WESTERN ATLANTIC HAGFISHES OF THE GENUS *EPTATRETUS* (MYXINIDAE) WITH DESCRIPTION OF TWO NEW SPECIES

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ABSTRACT

Recent trawl collections from the continental slopes of the western North Atlantic have yielded three species of the hagfish genus *Eptatretus* (treated herein) as well as two or three undescribed species of *Myxine*.

Eptatretus is accepted as the generic name for most of the multibranchiate myxinids including all the Atlantic species; *Paramyxine* Dean 1904, is restricted to western Pacific species.

The documentary material of *Paramyxine springeri* Bigelow and Schroeder 1952, contains two species, one of which is here described and named *Eptatretus minor*, new species. The two species are sympatric on the continental slope of the northeastern Gulf of Mexico, but appear to occupy relatively narrow, nonoverlapping depth ranges. *Eptatretus multidens*, new species, is described from the Caribbean Sea and Atlantic Ocean off French Guiana.

The value of tooth counts and the numbers of slime pores is stressed in systematic studies within *Eptatretus*.

Bigelow and Schroeder (1952) described *Paramyxine springeri* from three specimens caught in 1951 in the Gulf of Mexico. The only recognized species of *Paramyxine* at that time was *P. atami* Dean 1904 (now known to be a composite of two Japanese species, Fernholm unpubl. data). Other species of *Paramyxine*, later described from Taiwan (Teng 1958; Shen and Tao 1975) have strengthened the distinctiveness of that genus by having the generic character of crowded gill (or branchial) apertures even more pronounced than in the type-species.

We redescribe *P. springeri* and refer it to the genus *Eptatretus*. We also describe two new species of *Eptatretus* and point out the likely occurrence of at least two additional species of this genus from the midwestern Atlantic. We use the name *Eptatretus* for the Atlantic hagfishes with several gill apertures to stress that we believe they represent a phyletic line which is independent of, although similar to, that of the Asian hagfishes of the genus *Paramyxine*. It is more likely that *Eptatretus* from the Atlantic represents an offshoot from the western American *Eptatretus* group than that they are directly related to the Asian *Paramyxine*. That the western Atlantic species of *Eptatretus* seem to be restricted to Central American and adjacent waters indicates that they may have crossed between the American continents from the Pacific prior to the appearance of the isthmus. In the western Atlantic there are no records of *Eptatretus* outside those shown in Figure 1. On the European and African side of the ocean the only reported captures are those of *E. profundus*, *E. hexatrema*, and *E. octatrema*, all from South African waters (Barnard 1923, 1950).

All specimens treated herein were taken by bottom trawl, a method which usually produces few hagfishes. No doubt an expedition with baited traps would provide vastly more material that could fill in some of the gaps in the material we have at our disposal. However, the U.S. government research vessels (Springer and Bullis 1956; Bullis and Thompson 1965; Bayer 1969) that have secured most of our material give us data which are relatively homogeneous and complete, and thus yield some information on the hagfish habitats.

We show that *P. springeri* Bigelow and Schroeder includes two species, and describe some new forms of *Eptatretus*. We also mention here that hagfishes of the genus *Myxine* have been found in the western Atlantic (Hubbs unpubl. data). They are not yet systematically analyzed, but it is expected that they compose two new species. It thus seems likely that the hagfish fauna

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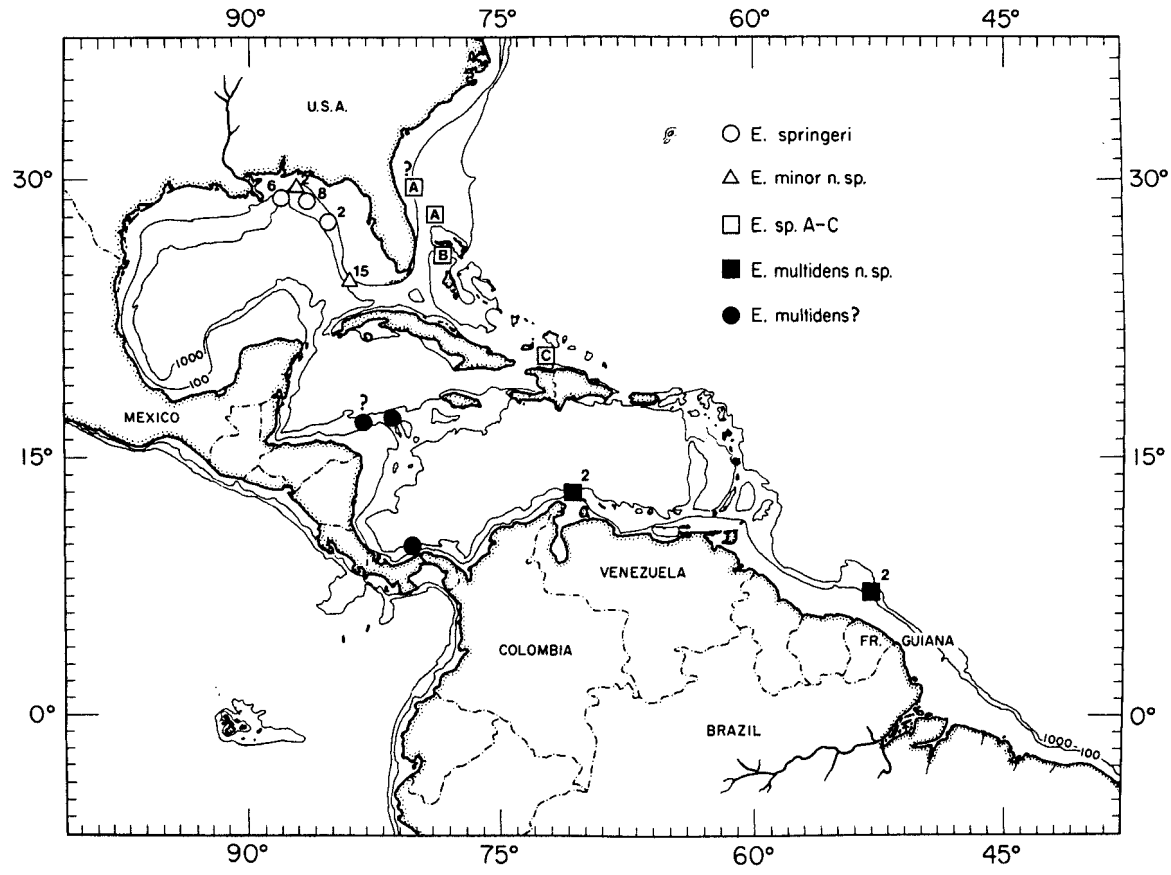

FIGURE 1.—Distribution of *Eptatretus* species in the western Atlantic Ocean. Numbers indicate more than one specimen taken. Two inferential records are indicated with question marks. Isobaths in meters.

of the western Atlantic is about as rich as it is in Japanese waters (cf. Dean 1904).

Anticipating more material of *Eptatretus* from this area, we have chosen to name only those forms that are represented by four or more specimens in the available material. Many hagfish species have been described from one or a very few specimens and this has caused much confusion, especially since subsequent investigators have not been aware of what may be regarded as normal intraspecific variation of characters in different genera of hagfishes.

MATERIALS AND METHODS

We have examined material from the following repositories: FMNH—Field Museum of Natural History, Chicago; MCZ—Museum of Comparative Zoology, Harvard University, Cambridge; SIO—Scripps Institution of Oceanography, La Jolla, Calif.; UMML—Rosenstiel School of Marine and Atmospheric Sciences, Miami; USNM—National Museum of Natural History, Washington, D.C. Details of the studied material are given under each species.

Weight for each preserved specimen was recorded in grams.

The following measurements have been taken on the left side of the specimen:

Total length (TL): from extreme tip of snout at midpoint, excluding barbels, to rear margin of fin around tip of tail; moderate stretching may be needed to approximate normal form. This process has been used for other measurements.

Trunk length: from front of pharyngocutaneous aperture to front of cloacal slit.

Tail length: from front of cloacal slit to tip of tail fin.

