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NOTES ON SOME HAWAIIAN PLECTOGNATH FISHES, INCLUDING A KEY TO THE SPECIES

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Fishes of the Order Plectognathi, although economically of little significance, are of interest to the scientific investigator because of some of their unique anatomical features, concerned principally with the mechanisms employed by these fish for defense. Among them are the expansible stomach of the puffer fish, the erectile dermal spines of the porcupine fish, the trigger-like mechanism in the first dorsal fin of the balistid, and the rigid exoskeleton or carapace of the box fish.

These fishes form a large fraction of the piscine population in the coral reef waters of the Hawaiian Islands and constitute a small part of the fishing catch which is brought in daily to Kewalo Basin. Many of the specimens used in this present study were obtained from this source.

The flesh of some tetraodontids, diodontids, and ostraciids is reputed to be quite palatable. Even the scantily meated monacanthids and balistids are sold for food, although on the whole the plectognaths are not important food fish. On the contrary all the groups mentioned, even the ostraciids (Whitley, 1943; Schultz and Stern, 1948), should be eaten with extreme caution, if eaten at all, as they are noted for occasionally producing poisonous effects which are sometimes erratic in their appearance. The poison is known to attack the nervous system, causing violent gastric disturbances (Herre, 1924; Yudkin, 1944). Larsen (1939) reported three cases of tetraodon poisoning in Hawaii, two of which resulted in death. His studies with rats, guinea pigs, and cats showed that in these animals the immature

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and ripe ova of the Hawaiian plectognaths, *Tetraodon hispidus* and *T. meleagris*, are definitely poisonous.

Quoy and Gaimard (1824) were the first to publish a record of plectognath fishes from Hawaii. In their account of the piscine collections made by the Royal French corvette "Uranie," in 1819, they listed 22 species of fish from Hawaii, three of which were the plectognath forms *Tetraodon meleagris*, *Canthidermis maculatus*, and *Cantherines sandwichiensis*.

In 1905, when Jordan and Evermann's comprehensive study of fishes of the Hawaiian Islands was published, keys were included to all the forms then reported. Since that time a number of synonymies and additions have been made, and many of the generic and specific names altered numerous times. Today some 41 species of Plectognathi are recognized from Hawaii. The purpose of this paper is to present an up-to-date key to these forms and to supplement the key with some notes on new collections examined by the writer while in Honolulu during the spring of 1947.

The members of the staff of the Bernice P. Bishop Museum offered friendly assistance during the course of this study, and I would like to extend my sincere thanks to them, especially to Dr. C. H. Edmonson who allowed me to examine the fish collection and who provided laboratory space and equipment. It is also a pleasure to acknowledge the assistance of Mr. Spencer Tinker of the Waikiki Aquarium, who was helpful in providing living specimens and materials used in making collections. Dr. Robert Hiatt of the University of Hawaii and Mr. Vernon Brock, Fisheries Director for the Territorial Board of Agriculture and Forestry, were most generous in supplying many specimens collected in the ocean area around Oahu during the previous year. Dr. Charles M. Breder, Jr., kindly read the manuscript.

BALISTIDAE

Balistes vidua, *B. bursa*, and *B. capistratus* were obtained in large numbers from fishing boats in Kewalo Basin along with occasional specimens of *Balistipus rectangulus*, *B. aculeatus*, and *Melichthys radula*.

Two adult females of what is designated in the key as *Canthidermis maculatus* (Bloch) were secured from the University of Hawaii's collection of fishes. One 258-mm. specimen was found in a collection of preserved fish obtained from Kewalo Basin

fishing boats during the summer of 1946. It was said to have been caught on hook and line in deep water off Oahu. The tail was mutilated and first dorsal spine broken, but otherwise it was in good condition. The other, a 275-mm. specimen, was caught in a net by the Territory's fishery ship on June 15, 1947, and turned over to me the next day in excellent condition.

Specimens of the genus *Canthidermis* are reported rarely from Hawaii. Only seven records could be found in the literature, and there is much confusion as to the identification of these few Hawaiian specimens. They have been listed under the following specific names: *maculatus*, *angulosus*, *aureolus*, *oculatus*, and *rotundatus*. Fowler (1928) has kept *C. maculatus* (= *Balistes maculatus* of Bloch, 1786) distinct and synonymized the rest under *C. rotundatus* (= *Balistus rotundatus* of Marion de Procé, 1822). He mentions a number of differences in his descriptions of these two species, but on checking the literature they are found to be overlapping or, as in the case of his head measurement for *C. rotundatus* ($2\frac{3}{5}$ to $2\frac{2}{3}$), apparently based on immature specimens. Bleeker's figure (1865) for a young specimen of *oculatus* conforms to this head measurement, but the adult *angulosus* figured in Jordan and Jordan (1922) measures well over three times in the standard length, falling into Fowler's measurement for *C. maculatus*.

