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Oculophryxus bicaulis, a New Genus and Species of Dajid Isopod Parasitic on the Euphausiid *Stylocheiron affine* Hansen

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Abstract—Shields J. D. & Gómez-Gutiérrez J. 1996. *Oculophryxus bicaulis*, a new genus and species of dajid isopod parasitic on the euphausiid *Stylocheiron affine* Hansen. *International Journal for Parasitology* 26: 261–268. A new genus and species of dajid isopod is described from the euphausiid *Stylocheiron affine* Hansen. The isopod is a member of the Dajidae Krøyer, 1842, which are ectoparasites of shrimp, mysids, and krill. The female of the new genus and species is unique in its attachment to the eyestalk of its euphausiid host. The well-developed antennae encircle the eye peduncles of the host. The parasite presumably feeds by sucking blood directly from the head of the euphausiid. The new genus can be distinguished from other genera by the elongate, spoon-shaped antennae, the number of pereopods, and the indistinct abdomen. The male parasite attaches to the posterior of the female near the margin of the marsupium. The male can be distinguished from other genera by the rudimentary 7th pereopod. Epicaridia, microniscus and cryptoniscus larvae were not observed. The parasite was found in samples taken during 7 oceanographic surveys made along the west coast of Baja California. The parasite was found on the furciliae, juveniles, and immature males and females of *S. affine*. Female isopods may castrate their hosts as none of the infected hosts ($n = 27$) had reached maturity. Of the 3 eco-phenotypes of *S. affine* that are found in the region, the isopod apparently prefers the California Current morph. However, in the Gulf of Mexico, a similar parasite was found on *S. longicorne* Sars.

Key words: Oculophryxus bicaulis; Epicaridea; Dajidae; parasite; isopod; *Stylocheiron affine*; *S. longicorne*; Euphausiacea; taxonomy; eastern Pacific.

INTRODUCTION

The Dajidae occur in all oceans and are ectoparasites of euphausiids, mysids and shrimps. The type genus and species of the Dajidae is *Dajus mysidis* Krøyer, 1842, but several of the described genera bear little resemblance to the type. Female dajid isopods are characteristically attached to the postero-dorsal carapace, abdomen, or ventral thorax of their hosts. A single dwarf male is usually found attached to the abdomen or marsupium of the female; but, in some cases, a female may have 2 or more attached males (Field, 1969). Prior to the present paper, there were 17 known genera of dajid isopods, with a total of 48 species. However, the morphology and host of one species, *Paradajus tenuis* Nierstrasz & Brender à Brandis, which occurs in the branchial chamber of a crab (Nierstrasz & Brender à Brandis, 1923), suggest that it does not belong in the family. Two dajids have been described from species of *Stylocheiron: Branchiophryxus koehleri* Nierstrasz & Brender à Brandis parasitizes *S. carinatum* G.O. Sars and *S. affine*

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Hansen, while *B. caulleryi* Koehler parasitizes *S. longicorne* G.O. Sars (see Sebastian, 1970; Mauchline, 1980).

We describe a new genus and species of dajid isopod parasitic on the euphausiid *S. affine*. The new genus bears superficial resemblance to *Branchiophryxus* Caullery in that the females of both genera lack a distinct cephalon, thorax and abdomen, and each has only 4 pereopods. The mode of attachment of the new form is, however, radically different to that of other genera. The new genus possesses highly modified, unsegmented antennae that are entwined around the eye peduncles of the host. In contrast, females of other genera do not use antennae for attachment; they lack antennae, possess weakly developed antennae, or posses antennae that are modified into flat oral lappets.

MATERIALS AND METHODS

Euphausiids were collected during nine oceanographic cruises made along the west coast of Baja California, Mexico (Table 1). The sampling grid extended from 23° to 29° N, with stations located up to 160 km offshore. Zooplankton samples were collected at each station by means of bongo nets with 500-μm mesh towed from 210 m to the surface as in Smith & Richardson (1977). Zooplankton were fixed immediately in 4% formalin buffered with sodium borate. The G_H statistic is from Sokal & Rohlf (1981).

