LIFE HISTORIES OF TOADFISHES (BATRACHOIDIDS), COMPARED WITH THOSE OF WEEVERS (TRACHINIDS) AND STARGAZERS (URANOSCOPIDS)

By THEODORE GILL

The toadfishes are prominent objects along the American seaboard and inquiries are frequent as to their habits and value. The inquirer is generally told that little is known about them but there is really a considerable literature respecting one species at least, although so scattered that it is known to extremely few and not even to many good ichthyologists. Data have consequently been brought together in the present communication from many sources. There are also a couple of other families whose habits are little known, but which, for different reasons, are of much interest. One is that of the weevers or Trachinids, famed for the venomous character of liquid secreted in pouches connected with opercular and dorsal spines and therefore comparable with some of the Batrachoidids (*Thalassophryne*). The other is that of the stargazers or Uranoscopids, whose species bear considerable superficial resemblance to the toadfishes of the genus *Thalassophryne* as well as to the weevers. There is doubtless a relationship between the three families and, although distant, closer than has been generally admitted. For this reason the habits of representatives of the two families are given for comparison with those of the toadfishes.

The behavior of a number of individuals of the common toadfish of the eastern American coast has been a favorite subject of observation for several years. The observations were made in the aquariums of the Bureau of Fisheries but in past years opportunities were afforded for earlier ones along the coasts of New York and New Jersey. To such observations have been added the records of those of others.

I. The Toadfishes or Batrachoidids

The *Batrachoidids,* or *toadfishes,* are a small family of remarkable fishes not very much like any others, and well defined. They have an oblong form, a broad flattish head, restricted lateral gill-openings, two dorsal fins, the anterior very small and with only two or three spines, the second very long, the anal moderately long, the pectorals broad, and the ventrals jugular and imperfect (1, 2 or 3-rayed). The most distinctive characteristics, however, are hidden by the skin and muscles and relate especially to the structure of the vertebræ, skull, shoulder girdle, and bones at the bases of the pectoral fins. The most striking character is the development of five well developed and elongated actinosts instead of four as in the great majority of fishes; the peculiar forms of these are well shown in the accompanying drawing by Mr. and Mrs. E. C. Starks. The

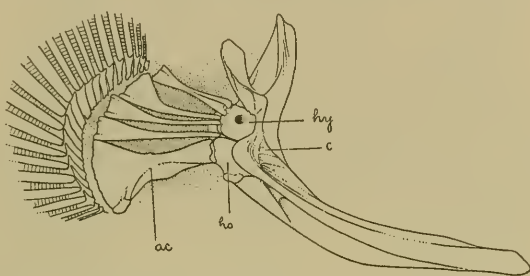

FIG. 103.—Toadfish's shoulder girdle. *ac,* Actinost 5; *c,* cœnosteon or principal bone; *ho,* hypocoracoid; *hy,* hypercoracoid. Original by Starks.

skull is flat and divided into two parts, a narrow anterior fronto-rostral and an abruptly widened parieto-occipital. The want of a suborbital chain of bones is a marked characteristic.

The species are not numerous—about twenty—but the differences among them are such as to have led ichthyologists to distinguish as many as seven genera. One of these is *Opsanus* represented by a common species along the Atlantic seaboard of the United States, and another *Porichthys,* typified by one along the Pacific coast.

The common name toadfish by which the Batrachoidids are almost universally known in the United States is elsewhere used in a very different sense, and even in the United States it is locally applied to other fishes. In Florida it is almost as generally used for the Malthids as for the Batrachoidids. Sometimes it is given to the Tetraodontids, more generally known as swell-toads or puffers. Occasionally, too, it is heard in connection with Antennarioid fishes, otherwise known as the frog-fishes. With a qualifying prefix it is also used for still other forms. According to Mr. Barton Bean, in parts of Florida poison toad or toadfish is applied to species of *Scorpæna* and electric toad is a name for the Astroscopes; at

FIG. 104.—European toadfish (*Batrachoides didactylus*). Skull from above. After Steindachner.

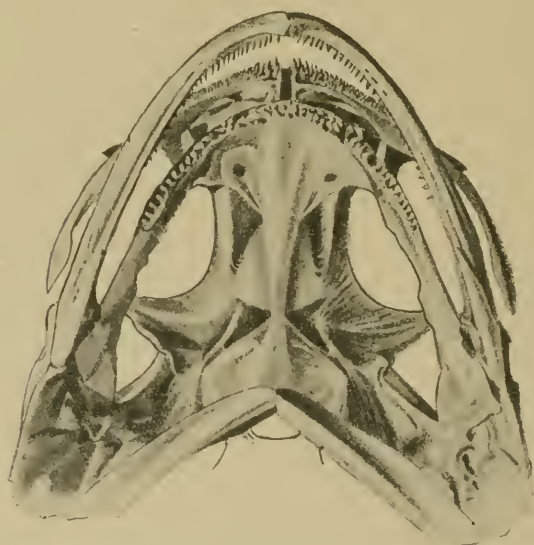

FIG. 105.—European toadfish. Skull from below. After Steindachner.

Beaufort, N. C., species of *Prionotus* are designated as flying toads. In England, toadfish is a little used synonym of the angler. In other countries, where the Batrachoidids are unknown, the Tetraodontids are almost universally designated as toadfishes, and the name in Australia and the Cape Colony always suggests those fishes and those only. Sapo is the Spanish equivalent of toad and in partly Spanish-speaking countries, as Florida and California, the name is used for the Batrachoidids.

Opsanus

The genus *Opsanus* has a naked and rather loose thick skin and the head more or less beset with skinny tags; the opercle has two

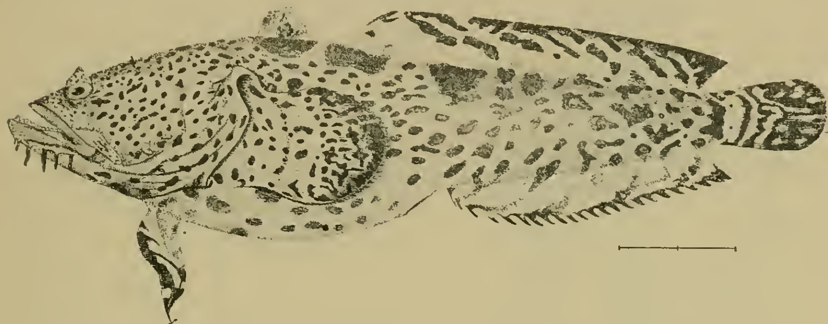

Fig. 106.—Southern toadfish (*Opsanus pardus*). After Goode.

divergent spines, the suboperculum two nearly parallel spines, or rather branches of one spine, of which the lower is much shorter, and the spinous dorsal has three short stout spines. The upper surface of the cranium has a median longitudinal ridge, and also a transverse one, together forming a T-shaped figure which is quite prominent in a dried skin, and suggested to Linnæus the singular name (tau, Greek for T) which he gave to the common species.

Like some others, but not all of the family, the toadfishes of the genus *Opsanus* have a pair of pocket-like sacks opening externally, one on each side, by a pore in the axil of the pectoral fin. The function of these sacks is unknown. Sörensen (1884) compared them with similar sacks of catfishes (Silurids), concerning which he remarks that " it would not be unreasonable to suppose that we had to deal with a case of poisonous secretion. But such an explanation cannot be considered acceptable, both because the sack can by no means be said to open close to the spine, and also because the only fishes probably in which an at least analogous condition obtains are *Batrachoidids,* in which the pectoral fin-rays are all soft and entirely incapable of wounding. In *Opsanus tau* there is found at the angle formed by the inner surface of the pectoral fin placed vertically to the body a large round opening (2 mm. in a female measuring 18 centimeters in total length), leading into a cavity on the inner surface of which there are about 15 lengthened tubular glands whose secreting cells are club-shaped, cylindrical, and uncommonly large (0.275 mm. long). The contents are either a fine-grained or a clear yellow substance, strongly refracting the light and resembling oil; it has a central position and is about half as large as the transverse diameter of the cell. The whole glandular mass has a pea-like form and is slightly compressed; its largest diameter (in height) is 8 millimeters."

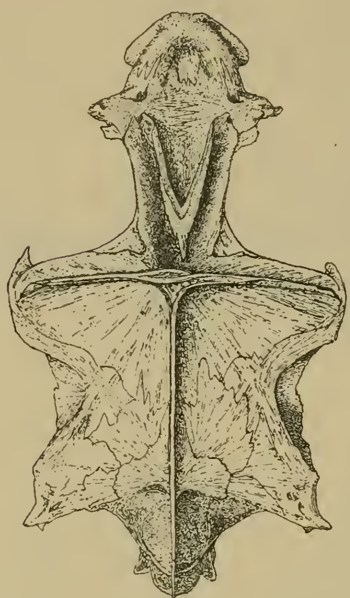

FIG. 107.—Common toadfish's skull from above. Original by Starks.

The toadfishes are emphatically ground fishes and inhabit a long reach of the eastern American coast from the Gulf of Mexico and Cuba to Cape Cod; Jordan and Evermann well express the facts in the statement that the northern form is "very abundant among rocks and weeds close to the shore northward,—in deeper water southward."

According to Goode (1884), "the bottom temperature of the water frequented by these fish would appear to range from 50° F. to 90° F.," the latter extreme, of course, being quite exceptional. "In the more northern regions throughout which they are distributed they appear to become torpid, or nearly so, in winter." They are very hardy and tenacious of life, and will survive, for hours, exposure in the dry air and "soon recover their ordinary activity when restored to the water."

In clear water, where circumstances favor, toadfishes may be seen, prone on the ground, mostly lying down for their full length, but not seldom more or less curved, and somewhat upraised at the head end; generally one is partly hidden by an overlying stone or weeds but, although assimilated to the color and appearance of its environments, a sharp eye can detect it. An early observer (Ayres with Storer in 1853) gave quite a graphic account of observations in Massachusetts of one of several conditions. "Examining the places where the water is but a few inches in depth at low tide, we see that under many of the stones and smaller rocks the sand on one side has been removed, leaving a shallow cavity, perhaps a foot in width, and extending back beneath the stone. If we approach this cautiously, we shall probably distinguish the head of a toadfish very much in the position of that of a dog as he lies looking out of his kennel. The fish is at rest and might be overlooked by a careless observer; a closer attention, however, readily distinguishes the curve of its broad mouth and delicately laciniated tentacles with which its jaws and other parts of its head are ornamented. Its eyes, and sometimes the anterior portion of its body, are truly beautiful. At the slightest alarm it retreats beneath the stone, but presently reappears; it is lying here merely as in a safe resting place, perhaps on the watch for its prey."

