

**BOTRYLLOPHILUS ABBOTTI NEW SPECIES
(COPEPODA: CYCLOPOIDA: ASCIDICOLIDAE)
ASSOCIATED WITH A COMPOUND ASCIDIAN FROM
THE MONTEREY PENINSULA**

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ABSTRACT

Botryllophilus abboti new species is fully described and illustrated from material collected from the Monterey Peninsula, California, on the eastern Pacific coast in 1979. The new species is associated with an unnamed compound ascidian (*Archidistoma* sp.) and the collection includes the female and male. The present paper represents the first fully described and illustrated treatment of both sexes in a single species and proves a first step to solving many difficulties of species identification in most of the recorded species of the genus.

The shores of the Monterey Peninsula (including Monterey Bay and Carmel Bay), California, located on the eastern Pacific coast, harbor many species of ascidians. About 16 species of ascidians were collected there for our studies on their copepod associates which include approximately 16 species. These ascidicoles are mostly associated with compound and more rarely social ascidians and included in the family Ascidicolidae. *Botryllophilus abboti* new species, which we present in this paper, is one of these ascidicolids.

The Ascidicolidae has been reorganized and subdivided by Illg and Dudley (1980) into seven subfamilies. The subfamily Botryllophilinae, one of these subfamilies, involves the genus *Botryllophilus* and has been left to a further study as the Botryllophilinae nomen conservandum by these authors; because almost all the recorded species have been insufficiently described and illustrated in the original papers.

Illg and Dudley (1980) have listed all 25 species so far recorded for *Botryllophilus* and selected 10 as species with substantial characterization; the remaining 15 are indeterminable. The 10 recognizable nominal species have been divided into two morpho-types (A and B) which we have formulated by using characters of females of 10 unrecorded species of the genus (Ooishi and Illg, 1988). Four of these 10 unrecorded species were derived from the Monterey Peninsula material and the present species was included among them as a type A species. Five of the 10 recognizable nominal species belong to type A and the present new species is distinct from these five species.

The new species is added to the genus as an important contribution by representing the first fully described and illustrated treatment for both sexes of a single species.

MATERIALS AND METHODS

Observation and drawings of living material were done at Hopkins Marine Station, Stanford University, during the summer in 1979. The text-figures in this paper were based on the dissections of specimens in lactic acid, using an Olympus microscope with its drawing apparatus.

The specific name has been chosen in honor of Dr. Donald P. Abbott, late Professor in zoology, Hopkins Marine Station, Stanford University, Pacific Grove, with whose great help we studied the present species and other Monterey Peninsula material (manuscript in preparation).

Abbreviations: A1, antennule; A2, antenna; MD, mandible; MX1, maxillule; MX2, maxilla; MXP, maxilliped.

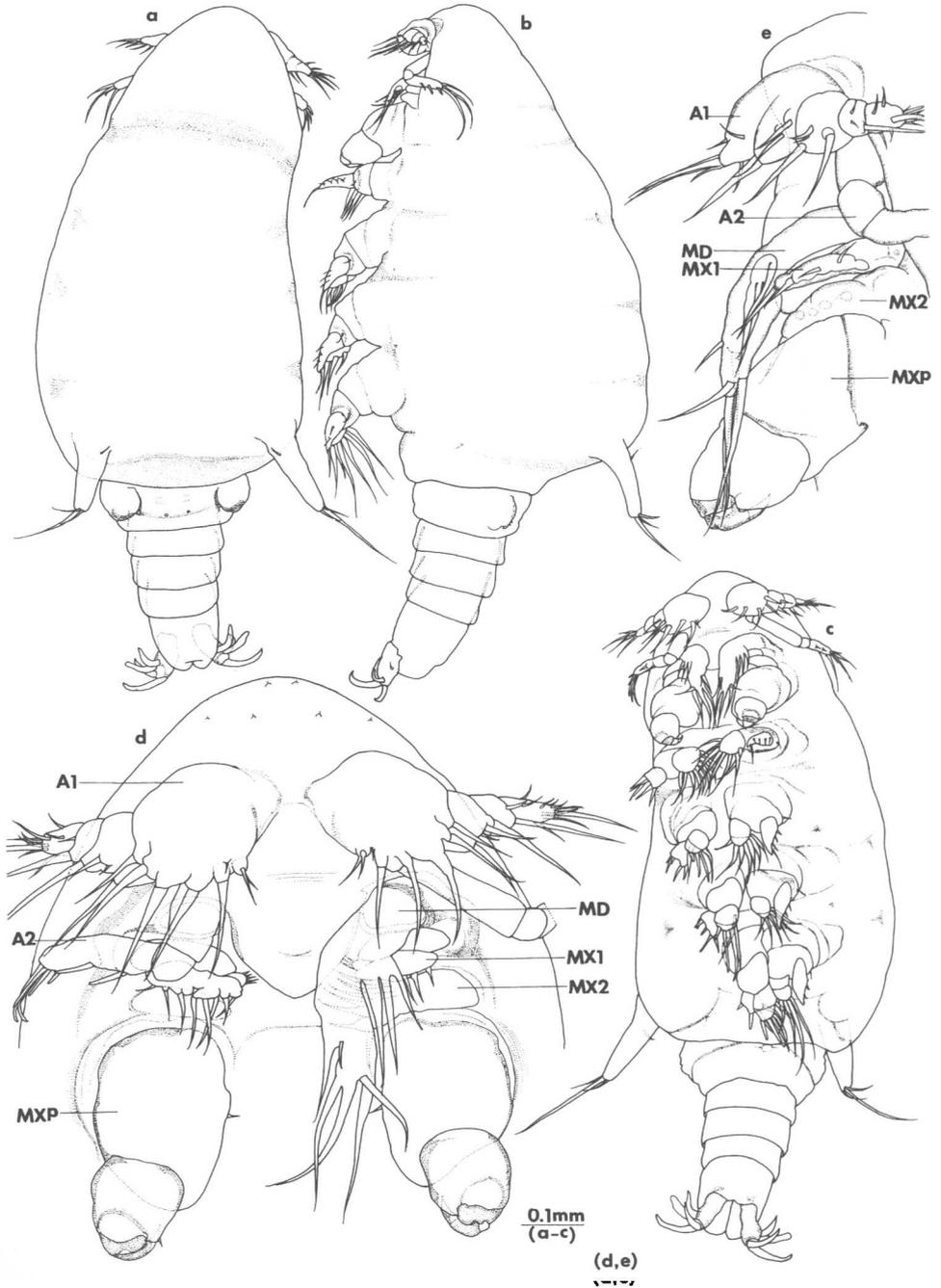


Figure 1. *Botryllophilus abbotti*, n. sp., female: a, habitus, dorsal; b, same, lateral; c, same, ventral; d, cephalosome, ventral; e, same, lateral.

Botryllophilus abbotti new species

Types.—Holotypic female, USNM 229946 (type locality, Mission Point, Carmel Bay (approximate position 36°31'N, 121°58'W)), 11 m depth, 3 August 1979; host, *Archidistoma* sp. gray form (by D. Abbott); allotypic male, USNM 229947, same locality, same host; and 4 paratypes (2 males, USNM 229948, and dissected male and female (Ooishi collection)).

Female.—Body (Fig. 1a–c) divided into cephalosome, metasome and urosome, with their proportional lengths measured on body axis on drawings about 1:2.4:1.5; urosome telescopically folded, including caudal rami. Prosome including cephalosome and metasome expanded dorsoventrally and slightly compressed. Asymmetry of prosome shown in appearance of habitus and in arrangement and structure of certain appendages of cephalosome and first to fifth legs in metasome. Prosome characterized by its massive appearance without distinct articulations. Body length of single specimen examined, measured from anteriormost border to end of caudal ramus without caudal spines, 1.12 mm.

Relatively small subtriangular cephalosome demarcated by integumental indentation from metasome; pleural folds weakly developed. Dorsal surface covered with sparsely scattered minute hairs with the cephalic plaque indistinct. Appendages (Fig. 1d, e) consisting of antennules, antennae, mandibles, maxillules, maxillae and maxillipeds. No prominent rostrum developed.