Large plankton samples were divided using a Folsom splitter (Smith & Richardson, 1977). Depending on the density of the euphausiids, 25, 50, or 100% of each sample was examined. Samples with a zooplankton biomass of less than 10 ml were analysed in their entirety. Euphausiids were sorted, identified, sexed, and counted. The sexual maturity of *S. affine* was determined by the presence of the spermatophore of the male or the presence of ripe ovaries, and ovigerous sacs of the female (Mauchline & Fisher, 1969). The total length of each host was measured to the nearest 0.01 mm using an ocular micrometer in a stereomicroscope. The total length and width of the body of each female parasite were similarly measured, while those of the male were measured with a compound microscope. Specimens prepared for scanning electron microscopy (SEM) were processed through an alcohol dehydration, dried with a critical point dryer, mounted on stubs with colloidal graphite, coated with gold–palladium at 20 nm (Anatech

Table 1—Station data, host data, and prevalences of *Oculophryxus bicaulis* gen. et sp. nov. on *Stylocheiron affine* off Baja California, Mexico. Only stations having infected euphausiids are shown. The sex of juvenile euphausiids could not be determined. Prevalence is the number of infected hosts (n_I) divided by the total number of hosts (n_T) given as a percentage

Date	Latitude north	Longitude west	*Stylocheiron* stage	*Stylocheiron* length	Prevalence n_I/n_T	Prevalence %
2.vi.1986	26°03′9″	113°39′00″	Furcilia*	3.05	1/3	33
4.vi.1986	25°09′7″	113°05′40″	Female	6.10	2/4	50
			Juvenile	3.29		
5.vi.1986	24°01′2″	112°23′10″	Juvenile	4.88	1/17	6
5.vi.1986	23°33′5″	112°31′30″	Juvenile	5.31	2/19	11
			Juvenile	5.80		
16.vi.1986	24°11′2″	112°04′50″	Juvenile	.	1/17	14
17.vi.1986	24°09′9″	112°53′70″	Juvenile	4.15	1/114	1
19.viii.1986	24°01′2″	112°23′40″	Juvenile	3.78	1/28	4
20.viii.1986	24°19′9″	112°34′80″	Juvenile	4.21	2/87	2
			Male	5.43		
20.viii.1986	24°35′5″	112°44′40″	Furcilia	3.11	1/39	3
20.viii.1986	24°09′9″	112°53′70″	Juvenile	4.03	1/64	2
11.vii.1987	26°57′0″	114°46′80″	—	.	1/20	5
12.vii.1987	26°15′3″	113°53′40″	Juvenile	3.35	1/12	8
10.x.1987	27°15′6″	114°54′15″	Juvenile	5.00	2/36	6
			Juvenile	4.09		
13.x.1987	25°23′6″	113°20′62″	Female	5.79	1/34	3
28.vii.1988	20°13′0″	117°07′80″	Female	6.47	3/49	6
			—	.		
			—	.		
28.vii.1988	28°52′3″	117°47′45″	Female	5.49	3/125	1
			Juvenile	5.19		
			Juvenile	3.66		
30.vii.1988	27°09′3″	116°36′14″	Male	5.92	1/26	4
31.vii.1988	25°27′8″	114°36′13″	Female	6.95	1/12	8
22.ix.1991	26°24′5″	116°31′50″	Juvenile	4.70	3/41	7
			Female	5.49		
			Female	7.02		
23.ix.1991	26°39′6″	116°55′10″	Female	6.53	1/22	5

*Furcilia in the F_4 stage (5 setose pleopod and 5 telson spines).

