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A review of the Atlantic flying-fishes, genus *Cypselurus*

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BOSTON UNIVERSITY
GRADUATE SCHOOL

Thesis

A REVIEW OF THE ATLANTIC FLYING-FISHES,
GENUS CYPSELURUS

by

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(B.A., University of Michigan, 1960)

Submitted in partial fulfilment of the
requirements for the degree of
Master of Arts

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ACKNOWLEDGEMENTS

This work was undertaken at the suggestion of Dr. Robert H. Gibbs Jr., and I am very grateful to him for his continuing helpful criticism and valuable suggestions.

For the loan of specimens I am indebted to Mr. Jack W. Gehringer of the Brunswick, Georgia Biological Laboratory of the Bureau of Commercial Fisheries and Dr. Giles Mead, of the Museum of Comparative Zoology, Harvard University. Specimens at the U. S. National Museum were examined through the courtesy of Dr. Leonard P. Schultz.

INTRODUCTION

The systematics of the flying-fishes (family Exocoetidae) have been in a state of confusion since the description of the second species in 1766. Though more than 60 names had been proposed for the Atlantic forms by 1935, investigators studying large series of specimens have recognized no more than 20 as valid. Bruun (1935: 5-8) listed the synonymy of the group and recognized 17 species. Breder (1938: 56) reduced this number to 16.

Much of the difficulty encountered in describing exocoetids results from the presence of usually considerable growth changes, such that adults of some species bear little resemblance to juveniles in color pattern and presence of mandibular barbels. Most early workers had so few specimens that no complete developmental series could be assembled, and many new species were named for the juvenile forms of existent species. Breder was the first to describe developmental series of many Atlantic species, but he did not have enough specimens to construct a key that would function for individuals of all sizes.

The object of this paper is to review the Atlantic species of Cypselurus in the light of the large numbers of specimens at my disposal, to describe in detail the ontogenic changes of each species, and to present a key adequate enough to identify juvenile as well as adult specimens.

MATERIALS

Specimens examined were from the following sources:
Boston University (BU): Museum of Comparative Zoology,
Harvard University (MCZ): Bureau of Commercial Fisheries
Biological Laboratory, Brunswick, Georgia (FWS): United
States National Museum (USNM).

specimens

METHODS

All measurements were taken with a dial caliper. The lengths were read to 0.1 mm and are presented as per cent of standard length. The methods of measurement are taken from Bruun (1935: 13), except for new ones used here.

Standard length (abbreviated SL): tip of snout to end of hypural plate.

Dorsal and anal fin heights: length of longest ray.

Pectoral and pelvic fin lengths: insertion of first ray to end of longest ray.

Prepectoral length: tip of snout to insertion of pectoral fin.

Interorbital width: least distance across the ossified portion of the orbits, not including any soft parts.

Barbel length: tip of barbel to point at which the posterior edge of the barbel meets the skin of the lower jaw.

First well developed pectoral ray length: tip of ray to its origin at the skin.

Distance between first and second pectoral rays: measured along a line at right angles to the rays at a point close to the distal end of the ray, but where the fin membrane is still intact.

Distance between the second and third pectoral rays: measured along the same line as the measurement for the first-second ray distance.

Meristic characters were examined with a binocular dissecting microscope. Counts were made as per Hubbs and Lagler (1958: 19-24).

Dorsal and anal fin rays: the last ray is frequently bifurcate to the base, but was always counted as one ray. All elements are counted, not just principal rays.

Pectoral rays: the first pectoral ray is small and difficult to see and is omitted in counts, conforming with the practise of previous workers.

Vertebrae: counts were taken from specimens stained with alizarin and cleared in glycerin, or from X-rays. The hypural plate was counted as one vertebra. Caudal and pre-caudal vertebrae were not noted separately.

Predorsal scales: counted along the mid-dorsal line from end of occiput to dorsal fin origin,

Postdorsal lateral scales: counted mid-laterally from the first row of scales behind the dorsal origin to the hypural plate.

Scales above the lateral line: counted along the diagonal scale row from dorsal origin to, but not including, the lateral line scale.

Gill rakers: recorded as total count on first arch.

Tooth size: several teeth were taken from close to the premaxillary symphysis and their average length recalculated to that of a fish of 100 mm SL after Bruun (1935: 14).

In Cypselurus furcatus and C. heterurus the teeth were too small to be measured. It was impossible to remove them from the jaws without breaking them.

Palatine teeth were exposed by cutting through the angle of the jaw, and were counted as present only when they could be seen as well as palpated. Strength of palatine dentition was based on the abundance of teeth.

Nomenclature used to describe the pectoral and pelvic fins is shown in fig. 1.

Cypselurus Swainson, 1838

SYNONYMS AND REFERENCES

Cypsilurus Swainson, Nat. hist. and classif. fishes 2, 1838:

187, 296(orig. descr.; type species - Exocoetus appendiculatus Wood, 1825 = E. comatus Mitchill, 1815; misprint for Cypselurus according to decision Int. Comm. Zool. Nomencl.); Bruun, Dana Rep. (6), 1935: 12 (descr., key, illust.).

Cypselurus. Lowe, Proc. Zool. Soc. London 8, 1840: 38 (descr.); Agassiz, Nomenclator zoologicus 8, 1846 (fide Breder); Breder, Bull. Bingham Oceanog. Coll. 6 (5), 1938: 3 (descr., key, illust.); Hubbs and Kampa, Copeia (4), 1946: 205 (descr., key, illust.); Parin, Trudy Inst. Okeanol. 43, 1961: 167 (descr., key, illust.).

Cheilopogon Lowe, Proc. Zool. Soc. London 8, 1840: 38 (orig. descr.; type species - Cypselurus pulchellus syn. for C. pinnatibarbatus (Bennett, 1831); Madeira; withdrawn because of priority of Cypselurus); Hubbs and Kampa, Copeia (4), 1946: 207 (descr., key, illust.); Parin, Trudy Inst. Okeanol. 43, 1961: 167 (descr., key, illust.).

Cyprilurus. DeKay, Zool. of New York 1 (3), 1842: 231 (misprint for Cypselurus).

Ptenichthys Müller, Arch. Naturgesch. 9 (1), 1843: 312 (orig. descr.; type species - Exocoetus furcatus (Mitchill, 1815)); Parin, Trudy Inst. Okeanol. 43, 1961: 173(descr.,

key, illust.).

Ptenonotus Ogilby, Proc. Roy. Soc. Queensland 21, 1908: 13

(orig. descr.; type species - Exocoetus cirriger Peters, 1877); Ann. Queensland Mus. 22, 1914: 13 (same as 1908).

Poecilocypsilurus Bruun, Dana Rep. (6), 1935: 84 (orig. descr.;

type species - Cypsilurus callopterus (Gunther, 1866));

Parin, Trudy Inst. Okeanol. 43, 1961: 165 (descr., key, illust.).

Eucypsilurus Bruun, Dana Rep. (6), 1935: 84 (orig. descr.;

type species - Cypsilurus heterurus (Rafinesque, 1810)).

Procypsilurus Bruun, Dana Rep. (6), 1935: 84 (orig. descr.;

type species - Cypsilurus exsiliens (Linnaeus, 1771));

Parin, Trudy Inst. Okeanol. 43, 1961: 168 (descr., key, illust.).

Paracypselurus Parin, Trudy Inst. Okeanol. 43, 1961: 167

(orig. descr.; type species - Parexocoetus papilio Clark; descr., key, illust.).

Maculocoetus Whitley and Colefax, Proc. Linn. Soc. N. S. Wales

63 (3-4), 1938: 287 (orig. descr.; type species -

Maculocoetus suttoni Whitley and Colefax, 1938; Gilbert

Islands); Parin, Trudy Inst. Okeanol. 43, 1961: 168

(descr., key, illust.).

Abeichthys Parin, Trudy Inst. Okeanol. 43, 1961: 171 (orig.

descr.; type species - Exocoetus agoo Temminck and Schlegel; key, illust.).

DIAGNOSIS

Pectoral fins greater than 45% of SL (except in very small juveniles, about 10 mm SL); reaching at least to the dorsal fin midpoint (except in very small juveniles). Pelvic fins longer than 26% of SL; reaching at least to anal fin midpoint. Base of anal fin shorter than base of dorsal; beginning well behind dorsal origin; usually with fewer rays than dorsal, never more. First pectoral ray simple, second bifurcate; in specimens less than 15 mm SL the rays usually simple. Anterior dorsal and anal rays longest. Eggs demersal, with long tendrils. Teeth present on both jaws. Adults rectangular in cross section.

ONTOGENY

In all species certain structures exhibit trends toward proportional increase or decrease with growth. Snout length, pectoral fin length, and greatest depth increase in size proportional to the SL. Barbel length, fleshy orbit diameter, pelvic fin length, and dorsal fin height decrease in size proportional to SL.

RANGE

Tropical and temperate waters of Atlantic, Indian, and Pacific Oceans. Atlantic Cypselurus appear to be in highest concentration about the islands of the West Indies. Only two, C. furcatus and C. exsiliens, are oceanic; C. comatus, C. heterurus, C. cyanopterus, and C. pinnatibarbatus are usually neritic. This preference for coastal waters leads to

their concentration, in both species and number, in warm, shallow areas of the Gulf of Mexico and the Caribbean, including the West Indies. The genus is reported as far as 42°N in the western North Atlantic (BU specimen - off Cape Cod) and 59°N in the eastern North Atlantic (Bruun, 1938 - Oslo Fjord); as far as 23°S in the western South Atlantic (Bruun, 1935 - 95) and 35°S in the eastern South Atlantic (Bruun, 1935: 95).

DISCUSSION

Parin has recently (1961) revised the Exocoetidae. He divides the Atlantic Cypselurus among two genera. Cypselurus comatus is retained, but the other five species are referred to Cheilopogon Lowe, 1841. Until his paper is translated from the Russian I can only state that I do not believe that the characters he sites in his key (which we have translated) are definitive or invariable enough for a valid separation.

KEY TO THE SPECIES

- I. Key to specimens less than 100 mm SL.
- 1a. Dorsal fin usually evenly pigmented: fin height greater than 20% of SL..... 2
- 1b. Dorsal fin either without pigment or with pigment appearing as a number of blotches on a clear background: fin height less than 20% of SL..... 4
- 2a. Barbel single, semicircular in shape, subdivided into 15-20 fringe-like appendages. 39-47 predorsal scales. 50-52 vertebrae.....
..... Cypselurus pinnatibarbatus
- 2b. Paired barbels, not divided into fringe-like appendages. 21-40 predorsal scales, 43-46 vertebrae.. 3
- 3a. Barbel greater than 80% of SL. Both caudal lobes pigmented. Pectoral fin with dark blotches on proximal half, solidly dark on the distal half. Rear edge of dorsal fin rounded. 31-40 predorsal scales..... Cypselurus cyanopterus
- 3b. Barbel less than 40% of SL. Upper caudal lobe very lightly pigmented. Pectoral fin dark with a light crossband and light posterior margin. Anterior edge of pectoral fin sometimes unpigmented. Rear edge of dorsal fin straight and nearly vertical to the body. 21-30 predorsal scales..... Cypselurus exsiliens
- 4a. Barbel single, greater than 40% of SL. Pectoral and pelvic fins evenly pigmented, without pattern.

Dorsal fin without pigment. Caudal fin without pigment, or evenly pigmented... Cypselurus comatus

4b. Paired barbels, less than 40% of SL. Pectoral and pelvic fins with pattern of spots and bands. Dorsal fin with dark blotches. Caudal fin with a number of pigmented blotches on both lobes..... 5

5a. First pectoral ray less than 38% of SL. Distance between first and second pectoral rays (measured at end of first) greater than 1.7 times the distance between the second and third. Barbels less than 16% of SL. Pectoral fin with five more or less distinct dark blotches and a clear proximal arc extending from just behind the anterior edge to the mesial edge; edge of pigment blotch on posterior half of fin not forming a straight line at right angle to body..... Cypselurus heterurus

5b. First pectoral ray greater than 38% of SL. The distance between the first and second pectoral rays (measured at end of first) less than 1.7 times the distance between the second and third. Barbels greater than 16% of SL, (sometimes less in specimens below 35 mm SL). Pectoral fin with four dark blotches; no obvious clear arc; anterior edge of pigment blotch on posterior half of fin forming a straight line at right angle to the body..... Cypselurus furcatus

II. Key to specimens greater than 100 mm SL.

- 1a. A prominent dark spot on the posterior half of the dorsal fin; fin height greater than 18% of SL in specimens shorter than 150 mm SL; greater than 12 % of SL in specimens longer than 150 mm SL.... 2
- 1b. No dark spot on dorsal fin; fin height less than 18% of SL in specimens less than 150 mm SL; less than 12% of SL in specimens longer than 150 mm SL..4
- 2a. Pectoral fin dark, with obvious light crossband. Upper caudal lobe much lighter than lower. 21-30 predorsal scales..... Cypselurus exsiliens
- 2b. Pectoral without a light crossband, or with a vague crossband. Caudal lobes evenly pigmented. 31-46 predorsal scales..... 3
- 3a. Pectoral fins bluish in preservation; without a light posterior margin; without a crossband. 31-40 predorsal scales. 43-46 vertebrae.....
.....Cypselurus cyanopterus
- 3b. Pectoral fins grayish in preservation; with a light posterior margin; with a vague crossband in some specimens. 39-46 predorsal scales. 50-52 vertebrae.
..... Cypselurus pinnatibarbatus
- 4a. Pectoral fin evenly pigmented. Palatine teeth present. premaxillary teeth tricuspid.....
..... Cypselurus comatus

- 4b. Pectoral fin with a light crossband. No palatine teeth. Premaxillary teeth unicuspid..... 5
- 5a. First pectoral ray less than 38% of SL. Pectoral grayish in preservation. Light pectoral crossband widest at mesial edge, in specimens over 150 mm SL ending well before anterior edge and triangular in shape. Pectoral with a narrow light posterior margin. Pelvic very lightly pigmented (nearly clear in specimens over 180 mm SL) with a vague crossband..... Cypselurus heterurus
- 5b. First pectoral ray more than 38% of SL. Pectoral fin nearly black in preservation. Light pectoral crossband widest at anterior edge, always reaching to, or near to the anterior margin, not triangular..... Pectoral with a wide light posterior margin. Pelvic darkly pigmented with an obvious light crossband... .. Cypselurus furcatus

Cypselurus comatus (Mitchill, 1815)

STUDY MATERIALS

BU (1) 20°10'N, 60°05'W, XII-10-1956: BU (1) between Grand Cayman and Swan Islands, I-15-1950: BU (1) 20°50'N, 93°00'W, XI-25-1956.

USNM 94722 (1) Cuba: USNM 170321 (3) Lesser Antilles - Saba Bank, IV-13-1956.

DISTINCTIVE CHARACTERS

Juvenile C. comatus may be distinguished from other Atlantic Cypselurus by their single, simple median barbel. Most other species have paired barbels. C. pinnatibarbatus has a median barbel, but it is short and fringed.

The adults are distinguished by their low, clear dorsal fin (held in common with C. heterurus and C. furcatus), evenly pigmented pectoral fins (unique within the low dorsal fin group), and tricuspid premaxillary teeth. No other species of Atlantic Cypselurus has as obviously tricuspid teeth as C. comatus.

DESCRIPTION

Palatine teeth weak, i.e., small and few in number in all specimens examined. The only specimen large enough to be measured had a tooth index of 0.11, lower than the range of 0.13-0.15 given by Bruun (1935: 54). All teeth examined had two extra cusps which were shorter than the central cusp, but much larger than the accessory cusps of the other species.

Counts and proportional dimensions (as per cent of SL) of study material, 82.4-242.5 mm SL; extensions from the literature in parentheses:

dorsal rays;	10-13
anal rays;	8-9
dorsal minus anal rays;	1-4(5)
pectoral rays;	12-16
predorsal scales;	24-30(33)
postdorsal lateral scales;	19-21
total gill rakers(first arch);	18-22(24)
scales above lateral line;	5-8
vertebrae;	40-43(44)
preanal length;	77.9-79.6(81.5)%
predorsal length;	(69.7)71.2-71.9(72.4)%
prepelvic length;	58.9-60.4(63.0)%
prepectoral length;	23.9-25.6%
head length;	(23.7)24.0-25.5%
snout length;	5.2-6.8%
fleshy orbit diameter;-	(7.3)7.6-8.9%
interorbital width;	(7.5)7.7-9.5%
pectoral length;	61.0-70.9%
pelvic length;	(27.8)28.5-39.7(41.0)%
dorsal height;	9.0-15.6%
anal height;	6.0-6.9%
dorsal base;	11.7-14.17.3-18.6%
anal base;	9.4-11.0%
greatest depth;	(17.8-19.9)20.0-21.2%

caudal peduncle depth;	6.8-7.3%
body width;	(13.1-14.3)14.7-15.1%
depth behind eyes;	15.4-16.1%

Pectoral fins grayish, pigment denser distally; light margin on posterior edge and the last few rays unpigmented. Pelvic fins grayish, the pigment denser distally. Dorsal and anal clear. Caudal fin quite heavily pigmented in adults. Body of adults light silver ventrally, dark dorsally. Juvenile coloration is discussed under ontogeny.

