

7.

Fishes that Live as Inquilines (Lodgers) in Sponges.

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(Text-figures 1 & 2).

INTRODUCTION.

The living habits of fishes are extraordinarily diversified and are interesting in like degree. Among inanimate objects, they seek protection in crevices in rocks, in holes in and under banks of streams (some burrowing fishes make the holes which they inhabit), under stumps, roots—projecting bodies of any kind in the water—and in aquatic plant growths, both marine and fresh-water. And recently it was noted that when a floating log was brought ashore, out came a catfish. All this, of course, is probably for protection from enemies.

But among the most interesting living habits of fishes are those in which they seek protection by associating as inquilines (Latin, *inquilinus*, a lodger) with the lower invertebrate water-dwellers—some of them normally fish-eaters. Thus the little *Nomeus* finds safety in associating with the very dangerous Portuguese Man-of-War, *Physalia*, with its long, trailing tentacles beset with thousands of the most virulent poison cells known in any hydroid. Then various small fishes live under the umbrellas of large jelly-fishes, protected from their enemies by the poison cells in the tentacles hanging from the outer edge of each umbrella. Again, certain small pomacentrid fishes live unhurt amid the poison-cell-laden tentacles of giant sea anemones found from the head of the Red Sea to the Fiji Islands, and from the South China Sea to the waters around northern Australia.

This last may be set down as a case of symbiosis. When pursued by other (predator) fishes, the little pomacentrids flee to their protectors, and the prosecutors following them meet their doom and are eaten by the protective anemones—the scraps falling to the little enticers. One student of this association of huge anemones and little fishes at the head of the Red Sea is convinced that the little fishes act purposely in leading to their anemone hosts the larger fishes.

In 1914, at the Marquesas Atoll, 20 miles west of Key West, I found a little *Apogonichthys* lodging in the mantle cavity of a large univalve mollusk (the conch, *Strombus*). Later I found that this had previously been recorded from the Bahamas, where the phenomenon is now well known. For an account of this find, see Gudger, 1927. This

fish is also known as a sponge inquiline, as will be shown later.

Then the little eel-like pearlfish, *Fierasfer*, has been found sojourning in the mantle cavity of the pearl oyster, *Meleagrina*, and in the posterior digestive tract of holothurians ("sea cucumbers").

That crustaceans live in the lowly sponges as inquilines has been recorded since 1850, but that fishes indulge in the practice has been known for but a comparatively short time, not farther back than 1917—so far as this study has shown. At least, no such titles were found in a check-up of G. C. J. Vosmaer's "Bibliography of Sponges, 1551-1913." Hence the accounts of fish-sponge inquilinism begin with 1917.

FISHES THAT LIVE IN SPONGES IN THE WESTERN CENTRAL ATLANTIC.

So far as this search has revealed, this curious form of inquilinism of fish-in-sponge seems to have been reported only from the central western Atlantic Ocean. It surely must occur in the warmer parts of the Pacific and Indian Oceans also. That there are no reports from these oceans can only mean that the habit has not been recorded from them because it has not been looked for.

The accounts of the discoveries of fish-sponge inquilinism will now be presented in the chronological order of discovery by genus and species. Where there is more than one report of a species and where two species of a genus are found to be inquilines, the chronological order of recording each species will be followed.

Evermannichthys spongicola Hubbs, 1923.

I (1)—*Garmannia spongicola*—Radcliffe, 1917.¹

The history of the first known record of fishes living in sponges is as follows:

In the summer of 1917, the U. S. Fisheries Steamer *Fish Hawk* came to the Fisheries Laboratory at Beaufort, N. C., to do some experimental trawling. On August 1, she made an exploratory trip to the fishing grounds about 20 miles south by west of

¹ The Roman numerals indicate the chronological order of discovery of sponge inquilines by genera. The Arabic numerals in parentheses (1) indicate the number of reports of inquilinism by the species.

