

## AUSTRALASIAN SPECIES OF LIMNORIIDAE (CRUSTACEA: ISOPODA)

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### Abstract

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Some members of the Limnoriidae are important marine wood-borers. The taxonomy of the family was studied with emphasis on species from the Australasian region. The Limnoriidae are reduced to two genera: *Limnoria* Leach and *Paralimnoria* Menzies. The genus *Phycolimnoria* is synonymised with *Limnoria*.

Species from Australia are redescribed: *Limnoria indica* Becker and Kampf, *L. insulae* Menzies, *L. multipunctata* Menzies, *L. nonsegni* Menzies, *L. pfefferi* Stebbing, *L. platycauda* Menzies, *L. quadripunctata* Holthuis, *L. rugosissima* Menzies, *L. sublittorale* Menzies, *L. tripunctata* Menzies and *L. unicornis* Menzies.

New species from Australia are: *L. agrostisa*, *L. echidna*, *L. gibbera*, *L. glaucinosa*, *L. orbellum*, *L. poorei*, *L. raruslima*, *L. torquisa* and *L. uncapedis*. The new species *L. loricata* and *L. convexa* are also described from The Snares, New Zealand.

Species from Papua New Guinea are: *Paralimnoria andrewsi* (Calman), *P. asterosa* Cookson and Cragg, *L. andamanensis* Rao and Ganapati, *L. indica*, *L. insulae*, *L. kautensis* Cookson and Cragg, *L. multipunctata*, *L. pfefferi*, *L. tripunctata* and *L. unicornis*.

*L. antarctica* Pfeffer and *L. stephensi* Menzies from Macquarie Island are redescribed.

Although not found near Australia, *L. tuberculata* Sowinsky is also redescribed to distinguish it from *L. tripunctata*.

Of the above species, 15 are wood-borers, 12 algal-borers or dwellers, and 2 scagrass-borers. Commensal crustaceans found with limnoriids, such as harpacticoid copepods, ostracods, and amphipods of the family Cheluridae are noted. *Tropichelura insulae* (Calman) (Amphipoda) is recorded from Australia for the first time.

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### Introduction

Isopod crustacean marine borers in the family Limnoriidae, commonly called "gribble", have received a great deal of attention from wood preservationists because of the damage they can cause to marine timber structures. They are one of four main groups of marine borers which can substantially damage timber in the sea. The three other groups are isopods of the genus *Sphaeroma*, and molluscs of the families Pholadidae (piddocks) and Teredinidae (shipworms). Studies on Limnoriidae have increased dramatically since Menzies (1951a) correlated the premature failure of creosote-treated softwoods in the USA due to the presence of *Limnoria tripunctata* Menzies. This species, and *L. quadripunctata* Holthuis and *L. lignorum* (Rathke), are the three most studied species.

Algal- and seagrass-boring species of Limnoriidae have received much less attention. The algal-borers can cause seaweeds to come adrift by boring into holdfasts (Jones, 1971). The importance of seagrass-borers to the erosion of seagrass meadows is not known.

### Ecology

Habitats in which limnoriids have been found include dead wood (e.g., Menzies, 1957); preservative treated wood (e.g., Menzies, 1951a;

Cookson and Barnacle, 1987a); bamboo (Richardson, 1909), dead and decaying wood from live mangroves (Kensley and Schotte, 1987); live soft uncorticated mangrove roots (Ellison and Farnsworth, 1990); holdfasts of brown algal kelps from the order Laminariales, such as *Macrocystis* (Pfeffer, 1887; Chilton, 1914a; Hale, 1937; Menzies, 1957; Paternoster and Elías, 1980; present study), *Egregia*, *Eisenia*, *Laminaria*, *Postelsia*, *Nereocystis* (Menzies, 1957), *Pelagophycus* (Jones, 1971), *Lessonia* (Stephensen, 1927; present study), *Ecklonia* (present study); kelps from the order Fucales, such as *Sargassum* (Pillai, 1957; Jones, 1971), *Durvillaea*, *Cystophora*, possibly *Acrocarpia* (present study); on the Fucales brown alga *Homosira* (present study); *Corallina* (Menzies, 1957) and other red algae (present study); possibly green algae (present study); on *Galeolaria* tube-worm colonies (present study); under algal covered stones (Pfeffer, 1887; present study); algal epifauna in rock pools (present study); under encrusting and coralline algae (present study); and in the seagrasses *Phyllospadix* (Kussakin, 1979), *Thalassia* (Müller, 1988), *Posidonia*, *Heterozostera*, *Zostera* and *Amphibolis* (present study). *Limnoria* has also been found in gutta-percha (insulating latex) from old submarine cables (Chilton, 1916), and can produce shallow pits in materials made from a com-

bination of certain plastics and ground wood (Griffin and Turner, 1980).

