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With Notes on Its Habits and Relationships

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Redescription of the Gobiid Fish *Coryphopterus lipernes* Böhlke and Robins, With Notes on Its Habits and Relationships

C. LAVETT SMITH¹ AND JAMES C. TYLER²

ABSTRACT

The bluenose goby, *Coryphopterus lipernes* Böhlke and Robins, was described in 1962 from three specimens collected in the Florida Keys; it has remained poorly known since that time. Recent collections and observations indicate that this species is widespread in the Caribbean and Bahamas but at low population densities wherever it occurs. It is also one of the few species of western Atlantic reef fishes that lives in relatively continuous close physical contact with live corals. All the individuals, observed at night and during the day, spent most of the time resting on live corals, with only a few brief forays onto nearby algal mats, or off the coral to feed. In this respect, the bluenose goby is an ecological counterpart of the Indo-Pacific clownfishes

(*Amphiprion*). The mechanism by which the bluenose goby avoids being stung by the nematocysts of the coelenterates may not be the same as that of the clownfishes because clownfishes become acclimated to individual anemones, whereas the bluenose goby can move freely back and forth among coral colonies of both the same and different species. Other species of fishes associated with live corals in the West Indies share with the bluenose goby certain features that we interpret to be specializations for this way of life. Within the genus *Coryphopterus*, two divergent lineages show progressive specialization toward coral-dwelling, on the one hand, and toward sand-dwelling, on the other.

INTRODUCTION

In the course of our work with Bahamian coral reef fish communities, we repeatedly have encountered a small, predominantly yellow goby, with conspicuous blue markings on its head, that lives in close association with the polyps of massive corals. Although we initially believed this to be an undescribed species, it is now apparent that it is *Coryphopterus lipernes* Böhlke and Robins, 1962. The purpose of the present paper is to supplement the original description of this little-

known species with color notes, measurements, observations on ontogenetic changes and sexual dimorphism, and general information on its habits and habitat.

Within the coral reef cosmos there is a spectrum of associations of fishes with invertebrates. In the West Indian fauna there are obvious obligatory relationships between the cardinal fish *Apogon stellatus* (Cope) and the gastropod conch *Strombus gigas* Linnaeus, the pearlfish *Carapuz*

¹Chairman and Curator, Department of Ichthyology, the American Museum of Natural History.

²Research Specialist, National Marine Fisheries Service.

bermudensis (Jones) and the holothurian *Actinopyga agassizi* (Selenka), and between certain highly specialized gobies such as *Risor ruber* (Rosen), *Evermannichthys* spp. and *Pariah scotius* Böhlke and Robins and massive sponges. These highly evolved associations usually entail apparent morphological specializations on the part of the fish as well as behavioral adaptations. Other, apparently less rigorous, associations also exist. For example some wrasses and pomacentrids use vase-shaped sponges as nocturnal resting places and blennies of the genus *Acanthemblemaria* utilize abandoned worm tubes and the shells of vermetiform gastropods as shelter sites.

Coryphopterus lipernes is one of a relatively few fishes that normally lives in close contact with live coelenterates. Other members of its genus also show specializations that are correlated with habitat preference. Some are hyaline sand-dwellers, some have more pigment and are associated with rocky bottoms, and some hover over the bottom and near vertical surfaces. Since these specializations are derived character states we have tested their usefulness in defining relationships among the Western Atlantic species of *Coryphopterus*.

ACKNOWLEDGMENTS

Assistance with our extensive scuba observations of *Coryphopterus lipernes* and associated fishes dwelling on live coral surfaces was helpfully provided at Bimini, Bahamas, by Mrs. Helga and Mr. Milan Tyler, and Mr. Pedro Romer of the Lerner Marine Laboratory staff made our boating operations as efficient as possible. Mrs. Norma Feinberg of the Department of Ichthyology of the American Museum assisted with the identifications of species of *Coryphopterus* that were compared with *C. lipernes*. Drs. James W. Atz and Gareth J. Nelson helpfully criticized the manuscript and figures 1 and 2 were drawn by Ms. Carol Gene Schleifer.

REDESCRIPTION OF

Coryphopterus lipernes Böhlke and Robins, 1962
Figure 1

Material Examined. (All specimens are catalogued at the American Museum of Natural His-

tory; all lengths are given as standard length; all specimens were collected by J. C. Tyler, C. L. Smith and associates.)

VIRGIN ISLANDS: St. John. AMNH 34948, one probable ♀, 11.5 mm., from TEKTITE study reef, Beehive Cove, Lameshur Bay, depth 11 m., October 8, 1973. (Listed in table 4, Smith and Tyler, 1975, as *Coryphopterus* sp.). AMNH 31118, seven additional specimens, one probable ♀, two probable ♂ and four juveniles, 8.1–15.4 mm., collected on coral head near the above locality at similar depth, October 11, 1973.

