

Rare cyclopoid copepods (Crustacea) from Mediterranean littoral caves

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SYNOPSIS. Three cyclopoid copepods are reported from anchihaline cave habitats on Mallorca. Both sexes of *Cyclopina esilis* Brian are redescribed. Sexual dimorphism in the mandibular exopod, as discovered in *C. esilis*, has not previously been reported for any cyclopinid. The male of the primitive marine cyclopid *Neocyclops* (*Protoneocyclops*) *mediterraneus* (Kiefer) is described in detail for the first time and the characters distinguishing this species are discussed. Both sexes of *Euryte longicauda* Philippi are redescribed. The genus *Euryte* Philippi is briefly reviewed and the characters used to differentiate species are critically reevaluated. It is concluded that all three genera, the cyclopinid genus *Cyclopina* Claus and the primitive cyclopid *Neocyclops* Gurney and *Euryte*, are in urgent need of revision, but that this process will be hampered by the inadequacy of published descriptions and the lack of available type material.

INTRODUCTION

Anchihaline cave habitats are rich sources of interesting and unusual crustaceans. Copepods of immense phylogenetic significance have been discovered in such caves in the last decade, including the platycopiid *Antrisocopia* Fosshagen, the misophrioid *Speleophriopsis* Jaume & Boxshall, and the calanoid *Erebonectes* Fosshagen (Fosshagen & Iliffe, 1985; Jaume & Boxshall, 1996). There have been few reports of cyclopoid copepods in anchihaline caves. Recently, however, Rocha & Iliffe (1991, 1994) described a new family of cyclopoidea, the Speleothonidae, and the primitive cyclopid *Troglocyclops*, from caves on the Bahamas Islands. During our studies of the copepod fauna of Mallorcan caves we discovered numerous cyclopoidea, including the three rare species described in this account. All three species were originally described from the Mediterranean Basin. All have been the subject of considerable taxonomic confusion because their original descriptions were inadequate and we have attempted to clear up some of this confusion at the same time as presenting full redescriptions.

THE CAVES

The copepods were collected from four caves located on the East coast of Mallorca, less than 20 m inland. These caves occur in two different types of substratum. Cova 'C' de Cala Varques and Es Secret des Moix are in Tortonian (10 Myr BP), coral reef-derived, porous calcarenites and mixing-zone corrosion processes seem to have played an important role in their development. Cova de na Barxa and Cova de na Mitjana are in Triassic, fissured limestones. All these caves have subaerial entrances; the difficulty of access can be deduced from their topographies, published elsewhere (see below). The water conditions varied from cave to cave: In Es Secret des Moix, the sampled lake (that located closest to the entrance) was completely marine (i.e., in water salinity, a detectable swell, the nature of the accompanying fauna), as was the lake in Cova de na Mitjana. Cova 'C' de Cala Varques and Cova de na Barxa are typical anchihaline caves (in the sense of Stock *et al.*, 1986), with a thin layer of fresh water on the top of the deeper saline waters of the lakes.

Sampling was undertaken using meat-baited traps placed at different depths in the cave lakes and left for several days, and by using a hand-held plankton net with an extensible handle. The terminology used in the descriptions follows Huys & Boxshall (1991).

SYSTEMATICS

Order **CYCLOPOIDA** Burmeister, 1834
 Family **CYCLOPINIDAE** Sars, 1913
 Subfamily **CYCLOPININAE** Kiefer, 1927
 Genus *Cyclopina* Claus, 1863

Cyclopina esilis Brian, 1938

(Figs 1–4)

Cyclopina cf. *kieferi*: Herbst (1953; 1962)

MATERIAL EXAMINED. Cova de na Mitjana (Capdepera). UTM coordinates: 539.10; 4390.95. Topography published by Ginés *et al.* (1975): 96 individuals, both sexes (BMNH 1995. 1331–1340). Collected by D. Jaume, 17 July 1994.

ADULT FEMALE. Body (Figs 1A, B) cyclopiniform, up to 0.37 mm long. Prosome 5-segmented, about 1.7 times longer than urosome. Rostrum developed, oval. Posterolateral margins of cephalosome vaulted. First pedigerous somite free, partially concealed by dorsal and posterolateral extensions of cephalosome. Second to fourth pedigerous somites with evenly rounded posterolateral angles. Urosome 5-segmented, with genital and first abdominal somites completely fused to form genital double-somite. Serrate hyaline fringe adorning posterodorsal margin of fifth pedigerous somite, posterior margins of genital double-somite and abdominal somites 2 and 3, and posterolateral margins of anal somite; degree of serration varying directly with body size. Genital double-somite (Fig. 1D) symmetrical, 1.6 times longer than wide, expanded anteriorly. Single copulatory pore opening mid-ventrally at about two-fifths of distance along double-somite. Paired gonopores located laterally, each covered by operculum armed with short spinous process, 1

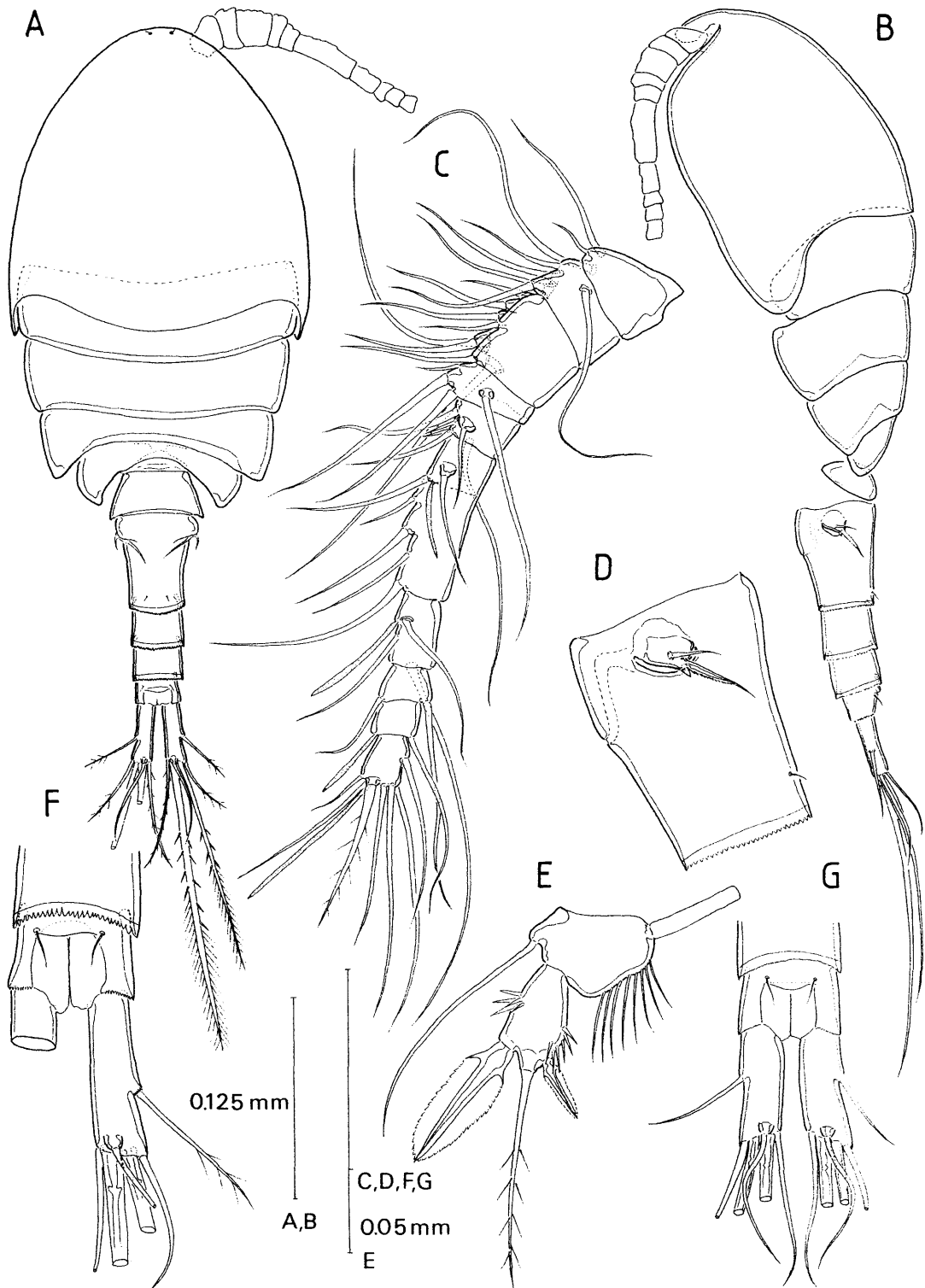


Fig. 1. *Cyclopina esilis* Brian, 1938, adult female. A, body, dorsal view; B, lateral; C, antennule; D, genital double-somite, lateral; E, fifth leg; F-G, dorsal view of anal somite and caudal rami, showing variation with body size in the position of the lateral seta of the caudal ramus.

seta, and 1 long flanged spine (Fig. 1D). Anal somite (Figs 1F, G) bearing smooth operculum. Caudal rami longer than anal somite, about 2.6 to 3.3 times longer than wide; proportional length related to body size. Armature consisting of 6 setae; position of seta II

variable, ranging from two-fifths (Fig. 1G) to three-fifths of distance along distal margin (Fig. 1F).

Antennules (Fig. 1C) symmetrical, 10-segmented, shorter than prosome (Fig. 1B). Segmental fusion pattern and armature as fol-

