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A New Species of Garden Eel (Congridae: Heterocongrinae) of the Genus *Gorgasia* from Hawaii[1]

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IN AUGUST OF 1969 the authors were engaged in a survey of the population of crown-of-thorns starfish (*Acanthaster planci*) at the island of Hawaii. One operated a small boat that towed the other as an observer at the surface. Just south of Puako on the Kona coast of the island, a colony of garden eels was discovered on a sand bottom at a depth of 18 m. On the following day, 12 specimens were collected with rotenone, and 3 days later, another 10 specimens were obtained from the same site. The eels proved to be an undescribed species of *Gorgasia*.

INTRODUCTION

The genus *Gorgasia* was established by Meek and Hildebrand (1923) for the species *punctata*, which they described from the Pacific coast of Panama. They classified this eel in the family Derichthyidae. Gosline (1952), however, stated that *Gorgasia* seems to be more closely related to *Heteroconger* than to *Derichthys*.

Böhlke (1951) described the second species of the genus from two specimens from Mindanao, Philippines, initially naming it *Taenioconger naeocepaeus*. He also suspected that *Gorgasia punctata* should be grouped with *Heteroconger*. In his synopsis of the Heterocongrinae, Böhlke (1957) placed *Gorgasia* in this subfamily and shifted *T. naeocepaeus* to this genus. He regarded *Gorgasia* as the most primitive of recent genera because of its larger gape, less specialized dentition, well-developed pectoral fins, nearly full complement of cephalic lateral-line pores, and anterior nostrils free from the upper lip. In lacking an external caudal fin, however, it is not primitive.

Klausewitz and Eibl-Eibesfeldt (1959) described the third species of the genus, *Gorgasia maculata*, from the Nicobar Islands. Klausewitz (1962) named the fourth, *G. sillneri*, from the Red Sea. Fricke (1969, 1970*a*, 1970*b*, 1971) and Clark (1971, 1972, 1974) discussed aspects of the ecology and behavior of this species.

Rosenblatt (1967) carried out an osteological study of *Gorgasia punctata*. He agreed with Böhlke that *Gorgasia* is the most primitive genus of the subfamily but is specialized in possessing expanded transverse processes on the anterior vertebrae and in its loss of the anterior maxillary pedicel. He stated that *Gorgasia* is probably an early offshoot of the heterocongrin line. He also confirmed the placement of the Heterocongrinae within the Congridae.

Abe, Miki, and Asai (1977) added a fifth species to the genus, *Gorgasia japonica*, from specimens collected at Hachijo Island, Japan (about 300 km south of Tokyo).

METHODS

Lengths of specimens in the present study are given as total length (TL) from the tip of the protruding lower jaw with the mouth closed to the tip of the tail. Head length was measured from the median anterior point of the upper lip to the upper end of the gill opening. The length of the maxilla is difficult to measure accurately without dissection because the posterior end is hidden in soft tissue. Therefore, the length of the upper lip was taken as an expression of the size of the gape. The width of the mouth was

