Pacific Science (1988), vol. 42, nos. 3–4

A Revision of the Hawaiian Lizardfishes of the Genus *Synodus*, with Descriptions of Four New Species[1]

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ABSTRACT: The Hawaiian lizardfishes of the genus *Synodus* are reviewed; 4 new species are described (bringing to 12 the number known from Hawaii), and the range of *S. capricornis* Cressey and Randall is extended to the Northern Hemisphere. It is also determined that the name *Synodus variegatus* (Lacépède) properly applies to the species commonly known as *S. englemani* Schultz. *Synodus dermatogenys* Fowler is the oldest available name for the species that has been known as *S. variegatus*. Gill-raker counts are used as diagnostic characters for the first time with synodontids, and color slides and observations of fresh specimens revealed species-specific pigmentation patterns, many of which typically disappear with preservation. The key includes all known lizardfishes from Hawaii (genera *Saurida, Synodus, Trachinocephalus*).

Synodus amaranthus sp. nov. is similar to *S. dermatogenys* but differs in having barred pelvic fins; more gill rakers; and greater head length, orbit diameter, and pectoral fin length. *Synodus falcatus* sp. nov. and *S. janus* sp. nov. have the high vertebral and lateral-line scale counts typical of *S. ulae* Schultz and *S. capricornis*, but have fewer gill rakers and different nasal flaps. *Synodus lobeli* sp. nov. is closest to *S. indicus* (Day), a species known only from the Indian Ocean and the Philippines, but has a shorter head, lower modal number of dorsal fin rays, and lacks the two dark marks found on the opercle of the latter species.

Electrophoretic data are presented for the seven species (*binotatus, dermatogenys, doaki, falcatus, ulae, usitatus,* and *variegatus*) for which fresh or frozen material was available. Each of these species could be separated from all others on the basis of multiple fixed allelic differences, and this facilitated unambiguous identification of morphologically similar species. Discriminant function analysis, with functions derived for groups identified by electrophoretic phenotype, was used in the identification of specimens that could not be sampled electrophoretically.

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[1] Color plates that appear in this paper were financed by a grant from the Englehard Foundation. Manuscript accepted 8 October 1987.

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THE LIZARDFISHES (family Synodontidae) are elongate, demersal predators that inhabit tropical and warm temperate seas from very shallow water to approx. 300 m. The genus *Synodus* is most diverse in the Indo-West Pacific, where the number of recognized species has more than tripled in the last 50 years [19 species in Cressey (1981) compared to 6 species in Norman (1935)]. A parallel pattern is seen in Hawaii: Cressey (1981) recognized 7 species, while Gosline and Brock (1960) reported only 4. This review further extends the list of *Synodus* species in Hawaii to 12, including 4 new species and a significant range extension for *S. capricornis* Cressey and Randall, 1978. We also show that the name *Synodus variegatus* (Lacépède, 1803) properly applies to the species commonly known as *S. englemani* Schultz, 1953. *Synodus dermatogenys* Fowler, 1912, is the oldest available name for the species that has been misidentified as *S. variegatus*.

The rapid increase in the number of recognized species of *Synodus* can be largely attributed to three factors. (1) Depth range of samples: Most of the recently described species are from slightly deeper water than are the older species. *Synodus lobeli*, sp. nov., and *S. capricornis* were collected by spear at about 30 m, the limit for routine sport divers. *Synodus doaki* Russell and Cressey, 1979, *S. usitatus* Cressey, 1981, and *S. falcatus*, sp. nov., are known in Hawaiian waters only from trawls at depths of about 100–200 m. (2) Electrophoresis: Biochemical genetic techniques are used here to identify unambiguously individuals from morphologically similar species. (3) Multivariate techniques: Analyses that simultaneously consider data from a number of variables often can separate species reliably even when no single character is diagnostic. The use of discriminant analysis based on data for specimens that have been phenotyped electrophoretically is a particularly powerful approach that has been used successfully with other morphologically cryptic species of Hawaiian fishes (Shaklee and Tamaru 1981, Waples 1981).

MATERIALS AND METHODS

Specimens from the following institutions were examined: Australian Museum, Sydney (AMS); Academy of Natural Sciences of Philadelphia (ANSP); British Museum (Natural History), London [BM(NH)]; Bernice Pauahi Bishop Museum, Honolulu (BPBM); California Academy of Sciences, San Francisco (CAS, SU); Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZ); Muséum National d'Histoire Naturelle, Paris (MNHN); National Science Museum, Tokyo (NSMT); Queensland Museum, Brisbane (QM); Scripps Institution of Oceanography, La Jolla, California (SIO); U.S. Fish Commission (USFC); U.S. National Museum of Natural History, Washington, D.C. (USNM).

Morphometrics and Meristics

Counts and measurements generally follow Hubbs and Lagler (1958). Standard length (SL) is the horizontal straight-line distance from the front of the upper lip to the caudal-fin base. Total length (TL) is the greatest horizontal length. Length of snout, diameter of orbit, and least interorbital distance were measured using bony parts of the orbit. Head length includes greatest extent of fleshy opercle. Vertebral counts were made from radiographs and include the hypural. All normal, pored scales in the lateral line were counted, but the modified scales (usually two to four) on the caudal base were not.

Other Morphological Characters

NASAL FLAP: Cressey and Randall (1978) and Cressey (1981) demonstrated the importance of the size and shape of the dermal flap over the anterior nares in identifying some *Synodus* species. Figure 1 illustrates this character in the Hawaiian species of the genus.

PERITONEAL SPOTS: Rows of dark spots persist on the peritoneum of adult *Synodus* as remnants of the well-known larval pigment spots of synodontids. A complete count requires opening the abdomen from the throat to posterior of the anal fin origin; the spots appear as small, discrete black dots ventrolaterally on either side of the fish.

GILL RAKERS: Gill rakers in synodontids are actually clusters of small tooth patches on the epi-, cerrato-, and basibranchials. Because of the difficulty in counting the patches on the basibranchial, only counts for the upper two bones are reported here. Tooth plates that merge near their base are counted as one, and the one patch in the angle is not counted (Figure 2). In many specimens, counts can be made directly with a dissecting microscope. Other specimens require staining to highlight the gill rakers (achieved by laying a wick saturated with alizarin in the gill opening for a few hours) or removal of the first gill arch.

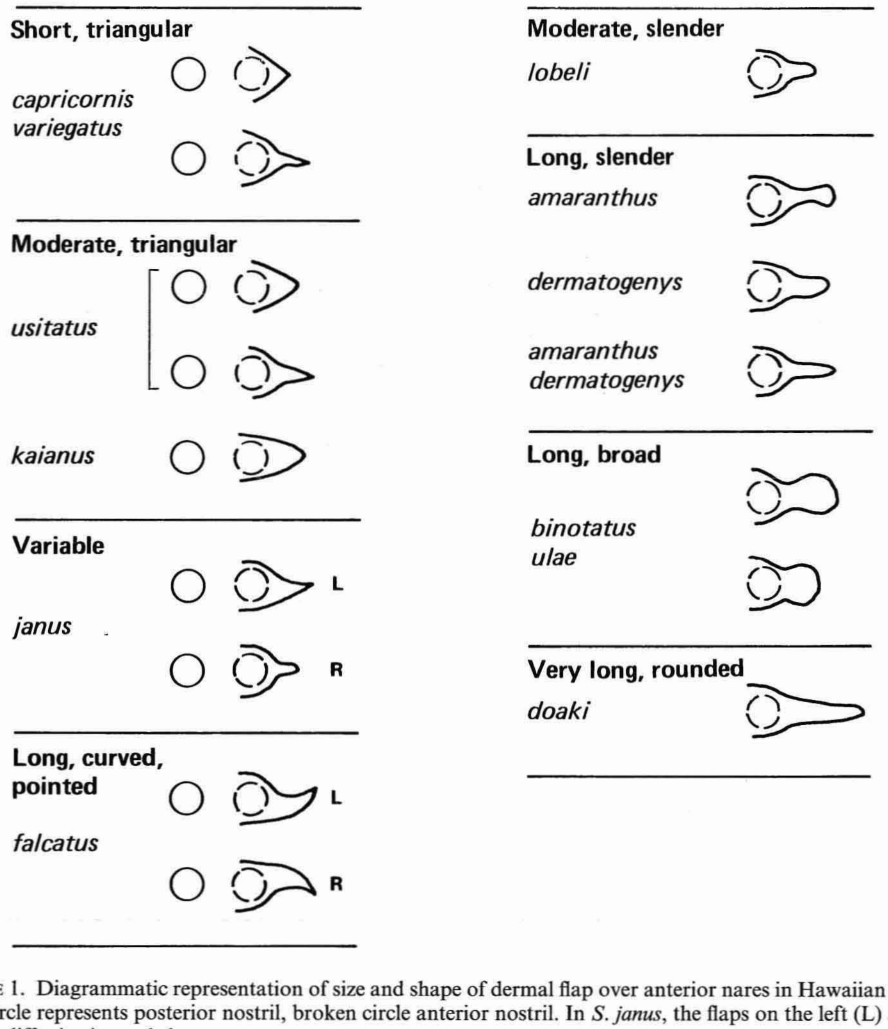


FIGURE 1. Diagrammatic representation of size and shape of dermal flap over anterior nares in Hawaiian *Synodus*. Closed circle represents posterior nostril, broken circle anterior nostril. In *S. janus*, the flaps on the left (L) and right (R) nares differ in size and shape.

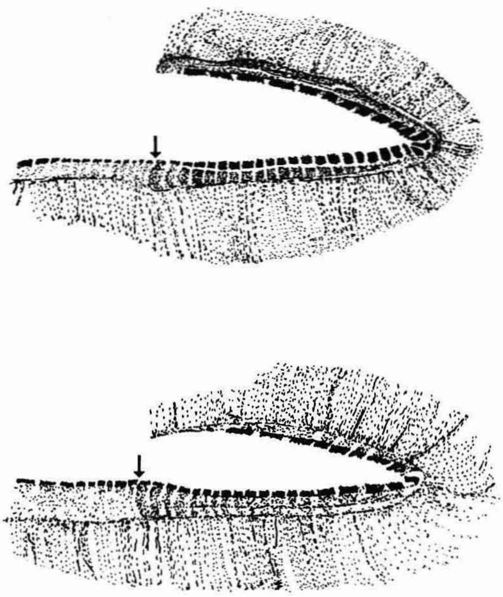


FIGURE 2. Drawing of the first gill arch from one specimen each of *Synodus variegatus* (above) and *S. dermatogenys* (below). Gill rakers are evident as discrete patches of teeth. Counts of gill rakers on upper and lower limbs are: *S. variegatus*—12 + 22 = 34; *S. dermatogenys*—8 + 18 = 26. The gill raker at the angle is not counted. Gill rakers are visible on the basibranchial (joint of basi- and cerratobranchials indicated by arrow), but are difficult to count without removing entire gill arch.

COLORATION: Markings on the back and along the side, presence of absence of bars on pelvic and anal fins, and presence of a red color phase are useful for separating many species. These features often fade or disappear completely with preservation, and their taxonomic value has not been fully appreciated. In the present study, much of the material was collected fresh by the authors, and field notes and color slides were used to document color patterns before preservation.

Electrophoresis

Waples (1981) described the procedures used for sampling and analyzing specimens by starch gel electrophoresis. The following species were assayed (number of specimens in parentheses): *Synodus binotatus* Schultz, 1953 (7); *S. doaki* (1); *S. variegatus* (8); *S. falcatus* (4); *S. ulae* Schultz, 1953 (45); *S. usitatus* (49); *S. dermatogenys* (24). No fresh or frozen material was available for *S. amaranthus* sp. nov., *S. capricornis*, *S. lobeli*, *S. kaianus* (Günther, 1880), or *S. janus* sp. nov. Previously, Shaklee et al. (1982) reported electrophoretic results for 29 presumptive gene loci in *S. binotatus*, *S.* "*englemani*" (=*S. variegatus*), *S. ulae*, and *S.* "*variegatus*" (=*S. dermatogenys*) using muscle, liver, and eye tissues. In this study, we provide new data for *S. doaki*, *S. falcatus*, and *S. usitatus*, frozen specimens of which were collected in the Northwest Hawaiian Islands by the Honolulu laboratory of the National Marine Fisheries Service. In these specimens, suitable enzymatic activity was found only in muscle tissue, so results presented here are limited to a number of easily resolved systems of diagnostic value. Aspartate aminotransferase (AAT) and glyceraldehyde-phosphate dehydrogenase (GAPDH) were resolved on *tris*-citric acid pH 6.9 gels (Whitt 1970); gels stained for creatine kinase (CK), glucose-phosphate isomerase (GPI), glycerol-3-phosphate dehydrogenase (G3PDH), lactate dehydrogenase (LDH), and phosphoglucomutase (PGM) were run on *tris*-citric acid pH 8.0 buffer of Selander et al. (1971).

Discriminant Function Analysis

In discriminant function analysis, data for a set of variables are considered simultaneously and used to construct discriminant functions (linear combinations of the original variables) that maximize separation of predefined groups. Species groups were defined by electrophoretic phenotype, and morphometric and meristic data for a suite of 19 characters were entered in the SPSS DISCRIMINANT program (Nie 1975) using DIRECT (not stepwise) mode. Input variables were: counts of dorsal and pectoral fin rays, lateral-line scales, vertebrae, and gill rakers (upper and lower limbs); and measurements [using raw (not ratio) data] of standard length, head length, snout length, orbit diameter, interorbital distance, upper jaw length, caudal peduncle depth, predorsal length, dorsal origin–adipose origin distance, dorsal fin base, and length of longest ray of dorsal, pectoral, and pelvic fins.

TABLE 1

VERTEBRAL AND LATERAL-LINE SCALE COUNTS IN HAWAIIAN *Synodus*

	VERTEBRAE															
	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
amaranthus								2	2	1						
binotatus		4	3													
capricornis													1	2		
dermatogenys						1	4	10	5							
doaki						1	1		1	1						
falcatus												2	8	10	8	1
janus													1			
kaianus									3	10	5	1				
lobeli		1	3	6	4											
ulae											1	22	25	10		
usitatus					1	4	7	2								
variegatus										6	3					

	LATERAL-LINE SCALES															
	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68
amaranthus								2	3							
binotatus	4	10	4													
capricornis													2	1		
dermatogenys							8	22	6	1						
doaki					1	1		2								
falcatus												4	6	11	11	3
janus													1			
kaianus								4	5	5	4	1				
lobeli	1	12	7													
ulae											5	19	42	13		
usitatus				4	3	10	3									
variegatus									2	5	6					

TABLE 2

DORSAL AND PECTORAL FIN RAY COUNTS FOR HAWAIIAN *Synodus*

	DORSAL RAYS						PECTORAL RAYS			
	10	11	12	13	14	15	11	12	13	14
amaranthus			2	3				2	3	
binotatus			4	15			1	17		
capricornis				3					3	
dermatogenys		5	30	2			1	18	18	
doaki				2	1	1			4	
falcatus			6	27	3	1		11	27	
janus			1						1	
kaianus	1	5	11	3				17	3	
lobeli		15	5					20		
ulae			2	47	30			3	70	6
usitatus		9	11	1				14	7	
variegatus			2	10	1			1	12	

TABLE 3

GILL-RAKER COUNTS FOR HAWAIIAN *Synodus*

	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
amaranthus							1		2	1	1									
binotatus						2	2	1		1					1					
capricornis													1		1		1			
dermatogenys	1		2	5	4	3	4					1								
doaki				1							2									
falcatus				5	4	9	5	7	2											
janus			1																	
kaianus	1			2	2	6	1	2												
lobeli			1	2	2	2														
ulae									2	5	5	6	12	8	3	6		3		1
usitatus						1		4		3	5	2	1	2						
variegatus												1	6	1	1	2	2			

KEY TO THE SYNODONTIDAE OF HAWAII

1a. Pelvic rays 9; two separate rows of teeth on the palate; several rows of teeth in both jaws visible when mouth closed . . . . 2 (*Saurida*)

1b. Pelvic rays 8; single row of teeth on the palate; single row of widely spaced teeth visible (on upper jaw) when mouth closed 4

2a. Lateral-line scales 52 or fewer; vertebrae 51 or fewer; usually 13 or fewer pectoral rays; no bright-orange coloration on mouth or body 3

2b. Lateral-line scales usually 54 or more; vertebrae usually 52 or more; usually 14 or more pectoral rays; fresh specimens with bright-orange bars on mouth and orange or rose tint on fins and body . . . . *Saurida flamma*

3a. Usually 12 pectoral rays; vomer toothless; inner palatine teeth in two distinct rows; pectoral fins reaching predorsal scale row 4–6 . . . . *Saurida nebulosa*

3b. Usually 13 pectoral rays; small patch of teeth on vomer (or outer palatine rows converge on vomer); pectoral fins reaching predorsal scale row 1–3 . . . . *Saurida gracilis*

4a. Anal fin rays 15–17; length of anal fin base >20% of standard length; scales present on procurrent caudal rays . . . . *Trachinocephalus myops*

4b. Anal fin rays 8–11; length of anal fin base <11% of standard length; no scales on procurrent caudal rays . . . . 5 (*Synodus*)

5a. Scale rows above lateral line 3.5 6

5b. Scale rows above lateral line 5.5 10

6a. Anterior palatine teeth longer than those posterior and in a discrete group; usually 13 or more dorsal fin rays; dorsal saddles usually prominent in fresh specimens 7

6b. Anterior palatine teeth not longer than posterior and not in a discrete group; usually 12 or fewer dorsal fin rays; dorsal saddles faint or lacking in fresh specimens 8

7a. Lateral-line scales 53–55; peritoneal spots 0–3; pectoral fin extending clearly beyond a line connecting origin of dorsal and pelvic fins; two prominent dark spots on tip of snout; maximum size <140 mm SL; taken in shallow water (<20 m) . . . . *S. binotatus*

7b. Lateral-line scales 57–60; peritoneal spots 6–14; pectoral fin extending to (but not beyond) a line connecting origin of dorsal and pelvic fins; two red spots on tip of snout in fresh specimens only; maximum size >240 mm SL; taken in deep water in Hawaii (>90 m) . . . . *S. doaki*

8a. Pectoral fin long, extending beyond line connecting origins of dorsal and pelvic fins; gill rakers 27–35; lateral-line scales 56–59, faint dorsal saddles may be present.......... *S. usitatus*

8b. Pectoral fin short, not reaching line connecting origins of dorsal and pelvic fin; gill rakers 22–29; fewer than 57 or more than 59 lateral-line scales; dorsal saddles absent 9

9a. Lateral-line scales 60–64; peritoneum black; posterior pelvic process narrow; tip of lower jaw fleshy; dorsum uniformly dark; three large, dark blotches along side, just below lateral line .... *S. kaianus*

9b. Lateral-line scales 53–56; peritoneum pale; posterior pelvic process wide; tip of lower jaw robust; dorsum greenish-gray with fine, dark, irregular markings; pale or blue stripe above lateral line but no markings below .... *S. lobeli*, sp. nov.