Beaufort Inlet. Here in about 15 fathoms she put out a beam trawl on hard bottom with corals and sponges. Among the spoils brought up was a large cup-shaped sponge, concave on top and 61 cm. in diameter. From its deep cavity there were taken six little gobies 24-28 mm. long. On August 11, another trip was made. This time the trawl brought up a sponge 45.7 cm. in diameter at the top and 53.3 cm. high. It, too, was cup-shaped. From this sponge were extracted 15 little gobies varying from 20 to 31 mm. in length. Both sponges were pretty heavily inhabited by these little fish.

These gobies were new to science and to them Lewis Radcliffe, at that time director of the U. S. Fisheries Laboratory at Beaufort, gave the name *Garmannia spongicola*—Garman's sponge-dwelling goby. These were named for Dr. Samuel Garman, ichthyologist of the Museum of Comparative Zoology in Cambridge, Massachusetts.

(2)—Later, Radcliffe found in the collections of the Bureau of Fisheries five unidentified gobies ranging from 17 to 27 mm. in length. These had been taken on January 13, 1913, off the Anclote Keys near Tarpon Springs, west coast of Florida, from a large sponge similar to those noted above. When examined, these little gobies were found to be identical with the above, and are so noted at the end of Radcliffe's article (1917). Presumably the members of this species normally lodge in sponges, wandering away in search of food, but coming "home" when they have fed or when molested.

In 1923, Hubbs, after studying Radcliffe's gobies and after working over other sponge-dwelling gobies collected by Metzelaar at Curaçao, Lesser Antilles, and named *Evermannichthys spongicola*, assigned the generic name *Evermannichthys* to Radcliffe's gobies. This genus is named in honor of Dr. B. W. Evermann, an outstanding student of American fishes. So the generic name of these little gobies is that at the head of this section. Metzelaar's work will now be noted.

***Evermannichthys metzelaari* Hubbs, 1923.**

II (1)—*Evermannichthys spongicola*—Metzelaar, 1919.

In 1919 Metzelaar described from many specimens this small goby (up to 26 mm. in length) found off Curaçao "in sponges . . . where the fish lives together with its congener, *Gobiosoma multifasciatum*." It should be noted that Metzelaar is the first to find two different but related genera of fishes living in the same sponge. Later, three such unrelated co-dwellers will be registered. As noted earlier, Hubbs in 1923 changed the specific name of this fish as recorded above.

(2)—In 1922, Metzelaar made a second finding of this same goby "living in sponges" in another locality off Curaçao, Dutch West Indies.

The next findings of the little Evermann-Metzelaar gobies are far away in time and space from the preceding.

(3)—In 1928, Beebe & Tee-Van, in their intensive study of the fishes of Port-au-Prince Bay, Haiti, say of these little gobies (*Evermannichthys metzelaari*) that "Seven of these remarkable fish were taken from the galleries of enormous sponges, where they lived in company with snapping shrimps and small crabs." And of the large pectoral fins of these little (19 mm. and smaller) fish, they note that: ". . . the webs are torn to ribbons, mostly by attrition on the silicious sponge substance"—as the little gobies make their way into and out of the sponges.

The careful observations of these veteran observers are what the reader has wished for with regard to the habits of these fishes. More of their observations will follow later for these and for other sponge-dwellers.

Two other records of the Evermann-Metzelaar goby have come to hand and from another quite distant locality:

(4)—In 1932, Pearse, in listing the denizens of a large vase-shaped sponge taken and dissected at Tortugas, Florida, records "a fish, *Evermannichthys metzelaari*." It is strange that, in all his work with sponges at the Tortugas Laboratory, Pearse found but a single inquiline fish.

(5)—Last of all, however, in 1941, "The Fishes of Tortugas, Florida" was published. In it, Longley & Hildebrand say (p. 229) of *Evermannichthys metzelaari*—"Common at Tortugas in loggerhead sponges." The largest of five in one sponge was 27 mm. long. This is from Longley's notes.