Metasome unsegmented but slight integumental indentations indicating first to fifth leg-bearing segments, subequal in lengths, bearing first to fourth pairs of legs ventrally and reduced fifth legs posterolaterally. In first pair, right and left legs well separated from each other and in following pairs right legs gradually come closer to left legs (Fig. 1c); all pairs lacking intercoxal plates. This arrangement causing series of first to fourth legs to be obliquely located from right to left and fourth legs placed almost entirely on left half of ventral body surface. Greatest width about 0.72 mm, occurring on fourth leg-bearing region and just anterior to portion with posterolaterally protruding fifth legs. Metasome increasing in thickness from anterior to posterior on dorsal side and then constricted behind fifth legs toward urosome.

Bodily constriction marking off narrow cylindrical urosome consisting of five distinct segments including widest first genital segment, narrow second to fourth true abdominal segments, and last anal segment bearing short caudal rami ornamented with short setae and claw-shaped spines (actually modified setae). Segments tending to contract telescopically, but in extended examples in same type (A) each of abdominal segments with sometimes length nearly 1.5 times as long as that seen in contracted condition.

Body slightly orange in color, with orange eye and gut and light green ovarian eggs. Minute hairs sparsely scattered on body surface. Ovisac not collected, but single oblong ovisac possibly present on dorsal side of genital segment between fifth legs.

Antennule (Fig. 2e) consisting of 4 segments, gradually tapering and ornamented with graduated non-plumose setae. First segment largest, occupying nearly proximal half of total length. Second segment wider than long and third and fourth segments longer than wide. Truncated distal margin of fourth about one-fifth as wide as basal width of first. Ornamentation as in following tabulation of arrangement of long (ls) and short (ss) setae in first to fourth segments (I–IV): (I) 6 ls, 3 ss; (II) 3 ls, 1 ss; (III) 1 ls, 2 ls, 11 ss. Long setae borne on distinct protrusions from segments; most proximal seta on segment I and seta next to distal seta on segment II relatively short. Total number of all these setae 28 (11 ls and 17 ss).



Figure 2. *Botryllophilus abbotti*, n. sp., female: e, antennule, left, anterior; f, antenna, right, posterior; g, antenna, left, posterior; h, labrum, anterior; i, mandible, left, anterior; j, same, masticatory lamella, anterior; k, same, posterior; l, maxillule, left, posterior; m, maxilla, right, posterior; n, maxilliped, right, posterior.

Appendages on both sides about same in size. Few minute hairs scattered on appendage.

Antennae proportionately asymmetrical in armature. Right antenna (Fig. 2f) composed of four segments with their proportional lengths about 1:2:1:2, measured on medial margin. First (coxopodite) wider than long and second (basipodite) elongated and slightly curved laterally, both without armature. Third triangular in anterior view, showing distinct articulations with second and fourth. Fourth segment nearly straight, but with integumental indentation at about distal fifth, and armed with seven ornamental elements: two short spiniform elements at proximal one-fourth and midway on medial margin; one similar but shorter element subterminally on medial margin; and four elongated and graduated elements on terminal margin with their proportional lengths from medial to lateral about 1:1.7:2.2:3. Longest lateral element on terminal margin about as long as fourth segment. These spiniform elements slightly serrated around their tips.

Left antenna (Fig. 2g) basically comparable to right in segmentation, but fourth segment seemingly shorter. All seven ornamental elements more elongated and somewhat more setiform in left antenna. Four graduated terminal elements, from medial to lateral, nearly 1.3 to 1.6 times as long as corresponding elements in right antenna. Longest lateral setiform element with tiny protrusion from medial margin near implantation.

Labrum (Fig. 2h) having subtriangular margin ornamented with minute hairs (almost indistinct in figure) at tip.

Mandibles (Fig. 2i) on both sides symmetrical in anatomy, each consisting of coxopodite with medial gnathobasic portion and elongated unsegmented palp ornamented with nine setae. Gnathobasic margin (Fig. 2j, k) distinctive with arrangement of teeth variously modified from usual pattern for type A. Anterior half of gnathobasic margin serrated with graduated tiny teeth, but anterior three-fourths of serrated margin seeming to represent folded lamella posteriorly curved on outer surface of gnathobasic lamella. At most distal extremity of curved portion, minutely serrated process considerably exceeding edge of principal gnathobasic margin. Process serrated by very small teeth and perhaps including in part a setiform element. Principal serrated gnathobasic margin continuing posteriorly as two stout conical and two long sharp spinous teeth. Anterior conical teeth equispaced and separated by deep interruption of margin, but without wide gap, from posterior two sharp teeth projecting from a common base. Anterior margin of common base distinctively curved by posterior expansion. Tiny tubercles scattered on outer surface of gnathobasic lamella.

Proximal half (basipodite) of palp (mandible, Fig. 2i) directed toward mouth-opening and distal half (endopodite) bent posteriorly. Distolateral part of proximal portion protruded as setiferous lobe, apparently representing exopodite, with two long setae on distal margin and one somewhat smaller seta at proximal base of lobe. Endopodite armed with six setae; two unequal setae (smaller seta located more laterally) on step-like marginal interruption at about distal third of medial margin, two long setae on truncated apex, and 2 long similar setae on another step-like marginal interruption laterally near apex.

Maxillule (Fig. 2l) consisting of coxopodite with setiferous gnathobase and palp apparently comprising basipodite and rami fused. Medial endite of coxopodite bearing 6 strong plumose setae. Epipodite represented by small rounded lateral lobe with single small and naked seta at tip. Basipodite with two long medial setae directed distally and hairs on proximal rounded margin. Endopodite broad distal lobe with three terminal setae directed in same way. Complex exopodite

comprising small digit-like projection protruded from lateral margin and three setae placed more laterally and proximally. Most proximal seta inserted on tip of elongated lobe from margin directed proximally; middle seta placed on anterior base of lobe and directed distally, and last seta located on its own small protrusion and directed distally.

Maxilla (Fig. 2m) weakly three-segmented, bearing nine (7 major and 2 additional) setae along medial margin and at apex. Major setae meaning those found consistently in appendage of genus. First segment about 1.3 times as long as second or third segment and bearing two large major setae on protrusions. Second segment ornamented with two similar major setae and proximal of these accompanied by two slender additional setae on posterior surface and at base; proximal additional seta twice as long as distal. Third segment bearing three major setae; one stout seta on protrusion on medial margin, one short slender seta at narrow apex and one long seta (directed distally) on lateral margin near apex.

Maxilliped (Fig. 2n) consisting of two large basal segments and small third segment set off from apical claw. Largest first segment about as long as wide and armed with one short naked seta proximally set on medial margin. Slightly smaller second segment bearing two (1 anterior and 1 posterior) setules facing each other around distal third on medial margin; medial margin between setules slightly and longitudinally concave to receive terminal claw. Smallest third segment possibly representing articulating ring between second segment and terminal claw. Claw about three times as long as third segment measured on lateral margin and demarcated into two portions at proximal two-thirds. Proximal portion bearing two setules; one midway on medial margin and one on posterior surface near demarcation of terminal portion. Concave medial surface of terminal portion with two notches at base and near tip.

In first to fourth legs (Fig. 3o-r, 4s-v), protopodites weakly bimerous, without distinct articulation on body surface, and partly sclerotized as shown in figures (dotted parts). Coxopodite unarmed. Basipodite ornamented with one slender seta on lateral margin. Row or patch of conical spinules (generally 4 or 5 in number) on mediolateral corner of basipodite except for that in right first leg. First endopodites apparently unimerous, although each exhibiting integumental transverse flexure on posterior surface. Second to fourth endopodites bimerous. First to fourth exopodites unimerous.

