

Redescription of *Gorgonolaureus bikiniensis* (Crustacea: Ascothoracica), with a Reevaluation of its Familial Affinities

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Abstract—The original description of *Gorgonolaureus bikiniensis* Utinomi, 1962, an ascothoracican parasite of a gorgonian, is superficial and inaccurate. The genus is here redefined, and clarifications are presented of the morphology, particularly of the first antennae, oral cone, dorsal "horn", thoracopods, and abdomen of the adult and the metanaupliar appendages. Because of its generalized tagmatization, first antennae, and thoracopods, *Gorgonolaureus* is removed from the highly modified family Lauridae and placed into the most primitive ascothoracican family, Synagogidae. Since it is permanently attached to the host and has a modified carapace, it is judged to be more advanced than *Synagoga*.

Ascothoracica is an enigmatic group of crustaceans that has been classified as an order of the Cirripedia or as a distinct subclass coordinate with them. The members parasitize various echinoderms and coelenterates. The adults of primitive forms possess a bivalved carapace, prehensile first antennae, piercing and sucking mouthparts, 6 pairs of biramous thoracopods, and 5 abdominal segments terminating in a pair of blade-like furcal rami. In advanced forms, there is a tendency for reduction of the thoracopods and expansion and fusion of the carapace valves or their lining to form a capacious brood chamber.

Gorgonolaureus bikiniensis is a parasite of the gorgonacean coral *Paracis squamata* (Nutting). It was described as a new genus and species by Utinomi (1962) from 2 specimens collected off Enyu Pass, Bikini Atoll, Marshall Islands. While describing a new species of *Gorgonolaureus* from Hawaii (Grygier, in preparation), I had occasion to examine these 2 specimens. Utinomi, an expert on thoracican and acrothoracican barnacles, had never worked with an ascothoracican before describing *G. bikiniensis*. His description was relatively superficial and contained some inaccuracies and misinterpretations, and leaves one with the impression of an animal much more highly modified compared to primitive ascothoracicans such as *Synagoga* Norman than is actually the case. A redescription of *G. bikiniensis* is presented to clarify the morphological characteristics of this species. This requires that the genus be redefined and that its familial affinities be reevaluated.

The Holotype (left half of carapace removed) and several metanauplii from its brood chamber were mounted and examined in lactic acid. The carapace was dissected away from the Paratype, which was then examined in lactic acid along with a number of eggs from its brood chamber. The fourth left thoracopod of the

Holotype and 2 metanauplii were mounted in Turtox CMC-10 with acid fuchsin, as was a first antenna from the Paratype. Additionally, a portion of the carapace of the Paratype containing digestive diverticula was mounted in glycerine jelly. Drawings were prepared with the aid of a camera lucida.

Genus *Gorgonolaureus* Utinomi, 1962 (emend.)

DIAGNOSIS—Ascothoracica living within cortical galls on gorgonacean corals. Bivalved carapace completely enclosing body, fused into bulbous dorsal chamber except for ventroposterior slit-like opening. Cephalic region of main body with 6-segmented, prehensile first antennae and piercing and sucking mouthparts surrounded by oral cone formed from labrum. Six thoracic segments, each with pair of biramous thoracopods; coxae of several legs containing sperm-filled sacs. Five short abdominal segments terminating in long, blade-like furcal rami. Median dorsal "horn" formed from cuticular expansion of second thoracic segment.

TYPE-SPECIES—*Gorgonolaureus bikiniensis* Utinomi, 1962

Gorgonolaureus bikiniensis Utinomi, 1962 (emend.)

MATERIAL EXAMINED—Holotype (USNM 107150), with about 15 metanauplii; Paratype (USNM 107151), with about 22 eggs.

TYPE-LOCALITY—Off Enyu Pass, Bikini Atoll, Marshall Islands; dredged from 213–221 m by J. P. Morrison during Bikini Scientific Resurvey, 22 August 1947.

DISTRIBUTION—Known only from type-locality.

HOST—Endoparasitic within cortex of gorgonacean coral *Paracis squamata* (Nutting).

DESCRIPTION—Holotype carapace 2.12 mm high, 1.94 mm long; dorsal part expanded and rounded; ventral part laterally compressed. Paratype carapace (Fig. 1A-C) 2.11 mm high, 2.03 mm long, 1.69 mm wide, shaped as Holotype but dorsal part somewhat asymmetrical and pair of bulges anteriorly on ventral part. Slit-like medial opening along posteroventral quarter of margin guarded by radially directed setae (Fig. 2F); lips slightly scalloped. External surface of carapace covered with small spinules. Main body (Fig. 1D) occupying anterior two-thirds of ventral half of carapace.