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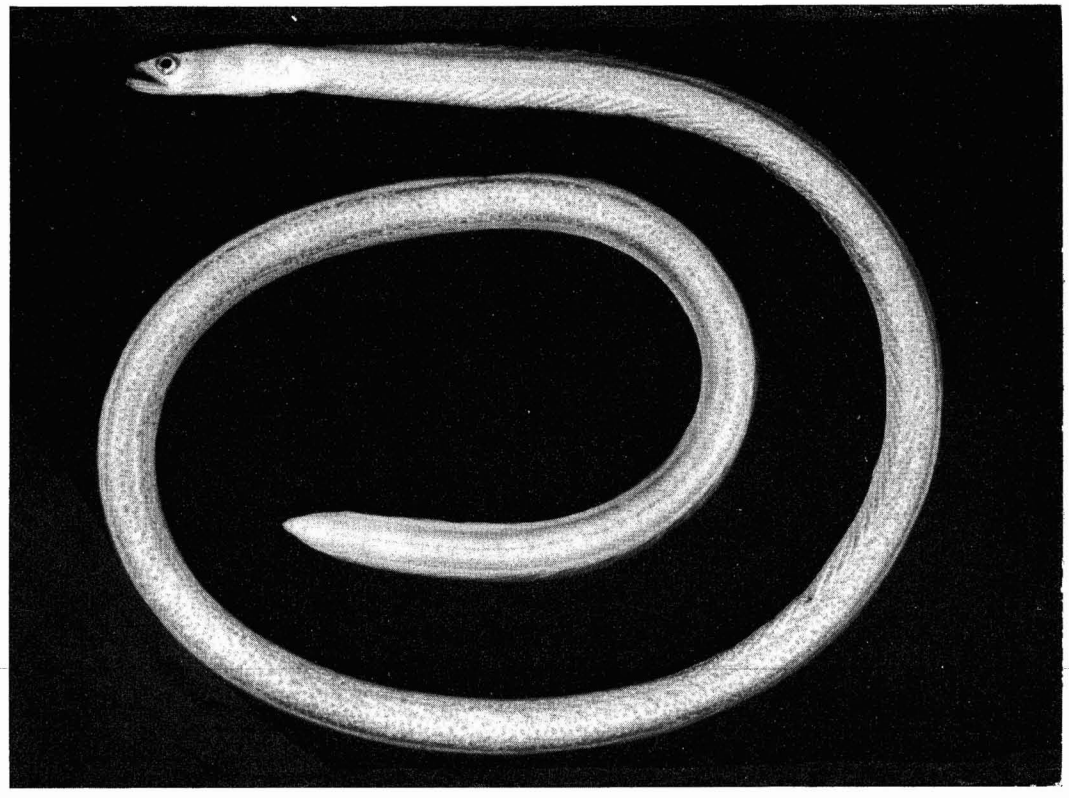

FIGURE 1. Holotype of *Gorgasia hawaiiensis* Randall and Chess, BPBM 21074, 521 mm, Hawaii.

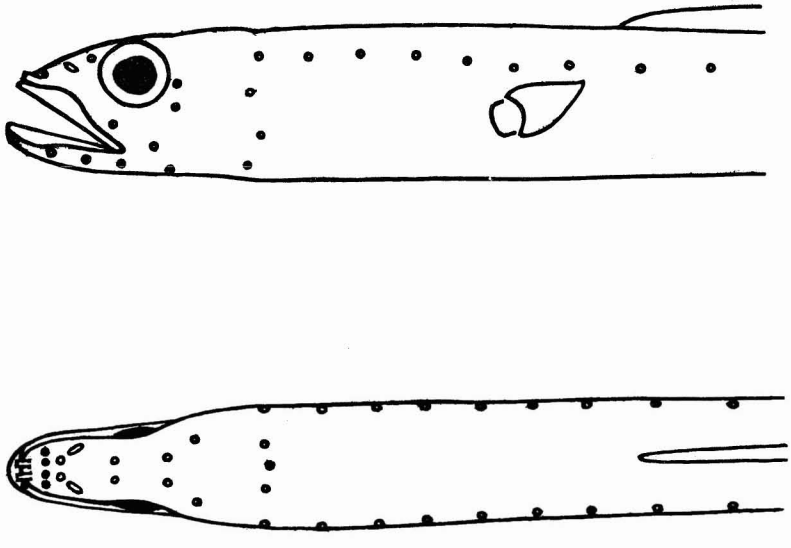

FIGURE 2. Diagram of head pores of *Gorgasia hawaiiensis*. Drawing by Helen A. Randall.