ONTOGENY

The young of C. comatus have a single, median mandibular barbel. It is fleshy, with two lateral folds of skin that extend for its entire length, and tapers distally to a point. The barbel undergoes a spectacular development. Breder (1938: 52, table XIV) lists a specimen of 71 mm SL with a barbel 102.8% of SL. This appears to be the maximum relative size. The relative length of the barbel decreases up to about 160 mm SL and then disappears quite rapidly, with no barbels reported for specimens over 170 mm SL. The structure of the barbel does not change with growth. The development and regression of the barbel is shown in fig. 2.

The dorsal fin undergoes a reduction in height with growth, as in all other species.

The pelvic fins become relatively smaller with growth. Specimens smaller than 150 mm SL have pelvic fins longer than

35% of SL, while in larger specimens the fin is less than 35% of SL. The fins are weakly pigmented in the adult, but fairly heavily so in the juveniles. This pigmentation appears to be greatest in specimens of about 155 mm SL. Bruun (1935: 53) states that pelvic fins of adults are generally clear, but with grayish bases.

The pectoral fins maintain the same pigmentation throughout development.

The caudal fin is light in juveniles, but becomes darker with growth. In a specimen of 82.4 mm SL the caudal was almost devoid of pigment, in a specimen of 151.0 mm SL it was darker, and in a specimen of 242.5 mm SL it was almost black, with both lobes uniformly pigmented.

RANGE

Tropical portion of the western Atlantic. Appears to be concentrated in the Caribbean and Gulf of Mexico with one specimen reported by Bruun (1935: 56, 96, text-fig. 28) from the east of Brazil at 36°W , 11°S . Almost all specimens have been collected in coastal waters. See fig. 8 for the distribution of the species in the North Atlantic.

REPRODUCTIVE BIOLOGY

According to Bruun (1935: 55) sex could not be determined generally in fish under 170 mm SL, and the smallest ripe fish he identified was 178.5 mm SL. The breeding season extends from February to April. (Breder; 1938: 52) Ovarian eggs are

about 1.28 mm in diameter and have filaments, as do those of the other species. (Breder, 1938: 52, fig. 27)

SYNONYMS AND REFERENCES

- Exocoetus comatus Mitchill, Trans. Lit. Phil. Soc. New York (1814) 1, 1815: 448 (orig. descr.; illust.; New York); DeKay, Zool. New York 1 (3), 1842: 231 (descr., illust.; New York); Valenciennes in Cuvier and Valenciennes, Hist. nat. Poiss. 19, 1846: 133 (descr.; S. Carolina); Storer, Mem. Amer. Acad. Arts Sci., Boston 2, 1846: 188 (descr.; New York; misspelled Exocetus);["] Gunther, Cat. Fishes Brit. Mus. 6, 1866: 286 (key, descr.; W. Atlantic);["] Lutken, Vid. Meddel. Kjobenhavn (1877), 1876: 399 (fide Breder).
- Exocoetus appendiculatus Wood, J. Acad. Nat. Sci. Phila. 4(1), 1824: 283 (orig. descr., illust.).
- Exocoetus bahiensis Ranzani, Acad. Sci. Inst. Bononiensis 5, 1842: 362 (fide Breder).
- Exocoetus heterurus. Jordan and Meek, Proc. U. S. Nat. Mus. 8 (1885), 1886: 59 (misidentification in part; descr., key); Jordan and Evermann, Bull. U. S. Nat. Mus. 47 (1), 1896: 735 (misidentification in part; W. Atlantic).
- Cypselurus vitropinna Breder, Bull. Bingham Oceanog. Coll. 1 (1), 1927: 20 (orig. descr.; W. Indies); Parr, Bull. Bingham Oceanog. Coll. 3 (4), 1930: 25 (descr.; Bahamas); Breder and Nichols, Amer. Mus. Novitates (417), 1930: 7 (listed; W. Indies); Nichols and Breder, Proc. Biol. Soc. Wash. 47, 1934: 42 (listed, descr.).

Cypselurus heterurus. Jordan, Evermann, and Clark, Rep. U.

S. Comm. Fisheries (1928) app. 10, 1930: 201 (misidentification in part; checklist); Nichols and Breder, Amer. Mus. Novitates (428), 1930: 7 (misidentification in part; key).

Cypselurus antarei Beebe and Hollister, Zoologica, New York 12 (9), 1933: 83 (orig. descr., illust.; 21°50'N, 63°32'W).

Cypsilurus comatus. Bruun, Vid. Meddel. Kjobenhavn 94, 1933: 382 (listed); Dana Rep. (6), 1935: 52 (descr., key, illust.; Atlantic).

Cypselurus comatus. Breder and Nichols, Proc. Biol. Soc. Wash. 47, 1934: 42 (listed; descr.); Breder, Bull. Bingham Oceanog. Coll. 6 (5), 1938: 51 (descr., key, illust.; W. Atlantic); Parin, Trudy Inst. Okeanol. 43, 1961: 165 (illust., key, listed).

Cypselurus alienus Herre, Field Mus. Nat. Hist. Zool. Ser. 18 (21), 1935: 392 (orig. descr.; Cuba); Field Mus. Nat. Hist. Zool. Ser. 21, 1936: 11 (listed, illust.).

Questionable:

Exocoetus spilopus Murray and Hjort, Depths of the Oceans, London, 1912: 82 (descr., illust.; Canary I.);

Cypselurus cyanopterus (Valenciennes, 1846)

STUDY MATERIALS

BU (1) 37°09'N, 9°42'W, XI-28-1957: BU (1) 12°00'N, 76°00'W, X-26-1956: BU (1) 34°45'N, 73°41'W, X-10-1957: BU (1) 39°07'N, 65°58'W, IX-21-1957: BU (2) 38°00'N, 65°25'W, V-1-1960: BU (1) 39°N, 68°W, IX-23-1957: BU (1) 39°28'N, 69°30'W, X-30-1956: BU (1) 23°10'N, 92°00'W, V-11-1954: BU (1) 37°45'N, 71°49'W, X-7-1957: BU (1) 21°42'N, 93°35'W, V-22-1954: BU (1) 36°42'N, 70°00'W, X-3-1957: BU (1) 21°N, 91°W, XI-21-1956: BU (2) 20°50'N, 93°00'W, XI-25-1956: BU (3) 20°10'N, 92°25'W, XI-24-1956: BU (1) 20°12'N, 91°59'W, VII-12-1957: BU (1) 24°54'N, 96°05'W, V-27-1954: BU (1) 19°13'N, 95°34'W, V-17-1954: BU (1) 20°01'N, 92°27'W, V-14-1954.

MCZ 34712 (1) 71°04'W, 38°20'N, VIII-5-1937.

USNM 158847 (1) 29°10'N, 86°17'W, IX-7-1955.

DISTINCTIVE CHARACTERS

The most distinctive juvenile character is the extreme development of the paired mandibular barbels, which exceed 100% of SL in specimens from 25 to 83 mm SL (longer than in any other Atlantic Cypselurus). The high dorsal fin (9.4-25.6% of SL) and bandless pectoral fin are also characteristic.

Adults are distinguished by a combination of high, pigmented dorsal fin, evenly pigmented caudal fin, evenly pigmented blue pectoral fin, and low number of vertebrae (43-46). The high dorsal fin separates C. cyanopterus from C.

comatus, C. heterurus and C. furcatus. The presence of pigment on both caudal lobes distinguishes it from C. exsiliens, as does the solidly colored pectoral. The low vertebral count separates it from C. pinnatibarbatus (50-52).

DESCRIPTION

Palatine teeth present in all specimens examined, varying considerably in number and size. Strength of palatine dentition, previously used as a distinguishing character, too variable to be valid. Tooth index of four specimens varied from 0.23-0.43, clearly the largest found in any Cypselurus examined. Premaxillary teeth are somewhat curved and frequently possess one or two protuberances beside the main point, but these do not compare in size or frequency of occurrence with those seen in C. comatus.

Dorsal fin higher than 12% of SL, with a rounded posterior edge; darkly pigmented in all stages of development, but the position of the pigment changes with ontogeny,

Counts and proportional dimensions (as per cent of SL) of study material, 15.7-297.1 mm SL; extensions from the literature in parentheses:

dorsal rays;	11-13(14)
anal rays;	8-11
dorsal minus anal rays;	1-4
pectoral rays;	12-16
predorsal scales;	31-39(40)
postdorsal lateral scales;	17-22
total gill rakers(first arch);	20-24(25)

scales above lateral line;	6-8
vertebrae;	43-45(46)
branchiostegal rays;	8-12
preanal length;	72.0-80.7%
predorsal length;	67.5-74.5%
prepelvic length;	56.0-61.0(61.6)%
prepectoral length;	20.3-25.2%
head length;	(22.4)22.7-27.4%
snout length;	3.2-6.7%
fleshy orbit diameter;	6.1-8.5%
interorbital width;	6.0-9.4%
pectoral length;	54.0-76.0%
pelvic fin length;	(26.3)27.1-41.9%
dorsal fin height;	9.4-25.6%
anal fin height;	5.6-16.2%
dorsal fin base;	18.5-22.3%
anal fin base;	11.6-15.1%
greatest depth;	13.1-18.5(18.8)%
caudal peduncle depth;	6.0-8.1%
body width;	10.3-14.6(14.8)%
depth behind eyes;	10.3-12.7%

Pectoral fins darkly pigmented, not banded; posterior few rays usually devoid of pigment. Pigment density changes with ontogeny.

Pelvic fins dark, the pattern changing with ontogeny.

Body generally dark dorsally, silver ventrally. No vertical dark banding in juveniles, as seen in C. furcatus, C. pinnatibarbatus, C. heterurus, and C. exsiliens.

ONTOGENY

The most striking ontogenic change undergone by this species is the development and regression of the mandibular barbels. The barbels are long and fleshy, tapering evenly to their ends. Each barbel has a pair of folds laterally along its entire length; the lateral fold about twice as wide as the mesial one. The smallest specimen examined (15.7 mm SL) possessed barbels that were 85.1% of SL. The barbels increase proportionally until the fish is about 80 mm SL (in a specimen of 82.6 mm SL the barbel was 149.6% of SL). After this the barbel decreases in length proportionally until it is lost between 190 and 200 mm SL. The largest specimen reported with a barbel was 190.0 mm SL with a barbel 24.9% of SL. (Bruun, 1935: 41, table 28) See fig. 2 for a comparison of this development with C. comatus and C. exsiliens.

The pelvic fins become relatively shorter with development. The proportions range from 40.2% of SL in a 25.1 mm specimen, 39.1% for 103.1 mm SL, 31.8% of SL for 199.6 mm SL, to 27.1% of SL for a specimen of 297.1 mm SL. The pelvics also undergo a color change with ontogeny. The juvenile pattern consists of a narrow pigmented arc at the fin base, a more distal clear arc approximately the width of the eye, with pigment over the rest of the fin. The distal

pigment is densest along the fin rays. This pattern persists up to about 70 mm SL, when the clear arc disappears and the fin assumes an overall mottled appearance. At about 100 mm SL the pigment begins to become more concentrated at the distal end of the fin, leaving the proximal portion clear. By 170 mm SL the proximal third of the fin is clear. The distal pigment gradually disappears until by 280 mm SL the entire fin is devoid of pigment.

The dorsal fin decreases in height with development. In juveniles less than 100 mm SL the fins are generally higher than 22% of SL; by 175 mm SL they have decreased to about 18% of SL; by 300 mm SL they are only 12% of SL. (In four of the specimens examined the fins were lower than 12% of SL, but their identity is clear on the basis of other characters). The dorsal fin pigmentation also changes with growth. Up to 100 mm SL the fin is evenly pigmented. In larger specimens the pigment is concentrated in the posterior of the fin, leaving the anterior portion clear. The posterior profile of the fin is rounded in juveniles and small adults, but by 300 mm SL this profile has become straight. See fig. 3 for a comparison of height decrease with C. exsiliens and C. heterurus.

The pectoral fin does not develop a band as is seen in C. heterurus and others, but there is a definite change in pattern with ontogeny. In specimens of about 15 mm SL the proximal half of the fin is light and the distal half dark.

At 25 mm SL dark pigment forms a number of blotches on the proximal half of the fin. As the fish grows, the distal evenly pigmented area enlarges, so that by 100 mm SL the blotches are present only on the membranes between the first and third rays. By 150 mm SL the blotches have disappeared and the entire fin is darkly pigmented. Throughout development the last few rays and first ray are generally free of pigment.

The caudal fin is weakly pigmented in small juveniles. By about 45 mm SL the fin has developed a dark background with a number of clear spots on it. These clear spots diminish in size until the fin is evenly pigmented at about 150 mm SL.

RANGE

Cypselurus cyanopterus, like C. comatus and others, appears to be primarily a neritic fish. The only specimen from the open sea was reported by Bruun (1935: 95, text-fig. 27) from about 1°N, 29°W. He was uncertain of its exact location and dismissed it as a possible wanderer. The species occurs on both sides of the Atlantic, from 39°N in the western North Atlantic, and 38°N in the eastern North Atlantic (see fig. 9 for the North Atlantic distribution of the species) to 19°S in the western South Atlantic. The northernmost collections have all been made in or near the Gulf Stream, so it is safe to assume, until further collections are made, that it is limited to tropical or subtropical waters.

REPRODUCTIVE BIOLOGY

Above 250 mm SL sex may be determined easily. (Bruun, 1935: 44) No ripe individuals have been reported.

SYNONYMS AND REFERENCES

Exocoetus cyanopterus Valenciennes in Cuvier and Valenciennes, Hist. nat. Poiss. 19, 1846: 97 (orig. descr.; Brazil);
"Günther, Cat. Fishes Brit. Mus. 6, 1866: 294 (descr., key; Brazil); Proc. Zool. Soc. London, 1869: 239 (listed; Madeira); Melliss, St. Helena, London, 1875: 110 (St. Helena); Jordan and Meek, Proc. U. S. Nat. Mus. 8 (1885), 1886: 63 (descr., key); Osorio, J. Sci. Acad. Lisboa 2 (3), 1895: 246 (listed; Dahomey); Jordan and Evermann, Bull. U. S. Nat. Mus. 47 (1), 1896: 739 (descr., key; Bahia, Rio de Janeiro); Osorio, J. Sci. Acad. Lisboa 2 (5), 1898: 199 (listed).

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Exocoetus albidactylus Gill, Proc. Acad. Nat. Sci. Phila. 1863: 167 (orig. descr.; Caribbean Sea).

Exocoetus bahiensis,["] Günther, Cat. Fishes Brit. Mus. 6, 1866: 293 (descr., key; W. Indies, Brazil); Jordan and Meek, Proc. U. S. Nat. Mus. 8 (1885), 1886: 64 (descr., key); Jordan and Evermann, Bull. U. S. Nat. Mus. 47 (1), 1896: 739 (descr., key); Osorio, J. Sci. Acad. Lisboa 2 (5), 1898: 199 (listed; Annobon I.); Norman, Discovery Rep. (12), 1935: 56 (listed).

Exocoetus parrae Poey, Repert. fis.-nat. Cuba 2, 1868: 385

(orig. descr.; Cuba).

Exocæetus bahiensis. Osorio, J. Sci. Acad. Lisboa 2 (3), 1895:

246 (listed; Annobon I.).

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Mus. 47 (3), 1896: 2836 (listed); Smith, Sea Fishes

Southern Africa, Capetown, 1950: 126 (key, illust.,

descr.; S. Africa).

Cypsilurus cyanopterus. Jordan and Evermann, Bull. U. S. Nat.

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1935: 40 (descr., key, illust.; Atlantic); Marshall,

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Afr. Atlantique Sud 4 (2), Poiss. III, 1953: 177 (descr.).

