

CABIROPS MONTEREYENSIS, A NEW SPECIES OF
HYPERPARASITIC ISOPOD FROM MONTEREY BAY,
CALIFORNIA (EPICARIDEA: CABIROPSIDAE)

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Abstract.—*Cabirops montereyensis* is described on the basis of cryptoniscus larvae and immature females from Monterey Bay, California. This cabiropsid isopod is a parasite of the bopyrid isopod *Aporobopyrus muguensis* Shiino, and is the first member of the genus described from the northeastern Pacific Ocean. The cryptoniscus of *C. montereyensis* is very similar in morphology to those of *C. codreanui* Bourdon and *C. orbionei* Bourdon, species from the North Atlantic and Indian Oceans respectively, and generally resembles other species parasitic on pseudionine bopyrids.

Cabirops Kossmann (1884) is the type-genus of the Cabiropsidae, a family of Cryptoniscina* parasitic upon other isopods. *Cabirops* species are typically parasitic within the marsupia of bopyrid isopods which are branchial parasites of decapod shrimps and crabs. The genus is presently known from eleven named species (for recent reviews see Lemos de Castro 1970; Restivo 1975) and four partially described species which have been assigned to the genus but not named (Bonnier 1900; Shiino 1942; Romano 1953; Bourdon 1966). No *Cabirops* species have yet been described from North American waters or from any part of the eastern Pacific Ocean. Markham (1979), however, has indicated the presence of one species in Bermuda (on the basis of an immature female).

Cryptoniscus larvae typical of the Cryptoniscina have occasionally been encountered in collections of the bopyrid isopod *Aporobopyrus muguensis* Shiino from Monterey Bay, California. In two instances these larvae were associated with female hyperparasites within the brood pouch of *A. muguensis* (a branchial chamber parasite of the porcellanid crabs *Pachycheles rudis* Stimpson and *P. pubescens* Holmes). The morphology of the females and the cryptoniscus stage individuals identify this form as a *Cabirops*. It differs from all known species of the genus, and is here described as a new species, *Cabirops montereyensis*.

A brief review of the valid species of *Cabirops* suggests two groups on the basis of coxal plate dentition patterns and the morphology of the dactyli of the anterior two pairs of pereopods. The first of these groups (to which *C. montereyensis* is assigned) is associated with pseudionine and orbionine hosts; the second is associated with ionine and bopyrine hosts.

Cabirops montereyensis, new species

Figs. 1A-G, 2A-G, 3A-B

Cryptoniscus: General body form.—1.0–1.2 mm long by 0.40–0.48 mm wide. Body tear-drop shaped and widest at pereoneal segment IV. Head length ap-

* I retain here the classification of Nielsen and Stromberg (1965) rather than the recently proposed unification of their 7 families within Liriopsidae (Bowman and Abele 1982).