Prebranchial length: from tip of snout to front of anteriormost gill aperture.

Branchial length: from front of anteriormost gill aperture to front of pharyngo-cutaneous aperture.

Preocular length: from tip of snout to center of clear area marking ocular region.

Body width: maximum, with body molded into seemingly natural conformation.

Body depth: maximum overall, near middle of body, including ventral fin fold (if applicable).

Body depth excluding fin fold: same region as in body depth, but excluding fin fold.

Body depth over cloaca: over front of cloacal slit.

Tail depth: maximum, taken at right angle to local axis, including fins.

Length of each of the three barbels: from crease at outer-anterior base.

The following counts have been taken:

Cusps on multicuspids (Figure 2): outer/inner row of teeth on both sides. Usually the head is cut open ventrally to count the teeth.

Unicuspids, outer row (including smaller cusps).

Unicuspids, inner row (including smaller cusps).

Total sum of all cusps.

Prebranchial (tip of snout to front of anteriormost gill aperture) slime pores (left side).

Branchial slime pores (left side).

Trunk slime pores (left side).

Tail slime pores (left side).

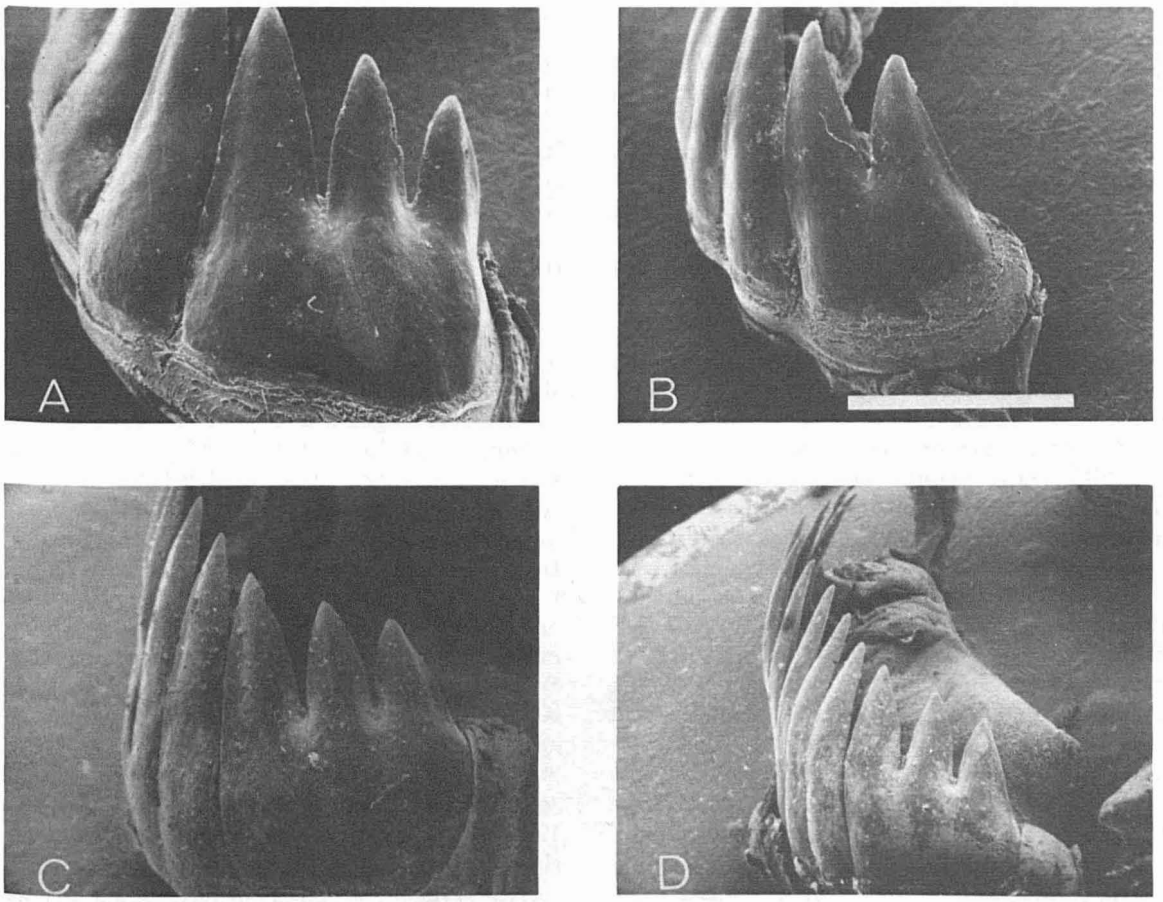

FIGURE 2.—Multicusps of *Eptatretus springeri* by scanning electron microscopy. A—right outer tooth row, B—right inner tooth row to show pattern of fused teeth 3/2 (see text). Multicusps of *E. minor*. C—right outer tooth row, D—right inner tooth row to show pattern of fused teeth 3/3. Scale indicated in B is 2 mm for all figures.

Total sum of slime pores on left side.

Total sum of gill apertures (not counting the pharyngo-cutaneous aperture if the left posteriormost gill aperture opens separately).

Many specimens were cut open to determine the number of gill pouches and their position relative to the tongue muscle and branching of aorta.

Sex was determined by examining the gonad through a cut in the lateral right side body wall anterior to the cloaca.

The usefulness of different counts and measurements for systematic studies in *Paramyxine* and *Eptatretus* have been discussed (Dean 1904; Bigelow and Schroeder 1952; Strahan 1975). We agree with Dean's (1904) statement that "... in the case of myxinoids it is peculiarly necessary to base specific determinations upon the average characters of as great a number of individuals as practicable." Dean (1904) and Strahan (1975) stressed the importance of the relative position of the gill apertures and body proportions, which we also find useful. Dean (1904) tended to disregard the number of slime pores as a systematic character, but we stress the value of that count and point out that both Bigelow and Schroeder (1952) and Strahan (1975) arrived at ranges for this character which are far too broad because they include two composite species (*P. springeri* Bigelow and Schroeder and *P. atami* Dean). This inclusion of an undescribed species (*E. minor*, see below) in *P. springeri* also led to the erroneous conclusion (Bigelow and Schroeder 1952) that the number of slime pores increased with length of the animal.

As indicated earlier (Dean 1904; Strahan 1975), the gill aperture counts vary slightly within the five- to seven-gilled species of *Eptatretus*, but when a larger sample is available, the character is, of course, quite valuable and is easily examined.

Tooth counts were considered of little value by Dean (1904) and Strahan (1975). We find, however, as had Regan (1912) in his admirable yet terse synopsis of the multibranchiate myxinids, that this is a very useful character. Especially we find the pattern of fused cusps (Figure 2) in the inner and outer row of teeth to be constant within species in all of the hundreds of specimens of *Eptatretus* and *Paramyxine* we have studied (unpubl. data).

The movements of the rasping lingual tooth plates are rather elaborate in hagfishes and complicate the terminology used to express positional relationships. In agreement with some previous authors (Dean 1904; Strahan 1975), we have chosen to call the row of teeth with larger teeth the outer row and the other row the inner. The fused tooth or multicusp we regard as the anterior in each row, and to designate the pattern of fused cusps or teeth in the multicusps of the outer/inner row we write 3/2 or 3/3, which are the two patterns found in the Atlantic species of *Eptatretus*.

The shape of the gill apertures, as well as extension and shape of the relatively low ventral fin fold, have been used as systematic characters, but we find it difficult to assess these characters in preserved specimens.

The pattern of fused teeth (3/2 or 3/3), supplemented with counts of gill apertures and slime pores, appears to suffice to distinguish the western Atlantic species of *Eptatretus*.

GENERIC ALLOCATION

The generic allocation of the polybranchiate species of hagfishes has been considerably discussed (for summary, see Holly 1933 and Strahan 1975). To us it is obvious that the name with priority, *Eptatretus* Cloquet, 1819, should be used. As stressed earlier (Bigelow and Schroeder 1948; Adam and Strahan 1963; Hubbs 1963; Strahan 1975), there is no obvious advantage in dividing the genus into subgenera.

