. Adult *L. russelli* have " six to seven longitudinal oblique golden stripes " in life, and " in young specimens three dark longitudinal bands " (Weber and De Beaufort 1936). These are absent in *L. monostigma.*

Lutianus fulviflamma (Forskal). (Pl. XI A.)

Sciaena fulviflamma Forskal (1775) ; *Mesoprion fulviflamma* Gunther (1895) ; *Lutianus fulviflamma* Day (in part) (1878–1888) ; *Lutjanus fulviflamma* Sauvage (1891).

Description.

Standard lengths 58 to 175 mm.

Proportions : depth 2·7–3·0 ; head 2·4–2·6 ; pectoral 3·2 (l)–3·9 (s) ; all in body length. Eye 3·4 (s)–3·7 (l) ; inter-orbital 4·2 (l)–6·0 (s) ; snout 3·3 (l)–4·8 (s) ; all in head length. Sub-orbital into eye 1·5 (l)–3·3 (s).

Dorsal fin count X (rarely XI) 12 to 13. Anal fin count III 7 to 8.

Second and third anal spines sub-equal. Second anal spine as long as or longer than snout.

Lateral line scales 52 to 58 (47 to 50). Six scales from the lateral line to the mid-dorsal profile. Six rows of cheek scales. One to three rows of inter-opercular scales. Scales on head begin at or behind vertical through hind border of eye. Scale rows run obliquely upward above the lateral line, and are parallel to the body axis below it.

Pre-opercular flange finely and regularly serrate on its vertical limb with the curve and lower limb coarsely serrate. Pre-opercular notch, absent, or occasionally an indistinct wide notch present. Inter-opercular knob absent.

Weak outer row of conical incisors in the upper jaw, with one or two pairs of strong canines anteriorly, and a band of sharp, back-pointing villiform teeth inside this row. Conical incisors in upper jaw moderate to weak, with three to four strong canines half way along jaw. A small patch of sharp villiform teeth present inside the incisors on either side of the symphysis. Vomerine teeth close set, sharp, and back-pointing, in an arrow-head shape, usually with an elongate posterior projection. Elongate patch of granular palatine teeth present. Tongue toothed.

Body colour (post mortem) yellow, dusky above to silvery below, with faint golden-brown longitudinal streaks following the scale rows. Head brownish above to silvery below. Eye pale yellow. Orange spot on upper pectoral base and orange on pre-opercular flange. All fins bright yellow except for posterior two pelvic rays. Caudal and dorsal faintly red-tipped. Lateral line spot oval with indistinct edges, often encircled by a pale area. Underwater photographs of adults show that in life a

thick dark stripe is present from the tip of the snout to the eye. The lateral line spot is often indistinct or absent under water.

Seen up to about one and-a-half lb.

Ecological note. An abundant species in the East African coastal area, and an important food fish, taken by hand lines, traps and shore seines. It is found in mangrove swamp areas, estuaries, about coral, and inside and outside the fringing reefs. In underwater observations it is always seen in shoals, usually of ten to fifty individuals, and often in company with other Lutianids, especially *L. kasmira* and *L. lineolatus*.

Distribution. Found on the East African coast-line from the Cape (East London) to the Red Sea; Indo-Pacific region as far east as Polynesia; New South Wales.

Note. This and the preceding species are closely allied and structurally very similar, but with very different habits and habitats. *L. fulviflamma* seems able to colonise reef areas, estuaries, mangrove swamp channels, withstanding wide salinity, turbidity, and temperature ranges. It is an abundant and successful fish. *L. monostigma* is virtually restricted to coral reef areas, and then only those with large coral growths giving adequate shelter, and the numbers are a fraction of those of the former species.

Adults of the two species are very distinct, with *L. monostigma* developing a much longer snout, with relatively small growth of eye, giving ratios of eye length into head length of about five (*L. fulviflamma* 3·7) and of snout into head length of 2·9 (*L. fulviflamma* 3·3), and of sub-orbital distance into eye of 0·8 (*L. fulviflamma* 1·5). Juveniles are more difficult to distinguish however. The height of the fins is distinctive in the E.A.M.F.R.O. specimens, with *L. monostigma* having a lower dorsal and anal, commensurate with very much weaker spines. In *L. monostigma* at 120 mm. the second anal spine is shorter than the snout, in *L. fulviflamma* longer. Throughout the range of *L. monostigma* the second and third anal spines are weak, with the latter the longer. In *L. fulviflamma* the second anal spine is very sturdy, thicker and longer than the third. In this latter point the E.A.M.F.R.O. specimens do not agree with Weber and De Beaufort's descriptions.

The shape of the lateral line spot and its relation to the lateral line does not seem to be a valid difference between the two species as it is variable. In large specimens of *L. monostigma* it becomes oval, relatively smaller, and is often almost absent. It may disappear on preservation. In small specimens of *L. monostigma* up to 220 mm., the spot is large, round, and bisected about midway by the lateral line, usually leaving more black above than below the line.

L. fulviflamma has always an oval lateral line spot, usually more below than above the lateral line and often surrounded by a paler area.

Klunzinger states that the presence or absence of lingual teeth is a valid difference between these species. *L. fulviflamma* has always lingual teeth, and *L. monostigma* has usually a smooth tongue. On a few of the E.A.M.F.R.O. specimens, however, a small patch of granular teeth is present in the latter.

As noted by Klunzinger (1870) *L. monostigma* is a much larger species, reaching at least 420 mm. standard length, and maturing at about 350 mm. *L. fulviflamma* matures at 150 mm., and the largest specimens seen in East Africa were 220 mm.

Lutianus rivulatus (C.V.). (Plate XI B.)

Diacope rivulata Cuvier & Valenciennes (1828); *Genyoroge rivulata* Gunther (1859); *Lutianus rivulatus* Day (1878–1888); *Diacope rivulata* Sauvage (1891); *Lutianus rivulatus* Barnard (1927); *Lutianus gibbus* Blegvad (1944); *Lutianus rivulatus* Smith (1953).

Description.

Standard lengths 254 to 583 mm.

Proportions : depth 2·3–2·4 ; head 2·5–2·6 ; pectoral 2·8–3·0 ; all in body length. Eye 4·8–6·6 ; inter-orbital 3·8 (l)–4·2 (s) ; snout 2·4(l)–2·9 (s) ; all in head length. Sub-orbital into eye 0·5 (l)–0·9 (s).

Dorsal fin count X 15 to 16. Anal fin count III 8 to 9.

Lateral line scales 52 to 54 (47 to 49). Eight scales from the lateral line to the mid-dorsal spines. Six to eight oblique rows of cheek scales. Inter-opercle with a single row of scales, embedded in large specimens. Scales on head begin above hind end of eye. Scale rows above the lateral line run obliquely upward towards the body profile. Scale rows below lateral line parallel to the body axis.

Pre-opercular flange finely serrate above, and coarsely below the notch in small specimens, but becoming completely smooth in large adults. Notch distinct, wide and smooth, not deep and narrow. A moderate, blunt inter-opercular knob present.

Moderate outer row of conical incisors in each jaw, with a few anterior pairs slightly enlarged in the upper jaw, but without fang-like anterior canines. In large fish the incisors become blunt and peg-like. Inner bands of sharp villform teeth present inside the incisors, in the lower jaw anteriorly only. Fine vomerine teeth in a V without posterior projection. Palatine teeth villiform, in a narrow band. Lingual teeth absent.

Body colour (post mortem) grey, with a yellowish tinge dorsally, each scale with a distinct blue-grey spot. Head golden above, with fine wavy blue lines roughly parallel to the body axis. Lips white, maxilla yellow. Chalky lateral line spot present in young fish, but lost in adults.

Maximum weight seen 25 lb.

Ecological note.—This species does not appear much in the catches of the fisheries research vessel, nor in the local markets. In underwater observations, however, it is seen to be fairly common inside the fringing reef, and in the fairly sheltered water inside the southern tip of Zanzibar Island, swimming in midwater in small numbers or in larger shoals of about 15 fish, usually about large coral growths. It is often seen in composite shoals with *L. argentimaculatus* and *Spilotichthys pictus*. It has also been seen in the channel between Tutia Reef and Kibondo Island (Mafia group).

Distribution. East African coastline from the Red Sea to Natal ; Madagascar ; Indo-Pacific as far east as Polynesia ; Japan.

Note. From the blunt snout, wavy cheek lines, and blue dotted scales of Blegvad's *L. gibbus* description and plate (1944, page 107, and Plate IV, fig. 2) his fish seems to be clearly *L. rivulatus* and not *L. gibbus*.

Lutianus lineolatus (Ruppell). (Pl. XII A.)

Diacope lineolata Ruppell (1828); *Mesoprion lineolatus* Gunther (1859); *Lutianus lineolatus* Day (1878–1888); *Lutianus lineolatus* Blegvard (1944); *Lutianus lineolatus* Smith (1953).

Description.

Standard lengths 89 to 168 mm.

Proportions: depth 3·2 (l)–3·7 (s); head 2·6 (s)–2·8 (l); pectoral 3·4; all in body length. Eye 3·3–3·5; inter-orbital 3·7 (l)–4·9 (s); snout 3·7–4·0; all in head length. Sub-orbital into eye 2·8 (l)–3·7 (s).

Dorsal fin count XI 11 to 12; anal fin count III 8.

Lateral line scales 51 to 53 (45 to 47). Five scales from the lateral line to the mid-dorsal spines. Six to eight rows of cheek scales. Two to three rows of inter-opercular scales. Scales on head begin above the middle or the front of eye. Scales above lateral line run obliquely upward to the dorsal profile, the first few anterior scale rows often distinctly sinuous. Scales below lateral line parallel to the body axis, but curving slightly upward on the caudal peduncle.

Pre-opercular flange in young fish finely serrate on the vertical limb, and coarsely serrate on the curve and lower limb. These serrations are gradually lost in larger fish. No notch or inter-opercular knob present.

Weak outer row of conical incisors present in each jaw, the upper with one enlarged pair of canines anteriorly, the lower with two to three strong canines half way along jaw. Inside the upper incisor row is a thin villiform band of teeth, the anterior teeth of which are curved back and slightly longer than the others. Anteriorly the lower jaw has a thin band of villiform teeth inside the incisors. Vomerine teeth, villiform, sharp, and curved back, forming an arrowhead with a long posterior projection. Tongue toothed.

Colour (preserved in formalin) yellow above and silvery below, with orange-brown lines following the scale rows on the back and sides. One wider fawn line runs along the side from the upper third of the eye to the caudal peduncle. Fins hyaline. Yellow spots present at the bases of the dorsal spines.

Ecological note. This is a common species of exposed coral reef areas, usually in large shoals of thirty to a hundred, sometimes swimming together with shoals of *L. fulviflamma* and *L. kasmira*. Not seen in mangrove inlet areas, nor commonly inside the fringing reef.

Maximum size seen, about three-quarters of a lb.

Distribution. East African coastline from the Red Sea to Moçambique; Indo-Pacific region as far east as Guam Island.

Lutianus vaigiensis (Quoy and Gaimard). (Pl. XII B.)

Diacope vaigiensis Quoy & Gaimard (1824); *Genyoroge marginata* Gunther (1859); *Lutianus marginatus* Fowler (1828); *Lutjanus vaigiensis* Fowler (1931); *Lutianus vaigiensis* Smith (1953): *Lutjanus vaigiensis* Schultz (1953); *Lutjanus vaigiensis* Randall (1955).

Description.

Standard lengths 101 to 225 mm.

Proportions : depth 2·3–2·5 ; head 2·4–2·5 ; pectoral 3·0 (l)–3·6 (s) ; all in body length. Eye 3·6–5·7 ; inter-orbital 4·5–5·3 ; snout 3·0–3·4 ; all in head length. Sub-orbital into eye 1·0–1·7.

Dorsal fin count X 13 to 15 ; anal fin count III 8.

Lateral line scales 53 to 55 (47 to 48). Seven scales from the lateral line to the mid-dorsal profile. Six to seven rows of cheek scales. Inter-opercle with one row of scales. Scales on head begin behind eye.

Pre-opercular flange finely serrate above and coarsely below a moderate to deep notch. Pointed inter-opercular knob present.

Upper jaw with a weak outer row of conical incisors, three pairs enlarged to form weak, back-curved canines. Inside this row a band of villiform teeth, four to five rows deep. The lower jaw with a weak outer conical incisor row, close-set posteriorly, with two to four pairs slightly enlarged half way down the jaw, and a small patch of fine villiform teeth on either side of the symphysis anteriorly. Vomerine teeth sharp, back-curved, fine, set in a V. Villiform palatine teeth present in an elongate patch. No lingual teeth present.

Body colour (post mortem) : Bronze or roseate, with longitudinal narrow golden lines, six strongly defined, with thinner ones between these. The longitudinal lines are also clearly seen in underwater photographs of living fish. Flecks of gold on the cheeks. Pectoral, pelvics, and anal yellow, the latter white edged. Dorsal and caudal dark grey, the soft dorsal and caudal dusky sub-marginally, and with a distinct white marginal rim. Juvenile coloration (100 mm. standard length) as in the adult, but with the pectorals hyaline, pelvics bright yellow, and the whole dorsal black beneath the white marginal rim, not proximally paler.

With formalin preservation the golden body lines fade, but the sub-marginal duskiness and the white rim remain distinct.

Maximum size seen in East Africa, about one lb.

Ecological Note. Not a common fish in this area. Occasional specimens are caught by local fishermen. Occasionally seen about coral reefs in the Zanzibar Channel, and inside the fringing reef on the Zanzibar east coast. Seen in the Mafia area in exposed coral areas, but not common. Usually seen singly or in pairs, and sometimes in conjunction with small numbers of *L. monostigma*. Juveniles have been taken from fish ponds at Chukwani (Zanzibar), a mangrove area.

Distribution. East African coastline as far south as Natal ; Indo-Pacific to the Tuamotu Archipelago ; northern Australia.

Bibliography.

Barnard, K. H. 1927. *A monograph of the marine fishes of South Africa.* Vol. XXI, part 2.

Bleeker, P. 1849. Bydrage tot de kennis der Percoiden van den Malayo-Molukschen Archipel, met beschrijving van 22 nieuwe soorten. *Verh. Bat. Gen.* XXII.

Blegvad, H. 1944. Fishes of the Iranian Gulf. *Danish Sci. Invest. in Iran.* Part III.

Cuvier & Valenciennes. 1828. *Hist. Nat. Poissons* II.

——. 1830. *Hist. Nat. Poissons* VI.

Day, F. 1865. *The Fishes of Malabar.* London.

——. 1878–1888. *The Fishes of India.* London.