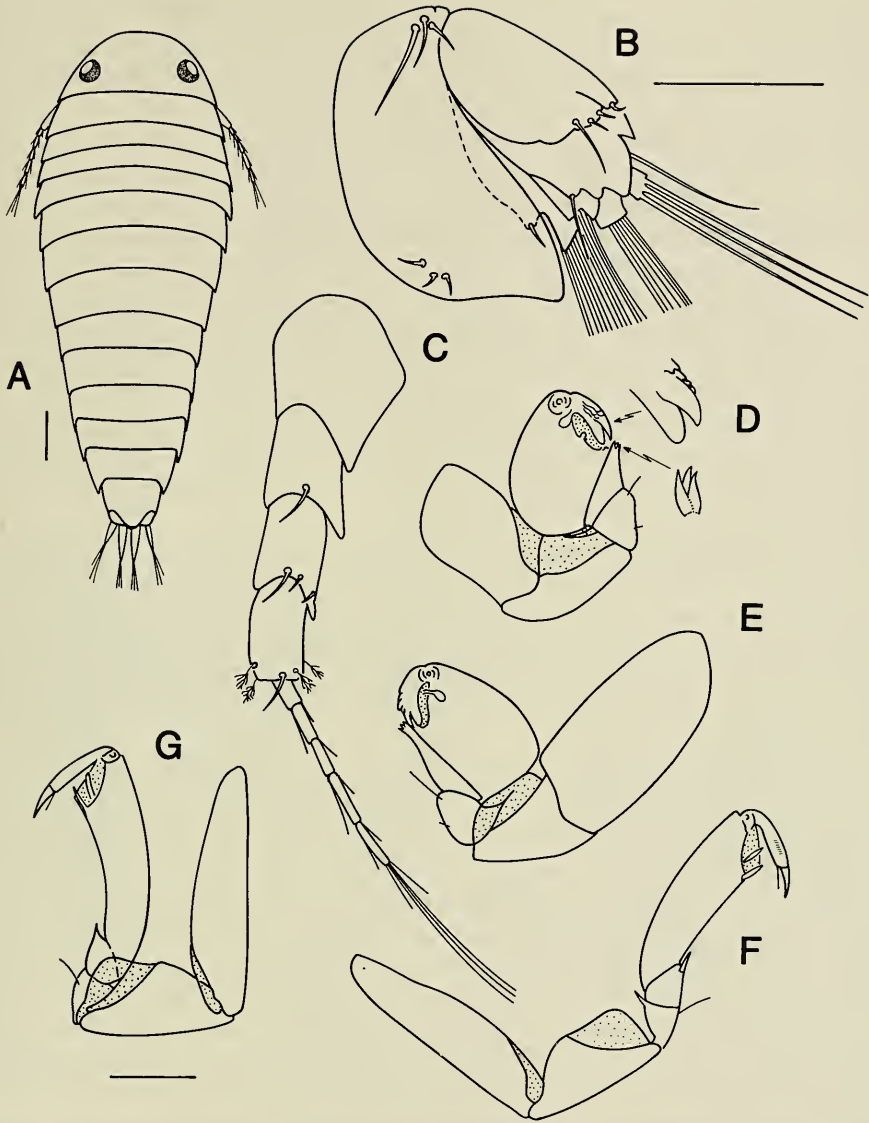


Fig. 1. *Cabirops montereyensis* n. sp. Cryptoniscus stage larva. A, Dorsal aspect of the entire larva (scale bar is 0.1 mm); B, First antenna in ventral view (scale is 0.05 mm); C, Second antenna; D, Peraeopod I; E, Peraeopod II; F, Peraeopod III; G, Peraeopod IV. (C–G are to the scale shown at the bottom of the figure—0.05 mm.)

proximately $\frac{1}{7}$ total body length. Most cuticular surfaces marked by distinct striations, especially visible on dorsum, coxal plates, and basal articles of peraeopods I and II. Second antenna (excluding terminal setae) reaches to posterior border of peraeonal segment III. Pericardium in pleonal segments 3 and 4.

Cephalon.—Anterior margin broadly rounded. Eyes in form of crystalline cup surrounded by pigment. Oral cone directed toward anterior. Antenna 1 of 3 articles with bifurcate flagellum. First article crescent-shaped and broadly touching

contralateral one. Six ventrally directed setae, 3 at anterolateral corner and 3 along posteromedial border. Anterolateral setae differ in size, medial seta longest and lateral seta shortest. Setae along posteromedial border smaller than those at anterolateral corner. Second article of antenna 1 with complex pattern of cuticular ridges or shelves elaborated into posterolateral teeth. Four setae in row along lateral border of most ventral shelf, 2 located medially on more dorsal shelves, one of these setae beneath first article in ventral view. Dorsal to second article are flagellar processes bearing groups of setae, and large aesthetasc bundle. First 2 articles of antenna 1 overlap (in ventral view) basal article of antenna 2. Antenna 2 with 4 peduncular and 5 flagellar articles. First peduncular article broadly rounded at anterior margin and bearing distinct apophysis on posteromedial edge. Second article with strong apophysis and one stout ventral seta. Third article with smaller process in form of wide spine and with 3 stout setae. Fourth article with one ventral stout seta and 2 medial and 2 lateral sensory setae near distal tip. Proximal flagellar article much shorter than distal 4. Distal end of first, third, and fourth flagellar articles with 2 setae, second with only one apparent, fifth with 3 long terminal setae and 2 short lateral setae.