It has been argued that *Paramyxine* as a genus should be treated as a junior synonym of *Eptatretus* (Strahan 1975). It is true that tendencies to shortening of the gill aperture area can be found in *E. springeri* (Bigelow and Schroeder 1952) and in *E. burgeri* (Strahan 1975), but we believe this represents a convergent trend of development in the Atlantic and Pacific Oceans. We retain the generic name *Paramyxine* for the western Pacific species. Dean (1904) defined the genus *Paramyxine* on the basis of a single specimen of *P. atami*. Now that much more material is available, it is somewhat a matter of choice whether one wants to retain *Paramyxine* for the Asian species. We choose to do so for the following reasons: 1) Dean's concept of crowdedness of gill apertures has been strengthened by the description of Taiwanese species of *Paramyxine* (Teng 1958; Shen and Tao 1975), which are more extreme in this character than is the type-species; 2) as a further characteristic of the many Asian *Paramyxine* species, we point to the absence of slime pores in the branchial area (with the exception that in *P. atami* Dean and *P. cheni* Shen and Tao, there may be a single pair of

slime pores in the branchial area); 3) *Paramyxine* defined in this way is a geographically, and we believe phylogenetically, distinct group limited to the waters of southeastern Asia.

Key to the Western Atlantic Species of *Eptatretus*

1a. Three anterior teeth in outer row and two anterior teeth in inner row fused at bases 2
1b. Three anterior teeth in each row fused at bases 4
2a. Gill apertures 6 or 7. Body and head stout (Figures 3, 4) 3
2b. Gill apertures 5. Body thin. Head narrow. One specimen, 308 mm (Figure 5). South of Bahama Islands ..... sp. B
3a. Slime pores 84-92. Maximum known length 590 mm. Northeastern Gulf of Mexico .. *E. springeri*
3b. Slime pores 78. One specimen, 433 mm. North of Bahama Islands ..... sp. A
4a. Gill apertures 7 ..... *E. multidens*?
4b. Gill apertures 6 (rarely 5) 5
5a. A thin whitish middorsal stripe. Total cusp count of teeth 46-54. Maximum known size 395 mm. Northeastern Gulf of Mexico. ..... *E. minor*
5b. No whitish middorsal stripe. Total cusp count of teeth 52-58. Caribbean Sea and Atlantic Ocean off French Guiana and Haiti 6
6a. Slime pores 75. Total cusp count of teeth 58. One specimen 380 mm. North of Haiti ..... sp. C
6b. Slime pores 87-91. Total cusp count of teeth 52-57. Maximum known length 655 mm. Caribbean Sea and Atlantic Ocean off French Guiana ..... *E. multidens*

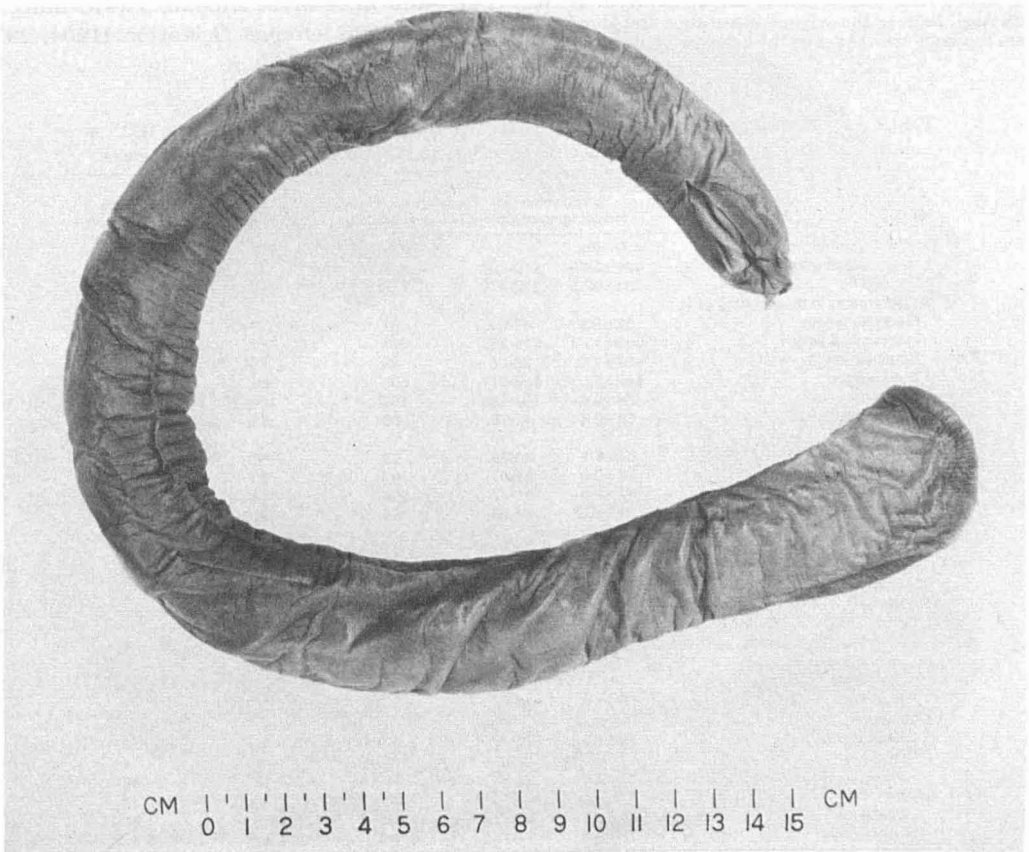

FIGURE 3.—*Eptatretus springeri* (MCZ 39939).

DESCRIPTION OF SPECIES

Eptatretus springeri (Bigelow and Schroeder) Figure 3, Table 1

Paramyxine springeri Bigelow and Schroeder 1952:1-10 (in part; original description; holotype, 590 mm, and an additional specimen, 505 mm; comparison with *P. atami*; includes, as do the following references, one 338 mm specimen of *E. minor*). Teng 1958:5-6 (comparison with other species referred to *Paramyxine*). Lindberg and Legeza 1959:23-24 (gill apertures). Strahan and Honma 1961:323-341 (comparison with *P. atami* and *P. yangi*). Adam and Strahan 1963:7 (characters; size; Gulf of Mexico). Lindberg and Legeza 1959:19, 21 (gill apertures). Rass 1971:18 (Gulf of Mexico).

Material.—MCZ 37399,[3] 1 (505 mm), 29 September 1951, 1340-1540 h, *Oregon* station 489, 27°44′ N, 85°09′ W, depth 465 m, bottom temperature 10.3° C, bottom type blue mud; MCZ 39939, 3 (500, 509, 576 mm), 13 March 1955, 0835-1305 h, *Oregon* station 1282, 29°10′ N, 88°03′ W, depth 475 m, bottom temperature 10° C, bottom type gray mud; MCZ 42423, 3 (410, 433, 450 mm), 12 March 1962, *Oregon* station 4076, 28°33′ N, 86°27′ W, depth 460 m; SIO 76-248 (formerly UMML 4405), 1 (542 mm), 18 February 1956, 0805-0835 h, *Oregon* station 1450, 29°17′ N, 87°41′ W, depth 440 m; USNM 161512 (holotype), 1 (590 mm), 29 September 1951, 1340-1540 h, *Oregon* station 489, 27°44′ N, 85°09′ W, depth 465 m, bottom temperature 10.3° C, bottom type blue mud; USNM 188210, 1 (522 mm), 23 October 1962, *Oregon* station 4005, 29°07.5′ N, 88°09′ W, depth 550 m; USNM 218396, 2 (513, 526 mm), 4 February 1970, *Oregon II* station 10899, depth 550 m; USNM 218397, 2 (500, 540 mm), 5 February 1970, *Oregon II* station 10900, 28°50.2′ N, 86°59′ W, depth 730 m; USNM 218394, 1 (417 mm), 29 August 1970, *Oregon II* station 11192, 29°19′ N, 86°45′ W, depth 420-460 m; USNM 218395, 1 (418 mm), 1 September 1970, *Oregon II* station 11204, 29°12′ N, 87°55′ W, depth 550 m.