Table 2—Comparative generic characters of female Dajidae

Genus	Distinct cephalon	Presence of segmented thorax	No. of pereopods	No. of abd. segments	No. of pleopods	No. of uropods	Shape of maxilliped	No. of oostegites	Shape of sternal plate
Allophryxus Koehler, 1911	+	+	5	5+	3	1	narrow	5	?
Antephrya Schultz, 1978	+	+	5	–	–	–	?	?	?
**Arthrophryxus* Richardson, 1908	+	+	4	+	–	rud	narrow	1–2	rud
Aspidophryxus G.O. Sars, 1882	+	±	5	–	–	–	broad	1	broad
Branchiophryxus Caullery, 1987	–	±	4	–	–	1	broad, rud	4	–
Colophryxus Richardson, 1908	+	+	5	–	–	–	?	?	?
Dajus, Krøyer, 1842	+	±	5	6	rud	0–1	narrow	5	trigonal
[+] *Dolichophryxus* Schultz, 1977	not described								
**Heterophryxus* G.O. Sars, 1885	–	+	5	–	–	–	?	5	?
**Holophryxus* Richardson, 1905	+	±	5, 7	–	–	–	backward	5	ridge
**Notophryxus* G.O. Sars, 1882	+	–	3, 5	5	0–1	–	broad	0–5	?
Oculophryxus present study	–	±	4	–	–	–	narrow	1–2?	–
Paradajus Nierstrasz & Brender à Brandis, 1923	–	+	6	4	–	–	broad	1	hexagonal
[+] *Paraspidophryxus* Schultz, 1977	not described								
**Prodajus* Bonnier, 1903	+	–	5	+	–	1	narrow?	1–3	ridge
**Prophryxus* Richardson, 1909	+	+	5	5	rud	0–1	?	2	?
Streptodajus Nierstrasz & Brender à Brandis, 1923	–	+	5	+	–	–	broad	1	trigonal
**Zonophryxus* Richardson, 1904	–	±	5–6	5 rud	–	–	broad	5–6	trigonal

*Specimens examined by authors at the U.S. National Museum.

[+]Known only from cryptoniscus stage.

+, Character present; –, character absent; ±, traces of character present; rud., rudimentary; ?, unknown; Abd., abdominal.

Corp., Hummer V), and examined with an SEM (AMR 1000) at 20 kV. Measurements are in micrometers (μm), and are given as the mean (range, ±S.D.). In some cases, measurements were only obtained from single specimens; these are given without ranges.

TAXONOMY

Oculophryxus, *n. gen.*

Diagnosis.

Female. Body symmetrical, small pyriform; body regions indistinct. Cephalon reduced. Anterior lamella absent. Buccal region subjacent to anterior margin. Antennules rudimentary. Antennae well developed, elongate, unsegmented; ending in spoon-like tips. Sternal plate indistinct. Female with 4 pereopods. Thorax with traces of segmentation; continuous with abdomen. Abdomen indistinct, indeterminate from thorax, without segmentation, without appendages and uropods.

Male. Body tiny, curved ventrally. Cephalon blunt, rounded, fused with first segment of thorax. Paired antennules and antennae present. Thorax with 5 free segments. Seventh segment of thorax fused to abdomen. Seven pereopods; limb 7 rudimentary. Abdomen without segmentation, without appendages.

Type species. *Oculophryxus bicaulis*, new species, by present designation and monotypy.

Etymology. The generic name refers to the habitus of the parasite [oculus = eye (L), Phryxus = a rider of the ram who fled with the Golden Fleece (L, G)]. The gender is masculine.

Remarks. The female of *Oculophryxus* can be distinguished from those of other genera by the presence of its highly-developed antennae. Other genera lack antennae, possess only weakly developed antennae, or have antennae modified as lappets. Females of *Oculophryxus*, *Branchiophryxus*, and *Heterophryxus* G.O. Sars share the reduced or inapparent cephalon, and abdomen (Table 2). In addition to the highly-modified antennae, *Oculophryxus* can be distinguished from *Branchiophryxus* by the lack of discrete oostegites and uropods. It can be distinguished from *Heterophryxus* by the highly developed 5th pereopod, and well-developed oostegites of the latter genus.

The males of the different genera have few distinguishing characters (Table 3). The male of *Oculophryxus* is similar to that of *Holophryxus* and *Heterophryxus* in the arrangement of the thoracic segments, and the unsegmented abdomens. The male of *Oculophryxus* can be distinguished from other genera by the rudimentary seventh pereopod.

Oculophryxus bicaulis *n. sp. (Figs 1–11)*

Description.