The two specimens I obtained are apparently the same species and agree with the description (Jordan and Evermann, 1905) and figure (Jordan and Jordan, 1922) for *C. angulosus*. The somewhat variable characters are as follows:

	SPECIMEN 1	SPECIMEN 2
Standard length	258 mm. ¹	275 mm.
Second dorsal fin count	3 + 20	3 + 21
Anal fin count	1 + 19	3 + 19
Scales from gill opening to base of caudal	46 ¹	52
Length of head in standard length	$3\frac{1}{4}$ ¹	$3\frac{1}{3}$

MONACANTHIDAE

Monacanthus spilosoma and *Cantherines sandwichiensis* were the most common plectognaths brought in by fishermen at Kewalo Basin. At fish markets they are found among the small "trash" reef fishes sold for a few cents a pound.

¹ Owing to the mutilated tail, these values may be slightly small.

Several specimens of large (about 340 mm.) *Alutera scripta* as well as numerous *M. spilosoma* and *C. sandwichiensis* were contained in the University's preserved collection made within the year preceding the spring of 1947.

OSTRACIIDAE

One specimen of *Ostracion diaphanus* and four *O. lentiginosus* were obtained from Kewalo Basin fishermen. They were both common in the recent collections of the University.

The length of the middorsal, preocular, and ventral spines of *O. diaphanus* appears inversely proportional to the size of the fish, being greatly exaggerated in very young specimens (16 to 20 mm.). Like the tail length of *Lactoria cornutus* (the older specimens have greatly elongated caudal fins) the length of the carapace spines in *O. diaphanus* is obviously a function of age and is not significant in species identification. The young specimens examined have four or five transverse series of scutes posterior to the dorsal fin, and the preocular spines are divergent. None, however, showed spines on the dorsolateral ridges as did the adults. In body outline the young closely resemble *Lactoria fornasini*. Since only small specimens (under 71 mm.) of *L. fornasini* have been found, it is possible that *L. fornasini* is the young of *L. diaphanus*. *L. fornasini* is separated from *L. diaphanus* on the basis that the preocular spines are parallel or divergent, the scutes behind dorsal fin are in three transverse series, and the dorsolateral ridges are absent.

Fraser-Brunner (1940) points out that there are striking sex differences in certain species of the ostraciid fishes which have caused them in some cases to be identified as separate species. He found this to be the case with *Ostracion lentiginosus* Bloch and Schneider and *O. sebae* Bleeker, the former being the female and the latter the male of the same species. We can now designate the species as *O. lentiginosus*, since Bloch and Schneider's description (1801) precedes that of Bleeker (1851) for *O. sebae*.

TETRAODONTIDAE

One specimen of *Tetraodon meleagris* and a number of *T. hispidus* were in the University's recent collection. The writer obtained two specimens of *T. hispidus* in Kaneohe Bay and many from Kewalo Basin fishermen. *T. hispidus* appears to be

the most common puffer fish of the Hawaiian Islands. Young preserved specimens (under 30 mm.) do not show spots on dorsal and lateral surfaces but have conspicuous lines on belly.

CANTHIGASTERIDAE

The writer found the Canthigasteridae to be the most difficult family of Hawaiian plectognaths to identify. There is only one genus known, and all the species are very similar in form. They probably do not get much larger than 160 mm. The preserved material varies in outline owing to the different stages of inflation at which the specimens were "fixed" when first preserved, but basically there is little difference in their forms.

The color patterns and the distribution of prickles have tremendous individual variation. In the past, taxonomists who based species differences mainly on these apparently genetic or perhaps age or sex characters have split up this group into a number of species which are not valid.

All of the canthigasterids have spotting to some degree. In *C. jactator* and *C. margaritatus* the spots are large, conspicuous, and evenly cover most of the body, whereas in *C. amboinensis* and *C. rivulatus* the spotting is smaller, less conspicuous, and unevenly distributed. Pietschmann (1938), however, describes a specimen of what appears to be *C. amboinensis* in most aspects but which has large ocellated spots evenly distributed over the body.