When at rest, its attitude is quite characteristic; its head is somewhat tilted, sometimes supported by a stone, a sloping decline of sand or mud, or, it may be, on the body of a companion. The fins, unlike those of most fishes, are often maintained erect, the first as well as second dorsal being completely upraised, while the caudal may be almost folded; the pectorals are near the sides but with the lower edges everted and borne on the ground; a slow movement of inspiration and expiration is kept up, the jaws being very slightly open and moved, and the gill-membranes slightly puffing and collapsing in harmony; otherwise the fish is motionless. Different individuals, however, may assume very diversiform attitudes, and some coil themselves up so that the tail touches the gills or, may be, is tucked under a pectoral fin. Where many are together, they may congregate in a heap in some retired nook. The eyes present rather a remarkable appearance, the pupils changing from greenish to bluish or blackish, according to the incidence of light, and the irises are traversed by St. Andrew's crosses. The element of beauty in such must be a matter of opinion. In contrast with Ayres, Baird thought that "few fishes are more repulsive in appearance" on account of "the laciniated processes or fringes about the jaw, goggle eyes, and slimy body."

The crowding together of many individuals just alluded to is a characteristic habit in aquaria at least. The toadfish is not a schooling or social animal as generally understood but there are very few others who will associate as closely as it does. All the fishes in a toadfish aquarium may occasionally be found massed together in a regular heap, as close together as possible, in some selected corner, some on top of the others. In such positions some may remain quite a long time (perhaps an hour even) and most of them scarcely move; there will be often some restlessness, nevertheless, and from time to time one or more may leave and swim about or possibly seek another corner. Generally, however, there are several

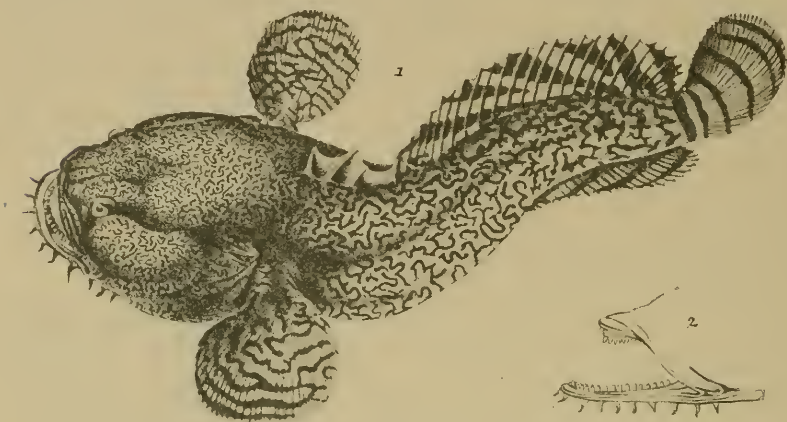

FIG. 108.—Common toadfish in characteristic posture. After Lesueur.

(one or more) moving about in another corner. When compelled at length to move away from its resting place a fish will progress with a wriggling movement, well represented in the accompanying figure,[1] and the soft dorsal fin especially is subjected to a rather rapid and regular undulatory action, reminding one of a screw propeller. If roused by a stick to action, the disturbed fish's first impulse is to snap at the offending instrument, and perhaps one in its anger may swallow a lot of pebbles, to disgorge when at rest again.

Most toadfishes are voracious and "almost omnivorous." The assumption of Günther ("all of the Batrachoids with obtuse teeth in the palate and in the lower jaw feed on mollusca and crustaceans") is only half true. Besides crustaceans, mollusks and worms, it preys on such small fishes as it may be able to catch, "especially upon Anchovies and Sand-Smelt." Verrill (1871) found that the large stomach was "usually distended with a great variety of food," enumerated various species he had identified, and deduced the proposition that "the toadfish is, therefore, a fish that should not be

[1] The figure of the sinuous toadfish is a reproduction of an illustration prepared about 1823 by Lesueur, "the Raffaele of zoological painters," the first ichthyological artist of his time.

encouraged." From Stearn's observations, it appears that "it secures its food rather by strategy and stealth than by swiftness of motion; hiding under or behind stones, rocks or weeds, or, stealing from one cover to another, it watches its victim until the latter is near by, when it darts forth with a quickness quite astonishing, considering its usual sluggishness, and back again to its hiding place, having one or more fish in its stomach and alert for others."

A number of individuals were dissected by E. Linton at Woods Hole (1901) as well as at Beaufort, N. C. (1905), and various shells and crustaceans were the principal contents. The univalve shells were mostly such as had been appropriated by hermit crabs for their own use, and the crustaceans, besides such hermit crabs, were shrimps (*Palæmonetes vulgaris*, etc.) and true crabs of various species; other univalve shells (such as *Ilyanassa*, *Urosalpinx*, *Crepidula*, etc.) and bivalves, especially scallops (*Pecten irradians*), had evidently been swallowed for the mollusks. Remains and fragments of fishes also were found and among them "a partly digested toadfish." A still more decided case of cannibalism fell under Linton's observation, for he had "seen a toadfish in the aquarium in the act of swallowing another of its own species but little smaller than itself." Sea-urchins (*Arbacia*) were also found in several fishes, and in one "no entozoa were found," and it appeared to Linton "that the diet of sea-urchins had in this case acted as an anthelmintic."

The strength of the jaws is wonderful in a fish of its size, although it rarely tries to bite unless provoked to do so. If, however, it is incautiously or roughly handled it will snap "at the finger, even when almost dried up," according to Baird. He aptly adds, "it is capable of inflicting quite a severe bite, and is always handled with a great deal of caution." One who is bitten by a large fish will not soon forget the impression left on him—the writer has had experience and speaks from feeling. There is, however, individual or environmental difference between toadfishes, and even the same fish may manifest difference of moods. Goode's experience was quite different from the present writer's, for he found (1884) that "when touched they show no disposition to bite, but erect their opercular spines in a very threatening manner."

A certain power of utterance is exercised when they are taken from the water for sometimes, when handled, they utter a loud croaking noise. But this power is also manifested in the water of their own volition, and has even obtained a distinctive name for the fish.

Captain Charles B. Hudson recently informed Dr. W. C. Kendall, that "when he was making color drawings of fishes at Key West, Fla., in the spring of 1897, he had for a studio a small hut on a pier some distance from shore. Frequently while at work there, under and near the pier, he heard a sound having somewhat of a musical quality, presumably produced by some fish, the identity of which for a long time he could not make out. The nearest verbal approach to the sound was 'kūng-kūng,' or 'koong-koong,' about the same pitch and time being given to both parts of the word or sound. Fisherman said it was a fish which from its voice they called 'Kung-Kung,' but no one had ever seen the fish to recognize it. Later Mr. Hudson caught a toadfish (*Opsanus pardus*) and placed it in a bucket or pan of water on the floor of the building where he was at work and ere long heard the sound, this time within the hut. He thus ascertained that it was the toadfish that was the mysterious songster. How the sound was produced he did not learn."

FIG. 109.—Common toadfish's air bladder. *a*, Anterior lobes of air bladder; *mso*, musculus sonans. After Sörensen.

W. Sörensen, in a work on the sound producing organs of fishes (Om Lydorganer hos Fiske, 1884), declared that the sounds emitted by the toadfish are produced by the air-bladder and the contraction and relaxation of the muscles of the bladder. The viscus has a characteristic form; it is rather small—about a ninth of the length of the fish—and nearly double, being so deeply divided that it appears as if paired for the greater part of its length and is only continuous behind; it is described by Sörensen as follows:[1] Above, the division extends backward half as far again as on the underside. The inner surface of the air-bladder presents no projecting membranous partitions or the like. The outer membrane is strong, tough, fibrous and rigid; the inner somewhat thicker than usual. On the sides of the air-bladder are found a couple of large muscular bands, especially thick behind, which cover more than half the surface of the organ. On the underside they do not extend as far toward the middle as on the upper surface, where they meet behind. The muscular fibers run transversely but at the same time somewhat obliquely backwards (on the ventral side beginning at the middle, on the upper side toward the middle); towards the hinder end of the organ the fibers gradually run evenly transversely. The pleura is strong, but rather thin; it is, however, thicker behind on the backside, where the muscle bands meet.

[1] Translated from the Danish.

On the approach of cold weather the toadfishes retreat from the shallow to deeper water and, according to Ayres (1842), "bury themselves in the mud and remain torpid, and are very frequently brought up with the spear while striking in the mud for eels." One was carried to Ayres "which had been taken in this manner, October 27, 1840; it was torpid and lived nearly twenty-four hours without water."

Having received protection during the winter, in its muddy retreat or water of considerable depth, from the conditions superinduced by the cold of the northern states, in the summer toadfishes closely approach the shore; this movement is to a large extent at least induced by the procreative instinct. In the southern states, the approach to shore and the reproductive season commence earlier—in the Gulf of Mexico "in April or May." The females and males seek suitable places for the deposit of the eggs and the duties of reproduction are duly assumed by the respective sexes. The eggs are large—very large as fish eggs go and almost as big as a wolf-fish's; they have diameters of "from 5 to 5½ millimeters," en-

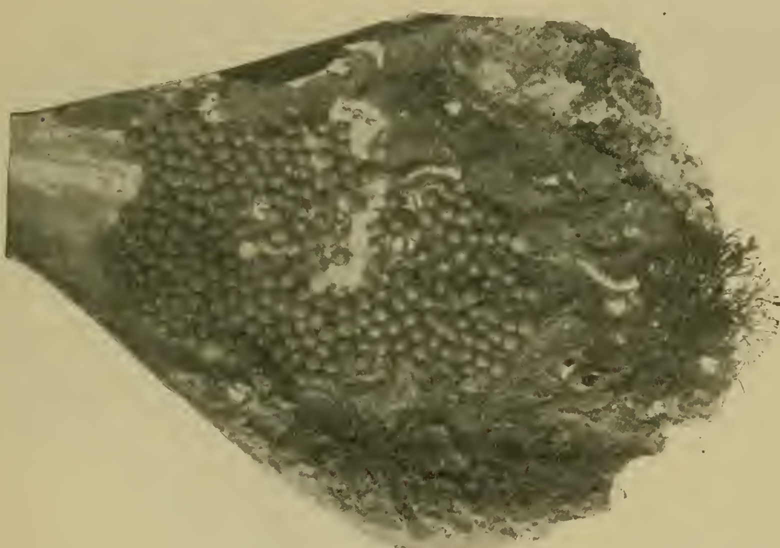

FIG. 110.—Common toadfish eggs on Pinna shell. After photograph by E. W. Gudger.

larged by the extent of the yolk, devoid of oil-globules, and "dirty yellow, almost amber-colored." They are fastened "to the surfaces of submerged objects" of stone, wood, or what not, and "a discoidal area" or disk, "about 3 millimeters in diameter at the upper surface of each egg, glues the latter firmly to the supporting surface." Preference is manifested for the undersides of boulders," when such are present, and under them "the parent fish seem to clear away the mud and thus form a retreat in which they may spawn." (Where stones are absent the insides of oyster or other bivalve shells are selected.) The eggs may be "attached to the roof of the little retreat prepared by the adults, where the eggs are found spread over an area about as large as one's hand in a single layer, hardly in contact with each other, and to the number of about 200."