Female (based on 8 mature specimens). Body pyriform, cream-colored, segmentation not apparent; length, 1034 μm (920–1280, ±115 μm) by 634 μm (430–790, ±109 μm). Cephalon reduced (Figs 1–2). Antennules rudimentary. Antennae highly-modified, long (494 μm by 85 μm), unsegmented, ending with

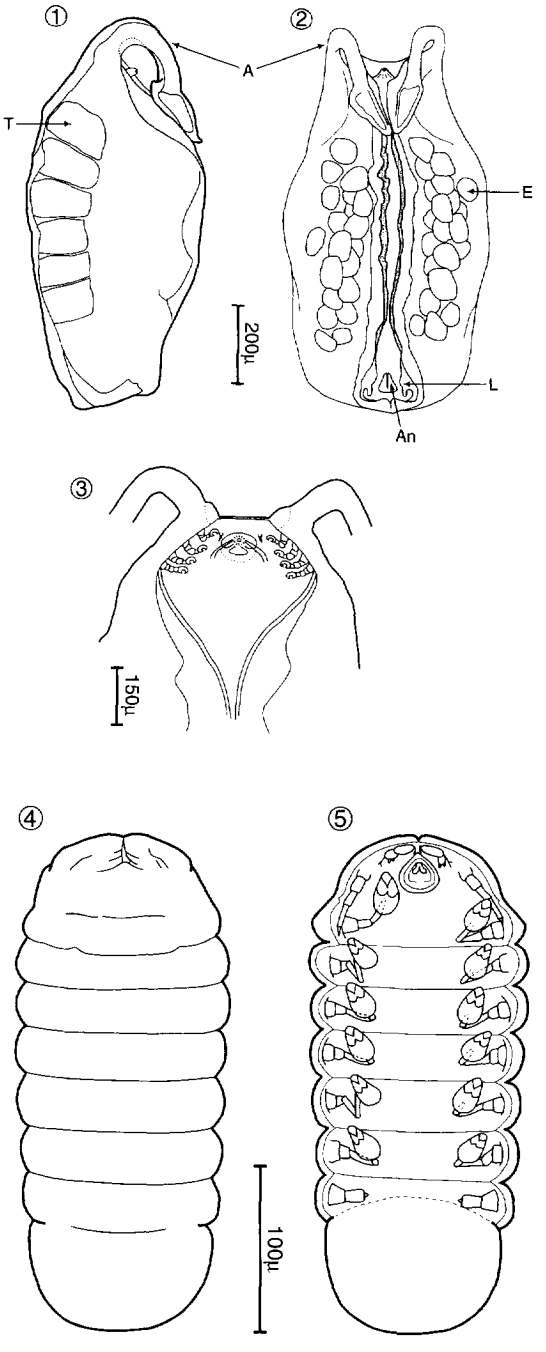
Table 3—Comparative generic characters of male Dajidae

Genus	No. of thoracic segments	No. of abdominal segments	Presence of pleopods	No. of uropods
Allophryxus Koehler, 1911	1+6	4	—	rud
Antephrya Schultz, 1978		not described		
Arthrophryxus Richardson, 1908	6	6	—	—
Aspidophryxus G.O. Sars, 1882	1+6	5	—	1 pair
Branchiophryxus Caullery, 1897	1+6	—	—	—
Colophryxus, Richardson, 1908	1+6	5–6	—	—
Dajus, Krøyer, 1842	1+6	—	—	rud
[+]*Dolichophryxus* Schultz, 1977		not described		
Heterophryxus, G.O. Sars, 1885	1+5+1	—	—	—
Holophryxus, Richardson, 1905	1+5+1	—	—	—
Notophryxus, G.O. Sars, 1882	7	0, 6?	—	—
Oculophryxus, present study	1+5+1	—	—	—
Paradajus Nierstrasz & Brender à Brandis, 1923		not described		
[−]*Paraspidophryxus* Schultz, 1977		not described		
Prodajus, Bonnier, 1903	1+6	6	rud	1 pair
Prophryxus, Richardson, 1909		not described		
Streptodajus, Nierstrasz & Brender à Brandis, 1923		not described		
Zonophryxus, Richardson, 1904	1+6	—	—	1 pair

[+]Only known from cryptoniscus stage.

+, Character present; −, character absent; ±, traces of character present; rud, rudimentary.