Cephalic region obscured by ovarian tissue lining interior of carapace. Basal, second, and third segments of first antenna of Paratype (Fig. 2A) roughly triangular, distal segments smaller, each with several rows of fine setae and spinules. Fourth segment very short with 2 large setae on dorsal surface. Fifth segment subrectangular with few large setae (5 in Paratype) along dorsal surface. Elliptical distal segment opposing dorsal sides of fourth and fifth segments. Two articulated structures (p)

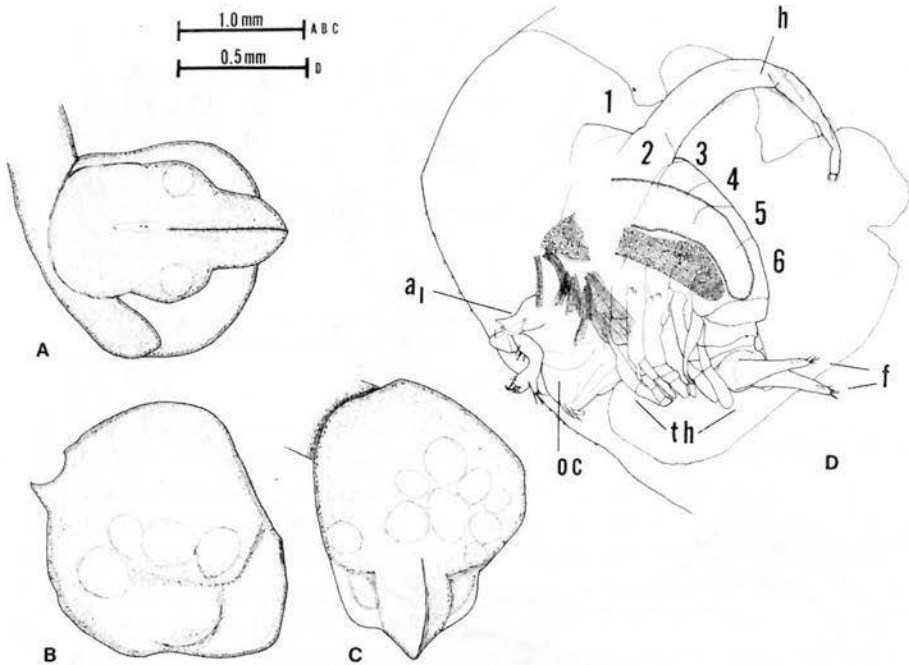


Fig. 1. *Gorgonolaureus bikiniensis*. A, Ventral view of Paratype attached to axis of gorgonacean host, showing oocytes as round objects within carapace; B, Same as A, lateral view, with gorgonacean host axis removed; C, Same as A, posterior view; D, Main body of Holotype exposed by dissection of carapace, anterior end left, thoracic segments numbered, first antenna (a_1) and oral cone (oc) damaged distally, thoracopods (th) diagrammatic, dorsal horn (h) and furcal rami (f) pointed out, gut with hatched border, nervous tissue stippled (not sure left-hand block of stippled tissue is really cephalic ganglion or not, but appearance under microscope identical to ventral nerve cord).

bearing 4 setae each on free side of distal segment; strong terminal claw (c) flanked by 2 lateral setae (medial one longest) and basal seta; several setae on this segment bifid. Second antennae apparently absent. Adductor muscle tentoria arising posterior to bases of first antennae, joined internally by transverse tendon. Oral cone (Fig. 1D, oc) ventral to adductor muscle, broad-based; edges of expanded labrum meeting posteriorly but not fused. Second maxillae (Fig. 2B) extending past pointed tip of labrum, harpoon-like points bifurcate with 1 tip strongly hooked, the other straight. Mandibles and first maxillae indistinct, apparently simple lobular structures. Large, unpaired, tongue-shaped process occupying anterior part of oral cone.