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1 (1), 1927: 22 (listed; W. Indies); Nichols and Breder,

Amer. Mus. Novitates (428), 1930: 1 (key, illust.,

descr.; Caribbean); Parr, Bull. Bingham Oceanog. Coll.

3 (4), 1930: 26 (descr.; Bahamas); Jordan, Evermann, and

Clark, Rep. U. S. Comm. Fisheries (1928) app. 10, 1930:

202 (listed); Fowler, Bull. Amer. Mus. Nat. Hist. 70 (1),

1936: 431 (descr.; Cape Verde I.); Smith, Sea Fishes

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key; S. Africa).

Cypselurus monroei Nichols and Breder, Zoologica, New York

8 (7), 1928: 432 (orig. descr., illust.; Coconut Grove,

Florida); Breder and Nichols, Amer. Mus. Novitates (417),

1930: 1 (descr., illust.; W. Indies); Nichols and Breder,
Amer. Mus. Novitates (428), 1930: 3 (key);

Cypselurus lineatus. Nichols and Breder, Amer. Mus. Novitates
(428), 1930: 3 (key, misidentification).

Cypselurus cyanopterus. Jordan, Evermann, and Clark, Rep. U.
S. Comm. Fisheries (1928) app. 10, 1930: 202 (listed);
Norman, Discovery Rep. (12), 1935: 58 (listed; 19°06'S,
38°39'W); Fowler, Bull. Amer. Mus. Nat. Hist. 70 (2),
1936: 1244 (listed; Canary I.); Breder, Bull. Bingham
Oceanog. Coll. 6 (5), 1938: 39 (descr., key, illust.;
W. Atlantic).

Cheilopogon cyanopterus. Parin, Trudy Inst. Okeanol. 43,
1961: 168 (listed, illust., key).

Questionable:

Exocetus solitarius Bennett, Gatherings of a Naturalist in
Australasia, London, 1860: 15 (orig. descr.; St. Helena).

Cypselurus exsiliens (Linnaeus, 1771)

STUDY MATERIALS

BU (1) 39°07'N, 65°58'W, IX-21-1957: BU (1) 19°13'N, 95°34'W, V-17-1954: BU (1) 24°00'N, 96°50'W, V-25-1954: BU (1) 38°00'N, 65°25'W, V-1-1960: BU (1) 32°00'N, 63°20'W, VI-14-1957: BU (1) 38°58'N, 66°26'W, VI-9-1957: BU (1) 39°28'N, 69°30'W, X-30-1956: BU (1) 22°10'N, 96°20'W, V-23-1954: BU (1) 94°10'W, 19°05'N, V-17-1954: BU (1) 26°40'N, 92°00'W, V-8-1954.

USNM 7731 (1) Mass., Cape Cod, no date: USNM 30975 (1) Panama, no date: USNM 159038 (1) 20°50'N, 86°10'W, IV-28-1954.

DISTINCTIVE CHARACTERS

The most distinctive character of the juveniles is the morphology of the paired barbels, which are unique among the Atlantic Cypselurus. Each barbel is short and flap-like, rather than cylindrical, which is common to C. heterurus, C. furcatus, and C. cyanopterus. Throughout development the upper caudal lobe is lightly pigmented, which separates it from all other Atlantic Cypselurus.

Adults are distinguished by a combination of unpigmented upper caudal lobe, high, pigmented dorsal fin (common also to C. cyanopterus and C. pinnatibarbatus), barred pectoral fin (separating it from C. cyanopterus), and low number of predorsal scales (separating it from C. pinnatibarbatus, as shown in table V).

DESCRIPTION

Dorsal fin the highest (2.7-34.4% of SL) of any Atlantic species. Dorsal edge of fin straight, especially in small specimens, in which the dorsal edge is almost vertical to the body. Fin always darkly pigmented, the pattern varying with ontogeny.

No palatine teeth. Tooth index 0.135 in one specimen, which is lower than the range given by Bruun (1935: 46) of 0.18-0.19. All teeth examined were unicuspid. Bruun felt that the absence of palatine teeth was perhaps an adult character, but I found no palatine in specimens from 71.0 mm to 105.3 mm SL.

Counts and proportional dimensions (in per cent of SL), of study material, 18.0-182.9 mm SL; extensions from the literature in parentheses:

dorsal fin rays;	13-15(16)
anal rays;	8-10(11)
dorsal minus anal rays;	3-6
pectoral rays;	13-16
predorsal scales;	21-29(30)
postdorsal lateral scales;	17-21
total gill rakers(first arch);	19-26(28)
scales above lateral line;	5-8
vertebrae;	43-44(45)
branchiostegal rays;	8-12
preanal length;	76.9-81.4%
predorsal length;	64.9-70.9%

prepelvic length;	53.8-59.2(59.4)%
prepectoral length;	20.3-26.7%
head length;	22.8-26.7%
snout length;	3.9-6.4(6.6)%
fleshy orbit diameter;	7.0-9.9%
interorbital width;	6.4-8.6(9.0)%
pectoral fin length;	52.8-75.0(75.7)%
pelvic fin length;	(26.7)34.3-45.3%
dorsal fin height;	(12.4)13.4-34.4%
anal fin height;	8.3-16.5%
greatest depth;	(14.9)16.6-19.3%
body width;	13.0-16.8%
depth behind eyes;	13.4-16.3%

Adult coloration dark dorsally and silver ventrally.

Small juveniles with a light background and six vertical dark bars. Pectoral fins dark with a light crossband; the posterior edge and first ray unpigmented or lightly pigmented (degree of pigmentation changing with ontogeny). Pelvic fin pigmentation similar to C. cyanopterus.

ONTOGENY

The barbels of C. exsiliens are flat, densely pigmented along their edges, with the center light or clear. The anterior edge is straight, the posterior serrate with a distal flap-like appendage. In the smallest specimen examined (18.0 mm SL) the barbel was 12.2% of SL. It increases to about 35% of SL at about 45 mm SL, decreases to about 12% of

SL in specimens 70-100 mm SL, and is lost between 105-116 mm SL. Of all species examined C. exsiliens possesses the barbel for the shortest length of time (see fig. 2).

The dorsal fin is the highest of all the species examined: over 23% of SL in small juveniles, reaching a peak of 34% of SL at 45.2 mm SL (see fig. 3). In juveniles the dorsal edge of the fin is nearly vertical; as the fin decreases in relative height the shape changes so that the dorsal and posterior edges form a rounded profile by 100 mm SL. The entire fin is dark until about 100 mm SL, at which point a dark spot forms posteriorly and a clear area anteriorly.

The pelvic fin is clear with dark pigment along all the rays up to about 40 mm SL. By 70 mm this pigment has formed an arc at the fin base and a spot distally. In specimens over 100 mm SL the basal arc of pigment has disappeared, leaving the fin clear over its proximal half and pigmented over the distal half.

The upper caudal lobe is devoid of pigment to over 100 mm SL; becoming lightly pigmented by 180 mm SL, but is never as dark as the lower lobe. In the small juveniles the lower lobe is clear with a number of dark spots; above 100 mm SL the entire lobe is densely pigmented.

In specimens below 50 mm SL the pectoral fin is light with two dark crossbands. These crossbands increase in width with growth of the fish until by about 70 mm SL the proximal and distal portions of the fin are darkly pigmented, leaving

a light crossband in the center. In the adults the light crossband does not reach the anterior edge of the fin (specimens over 120 mm SL) and the first few and last few rays are unpigmented.

RANGE

Tropical waters of the western and central Atlantic. Those found north of Bermuda are found primarily in the Gulf Stream. Found north to Cape Cod in the western North Atlantic; east to 29°30'W near the equator (4°45'N); and south to Rio de Janeiro in the western South Atlantic. See fig. 8 for the North Atlantic distribution.

REPRODUCTIVE BIOLOGY

Bruun (1935: 47) states that specimens could be sexed from 190 mm SL on, and that the only ripe specimen he examined was a female of 218 mm SL.

SYNONYMS AND REFERENCES

Exocoethus exiliens Linnaeus, Mantissa plantarum, 1771:

529 (orig. descr.; Carolina);

Exocoetus exiliens. Müller, Des Ritters Linne vollstand.

Natursyst., 1776: 209 (fide Breder; Carolina); Gmelin,

Systema naturae 1 (3), 1788: 1400 (descr.; Carolina);

Syst. Naturgesch. Fische, 1818: 325 (descr., illust.);

Valenciennes in Cuvier and Valenciennes, Hist. nat.

Poiss. 19, 1846: 114 (descr.; New Jersey); Gunther, Cat.

Fishes Brit. Mus. 6, 1866: 291 (key, descr.; Atlantic);

Günther, Ann. Mag. Nat. Hist. London 3 (8), 1909: 147
(descr. of Linnaean type specimen).

Exocoetus bicolor Valenciennes in Cuvier and Valenciennes,
Hist. nat. Poiss. 19, 1846: 111 (orig. descr.; Atlantic).

Exocetus exiliens. Storer, Mem. Amer. Acad. Arts Sci., Boston
2, 1846: 188 (descr.; New York).

Cypsilurus nigricans. Jordan and Evermann, Bull. U. S. Nat.
Mus. 47 (3), 1896: 2836 (listed).

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(417), 1930: 5 (orig. descr., illust.; N. of the Bahamas);
Nichols and Breder, Amer. Mus. Novitates (428), 1930: 3
(in key); Breder and Nichols, Proc. Biol. Soc. Wash. 47,
1934: 42 (descr.).

Cypselurus nigricans. Jordan, Evermann, and Clark, Rep. U. S.
Comm. Fisheries (1928) app. 10, 1930: 201 (listed).

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illust., key).

Cypselurus exiliens. Fowler, Bull. Amer. Mus. Nat. Hist. 70
(2), 1936: 1241 (descr.; W. Africa); Breder, Bull.
Bingham Oceanog. Coll. 6 (5), 1938: 46 (descr., key,
illust.; W. Atlantic); Imai, Studies Life-Hist. Flying-
Fishes Japan 1, 1958: 45 (descr., illust.).

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620 (descr., key, illust.; E. Atlantic).

Cheilopogon exiliens. Parin, Trudy Inst. Okeanol. 43, 1961:
168: (descr., illust., key).

Cypselurus pinnatibarbatus. Fowler, Bull. Amer. Mus. Nat.

Hist. 70 (1), 1936: 428 (descr.; New Jersey; misidentification).

Questionable:

Exocoetus nigricans Bennett, Narr. Whaling Voy. around Globe,

1840: 287 (descr.; Atlantic and Pacific); Bleeker, Atlas Ichthyologique Indes Orient. Nierland. (6), 1866: 75 (descr.; E. Atlantic); Günther, Cat. Fishes Brit. Mus. 6, 1866: 290 (descr.; Atlantic); Martens, Zool. Abtheil. 1876: 28, 34, 401 (Atlantic, 8°N; fide Breder); Jordan and Evermann, Bull. U. S. Nat. Mus. 47 (1), 1896: 737 (descr.; Brazil); Vaillant, Result. Camp. Sci. Monaco 52, 1919: 131 (listed; W. Mediterranean).

Exocoetus spilopus Valenciennes in Cuvier and Valenciennes,

Hist. nat. Poiss. 19, 1846: 118 (descr.; Atlantic).

Cypselurus furcatus (Mitchill, 1815)

STUDY MATERIALS

BU (4) 26°05'N, 95°25'W, V-27-1954: BU (2) 24°00'N, 96°50'W, V-25-1954: BU (1) 25°N, 91°W, XI-29-1956: BU (1) 25°30'N, 92°00'W, V-10-1954: BU (1) 26°40'N, 92°00'W, V-8-1954: BU (1) 24°54'N, 96°05'W, V-27-1954: BU (1) 26°40'N, 92°00'W, IV-8-1954: BU (1) 24°54'N, 96°05'W, V-27-1954: BU (2) 32°57'N, 64°19'W, X-13-1955: BU (2) 32°00'N, 63°20'W, VI-14-1957: BU (1) 34°N, 64°W, X-10-1955: BU (1) 38°00'N, 65°25'W, V-1-1960: BU (1) 37°08'N, 68°14'W, VII-12-1958: BU (1) 39°07'N, 65°58'W, IX-14-1957: BU (2) 32°57'N, 64°19'W, X-13-1955: BU (2) 19°39'N, 58°03'W, IV-30-1959: BU (5) 39°28'N, 69°30'W, X-30-1956: BU (2) 40°00'N, 68°45'W, IX-15-1957: BU (1) 35°50'N, 72°35'W, VII-19-1958: BU (1) 41°30'N, 66°15'W, VI-7-1957: BU (2) 36°42'N, 70°00'W, X-3-1957: BU (1) 36°40'N, 71°05'W, VI-25-1957: BU (3) 33°N, 64°W, X-12-1955: BU (5) 19°12'N, 62°05'W, V-1-1957: BU (1) 2

FWS (1) 26°30'N, 76°40'W, IV-18-1954: FWS (1) 26°30'N, 76°40'W, I-23-1954: FWS (1) Combat Stat. 295, V-18-1959: FWS (3) 31°28'N, 78°42'W, X-24-1953: FWS (1) 26°30'N, 76°40'W, I-24-25-1954: FWS (4) Tongue of the Ocean - E. of Andros I., I-28-1954: FWS (1) 33°15'N, 76°23'W, V-15-1959: FWS (1) 25°30'N, 77°10'W, I-27-1954: FWS (1) 24°30'N, 77°00'W, VI-13-14-1954.

MCZ 34747 (1) off Guantanamo Bay, Cuba, II-4-1937: MCZ no number (1) W. Palm Beach, Florida, Y-14-1920.

USNM 14070 (1) Noank, Conn., no date: USNM 21628 (1) Newport, R. I., XI-1878: USNM 37792 (1) Havana, Cuba, no date: USNM 116707 (2) Blackfish Grounds, N. C., VIII-10-1914: USNM 116709 (1) Grampus Stat. 10(182), II-19-1914: USNM 118884 (2) Fish Hawk, II-28-1914: USNM 132621 (1) Guadalupe, Pointe a Pitre, V-1946: USNM 157817 (1) 26°40'N, 88°45'W, XII-14-1954: USNM 164817 (1) Antares, VI-19-1933: USNM 185786 (1) 28°46'N, 88°40'W, VIII-30-31-1954: USNM 185803 (1) 28°27'N, 88°10'W, VIII-15-1954: USNM 185914 (1) 29°03'N, 88°02'W, VIII-11-1954.

DISTINCTIVE CHARACTERS

Juveniles (less than 150 mm SL) are distinguished from other Cypselurus by a combination of characters. In common with C. heterurus and C. comatus they have a low dorsal fin (less than 20% of SL), but, unlike C. comatus, the fin is unevenly pigmented. Compared with C. heterurus the mandibular barbels are longer (usually longer than 16% of SL, see fig. 6), the first pectoral ray is longer (usually more than 38% of SL, see fig. 4), and the distance between the first and second pectoral rays is usually less than 1.7 times the distance between the second and third (usually greater than 1.7 in C. heterurus; see fig. 5). Adults (greater than 150 mm SL) distinguishable by their low, unpigmented dorsal fin (less than 12% of SL); long first pectoral fin ray (greater than 38% of SL); and dark pectoral fin with distinct light cross-band, widest distally.

DESCRIPTION

No palatine teeth. Premaxillary teeth very small (not measured), without accessory cusps.

Counts and proportional dimensions (in per cent of SL) of study material, 8.8-211.6 mm SL; extensions from the literature in parentheses:

dorsal fin rays;	11-14(15)
anal rays;	8-12
dorsal minus anal rays;	1-5
pectoral rays;	14-17
predorsal scales;	22-34(35)
postdorsal lateral scales;	16-22
total gill rakers(first arch);	16-24
scales above lateral line;	6-8
vertebrae;	44-46
preanal length;	72.3-78.5%
predorsal length;	64.5-74.3%
prepelvic length;	51.9-58.7%
prepectoral length;	20.0-27.2%
head length;	20.5-26.4%
snout length;	2.3-8.5%
fleshy orbit diameter;	(7.0)7.3-12.2%
interorbital width;	6.9-9.1%
pectoral fin length;	31.9-74.8%
pelvic fin length;	(29.4)32.8-58.2%
dorsal fin height;	(7.5)9.6-19.5%

anal fin height;	6.8-15.9%
dorsal fin base;	19.1-23.7%
anal fin base;	13.2-16.7%
greatest depth;	15.5-20.7%
caudal peduncle depth;	5.2-8.1%
body width;	(12.5)12.6-15.8%
depth behind eyes;	12.8-16.6%

Adults light silver ventrally and dark dorsally. Dorsal fin sparsely pigmented in adults, frequently completely clear. Adult pelvic fins dark with a clear crossband. Adult pectoral fin dark with a clear crossband extending from the mesial edge obliquely towards curved anterior edge, edges of crossband curving laterally, so that it is narrow distally, widest proximally. Adult caudal fin darkly pigmented over its entire surface. The juvenile coloration is discussed under ontogeny.

