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Two species of deep-sea flabelliferan isopods from Taiwan (Crustacea: Peracarida: Aegidae, Anuropidae)

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Aega falcata sp. nov. is described from two female specimens from about 500 m off Taiwan. The species' most distinctive feature, which readily distinguishes it from all others described, is the flattened falcate plates of the two basal articles of the antennular peduncle. Three specimens of *Anuropus pacificus* Lincoln and Jones, 1973, are recorded from 400 to 500 m. These include a male, an ovigerous and a larvigerous female having numerous manca in the broodpouch. Given the rarity of specimens of *Anuropus*, all three forms, as well as the manca, are described in some detail.

KEYWORDS: Isopoda, Flabellifera, Aegidae, Anuropidae, Taiwan.

Introduction

The marine isopod fauna of Taiwan has received little attention, with only 15 records known specifically from the island, including three species of bopyrids (*Parabopyrella choprai* (Nierstrasz and Brender à Brandis, 1929), *Pseudostegias setoensis* Shiino, 1933, *Ione taiwanensis* Markham, 1995); four cirolanids (*Bathynomus doederleini* Ortmann, 1894, *Bathynomus decemspinus* Shih, 1972, *Excirrolana chiltonii* Richardson, 1905, see Bruce, 1986a), *Dolicholana enigma* Keable, 1999; seven cymothoids (*Ceratothoa guttata* (Richardson, 1910) (see Bruce and Bowman, 1989), *Cterissa sakaii* Williams and Williams, 1986, *Mothocya melanosticta* (Schioedte and Meinert, 1884) (see Bruce, 1986b), *Nerocila depressa* H. Milne Edwards, 1840, see Bruce, 1986a), *Ichthyoxenus formosanus* Harada, 1930, *Nerocila exocoeti* Pillai, 1954 and *Nerocila sigani* Bowman and Tareen, 1983 (see Bruce and Harrison-Nelson, 1988); and one aegid (*Renocila kohnoi* Williams and Williams, 1987). Soong (1992) reported *Bathynomus giganteus* A. Milne Edwards, 1879 from south-west Taiwan but the specimens were actually collected from Pratas Island in the South China Sea and not off the coast of Taiwan. Soong and Mok (1994) reported *Bathynomus doederleini* from the waters of eastern Taiwan.

Recently, the second author captured two unusual species of flabelliferan isopods from deep water during an ongoing faunistic survey of the large crustaceans of Taiwan. Close examination revealed that one belonged to a relatively rare genus, the other being new to science. The present report provides detailed descriptions of these two species, and again points to the presence of a diverse deep-sea fauna off Taiwan.

Material and methods

The specimens were collected from the by-catch of deep-sea commercial trawlers operating off the north-eastern coast of Taiwan. The specimens are deposited at the National Taiwan Ocean University, Keelung (NTOU) and the National Museum of Natural History, Washington, DC (USNM).

Taxonomy

Family AEGIDAE Leach, 1815

Aega falcata n. sp.
(figures 1A, 2, 3)

Material examined

HOLOTYPE. NTOU H-1999-4-8, one non-ovigerous female, 44.8 mm total length (tl), Su-Aou fishing port, I-Lan County, NE Taiwan, from commercial trawl, approx. 500 m, 8 April 1999.

PARATYPE, USNM 288055, (NTOU P-1997-12-2), one non-ovigerous female, 43.6 mm tl, Su-Aou fishing port, I-Lan County, NE Taiwan, from commercial trawl, approx. 500 m, 2 December 1997.

Description

Body dorsally smooth; about 2.6 times longer than wide, widest at pereonite 5. Cephalon with prominent, apically acute, oblique ventrally directed rostrum; frontal lamina posteriorly narrow, anteriorly expanded, trilobed, hollowed; eyes large, well pigmented, separate. Pereonites 1 and 5–7 subequal, longer than remaining pereonites; coxae of pereonites 2 and 3 with small posteroventral point; coxae of pereonites 4 and 5 posteroventrally rounded, those of pereonites 6 and 7 acute, bearing two oblique ridges. Epimera of pleonites 1–4 posteroventrally rounded, pleonite 5 laterally covered. Pleotelson mid-dorsal length slightly less than half basal width, with low rounded median prominence supported by very faint rounded ridge on posterior margin; two shallow depressions anteriorly.

Antennule with two basal articles each having broad plate-like anterior extensions with distal mesially directed acute points, basal article wider and longer than article 2; third peduncle article cylindrical, 2.5 times longer than wide; flagellum of 11 articles. Antennal peduncle with three basal articles short, basal article with broadly rounded anterior margin; article 4 twice length of article 3, having strong posterodorsal groove; article 5 cylindrical, about 2.5 times longer than wide; flagellum of 21 articles, reaching posteriorly to level of pereonite 2. Mandibular incisor narrowly rounded; molar absent; palp with basal article slightly less than half length of article 2, latter curved laterally, about 3.5 times length of article 3, bearing cluster of seven distolateral simple setae; article 3 strongly curved, bearing comb-like row of short stiff setae plus two more elongate terminal setae. Maxilla 1 elongate slender, bearing seven stout distal falcate setae. Maxilla 2 with mesial lobe about one-quarter width