In live animals the antennae are normally held perpendicular to the long axis of the body. The outer flagellar articles of the first antenna are held laterally and the aesthetasc bundle is periodically erected as a fan-shaped cone. The second antennal peduncle is held horizontally, with the flagellum at an angle of about 45 degrees to the vertical. The antennae are periodically pulled ventrally; this action is accompanied by stroking or grooming of the antennal processes by the first three peraeopods.

Peraeon.—Peraeonal segments with toothed coxal plates. Number of denticles in successive plates as follows: 1:2, 2:3, 3:3, 4:3, 5:3, 6:1, 7:1. Outer tooth in first plate and middle tooth of second plate broadly spatulate. Peraeopods I and II gnathopodal, with massive propodi and complex dactyli. Tips of dactyli bifid, outer branches pointed, inner branches bluntly rounded. Outer edges of dactyli rugose. Peraeopods III–VII ambulatory, with bases and propodi long and thin. Propodi with long axes curved, but with inner and outer edges diverging only slightly toward distal end in peraeopods III–V. Propodi of peraeopods VI and VII tapering toward distal tip. Dactyl of PIII with comb of small setae, other dactyli without. Dactyli of PIII–V with terminal claw and one small seta on inner margin. Dactyli of PVI and PVII bifid, one branch recurved. Outer edge of dactyl of PVI broadly rounded, on PVII slightly sinusoidal in outline.

Pleon.—Pleopods natatory with sympod, endopod and exopod. Sympod with 2 medially directed smooth setae, exopod with 5 plumose setae (4 posterior, one on posterolateral edge). Posterolateral seta of exopod minute on pleopod 1, well-developed on pleopods 2–5. Endopod with 5 plumose setae on pleopods 1–4, 3 on pleopod 5. In life, pleon occasionally flexed ventrally, at which time pleopods groomed by inner faces of peraeopods VI and VII. Pleotelson quadrangular, posterior edge entire. Uropodal basis with minute hairs along lateral border and with 2 posterior spines. Endopod slightly less than twice length of exopod, bearing 5 or 6 sensory setae set in shallow groove near dorsolateral corner of its base. Fringe of setae along medial margin of endopod. Exopod of uropod with 2 long, one medium, and 2 short terminal spines. Exact pattern of terminal spination of