ONTOGENY

The changes in dorsal fin height parallel those of C. heterurus, but the fin is generally somewhat higher.

The mandibular barbels consist of a fleshy shaft arising from the side of the mandible and gradually tapering to a point, with a dark posterior membrane extending the length of the shaft and gradually decreasing in width. The barbels are relatively longest (about 32% of SL) at about 34-64 mm SL, from which time they decrease in relative length slowly until they disappear. The barbels are retained much longer

than in C. heterurus (fig. 6): one specimen of 138 mm SL had a barbel 16% of SL; the smallest specimen without a barbel was 106 mm SL, while in C. heterurus a specimen of 79 mm SL had already lost its barbels.

Juveniles have a pale body with six vertical pigmented bars, just as in C. heterurus; C. furcatus, however, attains the adult pattern earlier, by 115 mm SL, compared to 125 mm.

The pectoral fin in specimens of about 25 mm SL has four pigment blotches: one covers the last few rays (mesial), the second covers the proximal half of the first ray and extends posteriorly onto the fin base, the third covers the distal half of the first ray and membrane, the fourth is the largest and appears as an oblique stripe running from the mesial spot on the last membranes to the tip of the fin. By 35 mm SL pigment from the oblique stripe has started to extend along some of the rays toward the posterior edge, giving the effect of several stripes perpendicular to the posterior edge and parallel to the mesial bar of pigment. At 45 mm SL the mesial pigment bar and proximal end of the oblique stripe have increased in width and the anterior edge of the oblique stripe has almost merged with the distal spot on the first ray, by 60 mm SL this merger is complete. At 70 mm SL the spot on the mesial edge of the fin has enlarged so that it covers nearly the entire mesial half of the fin and has begun to be divided into two by the opening of a V-shaped cleft on its lateral edge. By 90 mm SL the fin has

nearly attained its adult pattern. The postero-lateral edge of the mesial pigment area has merged with the oblique pigment area; the anterior edge of this oblique area is continuous with the posterior edge of the V-shaped cleft in the mesial spot; this continuous edge forms a straight line from the mesial edge of the fin to its tip. Behind this edge the posterior half of the fin is almost completely dark. By 105 mm SL the adult pattern is attained: the V-shaped cleft has reached the mesial edge of the fin; the oblique stripe occupies the posterior half of the fin, leaving a wide, clear margin on the posterior edge; the anterior half of the mesial spot has merged with the two spots on the first ray. This results in a fin with a clear stripe running obliquely from the mesial edge forward to the anterior edge. This stripe is widest distally, with its edges curved outward. The fin also lengthens proportionally with growth; fig. 7 shows this growth compared with that of C. heterurus.

The pelvic fins at 25 mm SL are pale with a pigment spot at the fin base, a pigment arc covering the middle, with an extension along the second ray to the posterior edge, and two small spots posteriorly between the third and fourth and fourth and fifth rays. The latter two spots increase in size to form two bands parallel to the lateral extension of the pigment arc. As the fish grows these three bands enlarge so that by 70 mm SL they cover two thirds the area of the fin. Simultaneously the pigment arc breaks up to form several

spots that merge with the ends of the bands. By 105 mm SL the entire fin is dark with several arcs of clear spots mesially. These clear spots merge to form a clear band one third out on the fin by 150 mm SL.

The dorsal fin at 25 mm SL has a slight amount of pigment on its anterior few membranes. By 35 mm SL several spots appear at the dorsal edge of the fin. These spots at first increase in size, but then they gradually decrease so that by 150 mm SL most of the fin is clear.

The anal fin develops a small spot of pigment on its posterior edge, but this disappears by 150 mm SL to leave the fin clear.

The juvenile caudal fin pattern consists of a spot on the tip of the upper lobe, another on the distal half of the lower lobe, and a third about a quarter of the way out on the lower lobe. These spots enlarge with growth so that by 115 mm SL the entire fin is dark.

RANGE

Found in oceanic and neritic tropical waters of the western and central Atlantic. It occurs north to 42° N in the Gulf Stream and 30° N in the central Atlantic. The eastern edge of its range is at the Cape Verde Islands (15° N, 23° W). Not found along the west coasts of Europe or Africa. Common about Bermuda, in the Caribbean, and in the Gulf of Mexico.

REPRODUCTIVE BIOLOGY

Sexually mature females have never been reported. Breder (1932: 22) felt that the breeding season might be continuous, because he found small juveniles in the Caribbean Sea in February and from May to July. Bruun (1935: 60) reports a ripe male in November, which would support a contention of a long, though not necessarily continuous breeding season.

SYNONYMS AND REFERENCES

- Exocoetus furcatus Mitchill, Trans. Lit. Phil. Soc. New York (1814) 1, 1815: 449 (orig. descr., illust.; New York); Valenciennes in Cuvier and Valenciennes, Hist. nat. Poiss. 19, 1846: 135 (descr.; Gulf of Mexico); Günther, Cat. Fishes Brit. Mus. 6, 1866: 286 (descr., key; Atlantic, Indian Oceans); Jordan and Meek, Proc. U. S. Nat. Mus. 8 (1885), 1886: 61 (key, descr.); Jordan and Evermann, Bull. U. S. Nat. Mus. 47 (1), 1896: 737 (key, descr.; Rhode Island).
- Exocetus furcatus. DeKay, Zool. of New York 3, 1842: 231 (descr.; New York); Storer, Mem. Amer. Acad. Arts Sci., Boston 2, 1846: 188 (descr.; New York).
- Cypsilurus furcatus. Jordan and Evermann, Bull. U. S. Nat. Mus. 47 (3), 1896: 2836 (listed); Bruun, Dana Rep. (6), 1935: 58 (descr., illust., key; Atlantic); Smith, Sea Fishes Southern Africa, Capetown, 1950: 125 (descr., key, illust.; S. Africa).

Cypselurus furcatus. Breder, Bull. Bingham Oceanog. Coll.

1 (1), 1927: 21 (listed; W. Indies); Nichols and Breder, Zoologica, New York 8 (7), 1928: 431 (descr., illust.; Atlantic); Breder and Nichols, Amer. Mus. Novitates (417), 1930: 3 (descr., illust.; W. Indies); Nichols and Breder, Amer. Mus. Novitates (428), 1930: 7 (key); Jordan, Evermann, and Clark, Rep. U. S. Comm. Fisheries (1928) app. 10, 1930: 201 (listed); Parr, Bull. Bingham Oceanog. Coll. 3 (4), 1930: 25 (descr., illust.; Bahamas); Fowler, Ann. Natal Mus. 7 (3), 1934: 412 (listed; St. Lucia Lake, Zululand); Breder and Nichols, Proc. Biol. Soc. Wash. 47, 1934: 42 (descr.); Fowler, Bull. Amer. Mus. Nat. Hist. 70 (1), 1936: 427 (descr.; Rhode Island); 70 (2), 1936: 1241 (descr.; Cape Verde I., Canary I.); Breder, Bull. Bingham Oceanog. Coll. 6 (5), 1938: 69 (descr., key, illust.; W. Atlantic); Smith, Sea Fishes Southern Africa, Capetown, 1961: 126 (key, descr., illust.; S. Africa).

Cypselurus heterurus. Nichols and Breder, Amer. Mus. Novitates (428), 1930: 7 (misidentification in part); Breder and Nichols, Proc. Biol. Soc. Wash. 47, 1934: 44 (misidentification in part).

Cheilopogon furcatus. Parin, Trudy Inst. Okeanol. 43, 1961: 174 (descr., illust., key).

Questionable:

Exocoetus nuttallii LeSueur, J. Acad. Nat. Sci. Phila. 11 (1), 1821: 10 (orig. descr., illust.; Gulf of Mexico).

Cypselurus heterurus (Rafinesque, 1810)

STUDY MATERIALS

BU (1) 26°05'N, 95°25'W, V-27-1954: BU (3) 24°22'N, 92°00'W, V-10-1954: BU (1) 26°40'N, 92°00'W, V-8-1954: BU (3) Gulf of Mexico, 250 miles from Clearwater, Fla., VI-30-1948: BU (3) 24°54'N, 96°05'W, V-27-1954: BU (1) 20°12'N, 91°59'W, XI-26-1956: BU (1) 25°N, 89°W, XI-20-1956: BU (1) 20°34'N, 95°37'W, V-20-1954: BU (1) 24°22'N, 92°00'W, V-10-1954: BU (1) 22°10'N, 96°20'W, V-23-1954: BU (3) 25°30'N, 92°00'W, V-10-1954: BU (2) 25°30'N, 92°00'W, V-10-1954: BU (5) 20°50'N, 93°00'W, XI-25-1956: BU (2) 26°40'N, 92°00'W, V-8-1954: BU (3) 20°01'N, 92°27'W, V-14-1954: BU (3) 23°10'N, 92°00'W, V-11-1954: BU (1) 20°12'N, 91°59'W, VII-12-1957: BU (3) 20°10'N, 92°25'W, XI-24-1956: BU (2) 24°00'N, 96°50'W, V-25-1954: BU (2) 20°34'N, 95°37'W, V-20-1954: BU (3) 39°07'N, 65°58'W, IX-21-1957: BU (1) 34°45'N, 73°41'W, X-10-1957: BU (3) 39°07'N, 65°58'W, IX-14-1957: BU (1) 37°08'N, 68°14'W, VII-12-1958: BU (3) 38°00'N, 65°25'W, V-1-1960: BU (1) 34°45'N, 70°25'W, III-20-1957: BU (1) 32°05'N, 71°45'W, III-26-27-1957: BU (1) 38°13'N, 66°48'W, X-23-1956: BU (13) 39°28'N, 69°30'W, X-30-1956: BU (4) 38°05'N, 65°58'W, IX-22-1957: BU (31) 38°17'N, 70°00'W, VI-25-1957: BU (2) 33°N, 64°W, X-12-1955: BU (9) 37°45'N, 71°49'W, X-7-1957.

FWS (1) 30°17'N, 80°11'W, X-15-1953: FWS (1) 24°28'N, 77°28'W, X-8-1955: FWS (1) 39°17'N, 71°49'W, X-6-1957: FWS (1) 27°00'N, 79°18'W, XI*8-1953: FWS (1) 31°41'N, 80°35'W, X-21-1953: FWS (2) 26°30'N, 76°40'W, VI-18-19-1954: FWS (1) 24°32'N, 77°18'W, X-7-1953: FWS (2) 29°40'N, 80°23'W, X-14-1953: FWS (1) 30°21'N, 79°26'W, VI-27-1954.

MCZ 37139 (1) Wareham, Mass., VIII-26-1960: MCZ 37990 (1) North Truro, Mass., VIII-4-1952.

USNM 10409 (1) Coast of Brazil, no date: USNM 21412 (2) Bermuda, no date: USNM 57837 (1) 34°42'N, 36°40'W, XI-1-1906: USNM 83748 (1) 39°44'N, 67°03'W, IX-1-1885: USNM 94694 (2) 29°47'N, 80°05'W, V-4-1886: USNM 94705 (3) 28°40'N, 78°46'W, V-3-1886: USNM 94716 (2) 34°38'N, 76°12'W, X-19-1885: USNM 94718 (2) 29°47'N, 80°05'W, V-4-1886: USNM 118883 (1) Gulf Stream, no date: USNM 120570 (1) Menemsha Bight, Martha's Vineyard, Mass.; VIII-21-1899: USNM 154013 (4) 3 miles off Hillsboro Inlet, Fla., V-1-1915: USNM 154016 (3) Yucatan Channel, Mexico, XI-22-1919: USNM 157817 26°40'N, 88°45'W, XII-14-1954: USNM 157987 (1) 24°08'N, 85°25'W, I-29-1956: USNM 158174 (2) 28°20'N, 88°37'W, VII-21-22-1956: USNM 158184 (1) 28°50'N, 87°58'W, VII-25-26-1956: USNM 158422 (2) 30°04'N, 86°48.5'W, IV-30-1951: USNM 158847 (1) 29°10'N, 86°17'W, IX-7-1955: USNM 161337 (1) off Palm Beach, Fla., I-1951: USNM 178152 (1) Bermuda, VI-26-1930: USNM 178269 (1) North coast of Cuba, III-9-10-1936: USNM 178434 (1) Bermuda, VI-24-1933: USNM 185803 (1) 28°27'N,

88°10'W, VIII-15-1954: USNM 185808 (3) 28°45'N, 88°40'W,
VIII-26-1954: USNM 185915 (3) 29°03'N, 88°02'W, VIII-11-
1954.

DISTINCTIVE CHARACTERS

Juvenile C. heterurus are distinguishable from C. exsiliens, C. cyanopterus, and C. pinnatibarbatus by their low (less than 20% of SL), unevenly pigmented dorsal fin. The presence of short, paired barbels (less than 16% of SL) separates them from C. comatus and C. furcatus. The short first pectoral ray (less than 38% of SL) and its wide separation from the second (greater than 1.7 times the distance between the second and third rays) serve to further differentiate C. heterurus from C. furcatus.

In large specimens, the low (less than 12% of SL), unpigmented dorsal fin; the short first pectoral ray (less than 38% of SL); and the light gray pectoral fin with the lighter, triangular crossband that is widest mesially serve to separate them from C. exsiliens, C. cyanopterus, and C. pinnatibarbatus (separated by the dorsal fin), and from C. comatus and C. furcatus (on the basis of pectoral fin characteristics).

DESCRIPTION

Adult dorsal fin low, generally less than 12% of SL. Dorsal fin pigmentation sparse; frequently lacking in specimens greater than 150 mm SL.

Palatine teeth lacking. Premaxillary teeth very small, even in the largest specimens; Bruun (1935: 63, text-fig. 13)

states that the teeth are very small, the index varying from 0.06-0.08. All teeth unicuspid.

Counts and proportional dimensions (as per cent of SL) of study material, 15.6-336.8 mm SL; extensions from the literature in parentheses:

dorsal fin rays;	10-15
anal rays;	8-12
dorsal minus anal rays;	0-6
pectoral rays;	13-17
predorsal scales;	22-32(38)
postdorsal lateral scales;	16-24
total gill rakers(first arch);	17-26
scales above lateral line;	6-9
vertebrae;	42-46(49)
preanal length;	(74.7)75.0-80.1(81.6)%
predorsal length;	65.3-71.7%
prepelvic length;	51.8-56.9(58.2)%
prepectoral length;	20.4-25.4%
head length;	20.0-27.1%
snout length;	3.2-8.7%
fleshy orbit diameter;	(6.0)6.3-11.5%
interorbital width;	(6.9)7.1-8.8%
pectoral fin length;	39.3-77.8%
pelvic fin length;	(31.0)31.3-49.5%
dorsal fin height;	7.8-23.8%
anal fin height;	6.2-13.4%

dorsal fin base;	18.0-23.0%
anal fin base;	10.7-13.5%
greatest depth;	(14.5)16.0-20.3%
caudal peduncle depth;	6.3-7.7%
body width;	(11.8)13.6-16.2%

Adults (longer than 150 mm SL) light silver ventrally and dark dorsally; dorsal pigment brown in preservation.

Anal fin unpigmented, in adults.

Adult caudal fin darkly pigmented.

Adult pectoral fin dark with light crossband and narrow light posterior margin; posterior half of fin darkest.

Crossband widest mesially and tapering toward edge of fin, triangular in shape. First ray often lightly pigmented.

Adult pelvic fin lightly pigmented with vague light crossband. Fin nearly clear in many specimens over 180 mm SL.

