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UNUSUAL FEATURES OF THE COLONIES OF THE COMMON WESTERN ATLANTIC GARDEN EEL (*Heterocongrinae*), WITH A NEW RECORD FOR BERMUDA

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ABSTRACT: Colonies of the common western Atlantic garden eel (*Heteroconger longissimus*) recently discovered in Bermuda have a larger size than anywhere in the Caribbean (a single specimen from Puerto Rico being exceptional) and most members of the colonies occur as male-female pairs in closely adjacent burrows, whereas pairing otherwise is unknown in this species. The heads of a minority of adults of both sexes develop prominent, fluid-filled, blister-like structures that, at their fullest form, significantly swell the size of the head. This condition has been found in Bermudian and Caribbean colonies of *H. longissimus* as well as in two species of *Heteroconger* from the Pacific.

Although colonies of the common western Atlantic garden eel (*Heteroconger longissimus*, formerly *H. halis*) are widespread throughout the Caribbean in appropriate current-swept, open-sand habitat, they have not yet been reported from Bermuda (Beebe and Tee-Van, 1933; Sterrer, 1986; Smith-Vaniz, manuscript). However, the leptocephalus larvae of this species have been taken in the waters off Bermuda (Smith, 1989b) and reports have been received over the past several years from a variety of sources in Bermuda of sightings of what seemed to be gardens of eels at several locations around the Bermuda reef platform. To confirm the identity of the eels forming these colonies, with their bodies partially out of their burrows during daylight, we used SCUBA, rotenone, and spears to collect voucher specimens for the Bermuda Natural History Museum and the Smithsonian Institution.

We were not surprised that the species in question proved to be the common western Atlantic garden eel, *H. longissimus*. However, we were amazed upon first seeing them in situ and collecting them that: most of the individuals occurred in male-female pairs (not previously known for this species, although pairing is present in a few Indo-Pacific species); the individuals were far larger than members of other colonies we had observed and measured in the Bahamas, Lesser Antilles, and western Caribbean (up to 452 mm total length in Bermuda versus typically less than 350 mm in most other Caribbean localities, except for one Puerto Rican specimen); some of the larger and more sexually mature males and females had blister-like, fluid-filled, and usually irregular and asymmetrical swellings on the head, in the most extreme condition resulting in a swollen, pug-headed appearance (such swellings are not otherwise known among eels, or other fishes to our knowledge).

Our subsequent examination of museum collections of garden eels shows that this blister-head condition also is present in colonies of *H. longissimus* from the Caribbean and has

simply gone unnoticed, and that it is present in a few other species of *Heteroconger* as well (*H. digueti* and *H.* sp., both from the Gulf of California, the latter a new taxon under study by P. H. J. Castle and D. G. Smith, pers. comm. from the latter).

We describe below these interesting new aspects of garden eel biology.

NOMENCLATURE AND MATERIALS

There is a single commonly observed and collected species of garden eel in the western Atlantic, now known to occur from Bermuda, the Bahamas, and all parts of the Caribbean. There are two other species of western or central Atlantic garden eels known only on the basis of two or three specimens, one in the Gulf of Mexico (*Heteroconger luteolus*) and one at Ascension and Fernando de Noronha islands (*H. camelopardalis*) (see Smith, 1989a, for a summary of garden eel systematics).

The common western Atlantic garden eel was described as *Nystactes halis* by Böhlke (1957) on the basis of specimens from the Bahamas and Puerto Rico. After several changes in its generic nomenclature and the placement of all garden eels in two genera based on the revision by Böhlke and Randall (1981), the common western Atlantic garden eel has come to be known as *Heteroconger halis*. However, it has just been recognized by Smith (1994) that the larva named *Leptocephalus discus* Eigenmann and Kennedy (1902) is that of the common western Atlantic garden eel; therefore, with *halis* as a junior synonym of *discus*, the name of this common species would become *Heteroconger discus*. This presumes that the common western Atlantic species is specifically distinct from the earlier described species of garden eel in the eastern Atlantic, *Heteroconger longissimus* Günther (1870). But Saldanha et al. (1986) have presented convincing evidence in an extensive comparison of the meristic and other features of large series of eastern and western Atlantic specimens of the common species that the differences between "*halis*" in the western Atlantic and of *longissimus* in the eastern Atlantic are insignificant. Upon careful consideration of the evidence presented by Saldanha et al. (1986), D. G. Smith (pers. comm.) now agrees that *halis-discus* is best considered to be conspecific with *longissimus*. Thus, we use the name *Heteroconger longissimus* Günther for the common Atlantic garden eel.