In Australia, the greatest depth where algae are likely to be found growing is 75 m (Rochford, 1980), while seagrasses are mostly within 35 m, although some have been found at 68 m (Lanyon, 1986). The deepest algal-borers are *L. rugosissima* Menzies and *L. nonsegnis* Menzies at 30 m, and *L. uncapedis* sp. nov. at 21 m (present study). The deepest seagrass-borer is *L. rarulima* sp. nov. at 12 m (present study). *L. torquisa* sp. nov. appears to be largely restricted to the tidal zone. Most known species of wood-boring *Limnoria* are found in comparatively shallow water. However, some species appear to be restricted to deeper water. These species are: *L. japonica* Richardson at 300 m (Richardson, 1909), *L. septima* Barnard (probably a wood-borer) at 340-460 m (Barnard, 1936), *L. sublittorale* Menzies at 110 m (Menzies, 1957), *L. reniculus* Schotte at 520 m (Schotte, 1989), *L. foveolata* Menzies (may be a wood-borer) at 52 m (Menzies, 1957), *L. borealis* Kussakin at 18-230 m (Kussakin, 1963), *L. emarginata* Kussakin and Malyutina at 1050 m (Kussakin and Malyutina, 1989) and *L. hicksi* Schotte at 1100 m (Schotte, 1989). *Paralimnoria asterosa* Cookson and Cragg and *L. kautensis* Cookson and Cragg have so far been found only at 8-9 m depths, despite collections from several more shallow locations in Papua New Guinea (Cookson and Cragg, 1988). The deepest occurring limnoriid species appears to be those boring into wood at 1514 m (Hicks, 1988).

### Commensals

A large variety of commensals has been found on the Limnoriidae and in their burrows. These include various microorganisms such as bacteria (Boyle and Mitchell, 1981), protozoans (Mohr, 1959; Sleeter and Coull, 1973) and diatoms (Sleeter and Coull, 1973). On several occasions numerous strands of filamentous algae were found on the antennae, mouthparts and body of certain algal feeding *Limnoria* such as *L. stephensi*, *L. antarctica* and *L. rugosissima*. Nematodes and polychaetes may also be found in limnoriid burrows (Sleeter and Coull, 1973).

Many crustaceans have been found in association with the Limnoriidae. *Donsiella limnoriae* Stephensen (Copepoda: Harpacticoida: Thalestridae) was found on *L. lignorum* (Stephensen, 1936; Holmes and Jeal, 1987), *L. tripunctata* and *L. quadripunctata* (Krishnaswamy and

Jones, 1958, 1962). Seven more donseilline species have been found recently, including three collected from the Australian limnoriid material (Hicks, 1988, 1990).

Other harpacticoid copepods associated with *Limnoria* include *Harrietella simulans* (Scott) (Laophontidae) (Coull and Lindgren, 1969; Boer, 1971). This species was also associated with some wood-boring *Limnoria* from Australia (Hicks, 1988). The Australian specimens of *H. simulans* were mostly associated with burrows of *Limnoria*, but were also collected when they became caught on setae of collected *Limnoria*. However, most of the donsielline specimens were found in the brood pouch and on the sternum of *Limnoria*. The specimens found in the brood pouches did not appear to have damaged the limnoriid eggs, as broken eggs or egg pieces were very rarely found.

*Aspidoconcha limnoriae* De Vos (Ostracoda: Podocopida: Paradoxostomatidae) was found on the dorsal surface of the pleotelson of *L. lignorum* (De Vos, 1953). At least four species of ostracods were collected from the brood pouch, pleotelson and sternum of *Limnoria* from Australia.

*Caecijaera borealis* Kussakin (Isopoda: Asellota: Janiridae) was found in association with *L. borealis* (Kussakin, 1962; Svavarsson, 1982), while *C. horvathi* Menzies was found with *L. tripunctata* (Cooke, 1977). Asellotans were also found in the current study with *L. stephensi* from Macquarie Island, and *L. pfefferi* and *L. indica* from Green Island, Queensland.

Species of *Corophium* (Amphipoda: Corophiidae) and Tanaidacea were often found in old *Limnoria* burrows which were overgrown with a film of algae.