ONTOGENY

The most striking ontogenetic change involves the pectoral fin color pattern. In specimens of about 20 mm SL the fin is clear with a scattering of pigment on the anterior half and two or three vague spots on the posterior half. By about 30 mm SL the pattern that will be retained to about 100 mm SL has been assumed. This juvenile pattern consists of five pigment spots: one large one along the proximal half of the first ray and membrane; the second is rounded and located opposite the distal end of the first ray; the other three are located along the posterior edge

of the fin. The largest of these posterior spots is near the mesial margin and extends over about two thirds of the mesial edge of the fin. The other two posterior spots parallel the posterior edge of the fin. By about 40 mm SL a small portion of the large anterior proximal spot has separated off to make a sixth pigment area lying between the large anterior spot and the large mesial posterior spot. These three spots delineate a clear arc between themselves and the fin base; this arc is about two thirds the diameter of the eye and extends from the rear edge of the large anterior spot to the mesial edge of the fin. By about 60 mm SL the proximal and middle spots on the posterior edge are partly merged, forming one large spot covering over half the rear edge of the fin. By 70 mm SL the small spot above the center of the clear arc begins to merge with the large spot on the posterior half of the fin (in some individuals this does not occur until later). The pattern attained by 70 mm SL is retained until 120 mm SL, when the fish develops the adult pattern: the posterior spots merge into a band along the posterior edge of the fin, leaving a narrow clear margin along the edge; the two anterior blotches also merge, although in specimens of 130 mm SL the two spots may frequently still be distinguished. By 150 mm SL the adult fin pattern is completely formed, showing a gray-brown background with a light crossband, widest at the mesial edge and tapering distad to form a triangular clear band. If this pattern is

attained prior to 150 mm SL the band extends all the way to the anterior edge of the fin, whereas it does not reach the anterior edge in specimens over 150 mm SL.

In specimens below 100 mm SL the distance between the first and second pectoral fin rays is generally well over 1.7 times the distance between the second and third rays (see fig. 5). In specimens larger than 100 mm SL the distance between the first and second rays decreases markedly so that above this length a separation from C. furcatus on the basis of this character is impossible. As is true for all Atlantic Cypselurus the pectoral fin lengthens proportionally with growth, but C. furcatus generally has a longer pectoral fin at any given length (fig. 7).

The pelvic fin in small specimens (shorter than 70 mm SL) is clear with several pigment spots: a small one at the fin base, followed by a clear arc; a larger one on the anterior half of the fin; and several small ones on the posterior half. The large anterior spot increases in size until by 50 mm SL it extends in an arc across the fin. The fin then has a pigmented base; followed by a clear arc; followed by a pigmented arc; with from three to five small spots on the posterior edge. By 90 mm SL the entire anterior edge of the fin is dark and the spots on the posterior edge are merging to form a band. At this stage the fin has two clear arcs, one between the basal pigment and the pigmented arc, and the other between the pigmented arc and the band

on the posterior edge. The pigmented arcs increase in size so that by 125 mm SL the entire fin is dark except for the first ray (which is light throughout development), a narrow posterior margin, and the mesial half of the clear arc near the fin base; thus the fin has a semblance of a light cross-band. The pigment disappears as the fish increases in size above 180 mm SL, becoming nearly clear in larger specimens.

The dorsal fin of C. heterurus is quite high in small specimens (fig. 3); up to about 70 mm SL it averages about 17% of SL. Above 70 mm SL the fin proportion decreases to a mean height of about 11% of SL (at 150 mm SL). Few specimens had fins as low as 10% of SL, even in the largest examined.

The paired mandibular barbels (morphologically identical to those of C. furcatus) are always small (fig. 6); no specimen had barbels longer than 15% of SL. Maximum length is attained at about 25 mm SL and is maintained to between 70 and 80 mm SL, after which the barbels decrease in proportion slowly until they disappear, generally by 110 mm SL.

The lower lobe of the caudal fin of small specimens is clear with a dark spot at its base and one on the distal half of the lobe. The upper lobe is frequently devoid of pigment until about 55 mm SL, at which time two spots appear in positions similar to those on the lower lobe. All these spots increase their area until at about 140 mm SL the entire fin is darkly pigmented.

The body coloration in juveniles consists of a light background with six vertical pigmented bands on the sides and ventral surface. The dorsal surface is light, but no bands are present. This pattern changes gradually, with the back becoming darker and the belly silvery until by about 125 mm SL the adult pattern is attained.

RANGE

Tropical and temperate waters of the Atlantic Ocean and Mediterranean Sea. It has been taken in the western Atlantic from 42° N to 23° S; in the eastern Atlantic from 59° N to 4° N. Bruun (1935: 97, text-fig. 29; 1938: 295) reports it twice from Oslo Fjord, farther north in the Atlantic than any other exocoetid.

The species appears to be confined to neritic areas. The only specimen from mid-ocean, shown in fig. 10, is perhaps C. furcatus (USNM 57837), indicated by the very wide posterior margin on the pectoral fin.

REPRODUCTIVE BIOLOGY

Sex can be determined from 175 mm SL. (Breder, 1938: table XV) Sexual maturity is reached at about 200 mm SL, and the maximum size attained is well over 300 mm SL.

Heldt (in Bruun, 1935: 64) reports that the species breeds off the Atlantic coast of Morocco from June to July; Bruun (ibid.) states that they breed in the Mediterranean from May to August.

Ovarian eggs range in size from 1.6-1.8 mm and are equipped with long adhesive tendrils. (Breder, 1938: 67).

DISCUSSION

Cypselurus luetkeni was described by Jordan and Evermann from one specimen from Cape San Antonio, Cuba. The characters used in their key to differentiate it from C. heterurus were (C. heterurus in parentheses): base of anal 2 times (1 2/3) in base of dorsal; pectoral fin 1 2/5 (1 4/9) in length; and pelvic fin 2 8/9 (2 3/4) in length.

Bruun (1935: 56) retained the species, but suggested that a reexamination of type specimens might lead to a change in synonymy. He separated it from C. heterurus by the following characters: 27-33 predorsal scales (30-38 in C. heterurus); 7-8, usually 7, transverse scales (vs. 7-9, usually 8); and 46-47 vertebrae (vs. 47-49). He furthermore considered C. luetkeni as a tropical form and C. heterurus as subtropical.

Breder (1938: 56) synonymized C. luetkeni with C. heterurus, pointing out that the only adequate character in Jordan and Evermann's key (dorsal-anal base proportions) was inadequate because of the overlap he found between the two species, and that Bruun's characters also did not afford a separation. Breder supported his synonymy with figures demonstrating this overlap. He also pointed out that no juveniles of C. luetkeni have been reported, while the juveniles of C. heterurus, C. furdatus, and C. comatus (all forms with low dorsal fins) have been reported from the West Indies, where all the forms are found.

Springer (1959: 166) provisionally reinstated C. luetkeni. Utilizing Bruun's and Breder's data he found separation in these characters: head length, snout length, diameter of eye, and pectoral fin length. All exhibited overlap, but he considered the divergence as possibly great enough to be of specific value. The populations he compared in all four cases numbered no more than eleven specimens of each species, which is extremely small for valid statistical analysis. Head length exhibited 91% average divergence; the other characters ranged from 79-86.3% divergence.

Jordan and Evermann, Bruun, and Springer list no meristic or morphometric characters of C. heterurus or C. luetkeni that do not lie within the range for western Atlantic C. heterurus given in this paper. The modes of the frequency distributions of Bruun's C. luetkeni data and the C. heterurus data presented here coincide exactly. The descriptions of the pectoral, pelvic, and body coloration of the holotype and subsequently described adult specimens are identical to the description of C. heterurus. Furthermore no juvenile C. luetkeni have been found, as indicated by Breder (1938: 61). C. luetkeni cannot, therefore, be considered as distinct from C. heterurus, even on a subspecific level.

SYNONYMS AND REFERENCES

Exocetus heterurus Rafinesque-Schmaltz, Caratteri di alcuni nuovi generi e nuove specie di animale e piante della Sicilia, Palermo, 1810: 58 (orig. descr.; Palermo).

Exocoetus maculipinnis Vinciguerra, Ann. Mus. Civico Storia
Nat. Genova 18, 1883: 577 (orig. descr.; Sicily, Naples,
Canary I.).

Exocoetus procne Filippi and Vernay, Mem. Acad. Sci. Torino
(1886) 8, 1885: 61 (orig. descr.; Tunis; fide Breder).

Exocoetus furcatus. Jordan and Meek, Proc. U. S. Nat. Mus.
8 (1885), 1886: 61 (descr.; misidentification in part).

Exocoetus heterurus. Jordan and Meek, Proc. U. S. Nat. Mus.
8 (1885), 1886: 59 (key, descr.); Jordan and Evermann,
Bull. U. S. Nat. Mus. 47 (1), 1896: 735 (descr., key;
W. Atlantic).

Exocoetus robustus Jordan and Meek, Proc. U. S. Nat. Mus.
8 (1885), 1886: 61 (orig. descr., key).

Exocoetus lutkeni Jordan and Evermann, Bull. U. S. Nat. Mus.
47 (1), 1896: 736 (orig. descr., key; Cuba).

Cypsilurus lutkeni. Jordan and Evermann, Bull. U. S. Nat.
Mus. 47 (3), 1896: 2836 (listed); Bruun, Dana Rep. (6),
1935: 56 (descr., key, illust.; W. Atlantic).

Cypsilurus heterurus. Jordan and Evermann, Bull. U. S. Nat.
Mus. 47 (3), 1896: 2836 (listed); Bruun, Dana Rep. (6),
1935: 61 (descr., illust., key; Bermuda, Mediterranean,
E. Atlantic); Nytt Mag. Naturvidensk, Oslo 78, 1938:
295:(descr.; Oslo Fjord); Poll, Exped. Oceanög. Belge
Eaux Cot. Afr. Atlantic Sud 4 (2) Poiss. III, 1953:
177 (descr.; 25°N, 17°W).

Cypselurus heterurus. Breder, Bull. Bingham Oceanog. Coll.

1 (1), 1927: 21 (listed); Parr, Bull. Bingham Oceanog. Coll. 3 (4), 1930: 25 (descr., illust.; Bahamas); Nichols and Breder, Amer. Mus. Novitates (428), 1930: 1 (key); Jordan, Evermann, and Clark, Rep. U. S. Comm. Fisheries (1928) app. 10, 1930: 201 (listed); Breder, and Nichols, Proc. Biol. Soc. Wash. 47, 1934: 42 (descr.); Fowler, Bull. Amer. Mus. Nat. Hist. 70 (2), 1936: 1242 (descr., illust.; W. Africa); Breder, Bull. Bingham Oceanog. Coll. 6 (5), 1938: 56 (descr., key, illust.; W. Atlantic); Rey, Peces Ganoideos y Fisostomos, 1947: 625 (descr., key, illust.; E. Atlantic, Mediterranean); Imai, Studies Life-Hist. Flying-Fishes Waters Japan, 1958: 55 (descr., illust.; Japan); Springer, Copeia (2) 1959: 166 (descr.); Abe, Rec. Oceanog. Works in Japan (4), 1960: 149 (listed).

Cypselurus lutkeni. Breder and Nichols, Amer. Mus. Novitates

(417), 1930: 6 (illust., descr.; W. Indies); Jordan, Evermann, and Clark, Rep. U. S. Comm. Fisheries (1928) app. 10, 1930: 201 (listed); Breder and Nichols, Proc. Biol. Soc. Wash. 47, 1934: 42 (descr.); Fowler, Bull. Amer. Mus. Nat. Hist. 70 (2), 1936: 1243 (E. Atlantic); Breder, Bull. Bingham Oceanog. Coll. 6 (5), 1938: 56 (synonymizes it with C. heterurus).

Cypselurus luetkeni. Springer, Copeia 2, 1959: 166 (descr.;

Gulf of Mexico).

Cheilopogon heterurus. Parin, Trudy Inst. Okeanol. 43, 1961:

174 (descr., illust., key).

Questionable:

Exocoetus volitans. Valenciennes in Cuvier and Valenciennes,

Hist. nat. Poiss. 19, 1846: 83 (descr., illust.;

Mediterranean); Roule, Res. Camp. Sci. Monaco 52, 1919:

40 (descr.).

Exocoetus melanurus Valenciennes in Cuvier and Valenciennes,

Hist. nat. Poiss. 19, 1846: 101 (orig. descr.; New York).

Exocoetus spilopus Murray and Hjort, Depths of Oceans, 1912:

63 (descr., illust.).

Cypselurus pinnatibarbatus (Bennett, 1831)

STUDY MATERIALS

None. Description from Bruun (1935), Breder, (1938), Hubbs and Kampa (1946), Abe (1954, 1960), and Imai (1958).

DISTINCTIVE CHARACTERS

The most distinctive juvenile character is the mandibular barbel, which is short, semicircular, and equipped with a number of fringe-like appendages radiating out from the basal portion. Adults may be distinguished by their high, spotted dorsal fin (separating them from C. comatus, C. furcatus, and C. heterurus), high vertebral count (50-52) (separating them from all Atlantic Cypselurus), high number of predorsal scales (shared with C. cyanopterus), and gray pectoral fin with light posterior margin and a vague light crossband, which is often very difficult to see (separating it from C. cyanopterus).

DESCRIPTION

Palatine teeth generally lacking in Atlantic specimens. The only specimen with obvious palatine teeth seen by Bruun came from the Cape of Good Hope. He suggested that it could be a member of an Indian Ocean subspecies (1935: 96). Abe (1954: 196) states that C. pinnatibarbatus japonicus lacks palatine teeth. Premaxillary teeth unicuspid, the index ranging from 0.12-0.17.

Counts and proportional dimensions (as per cent of SL) of study material from Bruun (1935) and Breder (1938):

dorsal fin rays;	12-14
anal rays;	10-12
dorsal minus anal rays;	0-4
pectoral rays;	14-16
predorsal scales;	39-46
total gill rakers(first arch);	20-24
scales above lateral line;	7-8
vertebrae;	50-52
preanal length;	76.1-83.1%
predorsal length;	71.4-77.6%
prepelvic length;	57.1-61.4%
head length;	20.3-21.8%
snout length;	4.6-5.9%
fleshy orbit diameter;	4.8-6.3%
interorbital width;	6.6-8.2%
pectoral fin length;	65.5-75.7%
pelvic fin length;	27.0-35.8%
dorsal fin height;	8.8-12.9%
greatest depth;	13.1-16.7%
body width;	10.7-13.4%

Body dark above, light below. Bruun (1935: 49) found no trace of the dark longitudinal stripe supposedly characteristic of the species. Abe (1954: 195) described Cypselurus pinnatibarbatus japonicus as blue-black dorsally (brown-black in formalin), whitish ventrally (brownish in formalin), with a dark blue longitudinal band on the side of the trunk.

Pectoral fins gray with light posterior margin and very light crossband; posterior few rays frequently without pigment.

Pelvic fins gray, the pigment more highly concentrated proximally.

Dorsal fin gray, a dark spot in center of fin.

Anal fin clear.

Caudal fin dark, the pigment more highly concentrated along the rays (juvenile fin light with several dark spots, as in C. cyanopterus).

This is one of the largest Atlantic Cypselurus. Bruun (1935: 52) mentions that most specimens were over 300 mm SL, the largest measuring 378 mm SL.

ONTOGENY

A complete developmental series is lacking for the Atlantic forms of this species. Most of this discussion is based on work done on Pacific subspecies by Hubbs and Kampa (1946) and Abe (1954, 1960).

The single median barbel, unlike that of C. comatus, does not grow to great proportions. The largest seen does not exceed the length of the head. It is present in specimens up to about 130 mm SL.

The dorsal fin in juveniles and young adults is very high (29% of SL in specimens of 100 mm SL), has a rounded posterior margin, and is dark over most of its surface. This pigment is lost in the adult, resulting in an adult

fin with a dark spot on its posterior margin.

All specimens considered juvenile by Bruun had a light crossband on the pectoral fin, this crossband evidently becomes indistinct with maturation. Abe (1954) has correlated the degree of distinctness of the crossband with the period of the day in which the specimen was collected: specimens caught at night showed an extremely indistinct crossband; those taken in the daylight show a much more distinct crossband. If Bruun's collections were made at night with the aid of a night-light, this could account for his failure to recognize the crossband in the adults. Both juveniles and adults have a light margin on the posterior edge of the fin.

The pelvic fin pigmentation does not change with ontogeny.

RANGE

Cypselurus pinnatibarbatus is not found in the North Atlantic west of the Azores. Goode (1876) reported a single specimen from the Bermuda area, but Breder (1938: 49) doubted its validity. This species is reported from the coast of South America at Rio de Janeiro, Brazil (Bruun, 1935: 95). All other Atlantic records are from the west coast of Africa and the coast of Portugal. The species is neritic and inhabits temperate as well as tropical waters.