Materials are from the collections of the Academy of Natural Sciences of Philadelphia (ANSP), Bermuda Natural History Museum (BNHM), University of Florida (UF), and the Smithsonian's National Museum of Natural History (USNM). Length is always total length. For the five specimens prepared for histological examination (after photography of their heads), their catalogue numbers in the Registry of Tumors in Lower Animals (RTLA) at the National Museum of Natural History are given after the USNM number.

Heteroconger longissimus. **Bermuda:** USNM 327624, 4, 423-452 mm (histological preparation of a 442 mm male without blistering, RTLA 5861, and a 445 mm male with blistering, RTLA 5860), on white sand flats and ledge sloping toward coral reef north-west of Devil's Flat, north of buoy 17A (north of Ireland Island) on west end of Bermuda (32°26.42′ N, 64°50.13′ W), 25-35 feet, 14 September 1993, J. Tyler, B. Luckhurst, I. Murdoch, rotenone squirted into burrows. All of the following specimens were collected by squirting rotenone into burrows and spearing individuals upon re-emergence on the white sand flats with nearby reefs south of the high point on the west end of Hamilton Island, known as the

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Southwest Breaker site (32°14.131′ N, 64°52.265′ W), 45 feet: USNM 327625, 5, 348-402 mm, 14 September 1993, J. and D. Tyler, B. Luckhurst, I. Murdoch; USNM 327626, 2, 394-417 mm, 16 September 1993, J. and D. Tyler, B. Luckhurst; USNM 327623, 2, 380-390 mm, 19 September 1993, J. and D. Tyler, B. Luckhurst, both members of pair speared; BNHM 1994-116-004, 3, 346-429 mm, 8 October 1993, B. Luckhurst and A. Glasspool; BNHM 1994-116-005, 2, 362-437 mm, 6 April 1994, B. Luckhurst and M. Vierros; BNHM 1994-116-001, 2, 299-397 mm, 26 April 1994, B. Luckhurst and A. Glasspool, both members of pair speared; BNHM 1994-116-002, 3, 332-362 mm, 26 April 1994, B. Luckhurst and A. Glasspool; BNHM 1994-116-003, 1, 319 mm, 4 May 1994, B. Luckhurst and A. Glasspool. **Belize:** USNM 316037, 172, 77-295 mm (histological preparation of a 224 mm male with blistering, RTLA 5858, a 245 mm female with blistering, RTLA 5857, and a 295 mm female without blistering, RTLA 5859), white sand flats inside dropoff reef about 300 yards east of Smithsonian marine laboratory on Carrie Bow Cay (Ellen Cay), about 18 km east of Sittee Point, south of Dangriga, 105 feet, 19 September 1990, J. and D. Tyler, C. L. Smith, R. E. Clark, G. D. Johnson, E. B. Brothers, K. S. Cole, rotenone dispensed under 12 by 20 foot tarpaulin. **Grand Cayman:** UF 12465, 107, 77-323 mm, white sand bottom off Paradise Rocks, about 400 yards off north end of Georgetown, west coast of island, 50-55 feet, 23 October 1964, C. R. Gilbert and J. C. Tyler, rotenone over open sand at time of minimum bottom current. The original collection of 215 specimens was divided into two parts for deposit at UF and ANSP, but the 108 specimens catalogued as ANSP 102415 have apparently long been lost while on loan. **Anguilla:** ANSP 103295, 80, 102-347 mm, flat, white, but slightly silty sand bottom of Dowlings Shoal, 1000 feet west of Crocus Bay off north end of Sand Island, 50-55 feet, 17 July 1965, J. C. Tyler and W. N. Eschmeyer, rotenone over open sand at time of minimum bottom current. Of the original 90 specimens from this collection, 8 were sent as gifts to several European museums, 2 were cleared and stained, and 20 were part of a long outstanding loan that has recently been returned. All 20 individuals in the returned loan are male, and it is apparent that they as well as the ten specimens sent as gifts or cleared and stained were selected from an all male lot of specimens after the original collection had been sorted by sex around 1970. **Honduras:** ANSP 138793, 3, 312-346 mm, West End, Roatan, 55 feet, 23 July 1975, D. G. Smith and W. H. Hulet, rotenone squirted into burrows; ANSP 138794, 11, 83-302 mm, same data as ANSP 138793 except 24 July 1975 and rotenone dispensed under plastic sheet. **Bahamas:** ANSP 109541, 12, 92-308 mm, white sand bottom west of Abraham Bay, one mile north-west of Start Point, south-west end of Mayaguana Island, 70 feet, 23 January 1968, C. L. Smith and J. C. Tyler, rotenone over open sand bottom at time of minimum bottom current. **Puerto Rico:** ANSP 75162, 1, 481 mm, sandy bottom of Crash Boat Basin off Ramey Field, Aquadilla, west coast of island, 30-50 feet, July 1956, Capt. Kuns through V. Biaggi, Jr., method of capture unrecorded (see Böhlke, 1957:69).