[3]"Additional material" of Bigelow and Schroeder (1952). Labelled as coming from *Oregon* station 321; 29°27′ N, 87°19′ W, 400 m, 28 April 1951. In the original description stated to have come from the same trawl haul as the holotype and so regarded here.

TABLE 1.—Characters of western Atlantic species of *Eptatretus* with 3/2 cusps (see text) on multicuspids of outer/inner row of teeth. Mean ± SD and range given for multiple specimens.

Item	*E. springeri* 16 specimens including holotype		Holotype	*E.* sp. A 1 specimen	*E.* sp. B 1 specimen
Depth of capture (m)	420-730		465	950	590
Total length, TL (mm)	496±53.9	410-590	590	433	308
Weight (g)	231±97.3	102-479	479	182	40
Measurements in thousandths of TL:					
Preocular length	53±5.6	47-64	61	53	—
Prebranchial length	243±13.3	215-268	243	215	250
Branchial length	37±7.9	25-56	39	79	39
Trunk length	568±17.5	529-611	563	550	568
Tail length	156±9.8	134-168	155	157	146
Body width	52±6.8	42-70	70	55	37
Body depth:					
Including fin fold	81±8.1	66-99	99	88	67
Excluding fin fold	77±9.4	62-97	97	85	62
Over cloaca	67±7.5	51-77	69	74	48
Tail depth	81±10.3	64-93	85	81	67
Barbel length:					
First	9±1.4	7-11	11	15	10
Second	10±1.8	7-14	7	16	12
Third	15±2.8	10-20	10	16	15
Counts:					
Teeth:					
Cusps on multicuspids	3/2		3/2	3/2	3/2
Unicuspids, outer row[1]		10-11	11 + 11	10 + 11	10 + 10
Unicuspids, inner row[1]		9-11	10 + 10	10 + 10	10 + 11
Total sum of cusps	50±1.4	48-52	52	51	51
Slime pores, left side:					
Prebranchial	18±1.1	16-19	19	14	18
Branchial	3.2±0.9	2-5	4	4	4
Trunk	54±1.8	52-57	55	48	48
Tail	11±1.1	9-13	13	13	11
Total sum	87±2.6	84-92	91	79	81
Gill apertures[1]	12±0.4	12-13	6 + 6	7 + 7	5 + 5

[1]Left + right count for single specimen.

Diagnosis.—An *Eptatretus* with six (rarely seven) gill apertures. Total cusp count 48-52, with three teeth fused in outer and two in inner row of teeth (Figure 2). Slime pores 84-92.

Description.—*E. springeri* is a large hagfish; the 16 available specimens range from 410 to 590 mm with the mean about 500 mm. The five sexually mature females were 500 mm or longer. Eggs in the most mature female, 526 mm, are about 10 × 36 mm.

Only 1 of our 16 specimens had the sixth left gill aperture opening separately in front of the pharyngo-cutaneous aperture (cf. *E. burgeri* with 10% of the animals showing this condition according to Dean 1904). Two animals had an extra gill aperture on the right side and one an extra on the left side. Of these three, two had an extra seventh gill pouch on the right side and one had an extra seventh pouch on each side; the extra pouches were all more or less reduced in size.

The tongue muscle typically overlies gill pouches 1-3, and the aorta divides between gill pouches 4 and 5.

The color of our specimens is dark brownish purplish to very light brown; the eyespots are not plainly visible.

Distribution.—*Eptatretus springeri* has been found only in the northeastern part of the Gulf of Mexico (Figure 1) at depths between 410 and 576 m, but it must be realized, of course, that incidental capture (by trawling) is hardly adequate for our distributional map. The southernmost record is that of the holotype (USNM 161512).

Habitat and biology.—Specimens were collected by bottom trawl in March (475 m) and September (465 m) where the habitat temperature was about 10° C. It could not be determined whether the animals were in or above the substrate, which seemed to be composed of blue or gray mud. At least six of the specimens were caught during daytime. Some females contained ripe eggs (21-41

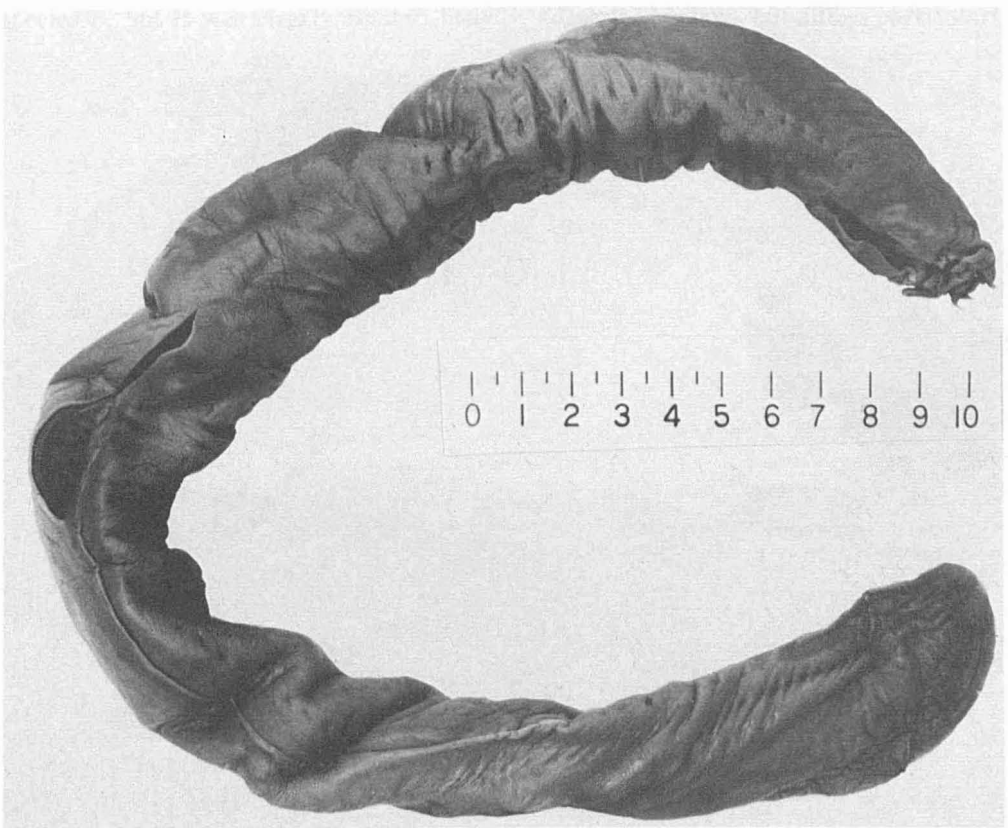

FIGURE 4.—*Eptatretus* sp. A (MCZ 40370). Scale in centimeters.

mm) in February, March, and September; thus the population presumably spawned throughout the year.

Eptatretus species A and B
Figures 4 and 5, Table 1

Material.—Species A, MCZ 40370, 1 (433 mm), 9 June 1958, 1925-2225 h, *Silver Bay* station 445, 28°03′ N, 78°44′ W, depth 910-950 m, bottom type coral and sand; Species A (inferential; the specimen cannot be located), 21 June 1958, 0730-1030 h, *Silver Bay* station 490, 29°49′ N, 80°11′ W, 330 m, bottom type green mud. Species B, SIO 76-252 (formerly UMML 31521), 1 (308 mm), 27 September 1973, RV *Columbus Iselin* station 137, 26°07′ N, 78°34.1-36.6′ W, depth 590-560 m.

Two specimens of *Eptatretus* (herein provisionally designated A and B) have been taken at depths of 950 and 590 m, respectively, in the vicinity of Grand Bahama Island (Figure 1). The pattern of fused teeth is 3/2 in these specimens and the total number of cusps is essentially the same. They exhibit differences large enough that they cannot be convincingly included in *E. springeri*. There are differences in the numbers of gill pouches and apertures, the relative branchial length, and number of prebranchial, trunk, and total slime pores (Table 1). Although there is variability in the number of gill pouches, and specimens having one more or less pouch are found among the six-gilled species of *Eptatretus*, it seems unlikely that our five- and seven-gilled specimens from south and north of Grand Bahama Island represent a single species with normally six gill pouches. The body width, the relative depth over the cloaca, and counts of prebranchial slime pores (Table 1) also indicate specific distinction for these two Atlantic *Eptatretus* specimens.