Fertilization of the eggs "probably occurs at the time of their extrusion by the female," after which she retires, manifesting no further interest in the deposit. "The male at once assumes the care of the brood and seems to remain in the vicinity until the young fish are hatched and set free."

According to Ryder,[1] "remarkable is the fact that as development proceeds the young adherent embryos are found to have their heads directed towards the opening of their retreat and their tails

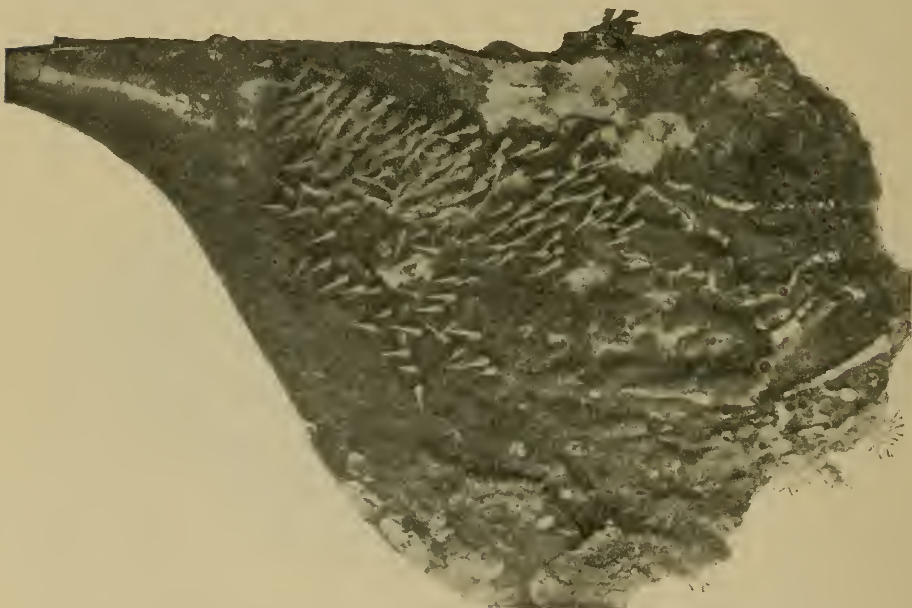

FIG. 111.—Common toadfish's newly hatched larvæ on Pinna shell. After photograph by E. W. Gudger.

towards its blind and dark extremity. This appears to be invariably the case, and it would seem that the direction from which light

[1] Bull. U. S. Fish Com., VI, 1886, 77–80; Am. Nat., XX, 77–80.

comes, in this instance, at least, has a great deal to do in determining the direction of the axis of the body of the future embryo. This position of the young fishes is maintained as long as they are attached."

Miss Wallace found (1898) that "not until the fourth or fifth day after fertilization does a distinct axial thickening appear."

The period of incubation was supposed by Ryder to be about 15 to 20 days, but by him "the exact duration of its development was not determined." "While the embryos are still adherent, the tail is not kept constantly vibrating, but the pectoral fins are kept in motion so as to keep up currents of water and effect the constant change of the latter, needful for the respiration of the embryos." Meanwhile the fins gradually approximate to the adult form, the body grows and the yolk becomes absorbed, and when finally free an unmistakable toadfish has been developed. By the time it has reached a third of an inch (8 mm.) in length, it has assumed the form of maturity and the fins are fairly developed although the heterocercal tail and embryonic fin folds connected with it are still retained; according to A. Agassiz (1882), who has described such a stage, "the whole fish was dotted with small pigment spots, with a few larger cells scattered irregularly over the surface; the pectorals were similarly colored. The general tint of body and fin was gray, with blackish and yellowish pigment cells."

The transition from egg to fish takes a rather long time compared with most fishes. Ryder judged that the fixed condition of the egg and embryo lasts for at least three or four weeks but "the egg membrane is ruptured in about half that time."

The subsequent development also presents some exceptional features. "The development, as it advances, enables the young embryo within the egg membrane to finally rupture the latter immediately over the back, which looks down and away from the surface to which the egg is attached. When the zona or egg-membrane is ruptured, the young fish is, however, not set free at once, as in the case of other adhesive ova, but remains firmly glued to the inside of the zona over a part of the ventral surface of the yolk-bag."

The care of the father, it has been claimed, does not cease with the liberation of the young from the eggs. According to Stearns, "when its young have been hatched, the older fish seem to guard them and teach them the devices of securing food in much the same

[1] Ryder's generalization appears to be rather more categorical than the facts warrant. At least a photograph taken from life by Dr. E. W. Gudger shows several deviations of larvæ from a uniform trend of direction.

manner that a hen does her chickens." He had "spent hours in watching their movements at this time, and was at first much surprised by the sagacity and patience displayed by the parent fish." If piscine intruders appear, he darts at them and drives them away; if a finger is pointed at him, he will snap at it and perhaps hold it for some seconds—if allowed! If driven or taken from his nest, he will return to it as soon as possible.

When released from paternal care the young toadfishes are prone to seek shelter in oyster shells and are not infrequently found between the valves of living oysters. One, 2½ inches long, found in a living oyster, was described by Lesueur (1823).

The subsequent history of a toadfish has not been made known, nor do the specimens in the United States National Museum furnish the necessary data for exact computation.

Goode, at Noank, Connecticut, had an opportunity of watching the progress of the spawning season. July 14, numerous eggs were found clinging to the stones in water one to two feet in depth; later in the season, July 21, young fishes half an inch long were plenty, and September 1, these had attained an average length of one inch. Individuals of the second year's growth were also common and would average perhaps three or four inches.[1] It is probable that maturity is reached in the third or fourth year.

The toadfishes, uncanny and repulsive in appearance as they are generally regarded, are usually rejected by most fishermen and never admitted to the tables of the well-to-do, if by any persons. Nevertheless, they may help to furnish a satisfactory and savory meal. We learn from Stearns that "its flesh is highly esteemed by many of the Gulf fishermen"; these, it may be urged, are mostly ignorant blacks. By eminent men, and good judges, however, the opinion of the Gulf fishermen has been endorsed. Storer testified that "its flesh is delicate and good" and Baird that it is "very sweet and palatable." The present writer tried one many years ago and was favorably impressed by it.[3]

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[1] In Goode's article it is stated that "individuals of the second years growth . . . would average three-fourths of an inch in length," a statement contradicted by the context and probably a lapsus calami for three or four inches.

[2] In many parts of Florida the fishermen are whites, especially at Key West, and some of them are quite well informed.

[3] According to Cantor the "*Batrachus grunniens*" of Indian waters is considered by the natives of the Malaccan coast to be poisonous. Pellegrin enumerates it as one of "*Poissons vénéneux*" (1899, p. 95), but adds that no confirmatory experiments have been signalized.

Goode (1885) forecast for the toadfish an acceptability which it did not enjoy in his time; it may, he foretold, "be regarded as constituting one of the undeveloped resources of our waters, and it can scarcely be questioned that in future years it will be considered as much more important than at present."

Porichthys

The genus *Porichthys* has a naked skin with several longitudinal rows of pores and shining spots, head smaller and less broad than in *Opsanus,* and with various rows of pores, the opercle chiefly developed as a single spine, the subopercle spineless and little

Fig. 112.—*Porichthys porosissimus.* After Jordan and Evermann.

developed, and the spinous dorsal reduced to two spines. The air-bladder has more attenuated anterior pointed divisions than that of *Opsanus.*

This is a genus remarkable for the silvery spots which remind one of the photophores of Scopelids and other deep sea fishes, though they are entirely dissimilar otherwise. The three species are confined to the American waters.

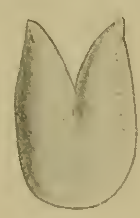

Fig. 113.—Porichthys air bladder. After Kner.

One of the species is common along the Californian coast; it is the *Porichthys notatus,* which attains a length of about fifteen inches. Its popular names are singing-fish, canary-bird-fish, midshipman, cabezon and sapo. "It makes a peculiar humming noise with its air-bladder, hence the name singing-fish," say Jordan and Evermann. It has been asserted by C. F. Holder to make "the loudest noise" he ever "heard made by a fish." One scarcely "a foot long," which he "kept in a tank," would utter "a loud resonant croak or bark under water which could be heard with startling distinctness fifty feet away."

A couple of other genera are noteworthy, one as the name-giving genus of the family and the other on account of the venomous exudations its species emit.

BATRACHOIDES

The genus *Batrachoides,* the name-giver of the family, is separated from the others by the scaly body and none of its species ascend to such high latitudes as some of *Opsanus* and *Porichthys.* The typical species, *B. didactylus,* is an inhabitant of the Mediterranean sea and the nearby Atlantic coasts, although occasionally wanderers have

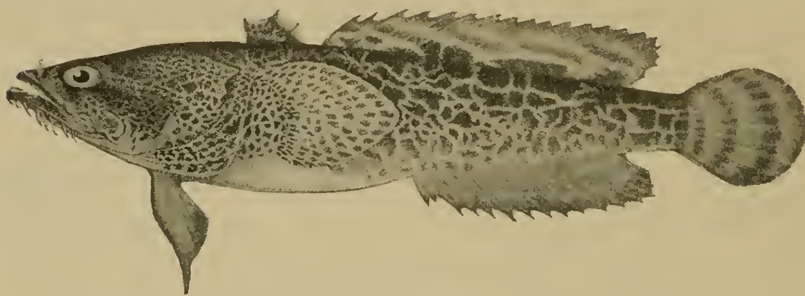

FIG. 114.—European toadfish (*Batrachoides didactylus*). After Smitt.

been found far away. Two species live along the American coasts; one (*B. surinamensis*) occurs in the Caribbean Sea and another (*B. pacifici*) along the coast of Panama and in neighboring waters. Other species are found in the tropical waters of the old world. Little is known of the habits of any of them. Even for the European form Smitt was forced to supply information respecting the genus from data gathered about the common American toadfish rather than from European sources.