Heteroconger digueti (Pellegrin). **Mexico, Gulf of California:** USNM 318320, 4, 285-530 mm, flat sand bottom at Los Frailes, near Cabo Pulmo, 15 meters, 2 July 1990, G. R. Allen and D. R. Robertson, rotenone.

Heteroconger sp. **Mexico, Gulf of California:** USNM 316694, 3, 442-627 mm, same data as for *H. digueti*, USNM 318320, above; this is a new species being investigated by P. H. J. Castle and D. G. Smith (pers. comm. from the latter) whose

specimens came from a colony that apparently was contiguous with a colony of *H. digueti*.

RESULTS

Identification of the Bermuda Garden Eels

The Bermuda garden eels have all of the distinctive features given by Smith (1989a:485) for *H. longissimus* (as *H. halis*), including the critically important number of vertebrae; 13 radiographed Bermuda specimens have a range of 159-167 total vertebrae, and an average of 162.4 that is in the middle of the range (157-169) recorded by Smith for 64 Bahamian and Caribbean specimens. Although the color pattern of the Bermuda specimens (Figure 1) when fresh was slightly darker than in other specimens we have seen throughout the Bahamas and Caribbean, it is otherwise the same, especially when preserved, featuring a background of very small dark spots interspersed with slightly larger yellow spots on the head and body, except for the pale gray anterior abdominal and lower branchiostegal regions. The yellow spots along the bases of the dorsal and anal fins are especially prominent in the paler posterior one-third of the body, and the yellow color is almost continuous in the posterior regions of the fin bases except at the tip. The yellow spots are not individually readily apparent in life and specimens in the colonies appear dark gray to blackish. Our putative identification of these Bermuda garden eels was confirmed by D. G. Smith, who has recently treated the western Atlantic members of the family.

Pairing in Bermuda Colonies

Most of the approximately 30 species of garden eels occur in the Indo-Pacific, and a few of these are known to have at least some of the individuals of the colony occurring in pairs in adjacent burrows rather than all individuals more or less evenly distributed throughout the colony. In the case of *H. polyzona* in the