FORSKAL. 1775. *Descr. Animalium.*
FOWLER, H. W. 1928. The Fishes of Oceania. *Memoirs B.P. Bishop Mus.* Vol. X.
——. 1931 (a) The Fishes of Oceania. Supp. 1. *Memoirs B.P. Bishop Mus.* Vol. XI, No. 5.
——. 1931 (*b*). Contributions to the biology of the Philippine Archipelago and adjacent regions. Part IV. *Bull. U.S. National Mus.* Vol. II, No. 100.
——. 1934 (*a*). Fishes obtained by Mr. H. W. Bell-Marley chiefly in Natal and Zululanp in 1929–1932. *Proc. Acad. Nat. Sci. Philadelphia*, Vol. LXXXVI.
——. 1934 (*b*). The Fishes of Oceania. Supp. II. *Mem. B.P. Bishop Mus.* Vol. XI, No. 6.
——. 1949. The Fishes of Oceania. Supp. III. *Mem. B.P. Bishop Mus.* Vol. XII, No. 2.
GUNTHER, A. 1859. *Catalogue of the Acanthopterygian fishes in the British Museum.* London.
KLUNZINGER. 1870. *Sypnosis des Rothen Meeres* I.
LACEPEDE. 1803. *Hist. Nat. Poissons* II. Paris.
PETERS, K. 1869. *Monatsbr. Akad.* Berlin.
PLAYFAIR, R. L., & GUNTHER, A. C. L. G. 1866. *The Fishes of Zanzibar.* London.
QUOY & GAIMARD. 1824. *Voyage de l'Uranie et de la Physicienne, Zool.*
RANDALL, J. E. 1955. Fishes of the Gilbert Islands. *Atoll Res. Bull.* 47.
RUPPELL. 1828. *Atl. Reise Nordl. Afrika, Fische.*
SAUVAGE, M. H. 1891. *Histoire de Madagascar*, Vol. XVI. Poissons, Paris.
SCHULTZ, L. P. 1953. *Fishes of the Marshall and Marianas Islands.* Vol. I.
SMITH, J. L. B. 1953. *The Sea Fishes of Southern Africa.* Cape Town.
——. 1953. Fishes taken in the Moçambique Channel by Mussolini P. Fajardo. *Memoirias do Mus.* Dr. Alvaro de Castro No. 2.
WEBER, M., DE BEAUFORT, L. F. 1936. *The Fishes of the Indo-Australian Archipelago.* Vol. VII, Leiden.

EXPLANATION OF PLATES.

PLATE IV.

A. *Lutianus ehrenbergi* (Peters). Length 70 mm.
B. *Lutianus argentimaculatus* (Forskal). Length 140 mm.

PLATE V.

A. *Lutianus argentimaculatus* (Forskal). Length 730 mm.
B. *Lutianus kasmira* (Forskal). Length 200 mm.

PLATE VI.

A. *Lutianus duodecimlineatus* (C. V.). Length 155 mm.
B. *Lutianus gibbus* (Forskal). Length 305 mm.

PLATE VII.

A. *Lutianus bohar* (Forskal). Length 228 mm.
B. *Lutianus bohar* (Forskal). Length 585 mm.

PLATE VIII.

A. *Lutianus sanguineus* (C. V.). Length 114 mm.
B. *Lutianus sanguineus* (C. V.). Length 230 mm.

PLATE IX.

A. *Lutianus sanguineus* (C. V.). Length 600 mm.
B. *Lutianus sebae* (C. V.). Length 270 mm.

PLATE X.

A. *Lutianus sebae* (C. V.). Length 595 mm.
B. *Lutianus monostigma* (C. V.). Length 385 mm.

PLATE XI.

A. *Lutianus fulviflamma* (Forskal). Length 200 mm.
B. *Lutianus rivulatus* (C. V.). Length 480 mm.

PLATE XII.

A. *Lutianus lineolatus* (Ruppell). Length 175 mm.
B. *Lutianus vaigiensis* (Quoy & Gaimard). Length 250 mm.

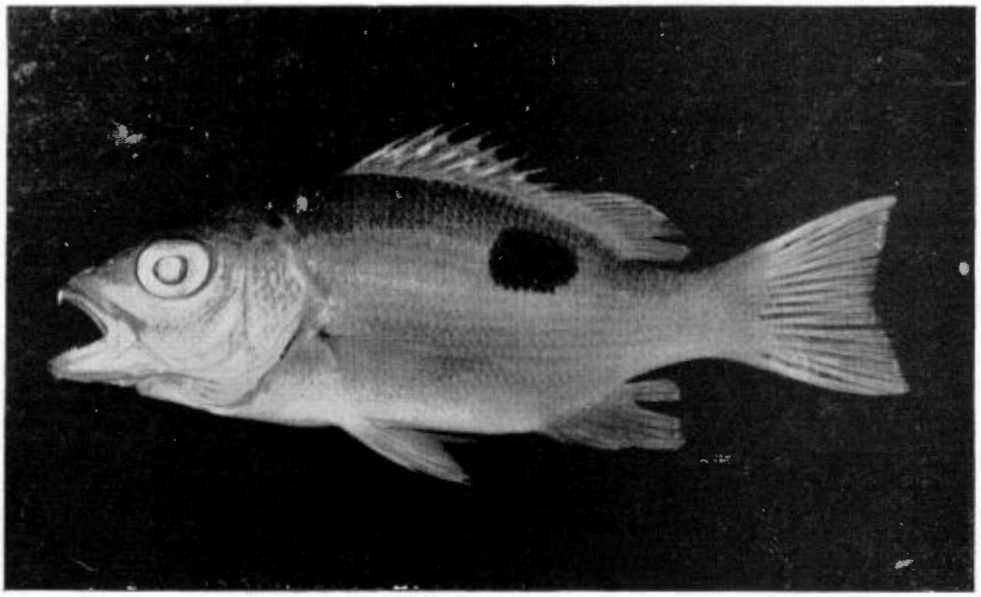

Plate IV A.

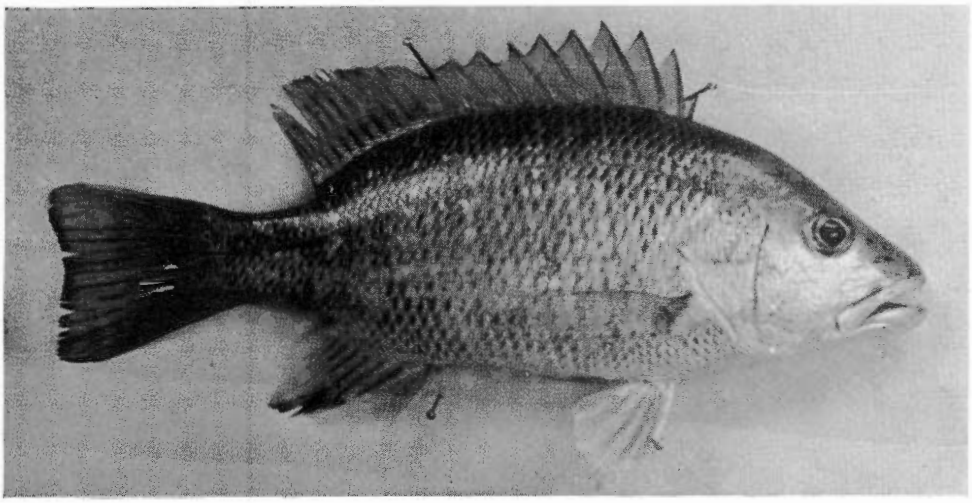

Plate IV B.

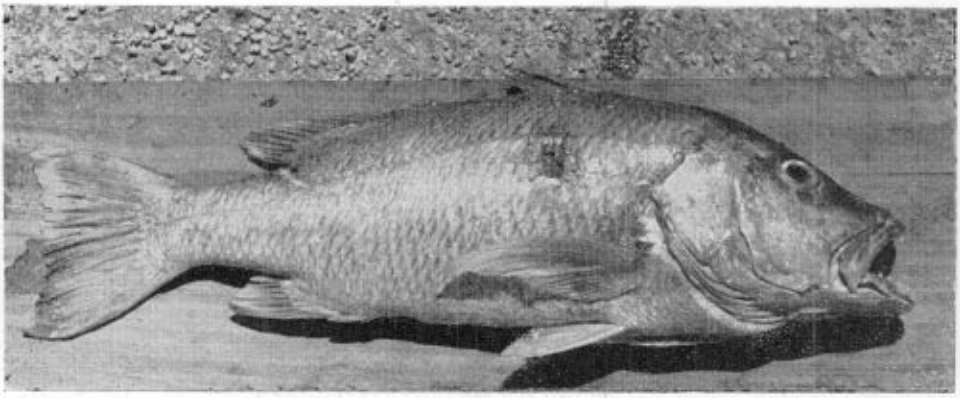

Plate V A.

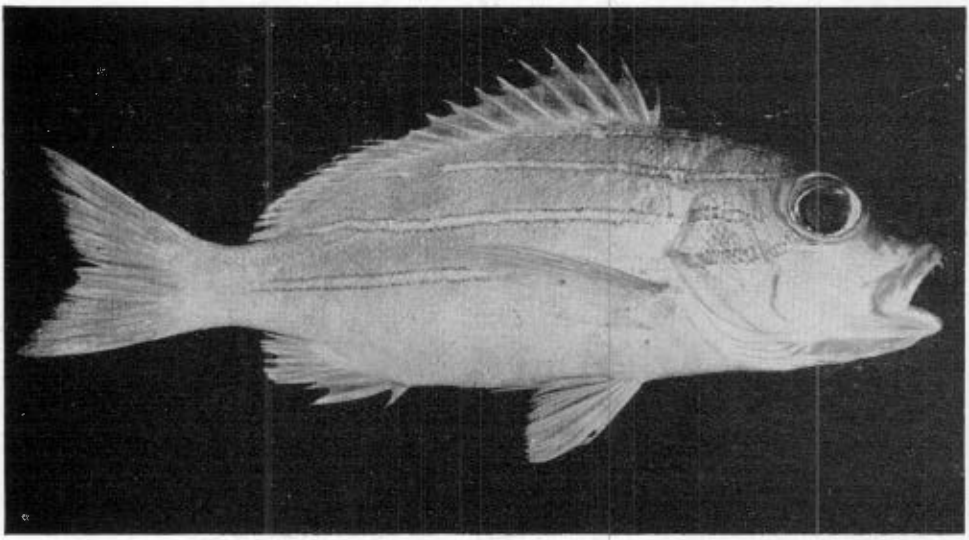

Plate V B.

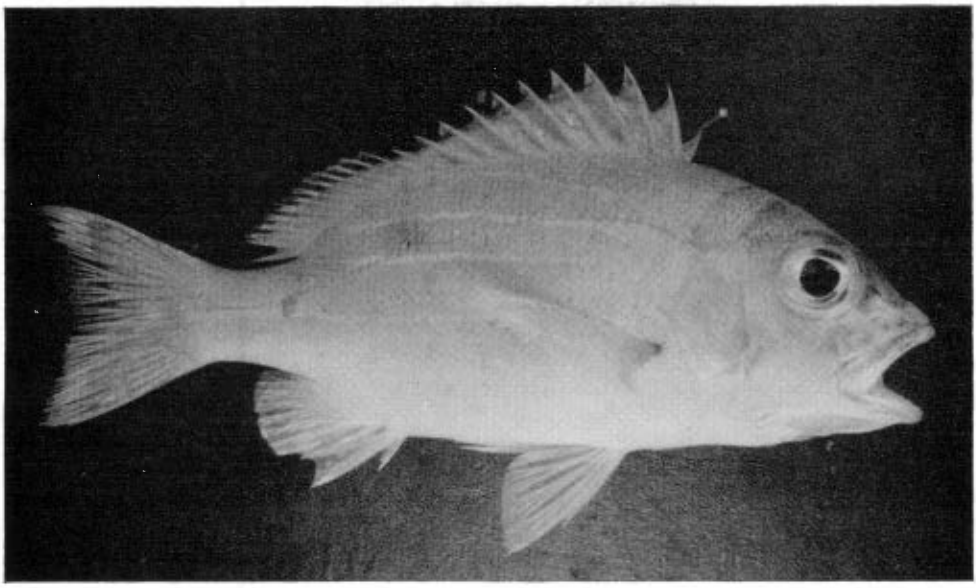

Plate VI A.

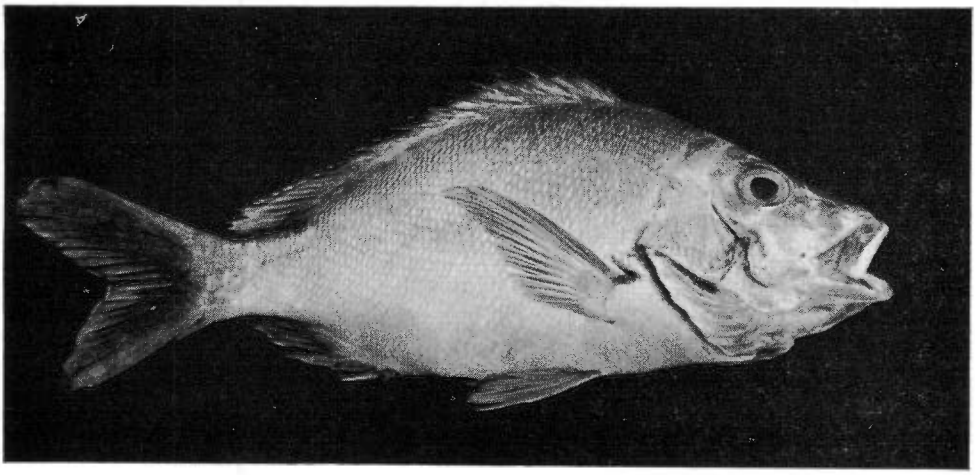

Plate VI B.

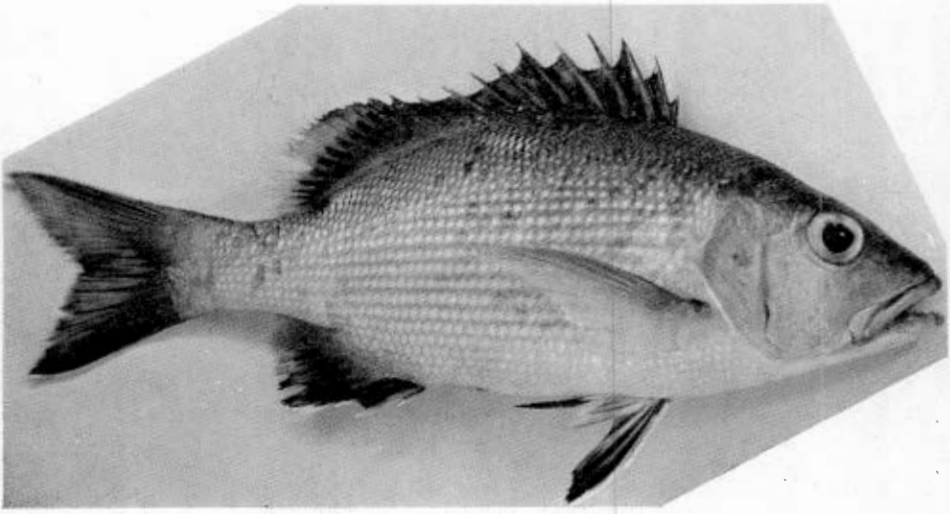

Plate VII A.