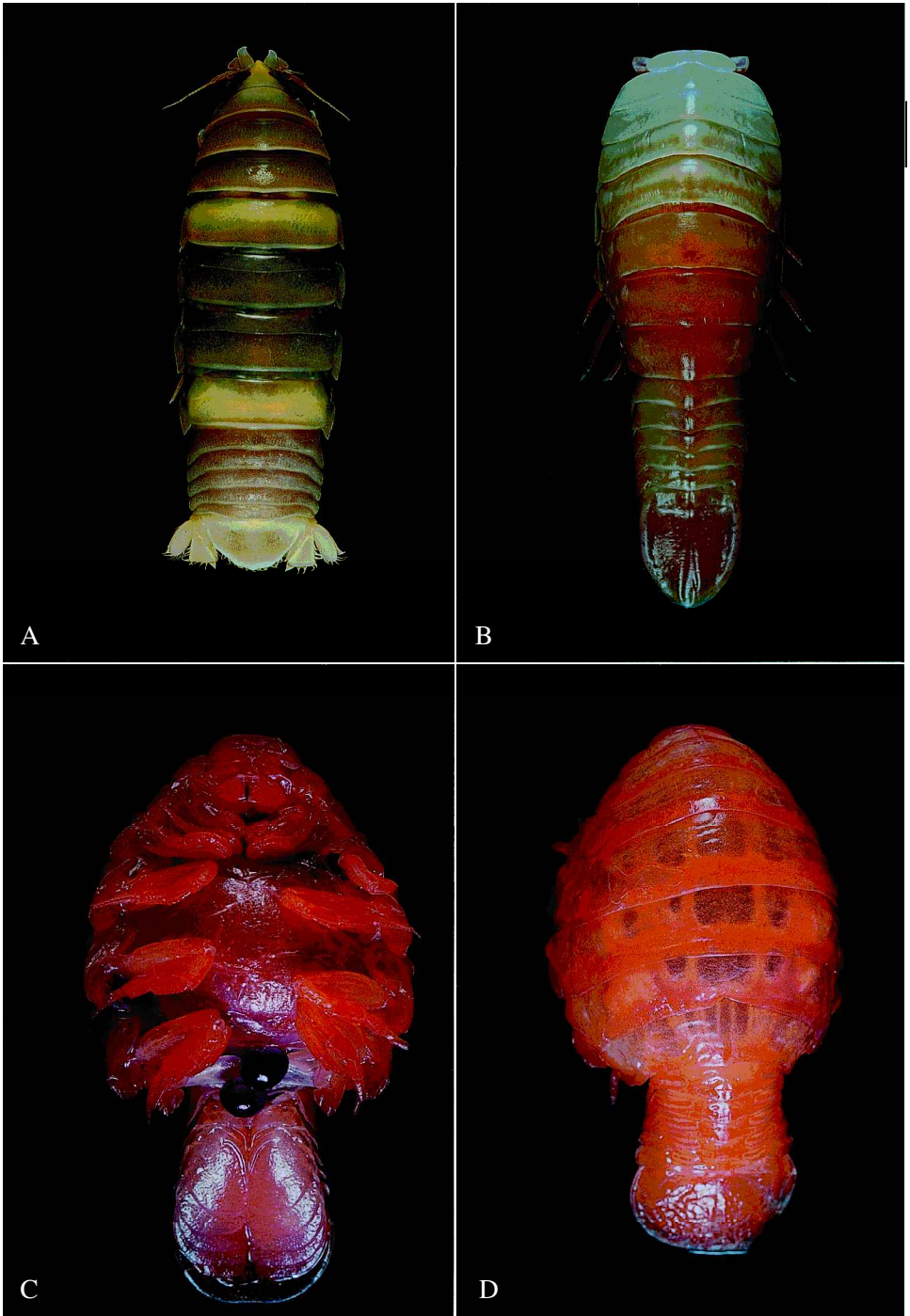


FIG. 1. (A) *Aega falcata*, female paratype, dorsal view; (B) *Anuropus pacificus*, male, dorsal view; (C) *Anuropus pacificus*, ovigerous female, ventral view, with two eggs extruded from broodpouch; (D) *Anuropus pacificus*, ovigerous female, dorsal view.

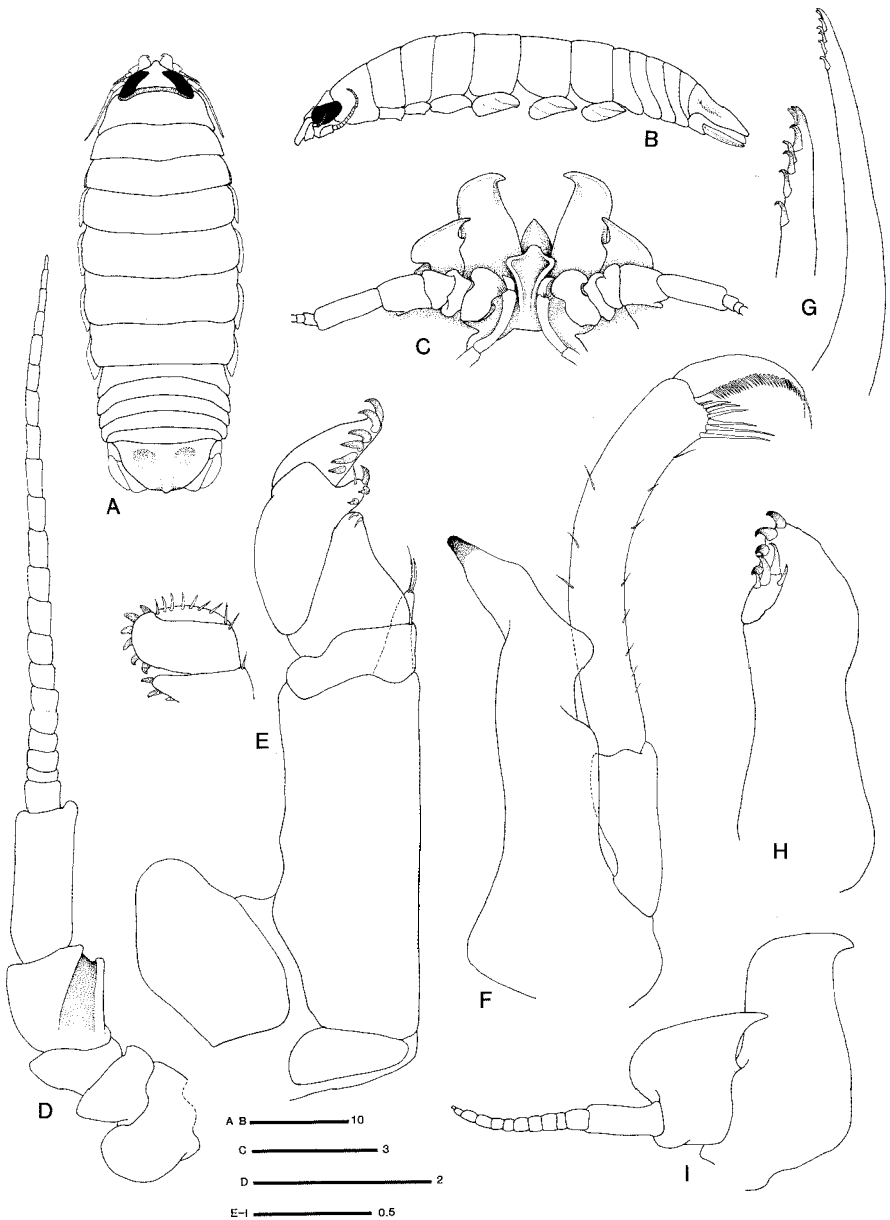


FIG. 2. *Aega falcata* n. sp., holotype: (A) whole animal in dorsal view; (B) whole animal in lateral view; (C) anterior cephalon and antennal and antular bases in ventral view; (D) antenna; (E) maxilliped, with palp articles 4 and 5 in buccal view; (F) mandible; (G) maxilla 1 with apex enlarged; (H) maxilla 2; (I) antennule.