Species A, a mature male, is considerably stouter than the thin specimen designated as species B and is about as stout as *E. springeri*. The tail is less flaring and more pointed than that of *E. springeri*. The skin is light brown overall with the ventral fin fold whitish. Patches of transparent skin overlie the eyes. Trunk and total slime pore counts are outside the range of *E. springeri* in this seven-gilled specimen (Table 1), but the internal

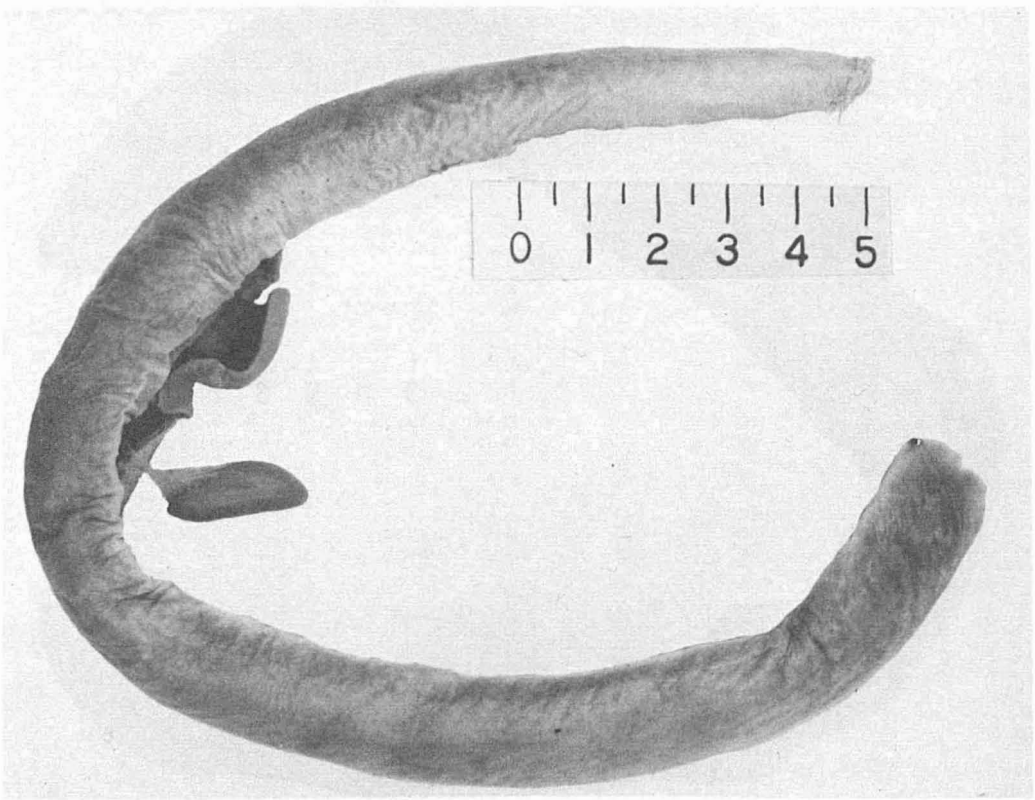

FIGURE 5.—*Eptatretus* sp. B (SIO 76-252). Object dependent from slit is an egg. Scale in centimeters.

anatomy is similar: the tongue muscle overlies gill pouches 1-3, and the aorta divides between gill pouches 5 and 6.

Species B is represented by a five-gilled female having a slender body and narrow head. The skin is light pinkish tan, with the ventral side only slightly lighter; no eyespots are visible. The thin ventral fin fold is white, and extends forward from the cloaca, reaching its maximum height at about the middle of the body, and gradually tapers off toward the posterior part of the branchial region. Several small depressions in the skin, about 0.4 mm in diameter, located mostly in the head region, may be traces of ectoparasitic trematodes. Species B differs from *E. springeri* in internal anatomy, having a tongue muscle overlying only the first gill pouch and an aorta bifurcating between the second and third gill pouch. *Eptatretus profundus* (Barnard 1923) is the only described species of *Eptatretus* having five gill apertures. Unfortunately, only the holotype is extant. It was measured by Hubbs (figures in parentheses, below) in the South African Museum (no. 13035) and was found not to differ much in length proportions from species B, but it was clearly stouter: body width (thousandths of total length), 37 (63); body depth including fin fold, 67 (94); body depth excluding fin fold, 62 (91); body depth over cloaca, 48 (68). The South African species yielded a lower total tooth count, 51 (42), but a similar number of slime pores, 81 (84). The difference in tooth count and stoutness indicate that the two specimens probably are not conspecific.

Eptatretus species C Figure 6, Table 2

Material.—USNM 218400, 1 (380 mm), 13 October 1963, *Silver Bay* station 5146, 19°55.5′ N, 72°00′ W, depth 860-910 m.

This six-gilled specimen, from off Haiti, is a female with eggs 2-3 mm long, apparently in quite early stages of development. The pattern of fused cusps, 3/3, and several other characters indicate relationship to *E. minor* (described below). It differs from that species, however, in having a longer tail, shorter branchial length, greater body depth, slightly higher tooth count, and a lower prebranchial slime-pore count. It is similar to *E. multidens* (described below), but differs particularly in hav-

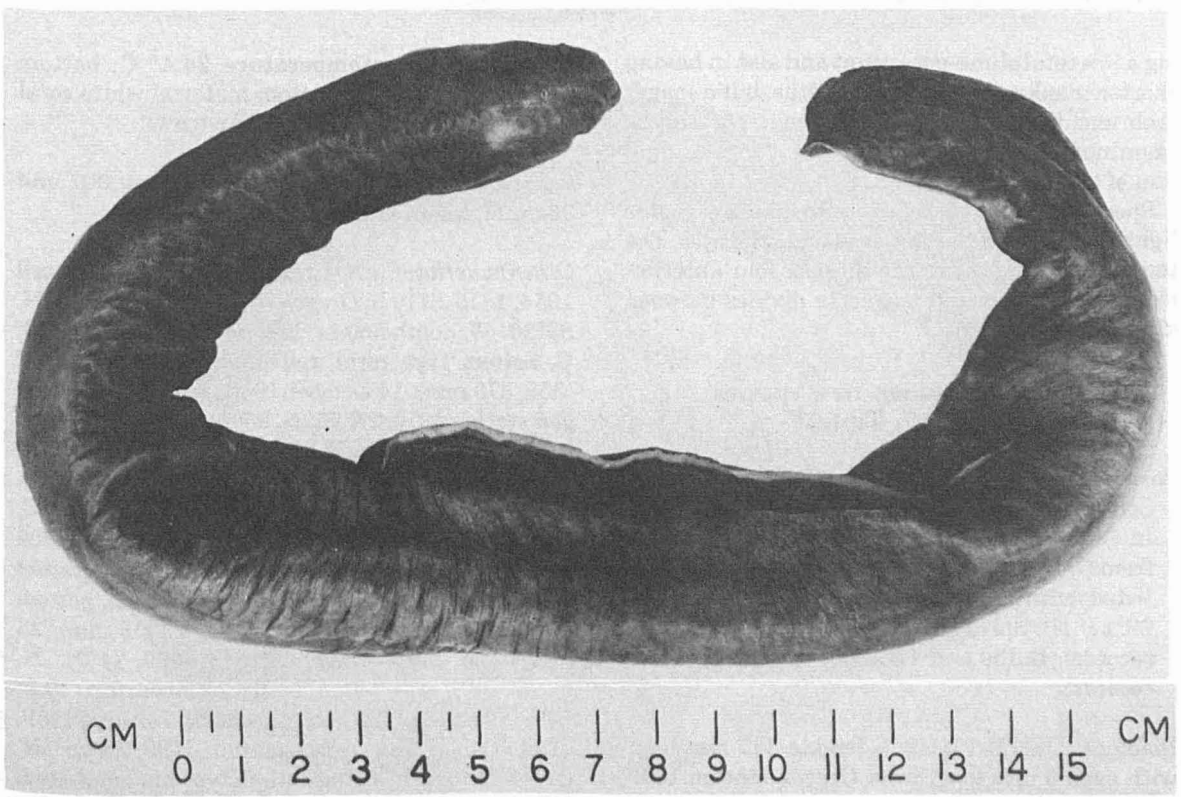

FIGURE 6.—*Eptatretus* sp. C (USNM 218400).