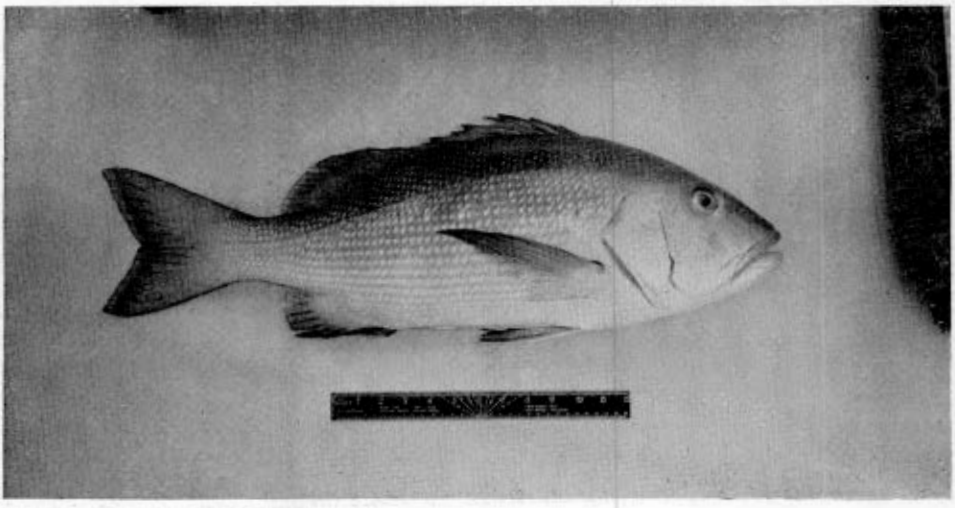

Plate VII B.

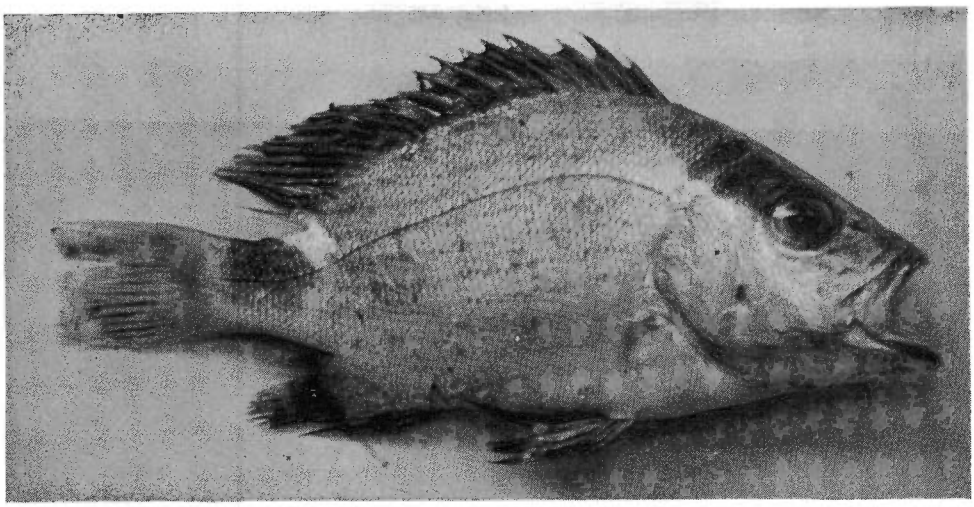

Plate VIII A.

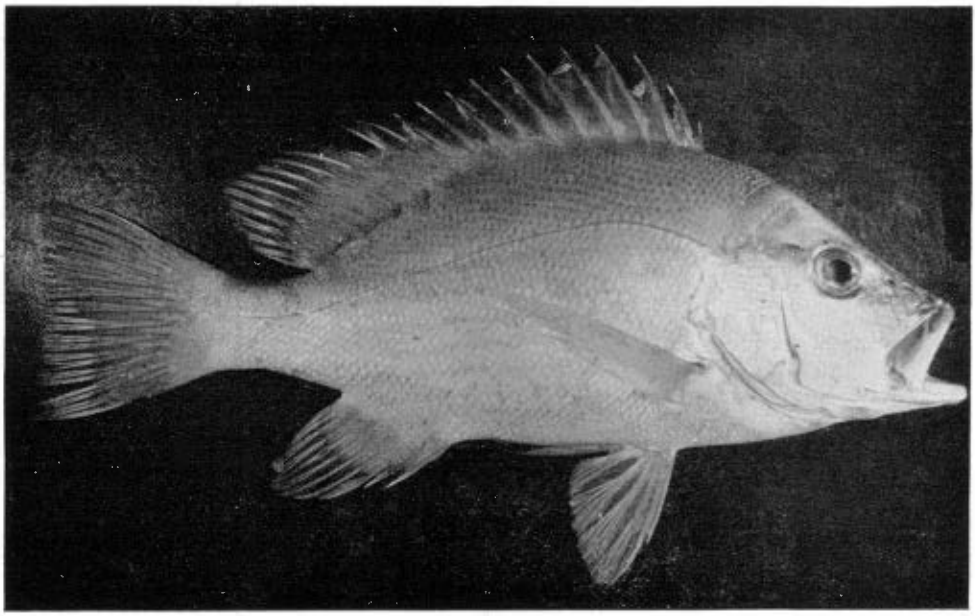

Plate VIII B.

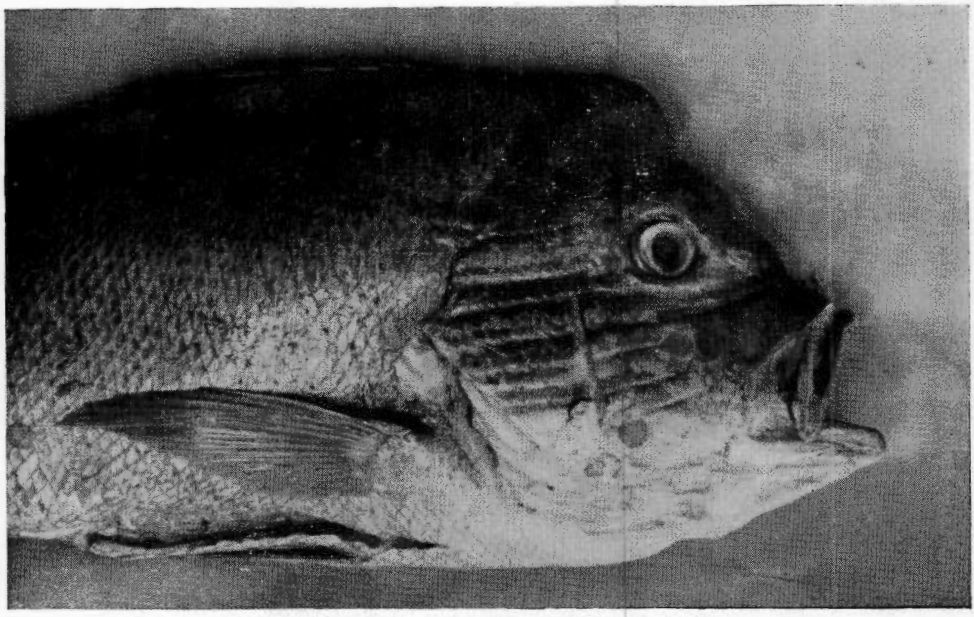

Plate IX A.

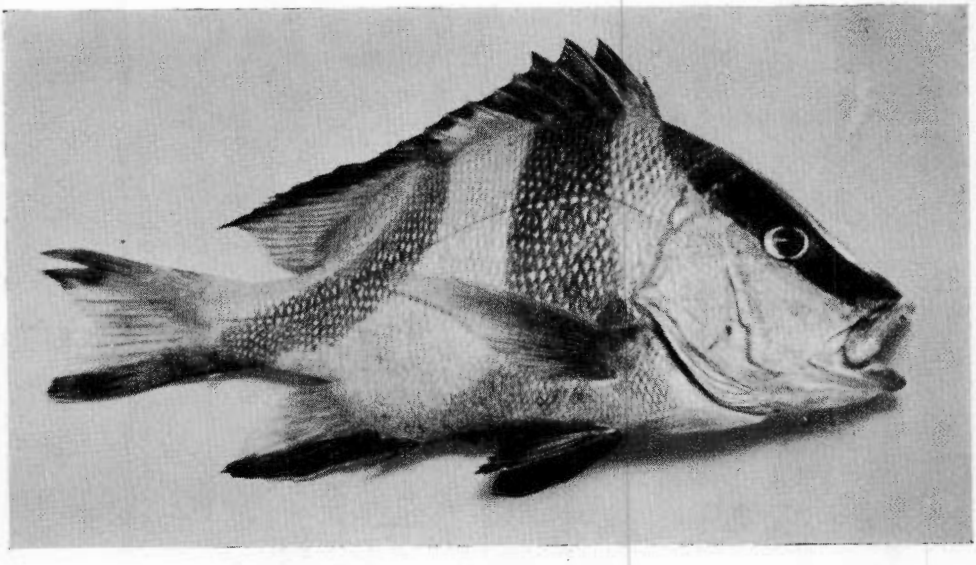

Plate IX B.

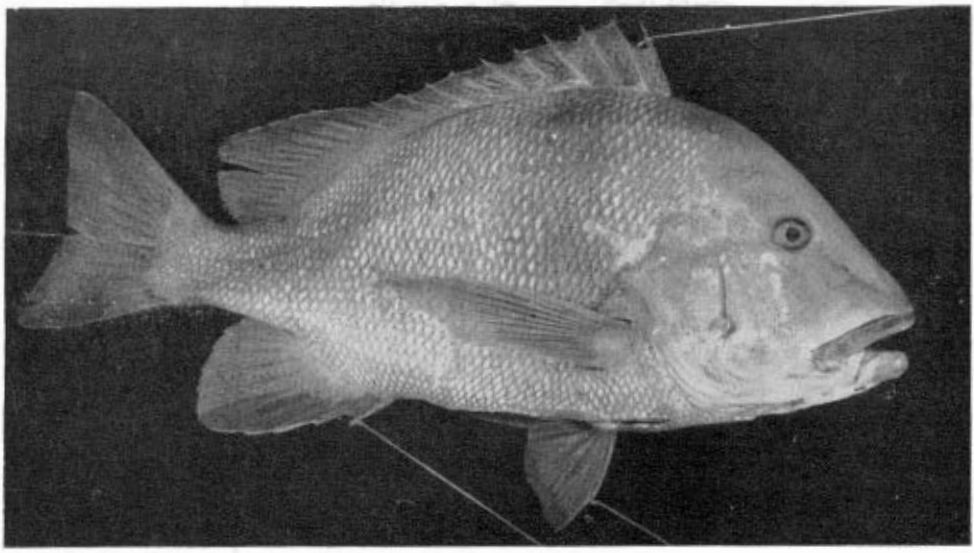

Plate X A.

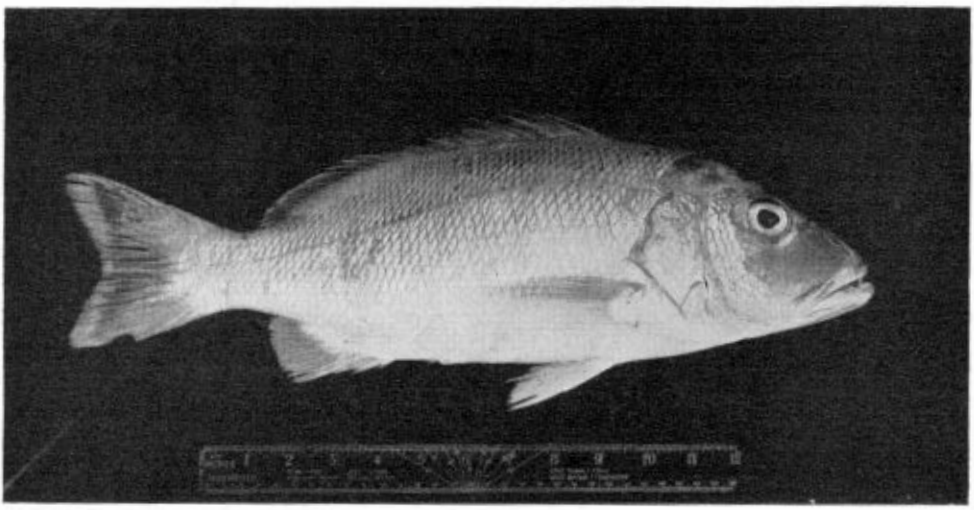

Plate X B.

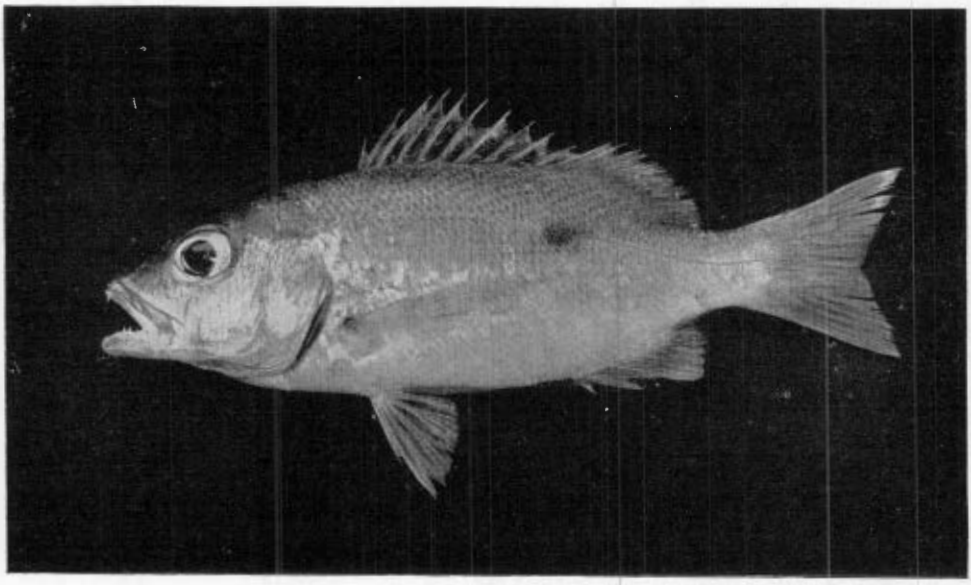

Plate XI A.

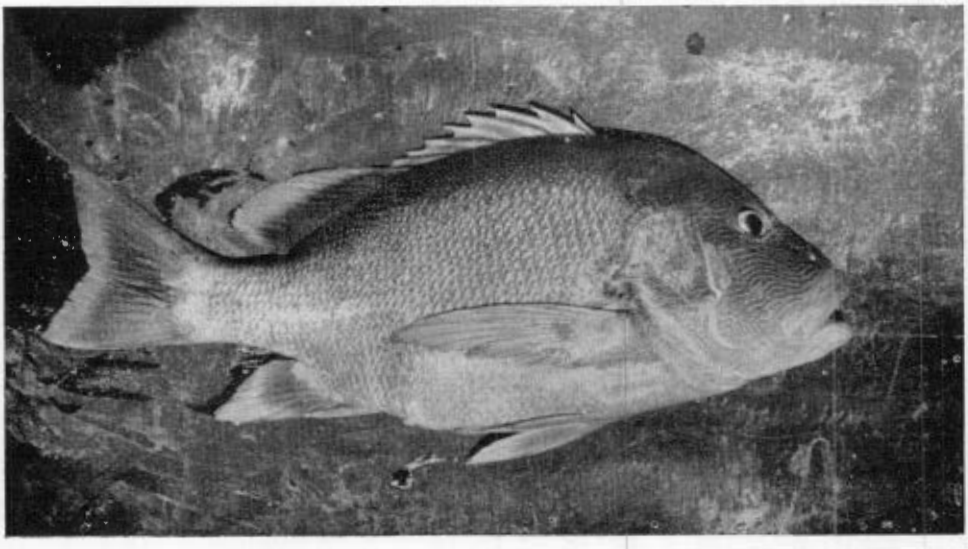

Plate XI B.