of lateral lobe, bearing four distal stout hooked setae; lateral lobe bearing four strongly hooked setae mesiodistally. Maxillipedal endite reaching beyond base of palp article 2, narrow, bearing two distal slender setae; palp of five articles, basal article wider than long; article 2 triangular, with two slender spine-like setae on rounded mesiodistal angle; article 3 with three stout hook-like setae and slender seta

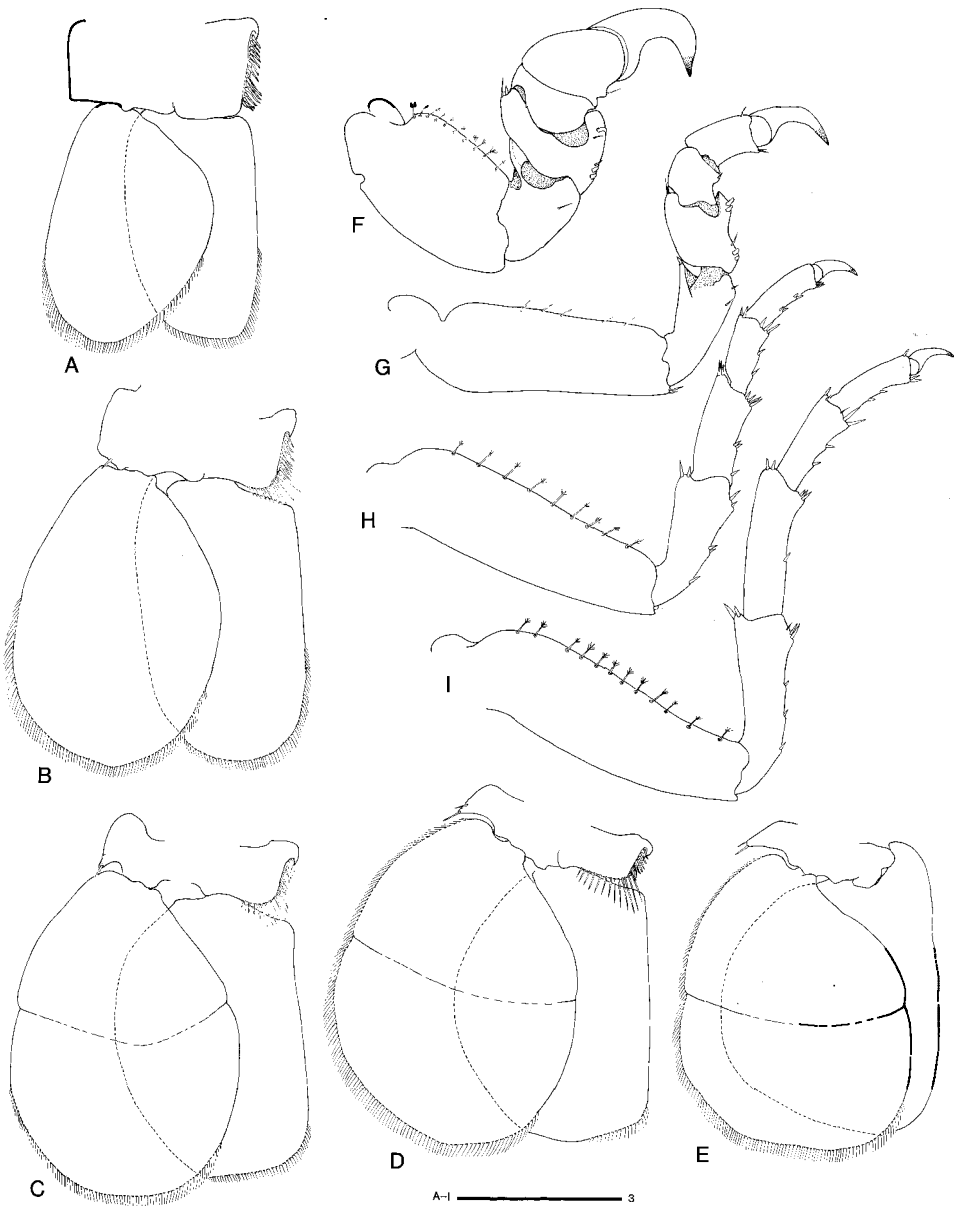


FIG. 3. *Aega falcata* n. sp., holotype: (A) pleopod 1; (B) pleopod 2; (C) pleopod 3; (D) pleopod 4; (E) pleopod 5; (F) pereopod 1; (G) pereopod 3; (H) pereopod 4; (I) pereopod 7.

on mesiodistal lobe; article 4 having six strong hooked spine-like setae on mesial margin; terminal article narrow, almost submerged in article 4 with eight slender setae on distal margin. Pereopods 1–3 prehensile, increasing in length posteriorly; pereopod 1 with basis longest and broadest article; propodus, carpus, merus, ischium all squat articles, merus bearing three short stubby setae on posterior surface; dactylus robust, strongly hooked, apically acute. Pereopods 2 and 3 similar; basis

about equal in length to propodus, carpus, merus, ischium together; merus with two pairs of stubby setae on posterior margin; carpus about two-thirds length of merus, roughly square; propodus about 1.5 times longer than wide; dactylus not as stout as in pereopod 1, but still strongly hooked. Pereopods 4–7 ambulatory, increasing in length posteriorly; basis about equal in length to merus and ischium together, with row of bottle-brush setae along anterior margin; anterodistal and posterodistal angles of propodus, carpus, merus and ischium bearing small cluster of short spiniform setae, one to three small clumps on posterior margin of same articles; dactylus about half length of propodus. Pleopod 1, protopod bearing row of about 14 coupling hooks on mesial margin; endopod roughly rectangular, 1.7 times longer than wide; exopod ovate, wider proximally than distally; both rami with fringe of short marginal setae; pleopod 2, protopod with row of coupling hooks transitioning to more elongate setae mesiodistally. Pleopods 3 and 4 similar, exopod broadly ovate, wider than endopod, with transverse suture at about midlength. Pleopod 5, protopod lacking coupling hooks; both rami broadly ovate, endopod with proximomesial extension over-reaching protopod; exopod with transverse suture. Uropod exopod elongate-ovate, about twice longer than wide; endopod slightly shorter than exopod, distally truncate, mesiodistal angle rounded, laterodistal angle right-angled; both rami bearing elongate marginal setae.

Colour

Eyes black. Dorsal surface of body light brown, with cephalon, pereonites 4 and 7, and pleotelson and uropods bright greenish yellow (the holotype also bears a short transverse bright greenish yellow band on pereonite 6).