BAHAMAS: Turtle Rocks, south of Bimini. AMNH 33931, 1♀ 21.0 mm., depth 7 m., May 5, 1975; AMNH 33925, 1♂ 24.5 mm., depth 7 m., June 26, 1975; AMNH 33908, one juvenile 10.7 mm., 1♀ 21.5 mm., 3♂ 18.0, 20.5, 24.4 mm. depth 7 m., June 27, 1975; AMNH 33946, 1♂ 23.2 mm., depth 7 m., June 29, 1975; AMNH 33703, two juveniles 11.8 and 14.4 mm., 1♂ 23.7 mm., depth 7 m., August 2, 1975; AMNH 33944, 1♂ 20.3 mm., depth 7 m., August 6, 1975. Berry Islands, Mamma Rhoda Rock. AMNH 34743, 1♀ 22.7 mm., depth 7 m., February 5, 1968.

Meristic and morphometric features of nine specimens, eight from St. John, Virgin Islands, and one from Turtle Rocks, Bimini, Bahamas, are presented in table 1. All specimens agree with the characters of the genus given by Böhlke and Robins (1960), except that the fleshy pad on the shoulder girdle is not well developed. Although the specimens examined by Böhlke and Robins apparently did not have enlarged neural and hemal spines on the penultimate vertebra, we find these to be present on a 21 mm. specimen, as seen in X-rays.

The following color and morphological notes supplement the original description by Böhlke and Robins (1962, pp. 186-187). Living specimens photographed during daylight hours are predominantly hyaline yellow with light electric-blue markings on the head. These blue markings include a round spot at the tip of the snout, the dorsal surface of the eyeball, and three longitudinal lines: one in the midline from behind the eyes to the nape, and one from behind each eye to above the operculum. Two bluish white lines, one on each side of the midline and apparently situated in the dorsal peritoneum, extend from

TABLE 1
Proportional Measurements and Meristics of Nine Specimens of
Coryphopterus lipernes^a
(Standard length in Millimeters; all proportions in thousandths of the standard length.)

Specimen Number	1	2	3	4	5	6	7	8	9	$\bar{x} \pm$	s.d.
Standard length	8.1	8.7	11.5	13.0	13.1	13.2	13.9	15.4	21.0	13.1	3.8
Head length	309	333	296	315	298	303	302	305	281	304.6	14.2
Head width	160	172	139	162	176	174	165	169	167	164.9	11.1
Eye length	111	115	104	108	107	114	115	110	105	109.0	4.2
Maxillary length	86	92	96	100	107	98	86	91	90	94.0	6.9
Snout length	62	57	52	69	53	61	58	58	48	57.6	6.2
Postorbital											
head length	136	149	130	146	153	144	144	149	133	142.7	7.9
Interorbital											
width	12	11	9	15	15	11	14	13	12	12.4	2.0
Body depth	160	184	148	185	176	182	173	169	200	175.2	15.2
Caudal peduncle											
depth	74	92	96	97	99	106	101	84	105	94.9	10.3
Caudal peduncle											
length	259	310	252	279	260	242	252	247	252	261.4	21.0
Upper caudal rays	—	—	—	246	—	—	—	—	—	—	—
Midcaudal rays	—	—	—	—	237	—	—	—	—	—	—
Pectoral fin											
length	—	287	243	300	298	295	273	286	281	282.9	18.5
Pelvic fin											
length	210	230	226	254	229	258	259	240	233	237.7	16.6
Snout to pelvic											
fin origin	321	368	304	369	336	341	360	338	305	338.0	24.7
Snout to dorsal											
fin origin	395	379	357	354	359	379	374	364	348	367.7	15.1
Length of first											
dorsal fin base	136	138	130	138	122	129	137	130	129	132.1	5.5
Length of second											
dorsal fin base	198	207	174	192	198	212	187	201	171	193.3	13.9
Longest dorsal											
fin spine	—	218	—	177	176	189	187	182	186	187.9	14.2
Longest dorsal											
fin ray	173	—	—	169	137	167	180	169	143	162.6	16.1
Snout to anal											
fin origin	543	575	557	608	565	598	597	578	567	576.4	21.2
Length of anal											
fin base	160	172	148	162	176	189	173	169	167	168.4	11.4
Longest anal fin											
ray	—	149	—	131	115	144	158	156	143	142.3	15.0
Dorsal fin	VI-10	VI-10	VI-10	VI-10	VI-10	VI-10	VI-10	VI-10	VI-10	—	—
Anal fin	10	10	10	10	10	10	10	10	10	—	—
Pectoral fin	17-17		16-17	17-17	17-17	16-17	17-17	17-17	17-17	—	—
Lateral scales	—	25	28	25	26	26	26	26	27	—	—
Circumpeduncular											
scales	12	12	11	12	12	12	11	12	12	—	—
Gill rakers	11	10	11	11	10	—	9	11	10	—	—

