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ISOMOLGUS DESMOTES, NEW GENUS, NEW SPECIES
(LICHOMOLGIDAE), A GALLICOLOUS POECILOSTOME
COPEPOD FROM THE SCLERACTINIAN CORAL
SERIATOPORA HYSTRIX DANA IN INDONESIA,
WITH A REVIEW OF GALL-INHABITING
CRUSTACEANS OF ANTHOZOANS

Masahiro Dojiri

ABSTRACT

Isomolgus desmotes, new genus, new species, a lichomolgid copepod with a swollen prosome, is described from galls in *Seriatopora hystrix* Dana collected in Indonesia. This is the first report of a gallicolous poecilostome copepod from a scleractinian coral. The morphology and possible scenario for development of the gall are discussed, and a review of gall-inhabiting crustaceans of anthozoans is provided.

Symbiotic copepods are well-known parasites of fishes and associates of marine invertebrates; they account for the majority of Crustacea associated with other animals. Cnidarians harbor more copepod symbionts than any other invertebrate group (Humes, 1985). Of the three extant classes of cnidarians, Anthozoa appears to be the preferred host class. Although Alcyonacea, Gorgonacea, and Actiniaria are hosts for many species of copepod associates, by far the greatest number of copepod symbionts of anthozoans have been described from the scleractinian corals (Humes, 1985).

Copepods inhabiting galls of soft-bodied anthozoans have been previously reported: *Mesoglicola* which inhabits galls in sea anemones (Haefelfinger and Laubier, 1965); *Staurosoma parasiticum* Will in galls of *Anemonia sulcata* (Pennant) (cf. Caullery and Mesnil, 1902) and *S. caulleryi* Okada from *Sagartia nitida* Wassilieff (cf. Okada, 1927); *Antheacheres duebeni* M. Sars in galls formed from the mesenteric walls of the sea anemone *Bolocera tuediae* (Johnston) in Norway (Vader, 1970a, 1975). Approximately 50% of the *Bolocera* were infected with this latter parasite with as many as 12 parasitic copepods per gall (Vader, 1970a). *Mesoglicola*, *Staurosoma*, and *Antheacheres* belong to families whose taxonomic affinities remain unknown. The anthozoans *Actinostola* and *Nemanthus* were also reported to harbor unidentified gall-inhabiting copepods, possibly belonging to *Antheacheres*, *Staurosoma*, or *Gastroecus* (cf. Vader, 1970b). A copepod belonging to the

order Harpacticoida has been reported living in "pocket-like" structures of the gorgonian *Eunicella stricta* (Bert.) (cf. Soyer, 1963). Finally Stock (1981, 1984) reported six asterocherid species belonging to four genera of the order Siphonostomatoida inhabiting galls on the stylasterine coral genera *Stylaster*, *Conopora*, and *Crypthelia*.

While working at the National Museum of Natural History, Smithsonian Institution, I had the opportunity to examine a few specimens of a gallicolous copepod collected from the scleractinian coral *Seriatopora hystrix* Dana. The copepods represent a new genus and species of the Lichomolgidae, a family of the order Poecilostomatoida. Lichomolgids are commonly associated with scleractinian corals (see revision of the Lichomolgidae by Humes and Stock, 1973). This is the first report of a gallicolous poecilostome copepod and the first time a copepod has been recorded from a gall of a scleractinian coral.

Isomolgus, new genus

Diagnosis.—Body stout. Prosome swollen. Urosome 5-segmented in female; 6-segmented in male. Caudal ramus with usual 6 setae. Rostrum linguiform. First antenna 7-segmented. Second antenna 3-segmented, with formula 1,1,I + 4.

Mandible with 2 rows of spinules and long spinulated lash. First maxilla with 2 setae. Second maxilla 2-segmented; second segment with long spinulated lash and 2 setae. Maxilliped in female 3-segmented; second

segment with 1 seta; third segment with pointed tip and 1 seta.

Legs 1–4 with 3-segmented rami, except endopod 2-segmented in leg 4. Legs 3 and 4 with third segments of exopods each with II,I,5; endopods each with I,2. Leg 5 with small free segment bearing 2 setae. Leg 6 in female represented by 2 lobes, each with 1 seta, on genital area.

Etymology.—The generic name is a combination of the Greek words *isos*, meaning equal or like, and *molgos*, a common suffix for lichomolgid genera, meaning hide or skin. The name alludes to the affinity of this genus with other lichomolgid genera. Gender masculine.

Type Species.—*Isomoligus desmotes*, new species, type by monotypy.