THALASSOPHRYNE

The genus *Thalassophryne* has a scaleless skin with only a single lateral line, head moderate and cuboidal, opercles very small and extended backwards into single strong hollowed spines, subopercles spineless, and the first dorsal with two hollowed spines. The hollowed opercular and dorsal spines are connected with special glands at their bases. The species of *Thalassophryne* have a distinctly developed poison apparatus, to some extent analogous to that of the weevers, first elucidated by A. Günther (1864). As just noted, there are hollowed spines to the opercle as well as to the dorsal fin. "The operculum is very narrow, vertically styliform, and very mobile; it is armed behind with a spine" which reminds one of "the venom-fang of a snake," but is "less curved"; "it has a longish slit at the outer side of its extremity, which leads into a canal perfectly closed and running along the whole length of its interior"; "a bristle introduced into the canal reappears through another opening at the base of the spine, entering into a sac situated in the opercle and along the basal half of the spine." This spine is filled with "a fluid which becomes of a whitish substance of the consistency of thick cream" in specimens

FIG. 115.—*Thalassophryne maculosa.* After Günther.

preserved in alcohol; from the sac "on the slightest pressure," the fluid "freely flows from the opening in the extremity of the spine." The spines of the dorsal, two in number, are also perforate, are slit in front of the tip, and "each has a separate sac" at the base with contents like the opercular sacs. "Thus," according to Günther, "we have four poison-spines, each with a sac at its base, the walls of which are thin, composed of a fibrous membrane, the interior of which is coated over with mucosa."

The natural inference that this apparatus is of a poisonous nature is justified by what is known of the fish. The slightest pressure on the base of a spine causes the poison to jet a foot or more from the spine. According to John M. Dow (1865), "the natives of Panama seemed quite familiar with the existence of the spines and of the emission from them of a poison"; this, "when introduced into a wound, caused fever, an effect somewhat similar to that produced by the sting of a scorpion, but in no case was a wound caused by one known to result seriously."

Three well-marked species have been attributed to the genus; one (*T. maculosa*) inhabits the Caribbean Sea about Puerto Cabello, a second (*T. reticulata*) the Pacific coast of Panama, and a third (*T. dowi*), distinguished by its elongate form, is a compatriot of the second.

Other Genera

Other genera of Batrachoidids are *Halophryne* or *Marcgravia* and *Thallassothia.*

II. The Stargazers.

The *Uranoscopids* or *Stargazers* are a very natural and well defined family readily distinguishable by their form and physiognomy. The general form is oblong and the head more or less cuboidal, with the eyes on the upper surface looking directly upwards; the mouth is almost or quite vertical, the snout being short and the suspensorium for the lower jaw pushing forward; the branchial apertures are very large, procurrent below in front of the pubic bones and covered in front by a fold of skin, continued from the branchiostegal membrane; the dorsal furniture is mostly developed as two fins, a short spinous one and a long soft one, but in a few the spinous fin is obsolete or united with the soft and consequently there is only a single fin; the anal fin is oblong and spineless; the pectoral fins have very wide bases procurrent forwards, and the ventral are close together, inserted far forwards under the throat, and have the normal acanthopterygian structure (1 + 5).

Coincident with these are many other characteristics, superficial as well as anatomical. Granular ossification is variously developed on the roof as well as sides of the head, and a membranous subopercular border is more or less developed and may extend forwards and connect with the fold covering the branchiostegal membrane. The lips are deeply slashed or fringed and the opercular membrane is also sometimes fringed.

The species are inhabitants of warm or temperate waters, some two dozen being known, representing eight or nine genera. Most of the genera are notably distinct and some of the kinds of variation may be realized by comparison of the main characteristics of the European and American species, the former being typical of the genus *Uranoscopus* and the latter constituting the genera *Astroscopus, Kathetostoma* and *Execestides.* It is only some of the most salient characters that are utilized for the distinction of the genera, for there are many more that differentiate them from each other and from other genera.

I

The Uranoscopes (*Uranoscopus*) have the opercles free all around, the branchial apertures extending upwards and forwards in front of the suprascapular region; the skull is completely ossified above; the preopercles are armed with acute spines directed downwards, each having four or five, and a similar subopercular spine is developed; further, there are two acute spines about each "shoulder" and two pointed forwards from the pelvic bones; the scales are arranged in oblique folds reminding one of those of a

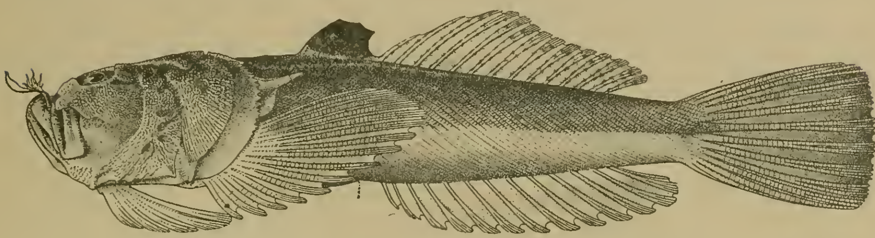

FIG. 116.—European stargazer (*Uranoscopus scaber*). Original by Starks.

Sand-launce (*Ammodytes*) and the spinous dorsal fin has four weak flexible spines; another very striking character is the development of a median protrusile filament or tentacle from the intralabial membrane or "valve."

The common Uranoscope of the Mediterranean was in ancient Greece known as the Agnos, Kallionymos and Ouranoskopos (*Uranoscopus*); the first name was homonoymous with an adjective meaning holy, sacred or chaste; the second (meaning a beautiful or fine name) was perhaps given in an antiphrastic sense to the first; the third (signifying a looker heavenward) was suggested by the position and direction of the eyes. The great physician of old, Galen, alluded to it in connection with a belief held by some among the ancients as well as moderns. "Those who believe that man was made erect so that he could easily look heavenward could never have seen the fish called Uranoscopus which always looks up to heaven in spite of itself." All these names, however, long ago fell out of use and the name now current in Greece is Lichnos (*Lichnus*) or Luchnos (*Lychnus*). The dominant of the many names in use west of Greece are

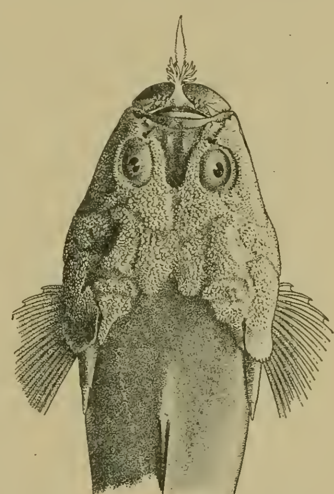

FIG. 117.—European stargazer. Original by Starks.

lucerna in Italy, rat in France, and rata in Spain. There is no English vernacular name for the reason that the species does not occur in English waters; stargazer is a book-name and translation of the scientific one.

The common Uranoscope is best known as a Mediterranean fish and in suitable stations in that sea it is found through its entire extent, in some places very common, in others moderately so, and in others still it is rare. The only considerable data respecting its habits have been published by R. Schmidtlein (1879) and L. Facciola (1883). Free translations are herewith presented of articles by both authors.[1]

According to Schmidtlein, the stargazer spends the greater part of its life in the mud. It is such a poor swimmer that it sinks to the bottom like a stone, as soon as it suspends the tail and fin movement. The quiet floating practiced by most other fishes at all depths is impossible for it; it is bound to the bottom like the poor flyer among the birds, and here it pursues the treacherous chase with which its heavy physiognomy so well harmonizes. It betrays, by its form, the peculiar manner of life that it leads. The clumsy body, enlarged and wedge-shaped forwards, and provided with powerfully developed pectoral fins; the broadly arched and upturned mouth; and the small mobile eyes situated in the roof of the frontal region, at once indicate the lurker. And, indeed, the first thing newly caught specimens do in the aquarium is to sink into the sand by means of a few vigorous shoveling movements of the pectorals, until only the mouth and eyes project. No movement is discernible in the fish thus buried, and only a very practiced eye is able to discover it and to notice, on careful observation close by, the gentle movement produced by the gills in breathing. Now and then the eyes are turned by jerks like those of a chameleon and watch out cautiously and attentively. We will disturb one! It starts up and swims awkwardly up and down with sidewise pendular beats, meanwhile incessantly thrusting a long vermiform tongue-like filament out of the mouth and drawing it in again. This filament is a structure with a broad basis between the inner angles of the lower jaw, and in an adult is about two to two and one-half centimeters long, and very similar to a thin slimy worm.

On closer examination we find that this filament is a band-like prolongation of the mucous membrane of the mouth, which appears

[1] An accurate figure of *Uranoscopus scaber* was not found in any European work and consequently the accompanying illustrations of the entire fish and its head were made by Mr. E. C. Starks. The intralabial filament is represented more branched than usually manifest in nature.

with an enlarged basis at the inner angles of the lower jaw and tapers gradually toward the free end. The lateral borders have the form of a lobed frill from the basis as far as two-thirds of the length, the lobes decreasing in size toward the point. The whole structure contains throughout an uncommonly rich vascular network which plays a part in the swelling, thrusting out and playing of the filament, as may be specially noted in larger individuals: when active the appendage is almost cylindrical and reddish; while that prepared from a dead fish appears flabby and flattened in a band-like manner. In its broader posterior portion it contains mostly some brown branching pigment spots, while the middle portion and also the largest hinder lobes of the frill are of a dark brown color. The exhaled breath is used in thrusting out the tongue.

In the swimming fish the little appendage plays on the forehead backward between the eyes on account of the pressure of the water, and moves with great rapidity. In a second the act of thrusting out and drawing in is accomplished. After a little the animal again sinks to the bottom, at once buries itself, thrusts out its filament a few times more, and then it lies, motionless as a block, in the sand. Here, however, the playing of the filament appears entirely different. Schmidtlein succeeded several times in watching an individual while it was performing this peculiar manœuver so familiar to fishermen. The ugly lurker lay perfectly concealed in his bed of sand, only the crown of the clumsy head with the eyes and the mouth-cleft being uncovered, and it bore a striking resemblance to a brownish gray stone in its immobility. Slowly the treacherous little filament, so deceptively similar to a mud-inhabiting annelid in shape, size, color and movement, projected out of the mouth. It bent, wound and waved, stretched and contracted, now crawling along the bottom, now playing upward vertically, in short, imitating so perfectly a harmless little worm that not a moment's doubt could be entertained of its significance as a bait for inexperienced young fry, and the assurance of fishermen was not needed that this angling method of the stargazer was an indisputable fact. And the deception is no doubt easier in the ever dusky, soft light in the shallow-seas which the Uranoscope inhabits, than in the light aquarium where it may have difficulty in procuring its food. Schmidtlein saw the fish in the latter place frequently start up from the sand and snatch up a goby or a blenny on a free hunt. But even its own species is not safe from its voracity; in the stomach of one specimen were found four young ones of the same species, each an inch long!