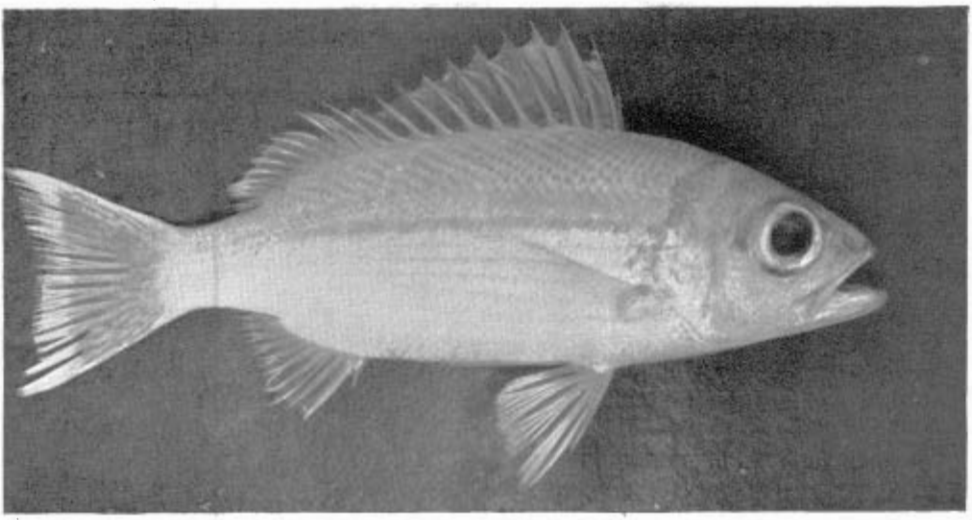

Plate XII A.

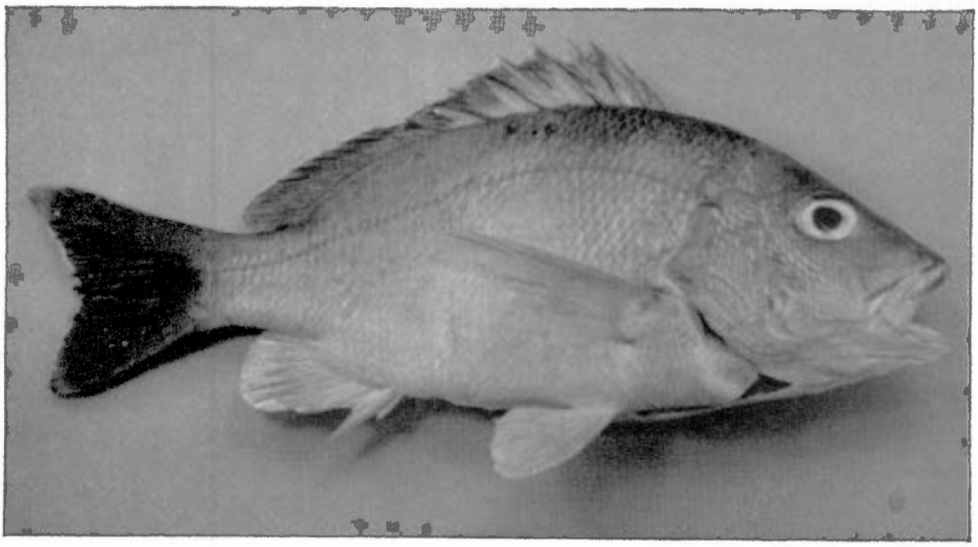

Plate XII B.

ANNALS

OF THE

SOUTH AFRICAN MUSEUM

VOLUME XLV

PART V, *containing*:—

Notes on the Biology of the Lutjanidae (Pisces) of the East African Coast, with special reference to L. bohar (*Forskal*). By F. H. TALBOT, M.Sc. (With 5 figures in the text.)

ISSUED JULY 1960 *PRICE* 3*s*. 3*d*.

PRINTED FOR THE

TRUSTEES OF THE SOUTH AFRICAN MUSEUM

BY THE RUSTICA PRESS (PTY.) LIMITED, COURT ROAD, WYNBERG, CAPE

NOTES ON THE BIOLOGY OF THE LUTJANIDAE* (PISCES) OF THE EAST AFRICAN COAST, WITH SPECIAL REFERENCE TO *L. BOHAR* (FORSKAL)

By F. H. Talbot, M.Sc.

(With 5 figures in the text)

Introduction

Lutjanid material for this study has been obtained during routine fishing from 1954 to 1957 inclusively, by the research ship M.V. *Research* and her replacement the M.V. *Manihine* of the East African Fisheries Research Organization, Zanzibar, while the author was a member of this Organization. During this period a study of bottom fishes was made, mainly in coral reef areas of from 3 to 14 fathoms, and also to a lesser extent in deeper water below the coral reef zone down to 100 fathoms. The work has centred on the reefs off Lamu on the Kenya coast, in the Mafia Archipelago off the Tanganyika coast, and on Latham Bank, a shallow bank surrounding a small island south-west of Zanzibar (see fig. 1). Handlines, gill-nets, trammel-nets, set-lines, basket-traps, underwater spearing, and explosives have been used for collecting. In addition fish were occasionally obtained from the local markets on Zanzibar Island. Information on Lutjanids from the unpublished East African Marine Fisheries Research Organization records from 1951 to 1953, and for 1958, has also been used by courtesy of the Director.

This paper is one of a series on hydrographic conditions, Newell (1957, 1959); fish systematics, Morgans (1958), Talbot (1957, 1958), Talbot and Williams (1956), Williams (1958a, 1959a and b); and fish biology, Talbot and Newell (1956), Williams (1953, 1956, 1958b), Williams and Newell (1957), providing some preliminary data on the systematics, distribution and biology of East Coast fishes of economic importance. A full description of the topography of the area is given in Williams, 1956. In this paper the systematics of the genus *Pristipomoides* is based on Smith (1954) and the systematics of the genus *Lutjanus* follows that used in a previous communication (Talbot, 1957).

The East African coastal area over which this study was made is markedly affected by the monsoon winds. In all seasons of the year it is bathed by the

* Both the spellings *Lutjanus* and *Lutianus* are in current use. The first nomenclatorially valid use of the generic name is in Bloch, 1790, *Nat. ausl. Fische*, **4**, p. 107, in the description of *Lutjanus lutjanus*. Cuvier, 1798, *Table. elem.*, pp. 357 and 705, uses *Lutianus* (as does Bloch occasionally after this date), and this is the form used by Jordan and Everman in their *Genera of Fishes*, Stanford Univ., 1917, with the footnote 'Also spelled *Lutjanus*'. As *Lutianus* has not been universally accepted it seems better to return to the original form *Lutjanus*.

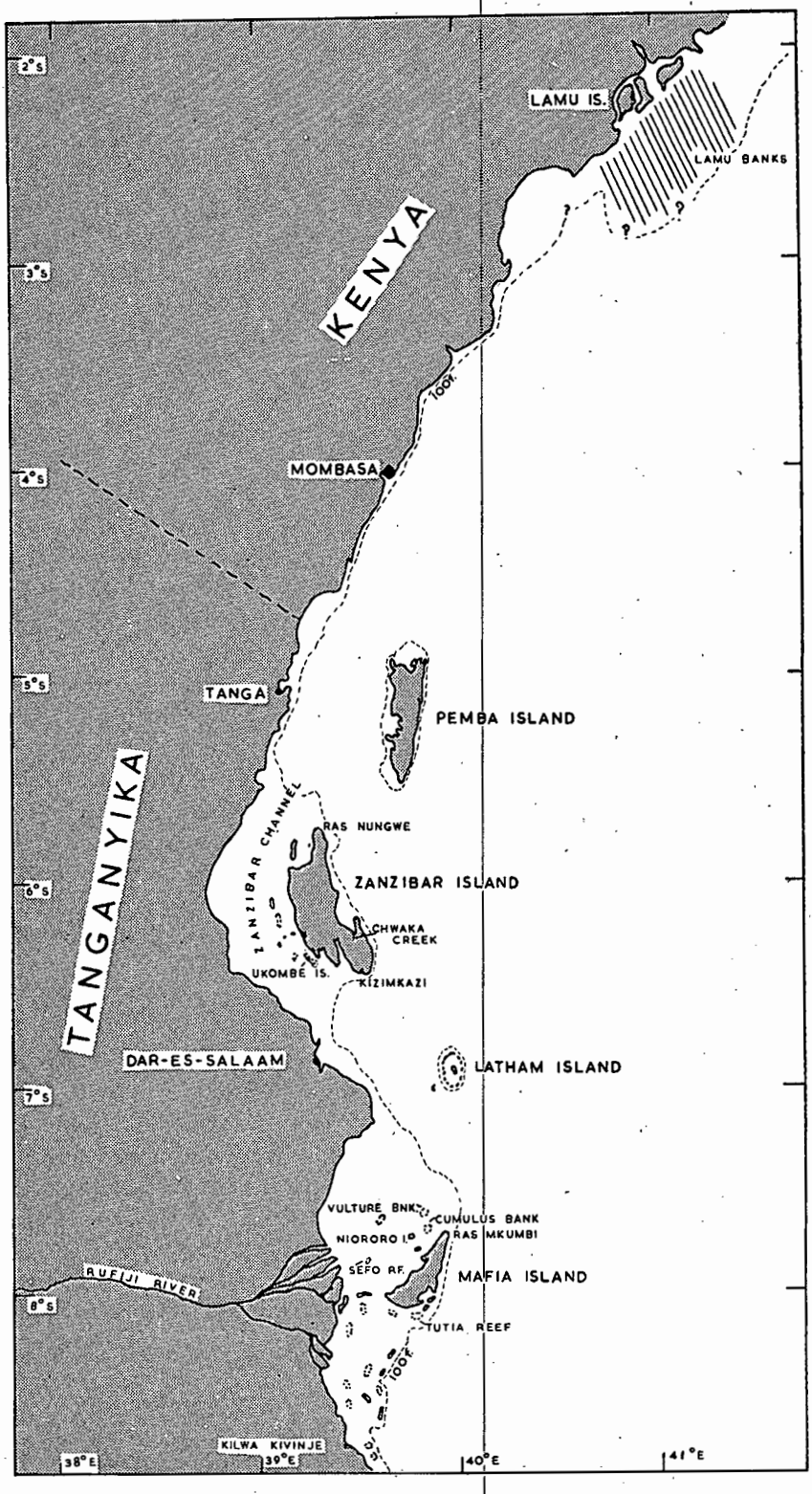

FIG. 1

Chart of the coastal areas where Lutjanids were collected. (From British Admiralty Chart 597.)

north-flowing East African Coastal Current, but from May to October ('winter', if one may talk of summer and winter so close to the equator) the strong south-east monsoon wind speeds up the current to 3–4 knots, and increases vertical mixing of the upper layers, lowering the thermocline to 50 fathoms. The surface temperature in this period is about 24°C.–25°C. In summer (November to April) the wind system is reversed, and the moderate north-east monsoon wind slows up the East African Coastal Current to 1–2 knots. Much less surfacing mixing takes place, and a very stable surface layer is formed with a marked thermocline at about 25 fathoms, and a surface temperature of 27°C.–29°C.

Although the majority of species mentioned here are widespread over the Indo-Pacific region, and many are found from the South African coast up to the Red Sea and across to Polynesia and the Tuamotu Archipelago, some 10,000 miles to the eastward, apart from systematics little or nothing has been published about their biology except some recent data on habits and habitats in systematic papers by American workers aided by U.S. Navy grants (Randall 1955, Schultz 1953, Harry 1953), and the Mauritius Seychelles Fisheries Survey undertaken by Wheeler and Ommanney (1953).

The latter authors, in a survey of the coral reef areas lying between Mauritius and Seychelles, obtained seven species of Lutjanids, all of which are also found on the East African coastline. Of these seven species four were seldom caught, but useful data were obtained on the remaining three: *L. bohar* (Forskal) (*L. civis* (C. & V.) of their report), *Aprion virescens* Valenciennes, and *L. sebae* (Cuvier).

In tropical coral areas the catches comprise many more species than do those of temperate waters, but the numbers of fish of each species are far smaller. In this survey it was difficult to obtain large enough samples of each species. With small numbers many established fishery techniques (such as deductions from length-frequency distribution) cannot be used.

Underwater observations using a Seibe-Gorman aqualung were made on Latham Bank, about Zanzibar Island, in the Zanzibar channel, and in the Mafia Archipelago, and showed that two species (*L. monostigma* and *L. vaigiensis*) were common on these reefs although they were very rarely taken by normal fishing methods. Small samples of these were collected by spear-guns. These observations also gave a much more accurate picture of relative abundance of species than did the use of handlines, nets, traps, etc., and some notes on habits were obtained. It was found that the method was strictly limited in its usefulness however, for an underwater observer with his trail of bubbles could not remain hidden, and had a marked effect on the fishes. Many of the smaller reef species are attracted by the aqualunger, who may become surrounded by shoals of small fishes. Often also the larger predators such as *Plectropomus maculatus* will come closer and inspect the unusual object from mid-water. Among the Lutjanids these effects can also be seen. *Aprion virescens* will often approach close to the diver before continuing down the reef. A shoal of

L. gibbus will move off or take shelter. *L. bohar* after a short time will usually leave the immediate reef area. Observation is therefore not of a normal undisturbed reef and its fish fauna—the 'observer' has influenced the fish population, and normal movements and feeding may not be taking place. This does not imply that the method of underwater observation is not useful. On the contrary, it is an obvious and developing method which will have important uses in ecology and ethology (see Reidle 1956). For coral reef observation however some 'hide' method must be used.

That scale rings occur in tropical marine fishes has been shown by a number of workers (summarized in Menon, 1953). The variation in surface temperatures from 24°C. to 29°C. between summer and winter in the East African area might be reasonably considered to be enough environmental change to affect the formation of annual rings. As is shown below, however, consideration of *L. bohar* scale edges with season did not bear this out.

Both scales and otoliths of *L. bohar* were examined for ringing. The otoliths showed no clear opaque and translucent zones even on grinding, and although the surface of the otoliths showed concentric ridges which gave the same counts as the scale rings in young fishes, in older fishes they were difficult to count due to crowding towards the periphery, and were also possibly covered over near the nucleus by further growth. Only the scales are therefore considered here. Scales of 273 *L. bohar* were examined, and of these approximately one in four showed rings considered clear enough to be counted, although rings of more or less clarity were present in all fish. On an average four scales per fish were counted, and scales from the same fish with few exceptions showed the same number of rings at similar relative distances from the scale nucleus. It was found that individuals of a single sample of fish, taken from the same bank at the same time did not necessarily have the outermost ring at a similar distance from the periphery, showing that the rings were not all formed at the same time of year in all fish. This suggests that the rings that do form are due to spawning, and not to seasonal changes. With checks forming at different times of year with different fish it is impossible to test whether the rings are annual by the method of watching the periphery of the scales of samples of fish periodically during the year.