^aColumn 1, 2; 4-8. AMNH 31118. St. John, Virgin Islands.
Column 3. AMNH 34948. St. John, Virgin Islands.
Column 9. AMNH 33931. Turtle Rocks, south of Bimini, Bahamas.

behind the head to below the first dorsal fin. There are two or three other small bluish white spots, apparently in the spinal meninges, the last of which is at the level of the base of the caudal fin. The iris is blue. The areas behind each eye and the lower parts of the opercula are light blue.

One specimen from Turtle Rocks obtained May 5, 1975 was examined after it had been in formalin for 10 days. The yellow pigment that remained was concentrated along the edges of the scales on the dorsal surface of the body and in the mid-dorsal line. There was an intense yellow line behind the middle of the eye, ending over the pectoral fin. Another bright yellow line ran on the lower sides from behind the middle of the pectoral fin base to over the end of the anal fin base. This lower line was broken posteriorly into short segments.

A second specimen from Turtle Rocks, collected June 26, 1975, was examined after about 15 hours in formalin. Body and head were uniform yellow above; belly and underside of head pure white below level of lower rim of orbit. Cheeks behind each eye with three dark lines; interspaces intensely yellow. Deep yellow bar across upper part of operculum. Prepectoral area with two longitudinal bands of melanophores: one extending forward from base of uppermost rays, another forward from base of middle rays. Scattered melanophores forming faint third line forward from base of lower pectoral rays. Between these lines, prepectoral area intensely yellow. Top of head and upper part of body uniformly pale yellow; sides yellow, shading to white ven-

trally. Peritoneum as seen through body wall bright silvery. A narrow, intense yellow line extends behind the pectoral fin along side of body, ending at lower half of caudal base. Another less intense and less regular line parallel and slightly above it. Pectorals, both dorsals, and caudal fins with pale reddish rays; pelvic rays pure white. Blue spots on head generally faded but intense on upper cheek and operculum and on tops of eyes.

Fresh specimens collected June 27, 1975 had orange-yellow streaks along bases of soft dorsal and anal fins. Each ray of dorsal, pectoral, and caudal fins was suffused with orange-red. In living fish, spinal meninges are pigmented and are seen as dark line with three light interruptions where pigment is less intense.

At night, with the fish resting quiescent on live coral surfaces, the color fades to an overall dull gray, and the unpigmented areas of the meninges stand out as chalk white spots. Neither the overall yellow coloration nor the blue head markings can be seen in this nocturnal pattern.

Sexual Dimorphism. The genital papilla of the adult male is long and slender, that of the female is short and broad. The papilla in both sexes has a midventral band of dense melanophores, but its lateral edges and dorsal surface are unpigmented or have only a few scattered melanophores.

The second dorsal spine of the male is strikingly elongated, reaching to the posterior end of the base of the soft dorsal fin in some specimens. There is no elongation of the second dorsal spine in the female, in contrast to the situation in

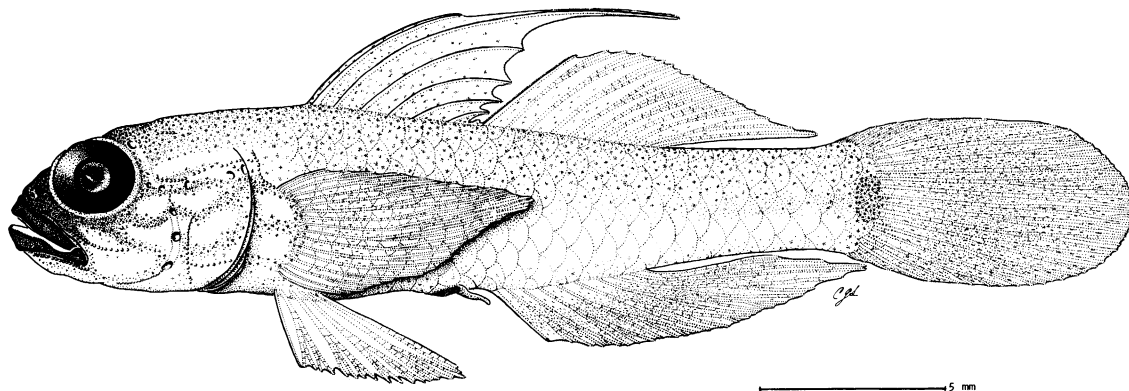


FIG. 1. *Coryphopterus lipernes*. AMNH 33908, an adult male 24.4 mm. S.I.

