

THE CORRELATION BETWEEN NUMBERS OF VERTEBRAE AND LATERAL-LINE SCALES IN WESTERN ATLANTIC LIZARDFISHES (SYNODONTIDAE)¹

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ABSTRACT

The 10 species of Synodontidae in the western Atlantic have a positive correlation between numbers of vertebrae and pored lateral-line scales. A ratio of close to 1:1 exists for all species, with individuals having from four more to two fewer scales than vertebrae, and the majority having at least one more scale than vertebrae. Geographic variation is suggested by vertebral counts of four species, and possible taxonomic heterogeneity is indicated by the counts of a fifth species. Scale counts are bilaterally symmetrical in most individuals and differ by one scale in most of the rest. Vertebral and scale counts are given for type specimens at the U.S. National Museum of Natural History.

The principal purpose of this paper is to describe the complements and correlations of vertebrae and pored lateral-line scales in samples of the western Atlantic species of Synodontidae, as a contribution to the knowledge of their morphology and to facilitate specific identification of various life history stages.

The species of the lizardfish family Synodontidae have been distinguished in part by differences in number of pored lateral-line scales for juvenile and adult stages (e.g. Norman 1935; Anderson et al. 1966a, b) and in number of myomeres for larval and prejuvenile stages (Gibbs 1959). Accurate scale counts may be impossible in damaged or small specimens, and myomeres are difficult to count in all but young stages. Numbers of myomeres in individual fish are equal or about equal to numbers of vertebrae, but species complements of vertebrae in synodontids have not been analyzed or utilized.

For the 10 species of lizardfishes in the western Atlantic, we have determined that:

- 1) complements of vertebrae and intraspecifically

variable with a relatively normal distribution around the mean (as occurs with complements of scales and myomeres);

- 2) numbers of vertebrae have a positive correlation to numbers of pored lateral-line scales;
- 3) in individuals, the number of vertebrae is in a ratio of close to 1:1 to the number of pored lateral-line scales, with scales ranging from two less to four more than vertebrae in our samples, and the majority of specimens of all species having more scales than vertebrae.

MATERIALS AND METHODS

Specimens used in this study are in the collections of the Florida State Museum (formerly in the Tropical Atlantic Biological Laboratory, Miami, Fla. and the Biological Laboratory at Brunswick, Ga.), the Academy of Natural Sciences of Philadelphia, and the U.S. National Museum of Natural History (USNM). Some of the specimens used in these analyses were specifically selected from material previously reported by us (Anderson et al. 1966a) to encompass high and low values in scale counts of the various species or to obtain geographic coverage.

Identifications, measurements, and counts were made as described by Anderson et al. (1966a) with the following additions:

Vertebrae—counted from the anteriormost centrum articulating with the occipitals to and

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including the triangular-shaped last or ultimate centrum articulating with the hypural bones. All counts were made from X rays. Vertebral counts for individual specimens are used twice in correlations with paired (bilateral) scale counts. Specimens with obvious abnormalities in vertebral structure were not included in the tabulations.

Pored lateral-line scales—counted from the first pored scale in the lateral line to and including the last pored scale in the lateral line, lateral to the median base of the caudal-fin rays. Specimens with one or more scales missing from the lateral line were included in the tabulations, if the position of the scale pockets or the remaining scales were adequate to allow an accurate reconstruction. Bilateral counts were made for each specimen, and the counts for both sides of each fish were included in all tables and in the correlations with vertebrae. The term scale or scales refers specifically to pored scales in the lateral line.

RESULTS

Vertebrae

Vertebrae in our samples of the 10 western Atlantic species range from 44 to 62. We know of one higher count for a synodontid—the holotype of *Synodus ulae* from Hawaii has 64 vertebrae. Statistics based on vertebral samples for the western Atlantic species are listed in Table 1 and graphically depicted in Figure 1. Samples of at least six of the species are probably too small (and possibly too heterogeneous) to adequately define the ranges of vertebral complements for these species. This is obvious from comparison of skewedness of the range and/or stan-

dard deviations and the relatively large values of the standard errors. For the two species for which we have the largest and most reliable samples, *Sy. foetens* and *Sy. intermedius*, the relation of variance to meristic complement is similar to that we have noted in some other fish families—the species with the larger number or larger range of elements has the greater variance. The extremely high variance and extensive range of vertebrae in *Saurida caribbaea* suggest a taxonomic or ontogenetic problem as yet unidentified.

Intraspecific geographic variation in these lizardfishes has not been investigated, but our limited samples of four of the species suggest that it may exist. *Synodus intermedius* appears to have fewer vertebrae in tropical continental waters and more in insular areas than in temperate and subtropical continental waters.