10a. Nasal flap on anterior nostril short and triangular (except for slender projection in some individuals), not reaching much beyond margin of anterior nares when depressed forward 11

10b. Nasal flap on anterior nostril longer, reaching at least one naris diameter beyond margin of anterior nares when depressed forward........ 12

11a. Lateral-line scales 61–63; vertebrae 61–62; 7–10 peritoneal spots; cheek completely scaled to margin of preopercle; a prominent dark stripe along side at level of lateral line .... *S. variegatus*

11b. Lateral-line scales 65–66; vertebrae 64–65; 10–12 peritoneal spots; no postoral cheek scales; a series of rectangular blotches, but no prominent stripe, along lateral line .... *S. capricornis*

12a. Lateral-line scales 62 or fewer; nasal flap long and slender........ 13

12b. Lateral-line scales 63 or more; nasal flap long and broad, long and curved, or variable (see Figure 1)........ 14

13a. A series of alternating light and dark bars visible on pelvic fins even in preserved specimens; 28–32 gill rakers; diameter of bony orbit 5.4–6.1% of standard length; length of longest ray of pectoral fin 10.3–11.3% of standard length.. *S. amaranthus*, sp. nov.

13b. No markings on pelvic fins even in fresh specimens; usually 28 or fewer gill rakers; diameter of bony orbit 3.4–5.3% of standard length; length of longest pectoral ray 9.0–10.5% of standard length........ *S. dermatogenys*

14a. Nasal flap long and broad; gill rakers 30 or more; ratio of longest pelvic ray/longest pectoral ray 1.85–2.15; dorsal saddles and rectangular blotches along side very prominent; bars on pelvic fins present in fresh specimens; maximum size >270 mm SL .... *S. ulae*

14b. Nasal flap long and curved or variable; gill rakers 30 or fewer; ratio of longest pelvic ray/longest pectoral ray 2.17–2.57; dorsal saddles and lateral blotches faint or missing; pelvic fins unmarked; maximum size <140 mm SL........ 15

15a. Gill rakers 24; diameter of bony orbit 5.1% of standard length; dorsal surface uniformly mottled with small, dark blotches rather than distinct saddles .... *S. janus*, sp. nov.

15b. Gill rakers 25–30; diameter of bony orbit 5.7–6.9% of standard length; dorsal surface not uniformly mottled with dark blotches (pigment instead concentrated in discrete, scattered spots, with outlines of dorsal saddles often visible) ...... *S. falcatus*, sp. nov.

SPECIES ACCOUNTS

Although we have, when warranted, examined specimens of some species from outside the Hawaiian Islands, the key and the species accounts that follow (including the data that appear in Tables 1–8) are based only on Hawaiian material. Accurate identification of individuals of some species may require examination of more than one or two characters; therefore, we recommend that those using the key consult the species accounts and tables and figures as well. The key includes all known Hawaiian species of lizardfishes.

Synodus Scopoli, 1777

Synodus Scopoli, 1777: 449 (type species by absolute tautonymy, *Esox synodus* Linnaeus).

Several recent authors (e.g., Anderson et al. 1966, Cressey 1981) attribute *Synodus* to Gronow (Gronovius), but the names of Gronovius (1763) are not considered to be binomial [opinion 261 of the International Commission on Zoological Nomenclature (1954); see note by Russell (1987)].

Three genera of lizardfishes occur in Hawaii. *Saurida* (see review by Waples 1981) is distinctive in possessing 9 pelvic rays (8 in *Synodus* and *Trachinocephalus*), two separate rows of teeth on the palate (a single row in other genera), and having several rows of teeth visible in both jaws with mouth closed (a single row on upper jaw visible in other genera). Hawaiian species of *Synodus* have many fewer rays in the anal fin (8–11) than does *Trachinocephalus* (15–17). See key for other generic characters. The following species accounts appear in alphabetical order.

Synodus amaranthus, sp. nov.

Figures 1, 3, 8

Synodus varius (*non* Lacépède) Jordan and Evermann, 1905: 63 (in part; figure 14) (Hilo and Honolulu).

Synodus dermatogenys Fowler, 1912: 566, figure 3 (in part) (type locality, Hawaiian Islands).

Synodus variegatus Cressey, 1981: 6 (in part).

HOLOTYPE: ANSP 28133, 114 mm SL, Honolulu market, U.S. Fish Commission, 1901 (USFC 03265).

PARATYPES: ANSP 28132 (1), 109 mm SL (USFC 03804); ANSP 28134 (1), 115 mm SL (USFC 03809); MCZ 64517 (1), 111 mm SL (USFC 03430, ex MCZ 28962); all with same data as holotype.

ALSO EXAMINED: BPBM 1734 (1), 92 mm SL, Hawaii, U.S. Fish Commission, 1901.

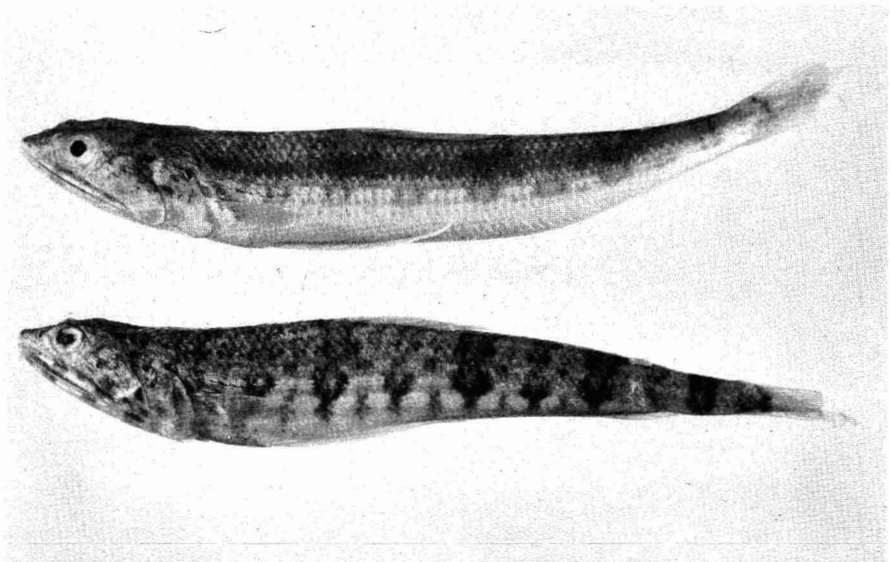


FIGURE 3. Above, holotype of *Synodus amaranthus*, sp. nov. (ANSP 28133, 114 mm SL, Honolulu); below, holotype of *S. dermatogenys* Fowler (ANSP 28130, 116 mm SL, Honolulu).

DIAGNOSIS: Dorsal rays 12 or 13; pectoral rays 12 or 13; 5.5 scale rows between lateral line and dorsal fin; lateral-line scales 60–61; vertebrae 59–61; gill rakers 28–32; diameter of bony orbit 5.4–6.1% SL; postoral portion of preopercle unscaled; anterior palatine teeth distinctly longer than posterior palatine teeth; membranous flap on anterior nostrils long and slender; longest ray of pectoral fins 10.3–11.3% SL and just reaching a line connecting origins of dorsal and pelvic fins; crossbars on pelvic fins persisting in preserved specimens; maximum size 115 mm SL.

DESCRIPTION: Data in parentheses apply to paratypes. Dorsal rays 12(12–13), the first two unbranched, the last branched to base; anal rays 8(8–9), the last branched to base; pectoral rays 12(12–13), the upper two and lowermost unbranched; pelvic rays 8, the most anterior and posterior unbranched; upper procurrent caudal rays 17(16–18); lower procurrent caudal rays 16(15–16); lateral-line scales 60(60–61); 5.5 scale rows between lateral line and dorsal fin; 7 scale rows between lateral line and anal fin; predorsal scales 19(19–20); gill rakers 31(28–30), 10(10–12) on upper limb and 21(18–19) on lower limb; vertebrae 59(59–61); peritoneal spots 12(11 in one paratype).

Body slender, the depth 7.5(6.5–7.6) in SL, and round in cross section; head length 3.4(3.3–3.55) in SL; snout moderately pointed (in dorsal view), its length 4.8(4.7–4.95) in head length; eye of moderate size, the bony orbit diameter 4.8(4.8–5.6) in head; interorbital space concave and narrow, the least bony width 9.25(9.25–10.4) in head; upper jaw extending about an orbit diameter posterior to the eye, the jaw length 1.6(1.5–1.6) in head; caudal peduncle narrow, slightly more than twice as long as deep, its least depth 5.5(5.4–5.9) in head.

Mouth terminal and slightly oblique; slender, slightly compressed, needle-sharp teeth in two close-set rows in jaws, angling inward; those posterior angling forward as well; inner row of teeth in jaws much longer than outer; outer row of teeth in upper jaw fixed; remaining teeth in jaws inwardly depressible; a single continuous band of slender, sharp, inwardly depressible teeth in two or three rows (teeth progressively longer medially on each palatine, the two bands converging and nearly joining anteriorly; anterior palatine teeth considerably longer than posterior teeth; free end of tongue with about 35–40 curved, arrow-tipped, posteriorly directed teeth, decreasing in size medially; back of tongue with about six rows of smaller teeth.

Nostrils situated in shallow depression on a line between upper edge of pupil and tip of snout, the posterior nostril about one-third orbit diameter in front of orbit; dermal flap posteriorly on anterior nostril long and slender, reaching beyond rear edge of posterior nostril when fully laid back. Scales dorsally on nape extending forward to a vertical at posterior end of upper jaw; cheek covered with about 5–6 rows of scales, but posterior (postoral) margin without scales; a vertical row of large scales anteriorly on opercle, the basal part of those adjacent to posterior margin of preopercle fleshy.

Origin of dorsal fin closer to adipose origin than to tip of snout; second dorsal ray longest, its length 1.8(1.8–2.0) in head; dorsal fin base 1.7(1.7–1.9) in head; anal fin base about one-half the length of dorsal fin base; second anal ray longest, 4.1(3.8–4.1) in head; adipose fin above middle of anal fin base; caudal fin forked (lobe tips broken in all specimens); pectoral fins rounded and short, just reaching a line connecting origins of dorsal and pelvic fins, the longest ray 2.6(2.55–2.9) in head; posterior pelvic process broad; sixth and seventh pelvic rays longest, 1.2(1.1–1.4) in head.

COLOR IN LIFE: We have not found any specimens of *Synodus amaranthus* collected after 1901. However, the colors of USFC 03430 (MCZ 64517) were described by Jordan and Evermann (1905:64) as follows: "Color when fresh ... ground white; a series of light reddish-brown quadrate spots along side, the markings over the back darker reddish brown; an indistinct bluish longitudinal band showing through just above the lateral row of quadrate spots along the side; a reddish spot on the upper angle of the gill opening; dorsal crossed by light-brown lines transverse to the fin rays; pectoral also crossed by narrow light-brown lines; ventral with 6 orange-colored crossbars."

COLOR IN ALCOHOL: Light brown above, with a series of five darker saddles across back: above pectoral origin, at dorsal origin, behind dorsal fin, anterior to adipose fin, and on caudal peduncle. Saddle on peduncle darkest and that on nape faintest. One dark spot at origin of adipose fin and two smaller dark spots at dorsal origin. Scales in first row above lateral line largely devoid of pigment, resulting in translucent stripe along length of fish. Scales in and below lateral line pale yellow or white, broken only by a series of eight darker, rectangular blotches oriented longitudinally along lateral line and scale row below, every other blotch forming the base of a dorsal saddle. Only a few scattered clusters of pigment below blotches. Four brownish spots on end of snout and assorted brownish mottlings on head. Iris reddish brown. Dorsal and pelvic fin rays with a series of about four alternating light and dark bands, those on pelvic faint but visible; one dark band on dorsal half of caudal fin base; other fins without markings.

DISTRIBUTION AND HABITAT: According to notes in the back of the log of the *Albatross* expedition, the holotype and paratypes were collected at the Honolulu market in 1901. Depth of occurrence and habitat are unknown. Possibly occurs in Australia (see below).

ETYMOLOGY: From the Latin *amarantus* (unfading), in reference to the markings on the pelvic fins that persist even in preserved specimens.

REMARKS: The holotype and two of the paratypes are from the type series of *Synodus dermatogenys*, the species that *S. amaranthus* most closely resembles. Apart from the differences in pigmentation (Figure 3), *S. amaranthus* generally has a larger head and eye, a longer pectoral fin, and a tendency for more gill rakers, lateral-line scales, vertebrae, and dorsal fin rays than *S. dermatogenys*. Excepting *S. variegatus*, other Hawaiian species of *Synodus* with 5.5 scale rows above the lateral line have more vertebrae and lateral-line scales than *S. amaranthus*. *Synodus variegatus* has postoral cheek scales and a prominent stripe along the side, both lacking in *S. amaranthus*.

Synodus amaranthus is similar to *S. houlti* McCulloch from Australia, which has been synonymized with *S.* "*variegatus*" (= *S. dermatogenys*) by Norman (1935), Cressey (1981), and others, but which is considered as possibly a distinct species in this account (see discussion of *S. dermatogenys*). The holotype of *S. houlti* has 58 vertebrae, 27 gill rakers, and 30 procurrent caudal rays, all slightly below the range of Hawaiian *S. amaranthus*, but this might be attributed to geographic variation. However, the type of *S. houlti* is also much larger (189 mm SL) than *S. amaranthus* (maximum 115 mm SL), has only 4.5 scale rows above the lateral line, and lies outside the range of *S. amaranthus* for about one-half of the morphometric measurements (Tables 4 and 7). Moreover, McCulloch's (1921) description indicates the fins of *S. houlti* are without markings. There is, however, some evidence that *S. amaranthus* may occur in Australia. A color photograph taken by J. E. Randall of a 135 mm SL specimen (BPBM 14338) taken at One Tree Island, Capricorn Group, shows barred pelvic fins, rectangular blotches along the lateral line but no pigment below, and a bluish streak above the lateral line, all consistent with *S. amaranthus*. This species is commonly identified as *S. houlti* in Australia (B. Russell, Northern Territory Museum, personal communication). However, BPBM 14338 has only 24 gill rakers and has a smaller head, snout, eye, interorbital distance, premaxillary, and pectoral fin than Hawaiian *S. amaranthus*. More extensive comparative work is necessary to determine the geographic range of *S. amaranthus*.

Sixteen years after his description of *Synodus dermatogenys*, Fowler (1928) placed *S. dermatogenys* in the synonymy of *S. japonicus* (Houttuyn), and in passing, remarked that the holotype and two paratypes were in the red color phase (the other two greenish) and that the reddish fish had slightly larger eyes. We find that the three *dermatogenys* paratypes referable to *S. amaranthus* have larger eyes (in percent SL), and suggest that it was not the holotype and two paratypes but these three paratypes that were red. This interpretation is

TABLE 4

PROPORTIONAL MEASUREMENTS OF TYPE SPECIMENS OF *Synodus amaranthus*, *S. janus*, *S. dermatogenys*, AND *S. houlti* EXPRESSED AS PERCENTAGE OF STANDARD LENGTH

	S. amaranthus				*S. janus*	*S. dermatogenys*	*S. houlti*
	HOLOTYPE	PARATYPES			HOLOTYPE	HOLOTYPE	HOLOTYPE
	ANSP 28133	ANSP 28132	ANSP 28134	MCZ 64517	SU 68883	ANSP 28130	QM 13543
Standard length (mm)	114	109	115	111	136	116	189
Body depth	13.4	13.2	14.4	15.5	14.2	—	—
Body width	14.6	14.1	15.9	14.9	14.0	—	—
Head length	29.2	28.8	30.3	29.1	28.8	28.5	30.1
Snout length	6.1	6.1	6.4	5.9	5.7	5.9	6.7
Orbit diameter	6.1	6.0	5.4	6.0	5.1	5.0	4.4
Interorbital width	3.2	2.9	3.1	2.8	2.3	3.0	3.8
Upper jaw length	18.1	18.1	19.7	19.1	17.2	17.9	19.4
Caudal peduncle depth	5.3	5.1	5.1	5.2	5.3	4.8	5.1
Caudal peduncle length	11.7	12.4	10.9	11.9	10.4	—	—
Predorsal length	43.4	42.1	43.5	42.0	41.3	42.2	43.4
Preanal length	82.4	81.7	82.6	81.1	84.6	—	84.7
Prepelvic length	33.8	33.0	34.3	36.3	34.0	—	—
Dorsal fin origin to adipose fin	39.9	40.3	41.7	40.3	41.3	40.0	41.2
Dorsal fin base	16.8	15.2	15.9	16.5	14.3	14.0	13.5
Longest dorsal ray	16.1	15.3	15.7	14.4	13.4	15.3	12.6
Anal fin base	8.8	8.8	8.3	7.8	7.2	8.3	7.7
Longest anal ray	7.1	7.5	7.0	7.8	6.6	—	—
Longest pectoral ray	11.1	11.1	10.3	11.3	9.3	11.4	Broken
Longest pelvic ray	23.7	22.3	22.0	22.5	24.0	24.7	21.8

in accordance with the description by Jordan and Evermann (1905) above and the fact that we have never observed a red-phase *S. dermatogenys*. It is not known whether *S. amaranthus* exists only in a red color phase, but evidence of a red phase in all four type specimens suggests the species may not be common in very shallow water, where red lizardfish of any species are rare. It is clear from notes in the *Albatross* log and information given by Jordan and Evermann (1905) that their text figure 14 was based on *S. amaranthus* paratype MCZ 64517 (USFC 03430). This figure errs, however, in showing the postoral portion of the cheek to be completely scaled.