REPRODUCTIVE BIOLOGY

The smallest specimen sexed by Bruun (1935: 52) measured 292 mm SL. No ripe specimens have been reported from the Atlantic.

DISCUSSION

Hubbs and Kampa (1946) synonymized Cypselurus lineatus (Valenciennes, 1846) with C. pinnatibarbatus (Bennett, 1831), indicating that C. pinnatibarbatus was undoubtedly the juvenile form of C. lineatus.

SYNONYMS AND REFERENCES

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Cypselurus pulchellus Lowe, Proc. Zool. Soc. London (1840), 1841: 38 (orig. descr.; type of Cheilopogon; Madeira); Günther, Cat. Fishes Brit. Mus. 6, 1866: 287 (descr., key; described as Exocoetus solandri, but he considers them synonymous).

Exocoetus lineatus Valenciennes in Cuvier and Valenciennes, Hist. nat. Poiss. 19, 1846: 92 (orig. descr.; Canary I., Corea); Günther, Cat. Fishes Brit. Mus. 6, 1866: 287 (descr., key; Madeira); Capello, J. Sci. Math. Phys. Nat. Lisboa 4, 1872: 86 (St. Jago, Cape Verde I.; fide Breder); Rochebrune, Act. Soc. Linn. Bordeaux ser. 4 (1882) 6, 1883: 139 (Corea, Dakar, Cape Verde I.; fide Breder); Jordan and Evermann, Bull. U. S. Nat. Mus. 47 (1), 1896: 739 (key, descr.; Corea); Osorio, J. Sci.

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43, 1961: 171 (descr., illust.; key).

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Figure 1. Diagram of terminology used to describe pectoral and pelvic fins.

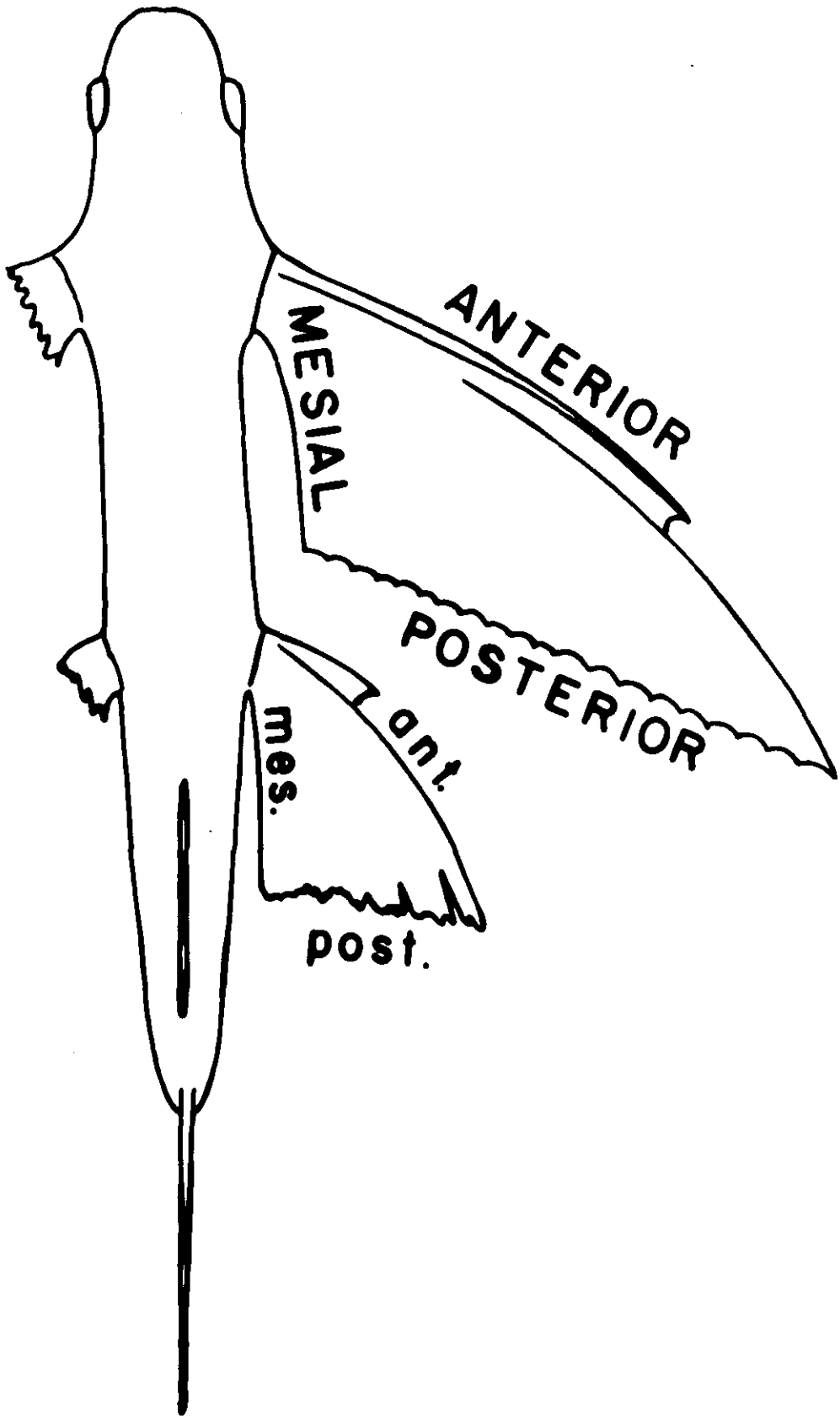


Figure 2. Development and regression of barbel length as a per cent of SL versus SL:

Cypselurus cyanopterus - open circles

C. exsiliens - triangles

C. comatus - black dots

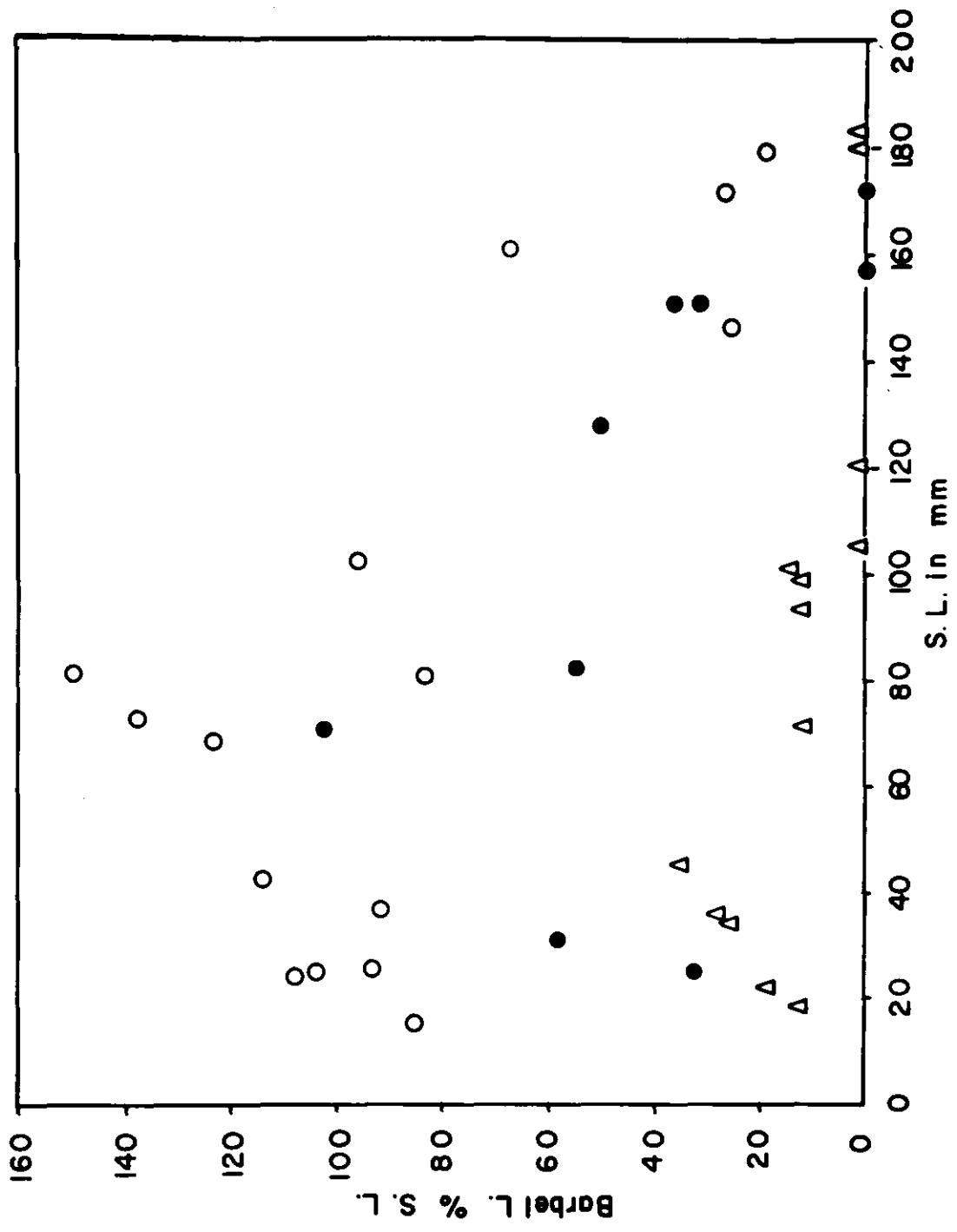


Figure 3. Dorsal fin height as a per cent of SL versus SL:

Cypselurus cyanopterus - black dots

C. exsiliens - triangles

C. heterurus - open circles

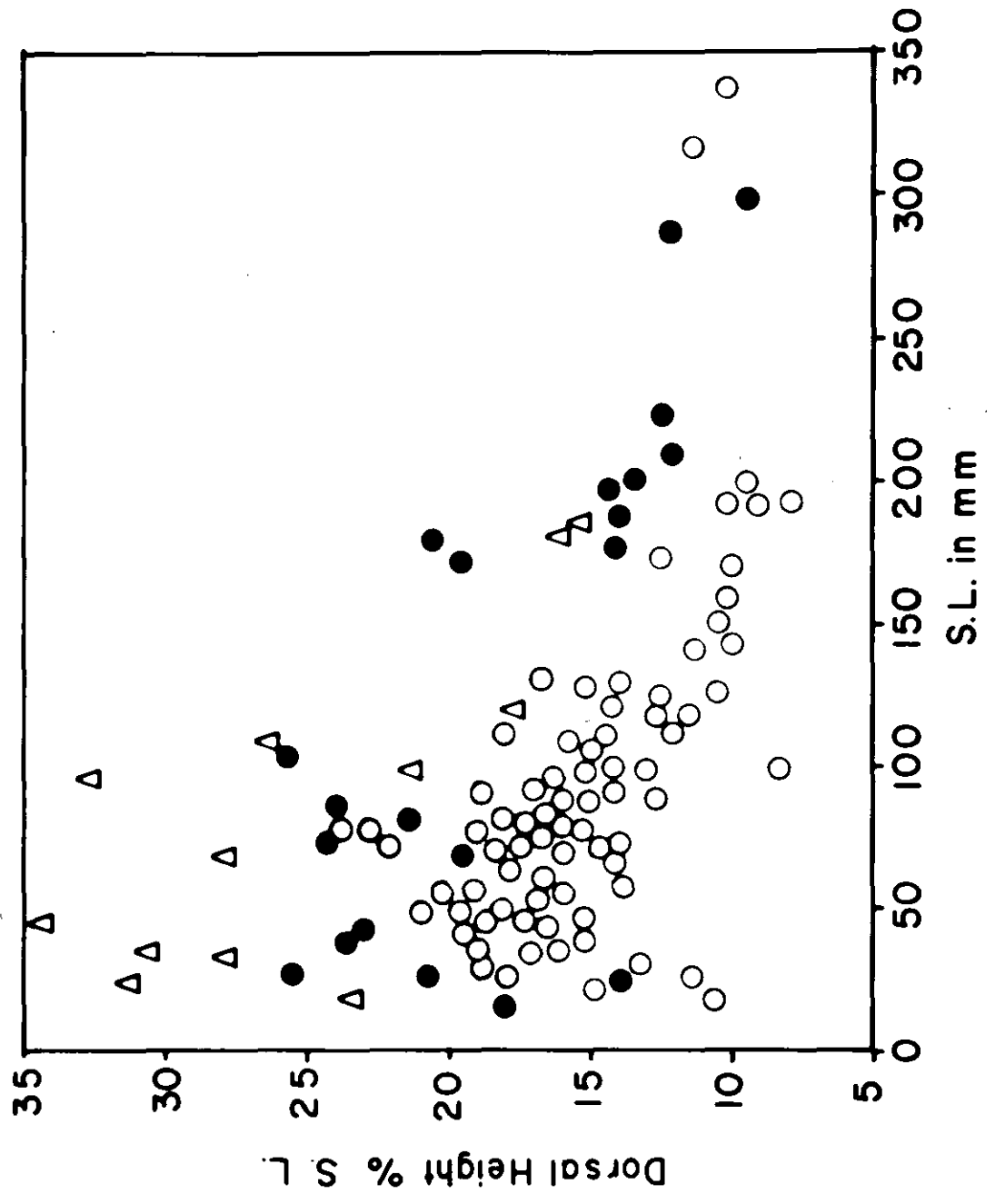


Figure 4. First pectoral fin ray length as per cent SL versus
SL:
Cypselurus furcatus - black dots
C. heterurus - open circles

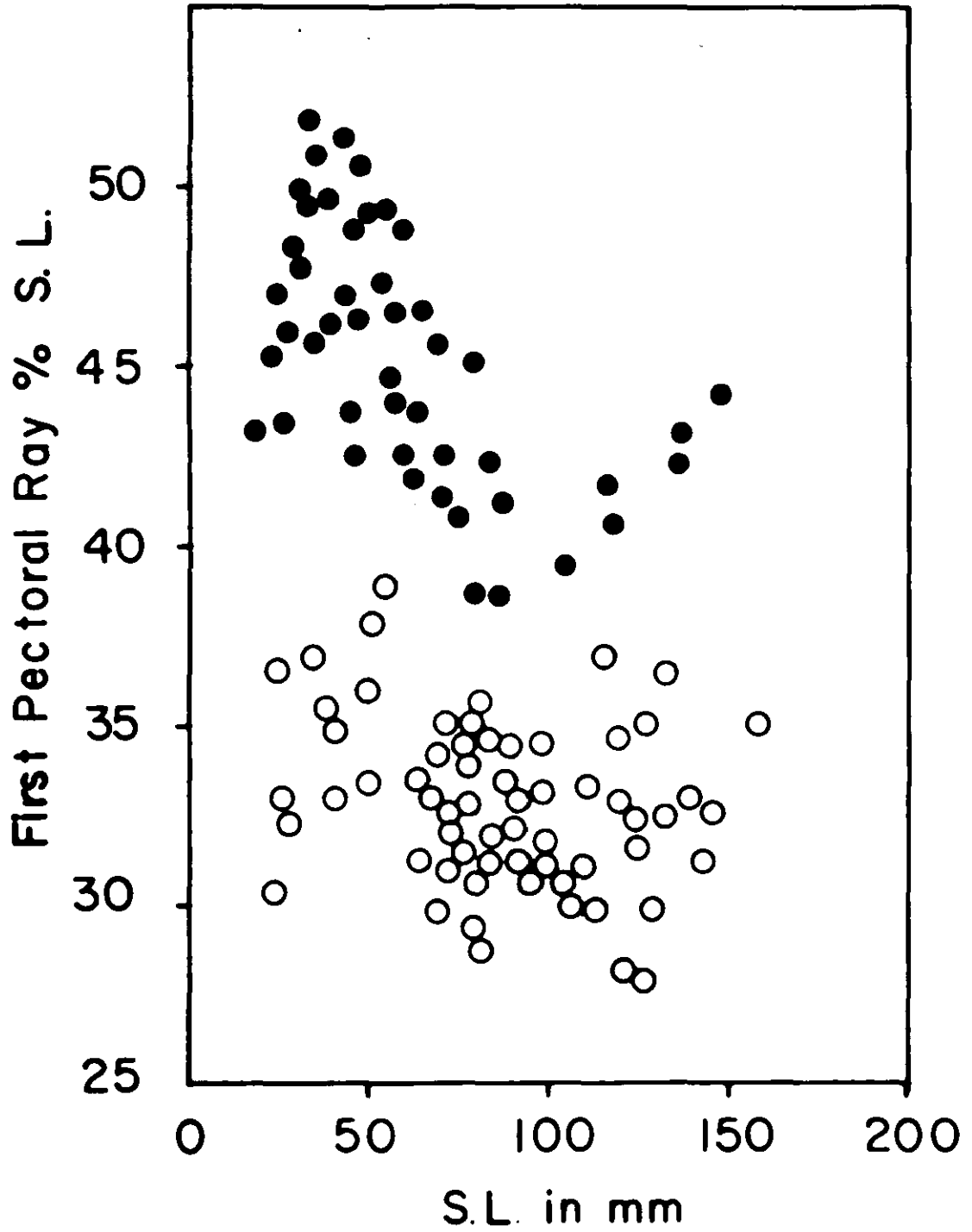


Figure 5. Distance between first and second pectoral fin rays as per cent distance between second and third pectoral fin rays versus SL:

Cypselurus furcatus - black dots

C. heterurus - open circles

D. between 1st. & 2nd. Pectoral Rays
% D. between 2nd. & 3rd.

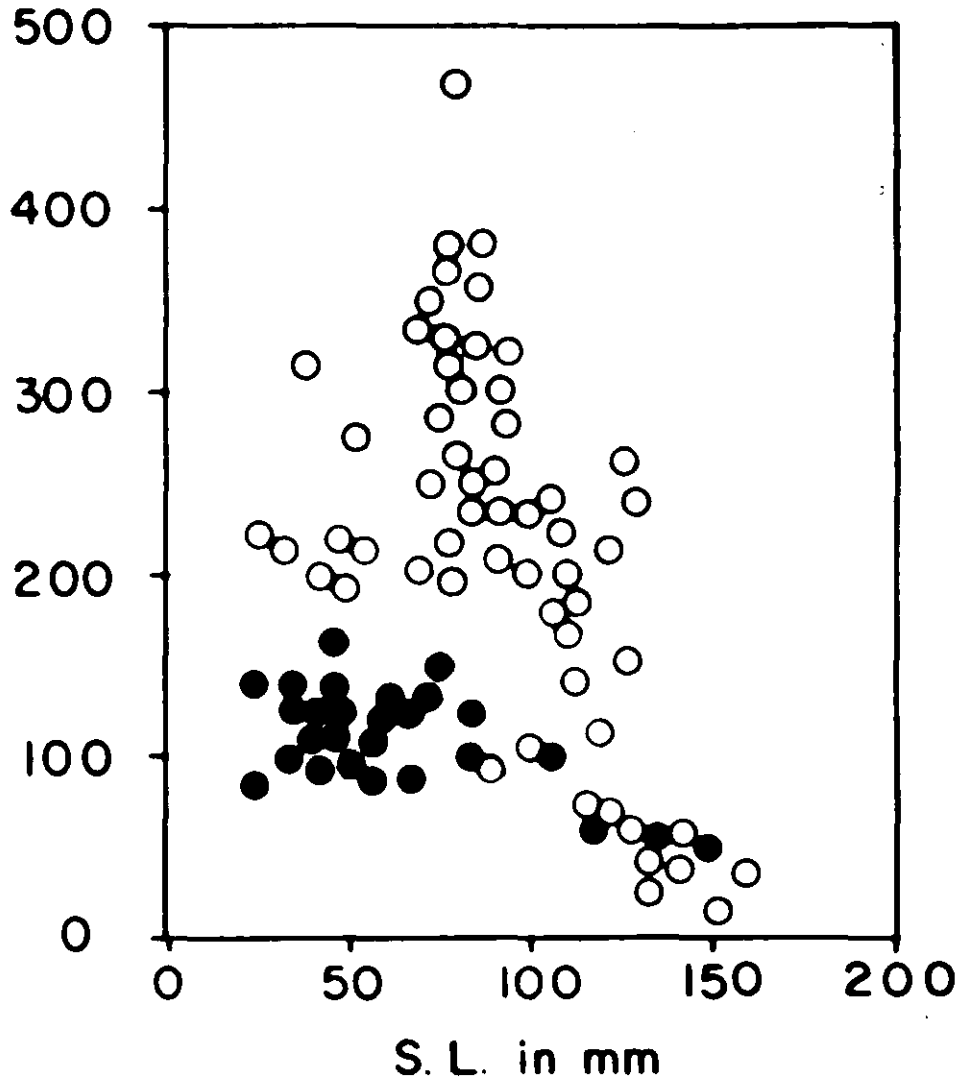


Figure 6. Development and regression of barbel length as
per cent SL versus SL:

Cypselurus furcatus - open circles

C. heterurus - black dots

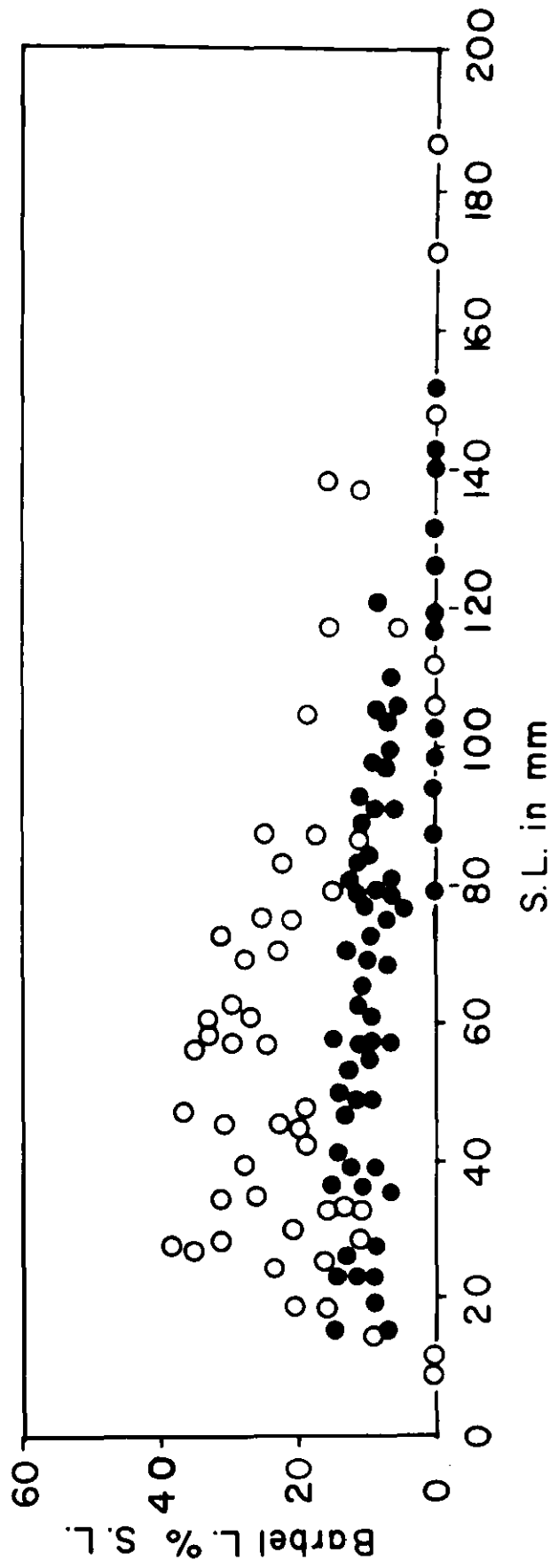


Figure 7. Pectoral fin length as per cent SL versus SL:
Cypselurus furcatus - black dots
C. heterurus - open circles

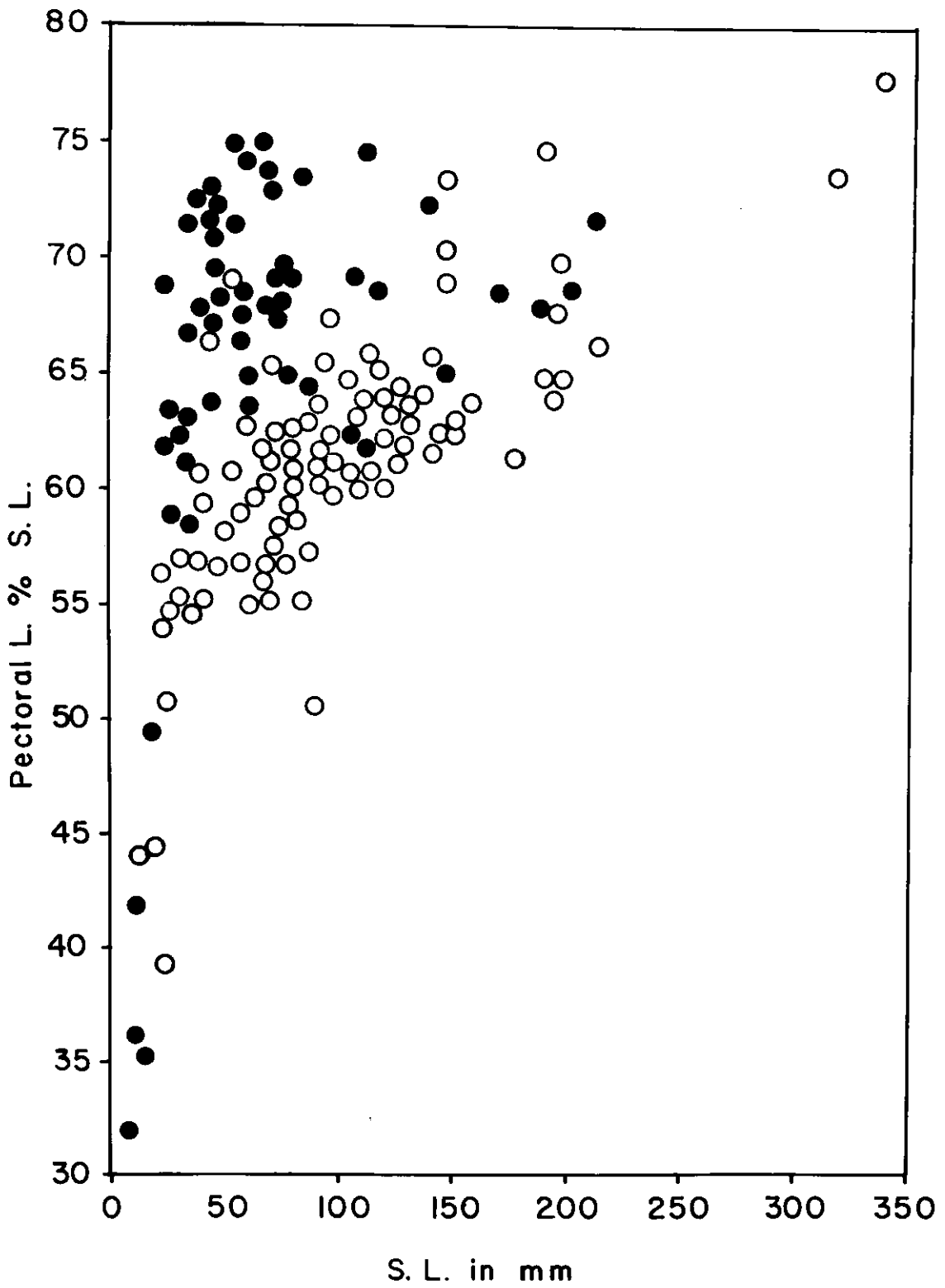
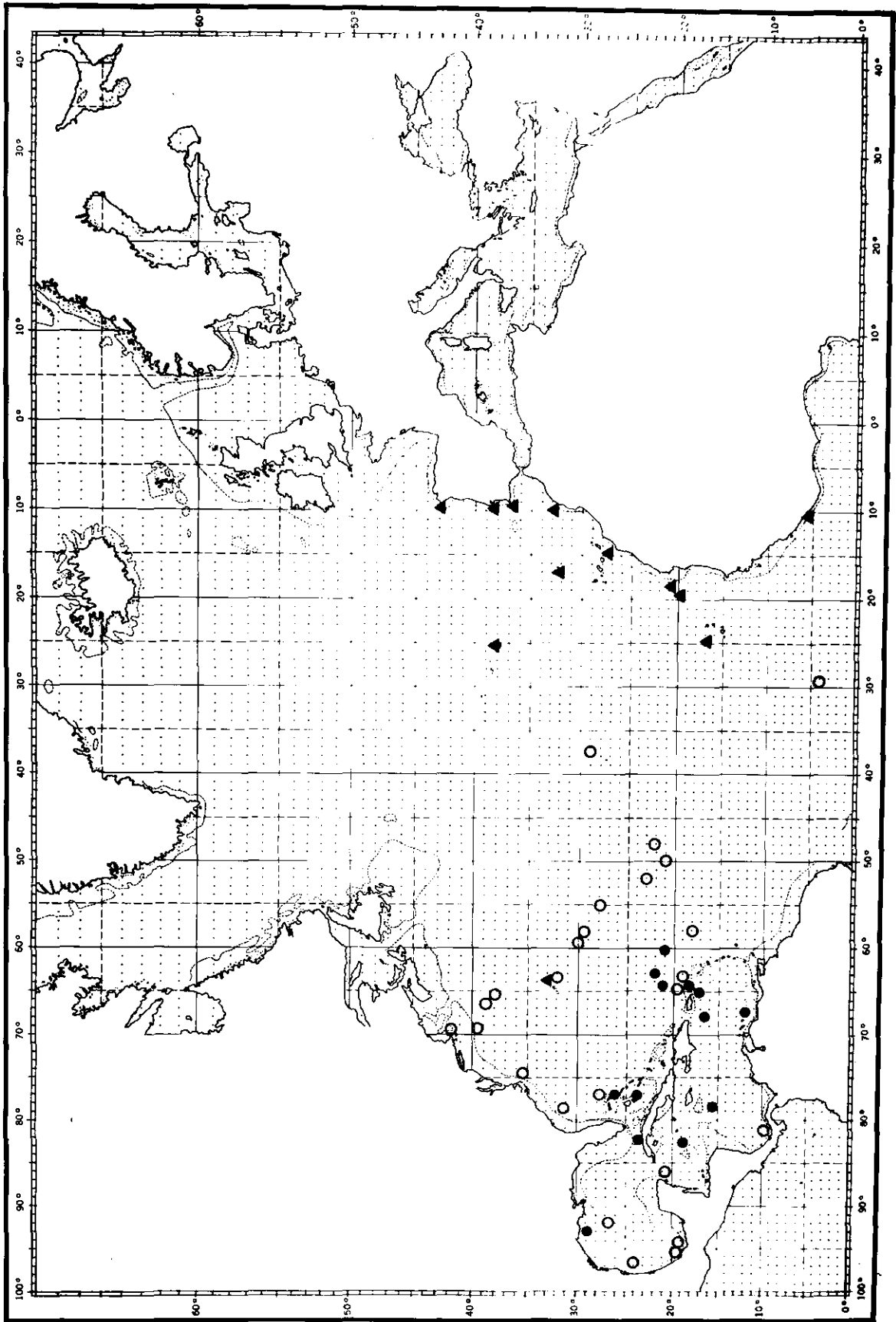


Figure 8. North Atlantic distribution of:

Cypselurus pinnatibarbatus - triangles

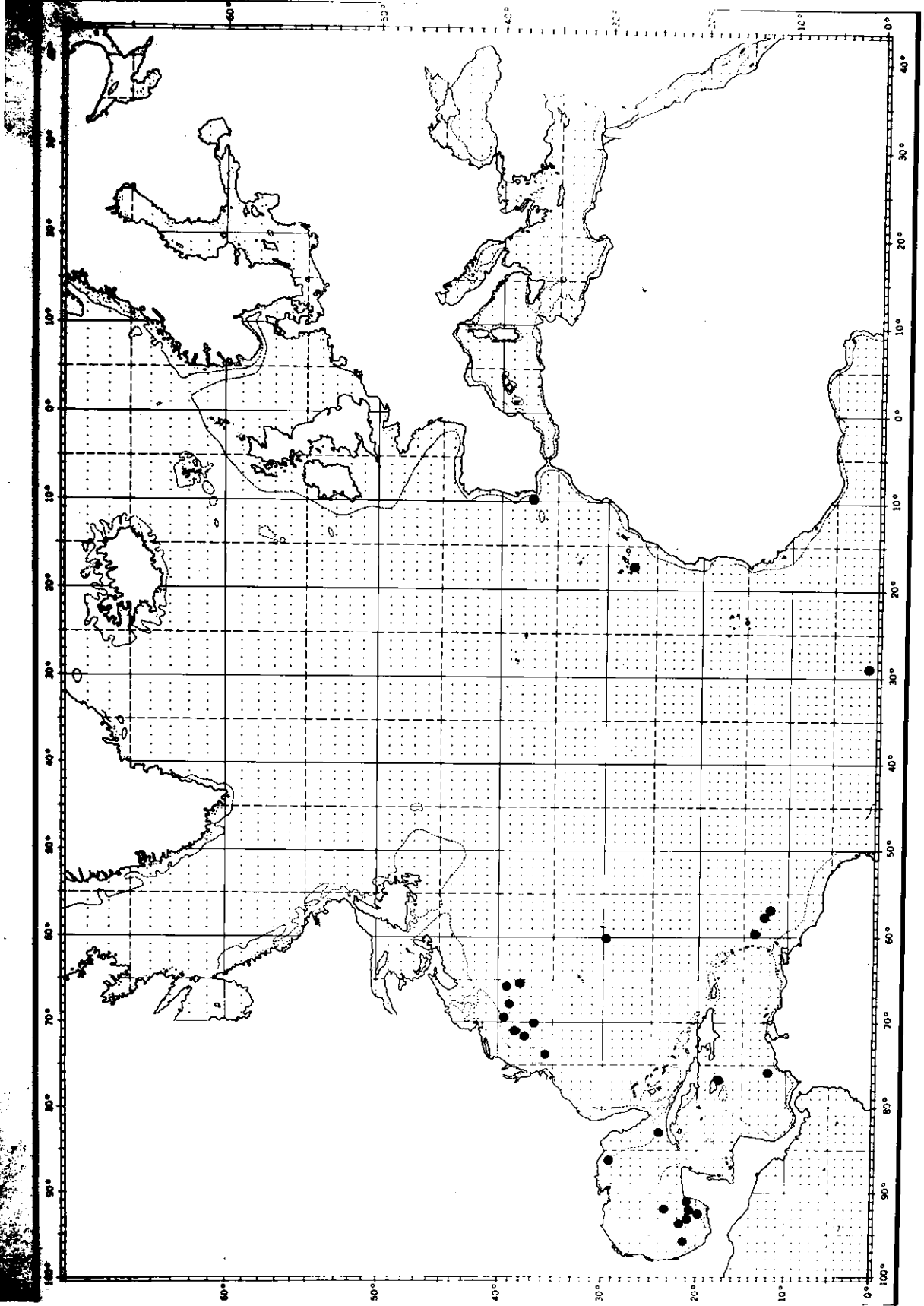
C. exsiliens - open circles

C. comatus - black dots



Map 15270

Figure 9. North Atlantic distribution of Cypselurus
cyanopterus.



Misc. 15210 (1)

Figure 10. North Atlantic distribution of Cypselurus
heterurus.

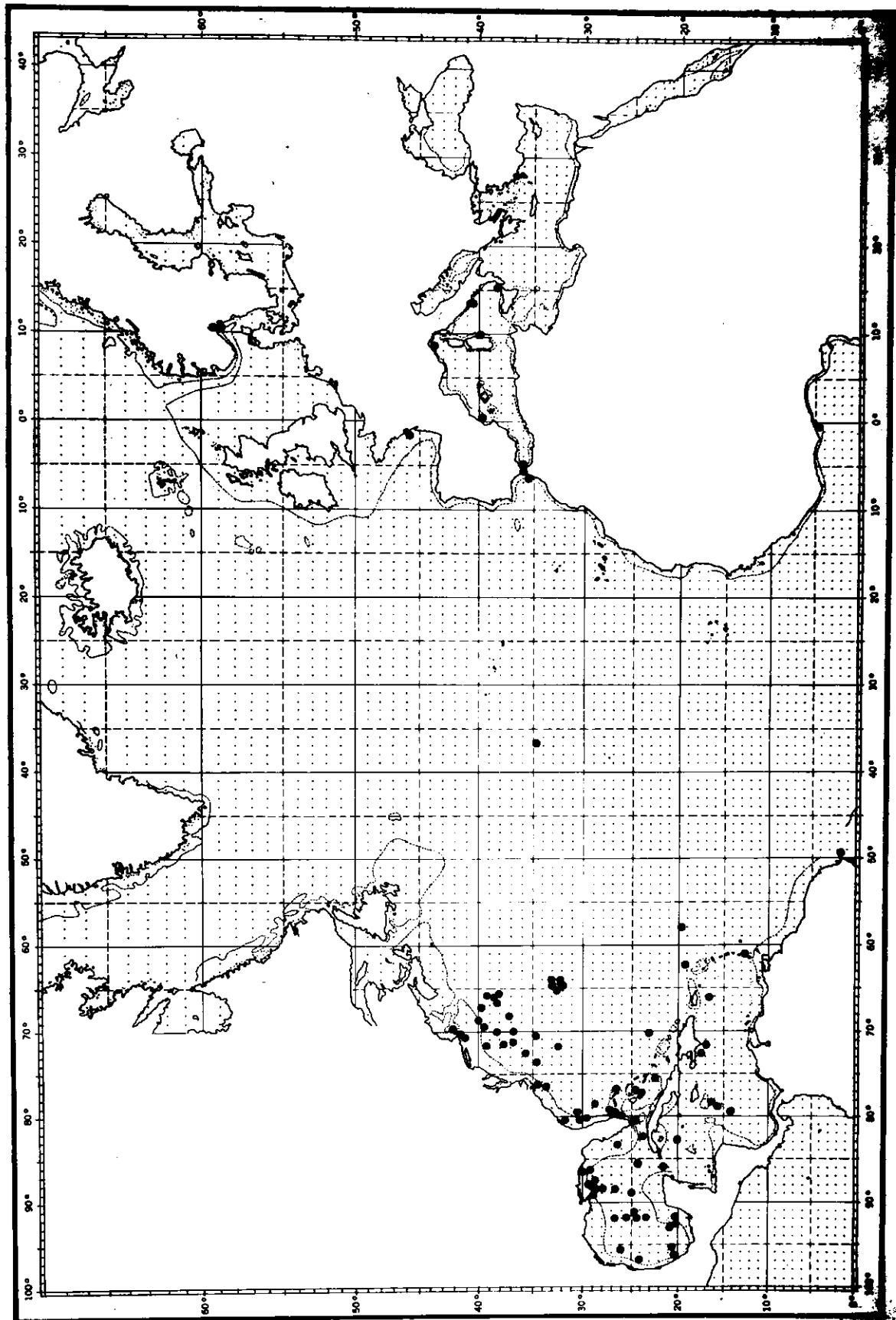


Figure 11. North Atlantic distribution of Cypselurus
furcatus.

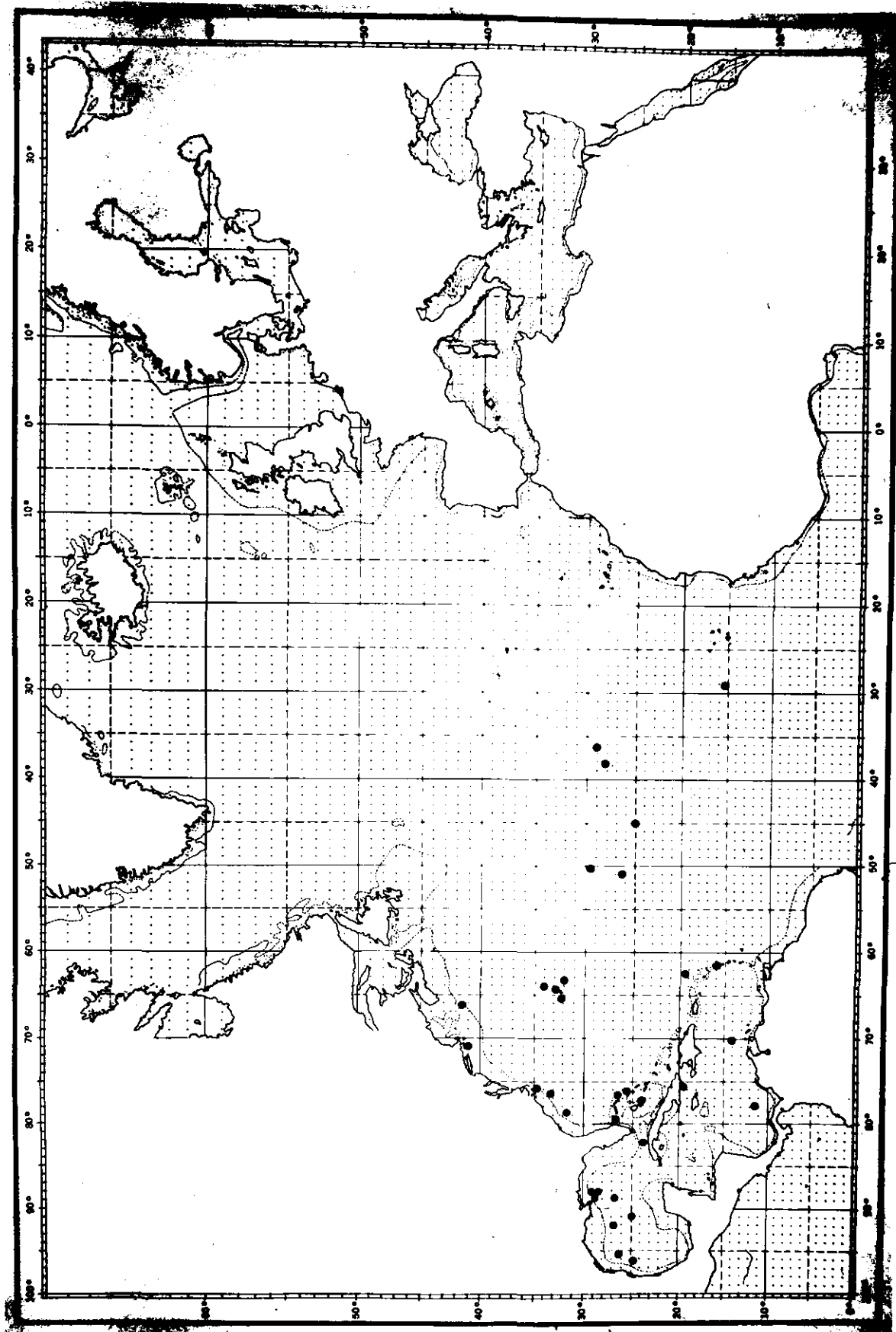


Table I. Frequency distribution of number of dorsal fin rays.

<u>Species</u>	<u>Number of Dorsal Fin Rays</u>						
	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>
<u>C. comatus</u>	1	2	10	6			
<u>C. cyanopterus</u>		2	14	21	4		
<u>C. exsiliens</u>				4	11	11	1
<u>C. furcatus</u>		4	10	60	20	1	
<u>C. heterurus</u>	1	3	17	119	43	1	
<u>C. pinnatibarbatus</u>			6	13	1		

Table II. Frequency distribution of number of anal fin rays.

<u>Species</u>	<u>Number of Anal Fin Rays</u>				
	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>
<u>C. comatus</u>	9	10			
<u>C. cyanopterus</u>	2	10	17	12	
<u>C. exsiliens</u>	1	10	14	2	
<u>C. furcatus</u>	6	26	45	18	1
<u>C. heterurus</u>	21	120	37	3	1
<u>C. pinnatibarbatus</u>			6	10	4

Table III. Frequency distribution of number of dorsal minus anal fin rays.

Number of Dorsal Fin Rays

<u>Species</u>	<u>Minus Anal Fin Rays</u>						
	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
<u>C. comatus</u>		1	1	5	10	2	
<u>C. cyanopterus</u>		4	13	15	9		
<u>C. exsiliens</u>				2	10	9	6
<u>C. furcatus</u>		4	15	43	22	10	
<u>C. heterurus</u>	2	3		39	105	42	2
<u>C. pinnatibarbatus</u>	1	8	7	4	1		

Table IV. Frequency distribution of number of pectoral fin rays.

<u>Species</u>	<u>Number of</u>					
	<u>Pectoral Fin Rays</u>					
	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>
<u>C. comatus</u>	1	1	7	13	1	
<u>C. cyanopterus</u>	2	5	24	4	1	
<u>C. exsiliens</u>		1	18	15	1	
<u>C. furcatus</u>			7	32	45	2
<u>C. heterurus</u>		3	14	70	77	8
<u>C. pinnatibarbatus</u>			7	19	1	

Table V. Frequency distribution of number of predorsal scales.

<u>Species</u>	<u>Number of Predorsal Scales</u>																										
	<u>21</u>	<u>22</u>	<u>23</u>	<u>24</u>	<u>25</u>	<u>26</u>	<u>27</u>	<u>28</u>	<u>29</u>	<u>30</u>	<u>31</u>	<u>32</u>	<u>33</u>	<u>34</u>	<u>35</u>	<u>36</u>	<u>37</u>	<u>38</u>	<u>39</u>	<u>40</u>	<u>41</u>	<u>42</u>	<u>43</u>	<u>44</u>	<u>45</u>	<u>46</u>	
<u>C. comatus</u>				1	2	5	4	2	1	1																	
<u>C. cyanopterus</u>											1	1	1	3	2	6	10	4	4	4							
<u>C. exsiliens</u>	1	1	2		3	9	3	2	5	1																	
<u>C. furcatus</u>		1	1	1	2	6	11	20	13	13	6	2	1		2												
<u>C. heterurus</u>		2		3	5	4	13	13	15	17	9	7	2	3	2				1								
<u>C. pinnatibarbatus</u>																				1	2	2	6	4	3	1	1

Table VI. Frequency distribution of number of postdorsal lateral scales.

Table VII. Frequency distribution of total number of gill rakers on first gill arch, right side.

<u>Species</u>	<u>Total Number of Gill Rakers*</u>												
	<u>16</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>20</u>	<u>21</u>	<u>22</u>	<u>23</u>	<u>24</u>	<u>25</u>	<u>26</u>	<u>27</u>	<u>28</u>
<u>C. comatus</u>			1	1	1	1	5	5	1				
<u>C. cyanopterus</u>					3	5	4	7	6	4			
<u>C. exsiliens</u>				1	1	3	6	6		4	1		1
<u>C. furcatus</u>	1	3	2	6	16	16	13	7	5				
<u>C. heterurus</u>		1	4	19	35	48	36	6	1	1	1		
<u>C. pinnatibarbatus</u>					1	1	5	2	8				

* On first gill arch - right side.

Table VIII. Frequency distribution of number of scales above the lateral line.

<u>Species</u>	<u>Number of Scales</u>					
	<u>Above Lateral Line</u>					
	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>
<u>C. comatus</u>		1	1	13	1	
<u>C. cyanopterus</u>			2	11	16	
<u>C. exsiliens</u>		1	8	11	2	
<u>C. furcatus</u>			1	22	50	
<u>C. heterurus</u>			4	82	44	2
<u>C. pinnatibarbatus</u>				12	4	

Table IX. Frequency distribution of number of vertebrae.

<u>Species</u>	<u>Number of Vertebrae</u>												
	<u>40</u>	<u>41</u>	<u>42</u>	<u>43</u>	<u>44</u>	<u>45</u>	<u>46</u>	<u>47</u>	<u>48</u>	<u>49</u>	<u>50</u>	<u>51</u>	<u>52</u>
<u>C. comatus</u>	1	3	5	1	1								
<u>C. cyanopterus</u>				1	3	6	1						
<u>C. exsiliens</u>				2	4	1							
<u>C. furcatus</u>					1	6	3						
<u>C. heterurus</u>			1		3	7	15	3	1	1			
<u>C. pinnatibarbatus</u>											6	2	1

Table X. Frequency distribution of the dorsal fin height
expressed as a per cent of SL.

ABSTRACT

The Atlantic species of the exocoetid genus Cypselurus are reviewed and six species recognized: Cypselurus comatus, C. cyanopterus, C. exsiliens, C. furcatus, C. heterurus, and C. pinnatibarbatus.

Discussions of the ontogeny, diagnosis, and range of the genus are presented, along with a synonymy.

Two keys to Atlantic species are presented; one for specimens under 100 mm SL, the other for specimens over 100 mm SL. Characters distinguishing the species are: dorsal fin height and coloration; barbel number, shape, and length; anatomy and coloration of the pectoral and caudal fins; predorsal scale and vertebral count differences.

For each species distinctive characters, description, and synonymy are given, and ontogeny, range, and reproductive biology are discussed.

Satisfactory characters for distinguishing C. heterurus and C. furcatus are given for the first time.

The validity of the synonymizing of C. luetkeni with C. heterurus and C. lineatus with C. pinnatibarbatus is upheld,