Some quite active and free swimming fishes fall prey to a Uranoscope's voracity. An individual of an Indian species (*Uranoscopus crassiceps*), occurring in deep water (at a depth of about a hundred fathoms), was found by Alcock (1890) with "seven entire individuals of *Scopelus pterotus* besides much debris" in its stomach. This observation is of exceptional interest for two reasons at least. The Uranoscopid is a bottom fish, dependent for its food upon the approach of a victim near enough to be pounced upon, and the Scopelids (Myctophids) devoured must consequently have approached sufficiently close to be so taken, thus indicating that the captured fishes probably had a diurnal range from near the surface to the bottom of the ocean within at least the hundred fathom line.[1] The phosphorescent emanations of the victim fishes were doubtless in this case detrimental to the interests of the fishes for they revealed their approach and facilitated their capture.

When warm weather becomes settled, the stargazers commence to perform their reproductive duties and from early May to late September eggs in various stages of development may be found floating in the water. The eggs have been described by Wenckebach (1886) and Raffaele (1888) and their descriptions and figures give many data respecting their early development. The eggs must be discharged and fertilized during early night ("nelle prime ore della notte," Raffaele says) because those collected in the morning (about seven or eight o'clock) are already quite well advanced in development.

The eggs of a Uranoscope, Raffaele considered, are among the most interesting and characteristic of floating eggs and among the very best for microtomic sections. They are rather large as fish eggs go (1.65 to 2 millimeters in diameter) and distinguishable at first sight by their opacity and whiteness. The opacity depends on the structure of the capsule which is completely covered on the external surface by a regular network of hexagonal meshes; the mesh-like appearance results from transparent elements ("listrelle") perpendicular to the surface of the capsule. The vitellus is homogeneous and in the first stage of development fills the cavity of the capsule; there are no oil-globules. The embryo rapidly progresses in development and while still in the egg-case reaches an advanced state, a true vitelline circulation being established before hatching.

[1] As a matter of fact specimens obtained from dredges cast in the Andaman Sea to the depth of "370 to 419 fathoms" were also identified with the "*Scopelus pterotus*," which is a true *Myctophum* (Ill. Zool: Investigator, Fishes, p. 162). This does not prove that the Myctophids were obtained from such a depth, although they may have been.

The larva after hatching is intensely colored and much less transparent than most pelagic larvæ. The larval fish, nevertheless, has a form not very dissimilar to that of the matured stage, or at least it suggestively resembles it. The internal organs, the mouth, the cartilaginous branchial skeleton, and the primitive cranial cartilages, which are mostly developed in extra-ovarian life, are all manifest in the egg stage.

No data are at hand respecting the postlarval and later development and growth of the fish.

In the countries round the Mediterranean, like almost all other fishes, the stargazer is utilized. Considerable numbers are sold in the French markets of Nice, Toulon, Marseilles, and Cette, often intermingled with other inferior fishes. Their flesh is white but more or less unsavory. According to Risso, the quality depends on the places where the fish live, those frequenting rocky places being the best, and not being as tough (coriaces) as others. They are principally used for making an inferior chowder.

II

The Astroscopes (*Astroscopus*) have the opercles tied by membrane to the shoulders so that the branchial apertures cease a short distance above the level of the pectoral axillæ; the head has a pair

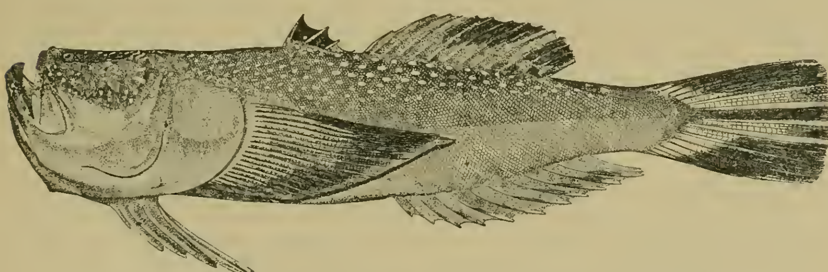

FIG. 118.—*Astroscopus y-græcum.* After Jordan and Evermann.

of naked areas above; the preopercles and subopercles are spineless, and so are the shoulder girdle and pubic bones, thus contrasting pointedly with the corresponding parts of the Uranoscopes, but in compensation the dorsal spines are very robust and pointed. The anterior nostrils are subtubular with fimbriated edges; the posterior have raised fringes continued backwards in curves parallel with the upper margins of the eyes. There is no intralabial tentacle. The differences between the Astroscopes and typical Uranoscopes are, indeed, so many and so great that surprise must be entertained at the disposition of European ichthyologists to ignore the genus. The habits must be a reflex of the differences of structure.

As the Astroscopes lack the peculiar linguiform extension of the mandibular valve and as the branchial apertures are roofed over by membrane, some of the most characteristic movements of the European stargazers cannot be exercised by the American. Little, however, is known of the habits of any Astroscope. Dr. Hugh M. Smith has made some observations of the common eastern coast species which he has kindly communicated for the present article.

"The stargazer has frequently been kept in the aquarium of the Bureau of Fisheries in Washington. The specimens have come from the lower Chesapeake in September, and have usually remained alive and in good condition until the following spring. The attendants report that the fish can invariably be found in fall at Old Point Comfort and Willoughby Spit, buried in the sand along the line of surf. The species is known to the fishermen of that region as 'sand toad.'[1] The collector for the aquarium states that on several occasions, while wading in the surf with a scoop-net in hand, he has come upon stargazers which in their fright leaped out on the beach instead of into the deeper water. The species is tender and difficult to transport, but is fairly hardy in the aquarium. The normal attitude assumed by the fish in the aquarium is complete self-burial in the sand with the exception of the minute eyes, which are so inconspicuous as to be easily overlooked, so that a tank may contain half a dozen full grown stargazers without a casual observer being aware of the fact.

"The fish prefers live minnows as food, and catches them with great dexterity. When a minnow comes within range, the *Astroscopus* emerges from the sand like a flash, seizes and swallows its prey, settles back in the sand, and conceals itself by a wriggling motion of its body and a fanning of its pectoral fins, the entire act occupying but a few seconds. The elevation of its body resembles the action of a flounder in seizing food, and the tail may remain on the bottom. Dead fish and chopped meat are eaten in the absence of live food. I have made no observations on the electric organ in this species, and the aquarium attendants are not aware of its existence. The fishermen of Beaufort, however, have learned of its presence and call the fish electric toad."

The reference to the "electric organ" of the Astroscope was evoked by the observations of Dr. J. A. Henshall and Professor C.

[1] In parts of North Carolina the Astroscope is called electric toad, according to Mr. Barton Bean as well as Dr. Smith.

H. Gilbert. The naked lateral areas on the upper surface of the head in the midst of the exposed granuliferous bones have been asserted to be the seats of a certain electric manifestation. According to Henshall, it was exhibited by the Florida fish (*A. y-græcum*), and Gilbert (1896), in a note on the Mexican Pacific coast species (*A. zephyreus*), remarked that "a distinct electric shock was given by this fish when alive, the electric organs being in the fleshy areas on top of head behind eyes." Such a manifestation certainly deserves more attention that it has received.[1]

Nothing is known of the embryology and development of any Astroscope. One notable fact in their growth, however, is that the naked areas on the crown and the scales become manifest rather late, for specimens over two inches long are naked (*i. e.,* scaleless) and the naked coronal areas do not stand out in strong relief. On a young specimen the *Uranoscopus anoplus* was based, as well as the genus *Astroscopus*.

Two well-defined species of the genus *Astroscopus* occur along the eastern coast of the United States and may be distinguished as follows:

Astroscopus y-græcum.

Naked postocular areas much longer than wide; preorbital spines reduced to two knobs in the adults; color yellowish brown with oblong spots between larger interspaces; small dots on postocular areas; long spots on back and sides of head, and dots on cheeks; spots, larger and less crowded than those of *A. guttatus,* on back and sides and extending to near the caudal fin; hindmost edge of dorsal fin white.

Astroscopus guttatus.

Naked postocular spaces not longer than wide; two distinctly defined spines on front of preorbital; color dark and reddish brown, with numerous small spots on naked postorbital areas and on sides, becoming larger backwards; a lateral dark band on the posterior half of the trunk and on the tail; a cross band on the sides and lower edge of the caudal peduncle; ventrals with interspaces between inner rays, third to fifth, dark, while in *y-græcum* the ventral fins are uniformly whitish.

There is a remarkable difference between the young and old; some up to a length of nearly or quite three inches are scaleless.

[1] Since the above paragraphs were written Dr. Ulric Dahlgren, of Princeton, has visited the coast for the purpose of observing the Astroscope and has verified the electric power of the fish. A preliminary note has been published in *Science* (March 23, 1906, p. 469, 470) and details may be expected later.

In specimens of both *guttatus* and *y-græcum* two and one-fourth to three inches long, the skin is scaleless, and the head above has an osseous casque extending close up to the nostrils and between the eyes. This was supposed to be characteristic of *Astroscopus* and that genus was originally based on such characters. As the fishes increase in size the slight naked space behind the nostrils becomes enlarged and the enlargement continues until the large naked areas characteristic of the adult *Upsilonophorus* are developed. The identity of the two genera was recognized by Gill as early as 1872, but the differences seemed to be so great that some elapsed before the identification was entirely accepted.

III

A third well-marked genus (*Kathetostoma*) is represented by a couple of species in warm American waters.

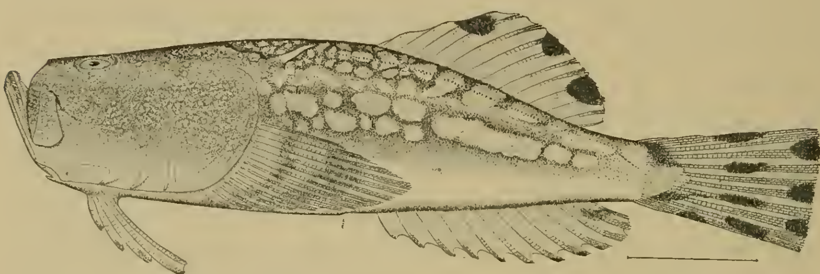

FIG. 119.—*Kathetostoma albigutta.* After Jordan and Evermann.

FIG. 120.—*Kathetostoma albigutta.* After Jordan and Evermann.