Isomoligus desmotes, new species

Figs. 1–5

Material Examined.—From galls of scleractinian coral *Seriatopora hystrix* Dana, 1846: 1 ♀ holotype (USNM 229600), 10 ♀ paratypes (USNM 220601), and 1 ♂ (lost) collected on western shore of Borear Island (off Kola and Wokam Islands), Kepulauan Aru, Indonesia (05°27'00"S, 134°25'30"E) at R/V *Alpha Helix* station M-97 by Gordon Hendler and Geerat Vermeij, 6 July 1979, in less than 1 m depth; 1 female (USNM 229598) collected at Obi Major Island, Ceram Sea, Indonesia (01°32'24"S, 127°23'48"E) at R/V *Alpha Helix* station M-106 by Gordon Hendler, 11 July 1979, in 3–12.2 m depth; 2 ♀♀ (USNM 229599) collected on western shore of Boekide Island, Poelau Poelau Toade Group, Sangihe Island, Indonesia (03°47'30"N, 125°35'18"E) at R/V *Alpha Helix* station M-130 by Gordon Hendler, 18 July 1979.

Female.—Body (Fig. 1A, B) with total length 1.14 mm (1.07–1.29 mm) and width at widest point 0.58 mm (0.54–0.69 mm) based on 7 specimens. Prosome swollen, much longer and wider than urosome; habitus having top-heavy appearance. Cephalothorax (Fig. 1B) thickened dorsoventrally. Ratio of length to width of prosome 1.20:1. Ratio of length of prosome to that of urosome 1.57:1. First pediger (somite of leg 1) separated from cephalothorax by relatively weak transverse dorsal furrow. Epimeral areas of first pediger not extended; those of second–fourth pedigers pointed.

Fifth pediger (Fig. 1C) 69 × 202 μm. Genital segment 143 × 244 μm, wider than long, and widest at about midlength. Genital areas (Fig. 1D) situated dorsolaterally slightly

posterior to middle of segment; each area with 2 lobes each bearing 1 seta (posterior lobe with medially directed spiniform process). Three postgenital segments from anterior to posterior 37 × 106 μm, 28 × 92 μm, and 74 × 83 μm. Caudal ramus (Fig. 1E) longer than wide, 85 × 28 μm, and bearing 6 naked setae (dorsal seta missing in specimen figured, but position indicated by arrow).

Rostrum (Figs. 1F, 5A) with rounded posterior margin. First antenna (Fig. 2A) 7-segmented; length of 7 segments (measured along posterior nonsetiferous margins) 54, 68, 17, 20, 23, 14, and 12 μm, respectively. Armature formula: 3, 11, 3, 3, 4, 2 + 1 aesthete, and 7 + 1 aesthete. Second antenna (Fig. 2B) 3-segmented with third segment bearing incomplete furrow; formula: 1, 1, 4, and 1 claw. Setae digitiform; claw approximately 45 μm and only slightly curved.

Labrum (Fig. 2C) with 2 broad posteroventral lobes. Mandible (Fig. 2D) with deep indentation on concave side, and curved row of spinules beginning on concave margin and continuing to convex margin; convex margin with row of spinules; lash long and bearing 2 rows of spinules from midlength to tip. Paragnath not observed. First maxilla (Fig. 2E) slender lobe with 2 stout setae. Second maxilla (Fig. 2F) 2-segmented; first segment robust and unarmed; second segment with 1 naked seta, 1 bristled seta, and spinulated lash (spinules gradually decreasing in length from proximal end to tip of lash). Maxilliped (Fig. 2G) 3-segmented; first segment unarmed; second segment with only 1 naked seta; and third segment with 1 naked seta and terminal, slightly curved, spiniform process.

Legs 1–4 (Figs. 2H, 3A–D) with 3-segmented rami except endopod of leg 4 2-segmented. Spinal and setal formula as follows (Roman numerals indicating spines, Arabic numerals representing setae):

P ₁	coxa 0-1	basis 1-0	exopod	1-0; 1-1; III, I, 4
			endopod	0-1; 0-1; 1, 5
P ₂	coxa 0-1	basis 1-0	exopod	1-0; 1-1; III, I, 5
			endopod	0-1; 0-2; I, II, 3
P ₃	coxa 0-1	basis 1-0	exopod	1-0; 1-1; II, I, 5 (or III, I, 5)
			endopod	0-1; 0-2; 1, 2
P ₄	coxa 0-1	basis 1-0	exopod	1-0; 1-1; II, I, 5
			endopod	0-1; 1, 2

Intercoxal plates of legs 1–4 with relatively straight (not reentrant or incised medially) and unornamented. Outer margins