Remarks

The present specimens are placed in the genus *Aega* Leach, for the following features: mandibular palp with article 2 elongate; maxilla 1 bearing strong apical and subapical spine-like setae; maxilla 2 bearing spine-like setae; maxillipedal palp of five articles, articles 2–4 bearing recurved hook-like setae, endite small, not reaching midlength of palp article 2; frontal lamina broad, separating antennal bases; pleon not much narrower than pereon.

Brusca (1983) divided the genus *Aega* into two subgenera, defining *Aega* (*Aega*) as having antennular peduncular articles 1 and 2 expanded or dilated, but lacking a true rostrum, having instead a cephalic process falling short of the frontal lamina. Bruce (1996), however, noted that some species of *Aega* (e.g. *A. komai*) did not fit the subgeneric definitions. The present specimen has the two basal antennular articles considerably expanded, but also has a well-developed and prominent rostrum, thus the species is not placed in either of the subgenera.

The degree of expansion of antennular peduncle articles 1 and 2 varies in *Aega*, some species such as *A. komai* Bruce, 1996 and *A. acuminata* Hansen, 1897 having especially the second article displaying a broad rounded expansion anterodistally. *Aega antennata* Richardson, 1910, described from the Philippines, possesses a single falcate plate on the antennular peduncle, while the posterior margin of the pleotelson is very strongly tridentate, unlike that of *A. falcata* which has the posterior margin barely sinuous.

While species of *Aega* are well known as external parasites/micropredators of fish, the present specimens were not found attached to any host. The thoracic

sternites of both specimens were greatly inflated and dark coloured, however, suggesting the guts were full of blood.

Etymology

The specific name is derived from the Latin *falcatus*, sickle-shaped or hooked, and refers to the distinctive structure of the antennule.

Family ANUROPIDAE Stebbing, 1893
Anuropus pacificus Lincoln and Jones, 1973
(figures 1B–D, 4–9)

Anuropus pacificus Lincoln and Jones, 1973: 80, figures 1–3.

Material examined

NTOU, larvigerous female, mid-dorsal total length 135 mm; brood pouch containing 52 manca each about 28 mm mid-dorsal length, Tai-Shi fishing port, I-lan County, NE Taiwan, approx. 500 m, 16 April 1999. NTOU, ovigerous female mid-dorsal length 95 mm, fishing pot, Tai-Shi fishing port, I-lan County, NE Taiwan, approx. 500 m, February 1999. NTOU, male mid-dorsal length 50 mm, Tai-Shi fishing port, I-lan County, NE Taiwan, approx. 400–500 m, September 1998.

BMNH 1972.523.2 male paratype of *A. pacificus*, from stomach of waved albatross, Galapagos region.

Description

Manca. Body with integument soft, large amounts of oil visible; pereon dorsally strongly arched. Coxal plates all posteroventrally rounded. Abdominal epimera all rounded. Telson subcircular, lacking dorsal ornamentation.

Antennule consisting of two articles, basal about half length of distal, latter three times longer than wide, distally rounded. Antenna consisting of seven articles, two basal articles about as long as wide, distal five articles narrow, cylindrical. Mandible roughly triangular, incisor a rounded ridge; molar a small semicircular flap; palp of three subequal articles, distal article bearing six very short distal spiniform setae. Left and right mandibles identical. Maxilla 1, lateral ramus distal margin obliquely truncate, bearing nine short spiniform setae; mesial ramus half length of lateral, bearing four very short squat distal setae. Maxilla 2 consisting of two rounded lobes bearing three or four undifferentiated distal bumps. Maxilliped consisting of three articles, distal article broadest and longest, with few tiny setae distally, mesial margin with small barely differentiated lobe. Pereopod 1, ischium basal width equal to posterior margin; carpus and merus each much shorter than wide, with three tiny setal precursors on posterior margin, carpus lacking free anterior margin; propodus somewhat inflated, slightly longer than wide, with about seven setal precursors on palmar margin; dactylus slender, about four times longer than wide. Pereopods 2–6 similar but increasing in length posteriorly; basis longest article, somewhat expanded; ischium with lobed anterior region bearing setal precursors; carpus and merus each roughly rectangular; propodus cylindrical, from two and a half to three times longer than wide; dactylus about one-third length of propodus. Pereonite lacking pereopods. Pleopods 1–5, protopod lacking coupling hooks on mesial margin; biramous, margins of rami bearing tiny setal precursors. Uropod similar in size to pleopods, rami slightly narrower, protopod with short lobe-like extension along mesial margin of endopod.