The five records above give quite an extensive distribution to Metzelaar's *Evermannichthys*. It is recorded from Curaçao, Dutch West Indies, Port-au-Prince Bay in Haiti, and from the Tortugas. And there is every reason to expect that it will be found in sponges throughout the whole Caribbean-Gulf region.

Having brought together in chronological order all the Evermann-Metzelaar gobies to show their wide distribution, we now return to the discovery by this Dutch ichthyologist of a new genus of sponge-dwellers.

III (1)—*Gobiosoma multifasciatum*—Metzelaar, 1919.

In 1919, Metzelaar recorded several specimens of this fish (length up to 23 mm.) from Curaçao, Dutch West Indies, all "living in sponges." And three years later our Dutch ichthyologist records another species of this genus—as will now be seen.

IV (1)—*Gobiosoma horsti*—Metzelaar, 1922.

Last of all Metzelaar's sponge-dwellers from the Lesser Antilles is the goby listed above. Of it he merely says—"Two specimens of 55 mm. from a sponge, Caracas Bay." No details are given, but in the same article he adds two more sponge-dwellers to his list—as will be noted further on.

(2)—Beebe & Tee-Van (1928) say of their specimens of this goby in Port-au-

Prince Bay, Haiti, that—"Almost all the Haitian fish were taken from tall tubular sponges" on reefs 12-15 feet down. However, "the gobies are not confined to the sponges, but came out during the daylight and were often seen resting on the bottom." But they found them in about half of these tall tubular sponges on the reef.

V (1)—*Garmannia rubra*—Metzelaar, 1922.

Metzelaar merely notes of this little goby—"Many specimens from sponges in Curaçao Bay." One wishes for details, particularly the kind of sponge in which they were found.

VI (1)—*Garmannia binghami*—Parr, 1927.

The Third Oceanographic Expedition of Mr. Harry Payne Bingham's *Pawnee* made very extensive collections of fishes, so many that a number of separate reports were needed to get the specimens properly studied and classified. Our interests are centered on the first report—that of Dr. Albert Eide Parr on the shallow-water bony fishes from the Bahama archipelago, and particularly on one little fish. This goby, only 22 mm. long, was taken off Crooked Island, and was "collected by Mr. Bingham from a sponge." This specimen and this statement about its habitat give us another sponge-inquiline fish. It is a new species and is named *binghami* in honor of its collector.

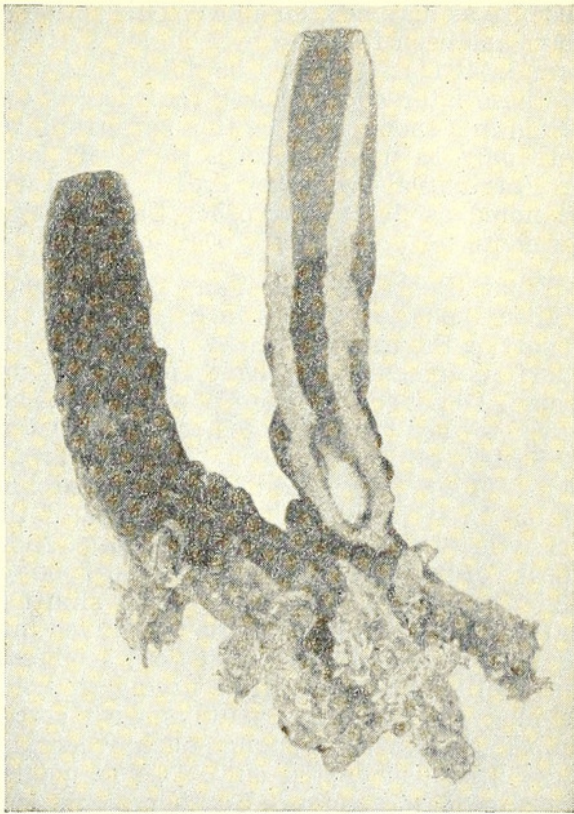
VII (1)—*Starksia cremnobates*—Metzelaar, 1922.