Thoracic segmentation not well delineated, apparent dorsally in Holotype, more obvious in Paratype. Six pairs of thoracopods (Fig. 1D, th), each with long coxa, rectangular basis, and multiarticulate endopodite and exopodite. Thoracopods (Fig. 2C) fringed with fine hairs medially and laterally; exopodite with 2 and endopodite with 3 segments (2 on first and sixth pairs); very large seta at laterodistal corner of

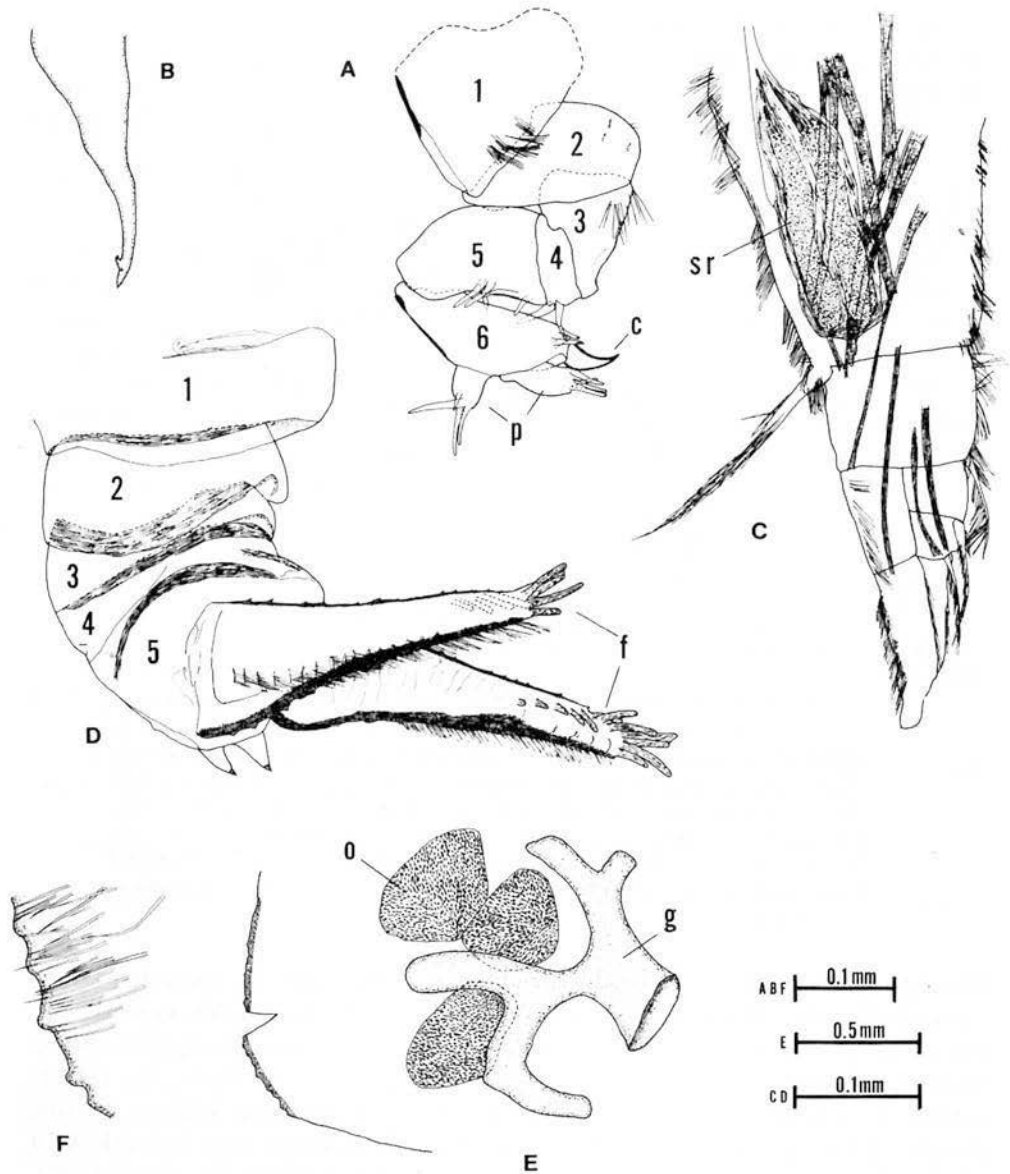


Fig. 2. *Gorgonolaureus bikiniensis*. A, First antenna of Paratype, medial view, segments numbered, articulated processes (p) and terminal claw (c) pointed out; B, Second maxilla of Paratype, distal end lowermost; C, Fourth left thoracopod of holotype showing seminal receptacles (sr), terminal setae missing on specimen; D, Abdomen and furca of Holotype, segments numbered, furcal rami (f) pointed out; E, Part of carapace of paratype, medial view, showing gut diverticula (g), oocytes (o), and scalloped margin of ventroposterior slit; F, Detail of slit margin in E, showing guard setae.