We consider BPBM 1734 to be the present species but have not made it a paratype because in preservation it has acquired a uniformly dark pigmentation.

Synodus binotatus Schultz

Figure 1; Plate I, Figure A

Synodus binotatus Schultz, 1953: 35, figure 8 (type locality, Kwajalein Atoll, Marshall Islands).

MATERIAL EXAMINED: Twenty-one specimens, 41–136 mm SL. Oahu: BPBM 6463 (1), BPBM 9785 (1), BPBM 12542 (2), BPBM 17813 (1), BPBM 22661 (1), BPBM 30964 (2), BPBM 30965 (1), BPBM 30966 (2), BPBM 30967 (1); Kona, Hawaii: BPBM 13827 (1); Johnston Island: BPBM 8947 (5), BPBM 8976 (1); Northwest Hawaiian Islands: BPBM 30958 (1); Kwajalein: USNM 140801 (holotype).

DIAGNOSIS: Dorsal rays 12–13(usually 13); pectoral rays 12(1 of 17 with 11); 3.5 scale rows between lateral line and dorsal fin; lateral-line scales 53–55; vertebrae 53–54; gill rakers 27–36; peritoneal spots 0–3; postoral portion of cheek scaled; anterior palatine teeth longer than posterior palatine teeth and in a discrete group; membranous flap on anterior nostrils long and broad; pectoral fin longer than one-half the length of pelvic fin, reaching beyond a line connecting origins of dorsal and pelvic fins; two prominent dark spots on tip of snout; maximum size 136 mm SL.

DISTRIBUTION AND HABITAT: Common but not abundant throughout the Hawaiian chain and the rest of the Indo-West Pacific, from South Africa to Gambier Island (Cressey 1981). Not recorded deeper than 20 m.

REMARKS: *Synodus binotatus* has fewer lateral-line scales and vertebrae than any other Hawaiian species of *Synodus*. The long pectoral fin, small size (maximum for 20 Hawaiian specimens = 136 mm SL), and two prominent spots on the snout further distinguish this species. Shaklee et al. (1982), based on data for 29 presumptive gene loci, found *S. binotatus* to be the most divergent genetically of the four Hawaiian species of *Synodus* examined [Nei's (1978) $D = 1.30$ for *S. binotatus* and mean of *S. ulae*/*S. variegatus* (=*S. dermatogenys*)/*S. englemani* (=*S. variegatus*) group]. *Synodus binotatus* is fixed for alleles not found in the other six species at five of the seven loci surveyed here (see Table 8).

Synodus capricornis Cressey and Randall

Figures 1, 8, 9; Plate III, Figure A

Synodus capricornis Cressey and Randall, 1978: 767, figs. 1–3 (type locality, Easter Island).

MATERIAL EXAMINED: Seven specimens, 77–136 mm SL. Oahu: BPBM 6974 (2); Lanai: BPBM 30275 (1); Easter Island: BPBM 6560 (holotype), USNM 218461 (paratype); Pitcairn Island: BPBM 16860 (2 paratypes).

DIAGNOSIS: Dorsal rays 13; pectoral rays 13; scale rows between lateral line and dorsal fin 5.5; lateral-line scales 65–66; vertebrae 64–65; gill rakers 34–38; head length 29.9–33.5% SL; postoral portion of cheek unscaled; anterior palatine teeth longer than posterior teeth and in a discrete group; membranous flap on anterior nostrils short and triangular; pectoral fin short (9.6–10.0% SL) and less than one-half as long as pelvic fin; a series of dark, rectangular blotches along the lateral line, wider than the intervening spaces; maximum size in Hawaii 136 mm SL (to 186 mm SL elsewhere).

DISTRIBUTION AND HABITAT: Previously known only in the Southern Hemisphere (Easter Island and Pitcairn Island). The two Oahu specimens and the one from Lanai were taken at depths (25–30 m) similar to the habitat (21–40 m) in which it was collected in the southern localities. We have tentatively identified one small specimen (BPBM 28617; 73 mm SL) taken off Penguin Banks, Molokai, at 88 m as *Synodus capricornis*, which suggests that this species may range into relatively deep water.

REMARKS: The three Hawaiian specimens agree well with the description of *Synodus capricornis* and with the types examined. It thus appears that *S. capricornis* is not merely the Southern Hemisphere counterpart to *S. ulae*, as suggested by Cressey and Randall (1978). From its present occurrence only in the northern and southern subtropical zones, *S. capricornis* seems to be another example of antitropical distribution (Randall 1981). The specimen in the underwater photograph in Plate III, Figure A, was not collected but appears to be *S. capricornis*.

Synodus dermatogenys Fowler

Figures 1, 2, 3, 8; Plate I, Figure B; Plate III, Figure B

Synodus dermatogenys Fowler, 1912: 566, figure 3 (type locality, Hawaiian Islands).

Synodus variegatus Gosline and Brock, 1960: 100 (Hawaiian Islands).

Synodus variegatus Cressey, 1981: 6 (in part).

MATERIAL EXAMINED: Forty specimens, 42–203 mm SL. Oahu: ANSP 28130 (holotype, USFC 03265), ANSP 28131 (paratype, USFC 03172), BPBM 3637 (2), BPBM 12517 (11), BPBM 15430 (2), BPBM 12534 (2), BPBM 30961 (1), BPBM 30979 (14), BPBM 30981 (1), BPBM 30982 (1); Kaanapali, Maui: BPBM 30980 (1); Kona, Hawaii: BPBM 28870 (2); Laysan Island, Northwest Hawaiian Islands: CAS 51785 (1).

DIAGNOSIS: Dorsal rays 11–12 (rarely 13); pectoral rays 11–13; scale rows between lateral line and dorsal fin 5.5; lateral-line scales 59–62; vertebrae 57–60; gill rakers 22–33 (usually 24–28); eye small (diameter of bony orbit 3.4–5.3% SL); postoral portion of cheek sometimes scaled to preopercular margin; anterior palatine teeth longer than those posterior and in a discrete group; membranous flap on anterior nostrils long and slender; longest ray of pectoral fin 9.0–10.5% SL; pelvic and anal fins unmarked, even in fresh specimens; a series of squarish blotches along lateral line, narrower than intervening spaces; maximum size 203 mm SL.

DISTRIBUTION AND HABITAT: *Synodus dermatogenys* is probably the most commonly encountered *Synodus* in shallow water throughout the Indo-Pacific region. Most Hawaiian specimens were taken in less than 10 m, although a pair of specimens (BPBM 28870) were collected in Kona at 32 m. *Synodus dermatogenys* is frequently found with *S. ulae*, and to a lesser extent *S. variegatus* and *S. binotatus*, in sandy areas adjacent to rocks or coral; *S. dermatogenys* often buries itself partially or completely in the sand.

REMARKS: This species has been known as "*S. variegatus*" by most recent authors, but the type of *Salmo variegatus* is not the present species (see discussion of *Synodus variegatus*, below). *Saurus lucius* Temminck and Schlegel, 1846, has long resided in the synonymy of *Synodus variegatus*; however, apart from the fact that the present species has not been reliably reported from Japan (type locality of *Saurus lucius*), other characters suggest *Synodus ulae or S. variegatus* (= *S. englemani*) is a more likely identification (see Nomina Dubia, below). This leaves *S. dermatogenys* as the oldest available name for the present species. The holotype and one paratype agree completely with the "*S. variegatus*" of Cressey (1981) and other authors; the remaining three paratypes we have made the holotype and two paratypes of *S. amaranthus*, sp. nov.

Fowler's description of *Synodus dermatogenys* cites 64 lateral-line scales, but we count only 59 in the holotype and 59–61 in the paratypes. Perhaps on the basis of Fowler's description, Gosline and Brock (1960) considered *S. ulae* a junior synonym of *S. dermatogenys*.

Synodus dermatogenys is most easily confused with *S. amaranthus*, but even fresh *S. dermatogenys* lack the bars on the pelvic fins found in preserved specimens of the latter species. *Synodus variegatus* narrowly overlaps *S. dermatogenys* in lateral-line scale and vertebral counts, but has more gill rakers, a short, triangular nasal flap (long and slender in *S. dermatogenys*), and a prominent stripe along either side at the level of the lateral line. We examined the holotype of *S. houlti* McCulloch, 1921, considered a synonym of "*S. variegatus*" by Norman (1935) and Cressey (1981), and find agreement in most respects with our material of *S. dermatogenys*. However, McCulloch's type has only 4.5 scale rows above the lateral line, a larger head (30.1% of SL) than our Hawaiian material of *S. dermatogenys* (26.3–28.9% of SL), and was taken at a greater depth (46–55 m) than any known *S. dermatogenys*. The multivariate analysis (below) also indicates that the type differs considerably from the Hawaiian *S. dermatogenys* in overall morphology. We therefore keep open the possibility that McCulloch's specimen represents a valid species; clearly, more collections from Queensland (the type locality) are needed to resolve the issue.

Synodus doaki Russell and Cressey

Figure 1; Plate I, Figure C

Synodus doaki Russell and Cressey, 1979: 166, fig. 1 (type locality, Poor Knights Islands, New Zealand).

MATERIAL EXAMINED: Four specimens, 68–235 mm SL. Oahu: BPBM 24758 (1); Molokai: BPBM 28623 (1); Maro Reef, Northwest Hawaiian Islands: BPBM 31994 (1), BPBM 21057 (paratype).

DIAGNOSIS: Dorsal rays 13–15; pectoral rays 13; 3.5 scale rows between lateral line and dorsal fin; lateral-line scales 57–60; vertebrae 57–61; gill rakers 25–32; eye large (diameter of bony orbit 5.5–7.2% of SL); cheek scaled to margin of preopercle; anterior palatine teeth longer than those posterior and in a discrete group; membranous flap on anterior nares very long and rounded; pectoral fin longer than one-half the length of pelvic fin; two red spots on tip of snout in fresh specimens; not taken shallower than 90 m in Hawaii; maximum size 244 mm SL.

DISTRIBUTION AND HABITAT: *Synodus doaki* has been taken, albeit rarely, from Oahu to the northwest Hawaiian Islands at depths of 90–200 m. Outside Hawaii, *S. doaki* is known from Africa, New Zealand, Australia, and Japan, and has been taken in water as shallow as 19 m (Cressey 1981).

REMARKS: Of the other Hawaiian species with 3.5 scale rows above the lateral line, only *Synodus usitatus* and *S. kaianus* overlap in counts of lateral-line scales and vertebrae. In *S. usitatus*, the palatine teeth are of uniform length (anterior teeth longer in *S. doaki*); *S. doaki* lacks the black peritoneum and fleshy tip of the lower jaw that characterize *S. kaianus*. The four specimens of *S. doaki* examined here are apparently the only ones known from Hawaiian waters. These four specimens vary considerably with respect to several counts and measurements. However, all have the very long nasal flap distinctive of this species. Fresh colors of the specimen BPBM 31994 agree well with the photograph by Doak (1972: plate 6) identified as *S. doaki* by Russell and Cressey (1979). The specimen in Plate I, Figure C (BPBM 24758), differs from Doak's photograph in being yellow-orange rather than red-orange, in having less well-defined dorsal saddles and markings below the lateral line, and in having fainter bars on the rays of the pelvic fin.

Synodus falcatus, sp. nov.

Figures 1, 4, 8, 9; Plate I, Figure D; Plate III, Figure C

Synodus varius (*non* Lacépède) Jordan and Evermann, 1905: 63 (in part: plate 2) (Hilo and Honolulu).

Synodus ulae Schultz, 1953: 38 (in part) (type locality, Honolulu).

Synodus ulae Cressey, 1981: 40, figs. 33, 34 (in part).

HOLOTYPE: BPBM 30960, 123 mm SL, Maro Reef, Northwest Hawaiian Islands, 25°24′ N, 170°53′ W, at 88–95 m, sand, rubble, pen shells, algae, shrimp trawl, J. Prescott (National Marine Fisheries Service, Honolulu), 9:07–9:40 AM, 28 July 1981.

PARATYPES: CAS 61346 (1), ANSP 159462 (1), USNM 285271 (1), all with same data as holo-

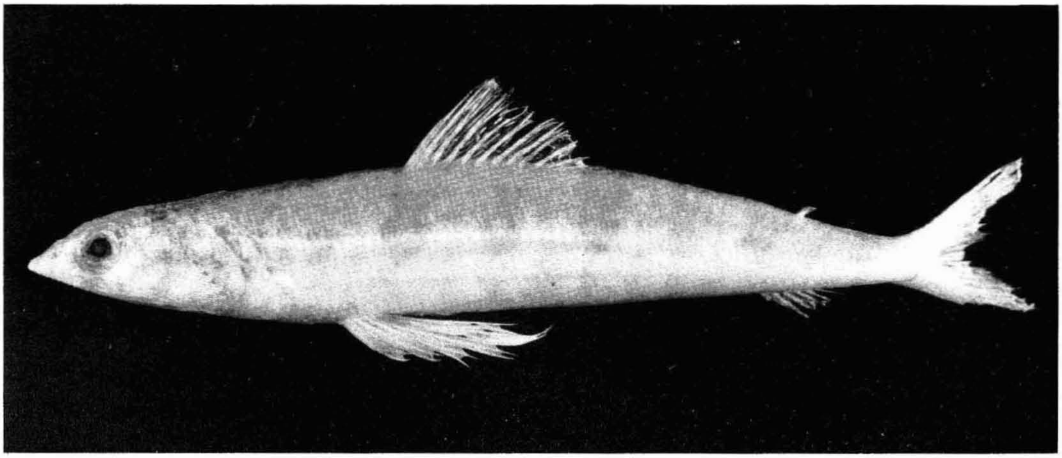


FIGURE 4. Holotype of *Synodus falcatus*, sp. nov. (BPBM 30960, 123 mm SL, Maro Reef, Northwest Hawaiian Islands).

type; USNM 55272 (3), 95–116 mm SL, off south coast of Molokai, at 43–63 fathoms, 8–12 April 1902, U.S.S. *Albatross* (paratypes of *Synodus ulae* Schultz); USNM 280212 (1), 115 mm SL, Laysan Island, Northwest Hawaiian Islands, U.S.S. *Albatross*, 1902 (paratype of *S. ulae* Schultz); MCZ 28965 (1), 101 mm SL, Honolulu market, U.S. Fish Commission, 1901 (USFC 03011); BPBM 23955 (8), 58–125 mm SL, Oahu, off Haleiwa, 21°37′ N, 158°12′ W, at 91–110 m, shrimp trawl *Townsend Cromwell* cruise 36, station 20, 3 May 1968; BPBM 15483 (1), 108 mm SL, Oahu, off Haleiwa, at 55 fathoms, shrimp trawl *Valiant Maid*, 27 August 1973; BPBM 23923 (15), 55–94 mm SL, Oahu, off Haleiwa, 21°40′ N, 158°07′ W, at 95–110 m, shrimp trawl *Townsend Cromwell* cruise 36, station 19, 3 May 1968; BPBM 28942 (3), 94–114 mm SL, Oahu, off Haleiwa, 21°40′ N, 158°07′ W, at 99 m, shrimp trawl *Townsend Cromwell* cruise 40, station 113, 30 November 1968; BPBM 23899 (15), 54–94 mm SL, Oahu, off Haleiwa, 21°37′ N, 158°11′ W, at 101–106 m, shrimp trawl *Townsend Cromwell* cruise 36, station 17, 3 May 1968; BPBM 23908 (5), 58–100 mm SL, same data as preceding.

ALSO EXAMINED: BPBM 28938 (4), 55–68 mm SL, Oahu; ANSP 93306 (1), 135 mm SL, Honolulu; CAS 11311 (1), 93 mm SL, Hawaiian Islands.

DIAGNOSIS: Dorsal rays 12–15; pectoral rays 12 or 13; scale rows between lateral line and dorsal fin 5.5; lateral-line scales 64–68; vertebrae 63–67; gill rakers 25–30; diameter of bony orbit 5.7–6.9% of SL; postoral portion of cheek unscaled; anterior palatine teeth not longer or only slightly longer than posterior palatine teeth; membranous flap on anterior nostrils long, pointed, and curved outward; pectoral fins just reaching a line connecting origins of dorsal and pelvic fins; base of anal fin short (5.5–7.9% of SL); rose or orange-brown in coloration; not taken shallower than 79 m (but tentatively identified from underwater photograph, Plate III, Figure C, taken at 30 m); maximum size 125 mm SL.

DESCRIPTION: Data in parentheses apply to paratypes. Dorsal rays 12(12–15), the first 2 unbranched, the last branched to base; anal rays 8(8–9), the last branched to base; pectoral rays 13(12–13), the upper 2 and lowermost unbranched; pelvic rays 8, the inner and outer rays unbranched; upper procurrent caudal rays 17(16–17); lower procurrent caudal rays 16(15–16); lateral-line scales 66(64–68); 5.5 scale rows between lateral line and dorsal fin; 8(7–8) scale rows between lateral line and anal fin; predorsal scales 21(19–21); gill rakers 25(25–30), 8(8–11) on upper limb and 17(16–20) on lower limb; vertebrae 65(63–

67); peritoneal spots (10–13, counts of 9 paratypes).