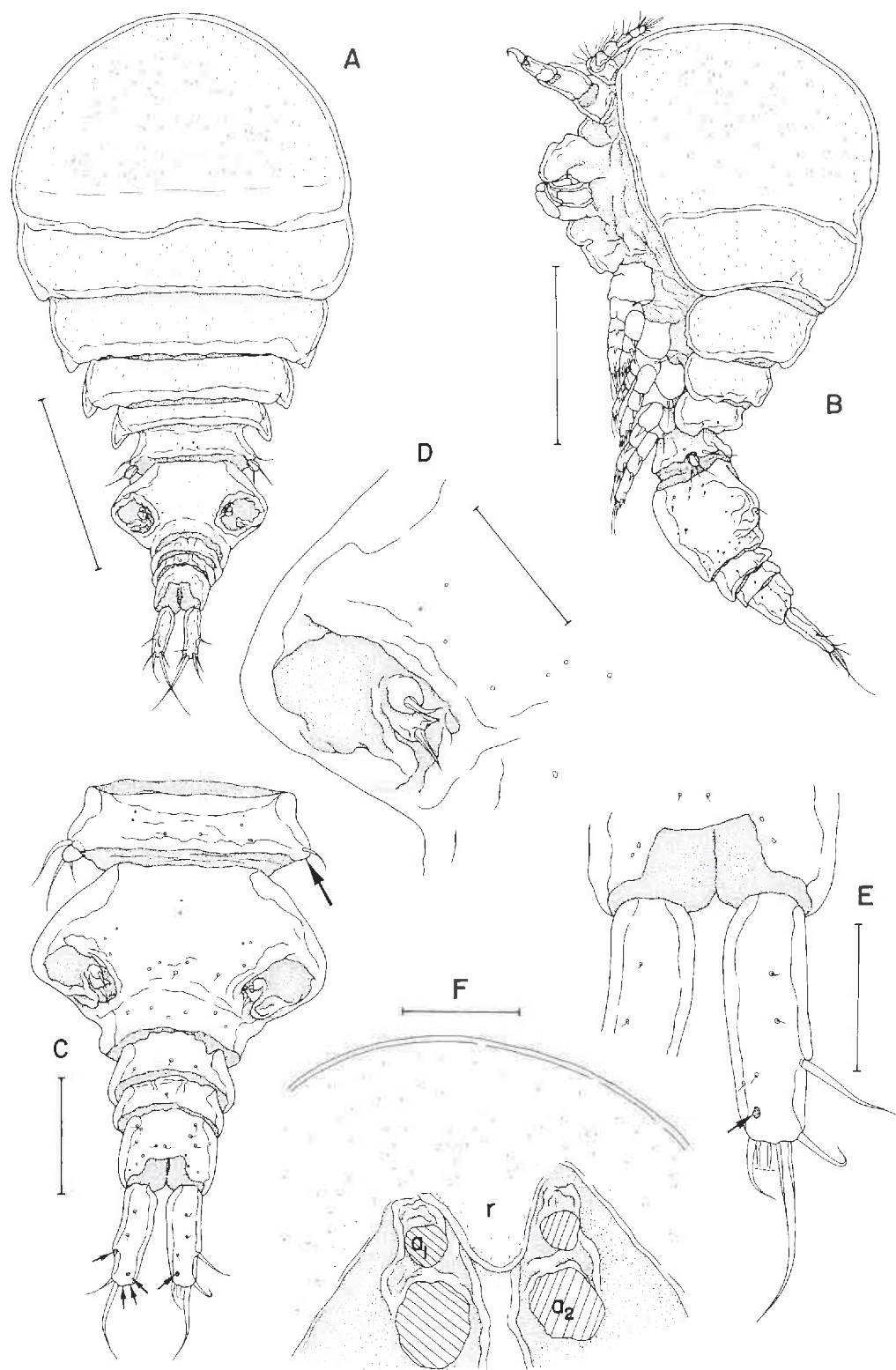


Fig. 1. *Isomolgus desmotes*, new genus, new species, female. A, body, dorsal; B, same, lateral; C, urosome, dorsal (large arrow indicating position of missing leg 5; small arrows indicating positions of broken setae); D, genital area, dorsal; E, caudal ramus, dorsal (arrow indicating position of broken seta); F, rostral area, ventral. Scales: 0.3 mm in A, B; 0.1 mm in C, F; 0.05 mm in D, E. Abbreviations: r = rostrum, a₁ = first antenna, a₂ = second antenna.