Area	n	\bar{x}
U.S.—Mexico	37	48.2
Honduras—Surinam	21	47.6
Brazil	25	48.6

These samples are relatively homogeneous, and the means of the three samples are significantly different ($P < 0.01$, anova). *Synodus foetens* may have a parabolic cline in mean vertebral number, with lower average numbers in tropical areas and higher average numbers to the more temperate north and south.

Area	n	\bar{x}
U.S.—Mexico	98	59.6
Honduras—Surinam	9	58.1
Brazil	10	59.6

TABLE 1.—Statistics from numbers of vertebrae, numbers of pored lateral-line scales, and correlation coefficients of the two variates from samples of the 10 species of western Atlantic Synodontidae.

Species	Vertebrae						Scales				Correlation (r)
	No.	Range	Mean	SD	SE	Var.	No.	Range	Mean	Var.	
<i>Synodus foetens</i>	118	56-62	59.4	1.4082	0.1296	1.98	236	57-63	61.1	2.11	0.86
<i>Synodus saurus</i>	14	56-58	57.6	0.6667	0.1693	0.40	28	58-60	58.9	0.57	0.20
<i>Synodus synodus</i>	11	55-57	55.7	0.9045	0.2727	0.82	20	55-58	56.1	0.68	0.44
<i>Synodus intermedius</i>	85	47-50	48.2	0.7661	0.0831	0.59	170	47-51	49.1	0.94	0.76
<i>Synodus poeyi</i>	19	44-48	45.6	1.2996	0.2965	1.69	38	43-48	45.8	3.00	0.83
<i>Trachinocephalus myops</i>	11	54-57	55.4	0.9244	0.2787	0.85	22	54-58	56.4	0.92	0.37
<i>Saurida brasiliensis</i>	10	46-48	46.7	0.8233	0.2603	0.68	20	47-49	48.2	0.56	0.52
<i>Saurida normani</i>	11	49-52	50.9	1.1362	0.3423	1.30	22	52-56	54.0	1.38	0.84
<i>Saurida suspicio</i>	11	49-52	51.3	0.9045	0.2727	0.82	22	52-54	52.8	0.47	0.50
<i>Saurida caribbaea</i>	27	48-58	54.2	2.6651	0.5129	7.10	38	51-60	56.2	8.69	0.96

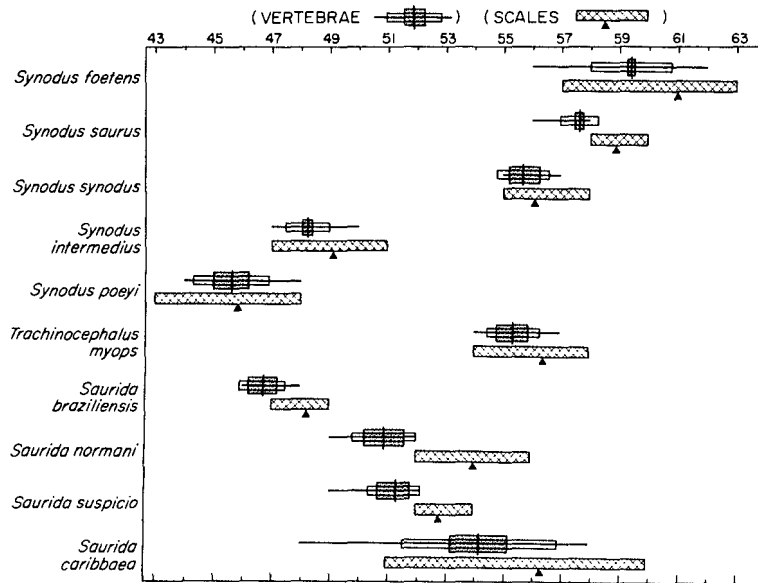


FIGURE 1.—Numbers and statistics of vertebrae and scales of the 10 species of western Atlantic Synodontidae. Vertebrae: range—horizontal line; mean—vertical line; standard deviation, one on each side of the mean—open rectangle; standard error—two on each side of the mean—shaded rectangle. Scales: range—cross-hatched bar; mean—small triangle.

Synodus saurus from the eastern Atlantic (5 specimens) had a range in vertebrae of 55-59, greater than the western Atlantic (14 specimens) vertebrae range of 56-58. *Trachinocephalus myops* had varying but similar vertebral ranges in small samples encompassing its extensive geographic range.