Body slender, the depth 6.5(5.6–8.4) in SL, and round in cross section; head length 3.4(3.1–3.5) in SL; snout moderately pointed (in dorsal view), its length 4.95(4.1–5.0) in head length; eye of moderate size, the bony orbit diameter 4.95(4.1–5.0) in head; interorbital space concave and narrow, the least bony width 10.0(9.4–15.9) in head; upper jaw extending about an orbit diameter posterior to the eye, the jaw length 1.65(1.5–1.7) in head; caudal peduncle narrow, slightly depressed, almost twice as long as deep, its least depth 5.7(5.2–6.3) in head.

Mouth terminal and slightly oblique; slender, slightly compressed, needle-sharp teeth in two close-set rows in jaws, angling inward, those posterior angling forward as well; inner row of teeth in jaws much longer than outer; outer row of teeth in upper jaw fixed; remaining teeth in jaws inwardly depressible; a single continuous band of slender, sharp, inwardly depressible teeth in two or three rows (teeth progressively longer medially) on each palatine, the two bands converging and nearly joining anteriorly; anterior palatine teeth barely longer than posterior teeth; free end of tongue with about 30 curved, arrow-tipped, posteriorly directed teeth, decreasing in size medially; back of tongue with about six irregular rows of smaller teeth.

Nostrils situated in shallow depression on a line between upper edge of pupil and tip of snout, the posterior nostril about one-third orbit diameter in front of orbit; dermal flap posteriorly on anterior nostril long and pointed, the protrusion originating on inward side of nares and curving outward, reaching about one naris diameter beyond rear edge of posterior nostril when fully laid back. Scales dorsally on nape extending forward to a vertical at posterior end of upper jaw; cheek covered with about 5–6 rows of scales, but posterior (postoral) margin without scales; a vertical row of large scales anteriorly on opercle, the basal part of those adjacent to posterior margin of preopercle fleshy.

Origin of dorsal fin closer to adipose origin than to tip of snout; second and third dorsal rays longest, their length 2.0(1.8–2.2) in head; dorsal fin base 1.85(1.7–2.0) in head; anal fin base less than one-half length of dorsal fin base; third anal ray longest, 3.95(3.9–4.9) in head; adipose fin above middle of anal fin base; caudal fin forked, the lobe tips broken in holotype, its length (1.7–1.8) in head; pectoral fins rounded and short, just reaching a line connecting origins of dorsal and pelvic fins, the longest ray 2.75(2.6–3.2) in head; posterior pelvic process broad; sixth and seventh pelvic rays longest, 1.2(1.1–1.3) in head.

COLOR OF FROZEN SPECIMENS: Holotype and three paratypes from Maro Reef examined. Orange interspersed with rose above lateral line, white below; a series of rose and orange spots on either side of dorsal fin base, and an orange spot at adipose origin; rose longitudinal band above lateral line running length of fish; a series of eight rectangular rose blotches along lateral line, alternately light and dark; intervening areas white just along lateral line and orange-yellow above and below; orange-yellow gridwork over basic white color of side below lateral line; belly pure white. Top of opercle rose, lower and posterior parts blotched orange and white; upper rim of opercle trimmed in bright red; bright-orange band vertically through the eye and continuing onto lower jaw, appearing as two orange bands under chin; snout orange with some flecks of rose; a series of about 3–4 pale-orange and white bars on dorsal fin; caudal and anal fins pale, pelvic fins yellow, all without markings; pectoral fin flecked with white; an orange blotch below base of pectoral fin.

COLOR IN ALCOHOL: The holotype and three paratypes from Maro Reef are uniformly pale yellow above lateral line and silvery white below. Other paratypes are pale yellow in ground color with scattered darker pigment on dorsal half ending abruptly at lateral line; remnants of a darker saddle visible on dorsal surface of caudal peduncle, and traces of more anterior saddles visible in some specimens; dark pigment spots at adipose fin origin, on either side of dorsal fin base, and on nape midway between dorsal fin origin and occiput.

DISTRIBUTION AND HABITAT: Presently known from Oahu, Molokai, and Maro Reef and

TABLE 5

PROPORTIONAL MEASUREMENTS OF TYPE SPECIMENS OF *Synodus falcatus* EXPRESSED AS PERCENTAGE OF STANDARD LENGTH

	HOLOTYPE	PARATYPES							
	BPBM 30960	CAS 61346	USNM 285271	ANSP 159462	BPBM 23955	BPBM 23955	BPBM 23955	BPBM 23955	BPBM 23955
Standard length (mm)	123	123	113	124	125	103	100	87	81
Body depth	15.4	15.6	15.0	13.9	17.7	17.5	15.5	13.3	11.9
Body width	16.6	14.6	15.5	15.9	14.9	15.2	14.0	14.9	12.1
Head length	29.2	29.1	28.9	28.2	30.2	29.8	28.5	31.4	30.7
Snout length	5.9	5.9	5.9	5.5	5.8	6.1	5.3	5.6	5.9
Orbit diameter	5.9	5.9	5.8	5.7	6.4	6.8	6.0	6.8	6.8
Interorbital width	2.9	2.5	2.8	2.5	2.6	2.6	2.4	2.4	2.5
Upper jaw length	17.8	18.1	17.8	16.8	19.4	17.5	17.3	19.3	20.0
Caudal peduncle depth	5.1	5.3	5.4	5.0	5.0	5.2	5.5	4.9	5.2
Caudal peduncle length	9.2	8.9	10.1	9.9	10.0	11.4	10.9	10.8	10.2
Predorsal length	41.2	42.7	41.4	40.8	43.8	42.1	42.1	42.5	41.5
Preanal length	82.1	82.9	83.2	81.5	84.1	83.5	83.0	82.8	82.7
Prepelvic length	33.5	33.8	33.5	31.7	34.1	31.1	33.0	36.2	32.8
Dorsal fin origin to adipose fin	42.8	41.1	43.6	42.8	40.2	40.3	41.5	42.5	41.1
Dorsal fin base	15.7	15.6	16.6	14.1	16.3	15.0	15.5	16.1	15.2
Longest dorsal ray	14.6	14.6	15.3	14.4	15.8	15.0	14.7	16.7	15.7
Anal fin base	7.3	7.5	6.8	6.4	7.0	5.8	6.9	5.5	6.0
Longest anal ray	7.4	6.4	5.9	6.1	7.8	—	6.5	7.4	7.2
Caudal fin length	Broken	16.6	Broken	Broken	17.1	17.3	16.3	18.3	17.2
Caudal concavity	Broken	8.4	Broken	Broken	7.9	8.6	8.4	9.2	8.4
Longest pectoral ray	10.6	9.9	10.7	10.2	11.1	10.8	11.0	11.6	11.2
Longest pelvic ray	24.9	23.6	25.5	23.9	24.6	25.3	24.8	28.0	24.6

Laysan Island, Northwest Hawaiian Islands. All known specimens are from trawls at depths of 79–115 m. The specimen shown in Plate III, Figure C, was photographed at 30 m and appears to be *Synodus falcatus*, but it was not collected, precluding a positive identification.

ETYMOLOGY: From the Latin *falcatus* (curved, sickle-shaped), in reference to the shape of the flap over the anterior nares.

REMARKS: *Synodus falcatus* has more vertebrae and lateral-line scales than any other Indo-Pacific *Synodus* except *S. ulae*, *S. capricornis*, *S. kaianus*, and *S. janus*. *Synodus kaianus* has a black peritoneum, narrow posterior pelvic process, and 3.5 scale rows above the lateral line. *Synodus ulae* and *S. capricornis* have more gill rakers and different nasal flaps than *S. falcatus*; *S. ulae* also has a longer snout, smaller eye, and longer anal fin base. *Synodus janus* has fewer gill rakers, a smaller eye, and a distinctive color pattern. Palatine dentition is more variable in *S. falcatus* than in other Hawaiian *Synodus*. In some specimens, the anterior teeth are slightly larger than those posterior, while in others the palatine teeth are of almost uniform length. No specimens examined have the distinctly longer anterior palatine teeth typical of a number of other Hawaiian species in the genus.

Muscle tissue from the holotype and the three paratypes from Maro Reef was fixed for unique alleles at two loci (*Aat-2* and *G3pdh*), and *Synodus falcatus* differs from some of the other Hawaiian *Synodus* at the remaining five loci surveyed (Table 8). The four Maro Reef specimens of *S. falcatus* have lost most of their pigmentation in alcohol, but agree in all other respects with the preserved material, which could not be analyzed electrophoretically. The other preserved material has retained more pigment, suggesting the possibility that these specimens were dark in coloration rather than red-orange, as were the Maro Reef specimens; for example, note that the paratype (BPBM 15483) depicted in Plate I, Figure D, shows dark spots on the back and lacks any bright-red pigment.

Three lots of specimens (BPBM 28938, ANSP 93306, CAS 11311) have been identified as *Synodus falcatus* but not made paratypes because of their poor condition.

Synodus janus, sp. nov.

Figures 1, 5, 8

HOLOTYPE: SU 68883, 136 mm SL, Hilo, Hawaii, U.S. Fish Commission, 1901 (USFC 03830).

DIAGNOSIS: Dorsal rays 12; pectoral rays 13; 5.5 scale rows between lateral line and dorsal fin; lateral-line scales 66; vertebrae 64; gill rakers 24; diameter of bony orbit 5.1% of SL; postoral portion of cheek unscaled; anterior palatine teeth somewhat longer than posterior palatine teeth; membranous flap on anterior nostrils long and slender; pectoral fin short (longest ray 9.3% of SL), not reaching a line connecting origins of dorsal and pelvic fins; pigment concentrated in small, brown blotches rather than large saddles evident in other species; known from a single specimen 136 mm SL.

DESCRIPTION: Dorsal rays 12, the first 2 unbranched, the last branched to base; anal rays 8, the last branched to base; pectoral rays 13, the upper 2 and lowermost unbranched; pelvic rays 8, the most anterior and posterior unbranched; upper procurrent caudal rays 17; lower procurrent caudal rays 16; lateral-line scales 66; 5.5 scale rows between lateral line and dorsal fin; 7 scale rows between lateral line and anal fin; predorsal scales 19; gill rakers 24, 8 on upper limb and 16 on lower limb; vertebrae 64; peritoneal spots 12.

Body slender, the depth 7.0 in SL, and round in cross section; head length 3.4 in SL; snout moderately pointed (in dorsal view), its length 5.1 in head length; eye of moderate size, the bony orbit diameter 4.8 in head; interorbital space concave and narrow, the least bony width 12.6 in head; upper jaw extending about an orbit diameter posterior to the eye, the jaw length 1.7 in head; caudal peduncle narrow, twice as long as deep, its least depth 5.4 in head.

Mouth terminal and slightly oblique; slender, slightly compressed, needle-sharp teeth in two close-set rows in jaws, angling inward;

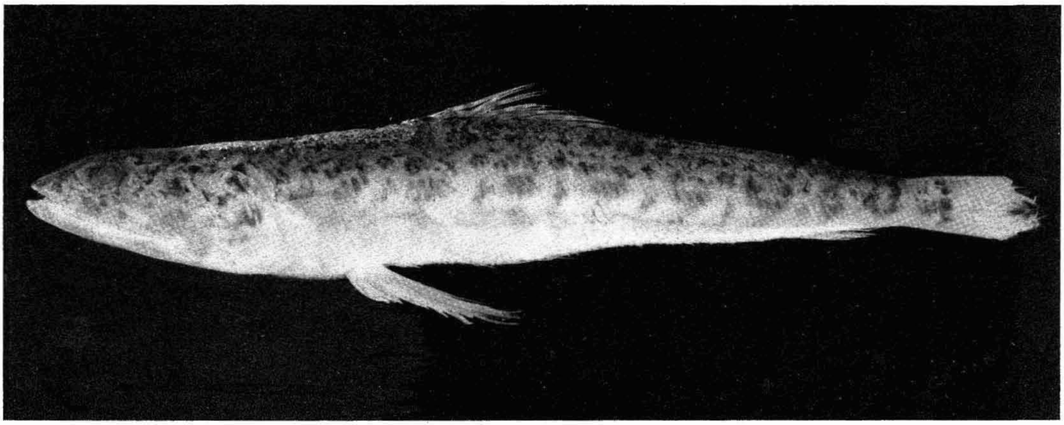


FIGURE 5. Holotype of *Synodus janus*, sp. nov. (SU 68883, 136 mm SL, Hilo, Hawaii).

posterior teeth also angling forward; inner row of teeth in jaws much longer than outer; outer row of teeth in upper jaw fixed; remaining teeth in jaws inwardly depressible; a single continuous band of slender, sharp, inwardly depressible teeth in two or three rows (teeth progressively longer medially) on each palatine, the two bands converging and nearly joining anteriorly; anterior palatine teeth somewhat longer than posterior teeth; dorsal surface of tongue with about 45 curved, arrow-tipped, posteriorly directed teeth, decreasing in size medially; back of tongue with several rows of similarly shaped teeth.

Nostrils situated in shallow depression on a line between upper edge of pupil and tip of snout, the posterior nostril about one-third orbit diameter in front of orbit; dermal flap posteriorly on left anterior nostril long and slender, reaching slightly beyond rear edge of posterior nostril when fully laid back; flap on right nostril short, slender, and rounded, not reaching rear edge of posterior nostril when laid back. Scales dorsally on nape extending forward to a vertical at posterior end of upper jaw; anterior portion of cheek covered with about 5–6 rows of scales, but naked posteriorly; a vertical row of large scales anteriorly on opercle, the basal part of those adjacent to posterior margin of preopercle fleshy.

Origin of dorsal fin equidistant from adipose origin and tip of snout; second and third dorsal rays longest, their length 2.15 in head; dorsal fin base 2.0 in head; anal fin base one-half the length of dorsal fin base; second anal ray longest, 4.35 in head; adipose fin above anterior portion of anal fin base; caudal fin forked, the lobe tips broken; pectoral fins rounded and short, not reaching a line connecting origins of dorsal and pelvic fins, the longest ray 3.1 in head; posterior pelvic process broad; sixth and seventh pelvic rays longest, 1.2 in head.

COLOR IN LIFE: Not known.

COLOR IN ALCOHOL: Background pale yellowish, dorsal half of head and body thickly mottled with dark brown, the pigment concentrated in small blotches rather than large saddles evident in other species; darkest markings at adipose origin, along dorsal fin base, just above gill opening, and on nape. Eight larger, irregularly shaped blotches along side (lateral-line pores pass through dorsal portion of these blotches). A series of smaller blotches interspersed between and below larger blotches 2–3 scale rows below lateral line. One dark bar under chin, and more dark pigment, fading away posteriorly, along lower jaw and on isthmus; ventral surface otherwise unpigmented. Iris brownish. A series of four dark bands on dorsal, pectoral, and upper caudal fin rays; one dark, vertical bar at base of caudal fin; pelvic and anal fins pale. One brown spot in middle of adipose fin.

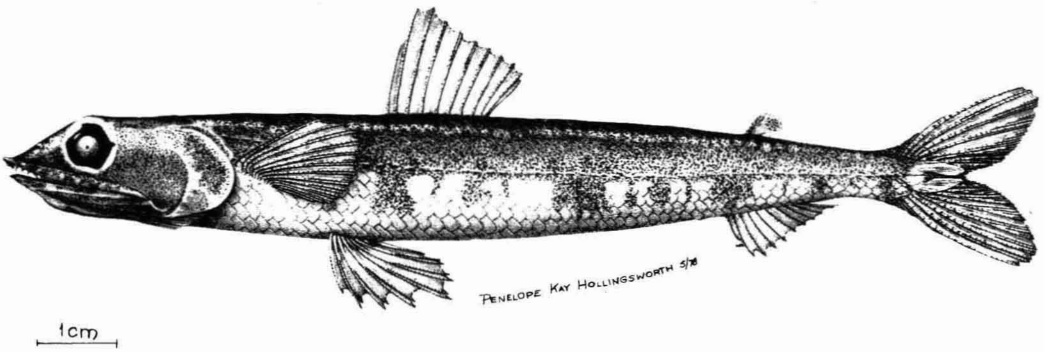


FIGURE 6. *Synodus kaianus* (Günther), USNM 217779, 135 mm SL, Kochi, Japan (reproduced from Cressey 1981).

DISTRIBUTION AND HABITAT: Presently known from a single specimen collected at Hilo in 1901 by the U.S. Fish Commission. Habitat unknown.

ETYMOLOGY: Named *janus*, after the Roman god with the two-faced head, because the dermal flaps on the left and right nares differ considerably in size and shape. This may well be an aberrant condition, however, as we have only a single specimen.

REMARKS: The only species of *Synodus* with as many vertebrae and lateral-line scales as *S. janus* are *S. ulae*, *S. capricornis*, and *S. falcatus*. *Synodus ulae* and *S. capricornis* have many more gill rakers, clearly different nasal flaps, and prominent saddles on the back and rectangular blotches along the lateral line. *Synodus janus* most closely resembles *S. falcatus*, from which it differs in having a smaller eye, fewer gill rakers, and a distinctive color pattern. In the back of the log of the *Albatross* expedition, USFC 03830 (holotype of *S. janus*) is listed with material identified as *S. varius*, but Jordan and Evermann (1905) did not mention this specimen in their account of *S. varius*.

Synodus kaianus (Günther)

Figures 1, 6

Saurus kaianus Günther, 1880: 50, plate 23, fig. c (type locality, Ki Islands).