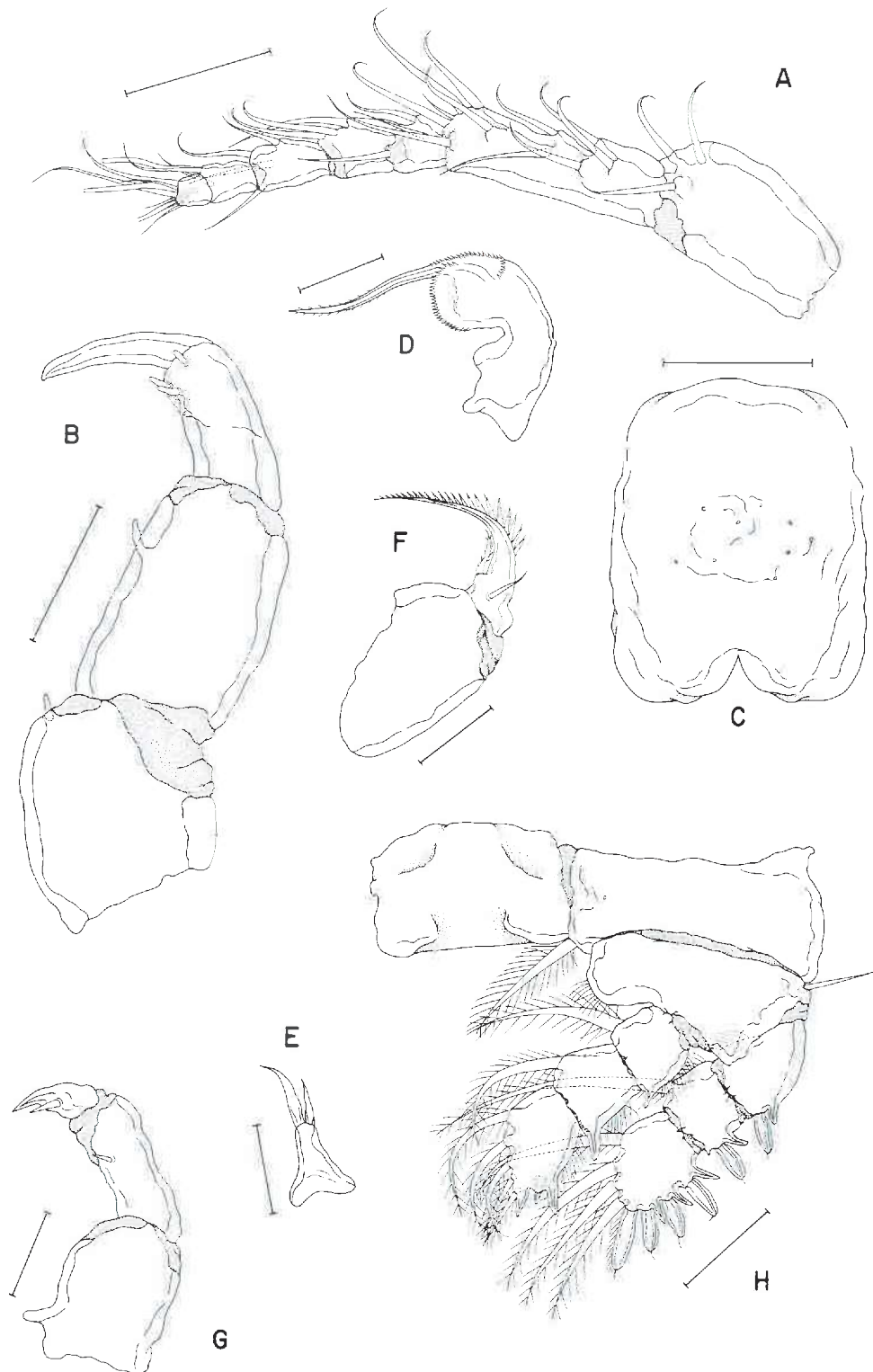


Fig. 2. *Isomolgus desmotes*, new genus, new species, female. A, first antenna, dorsal; B, second antenna, anterior; C, labrum, ventral; D, mandible, posterior; E, first maxilla, posterior; F, second maxilla, posterior; G, maxilliped, posteromedial; H, leg 1 and intercoxal plate, ventral. Scales: 0.05 mm in A-C, H; 0.03 mm in D-G.