The amphipod family Cheluridae appears to be found only in association with Limnoriidae. It contains three species: *Chelura terebrans* Phillippi, *Tropichelura insulae* (Calman) and *Nippochelura brevicauda* (Shiino) (Barnard, 1959). *Chelura terebrans* is unable to produce tunnels of its own (Johnson and McNeill, 1941), although it is able to produce furrows in softwood and widen the exterior ends of *Limnoria* burrows (Barnard, 1955). It may also feed on the faecal pellets of *Limnoria* (Kühne and Becker, 1964). *Chelura terebrans* has been previously reported from Melbourne and Sydney (Barnard, 1959). *C. terebrans* was found, in association with one or both species of *L. tripunctata* and *L. quadripunctata*, at Albany, Bunbury and Geraldton in WA; at Goat Island, Cabarita, Watsons Bay and Ulladulla in NSW;



at Williamstown, Sandringham and St Kilda in Victoria; and at Burnie, Tasmania. *Tropichelura insulae* was found with *L. pfefferi* and *L. indica* at Green Island, Queensland, and is the first record of this species from Australia.

### Taxonomy

Menzies (1957) divided the Limnoriidae into two genera: *Paralimnoria* Menzies, 1957 and *Limnoria* Leach, 1814. The most important feature separating the genera was the shape of the uropods. In *Paralimnoria* both rami are long and have an apical claw. In *Limnoria* only the reduced exopod has an apical claw. Menzies (1957) also erected the subgenus *Phycolimnoria* of *Limnoria* to accommodate the seven algal-borers then known. This separation was based on the absence in *Phycolimnoria* of rasp (Plate 1a) and file (Cookson and Cragg, 1988: Fig. 3e) incisors on the mandibles. *Phycolimnoria* was raised to generic status by Kussakin (1963), which was accepted by Kensley and Schotte (1987). However, the rasp and file no longer clearly separates the species known today.

*Hadromastax merga* Bruce, 1988, which was originally placed in the Limnoriidae, has been moved to a new family (Bruce and Müller, 1990). Other families closely related to the Limnoriidae are the Keuphyliidae Bruce, 1980 and the Lynseiidae Poore, 1987.

Prior to papers by Menzies (1951b, and comprehensive review in 1957), only eight species and one poorly known variety of Limnoriidae were known (Holthuis, 1949, Sowinsky, 1884). The species then thought to be most responsible for the destruction of timber structures was *Limnoria lignorum*. In Australia limnoriid attack of timber was usually attributed to *L. lignorum* (Hale, 1929; Iredale et al., 1932; Watson et al., 1936; Iredale, 1939; Dakin, 1987), an arctic-boreal species now known not to be present in Australia. Including the new species described herein, there are 51 species of Limnoriidae world-wide (Tables 1, 2), of which 28 are wood-borers, 17 algal-borers and feeders, 4 seagrass-borers, while the substrates for *L. septima* and *L. foveolata* are as yet unknown.

This study is concerned primarily with species from Australasia, and includes material from Australia, Macquarie Island, The Snares in New Zealand, Papua New Guinea and Cocos Islands.

Table 1. Check-list of the species of Limnoriidae.

\*Species described here.

\*\*Species examined but descriptions not published here.

- 
- Paralimnoria andrewsi* (Calman, 1910)\*  
*P. asterosa* Cookson and Cragg, 1988\*  
*Limnoria lignorum* (Rathke, 1799)\*\*  
*L. segnis* Chilton, 1883  
*L. tuberculata* Sowinsky, 1884\*  
*L. antarctica* Pfeffer, 1887\*  
*L. pfefferi* Stebbing, 1904\*  
*L. japonica* Richardson, 1909  
*L. septima* Barnard, 1936  
*L. quadripunctata* Holthuis, 1949\*  
*L. tripunctata* Menzies, 1951\*  
*L. platycauda* Menzies, 1957\*  
*L. saseboensis* Menzies, 1957\*\*  
*L. simulata* Menzies, 1957\*\*  
*L. algarum* Menzies, 1957\*\*  
*L. multipunctata* Menzies, 1957\*  
*L. unicornis* Menzies, 1957\*  
*L. foveolata* Menzies, 1957  
*L. sublittorale* Menzies, 1957\*  
*L. insulae* Menzies, 1957\*  
*L. segnoides* Menzies, 1957  
*L. nonsegnis* Menzies, 1957\*  
*L. rugosissima* Menzies, 1957\*  
*L. stephenseni* Menzies, 1957\*  
*L. carinata* Menzies and Becker, 1957  
*L. bituberculata* Pillai, 1957  
*L. indica* Becker and Kampf, 1958\*  
*L. bombayensis* Pillai, 1961  
*L. magadanensis* Jesakova, 1961  
*L. chilensis* Menzies, 1962  
*L. borealis* Kussakin, 1963\*\*  
*L. zinovae* (Kussakin, 1963)  
*L. andamanensis* Rao and Ganapati, 1969\*  
*L. sexcarinata* Kühne, 1975\*\*  
*L. clarkae* (Kensley and Schotte, 1987)\*\*  
*L. kautensis* Cookson and Cragg, 1988\*  
*L. emarginata* Kussakin and Maljutina, 1989  
*L. hicksi* Schotte, 1989  
*L. reniculus* Schotte, 1989  
*L. cristata* Cookson and Cragg, 1991  
*L. agrostisa* sp. nov.\*  
*L. convexa* sp. nov.\*  
*L. echidna* sp. nov.\*  
*L. gibbera* sp. nov.\*  
*L. glaucinosa* sp. nov.\*  
*L. loricata* sp. nov.\*  
*L. orbellum* sp. nov.\*  
*L. poorei* sp. nov.\*  
*L. varuslima* sp. nov.\*  
*L. torquisa* sp. nov.\*  
*L. uncapedis* sp. nov.\*
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Table 2. Annotated check-list of the species of Limnoriidae not described in text.