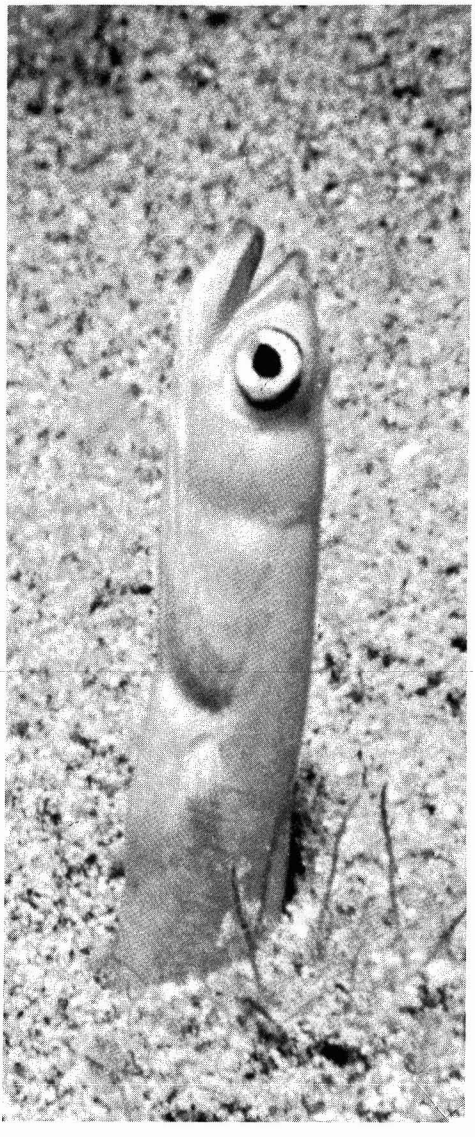

FIGURE 3. Underwater photograph of head of *Gorgasia hawaiiensis* protruding from its burrow, Kona coast of Hawaii, 18 m. The eel was under the effect of rotenone when the photograph was taken.

measured directly from rictus to rictus. The interorbital width was the fleshy width; this varied from specimen to specimen with the vagaries of preservation. The length of the gill opening also varied with preservation.

Type specimens of the new species have been deposited at the following institutions: Academy of Natural Sciences of Philadelphia (ANSP); Australian Museum, Sydney (AMS); Bernice P. Bishop Museum, Honolulu (BPBM); British Museum (Natural History), London BM(NH); California Academy of Sciences, San Francisco (CAS); Scripps Institution of Oceanography, La Jolla (SIO); Senckenberg Museum, Frankfurt (SMF); Zoological Institute, University of Tokyo (ZIUT); and the U.S. National Museum of Natural History, Washington, D.C. (USNM).

In the description below, data in parentheses refer to the paratypes when different from the holotype. Proportional measurements and counts of pores and pectoral rays were taken from the holotype and seven paratypes. Total vertebral counts were taken of the holotype and nine paratypes, and preanal vertebral counts on the holotype and five paratypes. Counts of the dorsal and anal fin rays were made of the holotype and three paratypes.

Gorgasia hawaiiensis, new species

Figures 1–3, Tables 1 and 2

Holotype

BPBM 21074, 521 mm, male, Hawaiian Islands, Kona coast of Hawaii, 100 m north of Waawaa Point (south of Puako), sand, 18 m, rotenone, J. E. Randall and J. R. Chess, 10 August 1969.

Paratypes

BPBM 21075, 6:333–553 mm, ANSP 109646, 467 mm; BM(NH) 1978.2.21.1, 505 mm; CAS 40722, 520 mm; SIO 69-430-26, 537 mm; USNM 218333, 548 mm—all with same data as holotype; BPBM 21076, 7:389–598 mm; AMS I. 20104-001, 502 mm; SMF 14 052, 419 mm; ZIUT 54065, 488 mm—all with same collecting data as holotype except the date, 13 August 1969.

Description

Dorsal fin rays 514 (459–525); anal fin rays 316 (291–336); pectoral fin rays 9

TABLE 1

PROPORTIONAL MEASUREMENTS OF TYPE SPECIMENS OF *Gorgasia hawaiiensis*

	HOLOTYPE, BPBM 21074	PARATYPE						
		BPBM 21075	BPBM 21076	BPBM 21075	BPBM 21075	BPBM 21075	BPBM 21075	BPBM 21075
Total length, TL (mm)	**521**	**333**	**389**	**408**	**440**	**461**	**497**	**553**
Depth of gill opening	1.4	1.7	1.5	1.5	1.5	1.5	1.4	1.2
Depth of anus	1.2	1.5	1.3	1.4	1.3	1.3	1.2	1.1
Snout to anus	39.3	42.1	42.9	42.0	41.8	41.3	42.3	41.3
Predorsal length	5.3	6.0	5.9	5.1	5.4	5.9	4.9	4.8
Head length	4.5	5.2	5.1	5.0	4.9	4.7	4.4	4.3
Head length (mm)	**23.5**	**17.2**	**19.7**	**20.5**	**21.8**	**21.7**	**21.7**	**23.0**
Width at gill opening	20.4	20.3	18.3	20.5	20.6	20.7	20.7	20.0
Width at anus	23.0	24.4	21.8	24.4	23.4	22.8	23.6	22.8
Snout length	17.2	16.8	15.2	17.1	16.7	15.7	15.2	16.9
Diameter of eye	17.7	20.4	19.3	19.5	18.3	18.2	19.3	17.2
Interorbital width	9.4	11.6	10.1	10.2	9.4	11.5	10.6	10.4
Length of upper lip	28.7	26.7	25.9	27.8	26.1	26.7	29.5	26.9
Width of mouth	16.2	18.0	10.6	13.1	11.9	12.9	12.9	12.6
Length of gill opening	7.2	7.0	6.6	7.3	6.4	7.3	7.4	6.5
Length of pectoral fin	12.6	11.0	10.4	10.7	12.6	12.9	13.3	11.3
Last pore to tail tip	37.0	35.4	33.0	29.3	32.2	32.3	32.3	32.6