Coryphopterus personatus (Jordan and Thompson) in which both sexes have the second dorsal spine prolonged.

The posterior two rays of the soft dorsal and anal fins are also slightly elongated in the male, forming lobelike extensions that reach the base of the procurvent caudal rays in large specimens. In the female, the ends of the depressed dorsal and anal fins fall about halfway between the end of the respective fin base and the base of the anterior-most procurvent caudal rays. The pelvic fins are longer in the male, reaching to or slightly beyond the origin of the anal fin; the pelvic fins end at a level between the anus and anal-fin in the female.

Ontogenetic Changes. Our smallest specimens have the inner rays of the pelvic fins completely connected by membrane, thus forming a typical gobiid pelvic disc (fig. 2A). In larger specimens, the interpelvic membrane is almost completely absent (as shown in fig. 2B) so that the pelvic fins are essentially separate.

LIFE HISTORY

A 21 mm. female obtained at Turtle Rocks (25° 40' N lat.) on May 5, 1975 had large eggs. On June 26, 1975, a small individual, estimated to be less than 5 mm., was seen there on a *Colpophyllia* colony but was not taken. This suggests a late spring spawning season for the Bimini area. An 8.7 mm. individual was taken in the Virgin Islands (18° 19' N lat.) on October 11, 1973, and this may indicate either a later spawning period for the more southerly locality, or that the breeding season is possibly prolonged in the warmer parts of the species range.

DISTRIBUTION

At the time it was originally described, *Coryphopterus lipernes* was known only from three specimens from the Florida Keys. Our specimens now extend the known range to the Virgin Islands and to the areas encompassing the Bimini and Berry islands of the Bahamas. We find no differences between the Bahamian and Virgin Island specimens. We also have a photograph of a specimen from Glovers Reef, British Honduras, and sight records from off Providencia (Old Providence) Island near the coast of Nicaragua, Grand

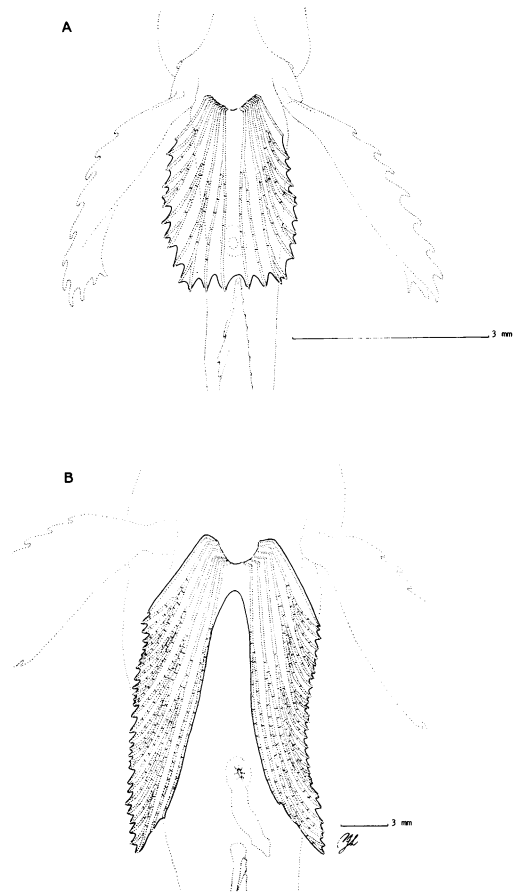


FIG. 2. Pelvic fins of *Coryphopterus lipernes*. A. AMNH 33908, a juvenile 10.7 mm. S.I. B. AMNH 33908, an adult male 24.4 mm. S.I.

Cayman Island (C. Gilbert, pers. commun.), and Freeport, Grand Bahama. Recently it has been reported from Providenciales Island, Caicos Bank; Discovery Bay, Jamaica; and Curacao, Netherlands Antilles (Colin, 1975). The species has been taken at depths ranging from 7 m. in the Bahamas to 26 m. in the Florida Keys.

HABITS

Coryphopterus lipernes is closely associated with live corals. It is not an especially abundant species, and most individuals we have seen were solitary or members of small groups of two or

three inhabiting a large coral colony, with only a few colonies in any given region acting as host to these fish. For example, our series of seven specimens from the Virgin Islands was collected alive in test tubes from two large contiguous colonies of *Diploria labyrinthiformis* (Linnaeus).