Formula for thoracic segments given as the number of segments fused with the cephalon + the number of free thoracic segments + the number of segments fused with the abdomen.



Figs 1–5. *Oculophryxus bicaulis*, new genus and new species.

Fig. 1. Ovigerous female, lateral view, holotype.

Fig. 2. Ovigerous female, ventral view, holotype.

Fig. 3. Detail of cephalic region of female, holotype.

Fig. 4. Male, dorsal view, paratype from holotype female.

Fig. 5. Male, ventral view, paratype from holotype female. A, antenna; An, anus or cloaca; E, embryo; L, lappets; T, traces of thoracic plate.

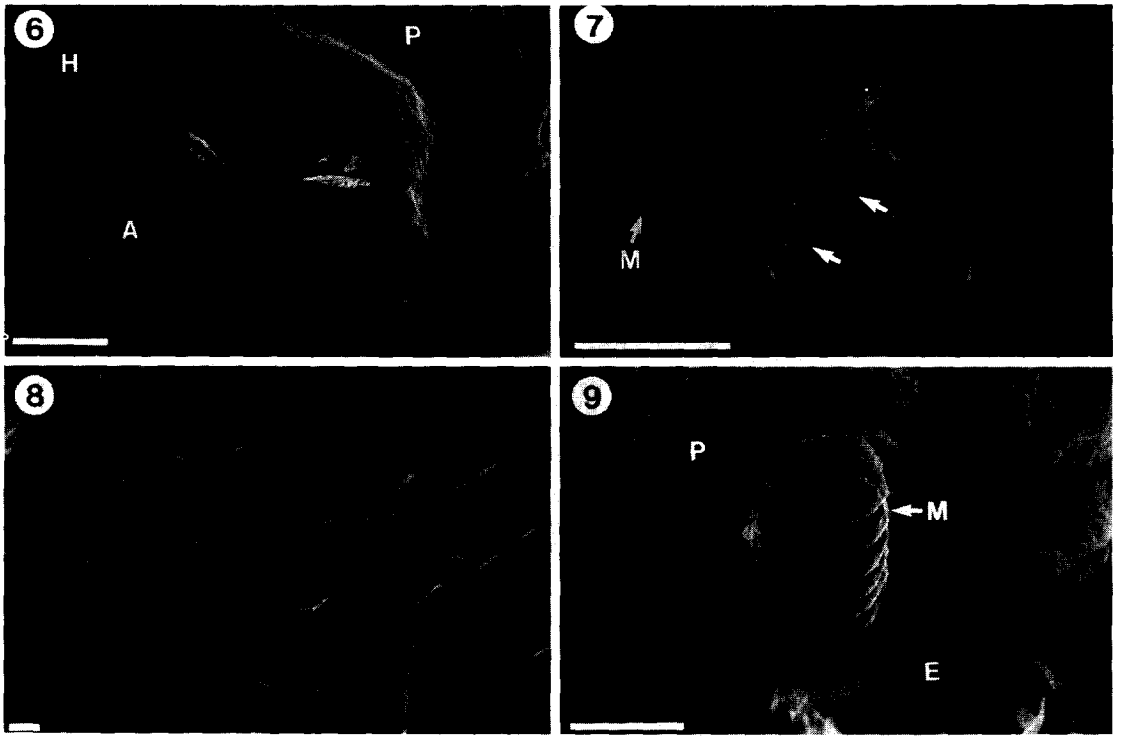
spoon-like tips (Fig. 6). Oral cone with 2–3 layers of sensillae at distal tip (Fig. 7); 74-μm-high with a base of 35 μm. Mandibles styliform, 69 μm by 15 μm at base. Maxillipeds narrow, straight, projecting posteriorly, 32 μm long by 5 μm at base, ending with a single point. Thorax inflated posteriorly, with traces of segmentation. Sternal plate small, indistinct, elliptical, 57 μm by 27 μm. Four subchelate pereopods, 5-segmented, subequal in length, 100 μm long by 20 μm in breadth (Figs 2, 3). Oostegites inapparent, presumably fused into a single marsupial pouch. Internal surface of marsupium covered with squamate spinules (Fig. 8). Brood pouch with pair of posterior, rudimentary lappets, 42 μm by 30 μm. Abdomen indistinct. Pleopods and uropods absent. Embryos range in size from 79 μm to 86 μm. Epicaridea, microniscus, and cryptoniscus larvae not observed.