In most canthigasterids there is a tendency for the spots to become closely packed on some parts of the body, often fusing to form solid areas or definite patterns of lines. In *C. rivulatus* some individuals have one or two broad horizontal bands on the sides of the body while in others the "bands" are resolved into spots. Even the conspicuous and usually radiating lines around the eyes of the canthigasterids are often found, in some individuals, to be somewhat broken down into discontinuous lines or spots.

In *C. cinctus* the broad saddle marks on the dorsal region are a fairly consistent and reliable pattern for species identification. Bleeker's figure (1865), however, shows these marks fused together to form a large, dark, dorsal area which breaks up into bands only as it descends laterally.

It is obvious that a great deal of material must be collected and studied before the proper identification of Hawaiian canthigasterids can be understood. Although the descriptions in the

literature have been studied, the key to the Canthigasteridae presented in this paper is based on the examination of comparatively few specimens.

The writer found no canthigasterids in the University's recent collections, although a fresh adult male of *C. cinctus* and one of *C. rivulatus* were obtained from Kewalo Basin fishermen on May 14 and May 29, respectively. The following color notes were taken on the fresh specimens:

Canthigaster cinctus. Standard length 101 mm.; D 9; A 8. Base color gray blue with four wide brown saddle marks, the first above the eye and the last extending out along the dorsal margin of the caudal fin. The ventral margin of the caudal fin is also brown. Outside the brown areas, the body is speckled with bright yellow spots of various sizes, blending together in the belly region to form a solid, slightly paler yellow area. The spots do not blend together to form even a suggestion of radiating lines around the eyes. The iris is pale blue with brighter blue and a few yellow spots. Dorsal and caudal fins are pale yellow; other fins are colorless.

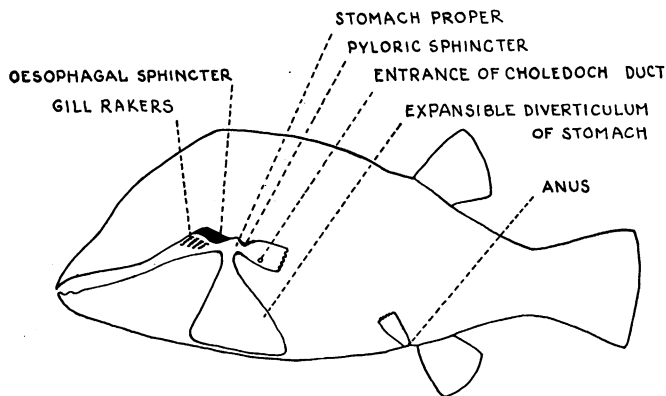


FIG. 1 Median sagittal section of *Canthigaster cinctus* showing inflating mechanism in the relaxed state.

Canthigaster rivulatus. Standard length 104 mm.; D 9; A 9. Belly light with a purple midventral line. Sides irregularly spotted with purple and a few bright yellow spots encircled with purple blending into a pattern of purple lines on the head, back, and caudal region. A bright yellow rim is present around the anterodorsal margin of gill opening. The iris is pale yellow. The

dorsal and anal fins each have five yellow lines parallel to their bases. Caudal region with irregular purple and yellow lines horizontal on penduncle, curving onto more of a vertical plane on the caudal fin. Prickles on belly are a bright yellow. Pectoral fins are colorless.

The inflatable stomach of the tetraodontids and diodontids has been most recently discussed by Breder and Clark (1947). The inflating mechanism of the canthigasterids is essentially the same. (Fig. 1.) The oesophageal and pyloric sphincters hold the fluid gulped in by the mouth in the highly expansible stomach. The stomach is attached ventrally to the body wall, similarly to the condition in the tetraodontids. There does not appear to be any line of separation between the stomach proper and the expansible ventral diverticulum. The length of the alimentary canal from mouth to anus is about two and one half times the standard length. The parietal peritoneum posterior to the pyloric sphincter is thick and non-expansible and contains the rest of the viscera.

DIODONTIDAE

One specimen of *Diodon holacanthus* was found in the University's recent collection, and two specimens of *Chilomycterus affinis* were obtained from fishermen at Kewalo Basin.

MOLIDAE

The three species of this family have been reported from the waters of Hawaii. *Ranzania truncata* is not known to attain the gigantic proportions of *Mola mola* and *Mola lanceolatus*, records for both of which exceed 10 feet, but the 3- to 4-foot adults still exceed those of any of the other families of the Plectognathi.

The writer was unable to examine any recently collected specimens of this family.