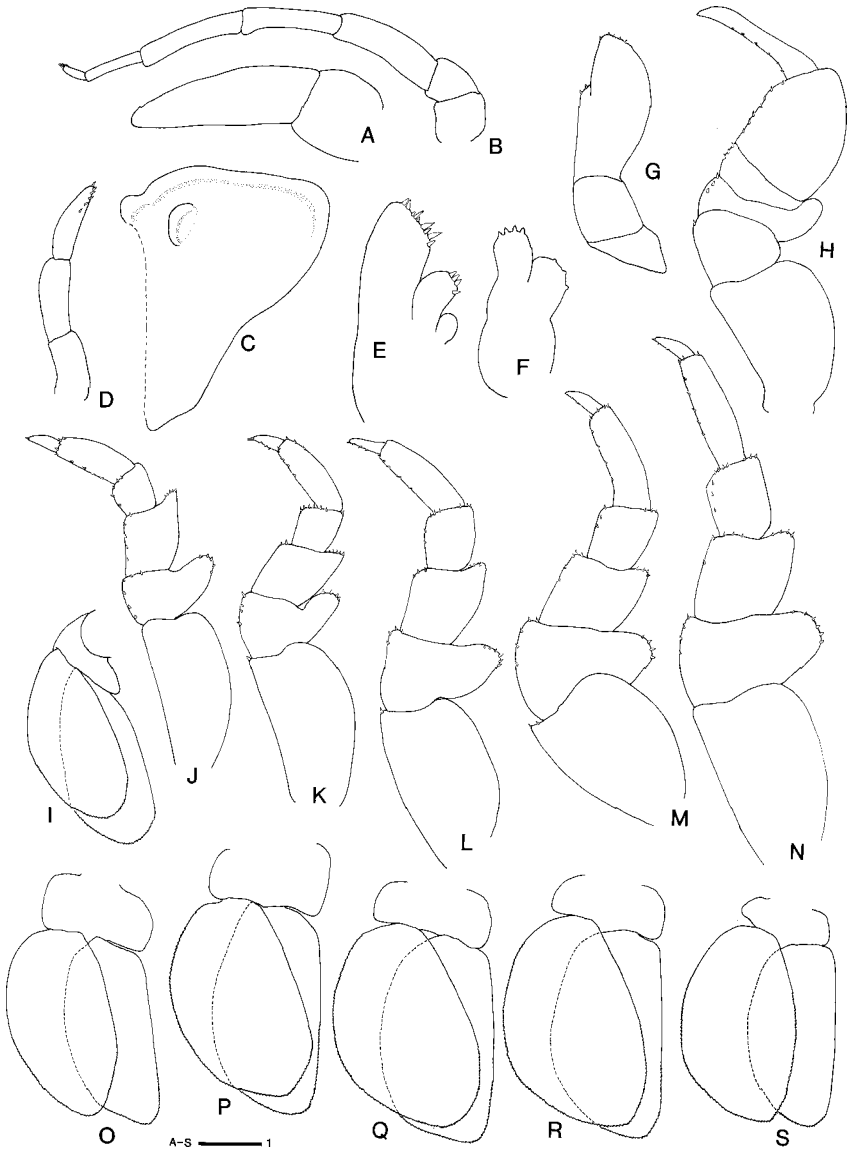


FIG. 4. *Anuropus pacificus*, manca: (A) antennule; (B) antenna; (C) mandible; (D) mandibular palp; (E) maxilla 1; (F) maxilla 2; (G) maxilliped; (H) pereopod 1; (I) uropod; (J) pereopod 2; (K) pereopod 3; (L) pereopod 4; (M) pereopod 5; (N) pereopod 6; (O) pleopod 1; (P) pleopod 2; (Q) pleopod 3; (R) pleopod 4; (S) pleopod 5.

Male. Body 2.8 times longer than greatest width at pereonite 4; pleon distinctly narrower than pereon. Cephalon much narrower than pereonite 1, anterior margin shallowly bilobed, with modified antennules extending laterally, when seen in dorsal view. Pereonites increasing in length posteriorly; pleonites decreasing in length posteriorly. Telson slightly longer than wide, ovate, dorsally with broadly rounded lateral ridge, with two rounded submedian ridges contiguous anteriorly, diverging posteriorly.

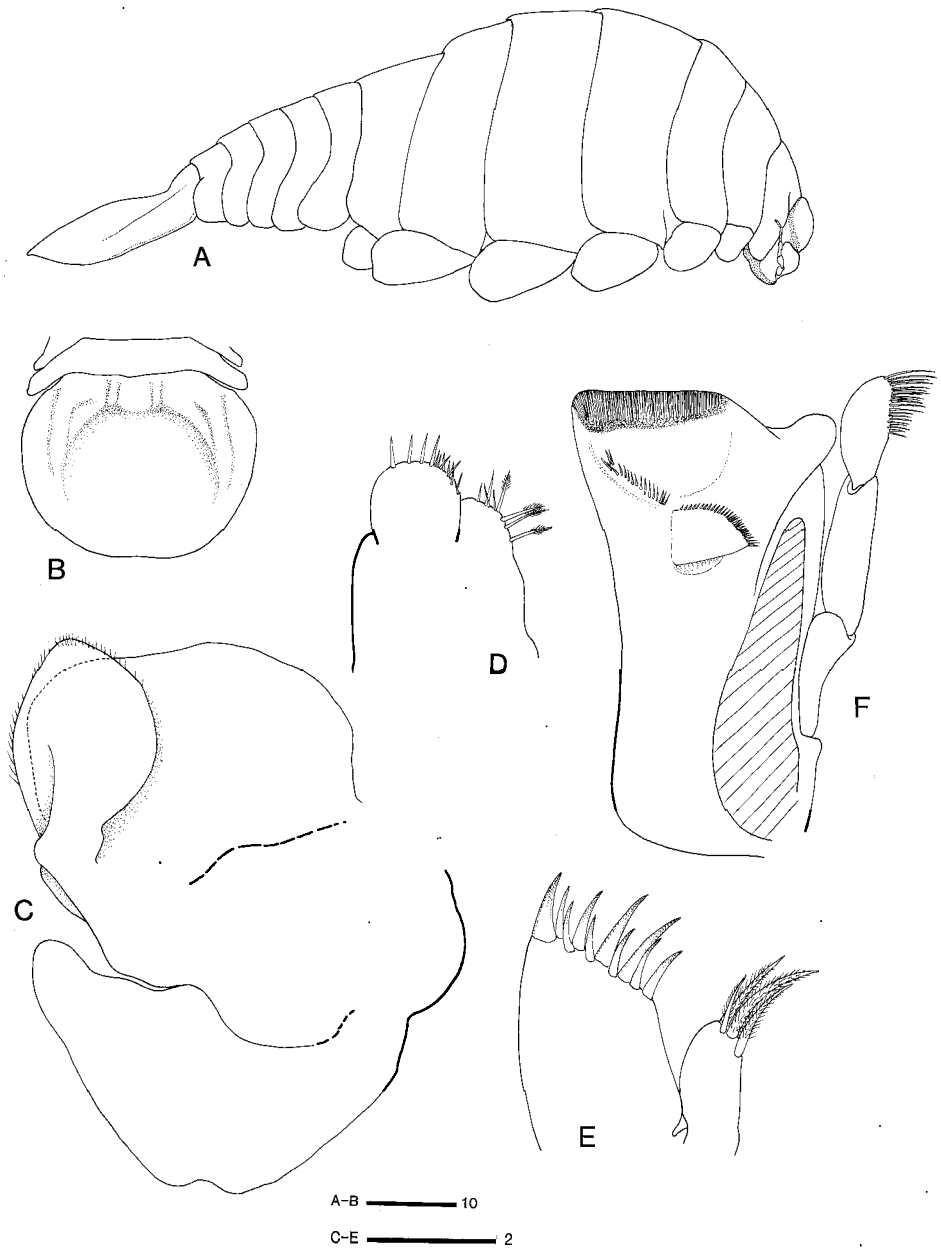


FIG. 5. *Anuropus pacificus*, ovigerous female: (A) lateral view; (B) pleotelson; larvigerous female: (C) maxilliped; (D) maxilla 2; (E) maxilla 1; (F) mandible.