Synodus kaianus Gilbert, 1905: 508 (Maui and Pailolo Channel).

MATERIAL EXAMINED: Twenty specimens, 121–235 mm SL. Oahu: BPBM 30955 (1); Maui: BPBM 24200 (9), BPBM 24229 (5); Maro Reef, Northwest Hawaiian Islands: BPBM 30956 (3), BPBM 30957 (2).

DIAGNOSIS: Dorsal rays 10–13; pectoral rays 12–13; scale rows between lateral line and dorsal origin 3.5; lateral-line scales 60–64; vertebrae 60–63; gill rakers 26–29; snout long (6.9–8.8% of SL); eye large (diameter of bony orbit 6.6–8.1% of SL); postoral portion of cheek scaled to margin of preopercle; anterior palatine teeth not longer than those posterior and not in a discrete group; membranous flap on anterior nostrils broad and triangular; posterior pelvic process narrow; peritoneum black; tip of lower jaw fleshy; pelvic fin short, less than 20% SL and less than $1\frac{1}{2}$ times as long as pectoral fin; dorsal surface uniformly dark, with three blocks of pigment below lateral line; not taken shallower than 200 m; maximum size 235 mm SL.

DISTRIBUTION AND HABITAT: Günther (1880) described *Synodus kaianus* from a single 5.5-in. specimen collected at 129 fathoms (236 m) off the Ki Islands, Arafura Sea. Cressey (1981) reported it from Japan, Western Australia, the South China Sea, and the Hawaiian Islands, where it occurs throughout the chain. This species apparently has not been taken shallower than 200 m.

REMARKS: The black peritoneum, narrow posterior pelvic process, short pelvic fin, and fleshy tip of the lower jaw together easily distinguish *S. kaianus* from any other Hawaiian *Synodus*.

Synodus lobeli, sp. nov.

Figure 1; Plate II, Figure A; Plate III, Figure D

Synodus varius (*non* Lacépède) Jordan and Evermann, 1905: 63 (in part) (Hilo and Honolulu).

HOLOTYPE: BPBM 29293, 116.3 mm SL, female, Hawaiian Islands, Kona coast of Hawaii, off Kailua, sand, at 32 m, rotenone, J. E. Randall, L. H. Strauss, and C. J. Boyle, 8 August 1983.

PARATYPES: MCZ 28962 (2), 94–121 mm SL, Honolulu market, U.S. Fish Commission, June 1901 (USFC 03010, 03236); BPBM 28869 (2), 38.7–87.4 mm SL, same locality as holotype, rotenone, J. E. Randall and P. S. Lobel, 18 June 1982; AMS I. 24995-001, 77.0 mm SL; BPBM 30337 (9), 52.4–94.3 mm SL; BM(NH) 1985.1.16.1, 83.5 mm SL; CAS 56098, 86.2 mm SL; MNHN 1985-1, 86.4 mm SL; NSMT-P 23888, 78.9 mm SL; SIO 85-13, 90.2 mm SL; USNM 268584, 81.4 mm SL—all with same data as holotype.

DIAGNOSIS: Dorsal rays 11 or 12; pectoral rays 12; rows of scales between lateral line and dorsal fin 3.5; lateral-line scales 53–55; vertebrae 53–56; gill rakers 24–27; preopercle scaled to posterior margin; anterior palatine teeth not distinctly longer than and not isolated from posterior palatine teeth; membranous flap on anterior nostrils slender; body depth 6.7–7.8 in SL; pectoral fins not reaching a line connecting origins of dorsal and pelvic fins; anal fin base about two-thirds dorsal fin base; pale with small irregular dark blotches forming longitudinal lines on upper half of body.

DESCRIPTION: Data in parentheses apply to paratypes. Dorsal rays 11(11–12), the first 2 unbranched, the last branched to base; anal rays 9, the last branched to base; pectoral rays 12, the upper 2 and lowermost unbranched; pelvic rays 8, the most anterior and posterior unbranched; principal caudal rays 19, the uppermost and lowermost unbranched; upper procurrent caudal rays 16(14–17); lower procurrent caudal rays 14(13–15); lateral-line scales 55(53–55); scale rows between lateral line and dorsal fin 3.5; scale rows between lateral line and anal fin 4; predorsal scales 17(15–17); circumpeduncular scales 16(14–16); gill rakers 8–9 + 15–17 = 24–27 (counts of 7 paratypes); vertebrae 55(53–56); peritoneal spots 10–11 (counts of 3 paratypes).

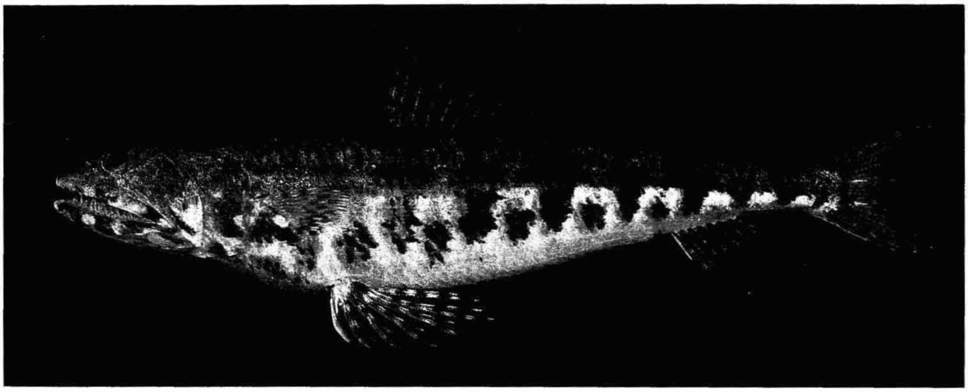
Body slender, the depth 6.7(6.7–7.8) in SL, and round in cross section; head length 3.6(3.7–3.85) in SL; snout moderately pointed (in dorsal view), its length 4.2(3.95–4.4) in head length; eye of medium size, the bony orbit diameter 5.7(3.9–4.9) in head; interorbital space concave and narrow, the least bony width 12.5(13–18) in head; upper jaw extending about an orbit diameter posterior to eye, the jaw length 1.7(1.6–1.7) in head; caudal peduncle narrow, twice as long as deep, its least depth 5.35(4.9–5.2) in head.

Mouth terminal and slightly oblique; slender, slightly compressed, needle-sharp teeth in two close-set rows in jaws, those posteriorly angling forward and those of upper jaw angling inward as well; inner row of teeth in jaws much longer than outer; outer row of teeth of upper jaw fixed; remaining teeth in jaws inwardly depressible; a single continuous band of slender, sharp, inwardly depressible teeth in three rows (teeth progressively longer medially) on each palatine, the two bands converging and nearly joining anteriorly; anterior palatine teeth only slightly longer than posterior teeth; dorsal surface of tongue with a row of about 9 slender, posteriorly directed teeth on each side, and about 12 smaller teeth on medial part of tongue.

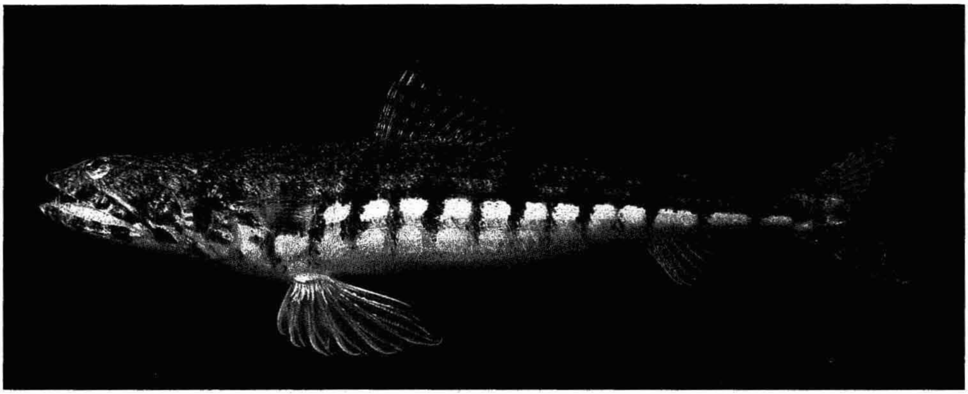
Nostrils in lateral view on a line between upper edge of pupil and tip of snout, the posterior nostril about one-third orbit diameter in front of orbit; dermal flap posteriorly on anterior nostril slender and moderately pointed, reaching to rear edge of posterior nostril when fully laid back.

Scales dorsally on nape extending forward to a vertical at posterior end of maxilla; preopercle covered with five diagonal rows of scales; a vertical row of large scales anteriorly on opercle, the basal part of those adjacent to posterior margin of preopercle fleshy.

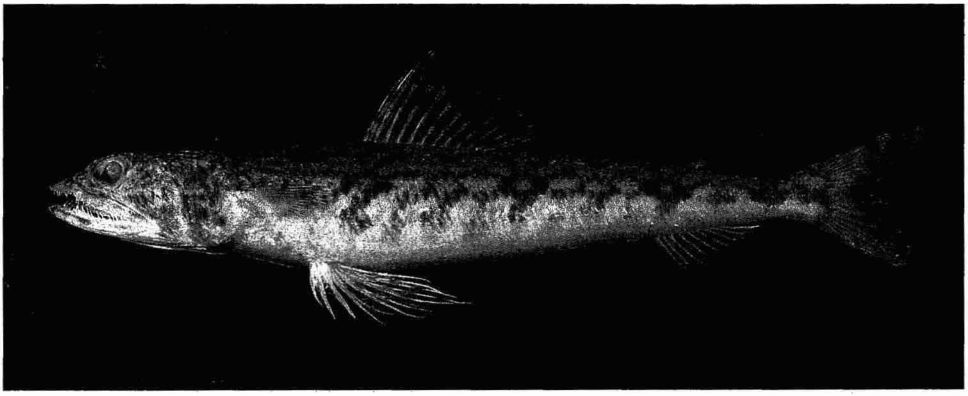
Origin of dorsal fin closer to tip of snout than caudal fin base; second dorsal ray longest, its length 2.0(1.6–1.85) in head; dorsal fin base 2.15(1.85–2.05) in head; anal fin base



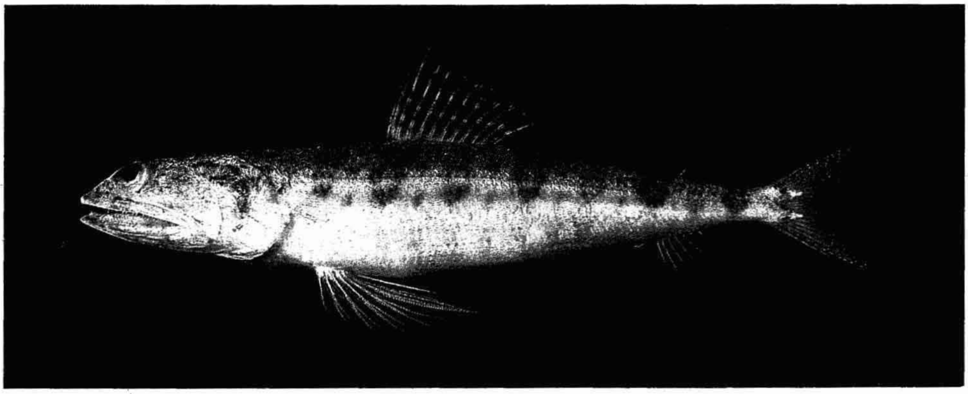
A. *Synodus binotatus,* BPBM 8947, 140 mm SL, Johnston Island.



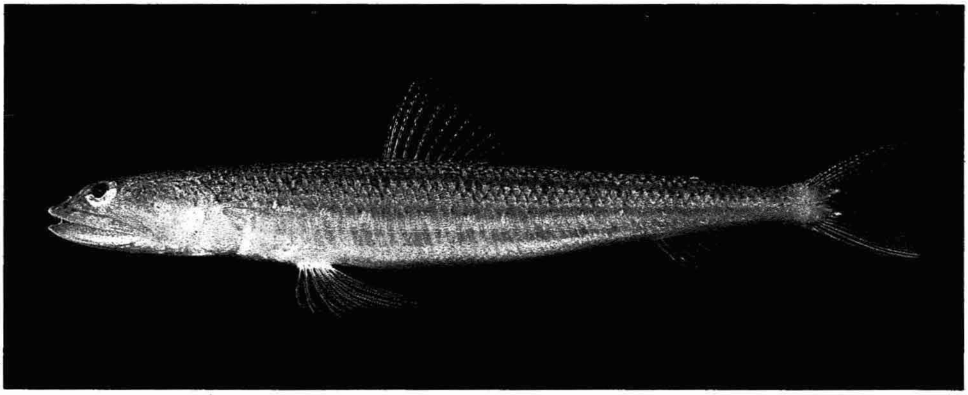
B. *Synodus dermatogenys,* 151 mm SL, Mauritius, specimen not extant.



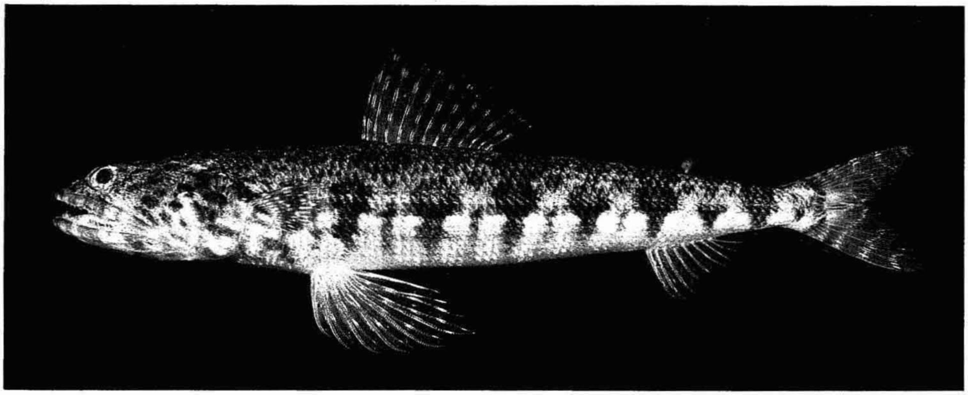
C. *Synodus doaki,* BPBM 24758, 135 mm SL, Oahu.



D. *Synodus falcatus,* Paratype BPBM 15483, 108 mm SL, Oahu.

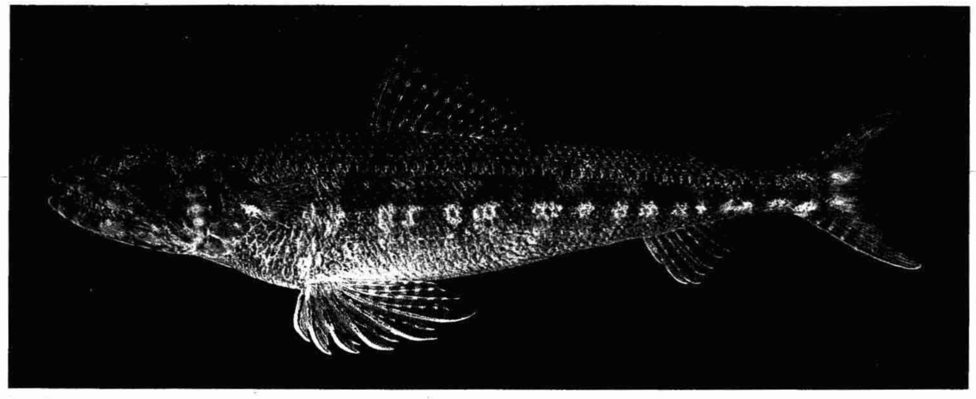


A. *Synodus lobeli,* holotype, BPBM 29293, 116.3 mm SL, Kona, Hawaii.

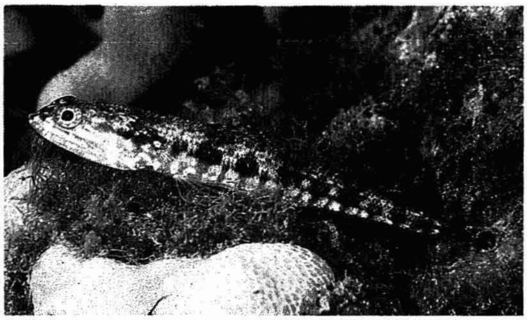


B. *Synodus ulae,* BPBM 6465, 153 mm SL, Oahu.

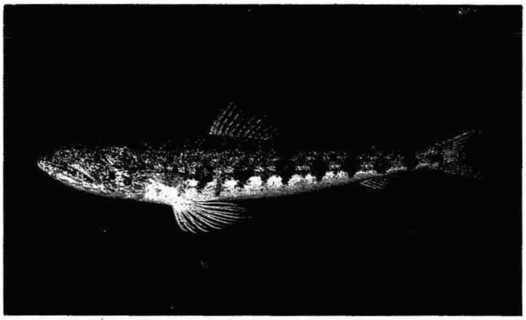
C. *Synodus usitatus,* paratype, BPBM 26544, 115.6 mm SL, Oahu.



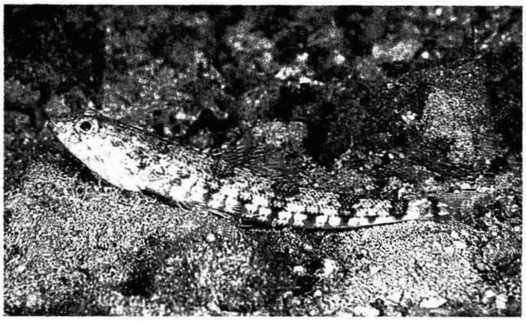
D. *Synodus variegatus,* BPBM 30970, 191 mm SL, Johnston Island.