The *Cathetostomes* (*Kathetostoma*) have the branchial apertures limited above by membranes partly bridging the interspace between the opercles and shoulders; the skull above is completely ossified, the preopercles are armed with three or four acute plectroid spines directed downwards, as in the Uranoscopes, but there is no subopercular spine; there are a pair of free and acute spines, one to each shoulder, and a pair of acute spines pointed forwards on the pelvic bones; the nostrils are very small, the anterior subtubular, the posterior a pore-like opening; scales are wanting; the soft dorsal fin alone is developed; there is no intralabial filament. Two species of the genus are known as Americans, one (*K. albigutta*) from the Gulf of Mexico, and another (*K. averruncus*) from the

Pacific coast of Columbia. These have been referred to the genus *Kathetostoma,* typified by a New Zealand fish (*K. monopterygium*), but have not been directly compared with the typical species on account of the absence of specimens of the last in the U. S. National Museum, and they may prove to represent another genus.

IV

Another distinct genus—*Execestides*—is represented by a recently described small species—or small specimen—found at Garden Key, one of the Tortugas. It differs from *Kathetostoma* by the peculiar sculpture of the preopercles and their aliform angles, the large opercles, longer anal fin, and general appearance. The only species, *E. egregius,* is only known from small specimens, a little more than two inches (2.3) long, "taken by Doctor Thompson on the reef at Garden Key."

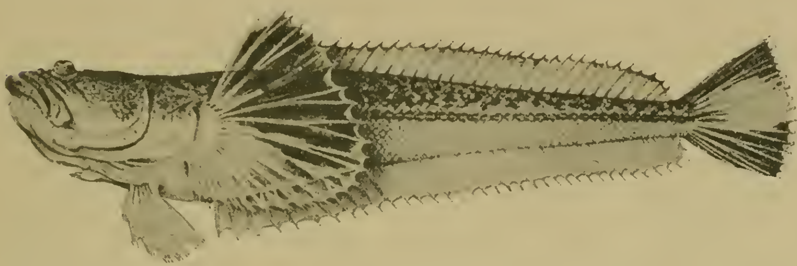

FIG. 121.—*Leptoscopus macropygus,* a distant relation of the Uranoscopids. After Richardson.

Although the Uranoscopids are so strongly marked a family, representatives of several others have assumed a nearly similar form. Besides the Leptoscopids and Dactyloscopids, which appear to be most closely related to them, species of unrelated families manifest some resemblance; such are the Batrachoidoid genus *Thalassophryne,* the Scorpænoid genus *Trachicephalus* (or *Polycaulus*), and the Trichodontoid genera.

III. The Weevers

The Trachinids, or weevers, constitute another compact and strictly limited family readily recognized by their physiognomy. The body is rather elongated and quite regularly tapers from the pectoral region to the tail, the head is rhombiform inclining to cuboidal, is narrower than in the Uranoscopids, and the eyes are mostly lateral, although somewhat directed upwards; the mouth is very oblique; the branchial apertures are continuous below, the branchiostegal membrane being very deeply cleft, only confluent in

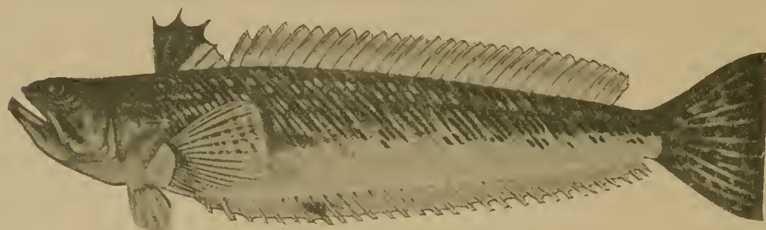

FIG. 122.—Greater weever (*Trachinus draco*). After Smitt.

front of the pelvis, and not bridged over by any fold; each operculum is armed above with a channeled spine directed backwards and connected with a special gland; the dorsal furniture is uniformly constituted by an anterior short fin with six or seven spines (the largest spines being channelled somewhat like the opercular ones), and a very long posterior rayed fin; the anal is also very long and the anus consequently in the breast; the pectoral fins have moderately wide but not procurrent bases, and the ventral are approximated, jugular, and have each a spine and five branched rays.

The range of variation within the family is much less than in the Uranoscopids or Batrachoidoids, the species so closely resembling each other that by all naturalists except one (Bleeker) they have been united in a single genus. Notwithstanding the superficial uniformity, however, some differences are manifest which are rarely developed in genera otherwise closely related; such are the differences in dentition and in the character of the lips. In the great weever (*Trachinus draco*) there are distinct pterygoid teeth, the lips are simple, and the cheeks and opercles scaly, while in the lesser weever (*Echiichthys vipera*) there are no pterygoid teeth, the lips are fimbriated, and the cheeks and opercles naked. Inasmuch as Smitt (1892) denies fimbriated lips ("lips without fringes") to the entire family Trachinidæ, this exception is especially noteworthy.[1]

[1] As the characters here given (and by Bleeker in 1861) are contradictory of statements given in highly esteemed European works, explanation may properly be demanded. According to Day (1880), *Trachinus vipera,* like *T. draco,* had teeth "villiform in jaws, vomer, ; alatines, and peterygoid bones." I have in vain searched the Lesser Weever for pterygoid teeth, as have also Prof. Gilbert and others. According to Smitt, all Trachinids have "lips without fringes" (p. 127), and this statement is uncontradicted in his notice

The family includes six or seven known species which have been generally retained in the single genus *Trachinus* but by others deemed to be referable to two or three genera. The distribution would be remarkable if real! All the described species are confined to the east Atlantic and Mediterranean coasts but one—and that one has been accredited to Chile. The so-called Chilian species (*Trachinus cornutus*), however, has not been found by Chilian ichthyologists and, in the "Catalogo de los Peces de Chile por Fedrico T. Delfin" (1901, p. 82), that as well as *T. draco* (the European greater weever) is retained as a Chilian fish solely on the authority of European authors.

Only two of the Trachinids are found in Northern Europe, the greater weever (*Trachinus draco*) and lesser weever (*Echiichthys vipera*). According to Boeke (1903), "both species are present in considerable abundance. The lesser weever is captured more often on the English coast (in the shrimp nets and sometimes in the trawl)"; the greater weever "especially on the Dutch coast, where they arrive in great numbers in summer to spawn, though here, too, the lesser weever is by no means rare. Both decrease in numbers towards the north." In the Baltic and further north only the greater weever occurs as a regular inhabitant although the lesser weever is admitted by Smith as an occasional or accidental visitor. "On the whole the lesser weever has a more southern distribution and lives in the shallow water near the shore and on sandbanks; the greater weever lives in deeper water."

All the species bear the English name weever, sometimes written weaver; this is by some claimed to be a derivative of the Anglo-Saxon word for a viper or serpent (wivere) and cognate with wivern, the dragon of heraldry, and by others to be a corruption of the French name for the fish (vive) or at least cognate with it. While weever is the best known and book name, however, it is not the only one. According to Day, the greater weever or stingfish is also known as the seacat (in Sussex), catfish, stingbull, and sand-eelbill (Ayrshire), while the little weever or stingfish is distinguished as the adder-pike, otter-pike, bishop, blackfin, and stony cobbler.

The weevers are essentially bottom fishes and affect sandy coasts specifically. According to Smith, "the greater weever lives in

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of the "*Trachinus vipera*" (p. 131); it is contradicted by Day (I, 82) who attributes to the species "a row of small papillæ along the upper edge of the lower lip." Papillæ are developed along the upper as well as the lower lip so large as to be readily discernible by the naked eye (of some persons at least).

water of a moderate depth with a sandy bottom. It buries itself in the sand and keeps in hiding in order more suddenly to attack its prey, which consists of small fishes and crustaceans." The hiding habit, however, appears to be sometimes deviated from; according to Day (1880), "in the Westminster aquarium these fish do not show any propensity to conceal themselves under the sand." Besides, it is not always the dorsal surface that is uppermost. According to A. Briot (1903), one of their favorite attitudes in the aquarium is repose on their sides with the outer opercle upraised and the spine nearly vertical. Perhaps in both cases the sand in the aquariums may have been too compact or otherwise unsuitable. The lesser weever is universally conceded to mostly hide itself in the sand, leaving little more than the eyes and parts on the same level exposed.

As to swimming, according to R. Schmidtlein (1879), weevers do not show much more endurance than their relatives, the star-gazers. Their movements are to be sure more active and, on account of the flexibility of the body, may almost be called winding, yet one falls to the bottom almost as awkwardly as the other, as soon as the muscles are at rest.

Sometimes, Schmidtlein also says, one puffs itself up for a few seconds while buried, opening wide the mouth and gill-covers and bristling the fins as if attacked by convulsive cramps. In many other fishes we frequently see the same kind of action which might by suggestively designated as yawning.

They are quite hardy and tenacious of life, and may easily survive being left during the recession of the tides on or in the sand. "In this situation of concealment," according to Couch, one "may chance to be left by the ebbing tide; but it is highly retentive of life, even when caught with a net or line, and therefore it suffers nothing by being left thus exposed." It may, however, work its way farther into the sand and become entirely concealed; Couch was informed of an instance where a dog, by pawing its way into the sand, showed its sense of some unwonted object that was concealed below, which, when discovered by digging, inflicted a blow on two persons who endeavored to grasp it, to their no little surprise and pain."

The weevers, or at least the greater weever, seem to be most active and prone to excursions in the night time; evidence to that effect was obtained by Jonathan Couch. He had known this fish taken in a floating net over thirty-five fathoms of water, and when several have been thus caught, it has always been in the early morning cast of the nets, as if they thus mounted aloft only in the darkness of the night. A fisherman expressed the belief that he had even seen this fish spring above the surface." It remains to be ascertained whether such excursions are habitual or confined to breeding fishes.

Schmidtlein contrasted the habits of the weever with those of the stargazers. Most closely connected with the latter are the species of Trachinids, both as regards biology and relationship. But the slenderer and more elongated body of the latter, with the abrupt flanks and the crest-like back, indicates more active creatures. Mouth and eyes are directed upwards; but the latter occupy a somewhat lateral position, are extremely mobile, having complete independence of both axes, and show a brilliant blue or bluish-green metallic luster. Schmidtlein had repeatedly noted, among fishes, a vivid curiosity regarding lustrous and strikingly colored objects, and urged, for instance, that the black eyes of the "Langouste" (*Palinurus*) and other craw-fishes frequently expose them to danger. He was led to the opinion that the brilliantly lustrous and mobile eyes of Trachinids may serve to lure fishes. They are at least the most conspicuous part of the little that may be seen of the creature buried after the manner of the stargazer.