TABLE 2.—Characters of western Atlantic species of *Eptatretus* with 3/3 cusps (see text) of multicuspids of outer/inner row of teeth. Mean ± SD and range given for multiple specimens.

Item	*E. minor* n. sp. 17 specimens including holotype		Holo-type	*E. multidens* n. sp. 4 specimens including holotype		Holo-type	*E. multidens*? MCZ 40409	USNM 218405	*E.* sp. C
Depth of capture (m)	300-400		370	510-770		510	500	365	910
Total length, TL (mm)	330±47.8	223-395	359	526±125.3	377-655	600	331	364	380
Weight (g)	85±33.5	22-138	107	494±302.1	164-757	561	84	128	154
Measurements in thousandths of TL:									
Preocular length	55±8.8	31-62	59	46±3.1	43-49	43	—	61	59
Prebranchial length	243±14.3	201-259	245	200±8.4	188-207	202	214	236	237
Branchial length	59±7.6	51-72	71	65±4.0	61-69	62	73	78	47
Trunk length	529±15.1	506-559	522	560±8.0	552-571	560	517	504	526
Tail length	165±14.1	139-183	162	179±8.0	169-188	182	196	181	190
Body width	61±10.6	48-78	62	45±5.7	39-50	39	48	77	57
Body depth									
Including fin fold	94±12.3	71-114	92	104±16.0	80-115	109	97	114	100
Excluding fin fold	89±10.5	71-108	88	102±16.0	78-113	107	—	105	99
Over cloaca	69±9.1	52-79	74	72±8.8	60-81	81	69	82	84
Tail depth	82±14.8	53-116	84	76±8.7	66-86	79	97	107	79
Barbel length:									
First	17±2.8	13-23	16	12±3.4	8-15	15	14	16	13
Second	18±3.3	13-25	22	14±0.6	13-14	13	19	17	14
Third	25±4.7	14-32	30	18±2.3	15-20	18	21	24	21
Counts:									
Teeth:									
Cusps on multicuspids	3/3		3/3	3/3		3/3	3/3	3/3	3/3
Unicuspids, outer row[1]		8-11	9 + 8		11-12	12 + 11	11 + 12	12 + 13	12 + 12
Unicuspids, inner row[1]		8-10	9 + 9		9-11	11 + 11	10 + 11	10 + 11	11 + 11
Total sum of cusps	50±2.7	46-54	47	55±2.4	52-57	57	56	58	58
Slime pores, left side:									
Prebranchial	16±1.0	15-18	15	15±1.0	14-16	16	13	15	13
Branchial	5.0±0.4	4-6	5	5.5±0.6	5-6	5	6	6	4
Trunk	45±2.1	41-48	48	54±1.5	52-55	55	50	47	44
Tail	12.4±0.7	11-14	12	15±0.0	15	15	12	11	14
Total sum	78±2.6	74-82	80	89±1.8	87-91	91	81	79	75
Gill apertures[1]	11.9±0.5	10-12	6 + 6	12±0.0	12	6 + 6	7 + 7	7 + 7	6 + 6

[1]Left + right count for single specimen.

ing a low total slime-pore count and also in having shorter trunk and branchial lengths, but a longer prebranchial length. Until more material can be examined, it seems desirable to delay the designation of this specimen as a new species.

Species C is light brown with plainly visible lighter patches on the skin overlying the eyes. The tongue muscle overlies the three or four anterior-most gill pouches and the aorta divides between gill pouches 5 and 6.

Eptatretus minor, new species
Figure 7, Table 2

Paramyxine springeri (in part).—Bigelow and Schroeder 1952:1-10 (the 338 mm long specimen in "additional material" stated to have come from *Oregon* station 321, which was erroneously listed with lat. 27°27′ N; correct latitude is 29°27′ N). Springer and Bullis 1956:40 (survey records). Bullis and Thompson 1965:17 (survey records).

Holotype: USNM 164119, a female 359 mm long, with eggs 9 mm long, from *Oregon* station 1009, 24°34′ N, 83°34′ W, 370 m, 14 April 1954, 0450-0730 h; surface temperature 24.4° C, bottom temperature 11.7° C; bottom material white coral and mud; in 12 m (40-ft) shrimp trawl.

Paratypes: USNM 218399, two females, 307 and 334 mm, taken with the holotype.

Other material: FMNH 59959, 1 (340 mm), 13 April 1954, 1815-2110 h, *Oregon* station 1006, 24°20′ N, 83°20′ W, depth 350 m, bottom temperature 10.6° C, bottom type coral and mud; FMNH 65817, 2 (355, 370 mm), 14 October 1959, 1805-2150 h, *Oregon* station 2670, 24°26′ N, 83°24′ W, depth 390 m, bottom type mud; MCZ 38707, 1 (313 mm), 19 April 1954, 2115-2300 h, *Oregon* station 1026, 25°08′ N, 84°19′ W, depth 300 m, bottom temperature 10° C, bottom type sand and gravel; MCZ 40679, 1 (306 mm), 7 June 1959, 1940-2140 h, *Silver Bay* station 1189, 24°20.5′ N, 83°25′ W, depth 300 m, bottom type mud and sand; MCZ 51084, 1 (355 mm), 23 November 1963, *Oregon* station 4529, 24°31′ N, 83°26′ W, depth 390 m, bottom temperature 10.2° C; SIO 76-251, 3 (223, 223, 310 mm), 7-8 June 1959, 2245-0045 h, *Silver Bay* station 1190, 24°28′ N, 83°34′ W, depth 330 m, bottom type mud and sand; SIO 76-249, 1 (341 mm), 26 July 1963, *Oregon*