Table 1. Terminal setation pattern of right thoracopods of *G. bikiniensis* Paratype.

Thoracopod	Endopodite	Exopodite
1	2	6
2	4	5
3*	4*	8*
4	4	8
5	5	8
6	3	5

* Both third thoracopods obscured; these values estimated from left one.

coxa; 1 or 2 large setae on mediobasal corners of basis and proximal 2 endopodite articles; many terminal setae, weak or missing in Holotype, but well developed in Paratype (see Table 1 for terminal setation pattern); muscles usually with medial insertions proximally, lateral insertions distally. Coxae of second through fifth thoracopods containing bilobed sacs apparently filled with sperm (Fig. 2C, sr); ducts from sacs opening on thorax dorsal to coxae, pairs of papillae over third and fourth thoracopods of Holotype (Fig. 1D) probably representing such openings. Setae of first thoracopod stronger and with shorter setules than others; exopodite of third thoracopod of Holotype reduced to short appendix, probably result of injury; sixth thoracopod smaller than rest.

Dorsum of second thoracic segment produced into long, medial "horn" (Fig. 1D, h) sparsely covered with clumps of 4-6 fine setae and extending dorsally and posteriorly into brood chamber.

Five abdominal segments (Fig. 2D) reduced but distinct, each disc-shaped, telescoping into preceding segment. Fifth segment (telson) bearing 2 furcal rami (f) and 2 heavy spines ventral to their articulations. Spines simple in holotype; in paratype each with 4 minute spinules. Each furcal ramus with 4 or 5 short terminal setae; variable number of medial setae distally (Holotype: 4 on left, 8 on right; paratype: 8 on left, 9 on right); dorsal and ventral margins of rami lined with spinules; fine setae arising from about 20 oval areas near ventral margins of lateral sides.

Gut large, thick-walled, extending apparently blindly to sixth thoracic segment. Pair of midgut diverticula leaving main body just anterior to adductor muscle, extending into carapace lining on each side (Fig. 2E, g); each branching twice for total of 4 terminal ramifications on each side. Ventral nerve cord a compact mass below gut; apparent cephalic ganglion large.

Eggs pear-shaped, 0.47 mm long, 0.35 mm wide, each containing a developing metanauplius. Little detail visible, but first antennae setose. Metanauplii (Fig. 3) about 0.59 mm long, 0.47 mm wide; dorsal shield with incised anterior and posterior margins. Labrum (l) on slight mound. Two small frontal filaments (ff) anterior to labrum. First antennae (a_1) uniramous, unsegmented, directed posteriorly, with medial subapical pocket. Second antennae (a_2) and mandibles (m) similar to one

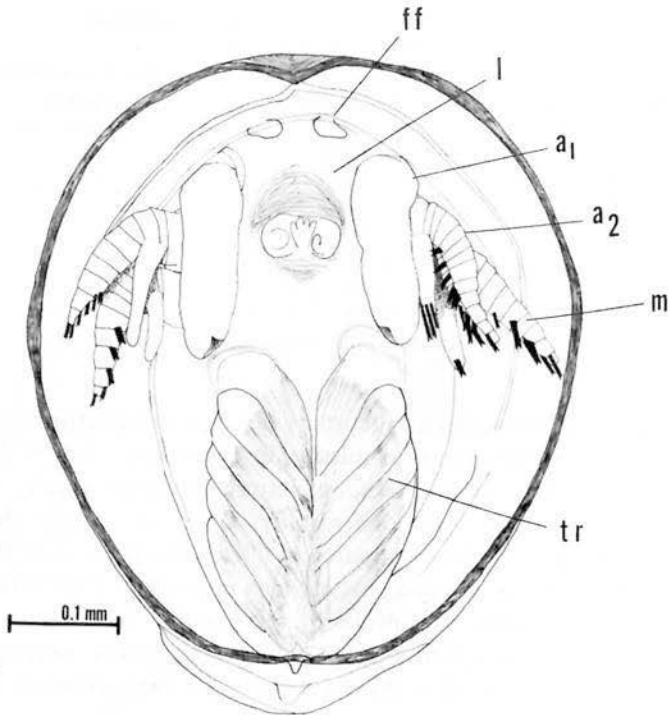


Fig. 3. *Gorgonolaureus bikiniensis* metanauplius, ventral view, only basal parts of setae shown on appendages. Abbreviations: ff, frontal filament; l, labrum; a₁, first antenna; a₂, second antenna; m, mandible; tr, thoracopod primordia.

another, with multiarticulate exopodites and smaller, unsegmented endopodites. Setation difficult to discern; none on first antennae; exopodites of other appendages with 1 or more terminal and several medial setae; endopodites with few terminal setae. Primordia (tr) of 6 postmandibular appendages visible. Furca indistinctly lobular or absent.