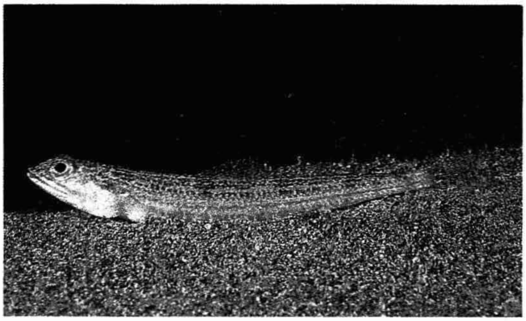
A. *Synodus capricornis,* about 75 mm TL, Kona, Hawaii, 26 m.



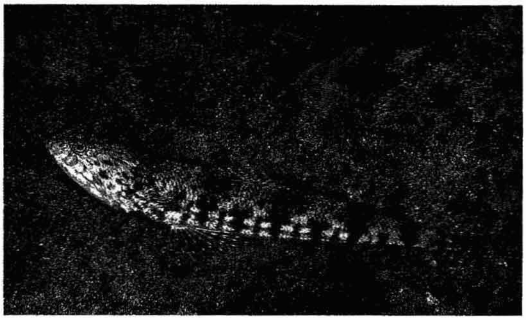
B. *Synodus dermatogenys,* BPBM 30980, 202 mm SL, Maui.



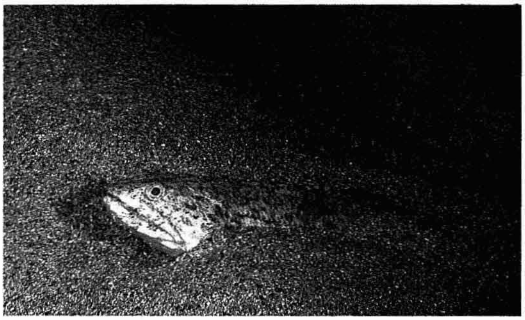
C. *Synodus falcatus,* about 120 mm TL, Oahu, 25 m.



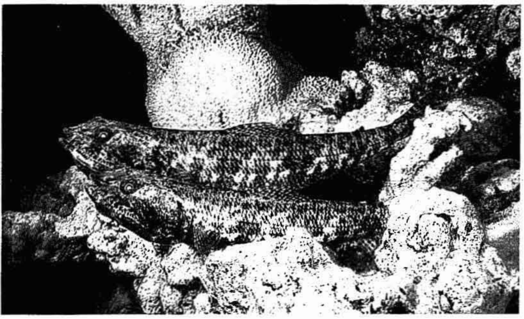
D. *Synodus lobeli,* about 90 mm TL, Kona, Hawaii, 30.5 m.



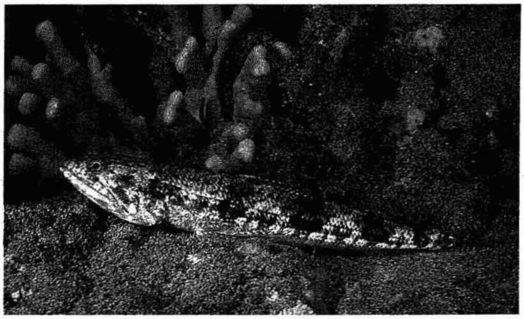
E. *Synodus ulae,* about 220 mm TL, Oahu, 10 m.



F. *Synodus ulae,* about 200 mm TL, Oahu, 10 m.



G. *Synodus variegatus,* about 120 mm TL, Johnston Is., 7 m.



H. *Synodus variegatus,* about 220 mm TL, Oahu, 8 m.

about two-thirds length of dorsal fin base; second anal ray longest, 3.65(3.3–3.85) in head; origin of adipose fin above base of fifth anal ray; caudal fin forked, the lobe tips pointed, its length 1.7(1.45–1.65) in head; pectoral fins rounded and short, not reaching a line connecting origins of dorsal and pelvic fins, the longest ray 2.45(2.25–2.4) in head; posterior pelvic process broad [as in figure 1b of Cressey (1981)]; sixth and seventh pelvic rays longest, 1.25(1.1–1.2) in head.

COLOR IN ALCOHOL: Pale greenish gray to level of upper edge of pectoral fins, whitish below; upper half of body with fine, irregular, dark-brown markings along longitudinal scale rows, thus forming a linear pattern (these markings often as a pair of short parallel lines, some as enclosed irregular figures); a pair of small dark spots or irregular short dark lines dorsally near tip of snout; dorsal rays with faint alternating dark and light spots; a small faint dark spot anterobasally on adipose fin; peritoneum white.

COLOR IN LIFE: Dorsal half of body greenish gray with dark-brown markings as described above, abruptly bluish white ventrally; a narrow midlateral yellow stripe (along lateral line); a narrow blue stripe on upper side (in space between rows of dark markings) and a second less intense blue stripe along upper edge of ventral bluish-white half of body; dorsal rays with a series of small pale-greenish spots.

DISTRIBUTION AND HABITAT: At present, *Synodus lobeli* is known only from the island of Hawaii on a sand bottom at a depth of 32 m.

ETYMOLOGY: Named *lobeli* in honor of Philip S. Lobel, who first discovered the species and suspected that it was undescribed.

REMARKS: Two of the specimens from Hawaii (MCZ 28962) identified as *Synodus varius* (Lacépède) by Jordan and Evermann (1905: 63–65) are *Synodus lobeli*. The color description of the specimen USFC 03010 applies to this species.

Synodus lobeli is most closely related to *S. indicus* (Day), an Indian Ocean species known from the Pacific from a single specimen taken in the Philippines (Cressey 1981). Meristic data are essentially the same for the two, exceptions being the modal number of dorsal rays (11 for *lobeli*; 12 for *indicus*) and the number of predorsal scales (15–17 for *lobeli*; 14–16 for *indicus*). Comparisons of the proportional measurements for *indicus* given by Cressey (1981 : 22) and data for *lobeli* (Tables 6 and 7 herein) fail to show complete separation of any, though there are obvious differences in the range and mean of some of these measurements. The range in head length of *indicus*, for example, is given as 27.0–32.1% SL, and the mean 29.2%. The range in head length for *lobeli* is 26.0–27.8% SL, with a mean of 26.8%. The color patterns of the two species are similar. A color photograph of a specimen of *in licus* 119 mm SL, collected by J. E. Randall in Lombok, Indonesia (BPBM 29791), shows longitudinal rows of fine dark markings on the upper half of the body and an abruptly white ventral half, but there are concentrations of brown pigment to form a series of eight indistinct blotches midlaterally on the body, and there are no narrow blue or yellow stripes. More importantly, *indicus* has two adjacent black marks dorsoposteriorly on the opercle that are not present in *lobeli*.

There also appears to be a difference in the maximum size of the two species. Cressey (1981) examined specimens of *Synodus indicus* to 188.3 mm SL. The largest of our 21 specimens of *lobeli* is 121 mm SL and appeared to be larger than any others observed underwater. The 116.3-mm holotype is a fully ripe female.

Synodus ulae Schultz

Figures 1, 8, 9; Plate II, Figure B; Plate III, Figures E, F

Synodus ulae Schultz, 1953 : 38 (type locality, Honolulu).

Synodus varius (non Lacépède) Jordan and Evermann, 1905 : 64 (in part) (Hilo and Honolulu).

MATERIAL EXAMINED: One hundred specimens, 50–275 mm SL. Oahu: USNM 52671 (holotype, USFC 03174), BPBM 355 (1), BPBM

TABLE 6

PROPORTIONAL MEASUREMENTS OF TYPE SPECIMENS OF *Synodus lobeli* EXPRESSED AS PERCENTAGE OF STANDARD LENGTH

	HOLOTYPE	PARATYPES								
	BPBM 29293	BPBM 30337	BPBM 30337	BPBM 30337	BPBM 30337	BPBM 30337	BPBM 30337	BPBM 30337	BPBM 30337	BPBM 30337
Standard length (mm)	116.3	52.4	56.4	74.8	79.6	81.3	85.2	89.4	90.8	94.3
Body depth	15.0	13.4	12.8	14.7	14.1	14.5	14.1	14.7	14.9	14.8
Body width	14.7	12.4	12.4	14.4	14.3	14.7	14.3	14.4	14.8	14.9
Head length	27.8	26.9	27.2	26.7	26.0	26.9	27.0	26.3	26.1	26.9
Snout length	6.6	6.1	6.6	6.4	6.3	6.2	6.3	6.3	6.6	6.4
Orbit diameter	4.9	6.9	7.0	6.7	6.3	6.2	5.9	5.8	5.4	5.5
Interorbital width	2.2	1.8	1.5	1.7	1.6	1.9	1.9	1.7	1.9	2.1
Upper jaw length	16.5	16.0	16.0	15.8	15.8	16.4	16.5	16.2	15.6	15.9
Caudal peduncle depth	5.2	5.5	5.4	5.3	5.1	5.2	5.2	5.3	5.3	5.5
Caudal peduncle length	11.0	10.3	11.2	11.3	11.0	11.3	11.4	10.2	10.5	11.1
Predorsal length	45.8	42.9	42.2	42.3	42.0	41.8	42.6	42.8	42.5	42.3
Preanal length	80.0	79.5	78.8	78.2	78.7	79.2	77.8	80.0	79.2	79.3
Prepelvic length	35.5	34.6	35.6	35.2	34.4	34.3	34.6	34.6	34.2	34.6
Dorsal fin origin to adipose fin	39.2	39.3	38.5	39.7	40.2	40.5	39.0	39.2	39.5	39.7
Dorsal fin base	13.0	14.5	14.2	13.9	14.2	13.0	14.1	12.7	14.0	14.0
Longest dorsal ray	13.8	15.4	15.5	15.4	16.5	16.1	15.5	15.0	15.9	14.5
Anal fin base	9.3	8.8	8.9	9.6	9.3	9.7	10.2	9.9	8.7	9.3
Longest anal ray	7.6	7.6	7.1	7.4	Broken	7.9	7.8	7.8	7.9	7.5
Caudal fin length	16.3	16.6	16.8	17.3	17.0	17.2	17.6	16.9	17.7	16.5
Caudal concavity	8.2	9.3	9.6	9.3	9.0	9.6	9.5	9.0	9.3	9.5
Pectoral fin length	11.3	11.4	11.5	11.2	11.4	12.0	11.5	11.4	11.8	12.0
Pelvic fin length	21.8	23.5	22.8	23.1	24.4	24.1	23.5	24.5	23.1	23.5

635 (1), BPBM 3634 (1), BPBM 3635 (1), BPBM 3636 (1), BPBM 6465 (1), BPBM 9853 (2), BPBM 10033 (6), BPBM 12528 (9), BPBM 12663 (1), BPBM 13829 (1), BPBM 15429 (1), BPBM 15464 (1), BPBM 23526 (1), BPBM 24393 (5), BPBM 30963 (2), BPBM 30971 (1), BPBM 30972 (1), BPBM 30973 (2), BPBM 30974 (20), BPBM 30975 (11), BPBM 30976 (2); Hilo, Hawaii: BPBM 276 (1); Hawaiian Islands: MCZ 64518 (1), CAS 11312 (1); French Frigate Shoals, Northwest Hawaiian Islands: BPBM 20886 (1), BPBM 25437 (1); Laysan Island, Northwest Hawaiian Islands: CAS 39948 (3), CAS 39949 (10), USNM 55376 (2 paratypes); Maro Reef, Northwest Hawaiian Islands: CAS 39950 (1); Japan: SU 20706 (5), USNM 59805 (paratype).

DIAGNOSIS: Dorsal rays 13–14(rarely 12); pectoral rays 12–14; scale rows above lateral line 5.5; lateral-line scales 63–66; vertebrae 62–65; gill rakers 30–42; eye small (diameter of bony orbit 3.9–5.5% of SL); postoral portion of cheek unscaled; anterior palatine teeth longer than those posterior and in a discrete group; membranous flap on anterior nostril long and broad; a series of dark, rectangular blotches along lateral line, as wide or wider than intervening spaces; occurs in red or brown/green color phase; found from shallow water to 99 m; maximum size 275 mm SL.

DISTRIBUTION AND HABITAT: *Synodus ulae* is very common in the main Hawaiian Islands and comprises over 90% of the shallow-water (<30 m) *Synodus* specimens we have seen from the Northwest Hawaiian Islands. It is frequently taken with *S. dermatogenys* in shallow areas of mixed rock and sand substrate, but also has been collected at moderate depths (99 m). Outside Hawaii, *S. ulae* is known only from Japan.

REMARKS: Cressey (1981) previously noted that one of Schultz' *Synodus ulae* paratypes was actually "*englemani*" (=*S. variegatus*). We have identified four additional specimens in the type series that are not *ulae* [USNM 55272 (3); USNM 280212 (ex 55376) (1)], all of which have been made paratypes of *S. falcatus*.

In Hawaii, only *Synodus capricornis*, *S. falcatus*, *S. janus*, and *S. variegatus* have 5.5 scale rows above the lateral line and vertebral and lateral-line scale counts that overlap with *S. ulae*. *Synodus capricornis* and *S. variegatus* have a short and triangular nasal flap (long and broad in *S. ulae*); *S. falcatus* and *S. janus* have fewer gill rakers and a long, pointed nasal flap. *Synodus ulae* most resembles *S. dermatogenys* in color pattern, but *S. dermatogenys* lacks the pelvic bars found on *S. ulae*, and the series of dark markings along the side are wider in *S. ulae* than in *S. dermatogenys*. Six of the 43 *S. ulae* specimens we collected fresh were in the red color phase. Although red and brown/green individuals were sometimes taken together, the average depth of capture was greater for those in the red color phase (13 m compared to 6 m).

Synodus usitatus Cressey

Figure 1; Plate II, Figure C

Synodus usitatus Cressey, 1981:42, fig. 35 (type locality, Oahu).

MATERIAL EXAMINED: Fifty-six specimens, 84–181 mm SL. Oahu: BPBM 26544 (paratype); Molokai: BPBM 23855 (3); Pailolo Channel: BPBM 24986 (2); Maro Reef, Northwest Hawaiian Islands: BPBM 30977 (33), BPBM 30978 (10); USNM 285272 (7).

DIAGNOSIS: Dorsal rays 11–13; pectoral rays 12–13; scale rows between lateral line and dorsal fin 3.5; lateral-line scales 56–59; vertebrae 56–59; gill rakers 27–35; eye large (diameter of bony orbit 5.9–7.5% of SL); postoral portion of cheek scaled to preopercular margin; anterior palatine teeth not longer than those posterior and not in a discrete group; membranous flap on anterior nostrils broad and triangular; dorsal saddles and blotches along side faint, if present at all; occurs in orange-red or brown color phase; maximum size 181 mm SL.

DISTRIBUTION AND HABITAT: *Synodus usitatus* was described on the basis of only four specimens: three from Hawaii and one from Japan. Frozen specimens collected by the National Marine Fisheries Service from Maro Reef, Northwest Hawaiian Islands, included 49 *S. usitatus*, 4 *S. falcatus*, 1 *S. doaki*, and about 40 *Trachinocephalus myops*; thus, *S.*

usitatus may be the dominat *Synodus* species there at depths of about 100 m.

REMARKS: *Synodus usitatus* is perhaps most easily confused with *S. doaki*, which also has 3.5 scale rows above the lateral line, a large eye, and overlapping counts of vertebrae, lateral-line scales, and gill rakers. However, *S. usitatus* usually has 11–12 dorsal rays (13–15 in *S. doaki*), palatine teeth of uniform length (anterior teeth longer in *S. doaki*), and a much shorter nasal flap. *Synodus lobeli* and *S. kaianus* have palatine teeth of uniform length, but have much shorter pectoral fins and generally different counts for lateral-line scales and vertebrae. Two of the specimens from the Northwest Hawaiian Islands have isopod parasites in the gill opening; these have been sent to Thomas Bowman (U.S. National Museum of Natural History) for identification.

Synodus variegatus (Lacépède)

Figures 1, 2, 7, 8, 9; Plate II, Figure D; Plate III, Figures G, H

Salmo variegatus Lacépède, 1803:157 (type locality, Mauritius).

Salmo varius Lacépède, 1803:224 (second name for same species).

Synodus varius (non Lacépède) Jordan and Evermann, 1905:63 (in part: plate II) (Hilo and Honolulu).

Synodus ulae Schultz, 1953:38 (in part) (type locality, Honolulu).

Synodus englemani Schultz, 1953:41 (type locality, Rongelap Atoll, Marshall Islands).

MATERIAL EXAMINED: Fourteen specimens, 116–240 mm SL. Oahu: BPBM 30325 (1), BPBM 30962 (1), BPBM 30968 (1), BPBM 30969 (3); Midway Island, Northwest Hawaiian Islands: BPBM 30959 (1); Johnston Island: BPBM 9728 (1), BPBM 29625 (2), BPBM 30970 (2); Rongelap: USNM 140815 (holotype of *Synodus englemani* Schultz); Mauritius: MNHN B.2165 (holotype).

DIAGNOSIS: Dorsal rays 12–14; pectoral rays 12–13; 5.5 scale rows between lateral line and dorsal fin; lateral-line scales 61–63; vertebrae 61–62; gill rakers 33–38; peritoneal spots 7–10; interorbital space wide (3.9–4.7% of SL); postoral portion of cheek fully scaled to margin of preopercle; anterior palatine teeth longer than posterior teeth and in a discrete group; membranous flap on anterior nostrils short and triangular; a prominent streak along and below lateral line running the length of the fish; occurs in both red and brown color phases; maximum size 240 mm SL.