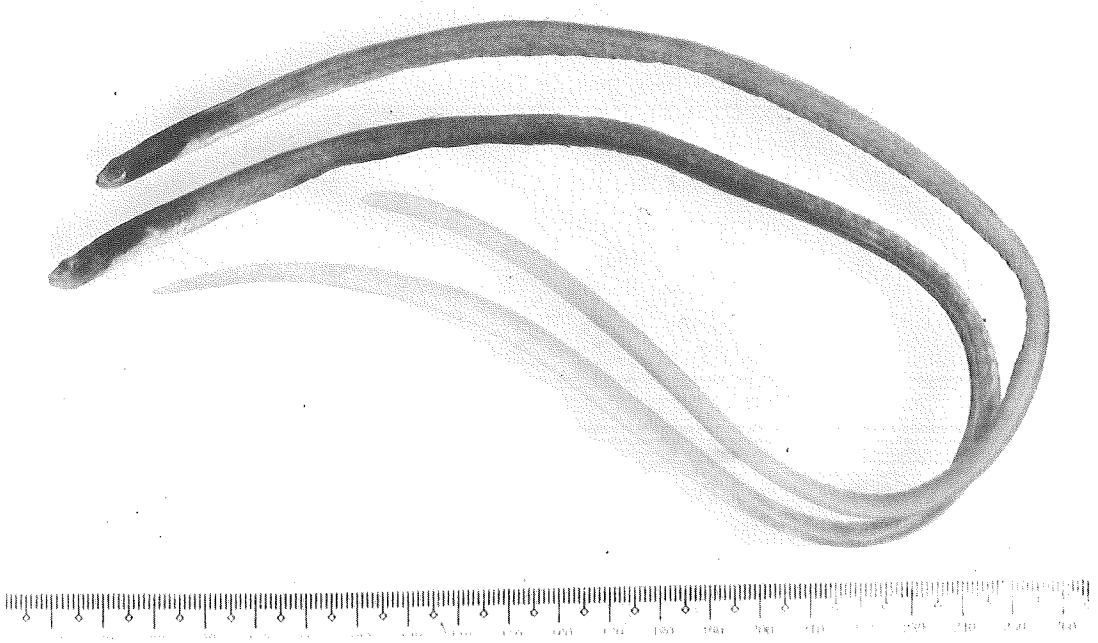

Figure 1. *Heteroconger longissimus*, USNM 327626, Bermuda, specimens typical of the majority of the colony, i.e., without blister-head condition; 394 mm female above a 417 mm male.

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Philippines, these have been shown to be male-female pairs (Tyler and Smith, 1992). Such pairing has not been reported for Atlantic garden eels. We have observed *H. longissimus* colonies in numerous localities in the Bahamas and throughout the Caribbean (see Tyler and Smith, 1992), including the northern coast of South America, and have never seen pairing. These observations have been made in many months of the year. At Carrie Bow Cay, Belize, for example, our observations were made during March, April, June, September, and November, between 1987-1994; nor is pairing evident in our many photographs of this colony during that period (C. L. Smith, pers. comm.).

By contrast, one of the most striking features of the Bermuda colonies of *H. longissimus*, along with the especially dark color (see above) and large size of its individuals (see below), is that most of the individuals occur in pairs. We devoted nine dives primarily trying to obtain both members of such pairs but found that, after squirting rotenone into both adjacent burrows and spearing the first individual upon its re-emergence, the other member of the pair rarely came up to the surface. This difficulty was unexpected because of the relative ease one of us (JCT) experienced in the collecting of both members of the pairs in the case of the species of garden eel from the Philippines mentioned above. In Bermuda we managed to collect both members of only two such pairs; gross microscopic examination of the gonads proved them both to be male-female pairs, just as with the four pairs of the Philippine species.

We observed this male-female pairing of the majority of individuals in the Bermuda colonies during the months of September, October, April, and May; therefore, we presume that pairing is probably a permanent feature of the spatial pattern exhibited by these Bermuda colonies. Because pairing in *H. longissimus* has been observed only in the Bermuda colonies of especially large individuals, we speculate that it is associated with breeding activity in older cohorts.

To provide an initial quantification of the distribution of burrow pairs in the Bermuda colonies, we took a preliminary set of measurements between and among pairs within 1 m^2 quadrats at the Southwest Breaker site. An analysis of these data reveals that the mean intrapair distance between the two burrows of 10 pairs of eels in September (17.4 cm) was not significantly different from the mean value in May (17.9 cm) (ANOVA, $F = 0.055$, $p = 0.818$). By contrast, the interpair distance between two neighboring pairs, as measured between the closest two burrows of the nearest pairs, was, on average, about five times as great as the intrapair distance: 10 interpair measurements had a mean value of 85.0 cm (standard deviation = 28.8 cm, range = 38.1-139.7 cm).

Size and Sex Composition of Bermuda and Caribbean Colonies

The 24 specimens collected at random (no special emphasis on collecting especially large specimens) from Bermuda colonies range from 299-452 mm, with a mean size of 382 mm. There are 14 males of 346-452 mm ($\bar{x}$ = 402 mm) and ten females of 299-423 mm ($\bar{x}$ = 355 mm). The diameter of the eggs in the specimens collected in September was 0.8-0.9 mm. The smallest of the females (348 mm) collected in September was ripe enough to have eggs easily squeezed out. One of the larger males (429 mm) collected in October was running ripe. Neither of these two especially ripe individuals had the blister-head condition.