REMARKS—The present description differs from that offered by Utinomi (1962). The following comparisons point out the aspects of the description which have been altered. The anterior and posterior regions of the carapace in Utinomi's description are actually the dorsal and ventral regions, respectively. He stated, "... oral cone (and the antennules too, if any) could not be well defined." These parts are damaged in the Holotype and are somewhat obscured by the adductor muscle and ovarial tissue, but they are actually well developed. There is but 1 dorsal "horn" on the second thoracic segment, not a pair arising from the "prosoma", as Utinomi stated; also there are longer and more numerous setae on it than indicated in his Fig. 5. Utinomi noted no distinct divisions between the thoracic segments; it is true that they are not prominent in the Holotype, but articulations are more readily visible in the Paratype. He

misplaced certain of the thoracopods in his Fig. 6. His fifth leg is actually the sixth, while his sixth leg, arising in the drawing from the middle of the abdomen, is actually the tip of the fifth leg which passes behind the sixth leg, though, of course, arising anterior to it. He noted that the thoracopods were biarticulate with long terminal setae, but, without dissecting the animal, was unable to tell whether they were uniramous or, as is actually the case, biramous. Utinomi's mistaken placement of the sixth thoracopod resulted in his belief that the abdomen was short and unsegmented, but he was considering only the telson in making this judgement. The abdomen begins more anteriorly than he thought, and consists of 6 short, but easily distinguishable, segments.

The organs in the thoracopod coxae appear to be filled with sperm. Utinomi considered these organs to be testes, which would make the animal a simultaneous hermaphrodite. My work on the Hawaiian *Gorgonolaureus* makes this appear unlikely. Similar structures appear in the Hawaiian species, which, when subjected to hot KOH clearing, remain visible, demonstrating that they are chitinous invaginations, seminal receptacles rather than testes. Due to scarcity of material, I was unable to perform this test on *G. bikiniensis*, but I suspect that the coxal organs are seminal receptacles in this species as well.

The metanauplius in Utinomi's Fig. 7 shows only 1 pair of appendages, which he identified as first antennae, but which apparently are actually the exopodites of the second antennae. In actuality, the first and second antennae and the mandibles are well developed in the metanauplius. None of the larvae I examined showed the furcal rami Utinomi illustrated. He interpreted the 6 pairs of limb buds as the thoracic appendages, and since there appear to be setae arising from each, this is probably correct. However, the adults have second maxillae (possibly first maxillae) as well; since the primordia of these appendages are not visible in the metanauplius, limb development is heterochronous in *G. bikiniensis*.

FAMILIAL AFFINITIES—Utinomi (1962) placed the genus *Gorgonolaureus* in the family Lauridae Gruvel (comprising the genera *Laura* Lacaze-Duthiers and *Baccalaureus* Broch) where it has remained since (cf. Wagin, 1976: 67). The justifications for this classification are not strong. There is a general external resemblance between the present species and *Baccalaureus*, in particular *B. japonicus* Broch (characteristics of *Baccalaureus* from Brattström, 1936, 1956; Broch, 1929; Okada, 1938; Pyefinch, 1934, 1936, 1937, 1939; Yosii, 1931). There are certain major differences in the structures of the 2 genera, however. *Baccalaureus* has a small median lobe situated between a pair of large, lateral, sac-like or coiled outgrowths of the carapace lining. The main body of the animal is contained within this lobe, which has a small, posterior opening to the outside, just as does *Laura* (Lacaze-Duthiers, 1880). In *Gorgonolaureus*, the carapace valves themselves are expanded, not just the carapace lining, though the external opening is located similarly to the other genera. Both *B. japonicus* and *G. bikiniensis* have external spinules; however, *Petrarca* Fowler, a nonlaurid ascothoracican, possesses similar spinules (Fowler, 1889; Okada,

1938), so this is not a familial character of Lauridae.