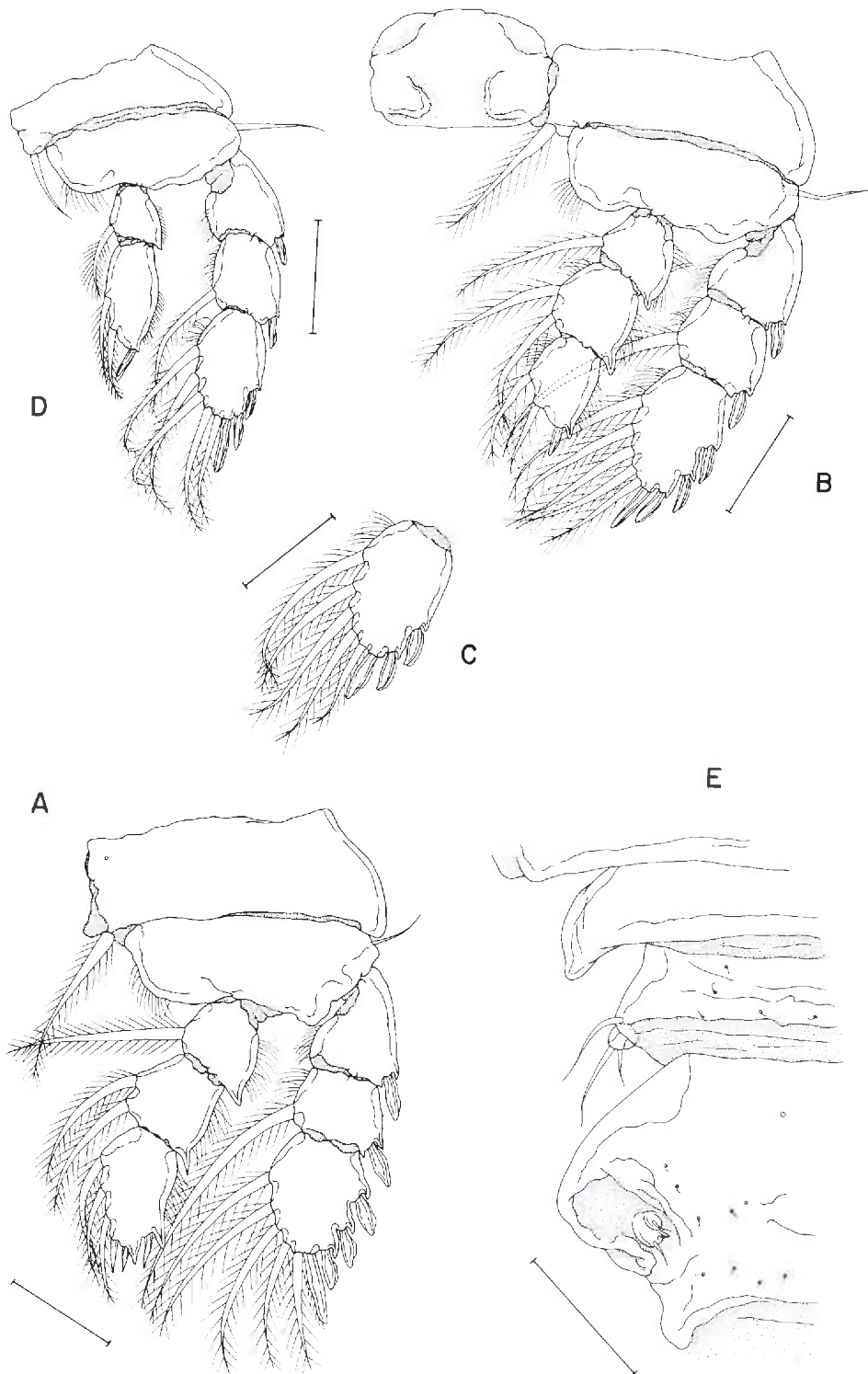


Fig. 3. *Isomolgus desmotes*, new genus, new species, female. A, leg 2, ventral; B, leg 3 and intercoxal plate, ventral; C, terminal exopodal segment of leg 3, ventral; D, leg 4, ventral; E, leg 5 and genital area, dorsal. Scales: 0.05 mm in A-D; 0.1 mm in E.

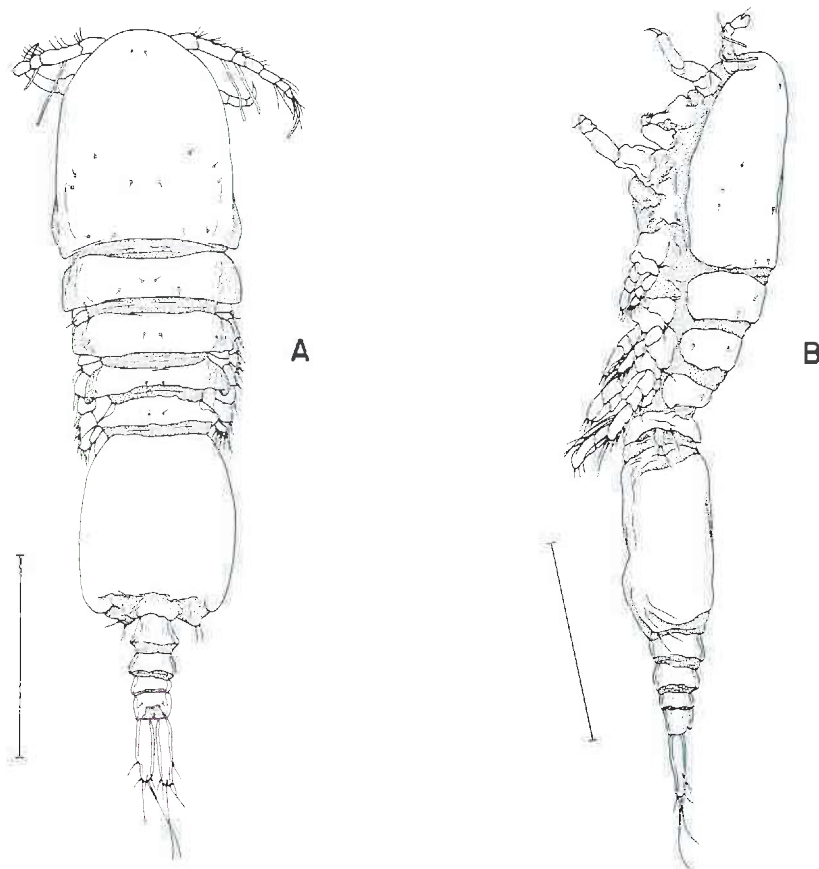


Fig. 4. *Isomolgus desmotes*, new genus, new species, male. A, body, dorsal; B, same, lateral. Scale: 0.3 mm in A, B.

of exopodal and endopodal segments of legs 1–4 with spiniform processes; these processes largest on leg 1 (Fig. 2H) and smallest on leg 4 (Fig. 3D). Exopodal spines of all 4 pairs of legs with transparent flange along lateral margins. Terminal exopodal segment of leg 3 (Fig. 3C) usually with formula II,I,5, but 1 specimen with abnormal formula of III,I,5 (Fig. 3B).