There are only two large (100+ specimens) samples to our knowledge from other colonies of *H. longissimus* that can serve to assess mean size and

sex ratios in colonies of this species from Caribbean localities. The largest of these consists of the 172 specimens (USNM 316037) collected by rotenoning under a tarpaulin at Carrie Bow Cay, Belize, with the collectors attempting to pick up all individuals killed to provide a relatively complete sample of the affected area of the colony. These specimens range from 77-295 mm, with a mean size of 221 mm. There are 90 males of 189-288 mm ($\bar{x}$ = 232 mm), 64 females of 182-295 mm ($\bar{x}$ = 233 mm), and 18 immatures of 77-185 mm ($\bar{x}$ = 125 mm), with a sex ratio of 1.4 male: 1.0 female. In the other large sample, 107 specimens (UF 12465), collected with rotenone over the open bottom of a colony at Grand Cayman during a period of low current, the specimens range from 77-323 mm, with a mean size of 194 mm. There are 18 males of 221-323 mm ($\bar{x}$ = 282 mm), 20 females of 228-315 mm ($\bar{x}$ = 264 mm), and 69 immatures of 77-311 mm ($\bar{x}$ = 151 mm), with a sex ratio of 0.9 male: 1.0 female.

We can relatively easily determine sex by gross microscopic examination of the gonads in most specimens larger than about 180 mm, but some specimens larger than this remain immature, probably indicating variation in maturation rates throughout what may be a relatively long breeding season. The plump ovaries of some of the females in these two large samples have eggs of up to 1.1-1.2 mm diameter, but most of the females that we consider to be relatively ripe have eggs of 0.9-1.0 mm diameter; one ovary often is somewhat larger than the other, and we establish that the larger side ovaries contain between 500-800 eggs whereas the smaller side ovaries contain between 300-500 eggs.

In both the Belize and Grand Cayman samples the smallest individuals in the colonies are 77 mm and these have probably just recently been recruited because the largest specimens of the leptocephali of this species from various locations are between 75 and 81 mm, with the latter being from Bermuda (Smith, 1989b:738). Moreover, some of the smallest specimens obtained from colonies still have larval melanophores visible (for a 78 mm specimen see Smith, 1989a:487), indicating that garden eels join colonies immediately upon metamorphosis from the leptocephalus stage (Smith, 1989a:483).

The sample from Grand Cayman, made on 23 October 1964, has a far larger number (65% of population) and larger mean size (151 mm) of immatures than that from Belize, made on 19 September 1990 (11% of population and 125 mm mean). The sample from the Grand Cayman colony apparently had more successful recruitment and is further removed than the Belize sample from the recruitment period, following what Smith (1989b:738) estimates on the basis of leptocephalus abundance to be the summer and fall breeding period of this species. The sex ratio and average size of males and females are not statistically different between the Belize and Grand Cayman samples, both being about equal

The mean size of individuals in the entire samples and of adult males and females from Belize and Grand Cayman (respectively 221 mm and 194 mm for the entire colonies) is substantially smaller than the 24 individuals in the Bermuda sample (382 mm). The smaller size in most Caribbean colonies of this species relative to those in Bermuda also is seen in other samples with fewer individuals of this species, with Caribbean specimens considered to be especially large if they reach as much as 346 mm (in ANSP 138793 from Honduras) and 347 mm (in ANSP 103295 from Anguilla). This conforms to our observations of colonies of this species throughout the Lesser Antilles, western Caribbean, and coast of

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northern South America, where we estimate the size of adults to be very similar to that of the Belize and Grand Cayman samples, and much smaller than the adults of the Bermuda colonies.

There is only one specimen known of *H. longissimus* from the western Atlantic of greater than 350 mm other than from Bermuda, and this is the only specimen reported from Puerto Rico, 481 mm. The notes that accompanied this specimen, sent to Philadelphia for inclusion in the original description of the species, indicated that the colony consisted of individuals with one to two feet (= 305-610 mm) of the body extending out of the sand (Böhlke, 1957:69). Even allowing for some exaggeration in the underwater estimate, the single specimen in hand vouches for a colony with at least some relatively large individuals, fully as large as in the colonies in Bermuda. We have no explanation to offer for the large specimen size in the colonies in Bermuda and Puerto Rico versus elsewhere in the western Atlantic. However, specimens over 500 mm are not uncommon in the eastern Atlantic (Saldanha et al., 1986).