Male (based on 3 specimens). Total length of males, 310 μm (290–330, ±20 μm); total width, 103 μm (100–110, ±6 μm). Attached to posterior of female (Fig. 9). Cephalon blunt, rounded, fused with first segment of thorax (Figs 4, 5). Antennules 2-segmented, with filiform, bifid epipod (Figs 10, 11). Antennae 5-segmented, lateral to oral cone; length 49 μm. Oral cone projecting anteriorly, height 42 μm, base 27 μm, with 2 short, distal projections (Fig. 10). Mandibles styliform. Maxillipeds small, flap-like, posterior and subjacent to oral cone. Thorax with 5 free segments. Seventh segment of thorax fused to abdomen. First 6 pereopods 5-segmented, subchelate; approximate length of each pereopod 130 μm. Chelae pyriform. Pereopod 7 rudimentary, 2-segmented, ending in a single seta. Abdomen round, without segmentation, without appendages.

Material. **Holotype** (USNM no. 274134), female, 28 July 1988, Station 190.140, 21.10 h, 29° 13′ N, 117° 07′ W, collector: Jaime Gómez-Gutiérrez, (vial marked Type). **Paratypes** (USNM no. 274135): male found on holotype, 28 July 1988, Station 190.140, 21.10 h, 29° 13′ N, 117° 07′ W, collector: Jaime Gómez-Gutiérrez, (slide, with specimen mounted in Hoyer's Medium); female and male, 4 June 1986, Station 510.80, 01.40 h, 25° 9′ 7″ N, 113° 05′ 4″ W, collector: Jaime Gómez-Gutiérrez, (slide, with specimen mounted in Hoyer's Medium); female, 28 July 1988, Station 190.140, 21.10 h, 29° 13′ N, 117° 07′ W, collector: Jaime Gómez-Gutiérrez, (vial marked Para, with host); female, 22 September 1991, Station 350.2, 21.09 h, 26° 24′ N, 116° 31′ 5″ W, collector: Jaime Gómez-Gutiérrez, (vial marked Para no. 2). SEM material retained in the authors' collections.

Type host. *Stylocheiron affine* Hansen, 1910.

Site of infection. External, attached between the eyestalks of the host via elongate antennae.



Figs 6–9. Scanning electron micrograph of female *Oculophryxus bicaulis* infecting the euphausiid *Stylocheiron affine* (specimens in authors' collection).

Fig. 6. Attachment of the female dajid to the eye-stalk of the euphausiid; star, eyestalk of host; P, parasite; H, host; A, antenna. Scale bar = 100 μm.

Fig. 7. Detail of the oral cone with 2–3 layers of sensillae (arrows); M, styliform mandible. Scale bar = 10 μm.

Fig. 8. Detail of internal surface of marsupium with scale-like spinules. Scale bar = 1 μm.

Fig. 9. Male attached to the female; M, male; P, thoracic plate; E, host eye. Scale bar = 100 μm.

Type locality. North America, Mexico, west coast of Baja California, 29° 13′ N, 117° 07′ W.

Date of collection. 28 July 1988.

Additional material. A single specimen of *Oculophryxus* (presumably *O. bicaulis*) was found attached to the eyestalk of an immature female of *Stylocheiron longicorne*, G.O. Sars (USNM no. 135313). The host was collected in the Gulf of Mexico (25° 33′ 5″ N, 88° 27′ 5″ W) in 1966, from a trawl at 125–500 m.