Area	n	\bar{x}	Range
U.S.—Brazil	11	55.4	54-57
Nigeria	1	55.0	55
Philippines	7	53.1	52-54
Hawaii	5	54.8	54-55

Abnormalities in vertebral structure (specimens not included in the tables or figure) occurred in 11 of 317 western Atlantic specimens examined. In six, pairs of vertebrae were shortened with irregular and expanded ossifications at their adjoining ends. In five, a single centrum in the caudal region was elongated and had two neural spines (in two), two hemal spines (in two), or double neural and hemal spines (in one).

Scales

Pored lateral-line scales in our samples of the 10 western Atlantic species range from 43 to 63 (Table 1). We have not confirmed any higher or lower values for these or other species of the family. Ranges in scale complements that we have confirmed for specimens from the western Atlantic, with clarification where these ranges differ from those given by Anderson et al. (1966a), are:

Synodus foetens 57-64; the range of 56-65 given by Anderson et al. was in error, as determined by our reexamination of the material originally reported. *Synodus saurus* 56-60; the range of 55-62 given by Anderson et al. included a low count for an eastern Atlantic specimen and a published but unsubstantiated high count. *Synodus synodus* 54-59. *Synodus intermedius* 47-51; the range of 45-52 given by Anderson et al. was in error, as determined by our reexamination of the material originally reported. *Synodus poeyi* 43-48. *Trachinocephalus myops* 53-59; the

range of 51-61 reported by Anderson et al. was based on previously published records from other geographic areas. *Saurida brasiliensis* 43-49; the range of 40-50 reported in Anderson et al. was based on a low count previously published and currently unconfirmable and on a high count that we have since confirmed in a specimen from the eastern Atlantic. *Saurida normani* 51-56. *Saurida suspicio* 52-54; a high count of 56 previously published has not been confirmed by us. *Saurida caribbaea* 51-60; examination of additional specimens has enlarged the range of 54-60 given by Anderson et al.

Many of the specimens used in the confirmations above are not included in Table 1, because corresponding vertebral counts were not made.

Bilateral symmetry in scale numbers characterized one-half to three-quarters of the specimens of each species. In the total sample, 62% were bilaterally symmetrical. Asymmetry appears to be random, 20% having more scales on the left side and 18% having more scales on the right side. Asymmetry was of only one scale difference in all species, except in our largest species sample. In *Sy. foetens*, which also has the greatest number of scales, of 118 specimens 3 had two more scales on one side than the other, 52 had one more scale on one side than the other, and 63 were bilaterally symmetrical.

Correlations

Frequency distributions of numbers of vertebrae and associated numbers of pored lateral-line scales are shown for the two species for which we examined the largest number of specimens, *Sy. foetens* (Table 2) and *Sy. intermedius* (Table 3). The trend of positive correlation is apparent from visual inspection of both tables. The coefficients of correlation (Table 1) document the positive nature of the correlation, *Sy. foetens* ($r = 0.86$) and *Sy. intermedius* ($r = 0.76$) (Table 1).

The same kinds of data for the other eight species are given below, with number of vertebrae separated by a hyphen from the number of scales and followed in parentheses by the frequency for that combination:

Synodus saurus, vertebrae 56-58 scales (2), 57-58(1), 57-59(4), 57-60(1), 58-58(7), 58-59(8), 58-60(5). *Synodus synodus*, 55-55(3), 55-56(7),

TABLE 2.—Frequency distributions of numbers of vertebrae and pored lateral-line scales in 118 *Synodus foetens*.

Scales	Vertebrae						
	56	57	58	59	60	61	62
63	—	—	—	—	10	25	2
62	—	—	—	4	57	15	2
61	—	—	4	15	21	4	—
60	—	1	19	14	2	—	—
59	4	15	5	2	2	—	—
58	4	7	—	1	—	—	—
57	—	1	—	—	—	—	—

TABLE 3.—Frequency distributions of numbers of vertebrae and pored lateral-line scales in 85 *Synodus intermedius*.

Scales	Vertebrae			
	47	48	49	50
51	—	1	9	2
50	—	5	37	2
49	2	44	16	—
48	26	21	—	—
47	2	3	—	—