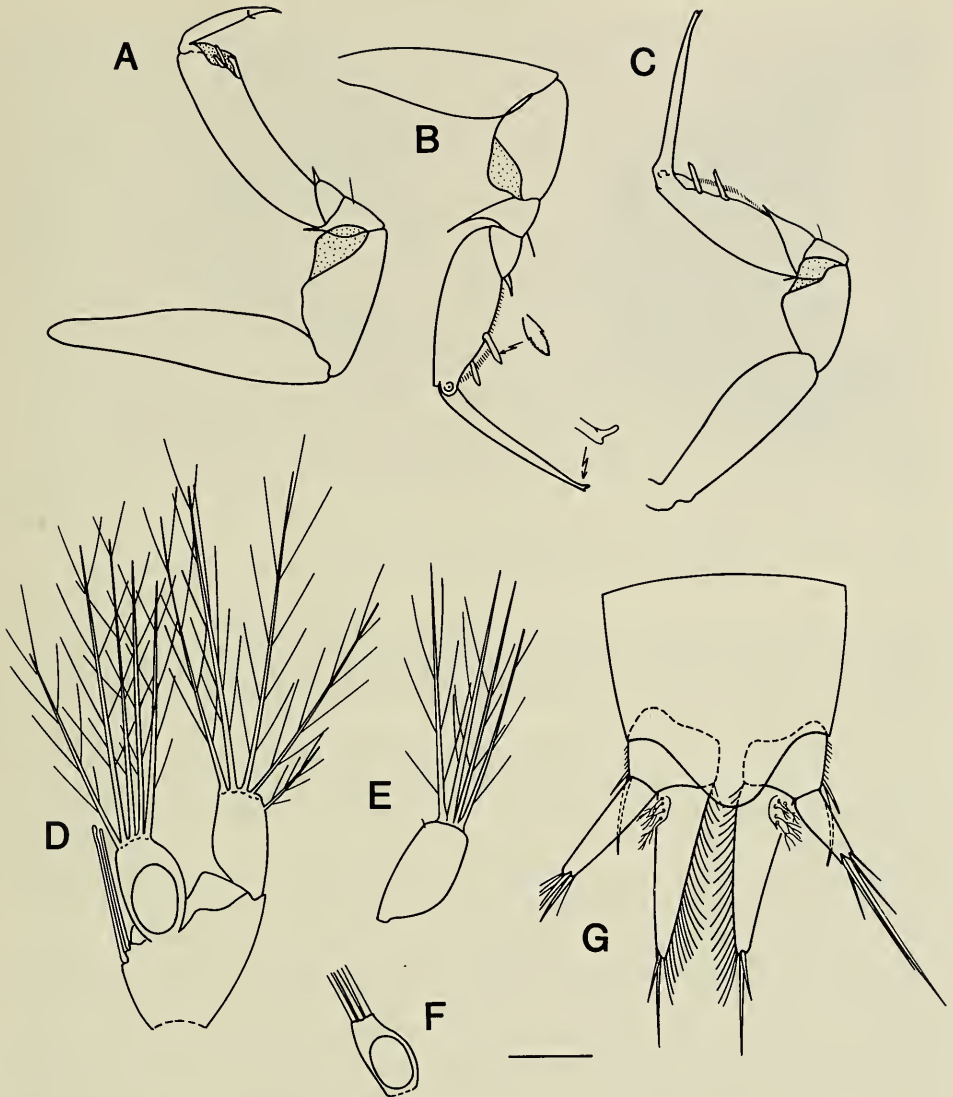


Fig. 2. *Cabirops montereyensis* n. sp. Cryptoniscus stage larva. A, Peraeopod V; B, Peraeopod VI; C, Peraeopod VII; D, Pleopod 2; E, Exopod of pleopod 1; F, Endopod of pleopod 5; G, Pleotelson (Dorsal aspect). All to the same scale (0.05 mm).

endopod obscured by medial fringe of setae, but several short terminal spines apparent.

Female: Immature stage A.—Body only slightly curved ventrally, broadly crescent-shaped in lateral aspect. Cephalon in form of distinct, hood-shaped rostrum. No appendages evident. Peraeon indicated by series of deep, ventral furrows and 7 large, fleshy, dorsal lobes. First dorsal lobe indented and hood-shaped, remaining lobes approximately conical. Lobes IV–VI larger than others. No trace of peraeonal

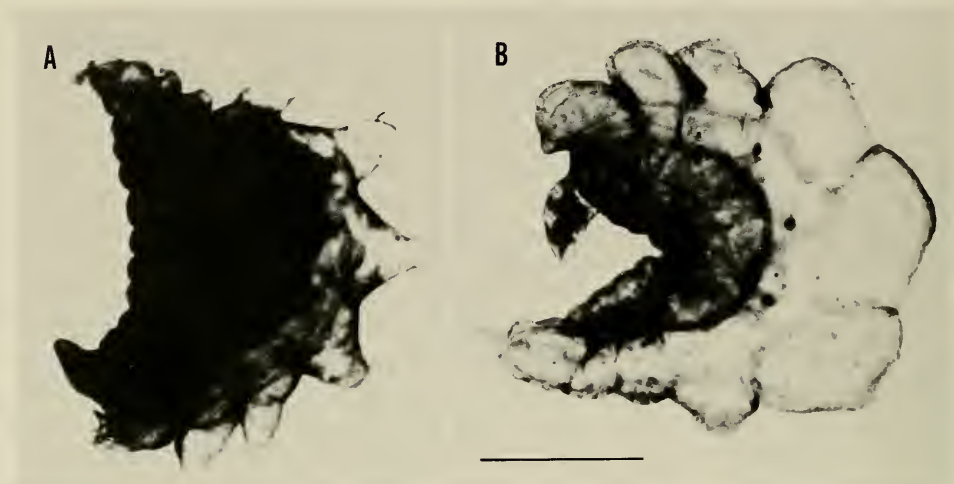


Fig. 3. *Cabirops montereyensis* n. sp. Females. A, Immature female—Stage A, paratype (USNM 205285); B, Immature female—Stage B, paratype (USNM 205283). Scale bar is 0.5 mm.

appendages. Longitudinal tracks of chitinous ribbing along bases of dorsal lobes. Transverse tracks along ventrolateral margins of peraeonal segments. Pleon indicated by 4 ventral furrows and 4 weakly defined dorsal lobes, followed by fleshy, conical tail piece.