*L. algarum* Menzies, 1957.

Distribution: Oregon to southern California (Menzies, 1957).

Depths: 0–15 m (Ghelardi, 1971).

Substrates: Holdfasts of *Macrocystis*, *Egrecia*, *Eisenia*, *Laminaria*, *Postelsia*, *Nereocystis*, *Sargassum* (Menzies, 1957) and *Pelagophycus* (Jones, 1971).

*L. bituberculata* Pillai, 1957.

Distribution: Kerala, India.

Depths: Littoral (tidal) zone.

Substrate: *Sargassum* (Pillai, 1957, 1961).

Remarks: In several important respects the descriptions given by Pillai in 1957 and 1961 differ, such as the presence or absence on pleonite 5 of a dorsomedial pair of longitudinal grooves, the exact position of the two pleotelsonal puncta, the number of flagellar articles on antenna 1, and the structure of the pereopods. This species seems most similar to *L. uncapedis*.

*L. bombayensis* Pillai, 1961.

Distribution: Bombay, India (Pillai, 1961).

Depths: Tidal zone and shallow water.

Substrates: Light woods (Palakar and Bal, 1957); various untreated and some CCA- and creosote-treated test timbers (Santhakumaran, 1969b).

Remarks: Pillai (1961) considered *L. bombayensis* most similar to *L. tripunctata*.

*L. borealis* Kussakin, 1963.

Distribution: Kandalaksha Gulf in the White Sea, Barents Sea, Okhotsk Sea, Japan Sea, USSR (Kussakin, 1963); probably Newfoundland, Canada (called *L. japonica* by Brunel, 1963); Iceland (Svavarsson, 1982).

Depths: 18–260 m (Kussakin, 1963).

Substrate: Wood (Kussakin, 1963).

Remarks: *L. borealis* seems most similar to *L. lignorum* and *L. japonica*.

*L. carinata* Menzies and Becker, 1957.

Distribution: Italy.

Depths: Precise depths unknown, shallow water.

Substrates: Softwood (Menzies and Becker, 1957).

Remarks: The taxonomic position of this species requires further examination, as Kühne (1971) suggested synonymy with *L. quadripunctata*. The foveolate surface found on *L. carinata* (Menzies and Becker, 1957) can also be found on some specimens of *L. quadripunctata*. The presence of only four flagellar articles on antenna 2 of *L. carinata* appears to be the most important character distinguishing the species; however, the reliability of this character in *L. carinata* needs to be checked.

*L. chilensis* Menzies, 1962.

Distribution: Chile (Menzies, 1962); Argentina (Paternoster and Elías, 1980).

Depths: Tidal zone, and probably shallow water.

Substrates: Algae (Menzies, 1962); *M. pyrifera* (Paternoster and Elías, 1980).

Remarks: The ornamentation on pleonite 5 differ in figures given by Menzies (1962) and Paternoster and Elías (1980) (V-shaped versus longitudinal). Paternoster and Elías (1980) may have been incorrect in describing five flagellar articles on antenna 1, a condition found normally in *Paralimnoria* not *Limnoria*. *L. chilensis* is most similar to *L. nonsegnis* (Menzies, 1962).

*L. clarkae* (Kensley and Schotte, 1987).

Distribution: San Salvador, Bahamas (Kensley and Schotte, 1987); Belize (unpublished).

Depths: Precise depths not published, but probably tidal (mangrove) zone.

Substrates: Dead and decaying red mangrove wood (Kensley and Schotte, 1987), soft uncorticated mangrove roots (Ellison and Farnsworth, 1990).

Remarks: Antenna 1 does not have three flagellar articles (Kensley and Schotte, 1987), but two.

*L. cristata* Cookson and Cragg, 1991.