In the aquarium, according to Schmidtlein, the weevers are much more active than the stargazers. If fishes are thrown into one's basin, they start up immediately from the bed and snatch them up as they fall. However, an American Uranoscopid (*Astroscopus y-græcum*) may do the same.

The weevers have been regarded as mainly piscivorous, and doubtless accept any small fishes that may come within reach, but later observations show that they feed largely on crustaceans. Couch (1863) actually found in the stomach of one "two gobies and a launce," and in others various small fishes as well as squids and macrurous crustaceans (shrimps, etc.) had been found. But the most satisfactory data were obtained by Dr. T. Wemyss Fulton and published in the "Twentieth Annual Report of the Fishery Board of Scotland" (part III, p. 493, 1902). He examined forty-three specimens of the lesser weever with interesting results. "In the stomachs of those collected in April, 1900, very little food was observed, and only four out of the fourteen examined contained matter that could be identified; this consisted chiefly of the remains of *Praunus inermis* [a kind of prawn], *Gammarus locusta* [sand flea], some remains of annelids and of two or three small fishes (Clupeoids). . . . In the stomachs of ten specimens examined in May the contents consisted chiefly of *Schistomysis* sp. [a schizopod]; an isopod—*Eurydice achata*—was also found in one, and in another the remains of a small Clupeoid. The specimens taken in September and January contained nothing that could be distinguished. The nine specimens from Collieston collected on July 5, 1900, had apparently been feeding largely on Schizopods, all of which appeared to belong to the one species, *Schistomysis spiritus;* the only other food observed consisted of the remains of a small fish, probably a young Clupeoid or sand-eel. . . . A considerable number of these specimens were examined besides the nine specially referred to here, but they all appeared to have been feeding on the same species of Schizopod."

According to Schmidtlein, a weever possesses, in the erectile spines of the dorsal, a weapon not to be despised; these spines are as stiff and pointed as needles, and are bristled up on the least disturbance of the fish. The edge of each opercle is also armed with a similar spine, the punctures of which are generally considered poisonous, wherefore the fishermen handle the otherwise valued fishes with great caution.

The opercular spines are not merely defensive but efficient offensive weapons, for they can be actively struck in some desired direction. Jonathan Couch (1863) aptly remarked that "the precision and skill with which the formidable spine of the" opercle, "is thus directed to an object of fear that shall touch it or approach too closely are indeed surprising, so that by a sudden and rapid impulse it will inflict a wound if even the touch is confined to the tail, and that too, without any injury to itself: and formidable indeed is the effect produced by the puncture."

The extent to which the weevers use their spines against other fishes is unknown. The fishermen of old apparently thought they were very aggressive and impressed the other fishes by the fact, if we may believe Ovid, who sang of the

> "Weevers, whose march the timorous shoals obey,
> Divide their ranks, and humbly give the way."

This, however, is undoubtedly "poetical license." It is, however, certain that wounds inflicted by the opercular spines of weevers upon fishes and batrachians may result in speedy death as was proved by the experiments of L. Gressin (1884) and A. Briot (1903).

There appears to be considerable difference between the effects of wounds made by the dorsal and opercular spines. According to A. Briot (1903) wounds inflicted by the dorsal spines, although very painful for a time on account of the acuteness of the spines, are of a mechanical nature and are not followed by any aggravated symptoms. The same experimentalist found that wounds resulting from punctures with an opercular spine, while equally or more painful, were followed by more serious consequences, such as fever, shivering, and, in extreme cases, œdema and gangrene. Briot was led to such conclusions by experiments made on animals (sticklebacks, toads and rabbits) as well as observation of wounds incurred by fishermen. The record of his investigations may be found in the Comptes rendus hebdomadaires des seances de la Société de Biologie (LV, pp. 623–624).

The experimental observations of Briot are not inconsistent with the histological investigations of L. Gressin and W. N. Parker (1888). Those observers, it is true, found venomiferous glands connected with dorsal spines of weevers as well as with their opercular ones but the former were much less developed and the spines themselves less formidable than the corresponding parts of the opercular apparatus. In the words of Parker, " distinct glands are present in the grooves of the opercular and dorsal spines, and in the former they are very large, extending a considerable distance both above and below the spine, along the greater part of its length. The glands consist of relatively enormous granular nucleated cells, the structure of which is apparently similar in both species " of northern weevers.

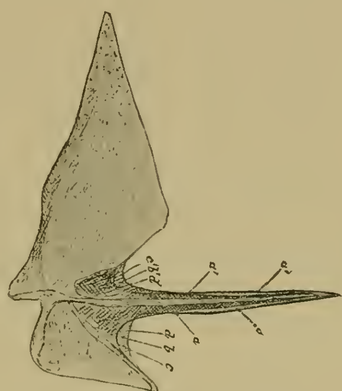

FIG. 123.—Lesser weever's operculum. Right opercular spine with the sheath removed, viewed upon the external surface, and magnified about five times in linear extent. *a*, *a*, *a′*, *a′*, The grooves in the edges of the spines; *b*, *b′*, the conical cavities in which the grooves terminate; *c*, *c′*, the external walls of the cavities; *d*, *d′*, the internal walls. The parieties of the cavities being transparent, *d′* is represented as visible through the external wall. After Allman.

It is remarkable that the poison glands were long denied existence by observers and histologists. For example, Cuvier and Valenciennes (1829) specifically asserted that the spines had none. " :n'ayant aucun canal, ne communiquant avec aucune glande, elles ne peuvent verser dans les plaies un venin proprement dit." G. J. Allman (1841) was also "not able to detect any specific gland connected with" the opercular spines, although he was led "to agree with the ancients in ascribing venomous properties to the weever." The first to demonstrate the existence of poison glands in the weevers was Leon Gressin in association with A. M. Remy (1884). He was followed by W. N. Parker (1888) who expressed, quite properly, "much regret" that he had been "unable to obtain a copy" of Gressin's thesis.

There is essential agreement between the observations and illustrations of Gressin and Parker. In the words of the latter, "distinct glands are present in the grooves of the opercular and dorsal spines, and in the former they are very large, extending a considerable distance both above and below the spine, along the greater part of its length. The glands consist of relatively enormous granular nucleated cells, the structure of which is apparently similar in both species." "No special muscles are present in connection with the glands" and Parker "inclined to think that in the discharge of their secretion the cells simply burst, their contents passing along the grooves amongst the other cells to the exterior."

The males and females have not yet been observed in the act of oviposition and fecundation. "The eggs are laid in the night," and presumably "in the very early hours of the morning, just before or after daybreak," but Brook sought in vain to discover the exact time; he "watched the fish up to 1 A. M., and resumed watch as early as 5 A. M.," but was never "able to catch them in the act of ovipositing." In the early morning, however, eggs may appear on the surface of the water, bouyed up by greenish-yellow globules, and already visibly on the way to development. This oviposition occurs from April to July in northern seas.

The embryology of two species of Trachinids is partially known through the labors of a number of naturalists, beginning with Brook in 1884, and both species were studied by Boeke in 1903, who succeeded in fertilizing the eggs and thus studying perfectly authenticated examples. The eggs of the two are readily distinguishable, those of the larger fish averaging smaller and having normally only a single oil-globule, while the eggs of the smaller fish are mostly larger and have four to twenty-five oil globules.

The eggs of the lesser weever have a diameter varying between 1.04 and 1.27 or even 1.37 of a millimeter in diameter; they are "of a beautiful pearly white, and quite translucent." Each contains a variable number of oil-globules, ranging from four up to as many as thirty, Raffaele finding the smaller number, George Brook the larger (11–30). "These oil-globules," according to Brook "are scattered over the upper hemisphere of the yolk, and lie between it and the vitelline membrane. They vary in size from .12 to .03 millim. The oil-globules cause the egg to float with the germinal disk downwards, so that the embryo is developed on its back, so to speak, and it is not till some time after hatching that the young fish is enabled to swin with the ventral surface downwards."

In a very few hours after extrusion the fertilized eggs show the evidence of segmentation. About 9 o'clock (A. M.) "the first two cells are formed." Development rapidly goes on and sometimes as early as the eighth day after emission, and thence to the eleventh day (the time depends on the temperature), the young are hatched out and begin life as free larvæ.

A "recent hatched larva," according to E. W. Holt, M'Intosh and Masterman, is nearly a seventh of an inch ("3.27 mm.") long and, with its prominent yolk, reminds one of a tadpole. The mouth is "only indicated by a slight depression in the newly hatched embryo."

The eggs of the greater weever have a diameter of from less than a millimeter (0.96) to considerably more (1.11) and only a single large oil-globule; they are "perfectly transparent." At "about 120 hours after fertilization (temperature of the water ranging from 15° to 70° C.) the embryos were hatched" and with a slight increase of temperature the hatching was accelerated to 110 hours.

According to Boeke, "immediately after hatching the buoyancy of the yolk-sac causes the little larvæ to float helplessly in the water, the yolk-sac uppermost, but very soon they are able to keep themselves in the normal position and swim about actively when disturbed. At rest they hang with the front end inclined downwards, as is also the habit in other very young fishes under these conditions. The oil-globule has now taken a position at the foremost part of the yolk-sac. The larvæ are still perfectly transparent, and but for the strongly marked black spots are difficult to see. . . . At about four or five days after hatching the yolk has almost entirely disappeared and the larvæ die." Consequently neither Boeke nor others have succeeded in tracing the early post-larval history of the species.

A kind of homœopathic remedy is resorted to by some to avert the evil effects of wounds inflicted by a weever. "In Bohuslän, says Fries, it is held to be a sovereign remedy to cut open the belly of the fish that has caused the wound, take out the liver and at once make the patient eat it. This remedy, strange as it may appear," adds Smitt, "is never omitted"! An analogous antidote was also found in the fish's brain. In the words of A. Saville Kent (1883) "in ancient days a so-called 'tisane,' thickened with the brains of the offending fish or the body of the fish itself cut open and applied to the wound, were reckoned among the more effective remedies." Even the boys in some parts of the country, however, know better. "At Fredrikshavn, it is a favorite pastime of the boys to fish for weevers in the harbor, and when they go fishing, they take with them a bottle of hartshorn or, still more commonly, of aquafortis, which they apply to the wound immediately, if they are stung by a weever."

Various myths have originated about the weevers and one prevalent for centuries (it is recorded by Willughby) and widespread in the British Islands is that "the pain of its sting will last until the tide has again arrived at the height at which it stood when the wound was inflicted." This opinion, Allman thought it not unnecessary to declare, "is altogether incorrect," although it "is universally believed by the fishermen of the south of Ireland." Allman adds that the weevers and "some other spiny fishes" are "confounded under a common unpronounceable Irish name, which may, I believe, be translated 'sting devil.'"