Blister-Head Condition

The most unusual feature of the Bermuda colony of garden eels is the presence in three of the 24 individuals of fluid-filled, blister-like upliftings of the skin on the head, these being unknown in any other families of eels (or other fishes in general). This swelling of the head is most fully developed in a 402 mm male, in which the uplifting of the skin away from the muscle mass of the skull is symmetrical and continuous from the cheeks onto the top of the head from the front of the eyes to the region just in front of the gill opening, resulting in a decidedly pug-headed appearance (far right specimen in Figure 2, top specimen in Figure 3), especially before preservation with resultant shrinkage of the

Figure 2. ***Heteroconger longissimus*****, USNM 327625, Bermuda, five specimens with both normal and blister-head conditions, from right to left: 402 mm male with well-developed blister over all of top and sides of head from eye posteriorly, giving specimen pug-headed appearance; 352 mm female with incipient blister-head condition, swelling confined to middle of top of head from eye posteriorly; to left three specimens without blister-head condition, 374 mm male, 363 mm female, and 348 mm female.**

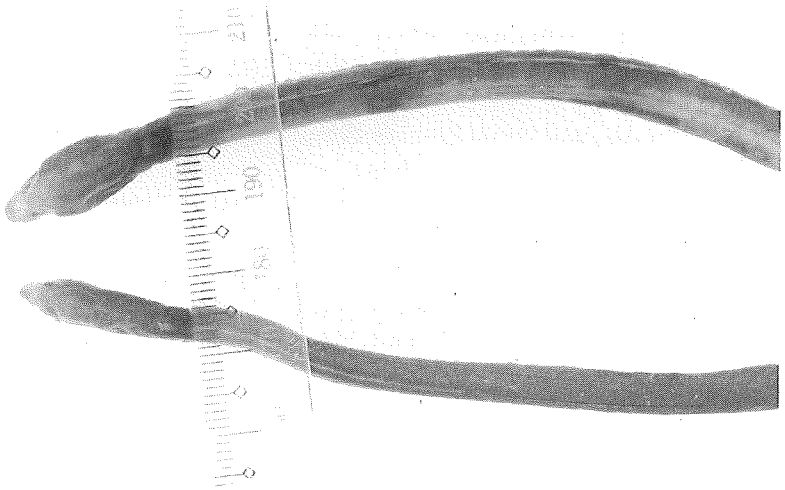

Figure 3. ***Heteroconger longissimus***, **the two blister-head specimens from Figure 2 shown in dorsal view, the 402 mm pug-headed male above the 352 mm female with an incipient blister-head condition.**

puffiness. When the swelling is less developed, as in a 445 mm male and a 352 mm female (for the latter, second from right specimen in Figure 2, bottom specimen in Figure 3), it is more irregular in shape and less symmetrically placed. For example, the 445 mm specimen has a blister on the top of the middle of the head behind the eye and two contiguous blisters on the left cheek, whereas the 352 mm specimen has the blisters slightly smaller, one on the top of the middle of the head behind the eye and incipient blisters on both cheeks below the eyes. Thus, the blister-head condition as found in the Bermuda materials occurs in both mature males and females, but not in all mature specimens and not necessarily in the largest specimens, there being both males and females substantially larger than the three with blisters (i.e., a 452 mm male without blisters is slightly larger than the larger blister-head male, 445 mm, and four of the other females without blisters, 363-423 mm, are larger than the blister-head female, 352 mm). The degree of development of blisters is not strictly size dependent within mature adults because the most extreme example of this swelling is in a 402 mm individual, and two larger individuals have a lesser development of blistering. Nor is the degree of development of blisters strictly related to full gonadal ripeness, for the single female with eggs easily squeezed out and the single running ripe male lack blisters.

We have found similar head blistering in some of the specimens of *H. longissimus* in the two large samples from Belize and Grand Cayman, although only to about the degree of development in the 352 and 445 mm specimens from Bermuda and not as extensively as in the pug-headed 402 mm specimen.

Among the 172 specimens from Belize, five males of 220-252 mm and two females of 203-245 mm have blister-heads, and there are numerous individuals of both sexes without blisters larger than those with blisters (Figure 4, top two specimens, males in lateral [above, 242 mm] and dorsal [224 mm] views; bottom specimen, female [245 mm]). One of these two females is judged to be very ripe (eggs of 0.9-1.0 mm diameter) and the other one not fully ripe (eggs of 0.8-0.9 mm) and among the females without blisters are individuals that are just as ripe or riper than the riper of the two females with blisters.

Among the 107 specimens from

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Grand Cayman, three males of 283-311 mm and one female of 288 mm have blister-heads, and there are numerous individuals of both sexes without blisters larger than those with blisters, and there are females without blisters that are just as ripe or riper than the one with blisters.