Distribution: Singapore.

Depth: Tidal zone.

Substrate: Driftwood plank.

*L. emarginata* Kussakin and Malyutina, 1989.

Distribution: Okhotsk Sea, USSR.

Depths: 1040–1050 m.

Substrate: Piece of wood (Kussakin and Malyutina, 1989).

*L. foveolata* Menzies, 1957.

Distribution: Near the Kai Islands, Indonesia.

Depth: 52 m.

Substrate: Unknown. The presence of rasp and file incisors on the mandibles suggests that this species is a wood- or seagrass-borer.

Remarks: This species requires further examination to show that it is clearly distinguishable from *L. saseboensis*. *L. foveolata* appears to have a longer maxillipedal epipod, more pitted pleotelson, and more apical teeth on the right mandible lacinia mobilis than *L. saseboensis*. However, these characters are not always reliable. The most useful distinguishing character may be the lack of a tuberculate pleotelsonal perimeter on *L. foveolata*.

*L. hicksi* Schotte, 1989

Distribution: Off New Zealand.

Depths: 1075–1100 m.

Substrate: Rotting wood (Schotte, 1989).

*L. japonica* Richardson, 1909.

Distribution: Near Hondo, Japan.

Depth: 300 m.

Substrate: Bamboo (Richardson, 1909).

Remarks: The specimens identified as *L. japonica* by Brunel (1963) from the Gulf of St Lawrence were probably *L. borealis* (Kussakin, 1963; Kühne, 1976).

*L. lignorum* (Rathke, 1799).

Distribution: Temperate and boreal northern hemisphere distribution; Norway (Rathke, 1799; Sars, 1899; Menzies, 1957); The Netherlands (Holthuis, 1949); USSR (Jesakova, 1961; Kussakin, 1963); northern USA (Menzies, 1957); Alaska (Richards and Belmore, 1976); Canada (Menzies, 1957; Brunel, 1963; Bohn and Walden, 1970); UK (Jones, 1963); Ireland (Holmes and Jeal, 1987); Iceland (Svavarsson, 1982); Hokkaido, Japan; Chinhae, Korea (Kühne, 1976); Germany (Jones et al., 1972).

Depths: 0–20 m (Kussakin, 1963).

Substrates: Mainly untreated timbers; wood and piling (Jones, 1963; Kussakin, 1963; Bohn and Walden, 1970); sawn *Pinus sylvestris* (Jones et al., 1972); unpreserved piles and regions of piles (Richards and Belmore, 1976); lightly creosoted piling (Vind and Hochman, 1961); water-logged stalks of the plant *Rumex* (Somme, 1940); untreated *Alstonia scholaris* (Eaton et al., 1989); light attack on creosote- and ammoniacal copper arsenate-treated pine (Baechler et al., 1970); in Scotland where only *L. lignorum* appears to be present (Jones, 1963), creosoted timbers (Stevenson, 1862), and greenheart (Stevenson, 1874).

*L. magadanensis* Jesakova, 1961.

Distribution: Sea of Okhotsk (Jesakova, 1961; Kussakin, 1963), Sea of Japan (Kussakin, 1963), USSR; Hokkaido, Japan (Kühne, 1976).

Depths: 4–112 m (Jesakova, 1961; Kussakin, 1963).

Substrates: Piling (Jesakova, 1961); wood (Kussakin, 1963).

Remarks: Contrary to the original description, *L. magadanensis* does have a dorsal row of scale spikes on the pleotelson posterior margin, and the pleotelsonal puneta are shorter than suggested in Jesakova's figure (Kussakin, 1963). Also contrary to Jesakova (1961), both *L. japonica* and *L. magadanensis* have setae on the maxilliped (Kühne, 1976), and probably pappose setae along a ventral median line on the uropod peduncle, a character not shown in Menzies' (1957) figure of the uropod of *L. japonica* where it appears in dorsal view.

*L. reniculatus* Schotte, 1989

Distribution: New Zealand.



Depths: 44–520 m.

Substrates: Rotting wood, timber, log (Schotte, 1989).

*L. saseboensis* Menzies, 1957.

Distribution: Sasebo, Japan; Florida (Menzies, 1957); Japan (Kühne, 1976).

Depths: Precise depths unknown, shallow water.

Substrates: From a causeway, presumably in wood (Menzies, 1957).

Remarks: This species requires redescription to separate it more clearly from *L. indica*. The length of the maxillipedal epipod is more variable in *L. saseboensis* than suggested by Menzies (1957).

*L. segnis* Chilton, 1883.

Distribution: New Zealand (Chilton, 1883).

Depths: Precise depths unknown, shallow water.