Antennule highly modified and inflated, consisting of two articles, basal article stout, distally wider than long; distal article with triangular inflated dorsal portion and ventral rounded ridge bearing dense fringe of fine setae. Antenna consisting of seven articles, reaching posteriorly to mid-length of pereonite 3; two basal articles subequal, short; articles 3–7 slender, cylindrical; article 3 about two and a half times length of article 2; articles 4 and 5 subequal; articles 6 and 7 subequal, half length

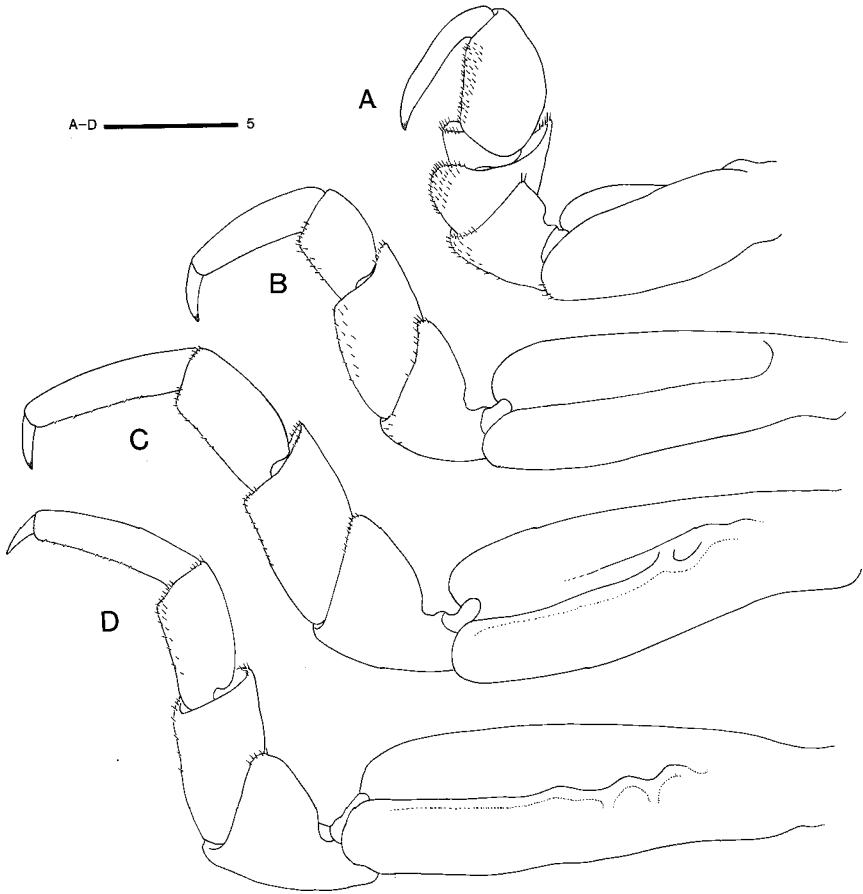


FIG. 6. *Anuropus pacificus*, larvigerous female: (A) pereopod 1; (B) pereopod 3; (C) pereopod 4; (D) pereopod 7.

of article 5; distal articles with two small simple terminal setae. Mandible heavily sclerotized, incisor with truncate corneous cutting edge; molar thin, triangular, with row of short setae along anterior margin, setal row extending on to body of mandible; palp of three articles, articles 1 and 3 subequal, article 2 slightly longer; article 3 with dense distolateral band of setae. Maxilla 1, lateral ramus with oblique distal margin bearing four large corneous spinose setae plus five much smaller setae; mesial ramus rounded, lobe-like, much smaller than lateral ramus, bearing four stout bristly setae. Maxilla 2 consisting of two poorly differentiated lobes, lateral lobe bearing about eight short simple setae; mesial lobe bearing six longer bristly setae. Maxilliped consisting of two articles, basal article proximally broad; distal article distally widened, bearing tiny bristle-like setae. Pereopod 1 subchelate; basis longest article with anterior margin hollowed to accommodate rest of flexed-back leg; ischium, merus, carpus and propodus each with patch of tiny bristle-setae on posterior surface; merus with hollowed anterior lobe; carpus much shorter than wide, with very short free anterior margin; propodus somewhat inflated, about twice longer than wide; dactylus slender, reaching back to carpus. Pereopods 2 and 3 similar, longer than pereopod 1, merus roughly rectangular, lacking anterior lobe; carpus

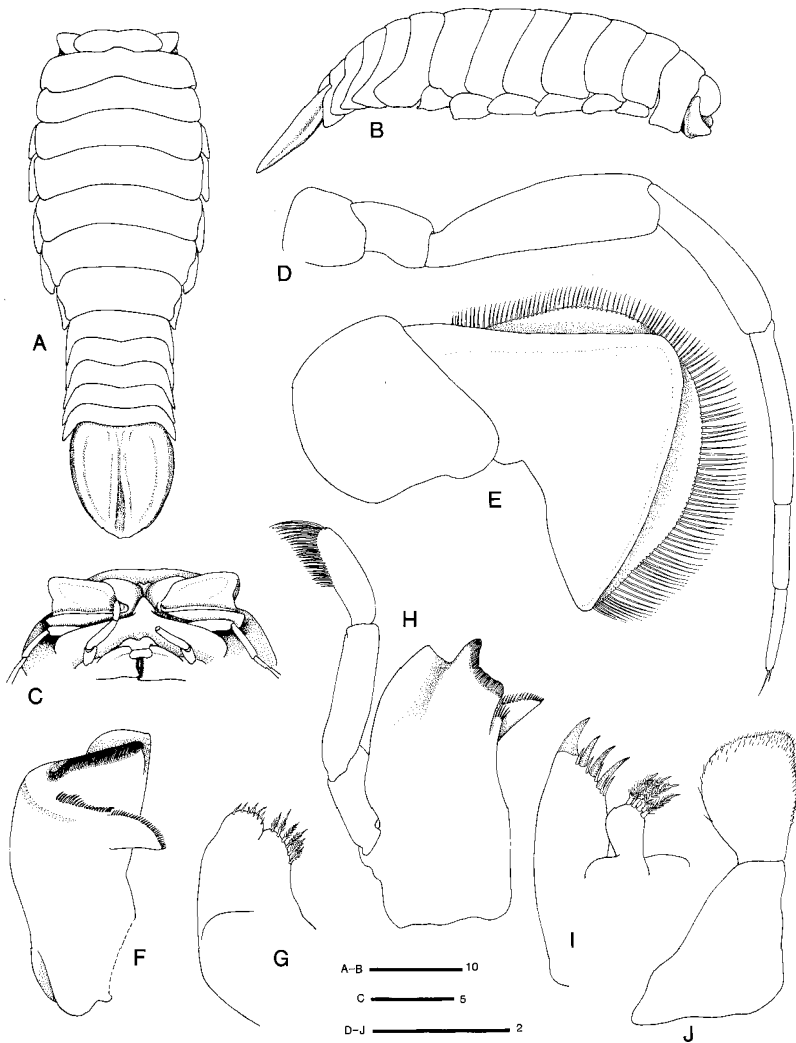


FIG. 7. *Anuropus pacificus*, male: (A) dorsal view; (B) lateral view; (C) anterior cephalon in ventral view; (D) antenna; (E) antennule; (F) mandible in buccal view; (G) maxilla 2; (H) mandible, external view; (I) maxilla 1; (J) maxilliped.