Immature stage B.—Body in lateral aspect highly recurved into characteristic U-shape of *Cabirops* females. Dorsal peraeonal lobes more inflated than in previous stage, ventral furrows less distinct. Chitinous ribbing more distinct. No appendages.

Host.—*Aporobopyrus muguensis* Shiino. In branchial cavity of the porcellanid crabs *Pachycheles rudis* Stimpson and *Pachycheles pubescens* Holmes.

Type-locality.—On pilings on Wharf #2, Monterey Bay, California.

Disposition of types.—National Museum of Natural History, Smithsonian Institution. Holotype cryptoniscus (USNM 205282), accompanying paratype female (USNM 205283), and their hosts (USNM 205284) collected 4 Mar 1983. Paratype female and three accompanying cryptoniscus larvae (USNM 205285) and their hosts (USNM 205286) collected 12 Nov 1982. All specimens from type-locality.

Etymology.—The specific name refers to the type-locality.

Variation.—Discrete variation in the cryptoniscus was seen only in pleopodal setation. One individual had two posterolateral plumose setae on one exopod; the contralateral pleopod was normal.

Remarks.—Several characters of the *C. montereyensis* cryptoniscus have rarely or never been described in *Cabirops*. The presence of sensory setae on the fourth peduncular article of the second antenna (Fig. 1C) has been described only in *C. marsupialis* (Caroli) (Restivo 1975), whereas those on the uropodal endopod (Fig. 2G) of *C. montereyensis* represent new characters for the genus. *Cabirops montereyensis* is only the second species in which a setal comb has been reported on the dactyl of peraeopod III (in *C. orbionei* Bourdon it is also found on the dactyli of peraeopods IV and V). The bifid dactyli of peraeopods VI and VII (Fig. 2B, C) are apparently unique.

In those species of *Cabirops* in which a developmental sequence of females has been described, there are profound morphological changes from the cryptoniscus to the mature female (Attardo 1955; Restivo 1971, 1975). Comparisons between the females of different species are hampered by the lack of information on this developmental progression in most species; the females of *C. montereyensis* (Fig. 3) can be compared only with those few species in which the earliest immature forms have been described. Relative to these other species, *C. montereyensis* differs in having a larger rostrum, and in the greatly inflated dorsal lobes and more pronounced ventral furrows of the peraeon. Other general features of the genus, such as the well-developed lateral plates and the marsupium, typically develop at a later stage than so far encountered in *C. montereyensis*.

Cryptoniscus larvae of *Aporobopyrus* were not found in any material from Monterey Bay. They were, however, occasionally found in samples collected in southern California. These larvae have the typical characteristics of bopyrid cryptoniscus larvae and are easily differentiated from those of *Cabirops montereyensis* by the following features:

1. Smaller size and narrower body (0.76 mm long \times 0.24 wide).
2. Second antenna with 8 articles (4 peduncular and 4 flagellar).
3. All peraeopods gnathopodal.
4. Posterior margin of coxal plates entire.
5. Basis of uropod massive and exopod about 3 times the length of the endopod.
6. Posterior margin of pleotelson with denticles.

Affinities and Relationships within the Genus

The genus *Cabirops* presents a number of taxonomic and nomenclatural problems. Although the species have been reviewed several times recently (Nielsen and Stromberg 1965; Lemos de Castro 1970; Restivo 1971, 1975), there are differences of opinion about what species constitute the genus. It currently contains one species generally believed to belong elsewhere, and some reviews do not include species described under other names, but subsequently added to *Cabirops*.

Cabirops serratus Bourdon has a number of characteristics unknown in other species of the genus (Nielsen and Stromberg 1973), most notably: teeth on the posterior margin of first-antennal article 1, an indentation on the posterior margin of the telson, and medioventral tubercles on the pleon. The species is being transferred to a new genus (Bourdon, pers. comm.) and will not be treated as a *Cabirops* here.