Right first endopodite (Fig. 3o) approximately as long as wide and bearing eight long non-plumose setae; three setae near lateral margin but more on posterior surface, four setae along rounded distal margin and one seta near medial margin but somewhat on anterior surface. First lateral seta located proximally to integumental flexure on posterior surface. Right first exopodite (Fig. 3o) having highly distinctive posture and structure. Ramus articulated on prolonged lateral margin of basipodite and extending almost directly laterally. Shape of ramus approximately trapezoidal. Anatomically lateral margin of appendage in two parts with proximal and distal portions bent at right angles to each other. Margins, having on trapezoid proximal and distal positions, corresponding to proximal portion of anatomically lateral margin and probably all of anatomically medial margin respectively. Proximal portion of anatomically lateral margin about equal in length to basal margin, this margin articulated on lateral margin of basipodite. Anatomically medial margin, distal on trapezoid, about 1.3 times as long as proximal portion of anatomically lateral margin and forming curve to account for widening of truncate distal margin of trapezoid, this distal portion of anatomically lateral margin about 1.5 times as long as basal margin. Truncate distal margin probably complex incorporating mostly lateral elements of normal appendage and probably

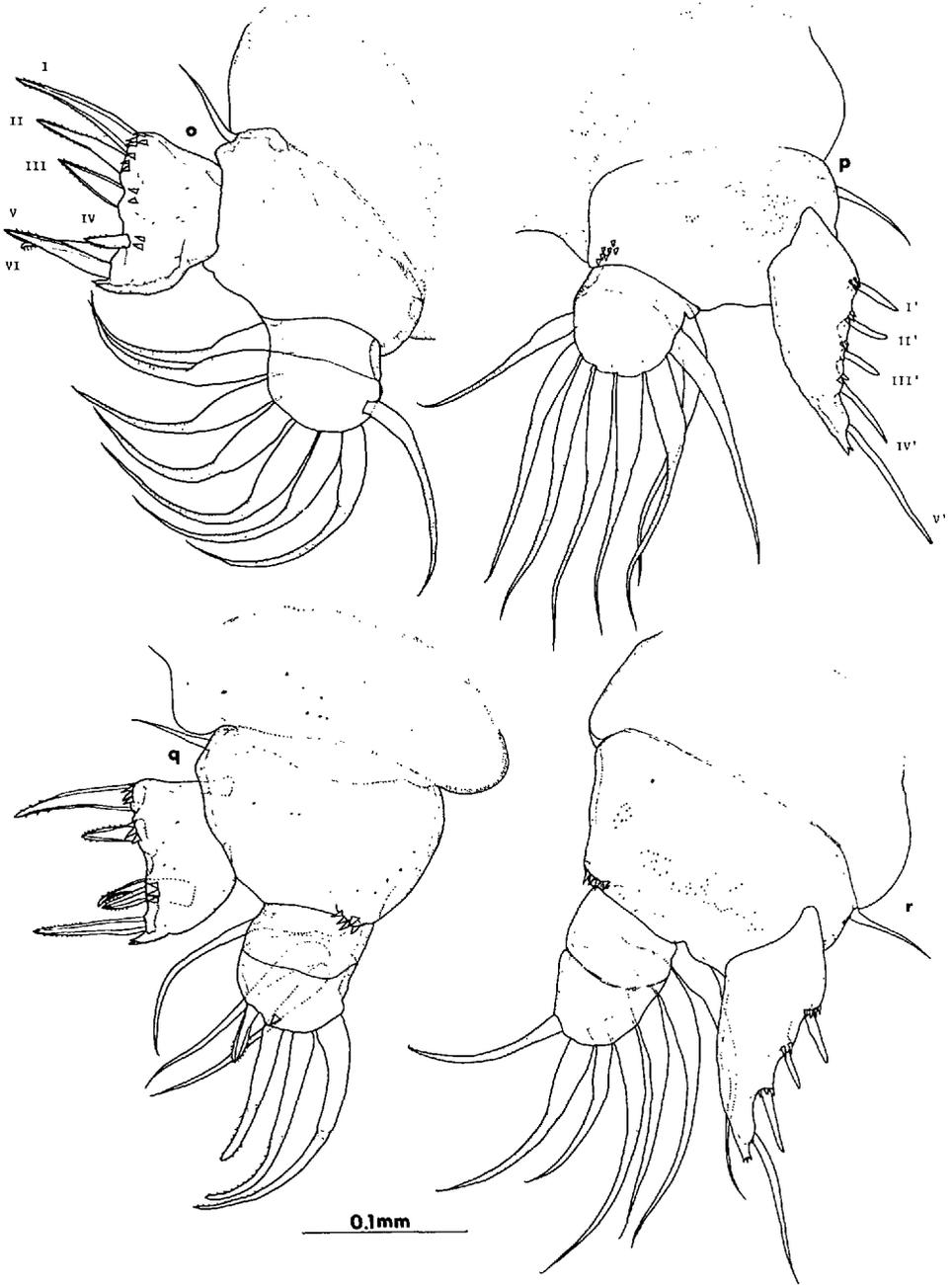


Figure 3. *Botryllophilus abboti*, n. sp., female: o, leg 1, right, anterior; p, leg 1, left, anterior; q, leg 2, right, anterior; r, leg 2, left, anterior.

normal apex. All armature of ramus arranged linearly along wide truncate margin. Same general plan of structure and posture exemplified in second and third legs. In right first exopodite armature consisting of six minutely and distally serrated marginal spines (I–VI numbering from proximal to distal); 5(I–V) arranged in

row on margin and one (VI) situated near margin but on posterior surface, with their proportional lengths from I to VI about 1:0.7:0.5:0.3:0.8:0.8 All these spines inserted at nearly right angle to truncated margin, with VI being found between IV and V in anterior view. Row or patch of conical spinules associated with each of spines (I-V) on surface of ramus. Formula of spinules for I to V as follows; (I)-4; (II)-3; (III-V)-2; two spinules for V protruded from mediolateral corner of ramus.

In left first leg (Fig. 3p), endopodite comparable to right in structure and armature, but exopodite including ornamental elements differently modified. Unimerous left exopodite (Fig. 3p), in approximately normal posture extending directly and distally from protopodite, also distinctively modified but corresponding to right exopodite. Elements of armature differing in number and type from those of right. Medial margin, about 1.3 times as long as equivalent margin on right, forming curve meeting lateral margin in pointed apex. Proximal third and distal two-thirds of lateral margin corresponding to proximal and distal portions on trapezoid of right. Distal (longer) lateral margin slightly undulate, furnishing five equidistant insertions for slender and more or less setiform elements of armature. Most distal of these longest and inserted slightly subapically. Proportional lengths of elements about 1:1:1:1.5:3; all smooth. Near base of each element minute conical spinules on ramus, corresponding in formula to those for elements I to V of right. Vestigial tubercle (dotted in Fig. 3p) at place for VI on medial and posterior surface of ramus.

In right second leg (Fig. 3q) bimerous endopodite (as long as wide) ornamented with seven elements including four setae and three graduated spiniform elements; one lateral seta (inserted on posterior surface near medial margin) on first segment and three (2 lateral and 1 mediolateral) setae and three (1 lateral, 1 distolateral and 1 apical) spiniform elements on second segment. Proportional lengths of three spiniform elements (serrated on distal half or more upper part in each) from proximal to distal about 1:2.5:3.5. Exopodite comparable to that in preceding ramus in morphology but reduced by one spine (probably corresponding to III) of truncate margin of first right exopodite, on account of wide gap distally to second spine (II). Therefore, armature consisting of five (I, II, IV, V and VI) spines with their proportional lengths in order about 1:0.4:0.4:1:1.

In left second leg (Fig. 3r) bimerous endopodite bearing seven ornamental elements, all setiform; first segment with one lateral seta and second segment with six (4 lateral, 1 apical and 1 mediolateral) setae; all lateral setae inserted on posterior surface. Exopodite reduced by one setiform element (probably corresponding to III) from preceding ramus and medial vestigial tubercle on posterior surface in first ramus completely reduced in second. Therefore, armature consisting of four setiform elements on lateral margin, with their proportional lengths from proximal to distal about 1:0.8:1.2:3.

In right third leg (Fig. 4s), bimerous endopodite reduced by two ornamental elements (1 seta and probably 1 spine) from second segment of preceding ramus, bearing five elements; one lateral seta (inserted on posterior surface near medial margin) on first segment and two (1 lateral and 1 mediolateral) setae and two (1 short lateral and 1 long distolateral) spines on second segment. Right third exopodite basically comparable to preceding ramus in structure and armature. Ornamentation consisting of five spines as in second exopodite but first spine (I) slightly reduced in length, with their proportional lengths about 1:0.6:0.6:1.4:1.4.