OTHER PLECTOGNATH FAMILIES

The other two families in this order are not known from the waters of the Hawaiian archipelago, although it is possible that they inhabit the area but have not yet been reported. *Triodon bursarius* Cuvier, the single species of the family Triodontidae, is a rarely found form. The place nearest to Hawaii from which it has been reported is the Philippines (Herre, 1925), but it is not improbable that its range extends to Hawaii as does that of many of

the Philippine plectognath species. The family Triacanthidae is represented by five species in Oceania (Fowler, 1928), none of which has yet been reported from Hawaii. Like *Triodon*, however, these deep sea triacanthids may well live in the inadequately studied, off-shore waters of Hawaii.

EXPLANATION OF THE KEY

The following key covers all the distinguishable species of the plectognath fishes that the writer could find listed from the waters of the Hawaiian archipelago. It is largely artificial, being based entirely on external and readily discernible features of the fish. It is workable for preserved as well as fresh material. In most cases the generic names used are those given by Fraser-Brunner, who bases his nomenclature on relationships determined by internal as well as external anatomical studies of the genera of the Plectognathi.

The outline drawings at the end of the key (figs. 2 to 9) are diagrammatic and for the purpose of emphasizing most of the characters used in the key and to show general differences and similarities in the forms of the various species. The only color patterns indicated in the figures are those that persist after the specimen has been preserved. Individual drawings have been modified from one or, more often, several figures, plates, and photographs in the literature, and a few are original. Wherever possible, they have been checked with actual specimens. The references consulted in making the key and illustrations are listed in the bibliography.

Starred species are rare in Hawaii and known only from one or a few records.

KEY TO THE SPECIES OF HAWAIIAN PLECTOGNATHI

- A. Jaws with distinct teeth.
 - B. Spinous dorsal fin present; body with scales or movable plates.
 - C. First dorsal fin composed of 3, rarely 2, spines; scales comparatively large, rough, bony, in a regular series forming a coat of mail; all soft fins with branched rays. Balistidae
 - CC. First dorsal fin of one spine with minute rudiment at its base; scales minute, not bony, the edges spinescent, giving the body a rough velvety surface; scales not in a noticeably regular series, rarely in contact; soft dorsal, anal, and pectoral fins with unbranched rays. Monacanthidae
 - BB. Spinous dorsal fin absent; body encased in an immovable carapace of hexagonal plates, only the jaws, bases of fins, and tail being free and covered by smooth skin. Ostraciidae

- AA. Jaws without distinct teeth, instead, a beak-like structure, with or without a median suture, is present in each jaw; spinous dorsal fin absent.
- D. Caudal region normally developed with a caudal peduncle; belly inflatable.
- E. Modified beak-like structure of upper and lower jaws each divided by a median suture.
- F. One or two lateral lines, not always evident; back broadly rounded; nostrils well developed. . . . Tetraodontidae
- FF. No lateral lines; back in most cases sharply ridged; nostrils obsolete or very small. Canthigasteridae
- EE. Modified beak-like structure of upper and lower jaws each undivided; body covered with deeply rooted spines. . Diodontidae
- DD. Body truncated behind dorsal and anal fins; without caudal peduncle and with caudal region aborted; jaws without median suture. Molidae

BALISTIDAE

- A. Enlarged scales or osseous plates developed behind gill opening.
- B. Preocular groove below nostril.
- C. Teeth uneven, more or less deeply notched, not incisor-like.
- D. Head entirely scaled up to lips.
- E. Distance from anterior bases of dorsal and anal fins equal or less than distance from snout to first dorsal spine.
- F. Scales from behind gill opening to tail with stout spines forming elevated lines which cover half of body. *Balistes bursa* Schneider
- FF. Elevated lines covering less than one-third of body and composed of small spines. *Balistes capistratus* Shaw
- EE. Distance from anterior bases of dorsal and anal fins greater than distance from snout to first dorsal spine.
- G. Caudal fin pale, much lighter in color than body. *Balistes vidua* Richardson
- GG. Caudal fin dusky or dark, about same shade as body. *Balistes nycteris* (Jordan and Evermann)*
- DD. Snout with large naked area; cheek scales reduced to five or six widely spaced rows of tubercles. *Balistes fuscus* Schneider
- CC. At least two middle teeth of upper and lower jaws even and incisor-like; body and fins dark; a pale line at base of dorsal and anal fins. *Melichthys buniwa* (Lacépède)
- BB. Preocular groove absent.
- H. A broad black band on side extending from eye to base of anal fin where it is wider than half the length of the anal fin. *Balistipus rectangulus* (Schneider)
- HH. No broad black band on side.
- I. About four diagonal stripes from middle of trunk to anal fin. *Balistipus aculeatus* (Linné)