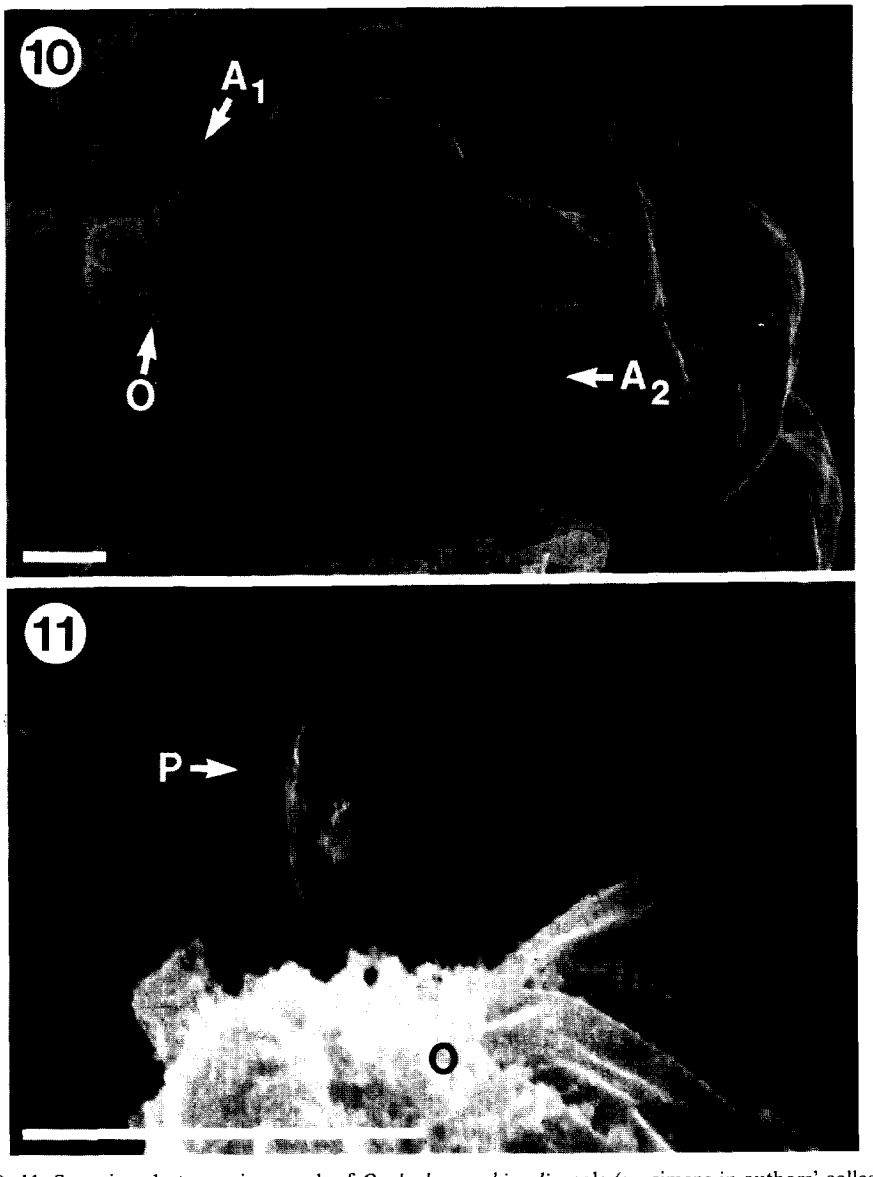
Etymology. The specific name refers to the elongate antennae [bi = two (L), −caulis = stalk (L)].

Remarks: *Oculophryxus bicaulis* is widely distributed along the west coast of Baja California (Table 1). The overall prevalence of *O. bicaulis* was 3.9% with a range of 1.0 to 50% (mean = 9%, S.D. = 12%, $n = 20$ stations, 9 surveys). The highest prevalences were found at stations with the lowest abundance of hosts. No seasonal trends were observed (Pooled by month, $G_H = 3.24$, d.f. = 5, ns). The parasite was found in 7 of 9 surveys; it was absent during surveys undertaken in November 1986 and December 1993 (Table 1). From 1986 to 1993, *S. affine* was present in 162 of 355 stations, with *O. bicaulis* present in 20 of the 162 stations.

Infections were more common in juvenile hosts ($n = 15$) than in larvae or adults ($n = 2$ and $n = 10$, respectively). More female hosts ($n = 8$) were infected than were males ($n = 2$) but the sex ratio of the host favored females in the populations (58–77% females, mean = 65 ± 6%, 7 months where samples had $n > 30$ adults; Gómez-Gutiérrez, unpublished data).