In left third leg (Fig. 4t), setation of bimerous endopodite decreased by two setae on distal segment from that of preceding ramus, with armature consisting of five setae; one lateral seta on basal segment and four (3 lateral and 1 terminal) setae on distal segment. Exopodite comparable to that in preceding ramus, bearing

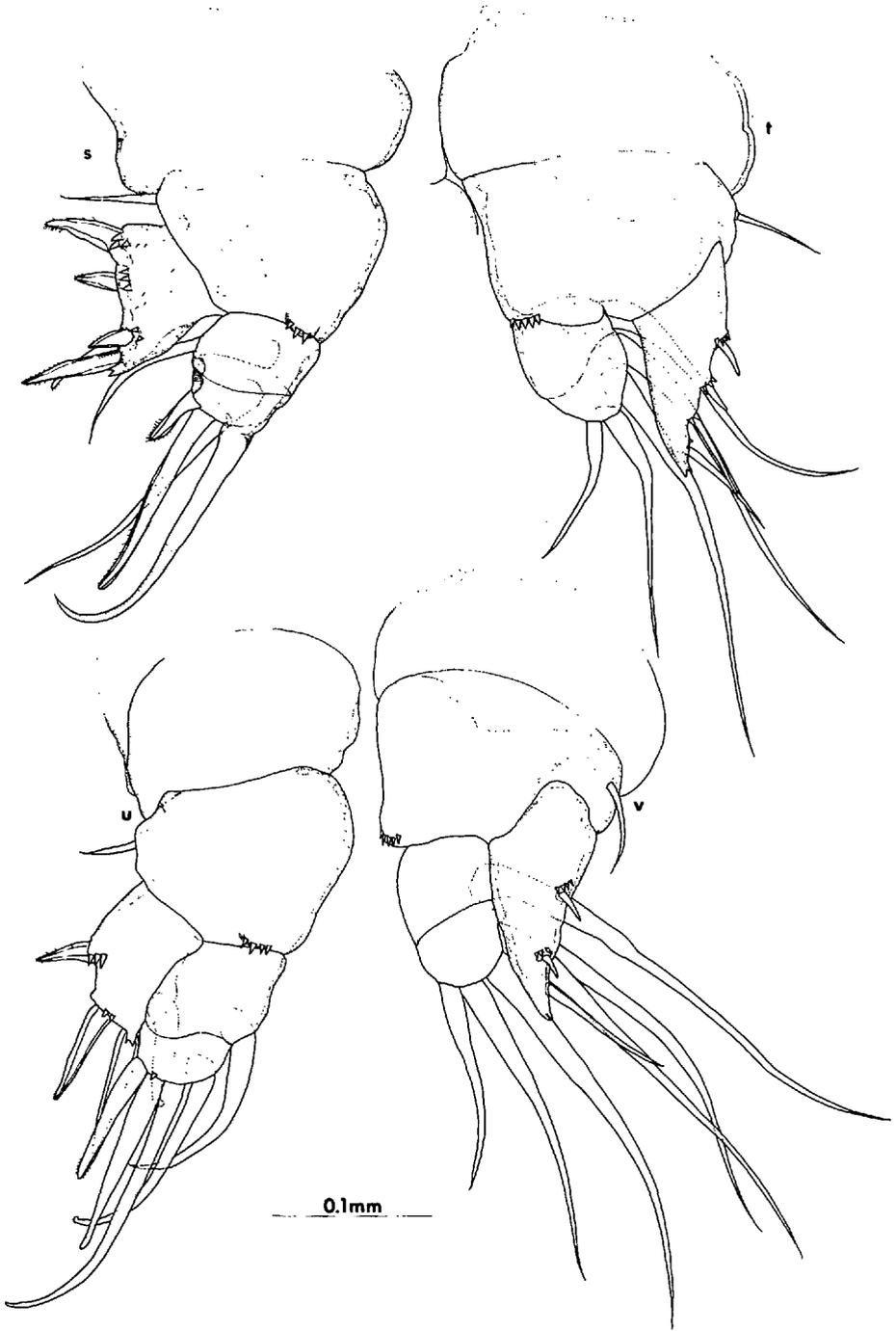


Figure 4. *Botryllophilus abbotti*, n. sp., female: s, leg 3, right, anterior; t, leg 3, left, anterior; u, leg 4, right, anterior; v, leg 4, left, anterior.

four setiform elements with their proportional lengths from proximal to distal about 1:0.8:2:3.

In right fourth leg (Fig. 4u), both rami somewhat transformed from those in preceding legs. Protopodite becoming narrow and basipodite about as long as wide (wider than long in preceding ones). Bimerous endopodite ornamented with five elements as in third leg, but their location and size partly changed. Basal segment armed with one medial seta and distal segment with two (1 medial and 1 terminal) setae and two (1 terminal and 1 lateral) spiniform elements. Spinule near base of terminal spiniform element on anterior surface of ramus. Much altered exopodite longer than wide (wider than long in all preceding right exopodites), directed distally, and armed with four (1 medial, 1, distal, 1 distolateral and 1 lateral) spines. Medial spine (possibly corresponding to spine VI) translocated to more medial margin on posterior surface and one of lateral spines on right third exopodite absent in fourth.

In left fourth leg (Fig. 4v), bimerous endopodite bearing six setae (typically 5 in type A); basal segment with one lateral seta and second segment with five (2 lateral, 2 terminal and 1 mediolateral) setae. Exopodite reduced by one ornamental element from preceding ramus, bearing three setiform elements with their proportional lengths about 1:0.7:3. Formula of spiniform (Roman numerals) and setiform (Arabic numerals) elements in the legs one to four in right and left as follows; total (T) numbers (italic numerals) shown within parentheses:

(Right)	Prp	(T)	Enp	(T)	Exp	(T)
Leg 1	0-o; 0-1	(<i>I</i>)	0-8	(8)	VI-o	(6)
Leg 2	0-o; 0-1	(<i>I</i>)	0-1; III-3	(7)	V-o	(5)
Leg 3	0-o; 0-1	(<i>I</i>)	0-1; II-2	(5)	V-o	(5)
Leg 4	0-o; 0-1	(<i>I</i>)	0-1; II-2	(5)	IV-o	(4)
(Left)						
Leg 1	0-o; 0-1	(<i>I</i>)	0-8	(8)	0-5	(5)
Leg 2	0-o; 0-1	(<i>I</i>)	0-1; 0-6	(7)	0-4	(4)
Leg 3	0-o; 0-1	(<i>I</i>)	0-1; 0-4	(5)	0-4	(4)
Leg 4	0-o; 0-1	(<i>I</i>)	0-1; 0-5	(6)	0-3	(3)

Fifth legs on both sides subrectangular and symmetrical in shape except for long terminal setae. In right leg (Fig. 5w), this seta about 1.4 times as long as basal width and six times as long as apical width measured on dorsal side. Armature consisting of four non-plumose setae; one short seta at proximal fourth on dorsal side and three (2 short and 1 long) setae along margin from subterminal (on dorsal side) to terminal (on medial side); their proportional lengths from proximal to terminal about 1:2:2:5.5. Long terminal seta slightly longer than appendage. No noticeable gap between two (1 subterminal and 1 terminal) short setae. In left leg (Fig. 5x), long terminal seta shorter than that in right and about four-fifths as long.

Genital apparatus (Fig. 5y) consisting of pair of dorsolateral oviducal apertures each with cuticular flap; trapezoidal, slightly sclerotized area with pair of hairs between apertures; inconspicuously developed genital atrium (containing probably pair of tiny insemination pores) on midventral surface close to proximal margin of segment, and diverging internal canals leading laterally to oviducts. Outer edge of cuticular flap (Fig. 5z) provided with two small conical spines, closely set midway on media free margin and articulated on it. Proximal spine slightly larger than distal and these spines corresponding to marginal spines of same flap in