- D. Dorsal surface with a large median spine.
 - E. Small spines on dorsolateral crest posterior to orbit.....
.....*Lactoria diaphanus* (Schneider)
 - EE. No spines on dorsolateral crest posterior to orbit.....
.....*Lactoria fornasini* (Bianconi)*
- DD. Dorsal surface without a large median spine.....
.....*Lactoria cornutus* (Linné)*
- AA. Carapace with a midventral keel and open behind dorsal and anal fin.....
.....*Aracana aculeata* (Houttuyn)*

TETRAODONTIDAE

- A. A ventrolateral ridge on each side of caudal peduncle.
 - B. Erectile small spines covering most of body; dorsal rays 8.....
.....*Lagocephalus hypselogenion* (Bleeker)
 - BB. Erectile spines confined to inflatable abdomen; dorsal rays 12 to 14...
.....*Lagocephalus lagocephalus* (Linné)*
- AA. Caudal peduncle lacking ventrolateral ridges.
 - C. Skin in most cases entirely smooth, free from spines; body with no spotting or other conspicuous patterns.....
.....*Spheroides cutaneus* (Günther)*
 - CC. Skin with many fine, setae-like spines; body spotted.
 - D. Dorsal region of body with conspicuous and regularly spaced light spots.
 - E. Body almost completely covered with small whitish spots...
.....*Tetraodon meleagris* Schneider
 - EE. Spotting does not extend over inflatable abdomen.....
.....*Tetraodon hispidus* Linné
 - DD. Spotting dark and irregularly spaced.....
.....*Tetraodon nigropunctatus* Bloch and Schneider*

CANTHIGASTERIDAE

- A. No broad, dark, saddle marks across back.
 - B. Dorsal fin count 11 to 13.....*Canthigaster amboinensis* (Bleeker)¹
 - BB. Dorsal fin count 10 or less.
 - C. Body with large, conspicuous, light spots.
 - D. Caudal fin spotted..*Canthigaster margaritatus* (Rüppell)*

¹ The single Hawaiian record for *C. striolatus* (Quoy and Gaimard) reported from Maui by Fowler (1928) is apparently a specimen of *C. amboinensis*. Miss Myvanwy M. Dick of the Museum of Comparative Zoölogy at Harvard was kind enough to send the original specimen (M.C.Z. No. 31181) and, on checking the measurements, I found that fin ray counts (D 1 + 12, A 1 + 10) and, markings (particularly the dark bases of the dorsal and anal fins) were in accord with those given by Jordan and Evermann for *C. oahuensis* (Jenkins) and *C. psegma* Jordan and Evermann, both of which I believe Fowler (1928) is correct in synonymizing under *C. amboinensis*.

Pietschmann's single record for *C. polyophthalmus* (1938) is, for the purposes of this key, considered as belonging to *C. amboinensis* although, as Pietschmann points out, a greater amount of material is needed before its identification can be established.

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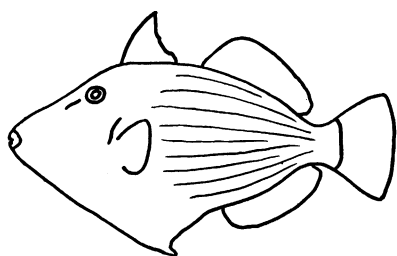
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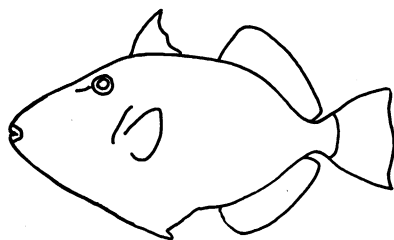
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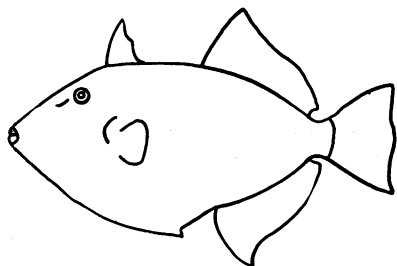
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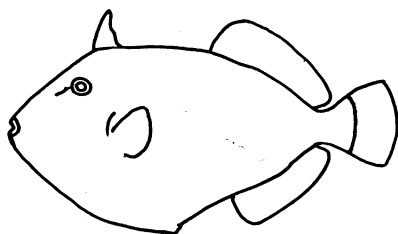
BALISTES BURSA