The relationship of *Cabirops* and *Paracabirops* Caroli has been historically troublesome. Reverberi (1950, 1952) first indicated the presence of several species of *Cabirops* in Italy parasitic on *Bopyrina ocellata* (Czerniavsky) [as *B. virbii* (Waltz)] and *Phryxus virbii* (Giard and Bonnier). Caroli (1953) instituted the new genus *Paracabirops* for *P. marsupialis*, to which he ascribed these hosts and added *Gyge branchialis* Cornalia and Panceri and another *Phryxus* sp. Unfortunately, Caroli's description was based solely on the female morphology of the *Gyge* parasite, and provided no information on the cryptoniscus. Romano (1953) incompletely described (without a name) the *Cabirops* from *B. ocellata*, and Attardo (1955) subsequently synonymized *Paracabirops* with *Cabirops*, also on the basis of individuals from *B. ocellata*. Subsequent description of the parasite from *Gyge*

(Reverberi and Catalano 1963) suggested specific differences between this form and that on *Bopyrina*, although the justification for a distinct genus was questioned (Nielsen and Stromberg 1965; Bourdon 1966). The junior synonymy of *Paracabirops* has recently been established by Restivo (1975), who provided the first complete description of the parasite of *Gyge*. She further suggested (Restivo 1975) that the *Gyge* parasite is distinct from that on *Bopyrina*. Unfortunately, the parasite of *Bopyrina* has generally been designated as *Cabirops marsupialis*, although that nomenclature is inaccurate (Nielsen and Stromberg 1965). The reduction of *Paracabirops* to a junior synonym of *Cabirops* requires that *C. marsupialis* (Caroli) be reserved for the *Gyge* parasite. The *Bopyrina* parasite is therefore without a valid name, and furthermore cannot be attributed to Attardo (1955), since she clearly regarded it as synonymous with the species described by Caroli. I will refer to the *Bopyrina* parasite as *Cabirops* sp. Romano, since she was the first to describe it. Still unsettled is the status and identity of the form(s) reported from *Phryxus* spp. (Reverberi 1950, 1952; Caroli 1953). Restivo (1975) has suggested that this parasite may represent another species, as yet undescribed.

The parasite of *Bopyrina* joins three other species which have been described and assigned to *Cabirops* but never named. Giard and Bonnier (1888) described a form from Dutch Malaysia (probably Amboine Island) which they thought was the bopyrid cryptoniscus of one of their new genera—*Probopyrus* or *Palaegyge*. Bonnier (1900) later assigned it provisionally to *Cabirops*, and Carayon (1942) and Shiino (1942) independently concurred. The host is uncertain since the cryptoniscus was in a bottle containing two species. Modern opinion is that *Palaegyge* is a junior synonym of *Probopyrus* (reviewed by Markham 1974); therefore, the host can be identified at least to *Probopyrus*. Indeed, one of the potential host species was *P. ascendens* (Semper), from which the female of *C. lernaedisoides* (Kossmann, 1872) was originally described from the Philippines (Caroli 1953). It is possible, although by no means certain, that the *Cabirops* described by Giard and Bonnier (1888) represents the unknown male of *C. lernaedisoides*. Another species, described by Stebbing (1910) as a parasite of *Trapezicepon amicum* (Giard and Bonnier), was subsequently added to *Cabirops* by Shiino (1942). Finally, Bourdon (1966) described an unnamed species from *Scyrracepon levis* Barnard which is similar in many respects to the species described by Stebbing, but which must for now be regarded as unique.

Excluding *C. serratus*, the genus is currently represented by 15 species, four of which are not named. Cryptoniscus larvae are known for all but *C. lernaedisoides*. In an effort to infer systematic relationships within the genus, and the probable affinities of *C. montereyensis*, I have surveyed the morphological data available on the 14 species known as larvae. Although a number of characters vary within *Cabirops*, much of this variation probably represents incomplete or inaccurate description. For example, the setation of the uropodal endopod (specifically the medial fringe and the dorsolateral setae) varies in its presence or absence. The distinction, however, is primarily between descriptions prior to Bourdon's (1966) study and those made more recently. There are also differences reported in the number of setae on the pleopodal endopods, although most recent descriptions indicate setation typical of the superfamily (c.f. Nielsen and Stromberg 1973). In contrast to these characters, however, some of the morphological variation in *Cabirops* may provide insight into intrageneric relationships. I have concentrated on three characters in the present summary: the coxal plate dentition

formulae for the seven peraeonal segments, the relative development of the internal apophysis of the second peduncular article of antenna 2, and the dactyli of peraeopods I and II. These characters, along with the classification of both the bopyrid and decapod hosts of each species of *Cabirops* are summarized in Table 1. The bopyrid classification follows the general scheme of Shiino (1965), with subfamily names following more recent conventions (e.g. Markham 1974); the decapod classification follows Bowman and Abele (1982).