Leg 5 (Fig. 3E) with small free segment $18 \times 14 \mu\text{m}$ and bearing 2 naked setae; dorsal seta near insertion of free segment $44 \mu\text{m}$ long. Leg 6 represented by 2 setiferous lobes in genital area (Fig. 1D).

Male.—Body (Fig. 4A, B) slender, 1.12 mm long \times 0.26 mm wide based on 1 specimen. Ratio of length to width of prosome 1.2:1. Ratio of length of prosome to that of urosome 1.57:1.

Single male lost before dissection and before detailed observations could be made.

Etymology.—The specific name *desmotes*, Greek for captive or prisoner, a noun in apposition, alludes to the copepods' habitation within galls.

Remarks.—Seventy genera of the Lichomolgidae are currently recognized. *Isomolgus* differs from all other genera of this family by having the following combination of characters: (1) greatly swollen prosome; (2) 7-segmented first antenna with the armature formula of 3, 11, 3, 3, 4, 2 + 1 aesthete, and 7 + 1 aesthete; (3) 3-segmented second antenna; (4) terminal exopodal segments of legs 3 and 4 with the formula II,I,5; and (5) terminal endopodal segments of legs 3 and 4 with I,2.

Five lichomolgid genera (*Amarda* Humes and Stock, 1972; *Cerioxynus* Humes, 1974; *Karanges* Humes, 1979; *Paramarda* Humes, 1978; and *Ravahina* Humes and Ho, 1968) exhibit a swollen prosome in the female. Of

these five genera only *Amarda*, *Cerioxynus*, and *Paramarda* also have a 3-segmented second antenna as in the new genus. *Isomolgus* differs from these three genera in the structure of the mandible, second maxilla, and armature of legs 1–4. Furthermore, the endopods of legs 3 and 4 are absent in *Cerioxynus* and *Paramarda*. In *Amarda* the endopod of leg 3 is missing, and leg 4 is entirely absent. On the other hand, *Isomolgus* possesses a 3-segmented endopod of leg 3 and a 2-segmented endopod of leg 4.

DISCUSSION

Review of Gallicolous Crustaceans of Anthozoans

Numerous Crustacea live in associations with Anthozoa (cf. Lauckner, 1980) and particularly scleractinian corals (cf. Patton, 1976). Many of the relationships are facultative associations, but some represent obligatory symbiosis. Among the obligate symbionts (mutuals, commensals, or parasites) there are both mobile forms that do not modify the coral skeleton and sedentary forms that do (Patton, 1976). A few species of decapod crustaceans are known to live in galls of stony corals. The pontoniine shrimp *Paratypton siebenrocki* Balss forms cysts or galls in the corallum of *Acropora* in the Indo-Pacific. The female and male are imprisoned within the same gall. This palaemonid exhibits a greatly swollen habitus compared to the more streamlined shape of its free-living counterparts (Bruce, 1976), and is one of a few shrimps known to alter the skeleton of its coral host (Bruce, 1969; Eldredge and Kropp, 1981). Some alpheidids live in tunnel systems in corals. Although the evidence is not conclusive, Kropp (in press) believed that these shrimps modify the coral skeleton by forming tunnels.

Two families of brachyuran crabs have members that live in either pits or galls of scleractinian corals. The best known species belong to the Cryptochiridae Paulson, 1875 (formerly the Hapalocarcinidae Calman, 1900; see Kropp and Manning, 1985). *Hapalocarcinus marsupialis* Stimpson lives inside galls of the pocilloporid coral genera *Pocillopora*, *Seriatopora*, and *Stylophora* from the Red Sea to the eastern Pacific (Patton, 1976). In addition, *Pseudohapalocarcinus ransoni* Fize and Serène inhabits galls

in *Pavona* spp. (R. K. Kropp, personal communication). *Utinomia dimorpha* (Henderson) and the remaining species of Cryptochiridae (approximately 40 species according to R. K. Kropp, personal communication) do not live in galls (defined as complete enclosures), but in pits. One unidentified species of *Cymo* (Xanthidae) is known to be incarcerated in a gall or cystlike structure of a scleractinian coral, i.e., *Acropora hyacinthus* (Dana) (cf. Eldredge and Kropp, 1981). Three other xanthid species that modify the skeletons of their coral hosts live in hollow cavities or crevices. *Domecia acanthophora* (Desbonne and Schramm) has been reported from cavities of *Acropora palmata* (Lamarck) in the Caribbean, but on *Acropora prolifera* (Lamarck) and *Acropora cervicornis* (Lamarck) it lives outside of the coral whose branch it grasps (Patton, 1967). Two species of the xanthid genus *Tetralia* inhabit V-shaped crevices of *Acropora* at Truk, Caroline Islands (Eldredge and Kropp, 1981).