Colin (1975, p. 191) provided data on the abundance of *C. lipernes* and several species of *Gobiosoma* in Discovery Bay, Jamaica. Apparently there are considerable fluctuations in abundance. The population density was lower in February, 1972 than in August, 1971 but reached high levels in June, 1972 and February, 1973.

Several species of massive corals serve as hosts; we have observed *C. lipernes* on the following:

Colpophyllia natans (Houttuyn)

Diploria labyrinthiformis (Linnaeus)

Montastrea annularis (Ellis and Solander)

Montastrea cavernosa (Linnaeus)

Siderastrea sp.

Mycetophyllia lamarckiana (Edwards and Haime)

In addition, Colin (1975, p. 253) presented a photograph of *C. lipernes* on the coral *Stephanocoenia michelini* and listed (p. 202) it as occurring on *Agaricia* spp., *Porites astreoides*, *Diploria clivosa*, *D. strigosa*, and *Manicina areolata*. Individuals sometimes enter holes, disappear under the free edges of the colonies, or rest on nearby algal mats.

We observed one extraordinarily large coral mound off Turtle Rocks in the Bimini chain, Bahamas, on five consecutive daylight periods from June 27, to July 1, 1975. This hemispherical mound (approx. 5 m. high and 5 m. in diameter) was at a depth of 9 m. It was dominated by *Montastrea annularis*, which made up perhaps 95 percent of its surface. Most of the *M. annularis* was of the helmet form, but a few colonies were partially ramose.

On the south side of the main mound, a colony of *Colpophyllia natans* measuring approximately 1 m. in diameter had four *Coryphopterus lipernes* on June 28, the day on which we cropped one to serve as a voucher specimen. On June 29, four individuals were present again when we first approached the colony, but one left as soon as we arrived. It moved to a nearby colony of *Montastrea cavernosa*, where it re-

mained until July 1 when it was again seen on the *Colpophyllia*. Of the three *C. lipernes* that remained on the *Colpophyllia* colony, two were large individuals and one was small. These appeared to have partitioned the coral surface into definite home ranges, although one of the large individuals apparently ranged over more of the surface than did the other two. On August 2, this large plate of *Colpophyllia* had two large and two small *C. lipernes* during daylight (18:30 to 19:00). Later the same day, at 20:30 to 21:30, one of the larger and one of the smaller individuals were found quiescent and in their drab nighttime coloration. Further observations of *C. lipernes* on this plate of *Colpophyllia* during daylight and nighttime on August 6 and 12 confirmed that this goby is brightly colored and active by daylight, but drab-colored and quiescent on the exposed coral surfaces at night.

On the southeast side of the dome, there were two adjacent colonies of *Montastrea cavernosa*, one grayish in color and one greenish. One *Coryphopterus lipernes* was seen in the gray *Montastrea* on June 28, and it moved freely back and forth between *Montastrea* and *Mycetophyllia lamarckiana*. On June 29, the *C. lipernes* was on the greenish colony of *Montastrea*. We did not observe this individual on June 30 or July 1, but it or a specimen of similar size was present during most observations made from August 2 to 12 during daylight and at night.

On the north side of the same dome, a flat colony of *Mycetophyllia lamarckiana* about 30 cm. in diameter had one *C. lipernes* from June 27 to 30. This individual, apparently a female, spent much of its daylight time on the algal mats adjacent to the colony and occasionally made brief forays onto the nearby *Montastrea annularis*. We did not observe this coral plate during the August 2 to 12 surveillance periods.

Although the *C. lipernes* of this huge coral mound occasionally moved onto the *Montastrea annularis* that dominated it, these gobies spent almost all of the time on the other species of corals that made up only about 5 percent of the surface.

Feeding consisted of the fish actively chasing particles in the water, sometimes leaving and hovering over the coral for several seconds at a time, and venturing as far as 20 cm. away from

the coral surface. Detrital particles were taken in and sometimes spit out. Clouds of small mysid shrimps were seen nearby during daylight, but they were never pursued by the gobies. Colin (1975, p. 207) also noted *C. lipernes* "hovering above coral heads apparently eating plankton."

Occasionally, other fishes such as *Pomacentrus planifrons* and *Holocentrus rufus*, passed close to the corals, sometimes remaining almost in contact with the corals for a few moments. At such times, a *Coryphopterus lipernes* would move away to avoid the larger fish but did not seek any shelter nor leave the coral surface.