Two characters, the coxal plate dentition formulae and the nature of the gnathopodal dactyli, suggest that the currently known *Cabirops* fall into two basic groupings of species (Table 1). The first grouping is of those species in which the coxal plates of the anterior peraeonal segments have multiple teeth, 2–3, but the latter segments (particularly PVI and PVII have only a single process. The second grouping includes those species in which multiple teeth (2–3) are found along the entire sequence of peraeonal segments. Additional evidence for these groupings comes from information on the gnathopodal dactyli; all known species of the first group have bifid dactyli, whereas three of four species in the second group have simple dactyli. It is, furthermore, noteworthy that all of the species classified in the first group are parasites of bopyrids of the subfamilies Pseudioninae and Orbioninae, whereas those classified in the second group are all described either from Ioninae or Bopyrinae.

It is interesting, however, that not all characters show this pattern of species distribution. In particular, the strength of development of the antennal apophyses varies. This variation is not correlated with the previous two characters (and hence bopyrid host distribution), but instead shows a strong association with the decapod host (Table 1). Well-developed antennal apophyses are associated with crab hosts, whereas the processes are weak or absent in species from Thalassinidea and shrimps. At present, it is unclear whether this latter pattern reflects differentiation within the primary groupings (Table 1), or vice versa. Alternatively, these patterns may be spurious; other, as yet undescribed, characters may better reflect the systematics of the genus. There are likely to be many more species added to *Cabirops* (Markham 1974, 1979; Restivo 1975; Bourdon and Bruce 1979; Bourdon, pers. comm.), and attempts to define intrageneric relationships may be premature. At present, however, the distribution of coxal plate denticles and the morphology of the anterior dactyli suggest a pattern of relationships that is attractive, particularly in its correspondence with the known host-parasite relationships.

On the basis of coxal plate dentition, *C. montereyensis* is indistinguishable from two previously described species, *C. codreanui* and *C. orbionei*. There are further similarities between these three species in characters of the second antenna, and of the peraeopods (Table 1). Indeed, the setal comb on the dactyl of PIII (Fig. 1F) of *C. montereyensis* is a character shared only with *C. orbionei* as far as is currently known. Nevertheless, there are distinct characters separating these species in the first antenna (particularly the second article), the second antenna (articles 2, 3 and 4), and the peraeopods (especially 6 and 7).

Incidence of *Cabirops montereyensis* on *Aporobopyrus muguensis*

Collection records for *C. montereyensis* from Monterey Bay are summarized in Table 2. The species was obtained on five occasions, generally whenever the

Table 1.—Morphological characters and host distributions of *Cabirops* species cryptoniscus larvae.