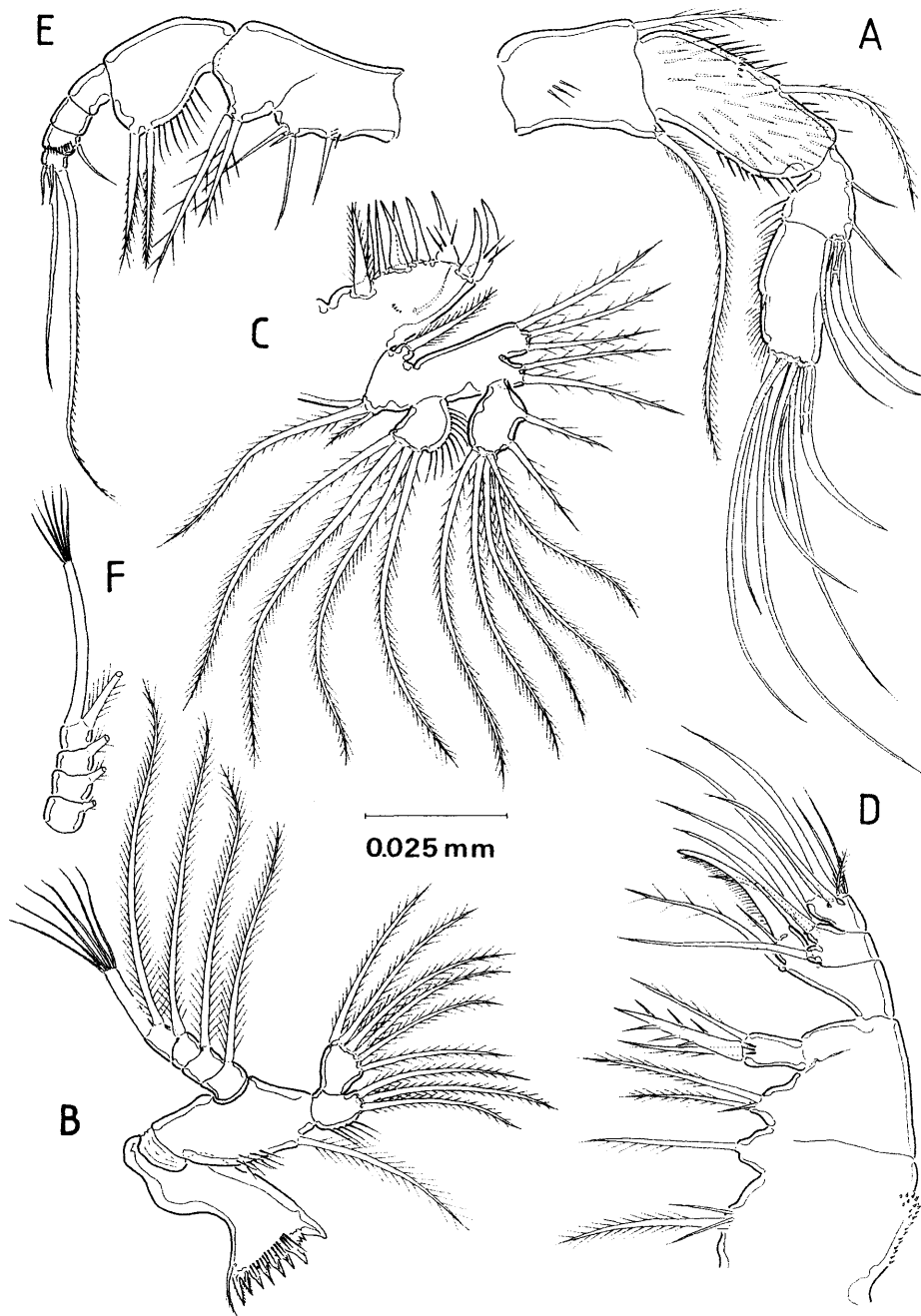


Fig. 2. *Cyclopina esilis* Brian, 1938, A and C–F, adult female, B, adult male. A, antenna; B, mandible; C, maxillule; D, maxilla; E, maxilliped; F, mandibular exopod.

lows: segment 1 (corresponding to fused ancestral segments I and II), 3 setae; segment 2 (corresponding to fused ancestral segments III to V), 5 setae; segment 3 (fused segments VI to IX), 8 setae; segment 4 (fused segments X and XI), 4 setae; segment 5 (fused segments XII to XIV), 6 setae; segment 6 (fused segments XV to XX, partial suture present between segments XVI and XVII), 6 setae + aesthetasc; segment 7 (fused segments XXI to XXIII), 3 + aesthetasc; segment 8 (XXIV), 2 setae; segment 9 (XXV), 1 + aesthetasc; segment 10 (fused segments XXVI to XXVIII), 7 + aesthetasc.

Antenna (Fig. 2A) 4-segmented. Fused coxa and basis short, about 1.5 times longer than wide, armed with 1 inner basal seta distally and 1 long seta (representing exopod) on outer margin.

Endopod 3-segmented. Proximal segment with 1 seta at about two-thirds of distance along inner margin; segment covered by long spinules on anterior surface. Second segment with 2 lateral and 3 distal setae (one of them claw-like) along inner margin. Distal segment with 7 distal setae, one of them claw-like. Secondary ornamentation on segments as figured.

Mandible (Figs 2B, F) with gnathobase armed with 10 unequal, sharp teeth plus 1 dorsal seta; row of 13 spinules located subdistally. Palp well developed; basis elongate, with patch of setules and 1 subdistal seta along inner margin. Exopod (Fig. 2F) inserted at about midway of distance along outer margin of basis; 4-segmented; setal formula 1,1,1,2; distal, brush-like seta somewhat shorter and thicker

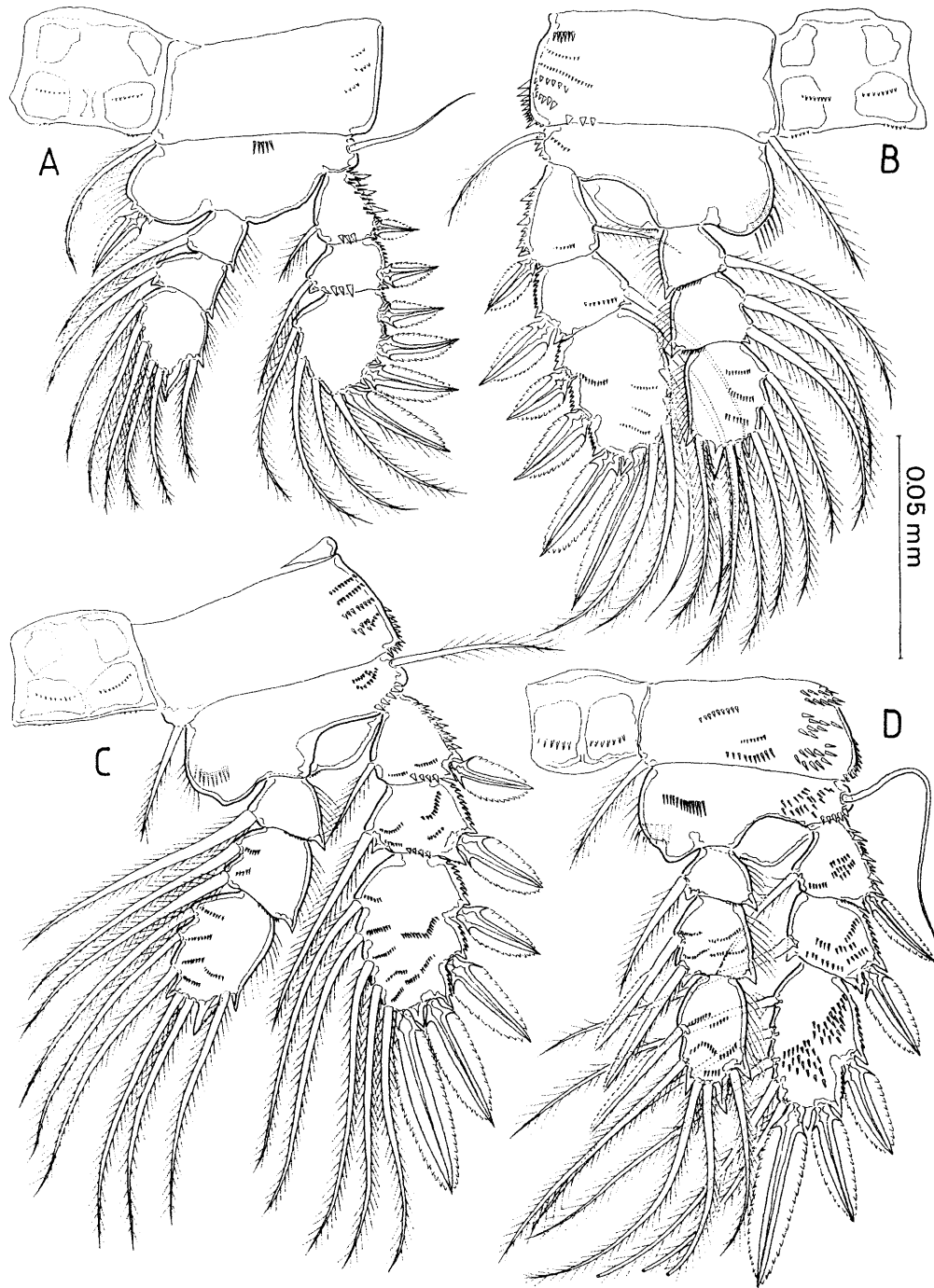


Fig. 3. *Cyclopina esilis* Brian, 1938, adult female swimming legs, posterior view. A, leg 1; B, leg 2; C, leg 3; D, leg 4.

than others, with brush of 6 setules on tip. Endopod 2-segmented, shorter than exopod, setal formula 3,6.

Maxillule (Fig. 2C) with well developed praecoxal arthrite, armed with 9 thick, unequal spines around distal margin plus isolated seta on posterior surface. Coxa and basis fused: coxal epipodite represented by 2 unequal setae; coxal endite represented by small cylindrical knob armed with 1 seta. Proximal and distal endites of basis discrete, bearing 3 and 2 setae respectively. Endopod 1-segmented, bearing 7 setae. Exopod 1-segmented, armed with 4 distal setae and marginal row of long setules.

Maxilla (Fig. 2D) well developed, 4-segmented. Praecoxa and coxa partially fused, endites with setal formula 3,1,3,3. Basis with large endite bearing claw-like spine plus 2 unequal setae. Endopod 2-segmented; proximal segment representing fused first and second ancestral endopodal segments; distal representing fused third and fourth ancestral segments; endopod setation formula (2+2),(2+4).

Maxilliped (Fig. 2E) slender, 6-segmented. Praecoxa and coxa fused forming syncoxa, bearing 3 (coxal) endites with setal formula 1,3,2. Basis with medial margin swollen, ornamented with marginal row of long setules; 2 setae implanted subdistally on medial margin.