Metzelaar had one specimen of this little blenny of 4 cm. "from a sponge in Curaçao Bay." The kind of sponge is not noted and Metzelaar apparently observed nothing else of the habits of the fish.

VIII (1)—*Apogonichthys puncticulatus*—Hildebrand & Ginsburg, 1927.

My observations on the conch-dwelling habits of this fish have already been noted (Gudger, 1927). But these observations have been much extended by Hildebrand & Ginsburg (1927) who, at Key West, not only confirmed the conch-inquilinism at Marquesas, but found this fish to be a sponge-dweller also. Their statement is that—"There were found in sponges as follows: Two specimens, 37 and 40 mm. June 7, 1918; 36 mm. August 20, 1919." It would be interesting for some student at Key West to investigate this dual-inquiline habit and to see if the fish there may not have other animate lodgings—as possibly in oysters, or under the umbrella of a jellyfish. It is, so far as I know, the only fish except *Fierasfer* having a double-inquiline habit.

In 1928, Beebe & Tee-Van published their valuable work "The Fishes of Port-au-Prince Bay, Haiti." As noted above, they found a number of sponge-inquiline fishes of genera recorded earlier herein. However, they described two others to be added to the two already listed. The first is:



TEXT-FIG. 1. Longitudinal section of a finger or chimney sponge showing a little cardinal fish (*Amia pigmentarius*) in the bottom of such a sponge found in Port-au-Prince Bay, Haiti. After Beebe, 1928.

IX (1)—*Amia pigmentarius*—Beebe & Tee-Van, 1928.

Of this cardinal fish taken in Port-au-Prince Bay, Beebe & Tee-Van say that their specimens without exception came from the interiors of tubular sponges and they add that in their habitat region more than fifty per cent. of the sponges examined were inhabited by these fish. See Text-fig. 1 herein—the first portrayal of this fish-sponge inquilinism. It is interesting to note that their method of collecting these *Amias* was by "Diving with the helmet and stuffing cotton into the different apertures of the sponges, and then sending the sponges to the surface, whence the fish were removed." Without the helmet, no specimens.

Pomacentrus partitus Poey, 1868.

X (1)—*Pomacentrus freemani*—Beebe & Tee-Van, 1928.

Of this little demoiselle (48 mm. in length), our authors say "Found in a sponge which was growing on a coral reef." This is the first known record of a pomacentrid-sponge inquiline. Note, however, in the introduction to this article, a reference to an extensive symbiosis between other pomacentrid fishes and certain giant sea anemones.

In 1930, Parr, in working on the synonymy of certain forms of the genus *Pomacentrus*, found that *P. freemani* Beebe & Tee-Van is identical with Poey's *P. partitus*. So Poey's generic name of this pomacentrid takes pre-

cedence as may be seen above. This action of Parr has been followed by Longley & Hildebrand (1941). It should be noted that none of these later specimens is recorded as collected in a sponge. Hence this paragraph refers only to nomenclature. However, later on Parr and also Longley & Hildebrand will be noted as describing other little sponge-dwellers.

What Beebe & Tee-Van say of their Haitian sponge-dwellers in their systematic report on the fishes is necessarily confined to short statements of where they were collected. To get some idea of how the fishes behaved toward their sponge hosts, we must go to Beebe's interesting book, "Beneath Tropic Seas" (1928), a record of his diving around Haiti. In it Beebe writes as follows of the behavior of the sponge-dwellers. On p. 15 he speaks of three tall hollow finger-like sponges and "As I looked, a flock of small slim fish darted past and with a single turn dived into the tops of one of the [cluster of] sponges." On another occasion, while diving in order to plug such sponge openings with cotton (p. 47), he "jarred a sponge bush, whereat a tiny, lithe fish darted out . . . and popped back into the sponge." Further along (pp. 123-129) he describes how a giant black sponge ("larger than a half barrel") was located, dislocated, and finally brought to the surface and its inhabitants studied.