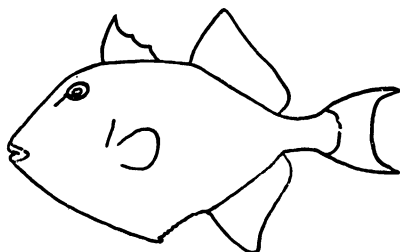
BALISTES CAPISTRATUS



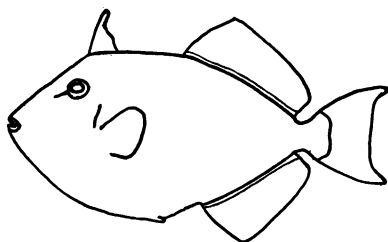
BALISTES VIDUA



BALISTES NYCTERIS

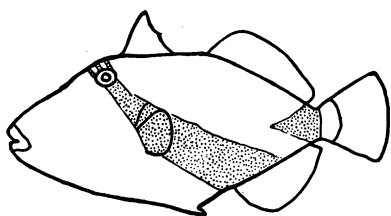


BALISTES FUSCUS

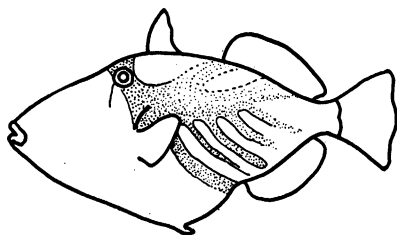


MELICHTHYS BUNIVA

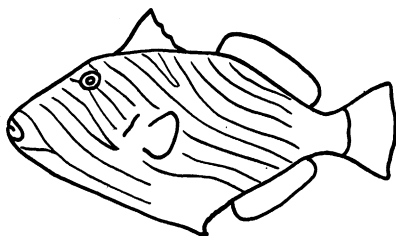
FIG. 2. Species of the family Balistidae.



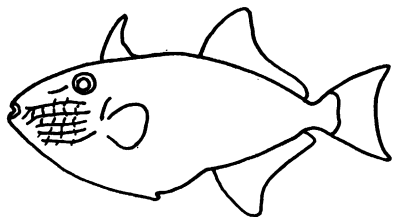
BALISTIPUS RECTANGULUS



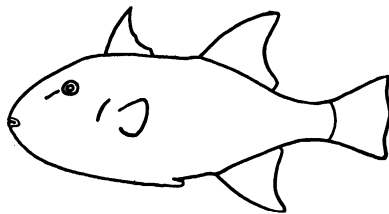
BALISTIPUS ACULEATUS



BALISTIPUS UNDULATUS

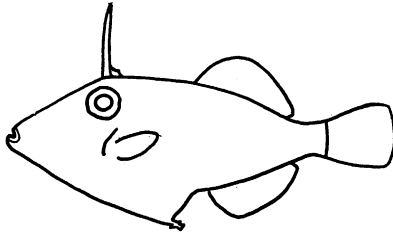


XANTHICHTHYS RINGENS

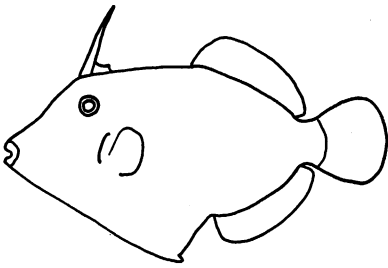


CANTHIDERMIS MACULATUS

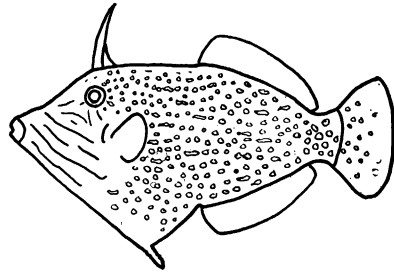
FIG. 3. Species of the family Balistidae (concluded).