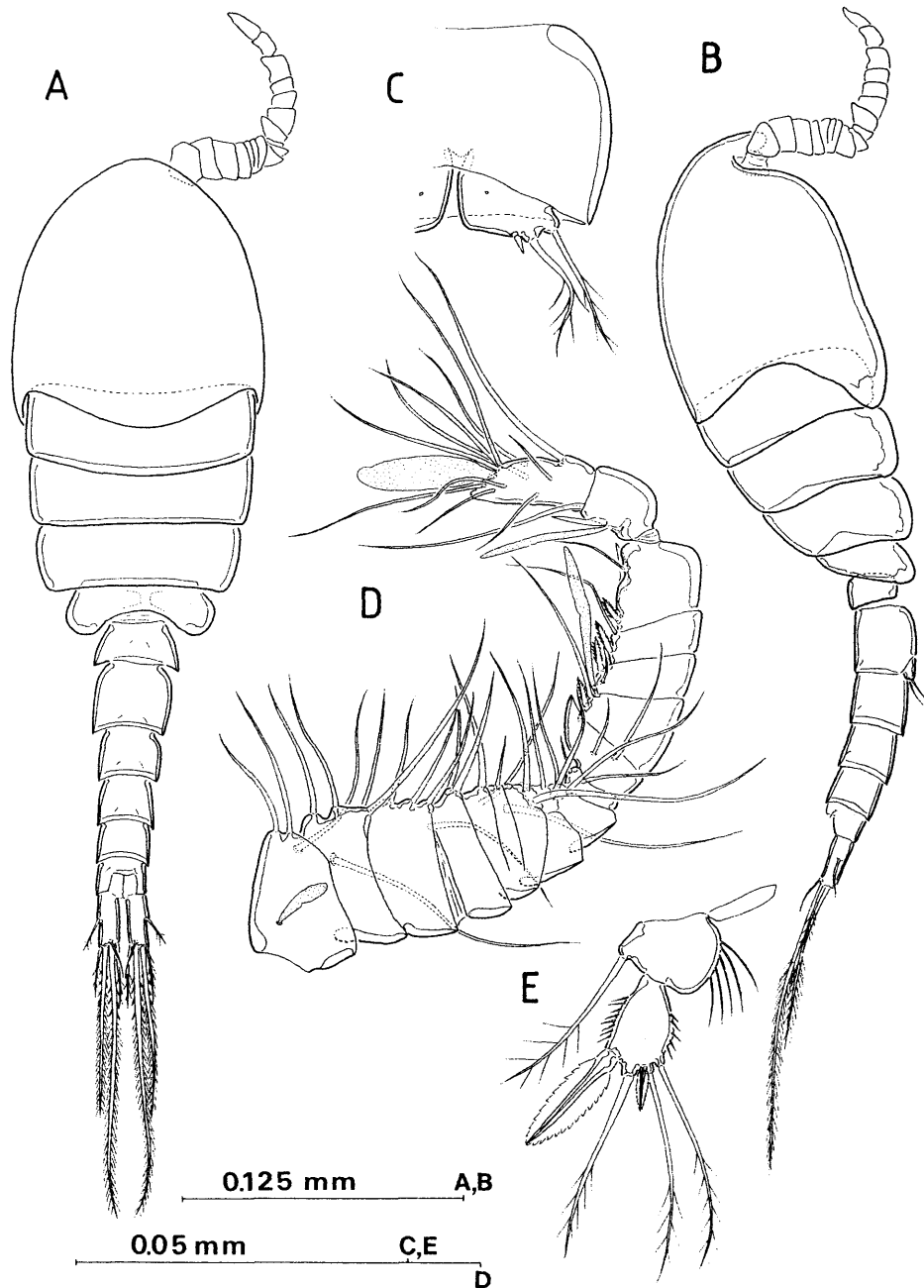


Fig. 4. *Cyclopina esilis* Brian, 1938, adult male. A, body, dorsal; B, lateral; C, genital somite, ventral; D, antennule; E, fifth leg.

Endopod 4-segmented, setal formula 0,0,1,4; transverse row of setules on segment 3.

Swimming legs 1 to 4 (Fig. 3) biramous, both rami 3-segmented. Legs subequal in size except first, somewhat reduced. All legs richly ornamented with denticles, as figured; anterior surface of coxae covered by small denticles, omitted from figures. Spines on exopodal segments flanged with serrate hyaline frill; distal spine on third exopodal segment of legs 1 and 2, and spines on endopod of leg 4 flanged only on one side. Armature as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-I	I-1;I-1;III,I,4	0-1;0-1;1,2,3
Leg 2	0-1	1-0	I-1;I-1;III,I,5	0-1;0-2;1,2,3
Leg 3	0-1	1-0	I-1;I-1;III,I,5	0-1;0-2;1,2,3
Leg 4	0-1	1-0	I-1;I-1;II,I,5	0-1;0-II;1,2,1+1

Fifth legs (Fig. 1E) uniramous, 2-segmented, joined by naked intercoxal sclerite. Coxa and basis fused forming trapezoidal protopodal segment; inner margin with row of long setules; outer margin with long, smooth seta subdistally. Distal segment (exopod) about 1.6 times as long as wide, produced distally into median

process bearing 1 long, plumose seta; 1 flanged spine present subdistally on each side of process, outer stouter, longer than segment; inner spine less than half length of outer spine; spinule ornamentation on segment as figured.

ADULT MALE. Body (Figs 4A, B) up to 0.38 mm long, more slender than female. Urosome 6-segmented, with genital somite (Fig. 4C) symmetrical, slightly expanded laterally; paired gonopores opening ventrally at posterior border of somite; genital opercular flaps each armed with tiny inner spine plus 2 long, outer setae.

Antennules (Fig. 4D) 15-segmented, symmetrical, digeniculate. Genuculations between segments homologous with ancestral segments XV and XVI (9 and 10), and between XX and XXI (13 and 14). Segment 9 (XV) cup-shaped, forming sheath around proximal half of segment 10 (XVI). Segmental fusion pattern and armature as follows: segment 1 (corresponding to fused ancestral segments I and II), 3 setae + aesthetasc; segment 2 (fused ancestral segments III to V), 5 setae; segment 3 (fused ancestral segments VI and VII), 4 setae; segment 4 (VIII), 2 setae; segment 5 (partially fused ancestral segments IX to XI), 6 setae; segments 6 to 9 (XII to XV), 2 setae each; segment 10 (XVI), 1 pectinate spine, 1 seta + aesthetasc; segments 11 and 12 (XVII and XVIII), 1 pectinate spine and 1 seta each; segment 13 (fused ancestral segments XIX and XX), 1 pectinate spine, 1 modified flattened spine, and 1 seta; segment 14 (fused ancestral segments XXI and XXII), 1 modified flattened, spine plate, 1 seta + aesthetasc; segment 15 (fused ancestral segments XXIII to XXVIII), 11 + aesthetasc.

Segmentation and setation of other cephalosomic appendages and swimming legs 1 to 4 as in female, except mandibular palp (Fig. 2B); distal brush-like seta on exopod much shorter and thicker, setules on tip longer than in female.

Fifth legs (Fig. 4E) resembling female condition, but with 2 additional setae implanted subdistally along inner margin of exopod.

REMARKS. The *Cyclopina* from the cave on Mallorca belongs to the group of species in the genus that displays a female leg 5 with the inner spine of distal segment less than half the length of the outer spine, the latter being longer than the segment itself. This group comprises *Cyclopina esilis* Brian, 1938, *C. americana* Herbst, 1982, and *C. cuipora* Lotufo, 1994. The taxon from Mallorca differs clearly from *C. cuipora*. The female antennule is 10-segmented (not 12-segmented as in *C. cuipora*), and the intercoxal sclerite of leg 4 is almost completely smooth (not powerfully ornamented with several rows of thick spinules as in *C. cuipora*) (Lotufo, 1994). Differences from *C. americana* include the short, subquadrate caudal rami (Herbst, 1982) which contrast with the elongate (2.5 to 3.2 times as long as wide) caudal rami of the Mallorcan taxon.

The *Cyclopina* from Mallorca is identified as *C. esilis*, based on the segmentation of the female antennule, the setation of leg 5 and the proportions of the caudal rami. We noted variation in the proportional length of the caudal rami within the Mallorcan population. A similar degree of variability in length of the caudal rami has been reported in *C. esilis* (Brian, 1938; Monchenko, 1979).

Apparent differences in the armature of mouthparts have not been evaluated since we suspect that the armature of mouthparts in *C. esilis* (as in most species of *Cyclopina*) were inadequately described in the original descriptions. This is evident in the presence of a coxal endite, armed with 1 seta, on the maxillule of the *Cyclopina* from Mallorca. This character state (presence of coxal endite) had never previously been noted in *Cyclopina* and was known only from *Cyclopinodes elegans* (T. Scott, 1894) in the family Cyclopinidae (Huys & Boxshall, 1991). The coxal endite may well be present on the maxillule of all *Cyclopina* species. It is present in *C. gracilis* Claus, 1863 from the coast of Scotland (BMNH 1986.377) (pers.

obs.), and perhaps also in *C. oblivia* Monchenko, 1981, according to Monchenko (1989: Fig. 9).

The *Cyclopina* reported by Herbst (1953; 1962) from Banyuls (South France) and from Brittany (NW France) as *C. cf. kieferi* Schäfer, 1936 was recorded living as a commensal with polychaetes (Bretagne) and free-living in the marine interstitial (Banyuls). The illustrations provided by Herbst differ from the original description by Schäfer (1936) in an important character for the taxonomy of the genus, the relative length of the female leg 5 exopodal spines. This discrepancy was already noted by Lotufo (1994) when he presented the differential diagnosis of *C. yutimaete* Lotufo in comparison to *C. kieferi*. As the female leg 5 of *C. cf. kieferi* figured by Herbst (1953; 1962) is identical to that of *C. esilis*, we here consider Herbst's material as belonging to *C. esilis*.

The distribution of *Cyclopina esilis* thus encompasses the littoral zone from the Black Sea to the western approaches of the English Channel; a distribution equivalent to the Mediterranean and Lusitanian provinces of classical marine biogeography (Ekman, 1953).

Family **CYCLOPIDAE** Dana, 1846

Subfamily **HALICYCLOPINAE** Kiefer, 1927

Genus *Neocyclops* Gurney, 1927

Neocyclops (Protoneocyclops) mediterraneus (Kiefer, 1960)

(Figs 5–7)

Pareuryte mediterranea: Kiefer (1960).

Neocyclops remanei mediterraneus: Pesce & Galassi (1987)

MATERIAL EXAMINED. Cova 'C' de Cala Varques (Manacor). UTM coordinates: 525.27; 4372.19. Topography in Trias & Mir (1977): Two adult males (one not preserved) and 2 copepodids (one not preserved) (BMNH 1995. 1329–1330). Collected by authors, 29 March 1995.

ADULT MALE. Body (Fig. 5A) cyclopidiform, up to 0.58 mm long, colourless. Nauplius eye absent. Prosome about 1.4 times as long as urosome, 5-segmented, first pedigerous somite completely concealed by carapace-like, posterior extension of cephalosome. Rostrum (Fig. 5B) triangular in frontal view. Urosome 6-segmented, robust. Fifth pedigerous somite with pointed posterolateral angles; entire hyaline frill adorning posterodorsal margin of somite. Genital somite (Fig. 5C) slightly expanded laterally, with ventrolateral fold each side of somite at about one-third distance from posterior margin; folds slightly projecting dorsally. Paired gonopores opening ventrally, each covered by opercular flap derived from sixth leg; flaps each armed with 1 inner flanged spine and 2 outer plumose setae. Abdominal somites 1 to 3 subequal, with posterior margins adorned with entire hyaline frill. Anal somite bearing operculum dorsally at about midlength; operculum ornamented with serrate hyaline frill; 4 rows of transverse setules adorning sides of anal cleft; posterolateral margins of somite bearing serrate hyaline frill. Caudal rami 2.6 times as long as wide, inserted widely separate from each other; secondary ornamentation of pores and tiny spinules distributed as figured; armature consisting of 7 setae; seta I reduced, tiny, implanted ventrolaterally about one-third of distance along ramus; seta II implanted dorsolaterally at about three-quarters of distance along ramus.

Antennules (Fig. 5E) 16-segmented, not extending beyond posterior margin of prosome, symmetrical, digeniculate (Fig. 5A).