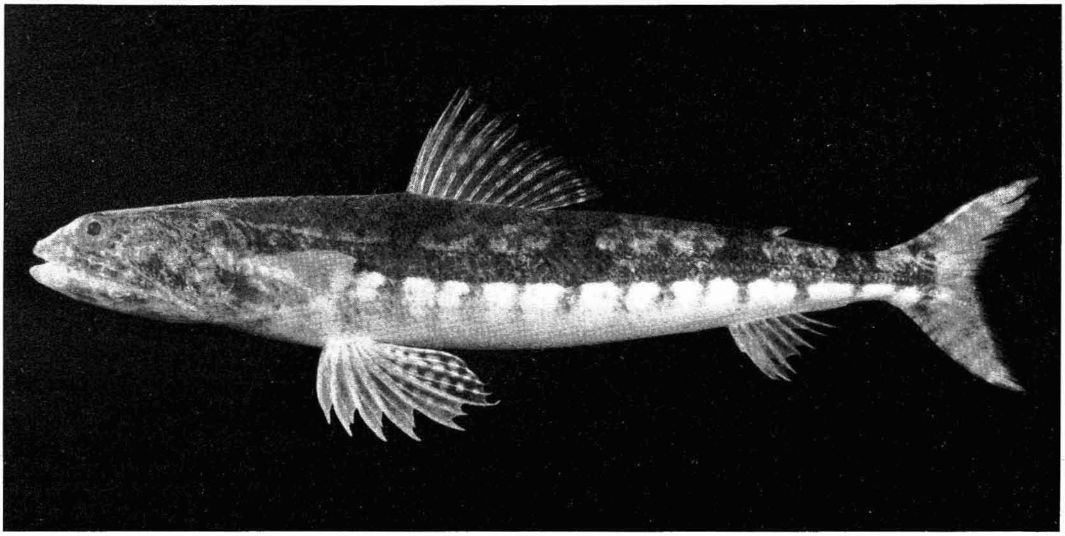


FIGURE 7. *Synodus variegatus* (Lacépède), 197 mm SL, Mauritius (specimen not saved).

DISTRIBUTION AND HABITAT: Very common throughout the Indo-West Pacific, from Pitcairn to South Africa in the south and from Hawaii and Okinawa to the Red Sea in the north. Found throughout the Hawaiian chain, although uncommonly, and generally at depths of 10 m or more.

REMARKS: The name *variegatus* has been associated with the species considered here to be *Synodus dermatogenys* for almost two centuries. However, Lacépède's description (1803: 224) agrees more closely with the species that has been known as *S. englemani*: "Les nuances un peu brunes du dos sont relevées par des taches rouges, et saccordent trés-bien avec le rouge, le jaune et le noir que deux raies longitudinales présentent symmétriquement de chaque côte du salmone, ainsi qu'avec le noir et le rouge dont les nageoires sont peintes."[4] *Synodus* "*englemani*" is the only species in the genus with prominent stripes along the side, and, unlike *S. dermatogenys*, is known to occur in a red color phase (Plate III, Figure G). Furthermore, the pelvic and anal fins of *S. dermatogenys* are pale yellow or orange, with no black or red.

With these suspicions in mind, R. S. Waples examined the type of *Salmo variegatus*, which exists as the dried skin of the left side of a specimen of about 166 mm SL. A number of potentially diagnostic characters are missing or uninformative: no pigmentation except faint bars on caudal rays, no peritoneal spots, nasal flaps and gill arches missing, and only 6 dorsal rays remain. However, the 5.5 scale rows above the lateral line, the 60–61 scales in the lateral line, and the 13 pectoral rays (not 14, as in the description) distinguish the type from all known Indo-Pacific species of *Synodus* except "*variegatus*," "*englemani*," *jaculum*, and *amaranthus*. In the type, the cheek is scaled to the margin of the preopercle. Postoral cheek scales occur in "*englemani*" but not in "*variegatus*," *jaculum* (Cressey 1981), or *amaranthus* (see description above). However, Cressey (personal communication) has subsequently indicated, and we have confirmed, that postoral cheek scales are present in some "*variegatus*" (= *dermatogenys*). Procurrent caudal ray counts provide more convincing proof of the identity of the type: 37 (19 dorsal, 18 ventral) in the type, in agreement with the range 29–37 (Cressey 1981) found in "*englemani*" (= *variegatus*) but outside the range of *dermatogenys* (26–34), *jaculum* (28–33) (Cressey 1981), and *amaranthus* (31–34). *Synodus variegatus* is widely distributed throughout the Indian Ocean, including Natal, South Africa, the Seychelles, Cocos-Keeling, Malagasy Republic, Amirante Islands, and Caragados (Cressey 1981). Although not yet reported from Mauritius, the type locality of *Salmo variegatus*, it does occur there. J. E. Randall collected two individuals of this species from Mauritius in 1973. The specimens were not preserved, but a photograph of the larger specimen is shown in Figure 7.

Believing the type of *Salmo variegatus* to have been lost, Cressey (1981) created a neotype (BPBM 21092). However, as Cressey did not give his "reasons for believing the holotype ... to be lost or destroyed, and the steps that had been taken to trace it" [International Trust for Zoological Nomenclature 1985: Article 75(d)(3)], this neotype was not validly designated.

The lateral-line scale and vertebral counts of *Synodus variegatus* are intermediate between those of *S. dermatogenys* and *S. amaranthus*, which have generally lower counts, and *S. ulae*, *S. capricornis*, *S. falcatus*, and *S. janus*, which have generally higher counts. None of these species, however, has the prominent streak along the side found in *S. variegatus*, and only *S. capricornis* shares the short, triangular nasal flap of *S. variegatus*. In addition, *S. falcatus*, *S. janus*, *S. amaranthus*, and *S. dermatogenys* have fewer gill rakers than *S. variegatus*. *Synodus variegatus*, as is *S. ulae*, is found in both red and brown color phases. Based on color pattern and the presence of postoral cheek scales, color plate II in Jordan and Evermann (1905) appears to be the present species.

[4] Translation: "The shades of light brown on the back are highlighted by red spots, and match well the red, yellow, and black of two longitudinal stripes symmetrically found on each side of the salmon, and also match the black and red colors of the fins."

Nomina Dubia

Several old names referable to the genus *Synodus* predate accepted names, but in none of the following cases is it possible to identify unambiguously the species to which the original description refers. *Cobitus japonicus* Houttuyn, 1782 (Japan), is the oldest available name for any Indo-Pacific *Synodus*, but, as Norman (1935) and Matsubara (1938) point out, Houttuyn's description is so brief that it might apply to any species in the genus [seven species reported from Japan by Cressey (1981)]. We therefore follow Cressey (1981) in considering *Cobitus japonicus* a nomen dubium.

Saurus ferox Eydoux and Souleyet, 1842, has been synonymized with *Saurida gracilis* (Norman 1935), but Waples (1981) pointed out that the 8 pelvic rays in the figure and description are consistent with *Synodus* or *Trachinocephalus* but not *Saurida*. The figure shows 13 dorsal rays, about 62 lateral-line scales, and postoral cheek scales, all consistent with *Synodus variegatus*. This identification is very speculative, however, as no type material exists (Eydoux and Souleyet 1842: 197), and the collection locality is unknown. In addition to its Indo-Pacific ports of call, *La Bonite* visited Rio de Janiero, Montevideo, and St. Helena, so *Saurus ferox* actually may refer to an Atlantic species.

Saurus lucius Temminck and Schlegel, 1846 (Japan), has long resided in the synonymy of *Synodus variegatus* (= *S. dermatogenys*), but Temminck and Schlegel's figure clearly shows bars on the pelvic and anal fins, while those of *dermatogenys* are unmarked. The authors never had any type material; their account is based on a description in D. W. Burger's manuscript, and their figure is an exact reproduction of a plate collected by Burger (Boeseman 1947). The figure shows about 70 lateral-line scales, more than any known *Synodus* species, but suggestive of *S. ulae* [range 63–66 this paper; 62–66 in Cressey (1981)]. The apparent lack of postoral cheek scales in the figure is also consistent with *ulae*, which is fairly commonly taken in Japan (often misidentified as "*variegatus*"). However, the markings along the side in the figure more closely resemble the stripe of "*englemani*" (= *variegatus*), which occurs in Okinawa but has not been reported from Japan (Cressey 1981). Furthermore, it is unclear from the figure whether *Saurus lucius* has more than 3.5 scale rows above the lateral line, so it is possible that Temminck and Schlegel's description was based on *Synodus doaki*, which does occur in Japan.

Because of the uncertainties involved in placing these three names, we consider them to be nomina dubia.

DISCUSSION

Use of Characters

NASAL FLAP: Several basic types of nasal flaps are found in Hawaiian *Synodus* (see Figure 1). *Synodus doaki* has easily the longest flap and is readily identified on this basis. *Synodus binotatus* and *S. ulae* have flaps that typically broaden substantially after an initial constriction. *Synodus variegatus* and *S. capricornis* have quite short, triangular flaps, although a narrow, pointed projection frequently is found at the apex of the triangle. *Synodus dermatogenys* and *S. amaranthus* have long, slender flaps, while those of *S. kaianus* and *S. usitatus* are broad and triangular. The flap of *S. lobeli* is short and slender. *Synodus falcatus* has a long and pointed flap that arises asymmetrically from the interior side of the nares and curves outward. Size and shape of the nasal flap is thus quite useful in separating a number of species, but this character is variable within some species (notably *S. ulae*, *S. falcatus*, and *S. dermatogenys*). Thus, care must be taken to avoid misidentifications due to damaged flaps. In making diagnoses, we recommend using this character in conjunction with others whenever possible. See also Cressey and Randall (1978) and Cressey (1981) for excellent drawings and photographs of nasal flaps for many species.

PERITONEAL SPOTS: Clear differences are apparent in counts of peritoneal spots for some species (Table 9); unfortunately, in most cases these are species that pose little problem in identification anyway. We have found this character of limited use with morphologically similar species. For example, a specimen with 5.5 scale rows above the lateral line and 11 peritoneal spots could be *Synodus amaranthus*, *S. capricornis*, *S. dermatogenys*, *S. falcatus*, *S. ulae*, or *S. janus*.

GILL RAKERS: The *Synodus* species can be roughly grouped according to low (*S. dermatogenys*, *S. falcatus*, *S. kaianus*, *S. lobeli*, *S. janus*), medium (*S. amaranthus*, *S. binotatus*, *S. doaki*, *S. usitatus*), or high (*S. capricornis*, *S. ulae*, *S. variegatus*) gill-raker counts (Table 3). Species in the low group are readily separated from those in the high group, and, in conjunction with other characters, counts can be helpful for identifying species in the intermediate group as well.

COLOR PATTERNS: The variety of color patterns found in species of *Synodus* has long been a source of confusion to taxonomists. For many years, and until quite recently, it has been common practice to treat many of these color variations as belonging to a single, variable species (*S.* "*variegatus*"). For example, Jordan and Evermann (1905) described a number of color morphs of *S. varius*, but we have identified seven different species in the material cataloged as *S. varius* in the *Albatross* log. Cressey and co-workers did much to resolve this confusion by identifying several new species that had been lumped with *S.* "*variegatus*." We have made extensive use of color slides and observations of fresh specimens to document similarities and differences in color patterns between species.

Certain basic pigmentation patterns are common to most Hawaiian species of *Synodus*; differences are due largely to species-specific elaborations of these underlying patterns. For example, *S. amaranthus*, *S. binotatus*, *S. capricornis*, *S. dermatogenys*, *S. doaki*, *S. ulae*, and *S. variegatus* all share two common features: a series of dark saddles on the back, and a stripe along the side at the level of the lateral line. This stripe is very prominent in *S. variegatus*; in the other species, it is relatively faint and largely obscured by a series of dark blotches along the lateral line. In *S. ulae*, *S. doaki*, and *S. capricornis*, these blotches are generally wider than the intervening pale areas; in *S. dermatogenys*, the reverse is true. In the last four species, some pigment extends several scale rows directly below these blotches; this is not the case with *S. amaranthus*. *Synodus binotatus* (and sometimes *S. doaki*) has a series of prominent, dark blotches between the lateral-line markings and several scale rows below; these lower markings are much reduced, if present at all, in the other species. The pattern of dorsal saddles and blotches along the lateral line is present but less distinct in *S. falcatus* and less distinct still in *S. usitatus*. No trace of dorsal saddles (except for one band on caudal peduncle) is found on *S. janus*, which has a rather uniformly mottled appearance and no distinct blotches along the lateral line. *Synodus lobeli*, with its series of longitudinal lines dorsally, and *S. kaianus*, which has a uniforml dark dorsum and three large blocks of pigment below the lateral line, have adopted color patterns rather distinct from the other Hawaiian *Synodus*.

In life, *Synodus amaranthus*, *S. binotatus*, *S. doaki*, *S. ulae*, and *S. variegatus* all have a series of alternating light and dark bars on the pelvic fins; these markings generally disappear entirely (except in the case of *S. amaranthus*) with preservation. *Synodus falcatus*, *S. lobeli*, *S. usitatus*, and *S. dermatogenys* have uniformly pale or yellow pelvic fins even in life. *Synodus capricornis* is unusual in having bars on only the second and third pelvic rays. We find no evidence of pelvic bars on *S. kaianus* or *S. janus* but have seen only preserved material.

Synodus ulae, *S. variegatus*, *S. usitatus*, and, apparently, *S. falcatus* all occur in two color phases: red and brown/green. *Synodus doaki* and *S. amaranthus* are presently known only in a red or orange phase. In contrast, all the fresh *S. dermatogenys* and *S. binotatus* we have seen were brown/green with at most some salmon-colored highlights. *Synodus capricornis* is orange-yellow with darker markings of brown and green. *Synodus lobeli* in life is greenish gray.

Size, Habitat, and Distribution

Five of the species (*amaranthus*, *binotatus*, *falcatus*, *janus*, *lobeli*) are relatively small, with no known specimens in excess of 140 mm SL. *Synodus capricornis* and *S. usitatus* grow to moderate size (approx. 180 mm SL), although the largest Hawaiian specimen of the former species is 136 mm SL. The remaining species all may exceed 200 mm SL, with *S. ulae* perhaps growing to the largest size [reported to 16 in. (over 400 mm) TL by Gosline and Brock (1960)].

In Hawaii, *Synodus dermatogenys* and *S. ulae* are easily the most commonly encountered species in shallow water. *Synodus dermatogenys* seems to be restricted to shallow water (deepest collection 32 m and most under 10 m), but *S. ulae* is taken in deeper water (to 99 m) with some regularity. We have noticed that at a given locality the relative abundance of these two species may fluctuate seasonally and from year to year. Two other species, *S. binotatus* and *S. variegatus*, also occur in shallow water but are less common in Hawaii. All the above species are typically found in areas where sand channels or pockets adjoin rocky reef areas and have been observed at least partially buried in sand. *Synodus capricornis* and *S. lobeli* are known in Hawaii only at depths of about 30 m. All specimens of *S. amaranthus* were "collected" at the Honolulu market in 1901, so depth of occurrence is unknown, as is the habitat of *S. janus*. The remaining species are found in somewhat deeper water and are unlikely to be encountered by sport divers (but see Plate III, Figure C). *Synodus falcatus* and *S. usitatus* are both consistently taken (often in the same collection) in bottom trawls at about 100 m. Only four Hawaiian specimens of *S. doaki* are known, all from 90–200 m. *Synodus kaianus* is not uncommon but has not been taken shallower than 200 m.

To date, the four new species described here (*Synodus amaranthus*, *S. falcatus*, *S. janus*, and *S. lobeli*) are not known outside the Hawaiian Islands. At the other extreme, *S. binotatus*, *S. dermatogenys*, and *S. variegatus* are abundant throughout the Indo-West Pacific. *Synodus capricornis* has an antitropical distribution (Hawaiian Islands, Easter Island, Pitcairn Island). The remaining species all occur in Hawaii and Japan, although only *S. ulae* and *S. usitatus* are restricted to these two areas. As noted above, many of these species are not found in shallow water, so currently recognized geographic ranges for them may reflect collecting effort as much as actual distribution.

Electrophoresis

Although many Hawaiian species of *Synodus* are separated by rather subtle morphological differences, it is apparent from Table 8 that the species examined electrophoretically are all quite distinct genetically. *Synodus ulae* and *S. dermatogenys* are fixed for different alleles at two of the seven gene loci surveyed; all other species pairs differ at four or more loci. Certain enzyme systems are almost completely diagnostic for the seven species surveyed. For example, at *Aat-2*, only *S. dermatogenys* and *S. variegatus* share electromorphs, the other five species each being characterized by a unique allele. As all systems were resolved from muscle tissue using only two buffer systems, complete diagnosis is possible by surveying several gene loci from the same gel. Thus, a *tris*-citric acid pH 8.0 gel could be stained for the enzymes CK, GPI, G3PDH, LDH, and PGM, providing more than enough information to separate all species. Note that in Table 8 the most common electromorph in *S. ulae* has been chosen as the reference and designated the "100" allele.