Substrate: *Macrocystis* holdfasts (Chilton, 1883).

*L. segnoides* Menzies, 1957.

Distribution: Misaki, Japan.

Depth: Low tide zone.

Substrate: Washed from the red alga *Corallina* (Menzies, 1957).

Remarks: *L. segnoides* seems most similar to *L. bituberculata* and *L. uncapedis*.

*L. septima* Barnard, 1936.

Distribution: Andaman Islands.

Depths: 340–460 m.

Substrate: Unknown, but at this depth the substrate is probably wood.

*L. sexcarinata* Kühne, 1975.

Distribution: Satta Hip, Thailand; Takeshiki, Koniya, Japan.

Depth: Precise depths not known, but shallow water.

Substrates: Wood (Kühne, 1975).

Remarks: Instead of having only three flagellar articles on antenna 1 (Kühne, 1975), there are four.

*L. sexcarinata* seems most similar to *L. pfefferi*.

*L. simulata* Menzies, 1957.

Distribution: Virgin Islands, West Indies (Menzies, 1957); Caribbean Sea of north Colombia (Müller, 1988); Tarpon Springs, Florida (Cookson, unpublished).

Depth: 0–4 m (Müller, 1988).

Substrate: Washed from the seagrass *Thalassia testudinum* (Müller, 1988); leaves of the seagrass *Thalassia* (Cookson, unpublished).

Remarks: Specimens of *L. simulata* which I examined from Tarpon Springs, Florida, were collected from leaves of the seagrass *Thalassia*. The identification from Kenya of *L. simulata* in wood by McKoy-Hill (1964) was probably incorrect. *L. indica* may not be a synonym of *L. simulata* (see discussion for *L. indica*).

*L. zinovae* (Kussakin, 1963).

Distribution: Ascold Island, Sea of Japan (Kussakin, 1963); Posvet Bay; Lake Ascold; Lake Kunashir, Sea of Okhotsk (Kussakin, 1979).

Depth: 20 m (Kussakin, 1963).

Substrate: Rhizomes of the seagrass *Phyllospadix iwatensis* (Kussakin, 1979).

Remarks: The original diagnosis (Kussakin, 1963) stated that the median tubercle was on pleonite 5, which was obviously incorrect, and the position was later corrected to the pleotelson (Kussakin, 1979). The maxillipedal epipod is still to be described for this species. *L. zinovae* seems most similar to *L. unicornis*, as both have a similar and sexually dimorphic sculpturing on the pleotelson.

#### Specimen sources

Material was obtained from the Museum of Victoria, Melbourne (NMV); Australian Museum, Sydney (AM); South Australian Museum, Adelaide (SAM); Western Australian Museum, Perth (WAM); Tasmanian Museum

and Art Gallery, Hobart (TM); National Museum of New Zealand, Wellington (NMNZ); Canterbury Museum, Christchurch, New Zealand; British Museum (Natural History), London; United States National Museum of Natural History, Washington D.C. (USNM); and Zoologisk Museum, Copenhagen.

Most wood-borers from the Australian Museum were collected from bait blocks and other timbers during an Australia-wide teredinid survey organised by CSIRO and the University of New South Wales (Anonymous, 1972). This work was followed up at the university by J.V. Marshall (now J.V. Ibrahim) with a baiting programme using blocks of *Pinus taeda* L. Another source of wood-boring *Limnoria*, now all housed with the Museum of Victoria, was from a Masters thesis project in Western Australia on teredinids by Mr R. Howlett in 1960–1961 using baits of *Pinus pinaster* Ait. Wood-boring limnoriids from Papua New Guinea (PNG) were also made available by Dr S.M. Cragg who at the time of collection was with the PNG Department of Primary Industry, Forest Products Research Centre, Boroko.

This material was supplemented by personal collections, and collections made by Mr J.E. Barnacle also of CSIRO, during inspections of various timber structures and CSIRO timber preservative tests, or through baiting. These specimens are now with the Museum of Victoria. The baits used were mostly blocks of *Pinus radiata* D. Don which were sent to various harbour authorities for submersion. Limnoriids in bait blocks were usually still alive when returned by courier within 1–4 days after removal from the sea. Limnoriids were mostly collected directly from their burrows with forceps. Occasionally they were collected from riddled wood by placing the block in a bucket containing seawater (not aerated), and laying a piece of paper towelling over the block. Over the next few days limnoriids could be collected directly from the paper towelling. Hochman et al. (1956) used a similar method for removing *Limnoria* directly from the wood surface. The method was also useful for collecting *L. nonsegnis* from a *Macrocystis* holdfast which at first appeared not to contain *Limnoria*. Bubbling seawater with carbon dioxide gas and then sealing the wood and water in a jar speeded the exit of limnoriids from the substrate.