ACTIVITY CYCLES

Coryphopterus lipernes is a day-active species. During our observation periods, sunrise occurred approximately at 06:45 to 07:00, and sunset at 20:00 to 20:15, with the moon at about one-quarter. Feeding behavior was observed from 07:40 to 08:15 and from 12:20 to 19:00 hours from June 28 to July 1, and August 2, 6, and 12, 1975, at Turtle Rocks, Bimini. At night, *C. lipernes* assumes its nocturnal, drab color pattern and rests motionless in valleys of meandriiform corals. Quiescent fish can be approached closely and are especially easy to collect at night by prodding them into a glass test tube. Our observations of quiescent nighttime behavior were made at 20:30 to 22:25 on August 2, 6, and 12.

DISCUSSION

Coryphopterus lipernes is associated with several different live corals and individual fish move freely from one to the other. This indicates that the mechanism by which it avoids being stung by coral nematocysts is quite different from that of the Indo-Pacific clownfishes (*Amphiprion*), which develop *ad hoc* immunity after a period of acclimation, during which time the fishes' slime is altered so that it prevents the anemone's nematocysts from discharging (Mariscal, 1970). It remains a question whether other fishes that live in close association with coelenterates utilize the same or different mechanisms for protection against the host's nematocysts.

The habit of resting on and hunting over live

corals is shared by several West Indian fishes. Along with *C. lipernes*, the most common species found on live corals is *Pseudemblemaria signifera* (Ginsberg), which darts rapidly over the surface of the colony as it searches for food or when it is disturbed. Unlike *C. lipernes*, *Pseudemblemaria* spends much of the time hidden in plants or in cavities on the dead surface of the reef (Smith and Tyler, 1972, p. 156). *Pseudemblemaria* does not venture as high above the coral surface as *C. lipernes*, nor does it hover like *C. personatus* (Jordan and Thompson). *Pseudemblemaria* is predominantly colorless with reddish brown blotches and flecks. Its spinal meninges are pigmented with alternating bands of red and white, a pattern not unlike that of the meninges of *C. lipernes*. We believe that *P. signifera* often retires at night into crevices or holes in the reef (Smith and Tyler, 1972, p. 156) even though we observed it on the surface of coral plates during all three of our nighttime surveillance periods of August 2, 6, and 12 from 20:30 to 22:25 at Turtle Rocks, Bimini, when it remained quiescent in valleys of the meandriiform corals *Colpophyllia natans* and *Mycetophyllia lamarckiana*. The cryptic and semitransparent coloration of *P. signifera* is much the same by day and night.

At depths of 16 m. off Freeport, Grand Bahamas, we observed that *Emblemaria bahamensis* (Stevens) has daylight and nighttime habits similar to those of *Pseudemblemaria*.

In the Virgin Islands, Smith and Tyler (1972, p. 164) reported that the goby *Gobiosoma saucrum* (Robins) is closely associated with coral heads of *Siderastrea* spp. and *Montastrea annularis*. It, too, is hyaline with internal pigment and exhibits a double yellow ocellus in the peritoneum that forms a figure 8 pattern within the body wall. The cleaner gobies *Gobiosoma evelynae* Böhlke and Robins and *G. genie* Böhlke and Robins also utilize the surface of live corals, frequently *Montastrea* sp. and *Agaricia* sp., as cleaning stations. These scaleless gobies have heavy skin pigmentation and a thick mucous coating. They are boldly striped during the day but fade to a pale, nearly uniform gray at night as they rest motionless between coral polyps. Colin (1975, p. 207) listed nine forms of the subgenus *Elacatinus* (genus *Gobiosoma*) that live on corals.

Another species with nighttime habits similar to those of *Coryphopterus lipernes* and *Pseudemblemaria signifera* is *Coryphopterus personatus*. Conspicuous during the day, *C. personatus* hovers and feeds a few centimeters above soft and hard corals, and feeds by pecking in the water column. Collette and Talbot (1972, p. 122) and Smith and Tyler (1972, p. 158) reported that it settles down on coral surfaces at nightfall and disappears from sight until the morning changeover. However, at night between 20:30 and 22:25, on August 2, 6, and 12 at Turtle Rocks, Bimini, we observed numerous individuals of *C. personatus* resting quietly on the surface of *Colpophyllia natans* and *Mycetophyllia lamarckiana*, usually in valleys on the coral face. These all showed coloration and color pattern similar to those of daytime. *Coryphopterus personatus* became active by daylight, or at least by 07:40, 40 minutes after sunrise, hovering in the water column. We suspect that some individuals of *C. personatus* do retire into holes or crevices on the reef at night, while others rest motionless but exposed on live coral surfaces.