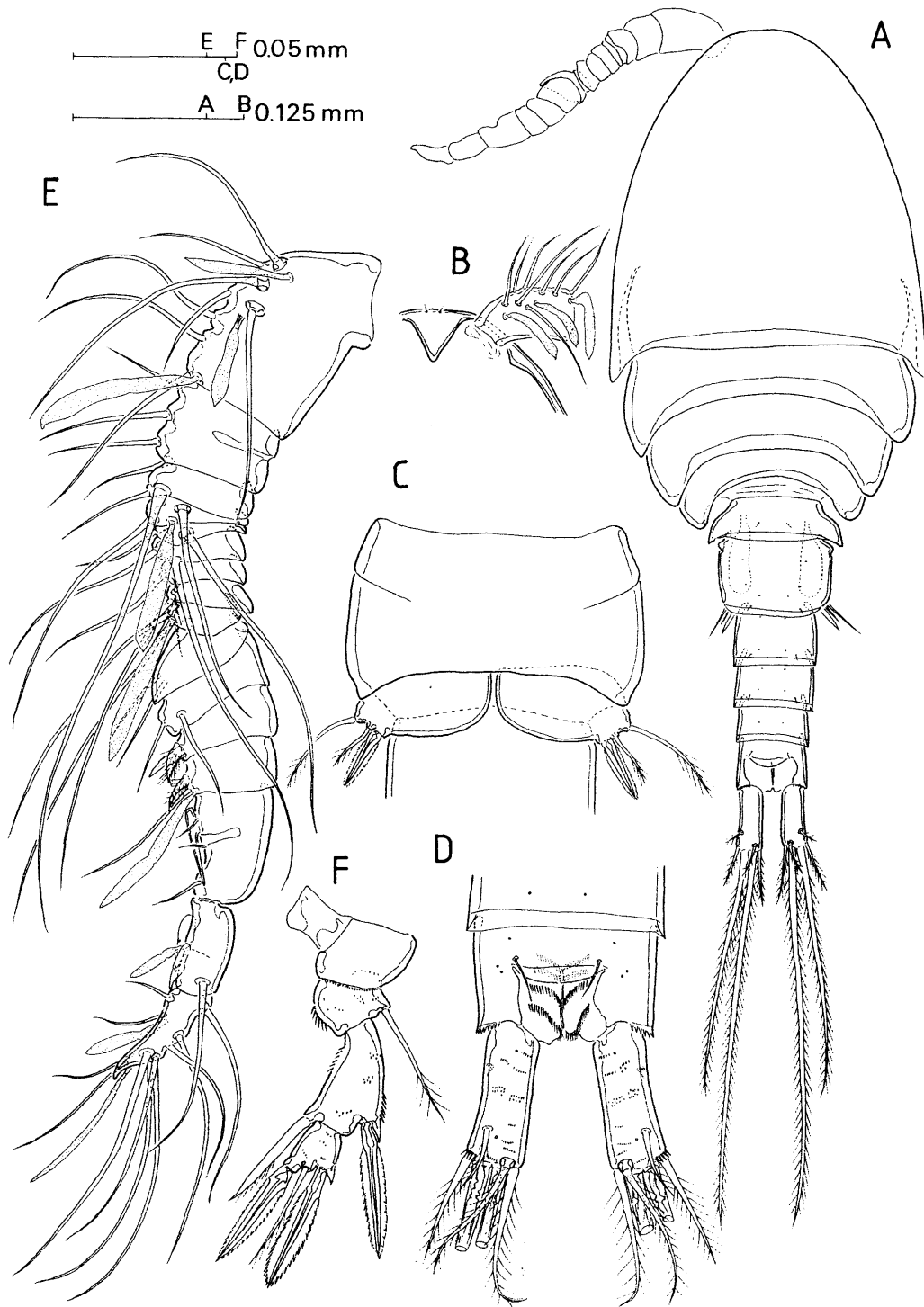


Fig. 5. *Neocyclops (Protoneocyclops) mediterraneus* (Kiefer, 1960), adult male. A, body, dorsal; B, detail of rostral plate; C, genital somite, ventral; D, anal somite and caudal rami, dorsal; E, antennule; F, fifth leg.

Geniculations between segments homologous with ancestral segments XV and XVI (10 and 11), and between XX and XXI (14 and 15). Segment 10 cup-shaped, forming sheath around proximal half of segment 11. Segmental fusion pattern and armature as follows: segment 1 (corresponding to fused ancestral segments I to V), 8 setae + 3 aesthetascs; segment 2 (partially fused ancestral segments VI and VII), 4 setae; segment 3 (VIII), 2 setae; segment 4 (IX), 2 setae +

aesthetasc; segments 5 to 8 (X to XIII), 2 setae each; segment 9 (XIV), 2 setae + aesthetasc; segments 10 and 11 (XV and XVI), 2 setae each; segment 12 (XVII), 2 setose spines; segment 13 (XVIII), 1 setose spine, 1 seta + aesthetasc; segment 14 (fused segments XIX and XX), 1 modified flattened spine and 3 setae; segment 15 (partially fused segments XXI and XXII), 2 modified flattened spines, 1 seta + aesthetasc; segment 16 (fused segments XXIII to

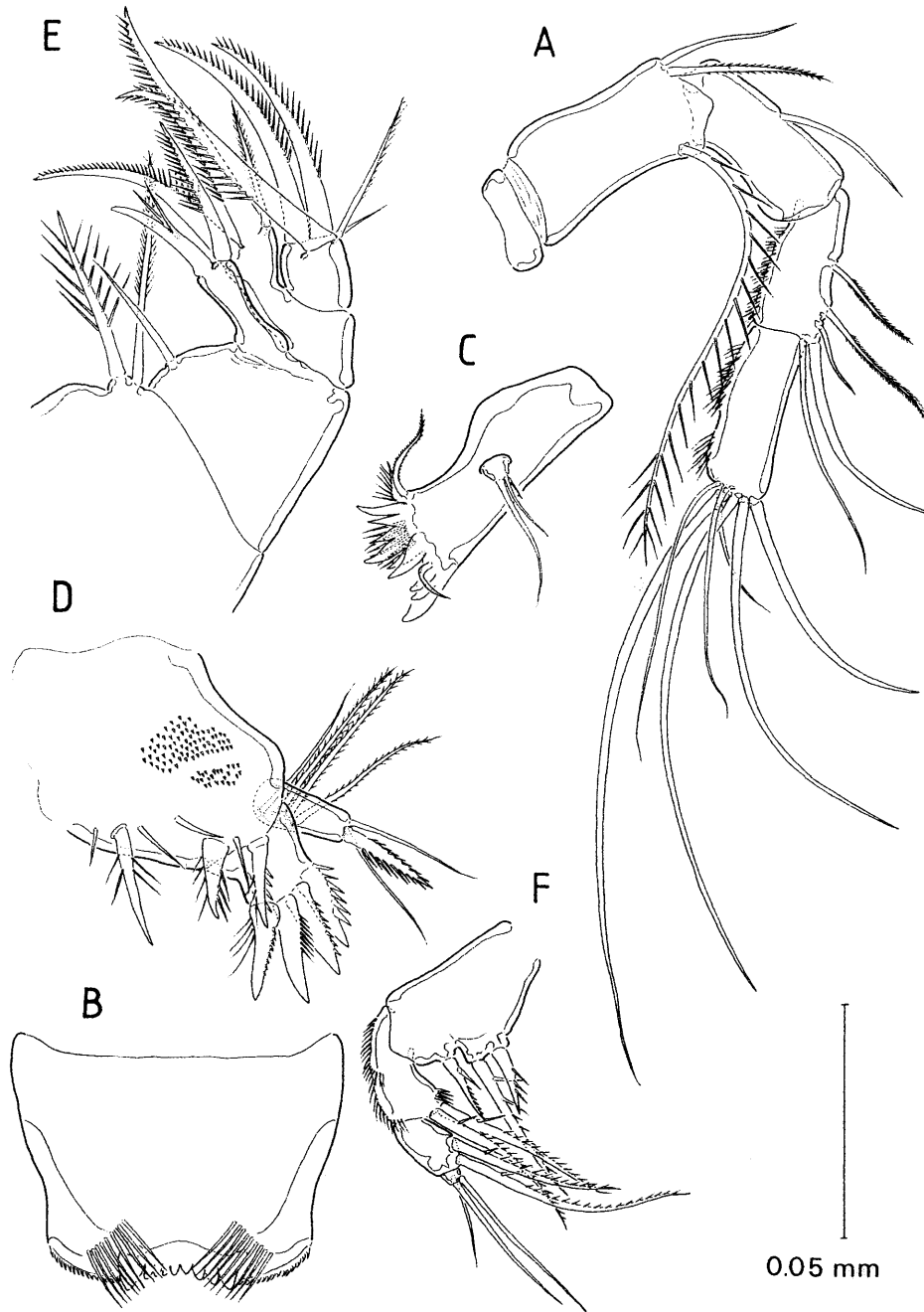


Fig. 6. *Neocyclops (Protoneocyclops) mediterraneus* (Kiefer, 1960), adult male. A, antenna; B, labrum, ventral; C, mandible; D, maxillule; E, maxilla; F, maxilliped.

XXVIII), 11 + 2 aesthetascs.

Antenna (Fig. 6A) well developed, 5-segmented. Coxa and basis separate, coxa small, unarmed. Basis with 2 distal setae on inner margin and long distal seta, representing exopod, on outer margin. First endopod segment with seta inserted midway along inner margin. Second endopod segment with 2 lateral and 3 distal setae along inner margin; outer margin covered by patch of setules. Third endopod segment with 7 unequal setae on tip; outer margin adorned with 2 patches of setules, as figured.

Labrum (Fig. 6B) with laterally serrate distal margin and row of 9 rounded teeth midway along margin; paired transverse rows of long

spinules located subdistally on anterior surface of labrum.

Mandible (Fig. 6C) with coxal gnathobase armed with 9 sharp, unequal teeth, 2 dorsal setae, and 1 naked setiform element located between third and fourth ventralmost teeth; inner dorsal seta with long spinules along one side; outer dorsal seta longer, with short spinules on both sides; transverse row of 7 long spinules disposed subdistally on cutting blade. Mandibular palp reduced to knob bearing 3 unequal setae.