Thus, in the large samples from Belize and Grand Cayman, blistering occurs in a small minority (3-4% of entire sample; 5-8% of adults) of the members of a colony and in adults of both sexes (perhaps more frequently in males than females), with the degree of development sometimes greater in smaller adults than in larger individuals and with many blisterless individuals larger than those with blisters and equally or even more sexually mature.

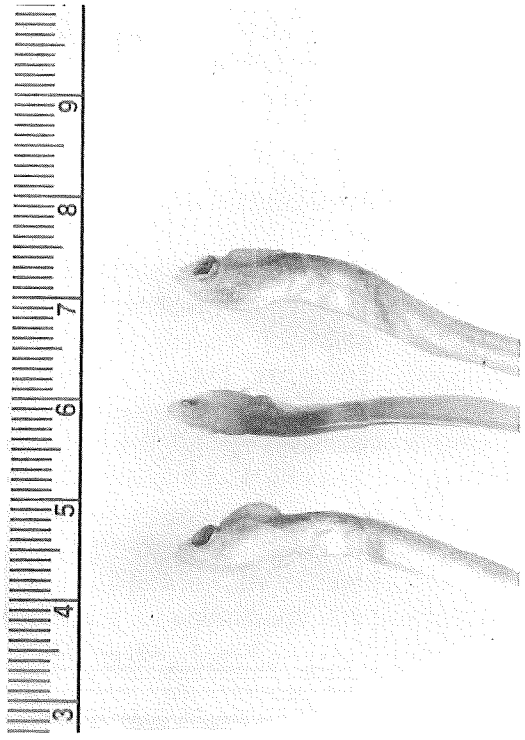

Figure 4. *Heteroconger longissimus*, USNM 316037, Belize, three specimens with blister-head condition, in lateral (top and bottom) and dorsal views, from top to bottom: 242 mm male with long irregular blister on middle of top of head behind eye and smaller blisters on cheeks; 224 mm male with long blister on top of middle of head behind eye and large blister on right cheek; 245 mm female with large high blister on top of head behind eye and on left upper cheek.

The small Bermuda sample of 24 specimens is similar to this, except for the suggestion of seasonality in blistering. Of the 16 specimens collected in September and October, three (19%) exhibit blistering, while none of the eight specimens collected in April and May have blistering. Given the greater frequency of blistering in the large specimens from Bermuda, it is also possible that blistering increases with cohort age, assuming that the average age of the large Bermuda specimens is greater than that of adults in the two large samples from Belize and Grand Cayman.

We are unable to confirm that latter assumption because E. B. Brothers (pers. comm.) has found it very difficult to interpret the otoliths of garden eels, including four specimens that were alcohol preserved for that purpose from the Belize collection; he estimates the presettlement leptocephalus duration of the Belize specimens of *H. longissimus* to have been three to four months, but daily postsettlement increments become indistinct after about 150-200 days.

The blistering is not an artifact of preservation, having been seen in fresh specimens from Bermuda as they were being collected and brought to the surface. Nor can the blistering be attributed to the use of rotenone in collecting the specimens, because only a small minority of all of the mature individuals of both sexes collected under the same conditions (i.e., rotenone evenly distributed under a tarpaulin or squirted into burrows) have blistering.

We had histological serial cross-sections prepared through the heads of five specimens of *H. longissimus* from both Bermuda and Belize, including both males and females, and those with and without blisters. The three blister-head specimens all have a similar histological appearance. The fluid-filled bubbles or

blisters are the result of an edematous subcutaneous swelling, forming a serous pseudocyst; i.e., the blister is a space without an epithelial lining between the dermis and the head musculature that is filled with a lymph- or serum-like clear fluid without cells. Our use of the term "blister" should not be taken to indicate that we think these structures are the result of some kind of trauma to the skin, such as thermal or chemical burning. We are confident that the blistering is a non-pathological condition and not induced during the collecting of the materials.

We do not know the significance of blistering in the life cycle of *H. longissimus*, but we are monitoring the Belize and Bermuda colonies to investigate both this and pair-formation. In the interim, we simply speculate that blistering is an ephemeral increase in head size in both sexes, involved in some prelude to breeding in both unpaired adults of moderate size and, increasingly so, in older paired adults.