#### Examination of specimens

Most whole specimens were examined in glycerine placed on a cavity slide. Best illumination of sculpturing on the posterior somites was obtained by positioning the light source almost horizontally to the specimen, and reflecting light at the edge of the glycerine onto a black stage. The pleotelson and pleonite 5 were drawn with the aid of a drawing tube fitted to a Wild

Leitz Dialux 20 EB transmission microscope. The wedge-shaped pleotelson was raised posteriorly, usually by the thickness of one glass coverslip, so that the dorsal surface was flat. Specimens were dissected in glycerine and mounted in Aquamount containing a little Rose Bengal dye. Dissected parts were examined and drawn using a Carl Zeiss Photomicroscope III fitted with a projection attachment screen. Parts could then be traced from the screen onto transparent plastic (AGFA copyproof positive film matt CPFm) under full illumination.

*Scales.* In the line drawings of the various species, single scale bars represent 50  $\mu\text{m}$ , double scale bars 10  $\mu\text{m}$ , and triple scale bars 200  $\mu\text{m}$ . Unless otherwise indicated by different scales, all pereopods within a figure were drawn to similar scale. Other groups of appendages each drawn with similar scales were the antennae, pleopods and penes, mandibles, and maxillae.

#### Terminology

The following terms have been used in the description of species, and are defined here. The bracketed numbers refer to structures found in Figs 1 and 2.

*Posterior margin of the ventral pleopodal cavity.* This line, although ventral, can usually be easily seen when examining the dorsal structure of the pleotelson with transmitted light. Pleopods do not extend beyond this line (1).

*True setae.* These have a hollow axial cavity which usually contain a nerve fibre and invariably protoplasm (Menzies, 1956).

*False setae.* These are entirely skeletal and lack a hollow axial cavity (Menzies, 1956).

*Simple setae.* True setae which lack projections or setules (2).

*Sheathed setae.* Found on the posterior margin of the pleotelson. The sheath surrounds the proximal end of the setal stalk and has a fluted appearance. The sheath may be long and wide or short and narrow. (3, see also Plate 1b, c).

*Stout setae.* These are only found on the posterior margin of the pleotelson, and appear to have the mechanical function of bracing the pleotelson (4, see also Plate 1c). Stout setae probably evolved from sheathed setae. An intermediate form between the two types of setae is a flexible unsheathed seta.

*Scale spikes (spike-like bristles).* False setae often found covering the body, including the pleotelson and its posterior margin (5, see also Plate 1c).





Figure 1. *Limnoria loricata* sp. nov. A–J, male, NMNZ Cr. 6456, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; D, flagellum of antenna 1; E, peduncle article 5 and flagellum of antenna 2; F, pleopod 2; G, pleopod 5; H, incisor of left mandible; I, right mandible; J, lacinia mobilis of right mandible.

1, posterior margin of ventral pleopodal cavity; 2, simple seta; 3, sheathed seta; 4, stout seta; 5, scale spike; 6, comb seta; 8, lacinia mobilis; 9, coupling hook; 10, brush seta; 11, plumose seta; 12, pappose setae; 14, aesthetasc.