Utinomi stated there were a pair of dorsal "horns" on the main body of *G. bikiniensis* and suggested they were homologous with the pair of large, anteriorly directed appendages arising near the juncture of head and thorax in most species of *Baccalaureus*, and further homologized them with the lateral filamentary appendages of certain barnacles. Since the dorsal "horn" is actually medial and unpaired, these homologies are without foundation. It is more likely analogous to the medial dorsal "horns" seen on the first 4 thoracic segments in the 2 species of *Ulophysema* Brattström (Brattström, 1937), analogous because there is little other evidence to link *Gorgonolaureus* with *Ulophysema* or other dendrogastrids.

The adults of both *Baccalaureus* and *Laura* have extremely reduced first antennae (assuming the structure extending posteriorly from the oral cone in the former is the first antenna; cf. Okada, 1938; Yosii, 1931). In each case, the appendage is nonprehensile with at most 3 segments, contrasting strongly with the condition in *G. bikiniensis*, where the first antenna is 6-segmented and extremely prehensile.

The thoracic appendages are utterly different in *G. bikiniensis* and the laurids. *Baccalaureus* species have 3–5 pairs of thoracopods (Pyefinch, 1937), not counting which, if any, of 3 disputed structures corresponds to the appendage of the first thoracic segment. The thoracopods are uniramous and unsegmented in the adult female, but those of the males are somewhat less rudimentary and are biramous (Okada, 1938). *Laura* has 6 pairs of uniramous, weakly segmented thoracopods (Lacaze-Duthiers, 1880). Neither laurid genus possesses natatory setae on these appendages, while *Gorgonolaureus* has 6 pairs of strongly setose, biramous, multiarticulate thoracopods.

Utinomi considered the abdomen of *G. bikiniensis* to be unsegmented. This corresponded well with the reduction in number of abdominal segments seen in *Baccalaureus* and *Laura*, each of which has 4. I have shown, though, that the present species actually has the plesiomorphic complement of 5 abdominal segments, eliminating the utility of this character as a possible link between it and Lauridae.

I conclude that incorporation of *G. bikiniensis* into Lauridae is unsupported.

Where, then, does this species belong? The most likely family is Synagogidae Gruvel. *Gorgonolaureus* and *Synagoga* are remarkably similar aside from the presence of a dorsal "horn" and an expanded, fused carapace in the former (characteristics of *Synagoga* from Newman, 1974; Norman, 1913; Okada, 1926, 1938). I will not be concerned with the relationship of *Gorgonolaureus* to the genera *Ascothorax* Djakonov or *Parascothorax* Wagin, for I am not certain that they will be retained in Synagogidae after I have described a number of new synagogids in my possession. *Gorgonolaureus* and *Synagoga* share the following characteristics: bivalved carapace (mostly fused in the former, but only hinged dorsally in the latter) with no independent expansion of the lining; 6-segmented thorax, each segment bearing pair of biramous thoracopods consisting of coxa, basis, biarticulate exopodite, triarticulate endopodite (biarticulate in first and sixth pairs); heavy setation on thoracopods; 6-segmented first antenna with pair of long setae or spines on fourth

segment, several long setae on fifth, and 2 articulated structures and claw on distal segment; and 5 abdominal segments with pair of large spines ventral to articulations of blade-like furcal rami with fifth abdominal segment. Differences aside from those mentioned above (dorsal "horn" and carapace shape) are minor, involving the setation of the furcal rami (medial setae lining the entire length of the rami in *Synagoga*, but only distally in *Gorgonolaureus*), an anteroventral flattening of the carapace valve margins where the parasite is appressed to the host in some species of *Synagoga*, and the presence of second antennae and a penis in *Synagoga*, but apparently not in *G. bikiniensis* (the Hawaiian *Gorgonolaureus* species possesses these structures, though the penis differs from that in *Synagoga*).

The unmistakable similarities of the main body in *Synagoga* and *Gorgonolaureus* are, I believe, sufficient reason to include the latter in the family Synagogidae. The presence of a dorsal "horn" and the expansion and fusion of the carapace valves, together with the ability to induce the formation of galls on the host, are the major features separating *Gorgonolaureus* from *Synagoga*, the latter being the more primitive genus.

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Note added in proof: The description of the Hawaiian *Gorgonolaureus* is in press in the Journal of Natural History.