Discriminant Function Analysis

Subtle differences in color pattern and considerable overlap in some diagnostic characters lead to difficulties in identifying many species of *Synodus* with 5.5 scale rows above the lateral line. In cases where biochemical identification is not an available option, we have found a multivariate approach to be very useful. Using data for 37 *S. ulae*, 17 *S. dermatogenys*, and 8 *S. variegatus* that had been typed electrophoretically, we derived two discriminant functions that were then used to classify additional specimens having more than 3.5 scale rows above the lateral line. Several points can be made regarding Figure 8, which is a plot of the scores of each individual on the two discriminant functions: (1) The

TABLE 7

RANGE OF SELECTED MEASUREMENTS (AS PERCENTAGE OF STANDARD LENGTH) FOR HAWAIIAN SPECIMENS OF *Synodus**

	amaranthus	*binotatus*	*capricornis*	*dermatogenys*	*doaki*	*falcatus*	*kaianus*	*lobeli*	*ulae*	*usitatus*	*variegatus*
Standard length (mm)	92–115	93–126	88–136	95–203	68–235	81–125	121–235	52–116	91–219	84–181	116–240
Head length	28.3–30.3	26.6–28.3	29.9–33.5	26.3–28.9	27.5–30.1	28.5–32.6	26.9–28.9	26.0–27.8	26.5–30.7	27.3–29.6	28.2–31.2
Snout length	5.9–6.4	6.0–6.8	5.9–7.8	5.7–6.9	6.3–7.1	5.3–6.1	6.9–8.8	6.1–6.6	6.0–7.2	5.2–6.3	6.0–8.3
Orbit diameter	5.4–6.1	4.9–5.8	6.3–6.5	3.4–5.3	5.5–7.2	5.7–6.9	6.6–8.1	4.9–7.0	3.9–5.5	5.9–7.5	4.1–6.2
Interorbital width	2.8–3.2	2.4–3.2	3.0–3.8	2.5–3.0	2.7–3.2	2.0–3.1	3.0–4.1	1.5–2.2	2.7–3.8	1.9–2.7	3.9–4.7
Upper jaw length	17.4–19.7	16.7–18.7	18.5–21.7	16.9–19.0	17.5–19.6	16.8–20.2	17.2–18.7	15.8–16.5	17.0–20.2	15.9–18.0	18.0–20.3
Caudal peduncle depth	5.1–5.3	5.2–6.6	4.9–5.4	4.6–5.9	4.7–6.0	4.8–5.5	3.7–4.7	5.1–5.5	5.1–6.1	5.1–5.8	5.0–5.9
Predorsal length	42.0–43.5	40.3–42.8	39.5–43.3	39.5–43.5	39.7–41.4	40.1–44.3	39.7–42.2	41.8–45.8	39.5–43.1	39.7–41.4	40.6–44.0
Dorsal origin to adipose fin	39.9–41.7	38.5–42.8	41.5	38.7–41.3	39.7–42.7	40.2–43.6	39.6–43.3	38.5–40.5	40.0–42.9	40.7–43.0	37.9–42.6
Dorsal fin base	14.6–16.8	15.8–18.1	15.6–16.2	13.5–15.3	14.7–18.5	15.0–16.7	10.8–13.0	12.7–14.5	15.3–17.7	11.8–14.3	13.8–16.1
Longest dorsal ray	14.1–16.1	13.4–16.1	13.4–14.9	12.0–16.3	14.0–15.7	14.4–16.7	12.0–14.5	13.8–16.1	13.4–15.9	13.9–16.0	13.3–16.5
Anal fin base	7.7–8.8	9.4–10.5	7.5–8.5	7.7–9.9	8.6–10.2	5.5–7.9	7.4–8.7	8.7–10.2	8.0–10.2	6.8–9.0	8.1–10.0
Longest pectoral ray	10.3–11.3	12.9–14.4	9.6–10.0	9.0–10.5	11.1–12.6	9.9–11.6	12.3–15.0	11.2–12.0	10.1–12.5	10.7–12.7	10.1–11.4
Longest pelvic ray	22.0–25.3	22.7–25.7	22.7–23.4	20.8–24.7	20.4–21.7	22.1–28.0	15.6–19.1	21.8–24.5	21.1–24.8	21.0–25.0	21.2–25.1
Number of specimens	5	7	3	19	4	19	10	10	37	13	12

* See Table 4 for data for *S. janus*.

TABLE 8

RELATIVE MOBILITIES OF ELECTROMORPHS FOR SEVEN PRESUMPTIVE GENE LOCI IN SEVEN HAWAIIAN SPECIES OF *Synodus*

LOCUS/ALLELE		*binotatus*	*dermatogenys*	*doaki*	*falcatus*	*ulae*	*usitatus*	*variegatus*
Aat-2	130	—	—	—	—	—	12	—
	100	—	—	—	—	34	—	—
	98	—	—	—	8	—	—	—
	80	10	—	—	—	—	—	—
	60	—	—	2	—	—	—	—
	40	—	22	—	—	—	—	10
Ck-A	145	4	—	—	—	—	—	—
	115	—	—	—	2	—	30	10
	110	—	8	—	—	—	—	—
	105	—	—	2	—	—	—	—
	100	—	—	—	—	18	—	—
Gapdh-2	200	—	—	—	—	1	—	—
	146	8	—	—	—	—	—	—
	108	—	1	—	—	—	—	1
	100	—	5	2	2	29	34	7
Gpi-B	>110	—	—	—	1	—	—	—
	110	—	1	2	—	—	—	—
	100	4	3	—	—	16	—	—
	89	—	—	—	1	—	17	10
	<89	—	—	—	—	—	1	—
G3pdh	158	—	—	—	—	—	—	12
	125	—	—	—	—	—	1	—
	100	4	22	2	—	28	—	—
	80	—	—	—	8	—	—	—
	42	—	—	—	—	—	97	—
Ldh-A	123	—	—	2	—	—	—	—
	100	—	18	—	8	22	98	—
	90	10	—	—	—	—	—	—
	78	—	—	—	—	—	—	14
Pgm	160	2	—	—	—	—	—	—
	150	6	—	—	—	—	—	—
	135	—	—	—	—	—	—	10
	125	—	—	2	—	—	—	—
	100	—	18	—	8	22	—	—
	90	—	—	—	—	—	63	—
	<90	—	—	—	—	—	1	—

NOTE: Alleles are numbered according to their mobility relative to that of the common allele in *S. ulae* (="100"). Numbers in body of table are number of alleles observed in each species with indicated mobility.

three species used as the predefined groups (*ulae*, *dermatogenys*, *variegatus*) form coherent, well-separated clusters. (2) The holotype of each of these species, although not typed electrophoretically, is clearly associated with the "correct" species. (3) The five specimens of *S. amaranthus* form a cluster that is quite distinct from any other species. (4) The holotype of *S. janus* is likewise far removed from any other species. (5) The holotype of *S. houlti* is not closely associated with the specimens of *S. dermatogenys*. This result may be due in part to geographical variation, as *S. houlti* was described from Australia and is being compared here with Hawaiian material of *S. dermatogenys*. Nevertheless, this result supports our decision not to consider *S. houlti* a synonym of *S. dermatogenys*. (6) There is overlap among the *S. ulae*/*S. falcatus*/*S. capricornis* groups.

To help resolve overlap among these three species we repeated the analysis, deleting *Synodus dermatogenys* (which is relatively distinct) and including as the third predefined group

TABLE 9

SELECTED DIAGNOSTIC CHARACTERS IN HAWAIIAN SPECIES OF *Synodus*

	DORSAL RAYS	PECTORAL RAYS	LATERAL-LINE SCALES	VERTEBRAE	GILL RAKERS	PROCURRENT CAUDAL RAYS	PERITONEAL SPOTS	SCALE ROWS ABOVE 11	NASAL FLAP	ANTERIOR PALATINE TEETH LONGER?	p2 LENGTH* / p1 LENGTH	BARS ON PELVIC FINS?	MAXIMUM SIZE (mm)	DEPTH RANGE (m)
amaranthus	12–13	12–13	60–61	59–61	28–32	31–34	11–12	5.5	Long, slender	Yes	1.98–2.33	Yes	115	Unknown
binotatus	12–13	11–12	53–55	53–54	27–36	26–29 (27–33)	(0–3)	3.5	Long, broad	Yes	1.69–1.86	Yes	136	2–30
capricornis	13	13	65–66	64–65	34–38	32 (32–33)	10–11 (10–12)	5.5	Short, triangular	Yes	2.27–2.43	Yes†	136 (186)	25–30 (21–40)
dermatogenys	11–13	11–13	59–62	57–60	22–33	27–31 (26–34)	(10–12)	5.5	Long, slender	Yes	2.11–2.46	No	203	0–32
doaki	13–15	13	57–60	57–61	25–32	30–34 (31–35)	6–14 (11–12)	3.5	Very long, rounded	Yes	1.67–1.91	Yes	244	90–200 (19–140 elsewhere)
falcatus	12–15	12–13	64–68	63–67	25–30	31–33	10–13	5.5	Long, pointed	Variable	2.17–2.49	No	135	79–115
janus	12	13	65	64	24	33	12	5.5	Variable	Yes	2.57	No‡	136	Unknown
kaianus	10–13	12–13	60–64	60–63	22–29	(23–28)	None	3.5	Short, broad	No	1.13–1.34	No‡	235	218 (to 300 m elsewhere)
lobeli	11–12	12	53–55	53–56	24–27	27–32	10–11	3.5	Slender, pointed	No	1.92–2.15	No	121	32
ulae	12–14	12–14	63–66	62–65	30–42	32–39 (30–38)	(11–12)	5.5	Long, broad	Yes	1.85–2.15	Yes	275	0–99
usitatus	11–13	12–13	56–59	56–59	27–35	28–31	(14–17)	3.5	Moderate, triangular	No	1.87–2.04	No	180	88–100
variegatus	12–14	12–13	61–63	61–62	33–38	32 (29–37)	(7–10)	5.5	Short, triangular	Yes	2.0–2.42	Yes	240	10–30

NOTE: All data from Hawaiian specimens only except for entries in parentheses, which are taken from Cressey (1981).
* pelvic fin length/pectoral fin length
† Bars on second and third pelvic rays only.
‡ Observation of preserved specimens only.

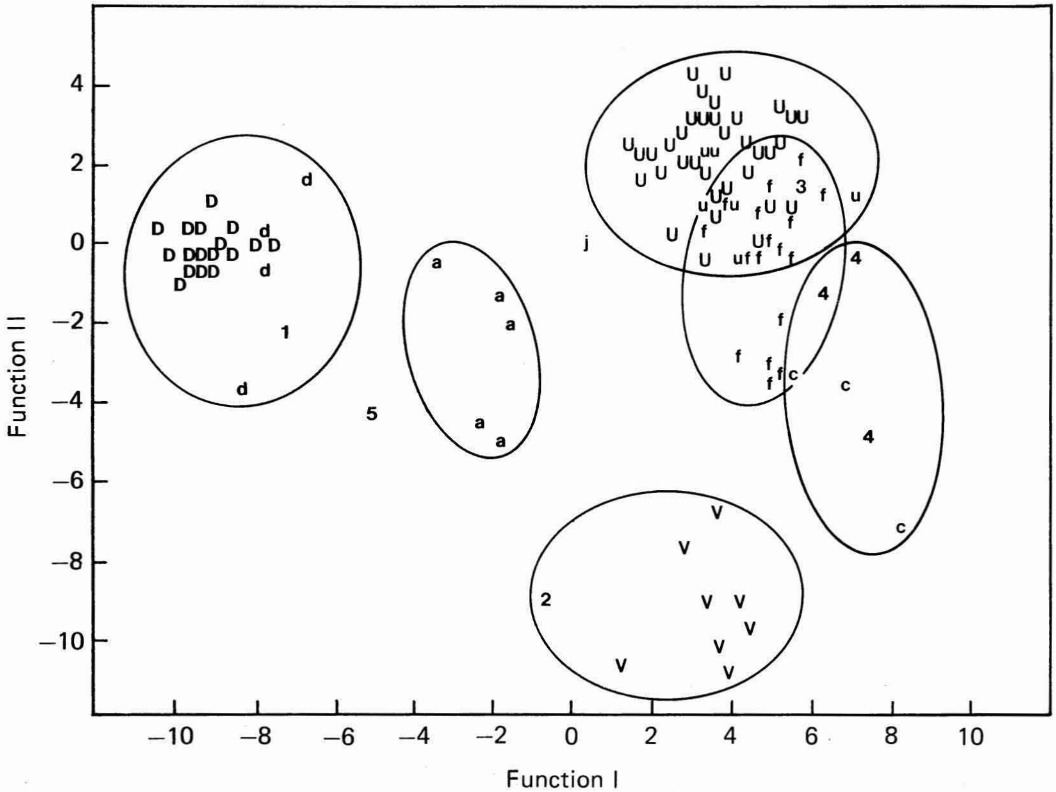


FIGURE 8. Plot of discriminant function scores for specimens with more than 3.5 scale rows above lateral line. Discriminant function units are indicated on the axes. Capital letters represent individuals phenotyped electrophoretically: D = *dermatogenys*, V = *variegatus*, U = *ulae*; lowercase letters represent preserved specimens of these species or *amaranthus* (a), *capricornis* (c), *falcatus* (f), or *janus* (j). Numbers indicate type specimens: 1 = holotype of *S. dermatogenys* (Hawaii); 2 = holotype of *S. englemani* (Marshall Islands); 3 = holotype of *S. ulae* (Hawaii); 4 = paratypes of *S. capricornis* (Pitcairn, Easter Island); 5 = holotype of *S. houlti* (Queensland, Australia). Clusters of individuals belonging to the same species are circled.

the four *S. falcatus* specimens that could be typed electrophoretically. The resulting discriminant functions emphasized characters that help distinguish *S. ulae*, *S. falcatus*, and *S. variegatus*. Even with a smaller than optimal number of specimens of *S. falcatus* and *S. variegatus* available to define the groups, there is no overlap in the three input species (Figure 9), and Hawaiian specimens of *S. capricornis* are quite distinct as well. More importantly, all the preserved specimens of *S. falcatus* clearly cluster with the four that were biochemically typed.

To summarize, we found that (1) the two new species for which no electrophoretic analysis was possible (*S. amaranthus* and *S. janus*) are distinct from any known species; and (2) the discriminant analyses support our identification of preserved specimens.

ACKNOWLEDGMENTS

Richard H. Rosenblatt and James B. Shaklee provided much valuable guidance at various phases of this research. We thank Roger F. Cressey and Barry C. Russell for loaning specimens, sharing information regarding *Synodus*, and reviewing the manuscript. We are grateful to others who loaned specimens in their care, including Marie Louise Bauchot (Muséum National d'Histoire Naturelle),

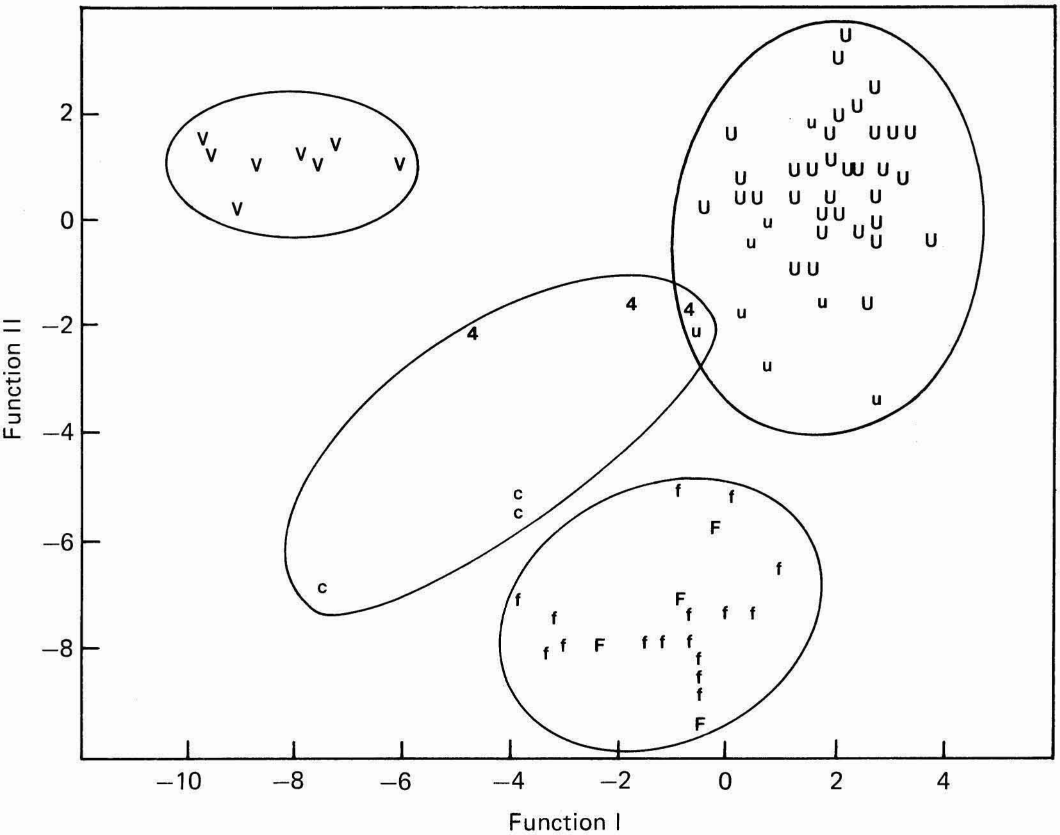


FIGURE 9. As in Figure 8, but deleting *Synodus dermatogenys* and *S. amaranthus* and using data for holotype and three paratypes of *S. falcatus* (F) that had been sampled electrophoretically to define third group.

William N. Eschmeyer (California Academy of Sciences), Karsten Hartel (Museum of Comparative Zoology), R. J. McKay (Queensland Museum), William F. Smith-Vaniz (Academy of Natural Sciences of Philadelphia), and Victor G. Springer (U.S. National Museum of Natural History). James D. Parrish (Hawaii Cooperative Fisheries Investigations) and James Prescott (then of National Marine Fisheries Service, Southwest Fisheries Center) donated frozen specimens from the Northwest Hawaiian Islands. Eugenia B. Böhlke (Academy of Natural Sciences of Philadelphia), Kent E. Carpenter (University of Hawaii), Michael Hearne (California Academy of Sciences), Arnold Y. Suzumoto (Bernice Pauahi Bishop Museum), and Clyde S. Tamaru (Hawaii Institute of Marine Biology) assisted with radiographs. Janet R. Gomon (U.S. National Museum of Natural History) kindly provided collection information for the U.S.S. *Albatross* specimens. We thank Alwyne Wheeler [British Museum (Natural History)] for information regarding Gronovius, and Marie Louise Bauchot and Gary Ward for help with translations from the French. Douglas Davis, Paula J. Jenson, Michael P. Krochina, Roland Pinot, and James B. Shaklee helped with field collections.

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