56-55(1), 56-56(1), 56-57(2), 57-55(1), 57-56(2), 57-57(2), 57-58(1). *Synodus poeyi*, 44-43(4), 44-44(2), 44-45(3), 44-46(1), 45-43(1), 45-44(2), 45-45(1), 45-46(2), 46-44(1), 46-45(2), 46-46(2), 46-47(9), 47-48(4), 48-48(4). *Trachinocephalus myops*, 54-56(3), 54-57(1), 55-54(1), 55-55(2), 55-56(3), 55-57(2), 56-56(1), 56-57(5), 56-58(2), 57-56(1), 57-57(1). *Saurida brasiliensis*, 46-47(4), 46-48(6), 47-49(6), 48-48(3), 48-49(1). *Saurida normani*, 49-52(3), 49-53(1), 50-53(2), 51-53(1), 51-54(3), 51-55(4), 52-54(2), 52-55(5), 52-56(1). *Saurida suspicio*, 49-52(1), 49-53(1), 51-52(7), 51-53(3), 52-53(7), 52-54(3). *Saurida caribbaea*, 48-51(2), 49-51(3), 50-52(2), 52-53(3), 52-54(1), 54-55(1), 54-56(1), 54-58(2), 55-57(2), 55-58(3), 55-59(5), 56-57(3), 56-58(4), 56-59(1), 57-59(2), 58-60(2).

The correlation coefficients of the samples for all species are positive, ranging from 0.96 for *Sa. caribbaea* to 0.20 for *Sy. saurus* (Table 1). The species with the larger number of specimens (19 to 118) generally had the higher correlation coefficients (r 0.76 to 0.96). Of the species with a lesser number of specimens (11 to 14), one had a high positive value (0.84), and the others were low (0.20 to 0.52). We suspect that the relatively low value of positive correlation for five of the species is due to the small and somewhat heterogeneous samples used for these species.

Statistics describing the samples of vertebrae and scales for each species (from Table 1) are illustrated in Figure 1. The nature of positive

correlation of vertebrae and scales for the 10 species is apparent in this figure.

The ratio of scales to vertebrae is nearly 1:1 for the 10 species, but in each species the total number of scales averages slightly more than the total number of vertebrae (50% or more of the scale counts in any species are greater than the vertebral counts). In species of *Saurida* the number of scales averages from one to three more than the number of vertebrae and ranges from an equal number of each to four more scales than vertebrae. In species of *Synodus* and in *Trachinocephalus* the number of scales averages one or two more than the number of vertebrae and ranges from two fewer to three more scales than vertebrae. Of 118 *Sy. foetens* 10% had three more scales than vertebrae, 57% had two more scales, 27% had one more, 5% had an equal number, and 1% had one less scale than vertebrae.

The positional relationship of scales to vertebrae in lateral aspect was investigated. In a *Sy. foetens* with 62 pored lateral-line scales on each side and 60 vertebrae, pins were inserted at the posterior margins of certain numbered lateral-line scales on the left side, and the specimen was X-rayed. The first scale was lateral to the junction of the 4th and 5th centra, the 30th scale was lateral to the junction of the 32nd and 33rd centra, the 60th scale was lateral to the last centrum, and the last scale was lateral to the posterior ends of the hypural bones and overlapping anterior ends of the median caudal-fin rays. Similarly, in a *Sy. intermedius* with 49 scales on each side and 48 vertebrae the first scale was lateral to the 4th centrum, the 47th scale was lateral to the 48th centrum, and the last scale was lateral to the posterior ends of the hypural bones.

DATA ON TYPE SPECIMENS AT USNM

Counts of vertebrae and pored lateral-line scales on type specimens of 12 nominal species of Synodontidae in the U.S. National Museum of Natural History are recorded here for use in future studies. The four data items following the collection number for each type specimen are,

in sequence, number of vertebrae, number of left-side scales, number of right-side scales, and standard length in millimeters:

Synodus binotatus Schultz, holotype USNM 140801, 53-54-ca. 54-86.5. *Synodus cinereus* Hildebrand, holotype USNM 53079, 57-58-59-112. *Synodus englemani* Schultz, holotype USNM 140815, 59-60-60-104. *Synodus evermanni* Jordan and Bollman, one of 11 syntypes USNM 41144, 47-48-48-142. *Synodus jenkinsi* Jordan and Bollman, holotype USNM 41171, 60-ca. 60-61-282. *Synodus lacertinus* Gilbert, holotype USNM 44300, 61-63-62-129. *Synodus marchenae* Hildebrand, holotype USNM 120171, 60-62-62-50.5. *Synodus sechurae* Hildebrand, holotype USNM 127829, 57-58-58-130. *Synodus simulans* Garman, paratype USNM 153607, 60-ca. 62-ca. 61-ca. 45. *Synodus ulae* Schultz, holotype USNM 52671, 64-ca. 63-ca. 63-177. *Saurida eso* Jordan and Herre, holotype USNM 57847, 59-62-61-290. *Saurida normani* Longley, holotype USNM 107330, 52-52-53-320.

In these type specimens the ratio of nearly 1:1 for number of vertebrae and scales suggests a positive correlation of these two variates in the species that they represent.

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