Maxillule (Fig. 6D) with well developed praecoxal arthrite; armature consisting of 3 stout spines, 1 tiny spine and 3 slender setae proximally, and distal lobe armed with 4 thick, denticulate spines; 2

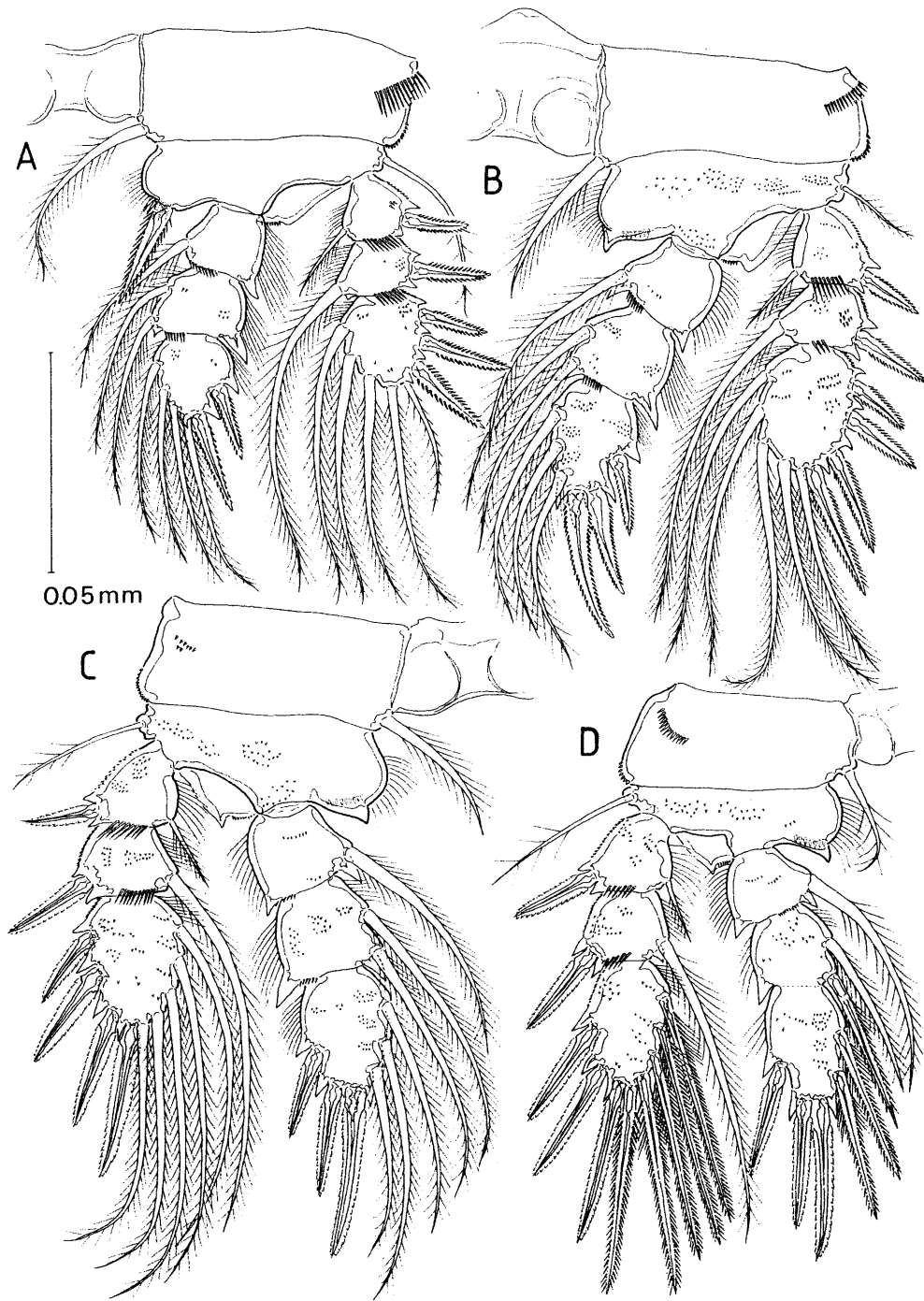


Fig. 7. *Neocyclops (Protoneocyclops) mediterraneus* (Kiefer, 1960), adult male swimming legs, posterior view. A, leg 1; B, leg 2; C, leg 3; D, leg 4.

patches of tiny denticles on segment, as figured. Palp comprising coxobasis with 1 spinulate spine and 2 setae distally and 1 seta (representing exopod) implanted on outer margin, and 1-segmented endopod bearing 3 setae (obscured in Fig. 6D).

Maxilla (Fig. 6E) 4-segmented, powerfully developed. Praecoxa and coxa separate. Praecoxa with single, distal endite armed with 2 elements. Proximal coxal endite represented by single seta; distal coxal endite discrete, armed with 1 spine fused to endite and ornamented with 2 strong spinules, and 1 pectinate spine. Basis with endite bearing 2 stout pectinate elements, one fused to segment, plus

reduced pinnate seta. Endopod 1-segmented, bearing 3 stout pectinate elements plus 2 reduced, unequal setae.

Maxilliped (Fig. 6F) somewhat reduced in size, 4-segmented. Syncoxa bearing 2 weakly developed endites with spine formula 2,1. Basis with 2 distal setae on inner margin; secondary ornamentation of spinules and setules on segment as figured. Endopod 2-segmented, setal formula 2,3. Ornamentation on spines and setae of maxilliped as figured; setae on distal endopodal segment naked.

Swimming legs 1 to 4 (Fig. 7) biramous, both rami 3-segmented, except leg 4 with 2-segmented endopod; distal endopodal segment

subdivided by posterior surface suture marking plane of fusion between second and third segments. Legs subequal in size except first somewhat reduced. Intercoxal sclerites lacking ornamentation. Legs richly ornamented with spinules, setules and denticles, as figured. Armature as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-1	1-1;1-1;III,1,4	0-1;0-2;I,1+1,3
Leg 2	0-1	1-0	1-1;1-1;III,1,5	0-1;0-2;I,II,3
Leg 3	0-1	1-0	1-1;1-1;III,1,5	0-1;0-2;I,II,3
Leg 4	0-1	1-0	1-1;1-1;III,1,IV	0-1;I,II,III+1

Spines on legs 1 and 2 adorned with spinules, those on leg 3 flanged with serrate hyaline frill. Outer spines on exopod and outer and distal spines on endopod of leg 4 ornamented with serrate hyaline frill; inner margin setae on both rami modified, spine-like, ornamented with short pinnules proximally and serrate membrane distally.

Fifth legs (Fig. 5F) 4-segmented, joined by smooth intercoxal sclerite. Coxa and basis separate, coxa unarmed, basis bearing plumose seta on outer margin. First exopodal segment elongate, about as long as coxa and basis combined, outer margin with subdistal spine flanged with serrated hyaline frill; spinous process just anterior to insertion point of spine; flanged spine longer than segment; inner margin of segment bearing 1 distal spine adorned with sparse setules and about as long as segment. Distal margin of second exopodal segment bearing 1 seta flanked by 2 spines flanged with serrate hyaline frill; spinous process just proximal to insertion point of outer spine; outer spine slightly longer than inner, and longer than first exopod segment; inner spine about as long as first endopod segment; seta shorter than spines. Secondary ornamentation on fifth leg segments as figured.

REMARKS. The genus *Neocyclops* Gurney, 1927 contains 15 species distributed in coastal waters of the Northeast and Tropical Atlantic (including the Caribbean), the Mediterranean, the Black and Red Seas, the Indian Ocean, as well as the Pacific (Papua New Guinea) (Petkovski, 1986; Fiers, 1986; Pesce & Galassi, 1993; Lotufo & Rocha, 1993; Rocha, 1995). Petkovski (1986) has split the genus into two subgenera according to the number of exopodal segments of the male fifth legs. The subgenus *Neocyclops*, characterized by a 3-segmented male leg 5, embraces the following species: *N. medius* Herbst, 1955, *N. vicinus* (Herbst, 1955), *N. affinis* (Plesa, 1961), *N. salinarum* (Gurney, 1927) and *N. remanei* (Herbst, 1952).

The subgenus *Protoneocyclops*, with 4-segmented male fifth legs, comprises *P. stocki* Pesce, 1985, *P. geltrudeae* Pesce & Galassi, 1993, *P. papuensis* Fiers, 1986, *P. mediterraneus* (Kiefer, 1960), *P. herbsti* Petkovski, 1986, *P. wellsi* Petkovski, 1986 and *P. ferrarii* Rocha, 1995. This subgenus displays the so-called full Tethyan pattern of distribution (Stock, 1993), i.e., circum-tropical in the entire region of the former Tethys Sea.

Three other species, viz. *N. improvisus* Plesa, 1973 from Cuba, and *N. magnus* (Sewell, 1949) and *N. parvus* (Sewell, 1949) from islands in the Indian Ocean, cannot be assigned to either subgenus as their males are unknown.

Three representatives of the genus are known so far from the Mediterranean region. *Neocyclops* (*N.*) *salinarum*, originally described from the Suez Canal, was reported also from the Camargue (South France) and the Sirbonian lagoon (Mediterranean coast of Sinai) (Gurney, 1927a; 1927b; Aguesse & Dussart, 1956; Por, 1973). As Petkovski (1986) pointed out, the identity of the French population needs to be confirmed. Similarly the single copepodid from the

Andaman Islands (Indian Ocean), assigned by Sewell (1949) to this species, should be reexamined. *Neocyclops* (*N.*) *vicinus*, a species distributed along the coasts of Brazil and the Lesser Antilles (Pesce & Galassi, 1993; Lotufo & Rocha, 1993), has been also reported from the Black Sea (as *Eurycyclops remanei vicinus*) by Plesa (1963) and Monchenko (1975). As pointed out by Lotufo & Rocha (1993), this record is dubious since their material seems more closely related to *N. (N.) remanei* than to *N. (N.) vicinus*.

The single representative of the subgenus *Protoneocyclops* in Mediterranean waters is *Neocyclops* (*P.*) *mediterraneus*, originally described by Kiefer (1960) as *Pareuryte mediterranea* from an anchihaline cave on Menorca (Balearic Islands). Later, Pesce & Galassi (1987) reported it from an anchihaline cave in Southern Italy. Plesa (1981) cited the same species from Cuba, but this record has been reassigned by Petkovski (1986) to *N. (N.) stocki*, a taxon widespread in the Caribbean region (Pesce & Galassi, 1993).

The *Neocyclops* from Mallorca has been identified on the basis of the 4-segmented condition of the male fifth legs and the relative lengths of the armature elements on this leg. Mallorca is also close to the type-locality of the species (Menorca). Other characters could not be checked against Kiefer's (1960) original description since this contained only 5 drawings (viz. female anal somite and caudal rami, distal segment of endopod of female leg 4; fifth leg of both sexes, and genital operculum of male). In addition, Kiefer did not designate types for the species. Pesce & Galassi (1987) had only 2 females at their disposal for their supplementary description.

A differential diagnosis of *Neocyclops* (*Protoneocyclops*) *mediterraneus* (Kiefer, 1960) can be constructed based on characters of the male fifth leg. It differs from *N. (P.) geltrudeae* Pesce & Galassi (1993) from Curaçao (Antilles) in the number of armature elements on the distal segment (3, compared to 4 in *N. (P.) geltrudeae*). Differences from *N. (P.) papuensis* Fiers, 1986 from New Guinea and *N. (P.) ferrarii* Rocha, 1995 from Brazil involve the relative lengths of the spines on the distal segment (the inner spine is clearly longer than the outer in both these species whereas in *N. (P.) mediterraneus* the outer spine is subsimilar, slightly longer than the inner). Differences from *N. (P.) herbsti* Petkovski (1986) from the Red Sea, and *N. (P.) stocki* Pesce, 1985 from the Caribbean, are based on the relative lengths of the flanged spines on the 2 distal segments of leg 5 (these are clearly shorter than the first exopodal segment whereas in *N. (P.) mediterraneus* they are longer than the segment). In addition, in *N. (P.) herbsti* the armature element on the inner margin of the first exopodal segment is a plumose seta, whereas in *N. (P.) mediterraneus* it is a thick spine. Differences from *N. (P.) wellsi* Petkovski (1986) from Mozambique lie only in the nature of the armature element on the inner margin of the first exopodal segment, which is also a seta in this species instead of a thick spine.