RELATIONSHIPS WITHIN THE GENUS *CORYPHOPTERUS*

Böhlke and Robins (1960) recognized six species of *Coryphopterus* from the western Atlantic. In 1962, the same authors demonstrated that the species previously called *Eviota personata* was also a member of this complex and described two additional species, *C. hyalinus* and *C. lipernes*, bringing the total number of western Atlantic species to nine. *Coryphopterus hyalinus* was said to differ from *C. personatus* by having less pigment, the anus not in the center of a black pigment spot, and three interorbital pores instead of two. The differences between *C. hyalinus* and *C. personatus* are not absolute, however; in a large series, we have found some intermediates. We therefore accept the species *hyalinus* with considerable reservation, especially since we have not been able to separate *C. hyalinus* from *C. personatus* in the field.

These nine species show well-marked habitat differences. Some occur on sandy or silty bottoms that are light in color; such species show a reduction in pigmentation. Others are confined to rocky surfaces and have correspondingly more

melanin pigment so that they have spotted or at least punctate patterns. The hoverers tend to be reddish in color with a black periproct. Also correlated with hovering is a reduction of the interpelvic membrane. Generalized and derived conditions of morphology and pigment are clearly determinable for these gobies and subject to cladistic analysis.

Our interpretation of the relationships of the Western Atlantic species of *Coryphopterus* is presented in figure 3. Derived characters used in the analysis are discussed with numbers indicated on the figure.

1. The synapomorphies (shared specialized characters) that unite this complex are included among the generic characters that were enumerated by Böhlke and Robins (1960, 1962). Some of these are undoubtedly plesiomorphic (shared generalized characters), but until all other related gobiid genera have been adequately studied, it will be difficult to be certain of the status of all these characters. We would be surprised, however, if the head-pore pattern and the presence of a fleshy crest on the predorsal midline is not shown to be derived.
2. Emarginate (rather than round) pelvic disc. In *C. glaucofraenum* and *C. punctipectophorous* the disc is of the usual rounded gobiid form. In the *C. thrix*-*C. hyalinus* line, the fifth rays are shorter than the fourth so that the disc is emarginate.
3. Pelvic frenum lost. In *C. glaucofraenum*-*C. thrix* there is a well-developed frenum (membrane) across the base of the pelvic rays. In *C. dicrus*-*C. hyalinus* the frenum is absent. A frenum occurs in a wide variety of gobies and we consider its absence to be the derived condition.
4. Separate pelvic fins. In *C. alloides*-*C. hyalinus* the pelvic fins are separate, with only a trace of the connecting membrane at the very base. In the young of *C. lipernes* the membrane is complete, but it is vestigial in adults. There can be little question that the loss of the membrane is the derived condition. Böhlke and Robins (1960) figured the inner (fifth) pelvic rays of *C. alloides* as unbranched but in our specimen (AMNH 29352) from the Berry Islands, Bahamas, it is deeply branched, although both branches are slender.
5. Pigmented periproct. In *C. lipernes*-*C. hyalinus* there is a conspicuous black ring around the anus. All other species have un-