DISCUSSION

Oculophryxus bicaulis occupies an unusual location on its host. Its body faces the head of its host with the antennae of the parasite wrapped around the eyestalks of the euphausiid. *Aspidophryxus frontalis* Bonnier is found in a similar position on its mysid host but it attaches by means of its pereopods (Koehler, 1911). Species of *Heterophryxus* use their highly modified 5th pereopods to grasp the eyestalks of their euphausiid hosts but they are otherwise



Figs 10–11. Scanning electron micrograph of *Oculophryxus bicaulis* male (specimens in authors' collection).
Fig. 10. Cephalic region; O, oral cone, A1, antennule, A2, antennae. Scale bar = 10 μm.
Fig. 11. Detail of antennule with bifid epipod; O, oral cone; P, sensory projection. Scale bar = 10 μm.

attached to the dorsal carapace of their hosts (Gotto, 1983). Most dajid isopods occupy the postero-dorsal carapace, the ventral abdomen or thorax, or the branchial chamber of their hosts.

Two previous studies have examined surface details of adult Dajidae. Brandt (1993) showed that the hypostome of *Notophryxus clypeatus* Sars, 1885 is not fused into an oral cone, rather the maxillipeds, labrum, and mandibles are distinct and form a sucking tube. The oral cone of *O. bicaulis* may be derived from the fusion of the maxillae with the labrum. Both *O. bicaulis* and *N. clypeatus* bear ornamentation (sensillae or spinules) on their mouthparts that may assist in attachment while feeding on the host. Jones and Smaldon (1986) studied the cephalon of male *Holophryxus acanthephyrae*. The antennules of *H. acanthephyrae and O. bicaulis* are similar in that both bear a bidif epipod. The morphology of the feeding apparatus is, however, different between the 2 species. The oral cone of

O. bicaulis bears 2 distal projections while that of *H. acanthephyrae* is unadorned. Lastly, the marsupial spinules of *O. bicaulis* have not been previously reported for the Dajidae. They may function to retain embryos in the marsupium. Other genera have well-developed oostegites that may function in the same manner (e.g. *Holophryxus* spp.).

Oculophryxus bicaulis may castrate or impair the reproductive behavior of its host because none of the infected hosts were mature. While many parasitic crustaceans castrate their hosts, few dajids have been found in large enough numbers to investigate their effects on host reproduction. Black (1956) found that *Dajus mysidis* Krøyer inhibited the development of *Mysis* spp. in Canada, and Field (1969) reported that *Notophryxus lateralis* reduced the size of the gonads of *Nematoscelis difficilis*. The relatively large size of *O. bicaulis* (6–13% of the size of the host) and other dajids (e.g., *Holophryxus* spp.) in relation to that of their hosts could represent a significant drain on the host's metabolism, which may thus effect castration.

Chatton (1920) and Lindley (1978) describe the geographical distribution of crustaceans infected with protozoan parasites and suggest that neritic populations have a higher prevalence of parasitic infection than oceanic populations. We cannot support their hypothesis with the data from the present study because no significant difference was found in the prevalence of *O. bicaulis* from inshore vs offshore locations (pooled by location, $G_H = 0.0$, d.f. = 1, ns).

Stylocheiron affine has 5 eco-phenotypes in the Pacific Ocean: the Indo–Australian, Central, West Equatorial, East Equatorial, and California Current morphs (Brinton 1962, 1975). Three of these morphs can be found along the west coast of Baja California (West Equatorial, East Equatorial, and California Current). *Oculophryxus bicaulis* infects primarily the California Current morph. We speculate that the ratio of the widths of the lower and upper portion of the eyes of the host (a character used to differentiate morphs) may represent a factor in the successful transmission or attachment of the parasite, and may explain the prevalence of the parasite on the California Current morph. Alternatively, the probability of infection with the parasite may be higher in the California morph simply because the morph is at the center of its abundance off Baja California (Gómez, unpublished data). None the less, the presence of *Oculophryxus* sp. on a specimen of *S. longicorne* from the Gulf of Mexico, indicates that *O. bicaulis* or a related species can infect other species of *Stylocheiron*.

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