Subfamily EURYTEINAE Monchenko, 1975

Genus *Euryte* Philippi, 1843

Euryte longicauda Philippi, 1843 emend. Giesbrecht, 1900

(Figs 8-11)

MATERIAL EXAMINED. Cova de na Barxa (Capdepera). UTM coordinates: 539.30; 4393.10. Topography in Andrews *et al.* (1989): Two adult females, 1 adult male, and 1 copepodid (BMNH 1995. 1323-1326). Collected by authors, 3 April 1995. - Cova de na Mitjana (Capdepera): 19 adult males, 7 adult females, and 5

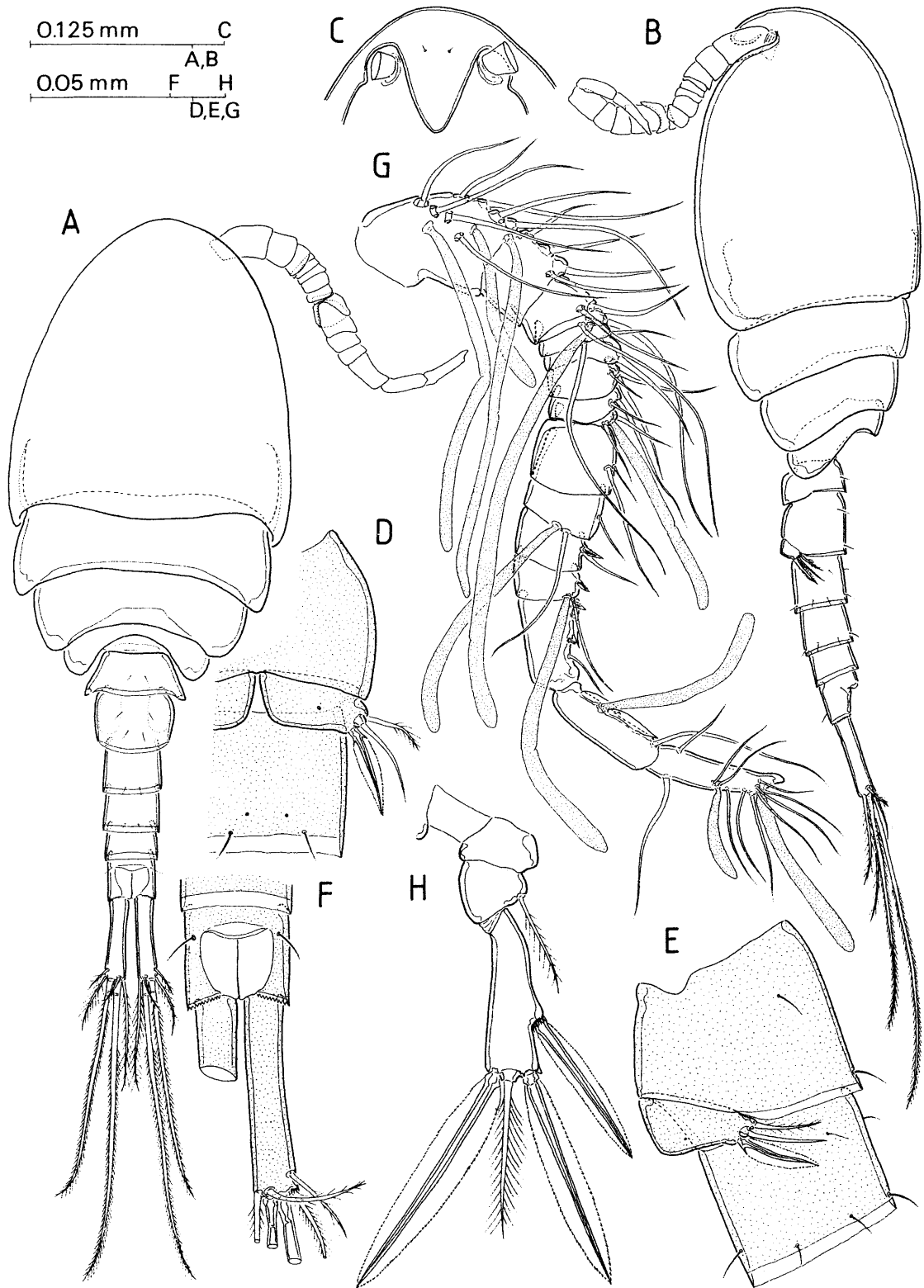


Fig. 8. *Euryte longicauda* Philippi, 1843, adult male. A, body, dorsal; B, lateral; C, detail of rostral plate; D, genital and first abdominal somites, ventral; E, same, lateral; F, anal somite and caudal rami, dorsal; G, antennule; H, fifth leg.

copepodids (BMNH 1995. 1313–1322). Collected by authors, 1 April 1995. – Es Secret des Moix (Manacor). Coordinates: 523.69; 4365.53. Topography in Ginés *et al.* (1975): One adult female

(BMNH 1995. 1327). Collected by D. Jaume, 25 May 1994.

ADULT MALE. Body (Figs 8A, B) cyclopiform, up to 0.61 mm long, body surface completely covered by tiny cuticular granulations.

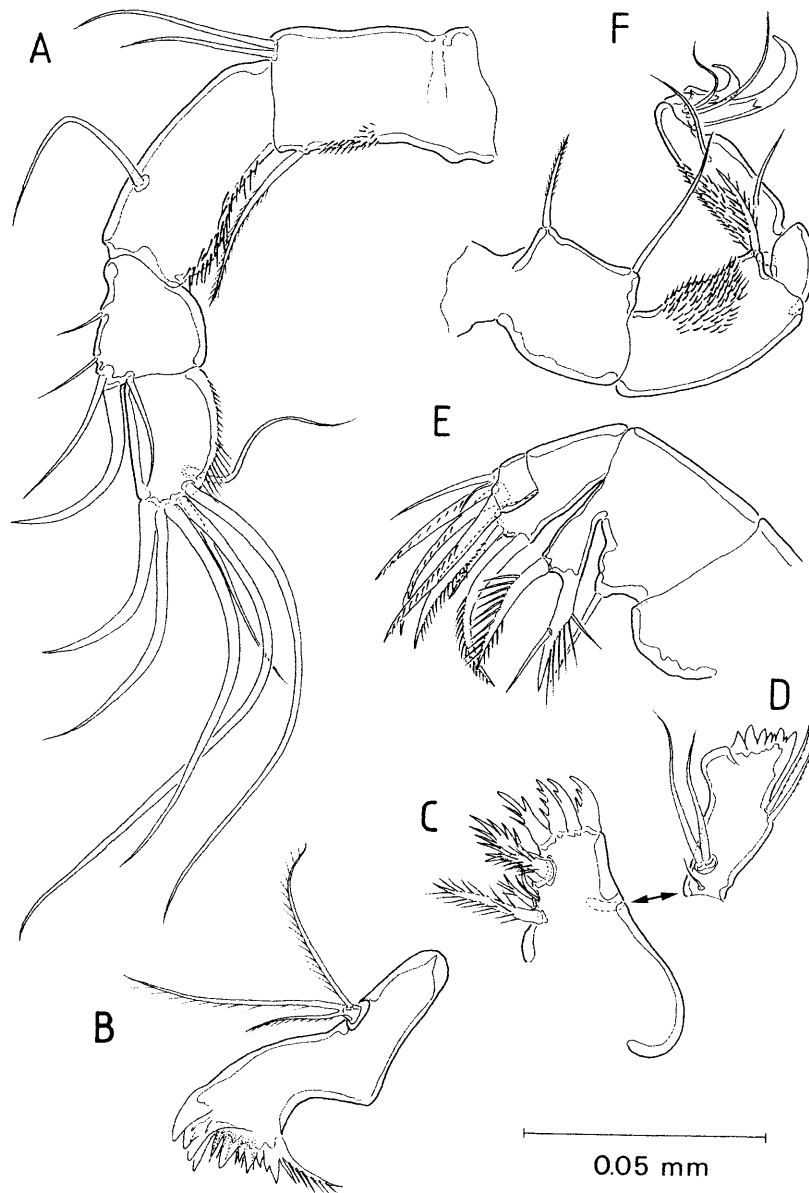


Fig. 9. *Euryte longicauda* Philippi, 1843, adult male. A, antenna; B, mandible; C, maxillule praecoxal arthritis; D, maxillulary palp; E, maxilla; F, maxilliped.

Prosoma about 1.4 times longer than urosome, comprising cephalosome plus 4 free pedigerous somites; first pedigerous somite completely concealed beneath posterior extension of cephalosome, with lateral margins weakly sclerotized; second to fourth somites with evenly rounded posterolateral corners. Rostrum (Fig. 8C) fused at base, well developed, subtriangular in frontal view. Urosome 6-segmented; first abdominal somite with pointed posterolateral angles; entire hyaline frill adorning posterodorsal margin. Genital somite (Figs 8D,E) symmetrical, laterally expanded, with entire hyaline frill around posterodorsal margin; pair of gonopores opening ventrally at posterior border of somite; opercular flaps each armed with 1 inner flanged spine plus 2 outer setae. Third to fifth urosome somites subequal, narrower than genital somite, with entire hyaline frill adorning posterior margin. Anal somite (Fig. 8F) about same size as preceding somites; smooth anal operculum present at one third of distance along somite; serrate hyaline frill around posterolateral margins of

somite. Caudal rami (Fig. 8F) of variable length, from 4.4 to 6.4 times longer than wide, slightly divergent; distal part slightly wider; armature consisting of 6 setae; seta II located subdistally.