NOTE: Total length and head length, given in millimeters, are shown in boldface type. The first five proportional measurements are expressed as a percentage of the total length (TL), the last ten as a percentage of the head length.

TABLE 2

STOMACH CONTENTS OF TEN SPECIMENS OF *Gorgasia hawaiiensis*

FOOD ITEMS	FREQUENCY
Calanoid copepods	10
Cyclopoid copepods	10
Harpactacoid copepods	10
Unidentified crustacean fragments	10
Solitary eggs	10
Masses of eggs	6
Unidentified crustaceans	4
Hyparid amphipods	4
Radiolarians	3
Ostracods	2
Pteropods	2
Gammarid amphipods	1
Euphausids	1
Mysids	1
Tanaids	1
Cypris larvae	1
Isopods	1
Decapod zoea	1
Diatoms	1

(9–13); lateral-line pores from gill opening to anus 35 (34–39); total lateral-line pores posterior to gill opening 83 (83–90); vertebrae 170 (164–173) ($\bar{x}$ = 168.2); preanal vertebrae 68 (67–69).

Body extremely elongate; the depth at anus contained 80 (64–86) times in TL and slightly compressed (becoming more compressed near end of tail); the width at anus 1.2 (1.1–1.2) times in depth. Anus in anterior half of length, the preanal distance 2.5 (2.3–2.5) in TL. Dorsal fin originating a short distance behind gill opening, the predorsal length 18.9 (16.1–21.3) in TL. Head length 22.1 (19.4–24.0) in TL. Snout moderately long, 5.8 (5.8–6.6) in head. Eye large, 5.7 (4.9–5.8) in head; interorbital space slightly concave and narrow, the fleshy width 10.7 (8.6–10.6) in head. Mouth large, oblique, forming an angle of about 30° to the horizontal, the maxilla extending posterior to a vertical at hind edge of pupil, the length of the upper lip 3.5 (3.4–3.8) in head. Gill opening on midside, hemispherical, the axis diagonal (forming an angle of about 22° to the vertical) with upper end anterior, its length 13.8 (13.5–15.5) in head. Pectoral fins short, the broad base immediately behind and parallel to axis of gill opening, and pointed, the fifth ray longest, the length 8.0 (7.5–9.6) in head.

Dorsal part of head with tiny pointed papillae. Branchial region with prominent longitudinal grooves, especially ventrally. Lips with free margins except the medial portion of upper lip; upper lip broadest ventral to posterior nostril. Anterior nostril in a short forward-projecting tube just medial to free portion of upper lip; posterior nostril with a low rim, slightly closer to eye than base of anterior nostril. Anterior lateral-line pores as illustrated in Figure 2.

A group of stout incurved canine teeth (8 on holotype) forming an egg-shape enclosure anteriorly on premaxillary-ethmovomer, followed by a median row of 6 (5–9 on paratypes) well-spaced stout incurved canines. Front of upper jaw with three rows of small slender canines, soon reduced to two rows, and then to a single row along side of jaw, these teeth curving posteriorly and angling inward (35 teeth in outer row on one side of jaw of holotype). Most specimens with 1 to 6 small canines in a well-separated inner row on about posterior half of upper jaw. Lower jaw with three or four rows of canines at the front, soon reducing to a single row of enlarged recurved teeth (about twice as large as teeth of upper jaw) that angle inward along side of lower jaw (holotype with 20 teeth in outer row of one side of lower jaw). Tongue free, narrow, the tip rounded.

Dorsal and anal fins low, the height of the dorsal when fully elevated about one-third body depth. Dorsal and anal fins ending just before fleshy tip of caudal fin. Three tiny rudimentary caudal rays (visible only on a radiograph of one large paratype).