However, before disturbing this huge sponge, Beebe noted (p. 125) that "two fish called it home"—one a squirrel-fish which peered out from beneath the body of the sponge. The second piscine frequenter was "a pugnacious little demoiselle which had taken possession of the open center of the sponge" and only when the sponge began to be loosened up did it disappear. It would seem that the squirrel-fish was not an inquiline, but a mere wayfarer temporarily hiding beneath the sponge. At any rate, there is no hint in the systematic part of the text of inquilinism here as there is of the little demoiselle as noted above.

After the great sponge had been brought to the surface and pretty thoroughly dissected, two slender gobies less than an inch long were found (p. 126). Later three more were collected, making five (*Evermannichthys metzelaari*) in all. All these inch-long fishes were "of an even diameter which would enable them to go in and out of all but the smallest holes in the sponge surface." Evidently they were not prisoners. In all five "the united ventral fins [as noted on p. 122 herein] were extremely worn and torn . . . the tips of the rays broken and lost . . . the effects of leaving off swimming for climbing about the roughened sponge channels." One needs to read the pages noted in Beebe's book to get a full appreciation of this curious inquilinism.

This present article will now be concluded with an account of the work of Dr. C. M. Breder, Jr. (1939), who in one "hand" of

tubular sponges has found three fish inquilines (each of a separate genus)—one of them a blenny, laying its eggs and hatching its young in the long sponge fingers. Surely this combination of three unlike inquiline fishes (and one of them breeding) in tubular sponges is little short of extraordinary.

Breder's studies were made in Pelican Bay near Palmetto Key, west of Useppa Island, Charlotte Harbor, Gulf coast of Florida, where abundant material was at hand. The sponges and their inquilines were in open water away from the mangroves and where there was a good tidal flow and change of water.

Under the heading "Habitat," Breder states that:

The collection area could be waded easily at low water, and both adults and eggs [of the blenny] were taken by gathering up the very abundant yellow sponge, *Verongia fistularis* (Pallas). During the time of these collections, February, every fourth or fifth sponge would be found to contain one or more fish and a much lesser number to contain eggs, usually with an attendant parent.

Associated with them in the sponge cavities were *Opsanus beta* (Goode and Bean) and *Bathygobius soporator* (Cuvier and Valenciennes). Other fishes did not seem to find these same refuges but they were shared with a large number of invertebrates.

The first of the associated inquilines to be considered is:

XI (1)—*Bathygobius soporator*—
Breder, 1939.

Breder found this goby living as an inquiline in the yellow sponges off Palmetto Key in Charlotte Harbor. Because of his preoccupation with the egg-laying blenny, he merely records this fish as a sponge inquiline. However, it is worthy of note that this is presumably the first record ever made of this habit in a fish of this genus.

The second of the inquilines is:

XII (1)—*Opsanus beta*—Breder, 1939.

Breder found this fish also living as an inquiline in yellow sponges in shallow water. But for the reason given above, he also does not discuss the inquilinism of this fish. But this secretive habit is to be expected of a fish of this genus. At the Beaufort, N. C., Laboratory of the old U. S. Bureau of Fisheries, I found the congeneric *Opsanus tau* living and laying its eggs and guarding them in dead Venus-fan shells, in tin cans and under logs projecting under water from sand banks (see Gudger, 1910). In the light of these studies, the living of *Opsanus beta* in sponges should not be unexpected, but it is interesting that it has been found and recorded.

The third and last and most important of Breder's sponge inquilines is:

XIII (1)—*Paraclinus marmoratus*—
Breder, 1939.

In studying the life history of this blenny,

our author has given very definite data as to its unique inquilinism. It was studied where abundant material made possible extensive observations not merely of the ordinary lodging-habit, but of its extraordinary egg-laying, hatching the eggs, and rearing its young within the tubular growths of its host. Nothing like this has ever been reported before as far as this search has revealed.