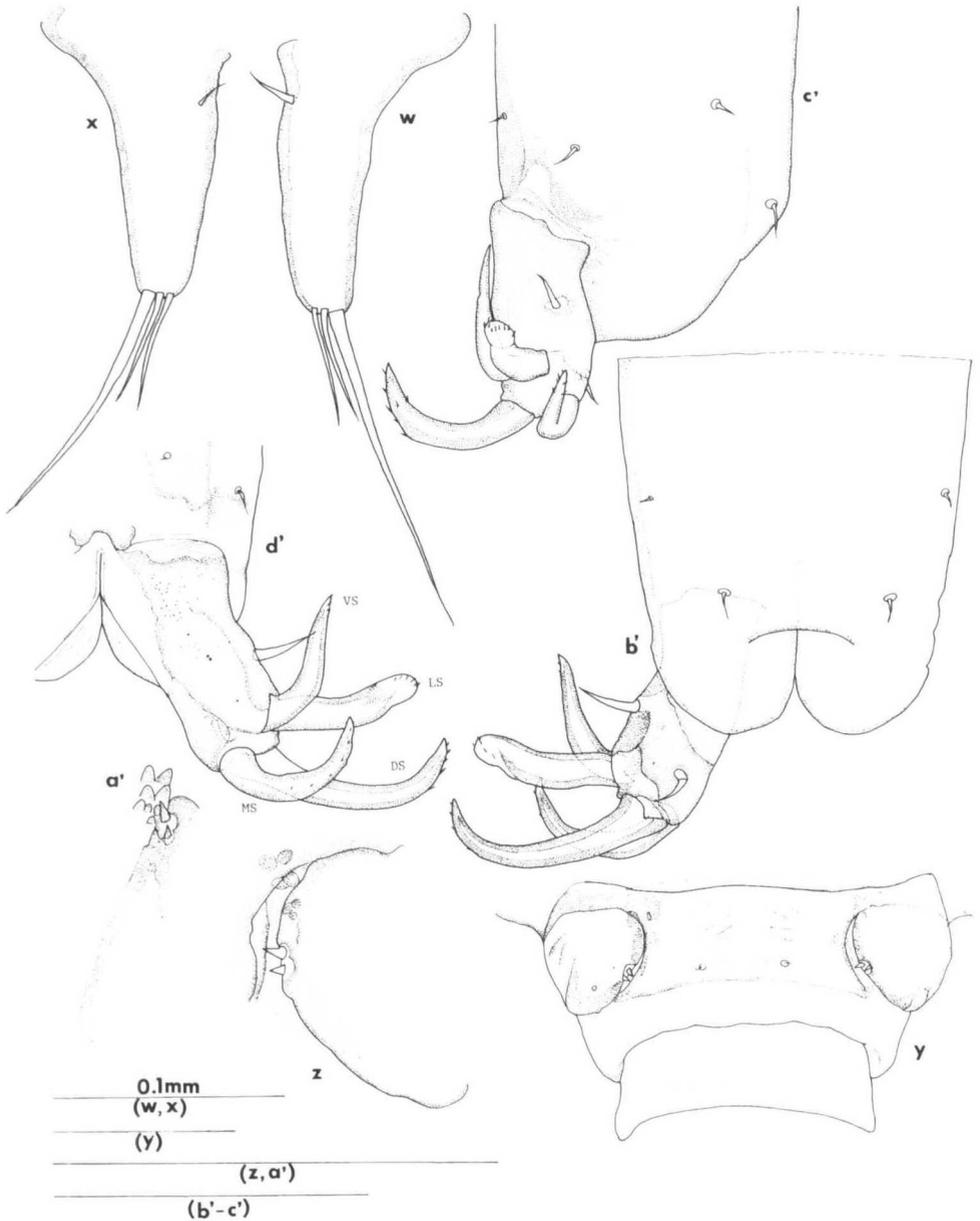


Figure 5. *Botryllophilus abbotti*, n. sp., female: w, leg 5, right, dorsal; x, leg 5, left, dorsal; y, apparatus at oviducal apertures, dorsal; z, margin of fold covering oviducal aperture, right, dorsal; a', same, internal, posterior; b', anal segment and left caudal ramus, dorsal; c', same, lateral; d', same, ventral.

Haplostominae. Inner edge of flap (Fig. 5a') furnished with about eight conical sclerotized projections.

Caudal rami (Fig. 5b'-d') symmetrical and their integument sclerotized except for insertions of armature consisting of four clawed terminal spines and two short smooth dorsal and lateral setae. All these spines curved ventrally and inserted in

four different points on terminal surface as ventral (VS), lateral (LS), dorsal (DS) and medial (MS); lateral spine (LS) rounded at apex, whereas remaining 3 (VS, DS and MS) pointed. Each spine slightly denticulated at tip. Two short setae inserted at distal third on each of lateral and dorsal margins.

Male: Body (Fig. 6a, b) corresponding to usual pattern for cyclopoid swimming males as well as males of the Haplostominae (includes *Haplostoma* by Ooishi and Illg, 1977 and *Haplostomides* by Ooishi, 1980, and Ooishi and Illg, 1986). Composed of cephalosome, metasome and urosome, including caudal rami, with their proportional lengths about 1:2:2.1. Body length of single representative specimen 1 mm, measured on dorsal side from anteriormost to the end of caudal rami, and total length including long caudal setae 1.2 mm.

Cephalosome (Fig. 7c) prolonged anteriorly and ventrally into small subtriangular rostrum. Ventrolateral margins of dorsal shield distinguishable. No asymmetrical structure, with regard to shape or to armature. Head appendages composed of six pairs: antennules, antennae, mandibles, maxillules, maxillae and maxillipeds.

Metasome consisting of four segments, clearly demarcated, with well-developed tergal plates, and bearing four pairs of swimming legs; first endopodites characteristic with modified spines and setae. Widest width of body 0.25 mm, occurring on first metasomal segment.

Urosome six-segmented with proportional lengths from basal to distal about 1:2.8:1.6:1.6:1.5:1.1; shortest first segment bearing simple fifth legs; enlarged second genital segment enclosing pair of oval spermatophores and bearing on ventral surface setiferous flaps representing the sixth legs; third to fifth narrow, small abdominal segments; similar but slightly shorter anal segment bearing pair of caudal rami.

Body color slightly orange as in female, with well-developed median reddish orange eye and orange gut.

Antennule (Fig. 7d) consisting of four segments as in female but more developed in armature in male; their proportional lengths from first to fourth, measured on medial axis, about 1:0.5:0.5:0.5. First segment wider than long with expanded hemispherical ventral margin. Second segment about as long as wide and almost half as wide as the widest width of first. Third and fourth segments longer than wide and narrower than second. Ornamentation having following tabulation of arrangement of long (ls) and short (ss) setae and aesthetes (ae) in first to fourth segments (I-IV): (I) 19 ls, 4 ss, more than 137 ae; (II) 3 ls, 1 ss, 1 ae; (III) 1 ls, 1 ss, 1 ae; (IV) 10 ls, 2 ae. Structure and arrangement of armature are fundamentally comparable to those in males of *Haplostoma* and *Haplostomides* except no aesthete on segment II in most species of *Haplostoma*.

Antenna (Fig. 7e) basically comparable to those on both sides in female but differing from that (3-segmented, with usually 4 ornamental elements) in males of *Haplostoma* and *Haplostomides*. Second segment elongated with proportional lengths from first to fourth segments, measured on medial margin, about 1:8:1.5:2.3. Shortest first segment wider than long and elongated second segment is five times as long as basal width. Triangular third segment as in the female. Armature on fourth segment consisting of seven elements as in female but more elongated in each: two spines with distinct marginal serration placed at regular intervals on medial margin; one longer element without noticeable serration subterminally on same margin, and four similar graduated elements on terminal margin with their proportional lengths from medial to lateral about 1:1.2:1.7:2 (the shortest terminal element as long as subterminal). Anterior surface of fourth segment ornamented with denticles as shown in figure (Fig. 7e).