rectangular, slightly longer than wide; propodus cylindrical, about three and a half times longer than wide; dactylus slightly less than half length of propodus. Pereopods 4–7 similar, increasing in length posteriorly; ischium, merus, carpus and propodus having patch of short bristle-setae on posterior surface; propodus cylindrical, five or six times longer than wide. Submedian penes on ventrum of pereonite 7 blunt, club-shaped, about three and a half times longer than wide, distally broadly rounded. Pleopods 1–5 increasing in size posteriorly. Pleopod 1 protopod bearing about eight coupling hooks on mesial margin; exopod and endopod bearing distal fringe of short marginal setae. Pleopod 2, protopod bearing eight coupling hooks on mesial margin; copulatory stylet articulating at base of endopod, tapering distally, reaching to apex of endopod, apically acute. Pleopod 3, protopod bearing eight coupling

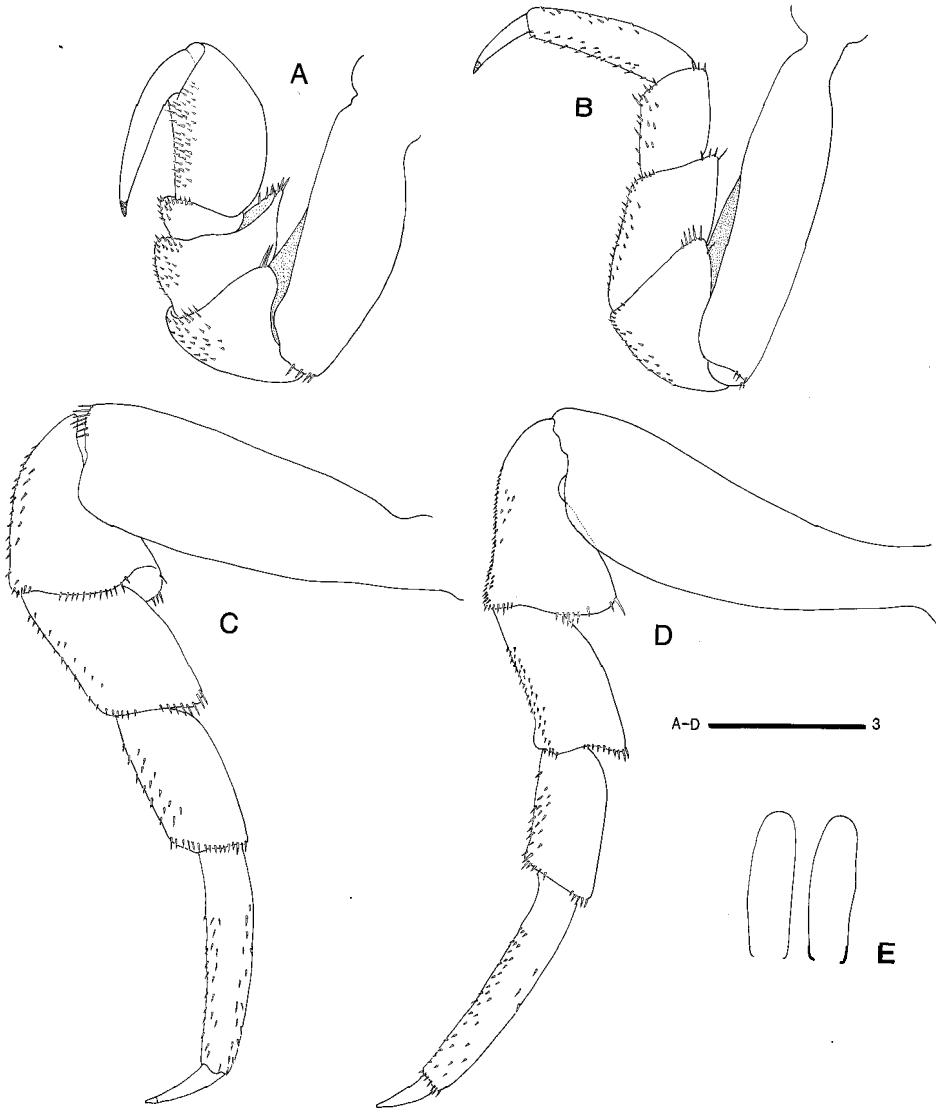


FIG. 8. *Anuropus pacificus*, male: (A) pereopod 1; (B) pereopod 3; (C) pereopod 4; (D) pereopod 7; (E) penes.

hooks on mesial margin; exopod having transverse suture in proximal half. Pleopod 4, protopod bearing eight much shortened coupling hooks on mesial margin; exopod with transverse suture in proximal half. Pleopod 5, protopod lacking coupling hooks; exopod having transverse suture in proximal half. Uropod tucked under telson, rami broad, lamellar, as continuation of pleopod series, exopod distally rounded, endopod subacute.

Ovigerous female. Body with pereon distinctly broader than pleon, dorsally strongly convex. Pereonites 1–4 increasing in length, pereonite 4 longest. Coxae of pereopods 2–7 posteroventrally rounded. Brood pouch formed by lamellae of maxilliped and first five pairs of pereopods, oostegites overlapping in midline. Eggs