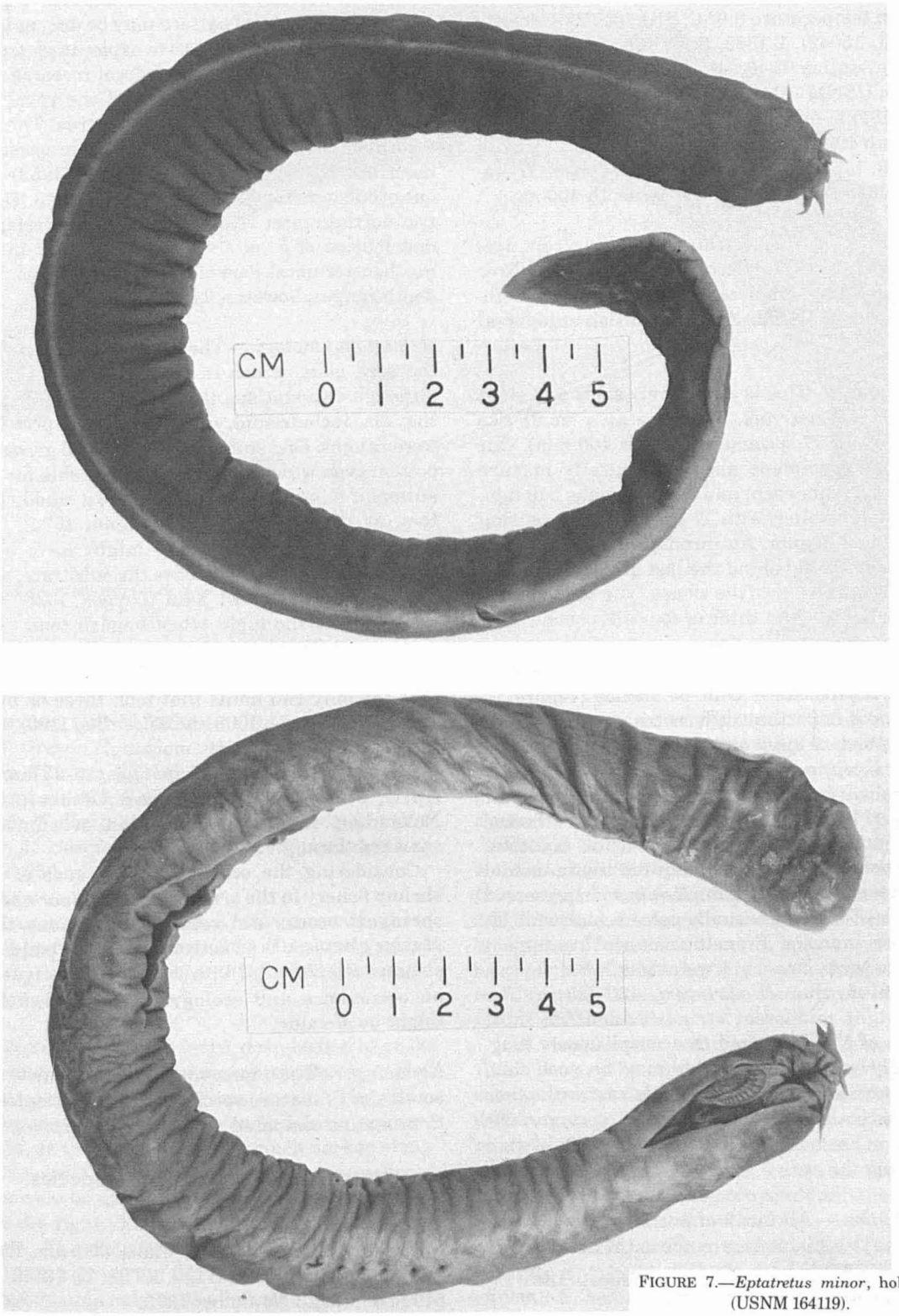

FIGURE 7.—*Eptatretus minor*, holotype (USNM 164119).

station 4338, 24°18′ N, 83°18′ W, depth 380 m, bottom temperature 8.9° C; SIO 76-250 (formerly UMML 15042), 2 (385, 395 mm), 29 July 1963, *Oregon* station 4346, 24°28′ N, 83°29′ W, depth 380 m; USNM 161513,[4] 1 (332 mm), 28 April 1951, 1630-1817 h, *Oregon* station 321, 29°27′ N, 87°19′ W, depth 400 m, bottom temperature 10° C; USNM 218398, 1 (358 mm), 23 June 1969, *Oregon II* station 10643, 29°30′ N, 87°09′ W, depth 400 m.

Diagnosis.—An *Eptatretus* with six (rarely five) gill apertures. Total cusp count 46-54, with three teeth fused in both outer and inner rows of teeth. Slime pores 74-82. A thin whitish middorsal stripe.

Description.—This is a relatively short and stout species of *Eptatretus*, maturing at a small size (none of our 17 specimens exceeds 400 mm). Our shortest specimens are two sexually mature males, 223 mm each, and a ripe female, 310 mm, extremely swollen with 12 eggs, each measuring about 10 × 31 mm. An inconspicuous ventral fin fold begins well behind the last gill aperture and extends backward to the cloaca. The tongue muscle overlies the first three or four gill pouches and the aorta branches between pouches 5 and 6.

Eptatretus minor and *E. springeri* are sympatric in the northeastern Gulf of Mexico (Figure 1). There are important differences between them. The pattern of fused teeth is 3/3 in *E. minor* and 3/2 in *E. springeri* (Figure 2). There may be a difference in the relative trunk lengths, *E. springeri* being longer. This difference is reflected in the nonoverlapping counts of trunk and total slime pores. The relative length of the branchial region tends to be greater in *E. minor*. In preserved material *E. minor* is usually pale in color, while *E. springeri* is darker. From the material available it appears that *E. minor* lives at shallower depths, 300-400 m, than *E. springeri*, 420-730 m. The thin, light middorsal stripe, evident on most species of *E. minor*, and the conspicuously long, laterally protruding barbels may be good field characters for that species. In contrast with other field species of *Eptatretus*, neither *E. springeri* nor *E. minor* has a conspicuous lighter patch of skin overlying the eye.

Distribution.—All but 2 of our 17 specimens are from the Dry Tortugas grounds in the archipelago extending westerly from the Florida Keys (Figure 1). The distributional pattern may be due, at least to some extent, to the massive exploratory trawling activities carried out by federal research vessels to monitor the population of the royal red shrimp, *Pleoticus robustus*, in that area. The two records outside this area are the 338 mm specimen described by Bigelow and Schroeder (1952) and one of 358 mm from *Oregon II* station 10643. These two northernmost records indicate an overlap in distribution of *E. minor* and *E. springeri* in the northeasternmost part of the Gulf of Mexico. The depth ranges, however, do not overlap.

Habitat and biology.—The bottom temperature in the area of *E. minor* is about 8.9°-11.5° C, and although two stations list coral as bottom type, they also include mud, where the hagfish probably were caught. One station lists sand and gravel as bottom type which would be less suitable for the animal if *E. minor* usually digs into a muddy bottom, as does *E. burgeri* (Fernholm 1974). The specimen from that station might have been caught when swimming above the substrate, as is likely, since the trawl haul (*Oregon* 1026) was taken during the night when hagfish tend to be most active (Fernholm 1974). An indication of increased night activity may also be found in the fact that the only two hauls that took three or more specimens (*Oregon* 1009 and *Silver Bay* 1190) were taken at night or in early morning.

Some females contained ripe eggs (25-33 mm) in April, June, July, September, October, and November; thus the population presumably spawned throughout the year.

Considering the economic importance of the shrimp fishery in the areas where *E. minor* and *E. springeri* occur, and recent suggestions that *Myxine glutinosa* is an active predator on pandalid shrimps (Shelton 1978), a detailed investigation on occurrence and ecology of these hagfishes might be of value.

Etymology.—The name *minor*, small, refers to the small size of mature specimens in our samples of *E. minor*, as compared with those of *E. springeri*.

Eptatretus multidens, new species
Figure 8, Table 2

Holotype: USNM 218401, a male, 600 mm long, from *Oregon II* station 11299, 12°52′ N, 70°43′ W, 510 m depth, 23 November 1970.

[4] "Additional material" of Bigelow and Schroeder (1952) and labelled paratype of *Paramyxine springeri*.