The weevers are market fishes to a greater or less extent. Smitt records that the flesh of the greater weever "is said to be of excellent flavour," but, nevertheless, on account of its dangerous spines, in Sweden "it is generally thrown away by the fishermen." According to Moreau, in France the flesh of the larger kinds is very highly esteemed. In some countries there are laws prohibiting the marketing of weevers unless their opercula and spinous dorsals are cut off.

APPENDIX

ON CERTAIN HABITS OF THE EUROPEAN STARGAZER

By LUIGI FACCIOLA

Dr. Luigi Facciola, in a long article on some organic characteristics of *Uranoscopus scaber* having relation to its hiding instinct,[1] has given some interesting details of the habits of that species. After a few references to previous observers (Oppian, Rondelet, Martens), the peculiar form of its stomach (subrotund), and contents found in it ("*Atherina hepsetus, Engraulis enchrasicholus,*

[1] Di alcune disposizione organiche dell' *Uranoscopus scaber* in rapporti al suo istinto insidiatore nota dell Dott. Luigi Facciola. Atti Soc. Nat. Modena, Ser. III, Vol. I (anno 16), pp. 17–28, 1883.

Alosa sardina"), reference is made to the spines at the front of the pelvis and the flatness of the belly which are believed to especially fit the fish for penetrating into the sand. The form and sculpture of the head and the color of the eyes are adapted to assimilation to its environments and concealment. The vermiform extension of the intralabial valve serves as a bait. How these structures were used was the subject of speculation. Now Dr. Facciola may speak for himself (pp. 22–28).

At this time I fortunately had a live individual. It stayed at the bottom of the basin, keeping the pectoral and ventral fins spread out, while the others were lowered. The mouth was opened to the extent of scarcely two millimeters, and the opercles were closed. The lower jaw moved very slightly backwards and forwards, the extension not amounting to more than one millimeter. But inside the mouth and within the jaw was seen a more energetic movement, like that of a kind of valve which was raised and lowered; this belonged to the transverse membrane which is attached to the inner border of the lower jaw and gives rise at the middle to a linguiform extension.[1] This participated in the movement and inclined to project out of the mouth. Thus there seemed to me to be no doubt that the sublingual membrane assumed the functions of the lower jaw which moved almost insensibly. I held the lower jaw apart by means of a pair of pincers to see what would happen under the circumstances. Then the sublingual membrane stopped beating and the hyoid was raised and lowered, but so regularly as to suggest that these movements were excited by the exceptional state in which the fish was placed through the forced abduction of the lower jaw. When the fish was free again, and I observed more carefully the movements of the transverse membrane, I became convinced that these movements were passive ones and produced by a quantity of water that comes between the membrane and the underlying hyoid and were impelled by the action of the latter bone. This easily explained the inertness of the membrane when the mouth was held open, the reason being that under the circumstances the hyoid is moved backwards and its upper border no longer corresponds to the lower part of the membrane. It is to be noted that the tongue does not advance much in front of the hyoid and forms with the latter a single border regularly convex and corresponding with the form and disposition of the transverse

[1] This membrane was well described by Rondelet, questioned by Willughby, and again confirmed by Cuvier and Valenciennes.—Facciola.

membrane. There were counted about forty acts of respiration in the first minutes, or the twofold movements of raising and lowering of the hyoid. But it now remains to account for the permanent closure of the opercles. The fish, meanwhile, being in the vessel, beat from time to time the pectoral and ventral fins, as though it sought to lie down flat.

I therefore placed some fine sea sand and water into a large receptacle, into which I put the fish. On feeling the sand with the paired fins (for its eyes could not see it) the fish buried itself in it by means of lateral movements of the tail aided by the paired fins, leaving in sight only the eyes and the upper portion of the mouth opening which formed a narrow and elongated cleft in the even sand layer. Farther back, toward the posterior part of the head, two round holes were visible on the sand, of which I shall speak shortly.

In this position, the lower jaw, of which only the extreme edge protruded, remained completely motionless, and the slight movements which we noted while the fish was in the midst of the water, and which were passive, had been stopped by the obstacle furnished by the sand which is not so easily displaced as the former element. Moreover, it follows that the jaw cannot move without the fine sand-grains, which cover it to its edge, falling into it. The jaw might move slightly in the direction of closure against the upper jaw, but the act of approaching would not have been followed by a withdrawal or return to the original position, because the sand would push itself more and more against the jaw and finish by closing it completely. This same jaw is so little open that its fringe almost touches the upper lip, thus preventing the entrance of foreign bodies into the mouth, such as small crustaceans, which pass over the surface of the bottom and which the fish could not in any way keep off. Besides, as we have seen, it is necessary that the mouth should be slightly open to accomplish respiration. The sublingual membrane beat more slowly than when the fish was in the midst of the water. As soon as it buried itself in the sand, respiration stopped for a moment. Moreover, the fish entered the sand with the mouth shut, and on opening it on the surface of the bottom, the small quantity of sand which covered the mouth, fell into it and was then expelled again through the branchial apertures. The eyes, which were almost on a level with the horizontal surface of the head, would remain buried, if the fish did not previously sink them into their cavities by raising the suborbital; in fact, the fish makes them protrude above the surface of the sand by lowering that bone. It has been stated that the eyes are favorably placed for discovering prey; we may add that if they were lateral the head could not bury itself very far into the sand without impeding the vision. It is also useful that the surface of the head is horizontal, because in this way it is likewise covered by the sand. If the opercles do not beat when the fish is surrounded by water, they close the branchial apertures still more effectually in the sand. Now at the place where the two apertures project behind the head, there forms immediately a little vortex of sand which is thrown up by the water; little by little the sand-grains are deposited around it and the hole is formed without a single grain stirring afterwards. At the bottom of the hole may be seen a constant rising and lowering of a whitish body which is none other than the upper end of the branchiostegal membrane. This end is soft, spongy and discoidal, and is attached to the scapula a little below the spine which is a posterior lengthening of the latter bone. It is solely from this point, or the upper angle of the branchial aperture, that the water finds an egress, because a doubling of the skin which prolongs posteriorly the border of the operculum permanently closes the aperture. In other fishes the branchiostegal membrane is often seen to project to a great extent below and also a little backwards beyond the border of the parts closing the branchial aperture, and in the latter place this membrane supplies that which the opercle lacks in closing the corresponding portion of the aperture.

In *Uranoscopus*, on the other hand, the upper border of the branchiostegal membrane does not project outside the edge of the opercle, because the latter, as has been stated, is enlarged by a membranous portion. Cuvier and Valenciennes[1] noted this peculiarity in the following words: "The borders of the opercular valve are enlarged by a portion of the skin which adds a large band to them." This skin portion is thick and notched in the margin, and covers pretty well over the scapular region. Also the free margin of the opercle is furnished with a portion of the skin, but narrower than that of the opercle. It is easy to explain the utility of these dispositions. The branchiostegal membrane is constantly agitated to throw out the water admitted by respiration. These movements would be impossible while the fish remained buried in the sand, if the opercles were not adapted in such a manner as to oppose the obstacle which the sand placed in their way. As a matter of fact, the opercles are somewhat hollowed, and thus permit the branchiostegal membrane to move freely within. The membranous por-

[1] Hist. Nat. d. Poissons, III, p. 292.

tion of the opercular valve closes the branchial aperture, thus forcing the water out at its upper angle, as from a kind of vent. This is also the place where the water is ejected when the fish is swimming free in the midst of that element.

The fish remained all night in the same position in which I had left it the day before. . . . On the following day I had it taken out, and touching its belly I found the stomach to be empty; I therefore supposed the fish to be very hungry. Having a few live specimens of *Gobius niger* I placed them near the *Uranoscopus* which had again buried itself in the sand. The *Gobius* passed over the head of the fish and stayed there, but the *Uranoscopus* would not take hold of one, either because it was so much annoyed, or because such fishes were not is natural prey.

It may be concluded from what has been said that the *Uranoscopus* is adapted for a life hidden in the sand or mud. I do not doubt that this habit is designed to procure its food for it. If it were a means of defence, the offensive weapons with which nature has provided the fish and which are of the most redoubtable kind would be almost superfluous. As the fish does not appear from its original organization to be a very agile swimmer, and especially from the weight of its head, those weapons will assist it when moving about in the water, either to change its place or to approach the female. The shape of its mouth will not permit it to lay hold of its prey in any other way than the insidious one which was already spoken of. I am assured by the fishermen that this fish is never taken with a line, but with a spear or sometimes in a net. As a matter of fact, it is nearly always seen in the market injured. The young of this species hunt smaller fishes according to the capacity of the stomach; and these latter fishes again pursue very small creatures, and thus there is an agreement between the instinct of the prey and that of the enemy.

In the stomach of a *Uranoscopus* more fishes are generally found; this shows that when it has obtained some prey, it continues its insidious manœuver, until its belly is filled. The abdominal cavity has an enormous gall-bladder, while in other fishes which feed exclusively on fish, that organ is of ordinary size. But in *Uranoscopus* a greater quantity of bile may be needed, because the fish is very voracious, and probably also because the flesh of the sardines, which are most frequently found in its stomach, is fatty.

It might be asked whether the various dispositions which render the fish adapted for staying buried in the ground, were established from the beginning, or whether they are the effect of adaptation.

To answer this we should have to go beyond the scope of this article. We shall only note a fact which gave occasion to put such a question. There are fishes in which the branchial aperture is very little open, as in the gobies; others in which it is reduced to a foramen or a kind of tube which opens posteriorly as in the eels. Therefore it would have been more reasonable and suitable to give to *Uranoscopus,* which does not beat the opercles in the water and cannot beat them buried in the sand, a conformation of the branchial aperture nearly similar to that of the eels. And in fact, if the branchial aperture appeared from the beginning as it is at present, then that would indicate that the hand from which it proceeded was not very wise, as it had sought to hinder that which it had first established; we refer to the skin portion which prolongs posteriorly the opercular valve and serves to close the branchial aperture in that place. We must, therefore, suppose this disposition to be the result of adaptation. But, it might then be asked, would it not have been more expedient if the branchial aperture had become restricted? The answer is, nature in her operations employs the most expeditious means to an end; it is easier, in fact, to enlarge the extension of a part than to establish continuity where there is an interruption.

These observations are printed here to call the attention of American observers to characteristics which will *not* be manifested by the American *Astroscopes.* As the latter have the opercles roofed over above and lack the intramandibular linguiform appendage, their habits must necessarily differ from those of the *Uranoscopes.* Their contrasting peculiarities should be the subject of early consideration. The details will show how much representatives of nearly allied genera may differ in their habits as well as the morphological characteristics which determine habits—or are the eventual outcome of differences of habits.