Forty scales were re-read a year after first reading to check error. Of these 19 were re-read exactly as in the first reading, 12 disagreed by one year, and 9 by more than one year. These discrepancies are due to faint rings being either considered as false checks or true annuli. This error can be stated thus: in about 47% of scales used here reading error is negligible; and in about 78% of scales an error of $\pm$ 1 ring may be present. If it is realized that the scales being read here are already only those showing the clearest rings (one-quarter of the total) it is obvious that the clarity of ringing does not approach that of many temperate species. Clark (1958) for example in the re-reading of young haddock samples by the same worker obtained 90% and 93% similarity. Nevertheless in many specimens of *L. bohar* consistent ringing is present in the

scale structure, due to some regular change in the metabolism of the fishes. It is possible that these periodic changes are not annual, but their regularity suggests that they will be found to be connected with the spawning cycle or be due to periodic feeding changes. As has been suggested above, the former is the more likely answer. Wheeler (in Wheeler and Ommanney, 1953) has suggested that *L. bohar* spawns twice a year. As will be seen in this report the results from East African coastal fish rather suggest an extended breeding season in the warmer months. Lacking evidence to the contrary the ringing here seen is considered as annual.

Description of Gonad Condition

Gonads were described macroscopically in the fresh condition as the fish were gutted on board. For females a system based on seven stages was used (after Bowers, 1954). For males five stages were discernible.

Males:
- I. *Immature.* Gonad small, usually threadlike, no sperm extruded on cutting and squeezing.
- II. *Mature unripe.* Gonad small, sperm extruded on cutting and squeezing.
- III. *Ripe.* Gonad enlarged and full of sperm.
- IV. *Ripe running.* As above, but milt extruded on pressure to flank.
- V. *Spent.* Testis shrunken, not full and round, little sperm.

Females:
- I. *Immature.* Ovaries small and threadlike, eggs microscopic.
- II. *Mature unripe,* or *Virgin maturing.* Gonad of moderate size, eggs microscopic, gonad often translucent. The two stages may sometimes be distinguished as there may be remains of corpora lutea in the mature fish visible as small orange flecks in the ovary.
- III. *Mature ripening.* Ovary of moderate size, eggs visible to the naked eye, opaque.
- IV. *Nearly ripe.* Ovary enlarged and extended, eggs clearly visible, opaque.
- V. *Ripe.* Ovary enlarged and distended, tunica breaks easily, some eggs transparent.
- VI. *Ripe running.* Nearly all eggs transparent, eggs extrude on slight pressure to flank.
- VII. *Spent.* Ovary flaccid, shrunken, and with some residual eggs.

Although stage II males are called mature unripe it seems probable that sperm may be present in the testis before the fish are capable of mating, as in *L. bohar* a very small gonad holding some sperm may be found in fish of about

200 mm. but the first males found with enlarged ripe gonads were of a much greater size than this. State II contains both virgin developing males, and mature males in resting condition. No macroscopic difference was noticed between the two.

Species	*No. Examin.*	*Immature*	*Mature*
Lutjanus bohar (Forskal)	854	443 (150–439 mm.)	411 (440–660 mm.)
Aprion virescens Valenciennes	259	18 (202–452 mm.)	241 (460–800 mm.)
Lutjanus rivulatus (Cuvier)	129	4 (395–449 mm.)	125 (450–640 mm.)
L. fulviflamma (Forskal)	126	41 (51–159 mm.)	85 (160–220 mm.)
L. gibbus (Forskal)	121	10 (170–219 mm.)	111 (220–355 mm.)
L. sanguineus (Cuvier)	102	39 (170–479 mm.)	63 (480–650 mm.)
L. kasmira (Forskal)	77	—	77 (125–205 mm.)
L. sebae (Cuvier)	27	12 (128–489 mm.)	15 (490–665 mm.)
L. monostigma (Cuvier)	18	7 (275–349 mm.)	11 (350–420 mm.)
L. argentimaculatus (Forskal)	13	9 (300–459 mm.)	4 (460–630 mm.)
		Size Range	
Pristipomoides microlepsis Bleeker	12	260–640 mm.	
Lutjanus ehrenbergi (Peters)	6	44–98 mm.	
L. vaigiensis (Quoy and Gaimard)	6	200–250 mm.	
L. lineolatus (Ruppell)	5	120–175 mm.	
Pristipomoides typus (Bleeker)	1	525 mm.	
Aphareus rutilans Cuvier	1	780 mm.	
Lutjanus duodecimlineatus	1	150 mm.	

TABLE I

A list of the Lutjanids taken during the survey, with the proportions of mature to immature fish. (For the commoner species the smallest length at which mature fish were found is used for a division into 'mature' and 'immature' fishes in the table.)

Lutjanus bohar (Forskal)

L. bohar is one of the commonest predators of exposed coral reefs in the East African coastal area. The majority of specimens were taken by handline, but the species was also taken in basket traps, trammel nets, and very occasionally on trolled lures. It is fairly common in local markets, seldom in abundance, but present in regular quantities throughout the year. Wheeler and Ommanney (1953) took larger numbers and a greater total weight of this species than any other on the Mauritius-Seychelles banks.

This species sometimes causes ciguatera poisoning in the Mauritius area and is banned in the markets there. Harry (1953) states that in Raroia Atoll of the Tuamotu Archipelago 'large adults of *L. bohar* are poisonous, and natives know to a few inches of length when an individual is poisonous or not'. Randall (1958) in his review of ciguatera mentions this species as causing poisoning in a number of areas. Whitley (1943) in his list of poisonous fishes of Australia includes the closely allied (perhaps synonymous) *L. coatsi*. In spite of this there is no record known to the author of this species being considered poisonous in the East African coastal region, and both there and in the Seychelles (Wheeler and Ommanney, 1953) *L. bohar* is considered a prime market species. Randall's suggestion that this type of poison enters the fish through one of its foods,

probably a blue-green alga, is consistent with the species being poisonous in some areas and not in others.

Handlining showed this species to be common on exposed areas with actively growing coral in from 4 to 15 fathoms. Adults were seen underwater on the outer slope of the fringing reef, and entering into gaps in the fringing reef where these were deep (five to seven fathoms), but were not seen in areas where the channel was shallower than this, or on the reef flat at high tide, (see figs. 4 and 5). Juveniles of about 100 mm. were seen in and about coral where the fringing reef channel was under 5 fathoms deep. On the outer edge of Tutia Reef and on Latham Bank the species was usually seen in loose and actively moving shoals of about two to seven fish, over coral in mid-water in 3 to 10 fathoms. Underwater observation did not go deeper than this. Shoals were loosely knit, and seemed to break up and rejoin, with no tight cohesion as with many other species of the genus. What shoaling instinct there was, however, results in the species being more often seen in twos and threes than singly. Unlike many related species which may stay around one coral head for the time observed (maximum 2 hours), *L. bohar* is continually on the move, as though actively searching for food over wide areas. Actual feeding has not been observed underwater.

L. bohar was also found to be common in deep water of the Kenya coast in the region of Lamu (see fig. 1). In this area the continental shelf is wider than in most of the East African coastal region, and rich populations of fishes were found on grounds approximately 25 to 65 fathoms deep. *L. bohar* was caught from 25 to 46 fathoms, but where a bathythermograph was used while fishing it was never found below the major thermocline, which varies from 25–50 fathoms with season (Newell, 1957). The dominant species in these rich populations were *Lutjanus bohar*, *Lutjanus rivulatus*, *Epinephelus undulosus*, *Lutjanus sanguineus*, *Lethrinus waigiensis*, and *Lethrinus kallopterus*, in order of abundance (Williams, 1958).

Sampling showed that this species is present on the reefs at all times of year and showed no evidence of migrations. Underwater observations proved that on certain small reefs the species could be present at one visit and not at the next.

Feeding

Of the 854 *L. bohar* examined, 58% of the fish caught had empty stomachs or contained only bait. Table II lists the food organisms found in *L. bohar* stomachs. The species is a euryphagous predator, feeding basically on fish (see fig. 2), but capable of eating crawfish, crab, prawn, squid, octopus, ophiuroids and even pelagic pteropods, doliolids and pyrosomas when these are abundant in the plankton. Although a wide variety of small reef fishes was the main food over the period of study, at certain times when there was an abundance of any one organism the samples contained nothing but these organisms. This was clearly seen in two samples from North Mafia Bay

(Cumulus Bank), and once in a deep-water sample from Lamu. In December 1952 a large proportion of the samples from these two banks was packed with Penaeid prawns, probably migrating to or from the mangrove areas of the huge Rufiji delta. In November 1953 there was an unusually large amount of a larval Stomatopod in the Mafia-Latham Island area. These were seen swimming on the surface at night, and almost everything caught from bottom-dwelling Epinephelids to pelagic Sphyraenids contained them. All *Lutjanus*

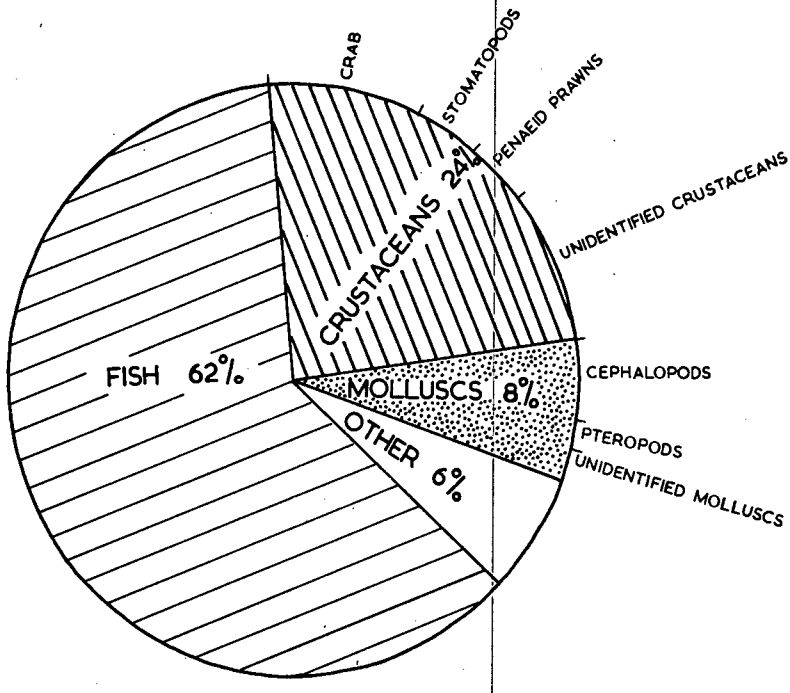

FIG. 2
Relative abundance of food organisms found in *Lutjanus bohar*.

bohar from Vulture, Cumulus and Latham Banks were full of Stomatopod remains. In one particular sample (14–19 November 1956) of the many taken from deep water off Lamu, *L. bohar*, *L. sanguineus*, *L. rivulatus*, *Aprion virescens* and one species of *Ephinephelus* all contained salp tests. Otherwise salps were not a common item of food in any of these species. *L. bohar* then follows the general pattern that most predatory species at any one time will eat the commonest foods available to them in their particular habitats (Stephen 1930, Allee *et al.* 1949).

Some change of diet with size was shown. The smallest *L. bohar* taken (150 mm.) were already fish predators and fish was the predominant food throughout the size range investigated. Crabs were first found in fish over 200 mm. in length, and Cephalopods only in fish over 250 mm. As the fish

increased in size above this Cephalopods became an increasingly important food.

Wheeler (in Wheeler and Ommanney, 1953) found essentially similar feeding for *L. bohar* of the Mauritius-Seychelles banks, although a greater frequency of crustacean and plankton food was found (Fish 114, Crustaceans 117, Plankton 116, Molluscs 83, other 31). Wheeler also concluded that plankton is taken only in times of special density.

Reptilia
Green Turtle (*Chelone midas* L.) juvenile.

Pisces
Carangid fish
Holocentrus sp.
Ostracion sp. juvenile
Echidnid eel.
Scaridae (many unident. species)
Lethrinus chaerorhynchus
Lethrinus latifrons Ruppell
Syngnathid fish
Canthidermis sp.
Monacanthid fish juvenile
Clupeidae
Mullidae.

Tunicata
Pyrosoma
Doliolid.

Echinodermata
Ophiuroids.

Mollusca
Cavolinia sp.
Turbo sp. ('Green Snail')
Octopus
Squid
Tectibranch rem.

Crustacea
Charybdis natator (Herbst)
Calappa sp.
Charybdis sp.
Lupa sanguinolenta (Herbst)
Achelous sp.
Thalamita sp.
Monomia sp.
Xanthid crab
Oxyrhynchid crab
Panulirus sp.
Penaeus sp.
Pagurus sp.
Metapenaeus sp.
Scyllarid larva
Megalopa larvae
Sphaeromid Isopod
Amphipods
Stomatopod
Stalked cirripede.

Polychaeta
Polychaete bristles.

Plants
Cymodocea leaves
Green alga.

TABLE II
Food organisms found in *Lutjanus bohar.*

GROWTH RATE

Wheeler (op. cit.) has estimated the growth rate of *L. bohar* on the Chagos Bank (Seychelles) from length-frequency curves, and has suggested that the one-year group is 180 mm. total length (136 mm. standard length), with additions of 120 mm. and 110 mm. in the second and third years respectively. He estimated that on the Seychelles plateau and the Amirantes 510 mm. total length (425 mm. standard length) was attained in four years. The Peterson method of age determination is dependent on a short spawning period and roughly equal growth rate of the individuals of each spawning. Wheeler found, in over 2,000 fishes taken during 1948–9, that ripe females were present only in October and November and again in March, suggesting that the first of these tenets is satisfied, with due allowance made for the addition of a new group every six months and not every year. As different banks were considered

separately there is every reason to suppose that growth rate is approximately the same and that the method is valid for *L. bohar* in the Seychelles-Mauritius area. In the East African coastal region, however, the breeding season seems to be an extended one, ripe female fish being taken over most of the year. This and the small size of samples has precluded the use of the Peterson method here.

Wide, diffuse rings (formed of a group of fine rings) were present in juveniles, but in adults the scale checks were often sharp, with the lamellae after the check beginning at different angles, as though either resorption had taken place, or growth had begun again after complete cessation. If the checks in the adults are spawning checks, the diffuse rings in the juveniles are possibly due to a physiological sex rhythm already existing in the juvenile, as suggested for the Hake by Hickling (1933).

Peripheral checks were seen in September, November, January, February, March, April, and May. This is mainly in the north-east monsoon period, which lasts from November to April, when the water temperatures are higher than the period of the strong south-east monsoon from May to October. The largest *L. bohar* taken during this survey and aged was 660 mm. standard length, and showed 12 growth rings. On one fish of 615 mm. 13 rings were found. The smallest fish whose scales were read was 200 mm., and showed three growth checks. Increments were 70 mm. and 60 mm. in the fourth and fifth year, and then gradually reduced to approximately 35 mm. per year (see Table III). Maturity was reached about the sixth to seventh year (450 mm.) and no difference in growth rate was seen between the sexes.

Age	*St. Length to nearest 5 mm.*	*Annual Increment*
0–2	?	?
3	240	?
4	310	70
5	370	60
6	420	50
7	465	45
8	510	45
9	550	40
10	585	35
11	620	35

TABLE III

Average lengths and increments for different age groups of *L. bohar*. Maturity reached at 6–7 years.

This is a very much slower growth rate than that given by Wheeler, increments being about half as much from scale ringing. The possibility cannot be excluded that two rings are laid down per year, although at present there seems no obvious reason for such double ringing in the coastal fishes.