Antennules (Fig. 8G) 16-segmented, symmetrical, digeniculate with geniculations between segments homologous with ancestral segments XV and XVI (10 and 11), and segments XX and XXI (14 and 15). Segment 10 cup-shaped, forming sheath around proximal half of segment 11. Segmental fusion pattern and armature as follows: Segment 1 (corresponding to fused ancestral segments I to V), 8 setae + 3 aesthetascs; segment 2 (corresponding to fused ancestral segments VI and VII), 4 setae; segment 3 (VIII), 2 setae; segment 4 (IX), 2 + aesthetasc; segments 5 to 8 (X to XIII), 2 setae each; segment 9 (XIV), 2 + aesthetasc; segment 10 (XV), 2 setae; segment 11 (XVI), 2 + aesthetasc; segment 12 (XVII), 1 short denticulate spine and 1 seta; segment 13 (XVIII), 1 short denticulate spine, 1 seta + aesthetasc; segment 14 (fused ancestral segments XIX and XX), 1 short denticulate spine, 1 modified flattened spine,

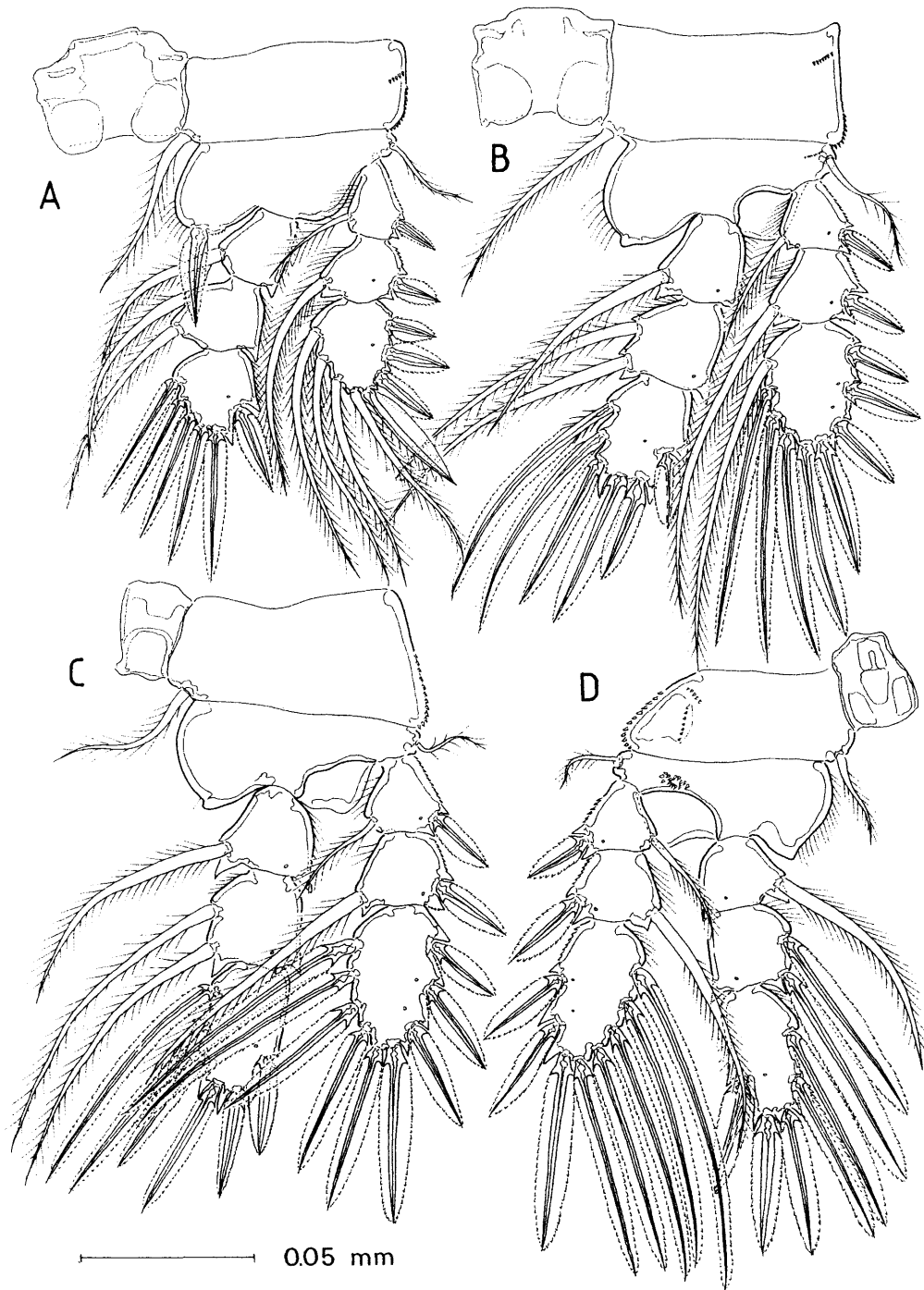


Fig. 10. *Euryte longicauda* Philippi, 1843, adult male swimming legs, posterior view. A, leg 1; B, leg 2; C, leg 3; D, leg 4.

1 seta + minute aesthetasc; segment 15 (fused ancestral segments XXI to XXIII), 2 modified flattened spines, 1 seta + aesthetasc; segment 16 (fused segments XXIV to XXVIII), 11 setae + 2 aesthetascs.

Antenna (Fig. 9A) 4-segmented. First segment representing partially fused coxa and basis, armed with 2 inner basal setae distally, and 1 outer seta representing exopod; patch of setules present midway along outer margin of segment. Endopod 3-segmented; first segment about as long as coxa and basis combined, armed with 1 seta at three-quarters of distance along inner margin; outer margin

ornamented with setules. Segments 2 and 3 subsimilar in size, each about half length of segment 1. Segment 2 armed with 2 lateral and 3 distal setae, one of latter (seta VIII in scheme of Boxshall & Evstigneeva, 1994) claw-like, along inner margin. Segment 3 armed with 7 distal setae, one claw-like; outer margin with 2 rows of setules, as figured.

Mandible (Fig. 9B) with large coxal gnathobase bearing 11 unequal, sharp blades, plus 2 dorsal spines; outer dorsal spine spinulate; transverse row of 6 thin spinules located adjacent to cutting edge. Palp reduced to knob bearing 3 setae.

Maxillule with praecoxal arthrite (Fig. 9C) well developed, armed distally with 4 stout, denticulate spines, plus 6 more proximal elements, ranging from a tiny seta to a thick denticulate spine. Palp (Fig. 9D) comprising coxobasis with medial gnathobase-like structure and minute endopodal segment bearing 2 setae; distal margin of coxobasal gnathobase provided with 9 irregular blades; coxobasis with 2 setae located subapically on dorsal margin and single seta, representing exopod, located proximally on distal surface.

Maxilla (Fig. 9E) well developed, 4-segmented. Praecoxa and coxa incompletely separate. Praecoxa naked, lacking endites. Coxa with proximal endite represented by single seta; distal endite powerfully developed, bearing 2 stout, spinulate spines, proximal spine bearing single, conspicuous strong spinule on outer margin and row of thinner spinules on inner margin. Basis with endite bearing 3 unequal, claw-like setae. Endopod 1-segmented, armed with total of 3 stout spine-like setae, 1 naked seta and 1 very reduced seta.

Maxilliped (Fig. 9F) 5-segmented, prehensile. Syncoxa bearing 2 weakly developed endites provided with single seta each. Basis with inner margin covered by patch of setules and single seta positioned distally. Endopod 3-segmented, first segment short, unarmed; second segment elongate, inner margin covered by patch of setules, armed with 2 setae laterally; small distal segment with 2 stout, curved claws plus 2 accessory setae.

Swimming legs 1 to 4 (Fig. 10) biramous, both rami 3-segmented. Legs subequal in size except first somewhat smaller. Intercoxal sclerites lacking ornamentation and getting progressively narrower from legs 1 to 4. All spines on segments flanged bilaterally with serrate hyaline frill except distalmost spine on exopod of leg 1, which is flanged with frill on outer side only, inner side adorned with row of setules. Secondary ornamentation and pore pattern on segments as figured; pores on coxa and basis possibly overlooked. Armature as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-1	I-1;I-1;III,I,4	0-1;0-2;I-II-III
Leg 2	0-1	1-0	I-1;I-1;III,I,IV+1	0-1;0-2;I-II-III
Leg 3	0-1	1-0	I-1;I-1;III,I,V	0-1;0-2;I-II-III
Leg 4	0-1	1-0	I-1;I-1;II,I,V	0-1;0-II;I-II-II

Fifth legs (Fig. 8H) uniramous, 3-segmented, joined by smooth intercoxal sclerite. Coxa and basis separate, former naked, latter with single seta on outer margin. Distal segment (exopod) elongate, about 2.5 times as long as wide; armature consisting of flanged spine as long as segment located two-thirds of distance along outer margin, plus 2 flanged spines and single seta on distal margin; distal seta shorter than both spines and segment itself; distal spines located either side of seta, flanged, both clearly longer than segment, inner longer, about 1.5 times as long as segment. Secondary ornamentation of spinules present on outer margin of exopod of some individuals, similar to that figured on female leg 5 (Fig. 11E), not present in figured specimen (Fig. 8H).

ADULT FEMALE. Body (Figs 11A, B) up to 0.74 mm long, resembling male. Urosome 5-segmented; genital and first abdominal somites partially fused to form genital double-somite. Genital double-somite (Fig. 11C) symmetrical, subdivided dorsally by partial suture line; single copulatory pore opening mid-ventrally about one-third of distance along somite, connected via copulatory duct to fused seminal receptacles. Paired gonopores located laterally; gonopores covered by opercula, each consisting of lobe projecting dorsally bearing 2 setae and 1 tiny spine. Tapering soft lobe pointing posteriorly located at both sides of somite just behind

operculum. Entire hyaline frill present along posterior margin of somite.

Antennules (Fig. 11D) 21-segmented, not extending beyond posterior margin of cephalosome (Figs 11A, B), symmetrical. Segmental fusion pattern and armature as follows: Segment 1 (corresponding to fused ancestral segments I to V), 8 setae; segment 2 (fused ancestral segments VI and VII), 4 setae; segments 3 to 9 (VIII to XIV), 2 setae each; segments 10 to 13 (XV to XVIII), 1 seta each; segment 14 (XIX), naked; segment 15 (XX), 1 seta; segment 16 (XXI), 1 seta + aesthetasc; segment 17 (XXII), naked; segment 18 (XXIII), 1 seta; segment 19 (XXIV), 2 setae; segment 20 (XXV), 2 + aesthetasc; segment 21 (fused XXVI to XXVIII), 7 + aesthetasc.

Segmentation and setation of other cephalosomic appendages and swimming legs 1 to 4 as in male.

Fifth legs (Fig. 11E) resembling those of male, but with shorter exopod, about twice as long as wide; inner distal spine almost twice as long as segment; spine on outer margin clearly longer than segment. Secondary ornamentation of spinules on outer margin of exopod not discernible in some individuals.

REMARKS. The genus *Euryte* typically contains shallow water hyperbenthic species, although Brady (1910) reported the genus from depths of 320 m in the Antarctic and some species have been found living in the interstices of coarse sand, or in association with seaweed or corals. Ten species are currently recognized, distributed worldwide (Gurney, 1927b; Sewell, 1949; Herbst, 1989; Humes, 1991; 1992), with the possible exception of the Pacific coast of South America. Apart from the original contributions by Giesbrecht (1900) and Sars (1913-1918), new species have been described mainly on the basis of a biometric analysis of characters that have otherwise proved to exhibit high intra-populational variability (such as the relative length of caudal rami), or that may vary significantly in their measurements simply according to the precise angle of observation (such as the relative length of the armature elements on the distal segment of the endopod of leg 4). Such characters are widely used in the two identification keys available for the genus (Vervoort, 1964; Herbst, 1989), and their use has resulted in the false impression of cosmopolitanism of some taxa (viz. *E. longicauda* and *E. robusta* Giesbrecht, 1900; see Kiefer (1929) and Sewell (1949)).