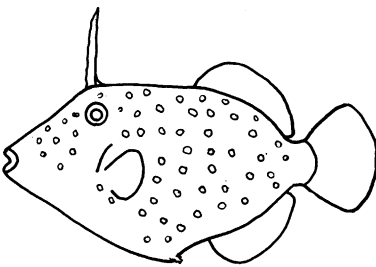
PARAMONACANTHUS GARRETTI



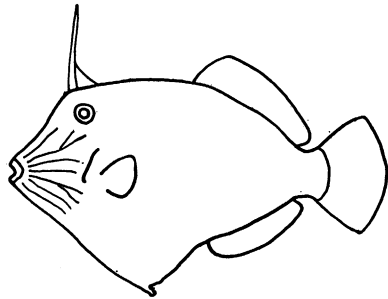
CANTHERINES SANDWICHIENSIS



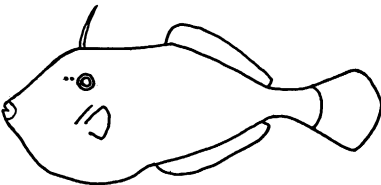
MONACANTHUS SPILOSOMA



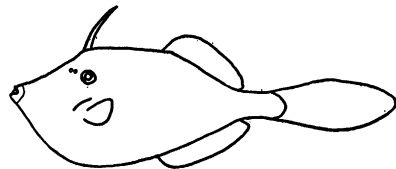
CANTHERINES HOWENSIS



CANTHERINES PARDALIS

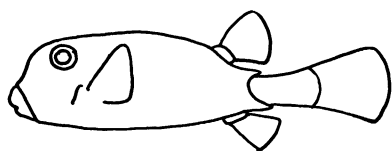


ALUTERA MONOCEROS

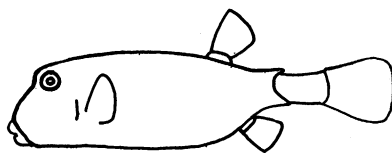


ALUTERA SCRIPTA

FIG. 4. Species of the family Monacanthidae.



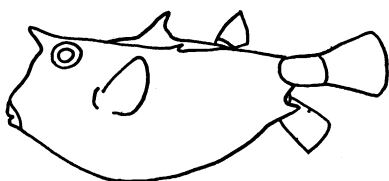
OSTRACION LENTIGINOSUS



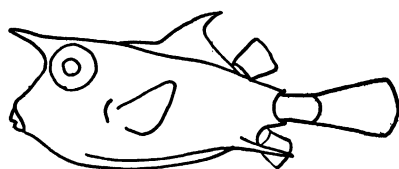
OSTRACION CUBICUS



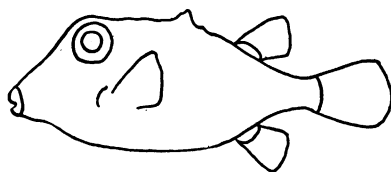
LACTORIA CORNUTUS



LACTORIA DIAPHANUS

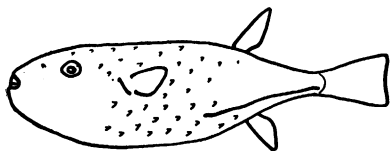


LACTORIA FORNASINI

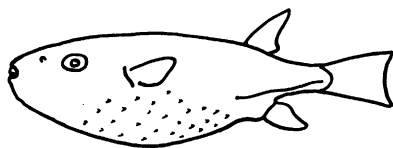


ARACANA ACULEATA

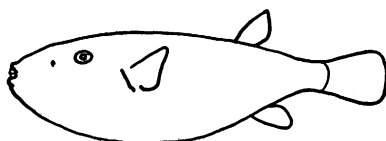
FIG. 5. Species of the family Ostraciidae.