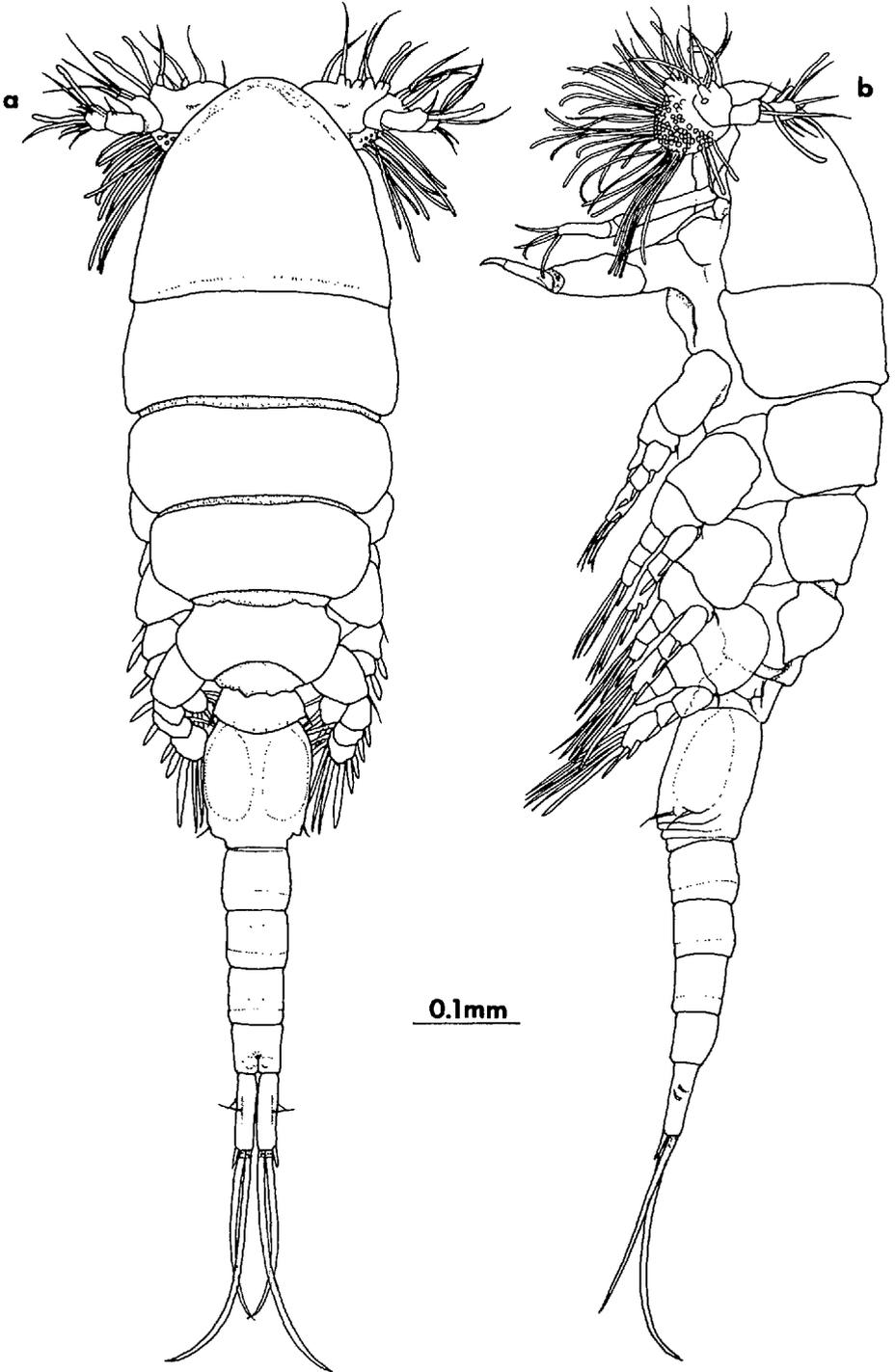


Figure 6. *Botryllophilus abbotti*, n. sp., male: a, habitus, dorsal; b, same lateral.

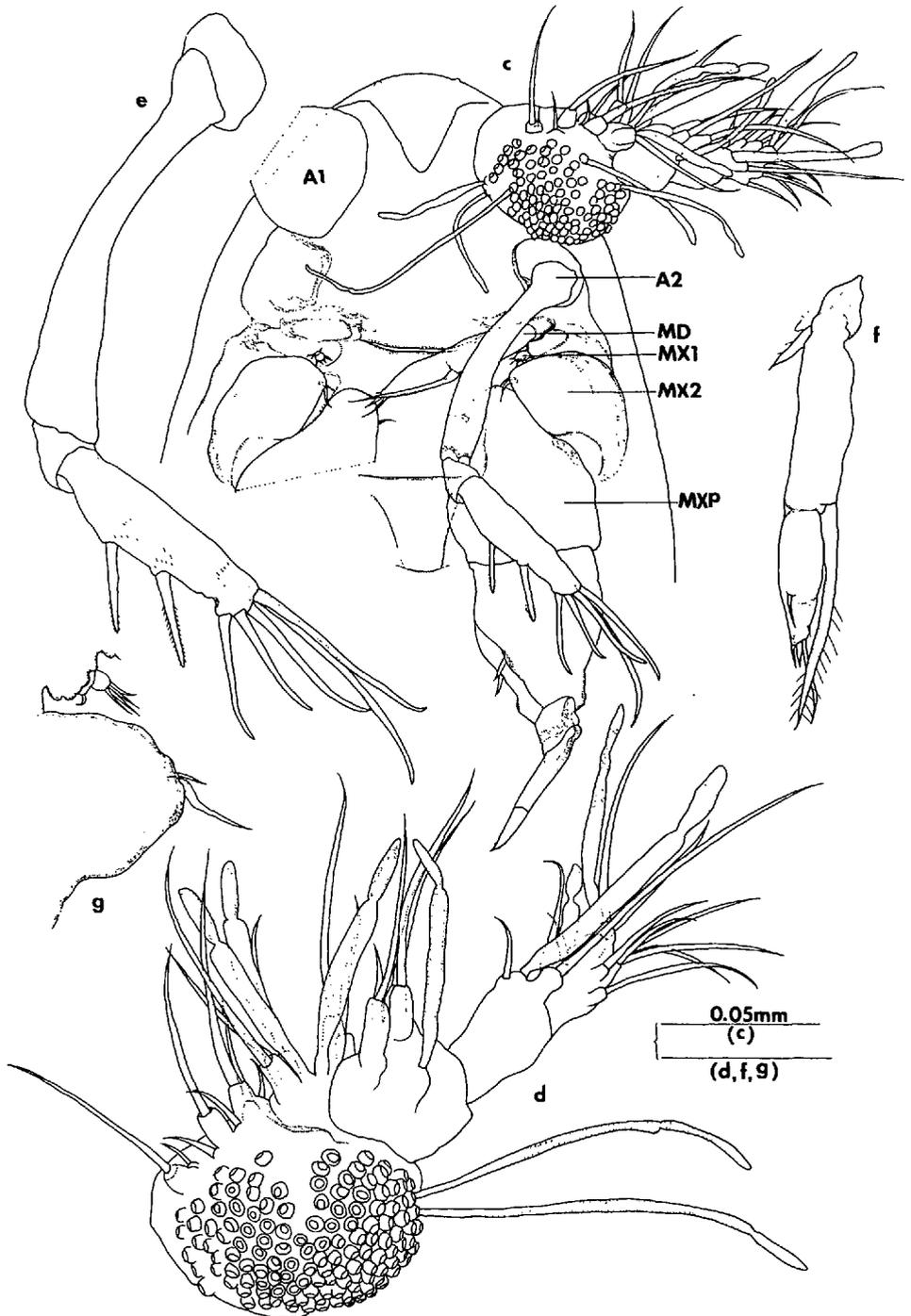


Figure 7. *Botryllophilus abbotti*, n. sp., male: c, cephalosome, ventral, right A1, A2, Md and Mxp removed; d, antennule, left, posterior, most aesthetes of basal segment removed; e, antenna, left, anterior; f, mandible, left, anterior; g, maxillule and maxilla, right, anterior.

Labrum (Fig. 7c) with smooth margin without distinct armature.

Mandible (Fig. 7f) reduced relative to that of female but more developed than that in males of Haplostominae. Coxopodite retaining small simple gnathobasic portion with few (seemingly 3) minute marginal teeth. Unimerous distal article forming unsegmented, elongated cylindrical lobe, about 6 times as long as widest part at proximal third; an integumental fold at about proximal two-thirds of appendage but this not a real articulation. Armature consisting of one long plumose seta corresponding to distal seta in exopodite armature in female, one small naked seta at distal seventh on medial margin but on anterior surface, and two short and one long similar setae from medial to lateral on apical margin and one vestigial setule near apex on lateral margin.

Maxillule (Fig. 7g) small, probable bimerous lobe closely set near anterior base of maxilla and bearing five small naked setae; one on probable anatomically mediodistal corner of proximal article and four similar but longer setae along margin of distal article. Appendage closely resembling that of males of *Haplostomides* (absent in *Haplostoma*).

Maxilla (Fig. 7g) reduced to large subtriangular sack-like lobe protruding medially as in that of males of Haplostominae. Armature consisting of two (1 anterior short and 1 posterior long) setae inserted on medially protruding apex.

Maxilliped (Fig. 8h, i) showing slight dimorphism in slightly different proportions and in somewhat transformed armature in male. First segment ornamented by single short seta (absent in both sexes in Haplostominae) midway on medial margin as in female. Slightly elongated second segment ornamented with two short medial spines (correspondingly to 2 setules in female), each finely serrated on its margin, and with three rows or patches of denticles on anterior surface. Similar denticle row also found on first segment near second segment on same surface. Third segment, as in female, short, perhaps merely constituting an articulating ring. Terminal claw elongated, as long as second segment, but demarcated into two portions at proximal two-thirds as in female. Proximal portion armed with two setules; one at distal third on posterior surface and one near distal margin on anterior surface. Distal portion ornamented with one similar setule and one trapezoidal protrusion near base. Pointed apex of claw having slight indentation on both sides.