MATURITY AND SPAWNING

No distinct spawning periods were found in *L. bohar*. Few ripe (Stage V) females were found, these being taken in July, September, November, February and March. This suggests an extended breeding season over most of the year. The double spawning period suggested by Wheeler (op. cit.) for *L. bohar* in the Seychelles area is not proved for coastal fish by these results. The smallest females with enlarged gonads (recorded as ripe or nearly ripe) were 445 mm. Although sperm was seen in males as small as 270 mm., when the testes are still threadlike, the first ripe (Stage III) males were found at 450 mm.

Aprion virescens Valenciennes

Aprion virescens is a fast-moving predator common over coral areas in 3 to 15 fathoms, feeding from the surface through the mid-water region to the bottom. It is the only Lutianid species to be regularly taken by surface lures. 259 specimens were taken by handline and surface lure from 202 mm. to 800 mm. standard length (25 lb.). This species was often taken when handlining for *L. bohar*, usually on non-weighted lines. Over coral reefs in from 4 to 14

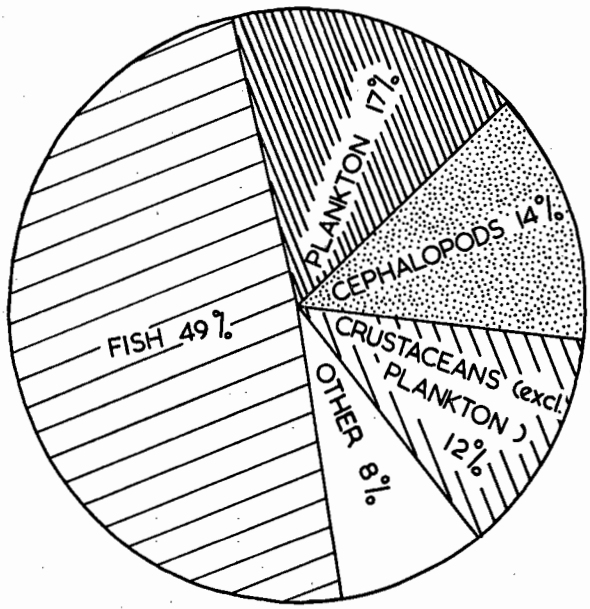

FIG. 3
Relative abundance of food organisms found in *Aprion virescens*.

fathoms *L. bohar* is typically caught from mid-water to the bottom, and *Aprion virescens* from the surface to mid-water. They therefore occupy distinctly different, but overlapping habitats. *A. virescens* has been caught on handlines fishing down to 50 fathoms. The statement by Williams (1956 p. 37) of this species being taken on lines fishing from 75–80 fathoms is an error, and refers to a specimen taken fishing at 50 fathoms off the north end of Pemba Island on 23 October 1953. More than once this species has followed handlines being hauled in from deep water (50–60 fathoms) to the surface. It is possible that the species, which is mainly known as pelagic, may take the bait as the lines are being hauled in, and not at the bottom. There is no proof at present of the species occurring below the major thermocline in the colder sub-surface water.

A. virescens is considered a prime food fish, and occurs in the local markets throughout the year in small numbers.

Underwater, *A. virescens* is commonly seen in coral areas (Mafia, Latham, Cumulus, Zanzibar Channel), always actively moving in mid-water, never

sheltering in coral. It is usually in loose and widely spaced shoals of two to five fish, but occasionally solitary.

FEEDING

A. virescens seems able to feed from the surface to the bottom. Fish was the most important food taken, and comprised *Lethrinus microdon*, *Iniistius* sp., Siganids, Tetraodonts, Scarids, Balistids, Labrids, Synodontids and Atherinids. Plankton was also often found in the stomachs of even the largest fishes, and included fish eggs, larval fish, stomatopod larvae, salps and zoeae larvae. Crustaceans, mainly Portunid crabs, and to a lesser extent Penaeid prawns, were also important. Squid was occasionally taken. (See fig. 3.)

MATURITY AND SPAWNING

The smallest female recorded as ripe (Stage V) was 465 mm. standard length, and another female of the same length as mature ripening (State IV). Gonads of males were seen with sperm at 410, 420, 455 and 460 mm., but the smallest males recorded with enlarged full testes were just under 500 mm.

Ripe females were found only in December, January and February, suggesting a breeding season during the warmer water of the north-east monsoon period. Nearly ripe fish (Stage IV) were recorded in most months, and more information will probably prove an irregular extended breeding season.

Lutjanus rivulatus (Cuvier)

One hundred and twenty-nine specimens were taken by handline and underwater spearing, ranging from 395–640 mm. (maximum weight of 19 lb.). This species had rarely been taken from the E.A.M.F.R.O. research vessels until the rich fish populations at Lamu off the Kenya coast had been found (mentioned under *L. bohar*) in 25–65 fathoms. *L. rivulatus* formed about 20% of the catch in these areas. Underwater observation has shown that although seldom caught by handline over shallow coral reefs, *L. rivulatus* is common in certain sheltered coral areas such as Tutia Gap (Mafia) and inside the fringing reef in 5–7 fathoms with *L. bohar* on the east coast of Zanzibar Island, and also at Ras Kizimkazi at the southern tip of Zanzibar Island. At these places occasional mid-water shoals of five to ten fish, often in conjunction with *L. bohar* and *L. argentimaculatus* are present. The species has also been seen singly sheltering under dense beds of the 'platform coral' (*Acropora hyacinthus* [Dana]) on Tutia Reef, and in rocky areas at 5 fathoms on Latham Bank.

FEEDING

L. rivulatus is predominantly a fish predator, also taking crabs, polychaetes, squid, octopus, echinoids, ascidians and polyzoa. It is chiefly a bottom feeder. One sample from deep water contained many fishes filled with salps.

Maturity and Spawning

Maturity is reached in both males and females at about 450 mm. standard length. Ripe females were found in February, March, April, November and December, and ripe males in March, April, August, November and December, suggesting an extended breeding season in the warm north-east monsoon period.

Lutjanus fulviflamma (Forskal)

This species is abundant over the whole East African coastline extending as far south as South Africa (33°S.), and although small in size is an important species economically, always present in the local fish markets, often in large numbers. It is common in the fringing reef channels, the outer reef slope, mangrove areas, the reefs of Zanzibar channel, the Mafia area and in estuaries (see figs. 4 and 5). Juveniles have been seen in pools on the reef flat, and in shallow water of from six inches to a foot around Zanzibar town over both sandy and weedy bottoms. No other Lutjanid species has as wide a distribution of habitats as *L. fulviflamma*.

One hundred and twenty-six specimens were examined, taken by basket-trap, handlines, trammel-nets, and bought from the local markets. The size range was from 51–220 mm.

Feeding

Crustaceans were the predominant foods; being mainly crabs (including Portunids and Callapids) and also Eupagurids, Sphaeromid isopods, Penaeid prawns and Stomatopods. Fish remains included Engraulids, Fistularids and gobies.

Different samples often contained foods of one type, presumably indicating local abundance of one particular food organism in the area in which the sample was obtained. Most of the food organisms found were bottom animals.

The investigation of small samples of this species in Durban Bay (South Africa) by the Zoology Department, University of Cape Town, has shown very similar results. Bottom-dwelling crustaceans (mainly *Hymnosoma orbiculare* Dem. and Penaeid prawns) predominated in the stomachs, with fish (Eleotrids, gobies and *Lutjanus* sp.) next in importance (from unpublished records by courtesy of Professor J. H. Day).

Maturity and Spawning

Of 112 fishes whose gonads were examined, 36 were immature and unsexed, of the remaining 76, 51 were female and 25 male. Of one sample of 13 fish, 12 were female and 1 male. Males were recorded with sperm as small as 145 mm., and the first fully ripe male was found at 170 mm. Ripe females were recorded as small as 160 mm.

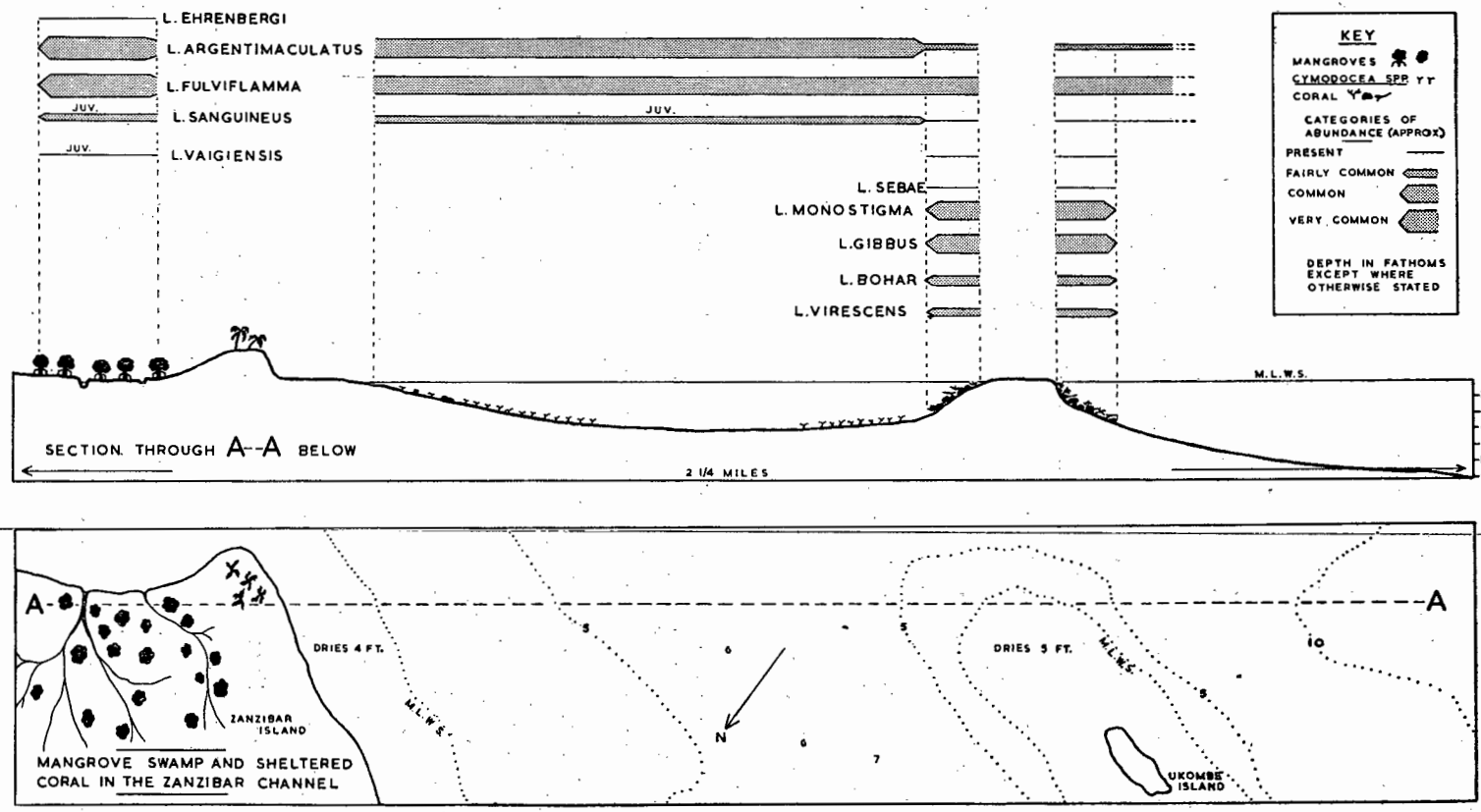

FIG. 4

Distribution of Lutjanids and an indication of relative abundance in mangroves and a coral area not exposed to violent wave action. This example has been taken from the Zanzibar Channel at Ukombe Island Reef. (Based on British Admiralty Chart 665.)

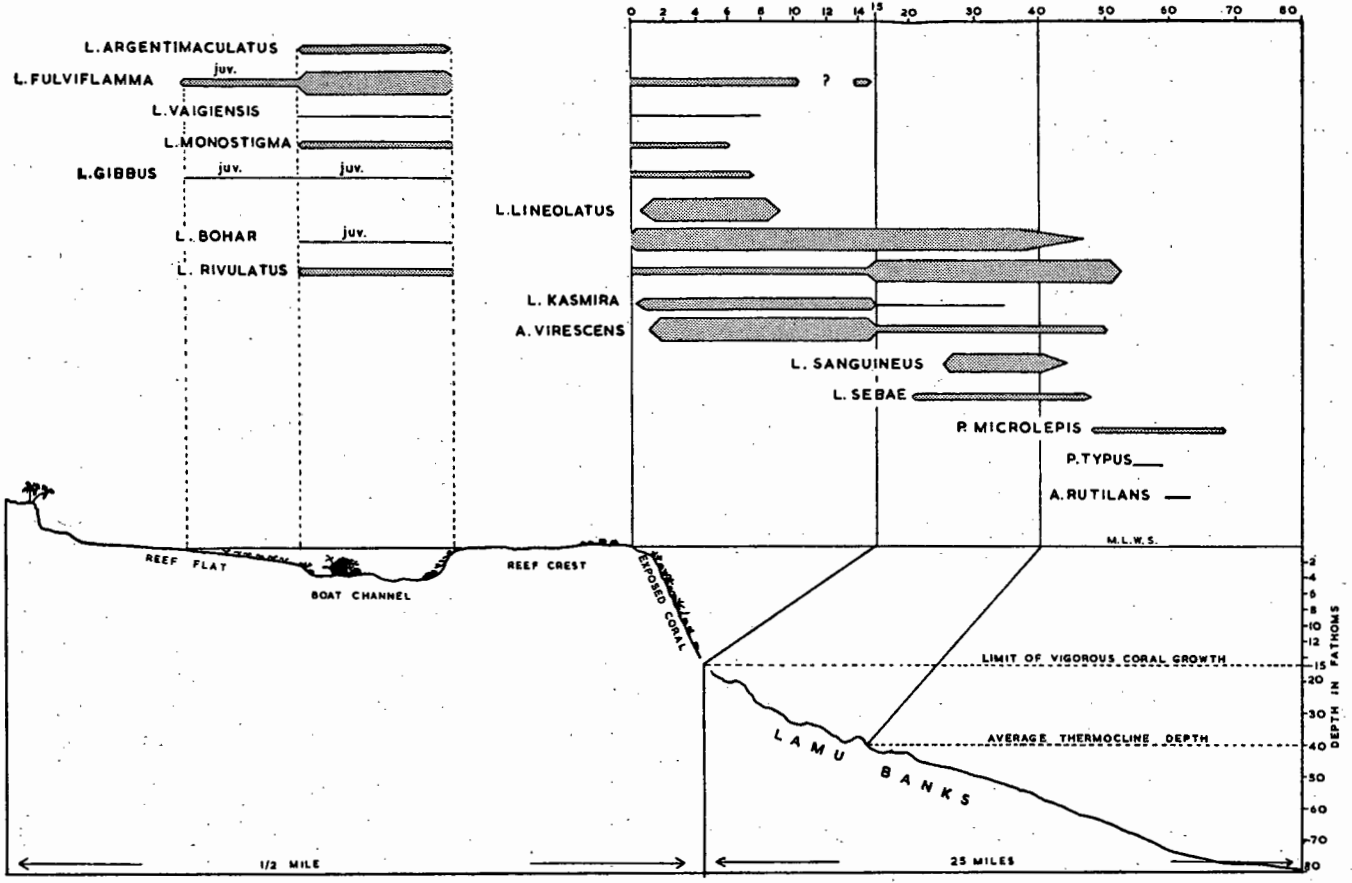

FIG. 5

Distribution of Lutjanids and an indication of relative abundance on a coral reef exposed to the open Indian Ocean, with its sheltered reef flat and boat channel, and the deep-water banks at Lamu. The profile is diagrammatic and based on no single area. An outer reef flat between the reef crest and the boat channel is not included here, as its fish fauna is similar to that of the inner flat. Key as in fig. 4.