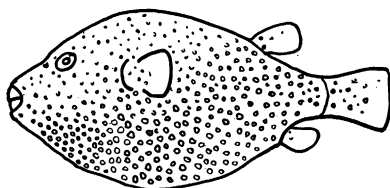
LAGOCEPHALUS HYP SOZENION



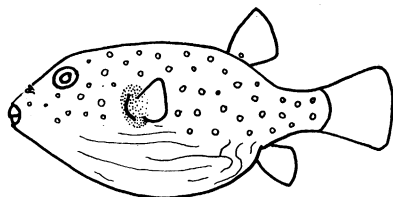
LAGOCEPHALUS LAGOCEPHALUS



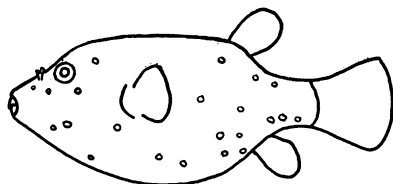
SPHEROIDES CUTANEUS



TETRAODON MELEAGRIS

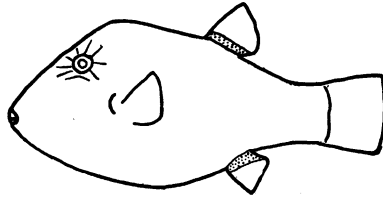


TETRAODON HISPIDUS

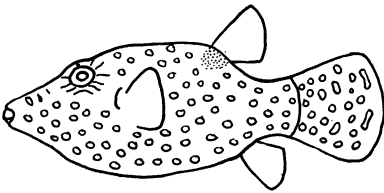


TETRAODON NIGROPUNCTATUS

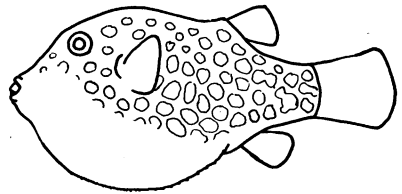
FIG. 6. Species of the family Tetraodontidae.



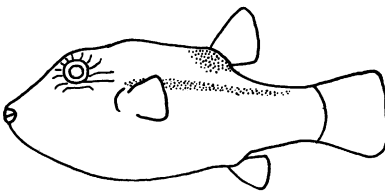
CANTHIGASTER AMBOINENSIS



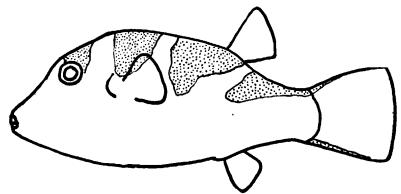
CANTHIGASTER MARGARITATUS



CANTHIGASTER JACTATOR

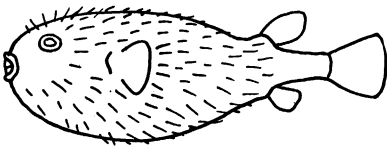


CANTHIGASTER RIVULATUS

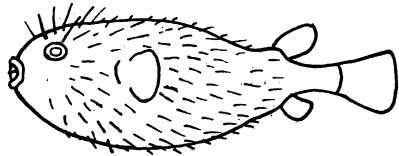


CANTHIGASTER CINCTUS

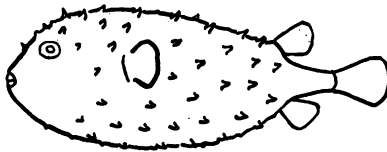
FIG. 7. Species of the family Canthigasteridae.



DIODON HYSTRIX

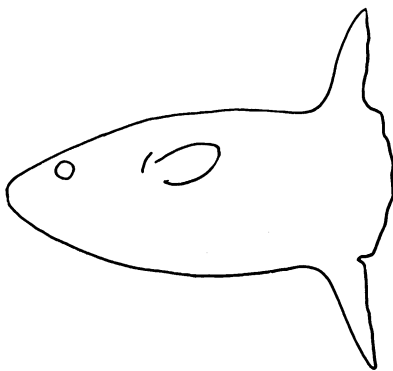


DIODON HOLOCANTHUS

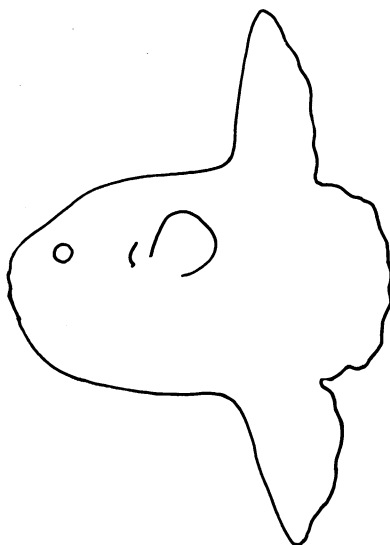


CHILOMYCTERIS AFFINIS

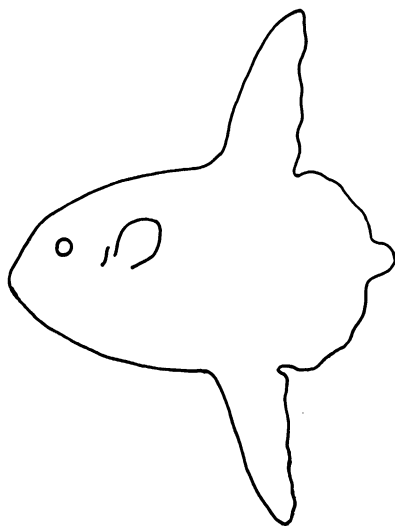
FIG. 8. Species of the family Diodontidae.



RANZANIA TRUNCATA



MOLA MOLA



MOLA LANCEOLATUS

FIG. 9. Species of the family Molidae.