Breder's diagrammatic text-figure is reproduced as Text-fig. 2 herein. It is a sagittal section through what might be called a sponge "finger" showing the canals through which water flows in and out, as indicated by the arrows. This ensures the parent fish and the eggs a constant flow of fresh oxygen-laden water. The attendant fish is the male, and the progressive dark coloration of the eggs shows that three lots have been laid in this sponge finger.

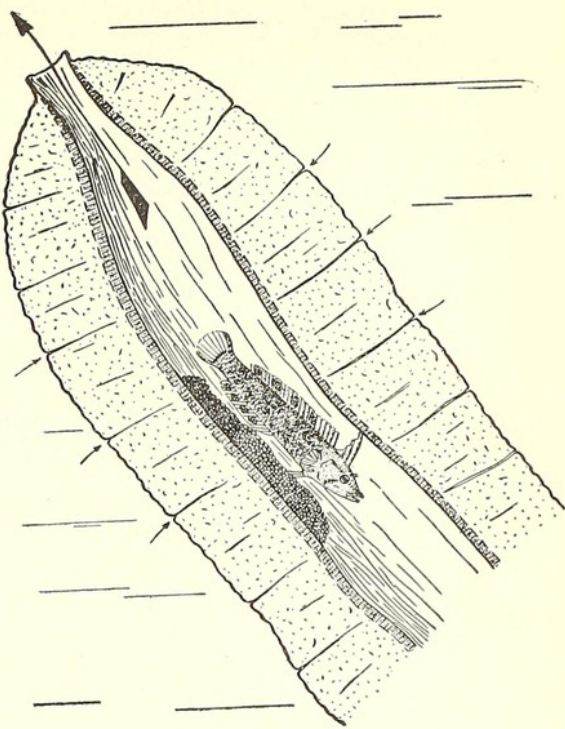
Breder noted that "The nesting cavities selected by the fish were found to be exceedingly varied. Most frequently they were found in broken-open lumens of old sponges." These were probably of easier ingress and egress. He notes that the flow of water from the oscula of the sponges (the tip of a "finger" in Text-fig. 2 herein) is very great and hence the eggs and the guarding fish are plentifully supplied with fresh water. In many cases guardian fish were taken with the eggs. These guardians were always males—the usual sex among fishes which guard their eggs. A total of twelve nests, all in excellent condition, were carefully examined and many others in fragmentary condition were also studied.

Our narrative of this extraordinary inquilinism of three different genera of fishes, with all but the lowest of the invertebrates, fortunately ends with the nesting and breeding in the living sponge by one of the fishes—certainly a high note in animal behavior.

RECAPITULATION.

Fish-sponge inquilines are recorded herein as follows: Gobies, 7 species; Blennies, 2 species; and single species of the following genera—*Amia*, *Apogonichthys*, *Opsanus*, *Pomacentrus*. In all, 13 species of small fishes have been recorded as living either in small finger-shaped or in big half-barrel-like sponges. All are recorded from tropical and semi-tropical waters of the central western Atlantic. Most remarkable of all is the blenny, *Paraclinus marmoratus*, which lives, lays and hatches its eggs, and brings up its young in tubular sponges.

The sponge-inquiline fishes are all small and some are noted as slender. The sponges are either tubular or finger-shaped, with terminal oscula (Text-figs. 1 and 2) into which the fishes can dive; or they are of the loggerhead vase-shaped type, in the large cavity of which the fishes can assemble or into the many lateral cavities they can worm



TEXT-FIG. 2. Diagrammatic figure showing in vertical section the cavity of a tubular finger sponge. This serves as a nesting-place for the sponge-blenny, *Paraclinus marmoratus*, which is guarding the eggs. That the eggs are of three layings is noted by the progressive darkening coloration. The guardian fish is a male. The arrows indicate the flow of the water induced by the sponge. After Breder, 1939.

their way to safety. The phenomenon herein considered is in all cases one-sided—the sponge gives a lodging to the fish which makes no return whatever to the sponge.

It is hoped that the publication of this article may bring to light like habits in fishes in the warm waters of the Pacific and Indian Oceans.

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