The type material for most species of *Euryte* is no longer extant. This hampers the necessary revision of the genus, that could permit the critical reevaluation of all those taxa established on the basis of variable characters.

Using material from the type locality of both species (the Gulf of Naples), Giesbrecht (1900) differentiated *E. longicauda* Philippi, 1843 from *E. robusta* Giesbrecht, 1900 mainly by the proportions of the caudal rami and by details of the armature of the male antennule. The proportions of the caudal rami of the Mallorcan population overlap the characteristic values for both species given by Giesbrecht (1900). The armature of the male antennule, however, corresponds to that of *E. longicauda*: the cup-shaped segment 10 carries 2 slender setae, whereas in *E. robusta* it carries a characteristic robust, S-shaped spine plus a seta. On this basis we have assigned the *Euryte* from the Mallorcan caves to *E. longicauda*.

The differential diagnosis separating *E. longicauda* from Mallorca from *E. robusta* can be completed as follows (see the detailed illustrations of the latter species in Huys & Boxshall, 1991): in *E. longicauda* the proximal spine on the distal coxal endite of the maxilla of both sexes is armed with a single, strong spinule on one side and a row of thinner spinules on the other side; in *E. robusta* both sides are armed with thin spinules. Additionally, in *E. longicauda* there is a transverse dorsal suture midway along the female genital double-somite that seems to be absent in *E. robusta*.

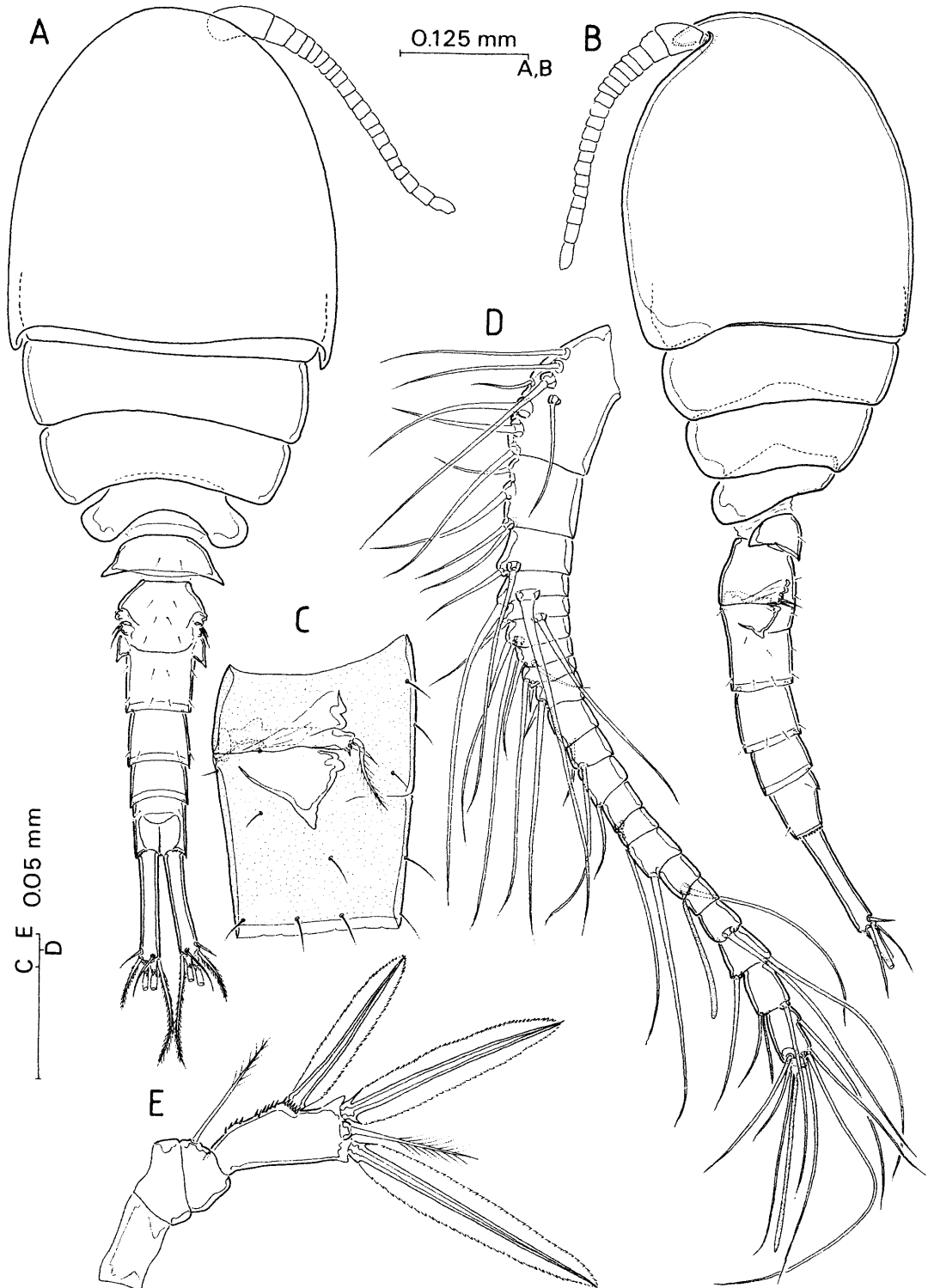


Fig. 11. *Euryte longicauda* Philippi, 1843, adult female. A, body, dorsal; B, lateral; C, genital double-somite, lateral; D, antennule; E, fifth leg.

The distribution of *E. longicauda* apparently encompasses all European coasts from the Black Sea to the Arctic Ocean (Franz-Joseph Land) and the East coast of Greenland (Giesbrecht, 1900; Herbst, 1989) but many of the records of this species are accompanied by inadequate descriptions, if any. Geographically remote records from outside the European region, such as those of Gurney

(1927b) from the Suez Canal and Samoa, or those of Thomson (1882) (as *Thorellia brunnea* var. *antarctica*) from New Zealand, require verification.

The body size of the *Euryte longicauda* from Mallorca falls in the range characteristic of the variety *E. longicauda* var. *minor* Scott, 1905, which was elevated, rather inconsistently, to full specific

status by Sars (1919–1921). This variety is supposed to inhabit deeper waters and never to occur in the littoral zone (Sars, 1913–1918; 1919–1921).

According to Sars (1913–1918) *E. longicauda* carries only modified flanged spines on the inner margin of the third exopodal segment of leg 2. In our material the proximalmost element on the inner margin of this segment is a plumose seta (Fig. 10B). However, this may be an observational error by Sars since material of *E. longicauda* from Raunefjorden in Norway (BMNH 1986.387) and from Scotland (BMNH 1951.8.10.587) in the collections of the Natural History Museum possesses a plumose seta in this position, as in the Mallorcan material.

REVIEW OF EURYTE SPECIES

The eight remaining species of *Euryte* are briefly reviewed here, in order to facilitate the identification of representatives of this problematic genus. The review is essentially comparative and emphasises the most robust and reliable characters available in published descriptions.

E. curticornis Sars, 1913 is characterised by short, 21-segmented female antennules and the shortened third segment of the maxilliped; the curved distal claws on this appendage are also reduced in size and subsimilar in length. These features contrast with the maxilliped of *E. longicauda*, which is provided with an elongate third segment and with long, unequal distal claws. The distal spines on the third segment of endopod of leg 1 are clearly unequal in length in *E. curticornis*, whereas in *E. longicauda* they are about equal.

E. longicauda can be distinguished from *E. grata* Herbst, 1989 and *E. verecunda* Humes, 1992 by some features of the maxilla and maxilliped. In *E. verecunda*, the proximal spine on the distal coxal endite of maxilla is adorned on both sides with slender spinules. On the maxilliped, the armature element on the proximal syncoxal endite is a seta in *E. longicauda*, whereas in *E. grata* and *E. verecunda* this endite is represented by a stout spine. *E. verecunda* differs additionally in the setose condition of the armature elements on the inner margin of the second endopodal segment of leg 4; these elements are flanged spines in *E. longicauda*. The generic placement of *E. verecunda* needs verification since, according to Humes (1992), this species displays a 2-segmented condition of leg 5. This is a characteristic of the genus *Ancheuryte* Herbst, 1989, whereas in *Euryte* leg 5 is 3-segmented in both sexes.

In *E. pseudorobusta* Vervoort, 1964 two distal setae are present in the outer margin of the antennary coxobasis, whereas there is only 1 seta in *E. longicauda*. The proximal spine on the distal coxal endite of maxilla has a different armature in the two species, with a row of setules along each side in *E. pseudorobusta*. Finally, the caudal rami of *E. pseudorobusta* are short, about as long as the anal segment, and differ significantly from the elongate caudal rami of *E. longicauda*.

Two other species, each described from a single female from the Addu Atoll (Maldives), viz. *E. brevicauda* Sewell, 1949 and *E. sewelli* Vervoort, 1964 (= '*Euryte* sp.' of Sewell, 1949) also differ from *E. longicauda* in their very short caudal rami. The status of *E. sewelli* Vervoort, 1964 as a distinct species from *E. brevicauda* is equivocal (Vervoort, 1964; Sewell 1949). The main difference between them is the apparently 18-segmented female antennule in the former species. Unfortunately, Sewell's (1949) original material is not preserved, thus precluding verification. However, if Sewell's illustrations are accurate, the 18-segmented antennule, combined with the absence of the inner seta on the proximal segment of exopod of leg 1, can be used as diagnostic characters of this taxon.

E. longicauda differs from *E. bellatula* Humes, 1991 in the nature of the two armature elements on the inner margin of the second endopodal segment of leg 4; these are flanged spines in the former species, whereas in the latter they are setae. *E. bellatula* also has the proximal spine on the distal coxal endite of maxilla armed with a row of thin spinules on both sides. As commented above for *E. verecunda*, the generic placement of *E. bellatula* must be confirmed due to the apparently 2-segmented condition of the leg 5. The association with corals of the two taxa described by Humes is similar to the life-style of *Ancheuryte*, a closely related genus characterized by its 2-segmented leg 5.

The status of *E. similis* Scott, 1912, originally described from the South Orkneys and never found since, is debatable. Scott pointed out its similarity to *E. robusta*, and that it appeared '... to differ in one or two minor points, such as in the armature of the first and fourth pairs of thoracic legs and in the proportional lengths of the abdominal segments' (Scott, 1912). The differences in the armature of the swimming legs mentioned by Scott in the text do not correspond with his figures. Also, as Sewell (1949) already pointed out, it seems certain that Scott had confused the legs so that his second leg is in reality the fourth, and his fourth leg is either the second or third. In fact, the original description is very superficial and does not permit any conclusion other than that the taxon belongs to *Euryte*. The only apparent diagnostic features displayed by this taxon could be the lack of an inner seta on both the first endopodal and first exopodal segments of leg 4 (Scott's leg 2). This is unreliable, however, since the number of armature elements on the swimming legs is a very conservative character at the generic level in the Cyclopidae. In our opinion, given the lack of type material, this taxon should be considered *species inquirendum*.

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