Members of the Petrarciidae, a cosmopolitan ascothoracican crustacean family found predominantly in the Indo-West Pacific, live in galls of scleractinian corals (Grygier, 1981, 1983, 1985). This family, comprised of three genera, *Petrarca* Fowler, 1888, *Introcornia* Grygier, 1983, and *Zibrowia* Grygier, 1985, is associated with about 30 species representing four suborders of scleractinian corals (Zibrowius and Grygier, 1985). Two types of galls, inside the calices of corals, and on the surface outside of the calices, have been identified and the developmental formation of both kinds of galls suggested by Zibrowius and Grygier (1985).

Several copepod species live within galls of the soft tissues of anthozoans (see above). However, Stock (1981, 1984) was the first to discover gallicolous siphonostome copepods in stylasterine corals. The discovery of *Isomolgus desmotes* represents the first report of a gallicolous poecilostome copepod of a scleractinian coral.

Gall Morphology and Development

The gall in which *Isomolgus desmotes* lives is a thin-walled, hollow protrusion originating from the surface of the coral. In lateral view (Fig. 5B) it appears as a small

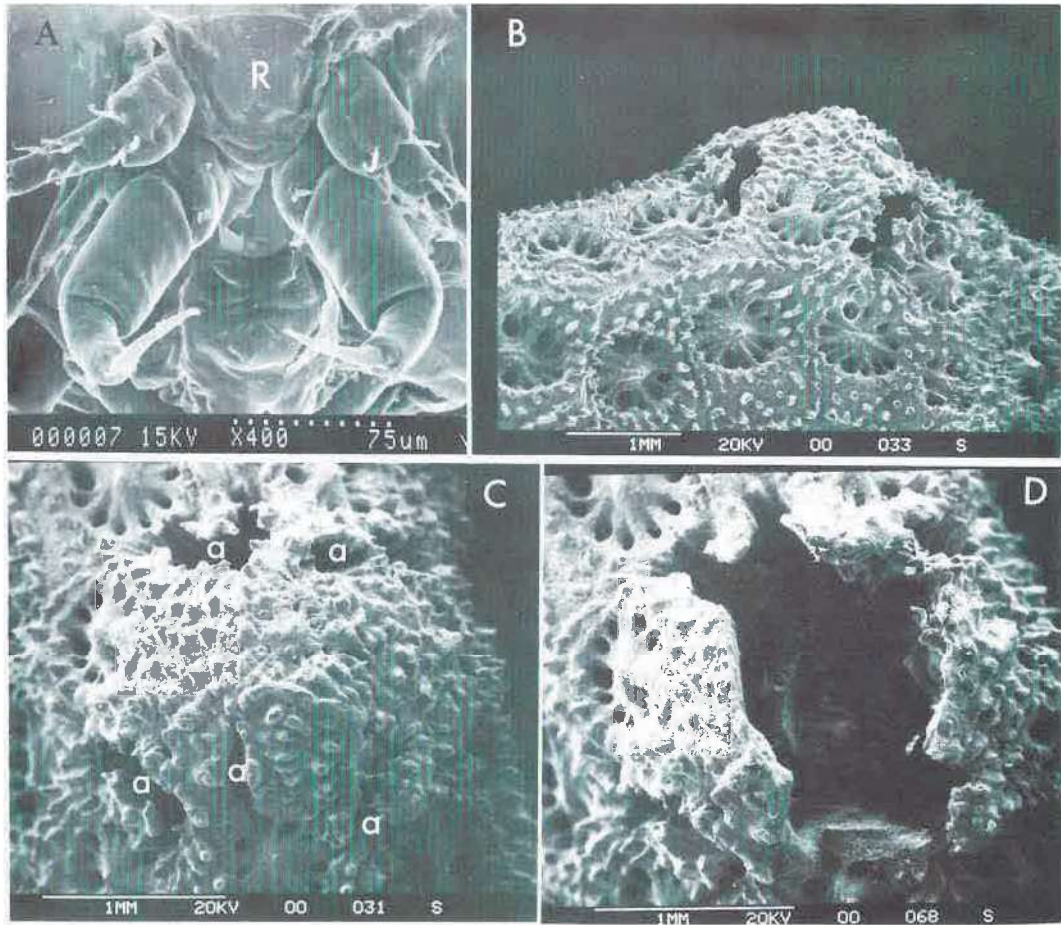


Fig. 5. Scanning electron micrographs. A, rostral area of *Isomolgus desmotes*, female, anterior; B, gall of *I. desmotes* on the coral *Seriatopora hystrix*, lateral; C, same, face-on view; D, same, wall broken and cavity exposed, face-on view. Abbreviations: R = rostral area; a = aperture.

hump similar to a branch bud. However, the thin, delicate walls and the five holes (Fig. 5C) distinguish the gall from the buds. It is not known if all galls of *Isomolgus* possess five holes. The cavity within the gall is somewhat spherical and has a diameter of approximately 2 mm (Fig. 5D). These apertures are small enough to prevent the imprisoned copepod from leaving; presumably the holes are large enough for the escape of the nauplius larvae. A single male, lost during manipulation, was found sharing a gall with one female. No larval stages were found. There can be more than one gall per infected coral branch. However, only one female per gall was found. The diameter of the gall cavity appears to preclude multiple occupancy by females. Other biological and behavioral factors may prevent cohabita-

tion of a gall by two or more females. Several empty galls were observed, suggesting that the copepods died and disintegrated, with the insoluble exoskeleton having been washed away from the gall.