Ripe females were found in March, August, October and December, suggesting an extended breeding season mainly in the north-east monsoon period.

Lutjanus gibbus (Forskal)

Lutjanus gibbus is a small species, seldom reaching more than 4 lb. in weight, occasionally seen in local fish markets, but seldom in large numbers.

One hundred and twenty-one specimens were taken by handlining and trammel-nets, always on the bottom and never in mid-water with *L. bohar* and *A. virescens*. The size range of fish taken was from 170 to 355 mm. This species was usually taken at night. It was only found in shallow water of from 3 to 8 fathoms.

Underwater observations showed that this species keeps a few inches above the coral, often sheltering in the branches of 'stag coral' (*Acropora formosa* [Dana]), and in the leaves of 'platform coral' (*Acropora hyacinthus* [Dana]). It was seldom seen singly but usually in dense, closely knit shoals, typically roving over the bottom in a single layer, closely following the bottom contours. Numbers ranging from one to fifty fish and over were seen, but usually shoals were from ten to twenty-five. The species is common on exposed and sheltered coral reefs with rich coral growth, and was seen at Tutia, Vulture, and Cumulus banks in the Mafia area, and on the fringing reef outer slope at Zanzibar. It was also taken on Latham bank and at Lamu. Adults were never seen in the fringing reef channels. Juveniles of about 50 mm. long were seen on the reef flat, and are occasionally taken in beach seine hauls on Zanzibar Island.

Feeding

Foods eaten were mainly crustaceans, including crabs and Penaeid prawns. Small coral fishes were also occasionally taken. Coral and sand were sometimes present in small quantities.

Maturity and Spawning

The smallest mature females with gonads approaching spawning condition (Stage IV) were found at 223, 235, 240 and 245 mm. standard length. The smallest mature males were 240 and 280 mm. Ripe fishes (either sex) were found in March, November, September and December, i.e. the north-east monsoon period.

Lutjanus sanguineus (Cuvier and Valenciennes)

One hundred and two specimens were taken by handline and basket-trap, ranging from 170–650 mm. (13 lb.). Juveniles were taken in basket-traps in the Zanzibar channel and in the Mafia area, in 6 to 7 fathoms on coral and

Cymodocea bottoms, and were also found in the Chukwani fish-ponds (Zanzibar Island), a mangrove area. Adults were not taken by basket-trap, or by handlining in daylight over coral reefs. On one bank in the Mafia area (Snapper Knoll, Niororo Island) adults were taken on four occasions by handlining at night. Adults and juveniles were also taken by trammel-nets overnight in shallow water in Lamu Harbour. Adults of *L. sanguineus* were common in 25–47 fathoms off Lamu, and were one of the dominant species in these deep-water catches (mentioned on p. 555).

At certain times of year (January, February and March) this species occasionally floods local markets (Zanzibar Island), being taken off the southern tip of Zanzibar Island in 40 fathoms. Off Shimoni (Kenya) it is also taken in quantity at certain times of the north-east monsoon (November to April).

L. sanguineus was never observed underwater.

When it is caught it is seldom taken singly, but usually a number within a few minutes suggesting a shoaling habit.

Feeding

Fishes were the commonest food (including *Syngnathus biaculeatus*, Monacanthids and Apogonids) but Penaeid prawns, crabs, stomatopods, cephalopods and plankton (salps, doliolids, pteropods and medusae) were also found. No change in diet with size was found.

Maturity and Spawning

The smallest males and females with ripe gonads were 480 mm. and 505 mm. respectively. Stage IV females were found in March, August, September and November and Stage V females in April and August. Stage III males were found in March, April, August and November.

Lutjanus kasmira (Forskal)

Seventy-seven specimens were caught by trammel-net, underwater spearing, and handline, ranging from 125–205 mm. *L. kasmira* is a small species seldom reaching $\frac{3}{4}$ lb. in weight, and is not caught unless very fine lines and hooks are used.

Underwater it is seen to be abundant, often in dense shoals of 25 fish and more, never singly, and usually about actively growing coral in exposed areas. It has been seen off Ras Nungwe (Zanzibar), Tutia Reef, and outside the fringing reef on the Zanzibar east coast, in 2–5 fathoms. One specimen taken in deep water (35 fathoms) off Malindi (Kenya) differs slightly in coloration, scaling, and the number of dorsal spines from the shallow water specimens, and is probably a deep water race. This specimen has been described in a previous communication (Talbot, 1957). The species is not found in sheltered mangrove areas, and has not been seen about the Zanzibar channel reefs. It is occasionally seen in local markets.

FEEDING

Crustaceans were the predominant food and included crabs and amphipods. Squid, fish remains and algae were also found.

MATURITY AND SPAWNING

Females were mature at the smallest sizes taken, i.e. 125 mm. Males were first seen with sperm at 155 mm., and first recorded as ripe at 165 mm.

Ripe fishes were found in March and November suggesting breeding in the warm water north-east monsoon period.

Lutjanus sebae (Cuvier)

Twenty-seven specimens were taken by handlines (adults), basket-traps and spear-guns (immature fish), ranging from 128 to 665 mm.

The juveniles of this species occur in shallow water (5–10 fathoms) and fish up to 360 mm. (3½ lb.) have been taken on banks in the Mafia archipelago (Snapper Knoll near Niororo Island and Sefo Reef). Larger specimens have been found to be fairly common in deeper water of 20–48 fathoms and were taken off Tutia Reef and on the Lanu Banks. Occasional specimens of up to 60 lb. have been seen at Ras Kizimkazi (Zanzibar Island) taken on handlines in 40 fathoms by local fishermen. *L. sebae* occurs regularly in small quantities in Zanzibar markets. It was never seen underwater by the author but has been seen in 5 fathoms on Sefo Reef by Dr. J. F. C. Morgans (personal communication).

FEEDING

Stomachs contained fish, stomatopods, crab and cephalopod remains.

MATURITY AND SPAWNING

Females with developed gonads (Stages IV and V) were only found above 490 mm. standard length. Insufficient data were obtained to estimate size at which males mature. Breeding is in the north-east monsoon period, ripe fish having been found from November to March.

Lutjanus monostigma (Cuvier)

Eighteen specimens were taken, 15 by underwater fishing and 3 by handlining in 1–4 fathoms. Size range was from 275 to 420 mm. This species is very rare in the local markets. Underwater observation, however, showed it to be common in areas where large coral growths form deep shelter, and it seems completely limited to this type of habitat. It was common about Tutia Reef, Latham Island, in the Zanzibar Channel, and was seen occasionally inside the fringing reef on the Zanzibar east coast. It was never seen in shoals although

two or three were often seen under one coral shelter. Individuals often remained under one coral for the whole period of observation (up to two hours).

FEEDING

Fish remains (including one Mullid and one Labrid) were present in most stomachs, and Penaeid prawn remains were also found.

MATURITY AND SPAWNING

Ripe or nearly ripe females (Stages IV–V) of 395 mm., 390 mm., 420 mm., and 400 mm. were taken. No ripe males were caught. From the meagre data the fish appear to mature at over 350 mm. (2 lb.).

Ripe females were found in November and February.

Lutjanus argentimaculatus (Forskal)

Thirteen specimens of 300 to 630 mm. (15½ lb.) were taken from sheltered reef areas in up to 7 fathoms by handlining or set nets at night. This species is abundant in East African coastal waters, and is an important market species. It does not occur on exposed coral reefs, however, and is therefore not well represented in the E.A.M.F.R.O. catches. It is very common in shallow mangrove areas and estuaries, and common in sheltered waters such as the Zanzibar channel. It was commonly seen during underwater observation inside the fringing reef off the Zanzibar east coast, in the semi-estuarine waters of Chwaka creek (Zanzibar) and about large, and often dead, coral growths in the Zanzibar channel. It may occur singly or in shoals of up to 20 fish. Juveniles are fairly common in sheltered mangrove areas.

L. argentimaculatus was never seen during underwater observation on exposed coral reefs.

MATURITY AND SPAWNING

Males were found with testes containing sperm at 330 mm., 410 mm. and 460 mm., and one ripe male of 515 mm. was taken in November 1958. One female was considered mature at 460 mm., and one ripe female of 630 mm. was taken in November 1957.

Lutjanus ehrenbergi (Peters)

Six specimens were taken from mangrove pools on Zanzibar Island (Chukwani fish-ponds) from 44 to 98 mm. standard length. Two of the specimens were fully mature females of 75 mm. These are the smallest mature *Lutjanids* found during the survey. *L. fulviflamma*, also maturing at a relatively small size, was first found mature at 150 mm. *L. ehrenbergi* was never seen during underwater observation.

Lutjanus lineolatus (Ruppell)

Five individuals of this small species were taken (standard lengths 120–175 mm.) but no biological data were obtained from them. Underwater observation showed this species to be often present in large shoals (30 to over 100 fishes) on exposed coral reefs, often in conjunction with *L. kasmira*. It is also fairly common in East African markets, and its rarity in E.A.M.F.R.O. catches are due to catching methods.

Lutjanus vaigiensis (Quoy and Gaimard)

Six specimens were taken by underwater spearing and handlines from 200 to 250 mm.

This small species has very occasionally been seen in local markets, and underwater observations shows that it is present, although not common, on shallow coral reefs (Ras Nungwe, Tutia Reef, inside the Zanzibar fringing reef), usually singly, but occasionally in pairs. It is always in or near coral shelter. It is often present in the same areas as *L. monostigma*. Shoaling in this species has never been seen. Juveniles have been taken in a mangrove area (Chukwani fish ponds, Zanzibar Island). Fully mature males were found at 190 and 205 mm.

Pristipomoides microlepis (Bleeker)

Twelve specimens were obtained by deep lining (47–67 fathoms) ranging from 260 to 645 mm. (14 lb.).

This species has been taken off Malindi, Pemba, and Tutia Reef. Smith (1954) records it as a major component of the Shimoni (Kenya) deep-water fishery. The species lives in the cold sub-surface water below the thermocline, and has not been taken in shallow water.

Pristipomoides typus (Bleeker)

One specimen of 525 mm. (8½ lb.) was taken off Tutia Reef in deep water (about 55 fathoms). Smith (1954) records it as occurring in the deep-water Shimoni fishery.

Aphareus rutilans Cuvier

One specimen, a mature female of 785 mm., was taken at 60 fathoms off Lamu. Water temperature at that depth was 19°C. from a bathythermograph reading.

Lutjanus duodecimlineatus (Valenciennes)

One specimen was purchased in the Zanzibar fish market (150 mm.).

Conclusion

Few *Lutjanids* are restricted to the East African coast. Of the seventeen species recorded here, all except two (*L. ehrenbergi* and *L. duodecimlineatus*) reach the Australo-Pacific region. In the reverse direction distribution of this family is not so uniform, however. Many Lutjanids found in the Parific Ocean and the Eastern Indian Ocean are not found in the Western Indian Ocean. For example, in the genus *Lutjanus* 32 species occur in the Hawaiian Islands (Herre, 1953), excluding the freshwater *L. maxweberi* and the doubtful *L. philippinus*. Of these only 13 are found in East Africa. This suggests a centre of origin, or at least strong adaptive radiation in the Australo-Pacific region. At present there is clearly difficulty of dispersal in an east-west direction for many species, but whether this is due to paucity of suitable environments in the north and western Indian Ocean, or to some physical barrier to migration is not obvious. Temperature, which limits the southerly distribution of this typically warm-water family down the coast of Africa, does not operate as a barrier to its spread along the Indian and Iran coasts. Lutjanid distribution bears out Ekman's statement that 'the rich Indo-Malayan fauna is distributed over a large part of the Indian Ocean, but the number of species constantly decreases as we proceed in a westerly direction'.

Down the African coast some species disappear at Delagoa Bay (26°S.), with the last coral reefs, and then there is a steady decrease in species to East London (33°S.), no members of the genus *Lutjanus*, and only the genera *Aprion* and *Etelis* (Indo-Pacific, not recorded during this survey) reaching farther south, to Knysna (34° 5′S.). (Note: Two specimens of *L. sanguineus* have been taken in Algoa Bay, and one at Plettenberg Bay, 34°S., during 1958–9.) The distribution of this family is paralleled by that of the reef-building corals. Although no coral reef growths have been found south of Delagoa Bay, reef-building genera are found to just north of East London (Stephenson, 1947). Coastal temperatures drop rapidly between Port St. Johns (31° 40′S.) and East London (33°S.) due to an outward turning of the Agulhas current. The latter port coincides with the 20°C. isotherm in winter (Sverdrup *et al.*, 1942).

Vertical distribution is very limited in most of the family (see fig. 4). Of the seventeen species taken eight species were never caught deeper than 14 fathoms. Of these most were common about coral reefs, and their deepest limits coincided with the limit of vigorous coral growth, which was usually between 10 and 15 fathoms. It is possible that the same factors might be the cause of both the limit of distribution of the fishes and the end of reef growth, but more likely that the fishes are limited to the coral habitat.

The thermocline, varying from 25–50 fathoms, is deeper than the foot of the actively growing coral area, and at 10–15 fathoms water conditions differ little from the surface. Temperatures at this depth were not found below 24°C. by Newell (1957) and in summer are very much above this, so temperature does not seem to be a barrier in this connection. Suggested reasons for the downward limit of coral growth will be discussed in a later paper; here it will

be sufficient to state that for *L. vaigiensis*, *L. monostigma*, *L. lineolatus*, *L. gibbus*, *L. fulviflamma* and the shallow-water form of *L. kasmira* (referred to on p. 565), the foot of the living coral reef (excluding tallus slopes) is the downward limit. Although some physical environmental factor or combination of factors may be the cause of this, the abrupt ending coincident with that of the coral suggests that in a downward direction the fish distribution is determined by the latter. *L. fulviflamma* was not restricted to coral areas but was also abundant in sheltered areas such as mangrove swamp channels and *Cymodocea* beds. *L. argentimaculatus*, also limited to shallow water, was found in more sheltered habitats only, including mangrove areas, the boat channel of fringing reefs, and sheltered coral. *L. ehrenbergi* was taken only in a mangrove swamp.

L. bohar and *L. rivulatus* were for a long period (1951–5) considered to have only a shallow-water distribution, never being taken below about 14 fathoms. In 1956, however, when the deep-water (25–65 fathoms) banks off Lamu, Kenya, were fished it was discovered that these two species were often abundant at much greater depths, reaching 46 and 51 fathoms respectively. In these areas the shelf is unusually wide for the East African coast (considered by Morgans, 1959, to be due to the deposition from an old river delta), and rich feeding-grounds are present. It seems clear that this favourable habitat is the reason for the presence of *L. bohar* and *L. rivulatus* in deeper water.