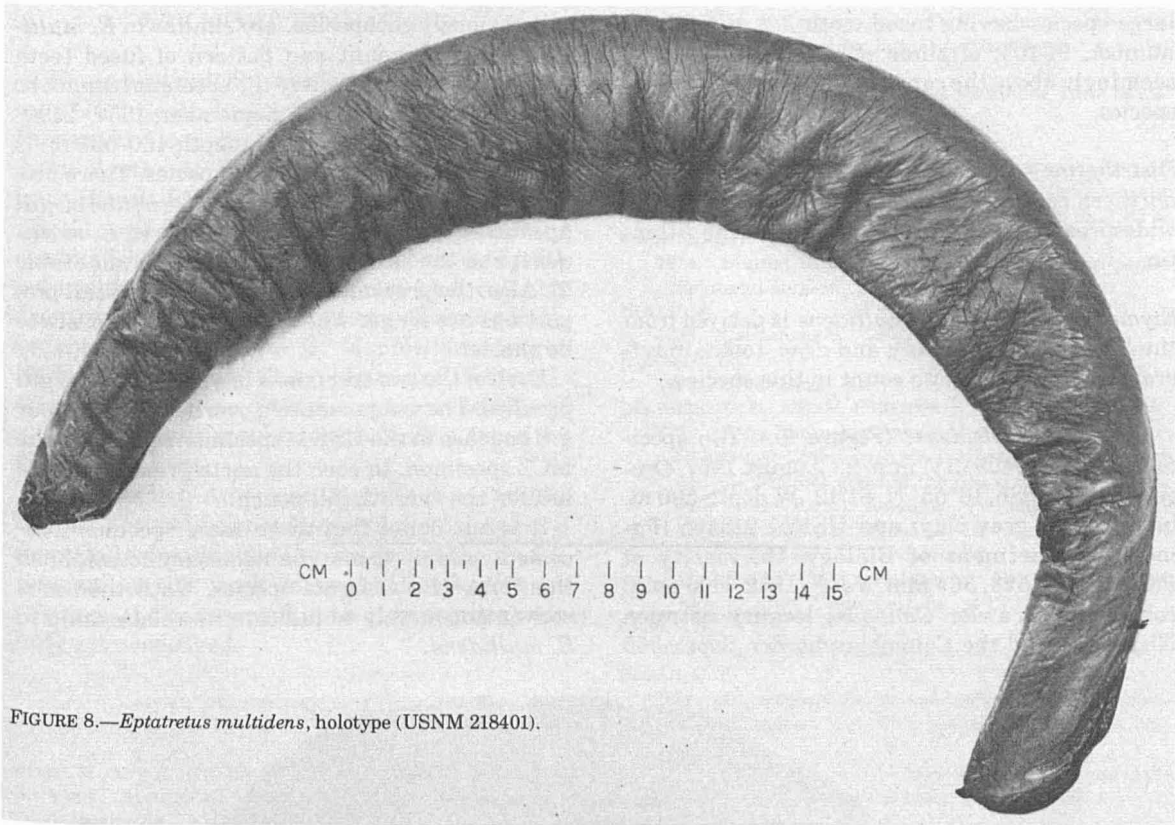

FIGURE 8.—*Eptatretus multidens*, holotype (USNM 218401).

Paratypes: USNM 218404, 1 (655 mm), 12 May 1969, *Oregon II* station 10611, 7°13′ N, 52°52′ W, depth 770 m; USNM 218403, 1 (473 mm), 19 November 1969, *Oregon II* station 10804, 7°18′ N, 52°56′ W, depth 710-630 m; USNM 218402, 1 (377 mm), 23 November 1970, *Oregon II* station 11300, depth 550 m.

Diagnosis.—A six-gilled *Eptatretus* with three fused teeth in each row (3/3). Total cusp count 52-57. Slime pores 87-91. No middorsal light stripe.

Description.—This is a large, deep-bodied hagfish. The color of the four preserved specimens varies from pale brown to medium brown. The paler specimens may have been bleached during preservation, as the wrinkled tail is much darker along the creases. On the paler specimens the eyespots can barely be discerned, while on the darker animals the light skin overlying the eyes is clearly visible. The holotype appears bleached on the right anterior part of the body which renders the eyespot visible only on the left side. A small ventral fin fold of noncontrasting brownish color is evident from the middle of the body to the cloaca.

The tongue muscle overlies the first two or three gill pouches, and the aorta branches at the level of the sixth posteriormost gill pouch.

When *E. multidens* is compared with *E. springeri*, noticeable differences in addition to the important pattern of fused teeth are the longer tail and branchial area but shorter prebranchial of *E. multidens*. These differences in body proportions are reflected in the higher slime-pore counts in tail and branchial areas and the lower prebranchial counts of *E. multidens*.

If *E. multidens* is compared with *E. minor*, to which it may be closely related by having the common pattern of fused teeth, it is found that the differences in body proportions are not pronounced. The best definitive characters to separate these two species seem to be the nonoverlapping trunk or total slime-pore count and the more noticeable eyespot in *E. multidens*.

Other than *E. springeri* and *E. minor*, the only Atlantic *Eptatretus* with six gills is the probably endemic *E. hexatrema* from South Africa. This is a

large species having fused teeth 3/2 and a high number, 91-105, of slime pores (Strahan 1975), seemingly above the range of the western Atlantic species.

Distribution.—Records of this species along the northern coast of South America indicate it to be widespread in both the Caribbean and the Atlantic.

Etymology.—The name *multidens* is derived from the Latin *mult(us)*, many, and *dens*, tooth, in reference to the high tooth count in this species.

Eptatretus multidens? (Figure 9).—Two specimens, MCZ 40409 (331 mm, 23 August 1957, *Oregon* station 1886, 16°55′ N, 81°12′ W, depth 500 m, bottom type gray clay) and USNM 218405 (formerly Department of Biology, University of Panama, no. 523, 364 mm, 5 July 1972, chartered commercial trawler *Canopus*, locality between Nicaragua and the Colombian border, depth 365 m), obviously conspecific, are similar to *E. multidens* in tooth count and pattern of fused teeth (3/3). A third record where the specimen cannot be located (MCZ 40218, 16 September 1957, 2100-2200 h, *Oregon* station 1945, depth 460-550 m) is inferred to belong to the same species. There are, however, important differences in counts of gill apertures, 7 + 7, instead of 6 + 6 as in *E. multidens*, and the slime pores seem to be fewer (Table 2). Also, the prebranchial, branchial, and tail proportions are longer whereas the trunk appears to be shorter.

Each of the two specimens has seven pairs of gill pouches. The tongue muscle overlies three or four gill pouches in the USNM specimen and five in the MCZ specimen. In each the aorta branches at the level of the seventh gill pouch.

It is our belief that when more specimens become available it may be necessary to establish this form as a separate species. Until then it is convenient merely to indicate its relationship to *E. multidens*.

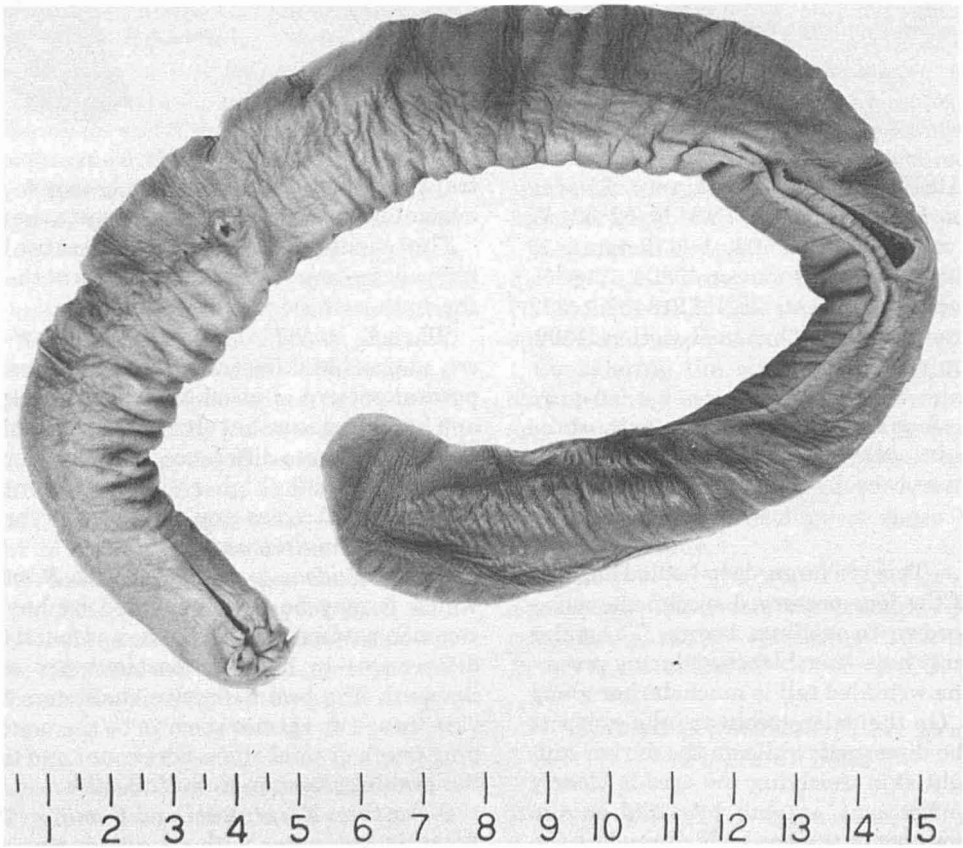

FIGURE 9.—*Eptatretus multidens*? (MCZ 40409). Scale in centimeters.

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