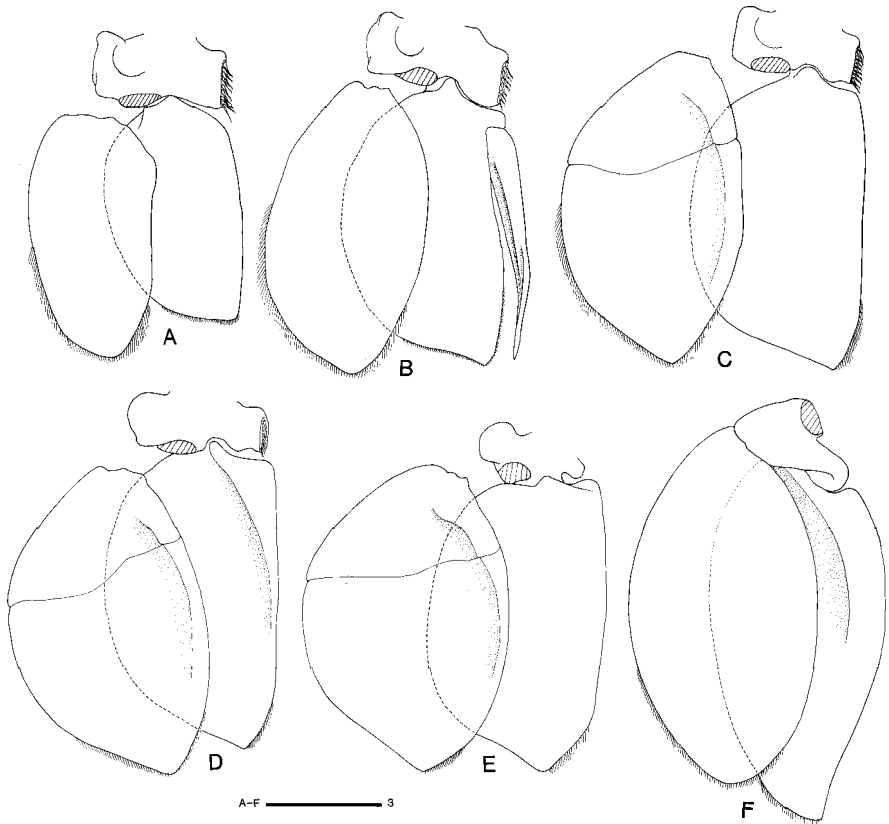


FIG. 9. *Anuropus pacificus*, male: (A) pleopod 1; (B) pleopod 2; (C) pleopod 3; (D) pleopod 4; (E) pleopod 5; (F) uropod.

purple in life, oval, about 6.5×5.0 mm. Pleonites subequal in length, epimera postero-laterally rounded. Uropods tucked under telson, part of pleopodal series. Telson subcircular.

Larvigerous female. Body shape as in ovigerous female. Telson subcircular, with two pairs of broadly rounded anterior ridges and shallow semicircular groove. Antennules and antennae as in male. Mandible strongly sclerotized, truncate incisor corneous; molar broadly triangular, with row of short setae on anterior margin; row of short stiff setae on mesial face. Maxilla 1, lateral ramus with 10 corneous spine-like setae of varying lengths distally; mesial ramus with four bristly setae. Maxilla 2 consisting of two poorly defined lobes, lateral lobe bearing four long and several short simple setae; mesial lobe bearing four bristle setae and several simple setae. Maxilliped consisting of single broad article bearing short marginal setae, plus epipodite expanded into broad anterior and smaller posterior lobed lamellar oostegite. Pereopod 1 subchelate, ischium, merus, carpus and propodus each having patch of very short spine-like setae on posterior surface; basis strongly grooved on anterior surface; merus with cupped anterior lobe; carpus short, having almost no free anterior margin; propodus expanded, about 1.8 times longer than wide; dactylus elongate slender, reaching back to carpus. Pereopods 2 and 3 similar, not subchelate, carpus rectangular; propodus elongate, slender, about 3.5 times longer than wide.

Pereopods 4–7, basis longest article, dorsally with strong gutter formed by lateral and mesial flange; carpus rectangular, about twice longer than wide; propodus slender cylindrical, about four times longer than wide. Pleopods 1–4, protopodite bearing about 10 coupling hooks on mesial margin, pleopod 5 lacking hooks; rami broad, thin-walled, completely lacking marginal setae; exopods 3–5 lacking transverse suture as seen in male. Uropodal rami thin-walled, broadly lamellar, forming sixth pair of respiratory appendages.

Colour

Body orange-red overall, but anterior somites somewhat paler in males. Eggs purple.

Remarks

Species of the genus *Anuropus* (see table 1) have been described on the basis of very few specimens, usually of only one sex. In four species, the specimens came from the gut contents of oceanic birds such as petrels or albatrosses. Menzies and Dow (1958) described and recorded five specimens of *Anuropus bathypelagicus* off California, observed many nematocysts in the gut of one specimen, and suggested that from their capture in mid-water depths, species of *Anuropus* are bathypelagic rather than benthonic in habit. Barham and Pickwell (1969) presented convincing evidence that species of *Anuropus* live in association with large scyphozoan jellyfish, either as commensals or as parasites, which is consistent with Menzies and Dow's observations, and would also explain the records of the isopods from oceanic bird stomachs. The present material was collected from the by-catch that had already been landed at the fishing port, and no sign of associated jellyfish was seen.

The only ovigerous female of *Anuropus* described is that of *A. sanguineus* Nunomura, 1983, from Japan. The present case, in which a male, an ovigerous and a larvigerous female in excellent condition are available is thus unusual, and warrants descriptive comments on all three forms, as well as on the manca.

The present material closely resembles *A. pacificus* Lincoln and Jones, 1973, from the stomach contents of a waved albatross from the Galapagos region. This species is known from three males, one of which was used in a comparison with present material. No differences between the paratypic male of *A. pacificus* and the present male could be detected; the shape of the pereopodal coxae, pleonal epimera, the pleotelson, and the structure of the antennules, antennae, mouthparts are all very similar (see Lincoln and Jones, 1973, figures 1–3). Only the anterior three pereopods

Table 1. Known species of *Anuropus* Beddard, 1886, with type localities.

<i>A. aeronautus</i> Sivertsen and Holthuis, 1980	Tristan da Cunha, albatross stomach
<i>A. antarcticus</i> Hale, 1952	Antarctic, snow petrel stomach
<i>A. australis</i> Schultz, 1977	Off Falkland Islands, 851–1071 m
<i>A. bathypelagicus</i> Menzies and Dow, 1958	Eastern Pacific off California, 930–2976 m
<i>A. branchiatus</i> Beddard, 1886	Between New Guinea and Admiralty Islands, 1960 m
<i>A. kussakini</i> Vasina, 1998	Bering Sea, 500–3770 m
<i>A. novaezealandiae</i> Jansen, 1981	New Zealand, grey-faced petrel stomach
<i>A. pacificus</i> Lincoln and Jones, 1973	Galapagos Islands, waved albatross stomach
<i>A. sanguineus</i> Nunomura, 1983	Okhotsk Sea, 600 m

of *A. pacificus* were illustrated, the remainder were missing, presumably lost when eaten by the albatross. These legs, too, are very similar to those of the present species.

In *Anuropus sanguineus* from the Okhotsk Sea, the shape of the coxal plates differ considerably from the present ovigerous female, while the antennule is short but barely inflated as it is in *A. pacificus*.

Acknowledgements

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