First to fourth legs (Figs. 8j-m, 9n) symmetrical and comparable to those in males of *Haplostoma* in segmentation. Protopodite 2-segmented with distinct articulation on body surface and with well-developed intercoxal plate between paired legs. First and second coxopodites unarmed whereas the third and fourth bearing one plumose coxal seta reaching to mediodistal corner of basipodite. In first to fourth basipodites lateral margin ornamented with one short naked seta and mediodistal corner of second to fourth with marginal short hairs. First and fourth endopodites bimerous and second and third endopodites trimerous. First to fourth exopodites all trimerous. Armature consisting of characteristically modified setae and spines in first endopodites and of usual pattern of setae and spines in all remaining endopodites and exopodites.

In first leg (Fig. 8j, k), bimerous endopodite nearly half as long as exopodite, bearing eight ornamental elements. First segment longer and wider than second and bearing one rather short plumose seta midway on medial margin. Second segment slightly longer than wide with medial margin expanded and lateral margin indented distally, perhaps because of effect of slight flexure. Ornamentation consisting of seven elements including three stout naked setae and four (2 forked and 2 smooth) spines; three setae placed at regular intervals and obliquely from medial to distolateral on posterior surface; two forked and two smooth spines implanted

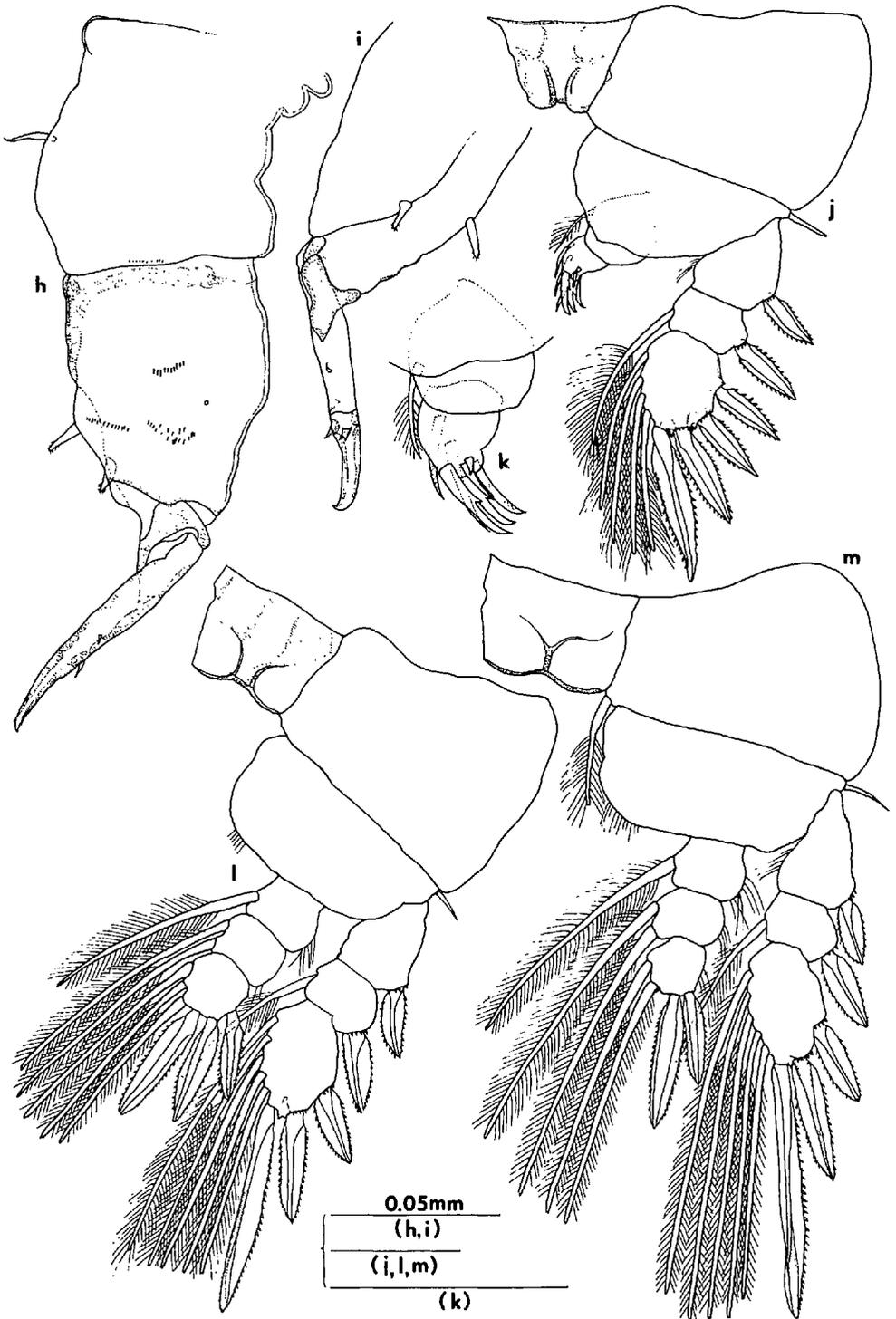


Figure 8. *Botryllophilus abbotti*, n. sp., male: h, maxilliped, left, anterior; i, same, distal structures, posterior; j, leg 1, left, anterior; k, same, endopodite, anterior; l, leg 2, left, anterior; m, leg 3, left, anterior.

from medial to distal along apical margin. All four setae on ramus and two forked spines subequal in length and as long as second segment.

Three-segmented exopodite armed with six spines (I'-IV' numbering from proximal to distal on lateral and distal margins), these spines fringed with serrated hyaline flanges, and five medial long plumose setae; first segment with one (I') lateral spine and medial hairs, second segment with one (II') lateral spine and one medial seta, third segment with four (2 (III'-IV') lateral, 1 (V') distolateral and 1 (VI') apical) spines and four medial setae. Longest apical spine (VI') about twice as long as first proximal spine (I'). Row of three to five minute marginal spinules on segment near base of each spine except for two (III' and VI') spines on third segment. Distolateral corner of third segment protruded into two points. Six spines (I'-V') possibly corresponding to those (I-VI) in same number in first right exopodite in female.

In second leg (Fig. 8l), trimerous endopodite armed with nine elements (6 setae and 3 spines); first segment with one medial seta and lateral hairs, second with two medial setae and third with three medial setae and three (1 lateral and 2 apical) spines. In exopodite armature consisting of 11 elements (6 setae and 5 spines), with one seta added to third segment and one spine reduced from same segment in preceding exopodite. In this case, reduced spine apparently corresponding to III' on same segment in preceding ramus and also to III on truncated lateral margin of right first exopodite in female.

Third leg (Fig. 8m) ornamented with seven elements (5 setae and 2 spines) on endopodite because of reduction of one seta and one spine from third segment of preceding ramus. Exopodite well comparable to second exopodite in structure and armature.

Fourth leg (Fig. 9n), bimerous endopodite armed with six elements (4 setae and 2 spines); first segment with one medial seta and second with three (2 medial and 1 apical) setae and two (1 subapical and 1 apical) spines. Exopodite comparable to preceding ramus in structure and armature.

Formula of spines (Roman numerals) and setae (Arabic numerals) in legs one to four is as follows; the total (T) numbers (italic numerals) shown within parentheses:

	Prp	(T)	Enp	(T)	Exp	(T)
Leg 1	0-0; 0-1	(1)	0-1; IV-3	(8)	I-0; I-1; IV-4	(11)
Leg 2	0-0; 0-1	(1)	0-1; 0-2; III-3	(9)	I-0; I-1; III-5	(11)
Leg 3	0-1; 0-1	(2)	0-1; 0-2; II-2	(7)	I-0; I-1; III-5	(11)
Leg 4	0-1; 0-1	(2)	0-1; II-3	(6)	I-0; I-1; III-5	(11)

No difference between *Botryllophilus* male and *Haplostoma* males (including swimming and clawing types) as regards formula of exopodites.