Whatever its significance, head swelling is found in at least some other species of garden eels. Among the limited number of species of garden eels represented in the collections of the Academy of Natural Sciences of Philadelphia and the National Museum of Natural History, blistering has been found in two other species besides *H. longissimus*. In one lot (USNM 318320) of four specimens of *H. diguetl* (Pellegrin) from the Gulf of California there is a ripe female of 530 mm with a highly swollen, fluid-filled, pug-headed condition, while the other three specimens (two males of 468-496 mm and one immature of 285 mm) have unswollen heads (Figure 5, the pug-head female above the 496 mm male). In one lot (USNM 316694) of three specimens of an undescribed species of *Heteroconger* from the Gulf of California there is a 627 mm male with blistering on the top left and, especially, top right of the head, while the other two specimens (442-506 mm males) have blisterless heads.

Figure 5. *Heteroconger diguetl*, USNM 318320: above, 530 mm female blister-head specimen with top and sides of head much swollen from eye posteriorly; below, 496 mm male without blister-head condition.

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We undertook this investigation of the Bermuda colonies of garden eels at the suggestion of Wolfgang Sterrer, Curator, Bermuda Natural History Museum, where he, Lisa Greene, and Leo Barbosa were most helpful. We received accurate directions about where to find the gardens from several Bermuda diving naturalists: Ian Murdoch, who took us to the colony near Devil's Flat and helped us collect voucher specimens for purposes of identification; and Jack Ward, Bermuda Aquarium, who provided a location near Southwest Breaker at which to start a garden eel search based on an earlier diving survey conducted by the Division of Fisheries for other purposes. The skilled navigation and boat handling of Capt. Lynchfield Eastmond, of the Division of Fisheries research vessel *Calamus*, simplified the original task of finding and sampling the colonies in

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September and October. Capt. John Whiting provided equally good service for the sampling in April and May. Anne Glasspool and Marjo Vierros of the Bermuda Biological Station for Research assisted on several dives to collect specimens.

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LITERATURE CITED

Beebe, W. and J. Tee-Van. 1933. Field book of the shore fishes of Bermuda and the West Indies. Dover Publications, New York. 337 pages.

Böhlke, J. E. 1957. On the occurrence of garden eels in the western Atlantic, with a synopsis of the Heterocongrinae. Proceedings of the Academy of Natural Sciences of Philadelphia, 109:59-79.

_____ and J. E. Randall. 1981. Four new species of garden eels (Congridae, Heterocongrinae) from the Pacific and Atlantic Oceans. Bulletin of Marine Science, 31 (2):366-382.

Eigenmann, C. H. and C. H. Kennedy. 1902. The leptocephalus of the American eel and other American leptocephali. United States Fish Commission Bulletin for 1901:81-92.

Günther, A. 1870. Catalogue of the fishes [Physostomi, etc.] in the British Museum. British Museum (Natural History), London. 549 pages.

Saldanha, L., G. E. Maul, M. Biscoito, and F. Andrade. 1986. On the identity of *Heteroconger longissimus* Günther 1870 and *Heteroconger halis* (Böhlke 1957) (Pisces Congridae). Bocagiana (Museu Municipal do Funchal), 104:1-17.

Smith, D. G. 1989a. Family Congridae. Pages 460-567 *in* E. B. Böhlke, ed., Fishes of the western North Atlantic, Pt, 9, Vol. 1, Orders Anguilliformes and Saccopharyngiformes. Sears Foundation for Marine Research, New Haven.

_____. 1989b. Family Congridae: Leptocephali. Pages 723-763 *in* E. B. Böhlke, ed., Fishes of the western North Atlantic, Pt. 9, Vol. 2, Leptocephali. Sears Foundation for Marine Research, New Haven.

_____. 1994. Catalog of type specimens of Recent fishes in the National Museum of Natural History, Smithsonian Institution, 6: Anguilliformes, Saccopharyngiformes, and Notacanthiformes (Teleostei: Elopomorpha). Smithsonian Contributions to Zoology, 566:1-50..

Smith-Vaniz, W. F. Manuscript. Annotated

check-list of the shore fishes of Bermuda.

Sterrer, W. 1986. Marine fauna and flora of Bermuda: a systematic guide to the identification of marine organisms. Wiley, New York, 742 pages.

Tyler, J. C. and C. L. Smith. 1992. Systematic significance of the burrow form of seven species of garden eels (Congridae: Heterocongrinae). American Museum Novitates, 3037:1-13.

DOI: 10.18785/negs.1302.03