Since all specimens were found unattached to the interior wall, it is assumed that the copepod lies free within this cavity. It is not known whether the coral polyps within and immediately adjacent to the galls were alive when collected, since all specimens examined for this study were preserved. However, since the galls of *Hapalocarcinus* contain live coral tissue, it would not be surprising to find such tissue within the gall of *Isomolgus* (R. K. Kropp, personal communication).

A scenario for the formation and growth of galls formed by ascothoracids has been

suggested by Zibrowius and Grygier (1985) and may be applicable to galls initiated by copepods. The sequence is as follows: (1) free-swimming larvae of ascothoracids attach to soft tissues of coral; (2) ascothoracids elicit defense reactions of host by causing irritation to coral tissue; (3) host deposits calcareous barrier which physically separates parasite from soft tissues of host; (4) cavity of gall may be enlarged by chemical dissolution and/or by mechanical means with the movements of the ascothoracids' appendages; and (5) enlargement of gall is by means of peripheral growth.

Stock (1984) suggested that partial dissolution of the stylasterine coral skeleton is the most important factor controlling gall formation. He further suggested that development of the gall is initiated by the settlement of the copepodid larva of gallicolous siphonostomes on the gastrozooids.

Eldredge and Kropp (1981) described the development of cysts (galls) induced by species of two xanthid genera, *Cymo* and *Tetralia*, in American Samoa and Truk. The formation of the gall of *Hapalocarcinus marsupialis* has been described by Potts (1915) and Hiro (1937). Patton (1976) reviewed the literature concerning the formation of galls by cryptochirid crabs. From the literature concerning gall induction by crabs, two important points emerge: (1) the respiratory current produced by the crab may be instrumental in the formation of the gall, and (2) the development of the cavity is initiated by the crab remaining stationary on the coral for an extended length of time.

Based on these seven points a possible scenario for gall induction by *Isomolgus desmotes* may be outlined. The infective stage, probably a copepodid, settles on the soft tissues of *Seriatopora hystrix*. As in other crustaceans associated with anthozoans, the copepod probably has protection, perhaps in the form of immunity, against the defenses of the host, e.g., nematocyst toxins. The copepodid remains relatively sedentary, attached by means of the second antennae and maxillipeds, long enough for the coral to deposit calcareous walls around and over the symbiont. This sedentary behavior represents an abrupt change from the presumed more active infective larva searching for a suitable host. The injury caused by attachment, and possibly feeding, by the co-

pepod on the corals may be the main stimulus initiating the formation of the galls. Loya *et al.* (1984) attributed abnormal growth and the resultant tumors on two species of *Platygyra*, a scleractinian coral, to a combination of environmental stress and an initial wound. In this respect the term "gall-forming" is a misnomer and should be substituted with "gall-inducing," since the actual formation of the gall is done by the host in response to the copepod. The formation of the cage-like gall represents a defense reaction by the host designed to put a physical barrier between the host and intruder. The swimming legs 1-4 of *I. desmotes* are not reduced and probably function in bringing water into the cavity through the incurrent apertures. The movement of water through the cavity would not only provide a respiratory current, but also may aid in the formation of the gall through erosion.

The gall offers protection to the copepod from predators in two ways: (1) the copepod is hidden inside the gall making it less conspicuous to its predators, and (2) the walls of its calcareous cage provide a physical barrier to predators. Mucus produced by the corals may be utilized as a food source. Although gall crabs (e.g., *Hapalocarcinus*) were thought to feed on nanoplankton by filter-feeding (Potts, 1915), recent studies have shown that, at least in three species of cryptochirids, coral tissues and mucus are consumed (Kropp, 1986). The gut of the sabelliphilid copepod *Paranthessius anemoniae* Claus (superfamily Lichomolgoidea) was reported to contain mucopolysaccharides, the major constituent of mucus (Briggs, 1977). Humes (1985) suggested that "copepods associated with cnidarians probably feed on mucus secreted by the host." Detrital matter quickly becomes suspended in coral mucus, providing a richer food source than would be indicated by a chemical analysis of pure coral mucus (see Kropp, 1986).

A striking morphological similarity among the gall-inhabiting crustaceans is the globose body. In the pontonine shrimp *Paratypton siebenrocki* (cf. Bruce, 1976), six copepod species belonging to four genera of the siphonostome family Asterocheridae (cf. Stock, 1981), and the new genus and species described herein, the body (or prosome in

the case of the copepods) is greatly swollen. The biological advantage of this convergent morphology is not clear. Perhaps the sheltered habitat of the gallicolous crustaceans allows them to be released from the restrictive confines of the environmental factors that select for streamlined bodies. Or, perhaps the globose body provides freedom of movement in three dimensions within the cavity of the gall.

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