Fifth and sixth legs (Fig. 9o) similar to those of *Haplostoma* males. Fifth leg represented by one relatively long naked seta on subtriangular lateral protrusion from first urosomal segment and two similar setae on oval lobe articulated on basal ventral extension from lateral protrusion. Sixth leg represented by two similar setae placed distally on flap-like cover of genital orifice of second (genital) urosomal segment.

Caudal ramus (Fig. 9p) relatively short, 4 times as long as wide (6 times in *Haplostoma* males of swimming type) and 1.5 times as long as anal segment, all measured on longest lengths. Ornamentation consisting of two medial and lateral setae (without distinct hyaline flanges) on apical margin, one stout smooth spine on distolateral corner, one slender relatively long setule (or short seta) midway

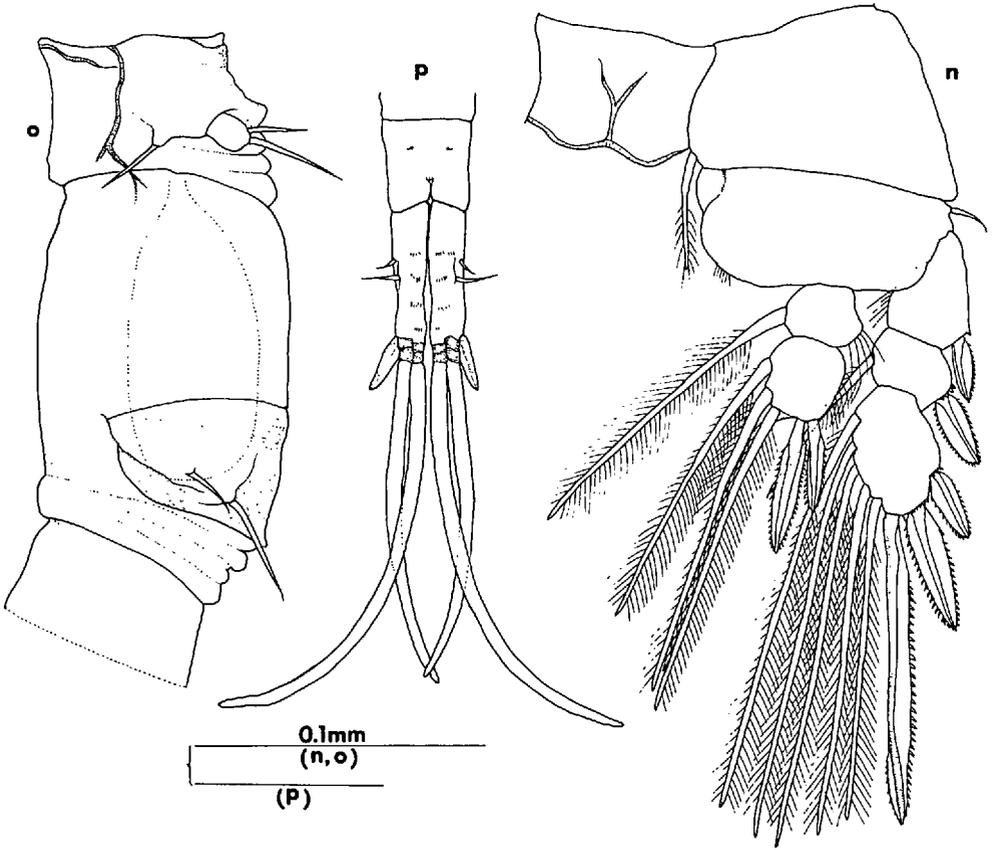


Figure 9. *Botryllophilus abbotti*, n. sp., male; n, leg 4, left, anterior; o, anterior urosomal segments bearing legs 5 and 6, right, lateral; p, caudal rami, dorsal.

on dorsal surface somewhat laterally, one similar but much shorter setule (or short seta) at two-fifths on lateral margin rather dorsally. Medial seta at apex about 1.5 times as long as lateral one and slightly curled laterally in fixed material. Shorter lateral seta also curled but in opposite direction. Distal ends of medial setae on both sides widely separated from each other, whereas those of lateral setae touching on axial line of body. In this way, medial and lateral setae on each side crossing each other around middle and distal third, respectively, in dorsal view. Corresponding setae in *Haplostoma* males always straight without curling. Except for curling, armature of caudal ramus comparable to that in *Haplostoma* males.

Remarks. The present new species is included in a group designated by us as Type A of the genus *Botryllophilus* in females. The type A includes *B. banyulensis* Brément, 1909; *B. bergensis* Schellenberg, 1921; *B. norvegicus* Schellenberg, 1921; *B. brevipes* Sars, 1921 and *B. inaequipes* Hansen, 1923. *B. abbottii* is markedly distinguishable from these five species by the characteristic gnathobasic margin of the mandible with the folded lamella furnished with the arrangement of teeth variously modified from the usual pattern but retaining the characters for type A. In addition, it is probable that the shape or proportional lengths of the ornamental elements in all legs would be distinguishable from those of other species.

However, these are not available as species characters at present because of the lack of detailed descriptions in all these known species.

In the five recorded species mentioned above the males are all unknown. However, there is partial information regarding males of two unnamed species, the females of which correspond to type A, from the eastern (Illg and Dudley, 1980) and western (Oishi and Illg, 1986) coastal waters of the Pacific. In the western Pacific species its mouthparts were reported in detail and the present new species is clearly distinguished from it by the somewhat reduced armature in the mandible and maxilla and by the more denticulated maxilliped.

Illg and Dudley (1980) reported that both males of *Botryllophilus* and *Haplostoma* astonishingly resemble each other because their antennules are ornamented by unusually numerous aesthetes. In fact it is difficult to distinguish *Botryllophilus* from *Haplostoma* and also from *Haplostomides* by the antennule. The maxillule of *B. abbotti* and the western pacific *Botryllophilus* species closely resembles that of *Haplostomides* whereas the appendage is absent in *Haplostoma*. However, the mandible is much developed in *Botryllophilus* but less developed in both *Haplostoma* and *Haplostomides*. The maxilliped of *Botryllophilus* is different from that of the latter genera. In addition, the antenna of *Botryllophilus* is easily distinguishable from that of *Haplostoma* and *Haplostomides*. In any case, from our study of the male of *B. abbotti* we distinguish the males of *Botryllophilus* from those of *Haplostoma* and *Haplostomides*.

We believe that the full description and illustration of the female and male of the present new species from the Monterey Peninsula forms a first step to clarify the taxonomy of the subfamily Botryllophilinae.

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LITERATURE CITED

- Brément, E. 1909. Contribution à l'étude de copépodes ascidicoles du Golfe du Lion. Arch. Zool. Exper. Gén., Notes et Reviews (5): 61-89.
- Hansen, H. J. 1923. Crustacea Copepoda, II. Copepoda parasita and hemiparasita. Danish Ingolf-Expedi. 3(7): I-II + 1-92, pls. 1-5.
- Illg, P. L. and P. L. Dudley. 1980. The family Ascidicolidae and its subfamilies (Copepoda, Cyclopoida), with descriptions of new species. Mém. Mus. Natn. Hist. Nat., Paris, sér. A, 117: 1-192.
- Oishi, S. 1980. The larval development of some copepods of the family Ascidicolidae, subfamily Haplostominae, symbionts of compound ascidians. Publ. Seto Mar. Biol. Lab., 25(5/6): 253-292.
- and P. L. Illg. 1977. Haplostominae (Copepoda, Cyclopoida) associated with compound ascidians from the San Juan Archipelago and vicinity. Speci. Publ. Seto Mar. Biol. Lab., ser. 5. pp. 1-154, pl. 1.
- and ———. 1986. Morphological comparison of the male mouthparts of *Haplostomides* with those of *Botryllophilus*. Proc. 2nd Interna. Conf. Copepoda. Syllogeus, (58): 392-399.
- and ———. 1988. Two morpho-types of *Botryllophilus* (Cyclopoida, Ascidicolidae). Proc. 3rd Interna. Conf. Copepoda. Hydrobiologia, 167/168: 561-566.
- Sars, G. 1921. An account of the Crustacea of Norway with short descriptions and figures of all the species. 8. Copepoda, Monstrilloida and Notodelphoidea. Pts. 1-6: 1-91, pls. 1-31.

Schellenberg, A. 1921. Neue norwegische Notodelphyiden. K. Norske Vidensk. Selsk, Skrifter, 1921, no. 3: 1-11, fig. 1-9.

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