Color in alcohol: brown, the head paler, particularly the branchial region, and the tail somewhat lighter posteriorly; front of chin and edges of mouth dusky; dorsal and anal fins pale, the edge of about the anterior fourth of the dorsal with a narrow interrupted blackish margin. Lateral-line pores not in a pale spot (though the very narrow rim of each is slightly paler than rest of body).

Color of holotype when fresh: pale gray-green with numerous small brownish-yellow spots; tail yellowish posteriorly; lower lip yellowish laterally, brown anteriorly; front of upper lip brownish; premaxillary-ethmovomer region of mouth red; dorsal fin clear with yellow spots, especially basally, the rays whitish, the anterior part of the fin with an interrupted narrow blackish margin; anal fin clear with small yellow spots basally; iris light blue-green inwardly, shading to darker blue outwardly.

Remarks

This garden eel is most closely related to *Gorgasia naeocepaeus* (Böhlke) from the Philippines. *Gorgasia hawaiiensis* differs in having 164 to 173 vertebrae, compared to 177 for the holotype of *G. naeocepaeus* (the single paratype has 175 vertebrae; however, the tip of its tail is missing); the head of *G. naeocepaeus* is longer (5.4 percent TL compared to 4.4–5.2 percent for *G. hawaiiensis*); the snout-to-anus distance is slightly shorter (38.7 percent in *G. naeocepaeus*, compared to 39.3–42.9 percent for *G. hawaiiensis*); and the distance from the last lateral-line pore to the tail tip is slightly greater (38 percent of head length in *G. naeocepaeus*, compared to 29.3–37 percent in *G. hawaiiensis*). There are also some apparent differences in dentition. *Gorgasia naeocepaeus* lacks the well-separated inner row of teeth posteriorly on the upper jaw, and the large canines posteriorly on the premaxillary-ethmovomer are scattered, whereas they are consistently found in a single row on *G. hawaiiensis*.

We name this species *Gorgasia hawaiiensis* in the belief that it will prove to be restricted to the Hawaiian Archipelago. Our only specimens have come from the Kona coast of the island of Hawaii.

Within the large bed of eels from which we collected our type specimens, we made some counts in measured sectors to determine the concentration. There were 26 eels in a 16-m^2 area (4 m on each side). Eels were also counted 1 m on either side along a 50-m line (thus, an area of 100 m^2); the count was 92. In the more concentrated areas of the bed, the holes averaged 20 to 30 cm apart. The minimum distance between holes in this area was 5.5 cm. Hole diameters varied from 5 to 9 mm.

To our knowledge, the first sighting of the Hawaiian garden eel was that of the late Vernon E. Brock, who informed us that he observed eels off Napoopoo in 1945. The senior author and Edmund S. Hobson made a dive to observe a small colony at this site at nightfall in an estimated 12-m depth on 5 September 1969. At 7 PM, the holes of the burrows were found, but the eels had all withdrawn completely into their burrows.

Robert F. L. Self of Hilo, Hawaii (personal communication), and associates have observed garden eels "at seven points along a 50-mile stretch of the Kona coast: Mahukona, Puako, 'Ruddles,' Kiholo Bay, 'Old Kona Airport,' Kealakekua Bay, and Keei Beach." The eels were sighted "as shallow as 35 feet in Kealakekua Bay and as deep as 175 feet in the Puako area." At the Kealakekua Bay locality, they also counted the number of eels along a line in an area of 100 m^2; their count was 138 eels.

Gorgasia hawaiiensis feeds in the same manner as has been observed for other heterocongrin eels. They extend at least two-thirds of their bodies out of the burrow to feed on the zooplankton (though they may take food with as little as one-fourth extended), the body often forming a sinuous curve as they move from side to side or up and down to prey upon individual plankters.

We examined the stomach contents of the ten paratypes, 389 to 598 mm, that were collected on 13 August. Table 2 lists the groups of organisms that were found and the frequency with which they were encountered in the ten stomachs. Copepods of all three groups made up approximately 80 percent by volume of the total stomach contents. The smallest discrete particles from the stomachs were eggs of about 100 μ. The smallest crustaceans were harpactacoid copepods of less than 500 μ. The largest food animals were calanoid copepods that were nearly 3 mm in length.

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