Species	Coxal plate dentition							Dactyli of P I and P II	Bopyrid subfamily	Antenna 2 article 2 internal apophysis	Decapod infra-order
	Plate number										
	1	2	3	4	5	6	7				
<i>C. codreanui</i> Bourdon, 1966	2	3	3	3	3	1	1	bifid	Pseudioninae	strong	Anomura
<i>C. montereyensis</i> n. sp.	2	3	3	3	3	1	1	bifid	Pseudioninae	strong	Anomura
<i>C. perezii</i> Carayon, 1942	3	3	3	3	1	1	1	?	Pseudioninae	strong	Anomura
<i>C. ibizae</i> Bourdon, 1966	2	3	3	3	1	1	1	bifid	Pseudioninae	strong	Anomura
<i>C. reverberii</i> Restivo, 1971	3	3	2	1	1	1	1	bifid	Pseudioninae	none	Thalassinidea
<i>C. pseudione</i> Lemos de Castro, 1970	3	2	1?	1?	1?	1?	1?	bifid	Pseudioninae	none	Thalassinidea
<i>C. marsupialis</i> (Caroli, 1953)	3	3	1					bifid	Pseudioninae	none	Thalassinidea
<i>C. orbionei</i> Bourdon, 1972	2	3	3	3	3	1	1	bifid	Orbioninae	weak	Penaeoidea*
<i>C. tuberculatus</i> Shiino, 1942	2	3	3	3	≥2	≥2	≥2	simple	Ioninae	strong	Brachyura
<i>Cabirops</i> sp. Bourdon, 1966†	2	3	3	3	3	3	3	bifid	Ioninae	strong	Brachyura
<i>Cabirops</i> sp. (Stebbing, 1910)†	2	3	?	3	3	3	2?	?	Ioninae	strong	Brachyura
<i>Cabirops</i> sp. (Giard and Bonnier, 1888)†	3	3	3	3	3	3	3	simple	Bopyrinae	none	Caridea
<i>C. lobiformis</i> Lemos de Castro, 1970			3?	3?				?	Bopyrinae	?	Caridea
<i>Cabirops</i> sp. Romano, 1953†								simple	Bopyrinae	none	Caridea

* Superfamily of the suborder Dendrobranchiata; all other decapod hosts are in the suborder Pleocyemata.

† See text for discussion.

Table 2.—The incidence of *Cabirops montereyensis* on *Aporobopyrus muguensis* at Monterey Bay. Unless otherwise noted, the hosts were removed from the branchial chambers of *Pachycheles rudis* collected amongst *Phyllochaetopterus prolifica* Potts tubes.

Date	No. of <i>A. muguensis</i>	No. with <i>Cabirops</i> larvae	Total no. of <i>Cabirops</i> larvae	No. of hosts with <i>Cabirops</i> females
4 January 1982	10	2	6	0
1 February 1982	4	0	0	0
8 March 1982*	9	4	11	0
12 November 1982	2	1	6	1
7 January 1983	1	0	0	0
4 March 1983	10	3	13	1
29 May 1983	1	0	0	0
10 September 1983	2	0	0	0
1 March 1984	1	1	21	0
Totals	40	11	57	2

* Crabs from a kelp holdfast, 3 of 9 *Aporobopyrus* were from *Pachycheles pubescens*, 2 of 3 were parasitized.

host was relatively common. No *Cabirops* were found infesting 27 individuals of *Bopyrella calmani* (Richardson) parasitizing *Synalpheus lockingtoni* Coutière in the same set of samples (Sassaman et al. 1984). To date, *C. montereyensis* is known only from the type-locality; no individuals were obtained among two hosts collected at Point Piedras Blancas (San Luis Obispo Co.) or among 19 *A. muguensis* collected at Venice (Los Angeles Co.) and Laguna Beach (Orange Co.) in southern California. In the Monterey collections, there was no significant difference between the incidence frequencies among the nine samples (G-statistic) and the overall incidence of cryptoniscus stage larvae was 28%, quite comparable to the incidences of *C. codreanui*, *C. ibizae*, and the *Cabirops* from *Bopyrina* (Bourdon 1968). However, only two of the 40 hosts from Monterey contained female *Cabirops*.

The number of cryptoniscus larvae per host was quite variable, ranging from one to 21, and the distribution was non-random when tested against an expected Poisson distribution. Larvae were aggregated in their occurrence in selected hosts, most often in those hosts containing a *Cabirops* female. Medium-sized hosts (2.5–3 mm in length) were most commonly infected. Six of the eleven occurrences of *Cabirops* were with female *Aporobopyrus* which lacked their own male partner; however, both of the *Cabirops* females were found in *Aporobopyrus* which were paired with their males. In other species of *Cabirops*, female parasites often are found only in female hosts that are unaccompanied by males (Bourdon 1966; Restivo 1971).

Eight parasites and the host female collected in March 1984 (Table 2) were maintained in vitro (at 11°C) to determine whether the cryptoniscus larvae would transform in the laboratory. Several larvae maintained continuous contact with the host for several days, remaining within the marsupium or burrowed among the oostegites, while the other larvae swam about the culture dish. None of the larvae transformed or molted. After about five days, the host female was moribund and was removed, and after two more days the *Cabirops* themselves were moribund.

Acknowledgments

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