On these banks the bottom temperature may vary from 22°C. to 29°C. Newell also gives one reading of 18°C. at 50 fathoms. (Newell 1959, Morgans in unpublished E.A.M.F.R.O. reports.) From the foods taken by these members of the genus *Lutjanus* it appears that they are all bottom feeders, and it is probable that temperature becomes an important factor in the distribution of these members of this genus to the colder deeper portions of these banks, if we may judge by their distribution down Africa, referred to above. It is quite clear from the great deal of fishing that has now been done in this area that the genus *Lutjanus* is only found in water of the East African coastal current, and not below the thermocline. No members of this genus have been taken in water below 23°C. where a bathythermograph has been used in conjunction with fishing. In addition to *L. bohar* and *L. rivulatus* this also applies to *L. sebae* and *L. sanguineus* whose adults were common on these banks. In the former only juveniles and young fishes up to 360 mm. were taken in shallow water, and adults in water of 30–49 fathoms. Adults of the latter extended from the shallow water of Lamu Harbour (a mangrove area of 4 fathoms) to 47 fathoms, and were more abundant in deep water. Juveniles of these species were only taken in sheltered water.

In contrast to the genus *Lutjanus* the two species of the genus *Pristipomoides* and *Aphareus rutilans* were taken in 47–67 fathoms and 60 fathoms respectively and never in shallower water. Also found on the Lamu Banks, these species are usually present below the thermocline. *A. furcatus*, not taken during this survey but recorded by Smith (1954) in East Africa, seems to be a shallow-water species, being referred to by Randall (1955) as fairly commonly seen underwater

in shallow coral-rich areas of the Gilbert Islands, and taken on the surface on lures by Schultz (1953) on Bikini Atoll. Smith's record is of one specimen from 20 fathoms off Pemba Island.

The genus *Aprion* has a pelagic habit and a depth range to about 50 fathoms, but is more abundant in shallow water over the reefs.

Clear differences were found between the catches of Lutjanids from coral areas facing the open Indian Ocean and exposed to violent wave action, and those of sheltered coral islands in the 15-mile channel between the African mainland and Zanzibar Island or from the inner Mafia Archipelago (see fig. 1). *L. argentimaculatus* was taken both in the boat channel and also from sheltered coral reefs, but never on the outer exposed reef slope. *L. kasmira*, common on the outer slope, was never taken in sheltered water. Numbers of species common to both types of coral area also differed. *L. bohar* was one of the dominant species of the outer slope, but although present in the more sheltered water it was very much less common. Conversely *L. gibbus* was common and sometimes abundant in sheltered areas, but on the outer slope it was poorly represented in the catches.

The reasons for the patterns of distribution described in the above paragraphs are obviously complex, and not within the scope of this work, but many of the problems here raised could be approached experimentally. Temperature, salinity, light, O_2 concentration and turbidity preferences of the juveniles and adults of different species could be tested with carefully designed aquarium equipment, especially for the smaller species, and would undoubtedly give valuable clues to the reasons for their distribution.

On a typical East African reef the Lutjanids are a major component of the fish fauna. They and the *Serranidae* form in general the bulk of the non-pelagic predators, in contrast to the *Carangidae*, *Scomberomoridae* and *Sphyraenidae*. They differ from the *Serranidae* in that while members of this family are usually often solitary and many are more or less stationary for long periods most Lutjanids tend to school and move actively over the coral. The commonest line-caught fish over exposed coral was the large, mainly fish-eating, *L. bohar*, with *A. virescens* common in mid-water and at the surface in the same areas. The commonest smaller species, *L. fulviflamma*, *L. kasmira* and *L. lineolatus*, are often present in shoals numbering 50 and more. These species swim close to the coral and are predominantly crustacean feeders. On sandy bottoms and *Cymodocea* beds their place is taken by the *Lethrinidae*.

In the deeper Lamu Banks off the Kenya coast this family forms the bulk of the predators, if we may judge by the quantities of line-caught fish. Lutjanids, mainly *L. bohar*, *L. rivulatus*, and *L. sanguineus* formed 54% of the fishes taken, the *Serranidae* 26% and the *Lethrinidae* 15%, with 5% of sharks and other species (Williams, 1958).

No sharply marked breeding seasons were found in any of the species studied, although sometimes a single sample would contain many ripe fishes of both sexes. In general all species seemed to breed over a large part of the year, but mostly in the warm north-east monsoon period.

Acknowledgements

My thanks for help and encouragement are due to the Director, Dr. J. F. G. Wheeler and Mr. Frank Williams, Dr. J. F. C. Morgans and Mr. B. S. Newell of the East African Marine Fisheries Research Organization, Dr. P. H. Greenwood of the British Museum, and to Professor J. H. Day, University of Cape Town, for helpful criticism of the manuscript.

Summary

Seventeen species of the family Lutjanidae from the East African coast are discussed, and notes on their distribution, feeding, spawning seasons and shoaling habits are presented.

Eight species of the genus *Lutjanus* were found only in shallow water, and were never found below the limit of active coral reef growth (approximately 15 fathoms). The major thermocline at from 25–50 fathoms is suggested to be a barrier to deeper distribution of the five species (four of the genus *Lutjanus* and *Aprion virescens*) found from shallow water to below the living coral reefs. Three species (two of the genus *Pristipomoides* and *Aphareus rutilans*) were found only in deeper water, and never above the major thermocline.

No evidence of migrations was found.

Sheltered coral, and coral exposed to violent wave action were found to differ in the presence or absence of some species of the family, and also in the numbers of species common to both habitats.

All the species studied were euryphagous predators. Details of feeding are given.

No sharply defined breeding seasons were found, but the extended periods in which breeding took place were mostly in the warm months, November to April.

Regular growth rings were found on the scales of *Lutjanus bohar*. Checks were formed at different times of year in different fishes. It is suggested that these are related to spawning. Growth increments of from 70 mm. (3rd–4th year) to 35 mm. (10th – 11th year) were estimated.

References

Allee, W. C., & others. 1949. *Principles of animal ecology*. Philadelphia: Saunders.

Bowers, A. B. 1954. Breeding and growth of whiting (*Gadus merlangus* L.) in Isle of Man waters. *J. Mar. biol. Ass. U.K.*, **33**, 97–122.

Clark, J. R. 1958. Consistency of scale reading. *Spec. Publ. int. Comm. N.W. Atlantic Fish*, **1**, 191–192.

Ekman, S. 1953. *Zoogeography of the Sea*. London: Sidgwick & Jackson.

Fowler, H. W. 1931. Contributions to the biology of the Philippine Archipelago and adjacent regions. Pt. IV. *Bull. U.S. nat. Mus.*, **100**, 11, 1–388.

Harry, R. R. 1953. Ichthyological field data of Rarioa Atoll, Tuamotu Archipelago. *Atoll Res. Bull.*, **18**, 1–190.

Herre, A. W. 1953. Check list of Philippine fishes. *Res. Rep. U.S. Fish. Serv.*, **20**, 1–977.

HICKLING, C. F. 1933. The natural history of the hake. Part IV. Age determination and growth rate. *Fish. Invest., Lond.* (2), **13,** 1–120.

MENON, M. D. 1953. The determination of age and growth of fishes of tropical and sub-tropical waters. *J. Bombay nat. Hist. Soc.*, **51,** 623–625.

MORGANS, J. F. C. 1958. Three confusing species of Serranid fish, one described as new, from East Africa. *Ann. Mag. nat. Hist.* (13), **1,** 643–656.

MORGANS, J. F. C. 1959. The North Kenya banks. *Nature, Lond.*, **184,** 259–260.

MORGANS, J. F. C. In unpublished field data of the East African Marine Fisheries Research Organization, Zanzibar.

NEWELL, B. S. 1957. A preliminary survey of the hydrography of the British East African coastal waters. *Fish. Publ., Lond.*, **9,** 1–21.

NEWELL, B. S. 1959. The hydrography of the East African coastal waters. Part II. *Fish. Publ., Lond.*, **12,** 1–18.

RANDALL, J. E. 1955. Fishes of the Gilbert Islands. *Atoll. Res. Bull.*, **47,** 1–243.

RANDALL, J. E. 1958. A review of ciguatera, tropical fish poisoning, with a tentative explanation of its cause. *Bull. Mar. Sci. Gulf & Caribbean*, **8,** 236–267.

RIEDL, R. 1958. An attempt to test the efficiency of ecological field methods and the validity of their results. *In* Buzzati-Traverso, A.A., *ed. Perspectives in marine biology.*, 57–65. Berkeley & Los Angeles: University of California press.

SCHULTZ, L. P., & collaborators. 1953. Fishes of the Marshall and Marianas Islands. *Bull. U.S. nat. Mus.*, **202,** 1, 1–685.

SMITH, J. L. B. 1953. *Sea fishes of southern Africa.* 2nd ed. Cape Town: Central news agency.

SMITH, J. L. B. 1954. Fishes new to Africa obtained by deep line fishing in Kenya waters, with a revision of the East African species of the genus *Pristipomoides* Blk. 1852. *Ann. Mag. nat. Hist.* (12), **7,** 481–492.

STEPHENSON, T. A. 1947. The constitution of the intertidal fauna and flora of South Africa. *Ann. Natal Mus.*, **11,** 207–324.

STEVEN, G. A. 1930. Bottom fauna and the food of fishes. *J. Mar. biol. Ass. U.K.*, **16,** 677–700.

SVERDRUP, H. U.; JOHNSON, M. W.; & FLEMING, R. H. 1942. *The Oceans.* Engelwood Cliffs, N.J.: Prentice-Hall.

TALBOT, F. H. 1957. The fishes of the genus *Lutjanus* of the East African coast. *Ann. Mag. nat. Hist.* (12), **10,** 241–258.

TALBOT, F. H. 1958. On *Plectropomus maculatus* (Bloch) and *P. marmoratus* (n.sp.) from East Africa (Pisces, Serranidae). *Ann. Mag. nat. Hist.* (13), **1,** 748–752.

TALBOT, F. H., & NEWELL, B. S. 1957. A preliminary note on the breeding and growth of Tilapia in marine fish ponds on Zanzibar Island. *E. Afr. agric. J.*, **22,** 118–121.

TALBOT, F. H., & WILLIAMS, F. 1956. Sexual colour differences in *Caranx ignobilis* (Forsk.), *Nature, Lond.*, **178,** p. 178.

WHEELER, J. F. G., & OMMANNEY, F. D. 1953. Report on the Mauritius-Seychelles fisheries survey, 1948–49. *Fish. Publ., Lond.*, **3,** 1–148.

WEBER, M., & DE BEAUFORT, L. F. 1936. *The fishes of the Indo-Australian Archipelago*, **7.** Leiden: Brill.

WHITLEY, G. P. 1943. Poisonous and harmful fishes. *Bull. Coun. sci. industr. Res. Aust.*, **159,** 1–28.

WILLIAMS, F. 1953. Catches of *Coryphaena hippurus* (L.) in the Western Indian Ocean. *Nature, Lond.*, **171,** p. 703.

WILLIAMS, F. 1956. Preliminary survey of the pelagic fishes of East Africa. *Fish. Publ., Lond.*, **8,** 1–68.

WILLIAMS, F. 1958a. Fishes of the family Carangidae in British East African waters. *Ann. Mag. nat. Hist.* (13), **1,** 369–430.

WILLIAMS, F. 1958b. A preliminary report on deep water fishing off the North Kenya coast. *E. Afr. agric. J.*, **24,** 61–63.

WILLIAMS, F. 1959a. Marlins in British East African waters. *Nature, Lond.*, **183,** 762–763.

WILLIAMS, F. 1959b. Black marlin in British East African waters. *Nature, Lond.*, **184,** B.A.78.

WILLIAMS, F., & NEWELL, B. S. 1957. Notes on the biology of the dorade or dolphin-fish (*Coryphaena hippurus*) in East African waters. *E. Afr. agric. J.*, **23,** 113–118.

The *ANNALS OF THE SOUTH AFRICAN MUSEUM* are issued in parts at irregular intervals as material becomes available.

Out of print: Vol. I, II (Parts 1–3, 5, 7, 8), III (Part 1), V (Parts 1, 2, 5, 8, 9), VI (Part 1, Index), VII (Parts 1–3), VIII, IX (Parts 1, 2), X (Part 2), XI (Parts 2, 7, Index), XXI (Part 1), XXIV (Part 2), XXXI (Part 1).

Current prices:

Vol. II.	1900–1902	Zoology and Geology (excl. Parts 1–3, 5, 7, 8)	£1	7	3
III.	1903–1905	Zoology (excl. Part I)	2	3	6
IV.	1903–1908	Palaeontology	4	0	6
V.	1906–1910	Geology, Palaeontology, Zoology, Anthropology (excl. Parts 1, 2, 5, 8, 9)		19	6
VI.	1908–1910	Zoology (excl. Part I, Index)	2	14	9
VII.	1908–1913	Palaeontology (excl. Parts 1–3)	1	4	0
IX.	1911–1918	Botany (excl. Parts 1, 2)	3	0	3
X.	1911–1914	Zoology (excl. Part 2)	5	12	6
XI.	1911–1918	Zoology (excl. Parts 2, 7, Index)	3	7	3
XII.	1913–1924	Palaeontology and Geology	5	17	0
XIII.	1913–1923	Archaeology and Zoology	4	5	3
XIV.	1915–1924	Zoology	4	0	3
XV.	1914–1916	Zoology	5	2	6
XVI.	1917–1933	Botany	4	5	9
XVII.	1917–1920	Zoology	4	4	6
XVIII.	1921	Zoology	5	3	3
XIX.	1924–1925	Zoology	4	1	0
XX.	1924–1926	Zoology	3	2	9
XXI.	1925–1927	Zoology (excl. Part 1)	2	3	3
XXII.	1925–1928	Palaeontology	2	8	6
XXIII.	1925–1926	Zoology	2	2	6
XXIV.	1929–1938	Anthropology and Ethnology (excl. Part 2)	3	0	0
XXV.	1927–1928	Zoology	2	7	0
XXVI.	1928	Zoology	1	16	0
XXVII.	1929	Anthropology	1	16	0
XXVIII.	1929–1932	Palaeontology	3	3	0
XXIX.	1929–1931	Zoology	2	18	0
XXX.	1931–1935	Zoology	4	8	9
INDEX		of papers, authors and subjects published in Vols. I–XXX		2	3
XXXI.	1934–1950	Palaeontology (excl. Part 1)	3	1	3
XXXII.	1935–1940	Zoology	3	16	3
XXXIII.	1939	Zoology	2	10	6
XXXIV.	1938	Zoology	2	17	6
XXXV.	1956	Zoology	7	4	0
XXXVI.	1942–1948	Zoology	3	1	3
XXXVII.	1947–1952	Archaeology	2	3	3
XXXVIII.	1950	Zoology	4	10	0
XXXIX.	1952	Zoology	3	5	6
XL.	1952–1956	Botany	1	11	9
XLI.	1952–1955	Zoology	4	16	0
XLII.	1953–1956	Palaeontology	4	1	0
XLIII.	1955–1957	Zoology and Palaeontology	2	8	0
XLIV.	1957–1959	Zoology and Palaeontology	3	6	3
XLV.	1959–	Zoology and Palaeontology Part 1	2	15	3
		Part 2			9
		Part 3		16	0
		Part 4	1	17	0

Copies may be obtained from—

The LIBRARIAN, SOUTH AFRICAN MUSEUM, CAPE TOWN.