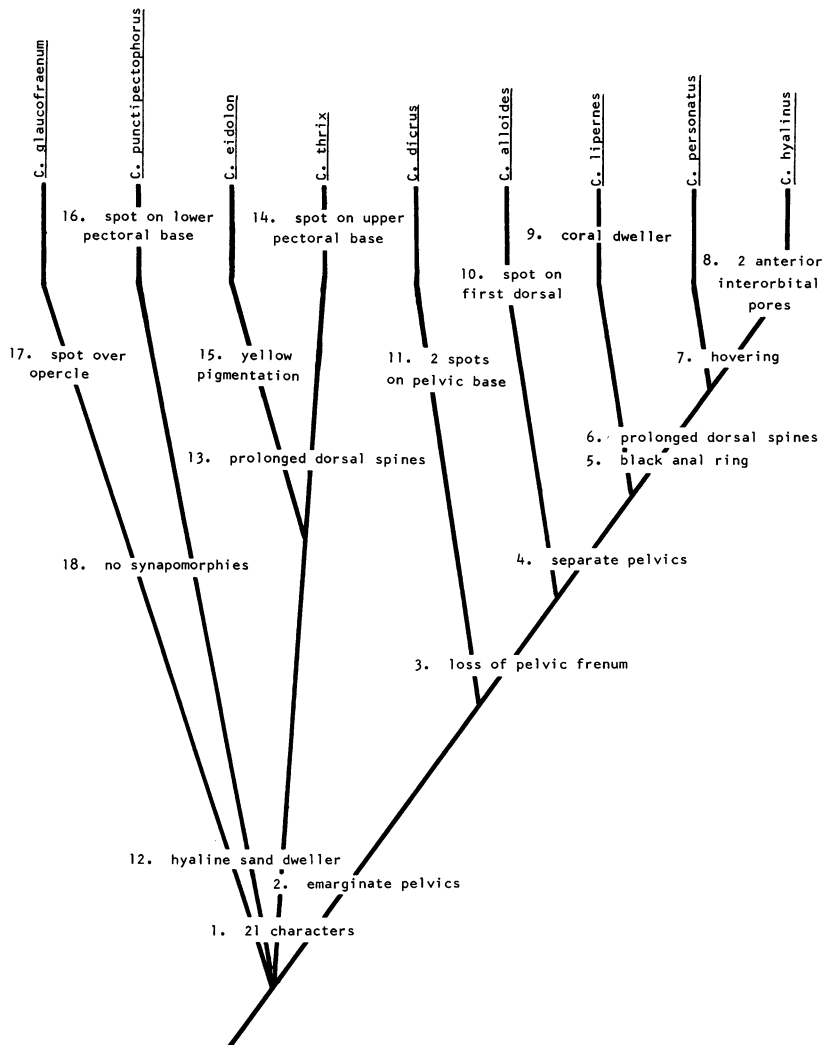


FIG. 3. Inferred relationships of the Western Atlantic species of *Coryphopterus*. For a discussion of the characters see text.

pigmented periprocts, as do most other fishes.

6. Filamentous dorsal. The presence of produced dorsal-fin spines occurs in both sexes of *C. thrix* and *C. eidolon*, although only small specimens of *C. eidolon* have the rays produced. In *C. lipernes* only males have produced rays, whereas in *C. personatus* (and presumably *hyalinus*) both sexes exhibit them. We suggest that this feature has been developed and lost repeatedly within the group.
7. Synapomorphies that unite *C. personatus*

and *C. hyalinus* are the habit of hovering, the reddish coloration, and the characteristic head markings (the latter being less well developed in *C. hyalinus*).

8. An autapomorphic feature of *C. hyalinus* is the presence of two anterior interorbital pores instead of one.
9. Autapomorphies for *C. lipernes* include yellow and blue coloration, coral-dwelling habits, and sexual dimorphism in the dorsal-fin spines.
10. Dorsal fin coloration. A prominent bar on the anterior interradiial membranes of the

spiny dorsal is autapomorphic for *C. alloides*.

11. A generally speckled color pattern, particularly with two prominent spots on the pectoral base, is apomorphic for *C. dicrus*.
12. Sand-dwelling habits. The *C. dicrus*-*C. hyalinus* lineage shows a progressively increased specialization of the pelvic fin, culminating in their complete separation. A specialized pigment pattern has also appeared. We believe that *C. dicrus* and *C. alloides* are specialized for rock-dwelling; *dicrus* on the basis of our own observations and *alloides* because of its rarity in collections and from the fact that it is never taken in large numbers. Hoverers such as *personatus* and *hyalinus* are taken in swarms. We report here that *C. lipernes* dwells in live coral.
Coryphopterus thrix, *C. eidolon*, *C. glaucofraenum*, and, to a lesser extent, *C. punctipectophorus* are hyaline forms that live around the base of reefs and feed on minute invertebrates at the surface of the sand bottom. We consider this habit and associated pigment loss to be a single apomorphic character complex within the *C. thrix*-*C. hyalinus* lineage. An alternative hypothesis, which we tentatively reject, is that sand-dwelling has developed once and that emarginate pelvics have developed independently at least twice.
13. The filamentous dorsal spines unite *C. thrix* and *C. eidolon*. We believe that this is an independent development and does not indicate any relationship with *lipernes*, *personatus* or *hyalinus*, all of which also have prolonged dorsal spines.
14. A large spot at the upper pelvic base is autapomorphic for *C. thrix*.
15. The yellow pigment around the head and anterior part of the body is autapomorphic.
16. An autapomorphy for *C. punctipectophorus* is the presence of a large spot on the lower part of the base of the pectoral fin.
17. Autapomorphic features of *C. glaucofraenum* are polytypic coloration (some individuals pale, some with considerable pigment) and the presence of a spot over the operculum.
18. We are unable to find a synapomorphy to unite *C. punctipectophorus* with *C. glaucofraenum* or with any other *Coryphopterus*. On the basis of pelvic disc struc-

ture, *C. punctipectophorus* seems to be closest to *C. glaucofraenum*. We believe, however, that this is a primitive condition and therefore consider the relations of *C. punctipectophorus* and *C. glaucofraenum* to be unresolved.

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