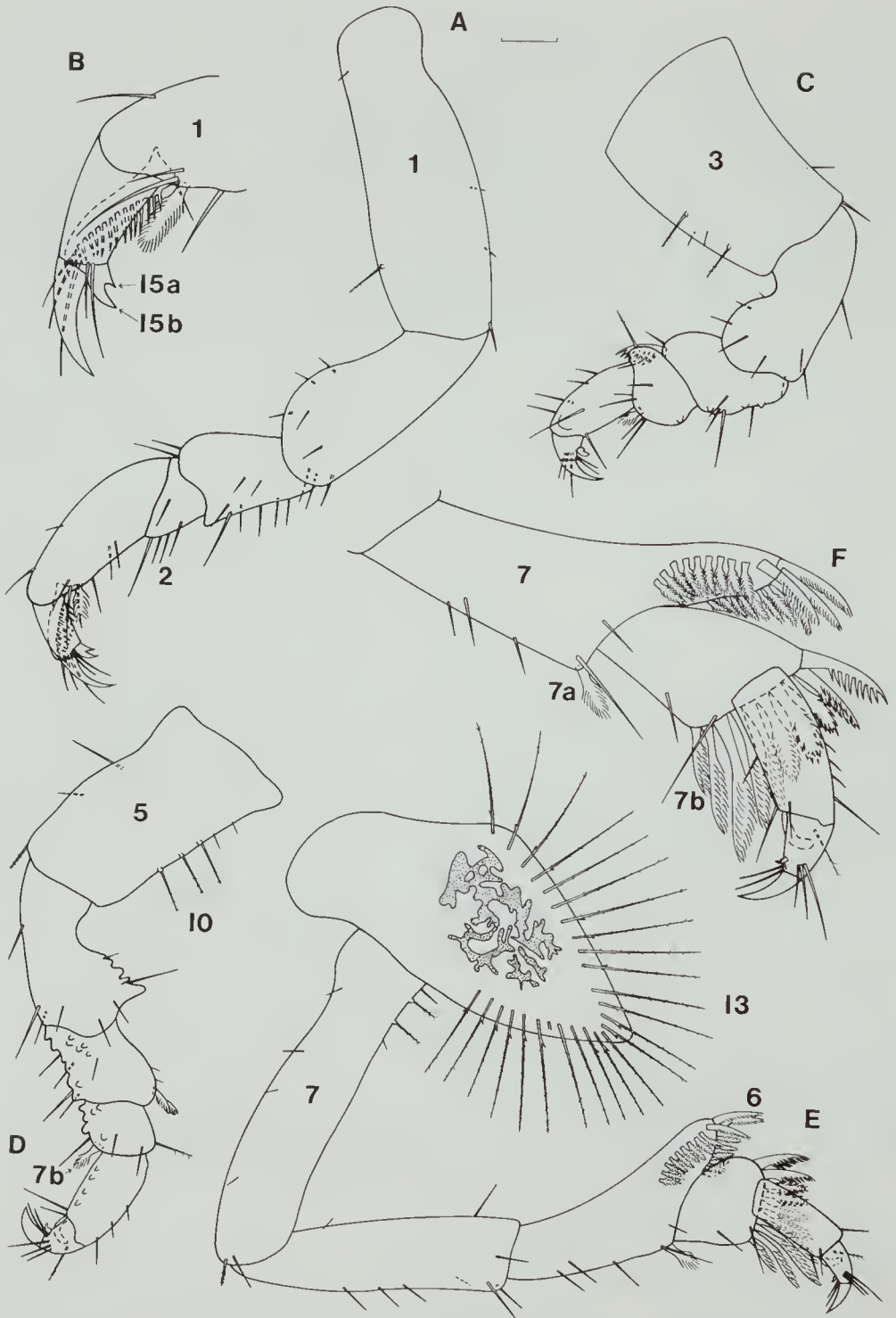


Figure 2. *Limnoria kautensis* Cookson and Cragg. A-F, male, NMV J14773, holotype: A, pereopod 1; B, dactylus of pereopod 1; C, pereopod 3; D, pereopod 5; E, pereopod 7 with coxa; F, distal articles of pereopod 7; all lateral views.

2, simple seta; 6, comb seta; 7a, ventral comb seta on merus; 7b, ventral comb seta on carpus; 10, brush seta; 13, proximally bifurcate pappose seta; 15a, ventral branch of secondary unguis; 15b, dorsal branch of secondary unguis.

*Spines.* Large blunt setae found distally on maxilla 1.

*Comb setae (pectinate setae).* Setae with two rows of thin projections or teeth which are both directed away from the same side of the shaft (6).

*Ventral comb setae.* Found on the merus (7a) and carpus (7b) of pereopods.

*Lacinia mobilis.* Located on the right and left mandibles (8).

*Coupling hooks.* Specialized setae found on the maxilliped and pleopods (9).

*Brush setae (palmate setae).* Setae with apical setules (10).

*Setules.* Thin false setae (epicuticular projections) found on some true setae.

*Plumose setae.* Setae with two opposing rows of setules along the setal shaft, arranged so that setae have the appearance of feathers (Oshel and Steele, 1988). Found on pleopods (11).

*Pappose setae.* Setae with setules which arise all around the setal shaft (Oshel and Steele, 1988) (12).

*Proximally bifurcate pappose setae.* Pappose setae which have a short branch near the proximal end. Setules are usually level and distal to this branch (13).

*Aesthetascs.* Found on antenna 1. Highly modified hollow setae with an apical pore (14).

*Secondary unguis, ventral branch (15a) and dorsal branch (15b).*

*Tubercles.* Swellings and globular projections from the exoskeleton.

*Puncta.* Large tubercles (Plate 1d).

*Nodes and bosses.* Large raised areas, usually involving a larger area than for puncta; also with gradual sloping sides, sides less abrupt than for puncta (Plate 1e).

*Crests.* Dorsolateral ridges found on pleotelson, pleonite 5, and sometimes other pleonites, which help to produce a flat or scalloped dorsal appearance to these segments.

The relative length to width of the maxillipedal epipod was determined by measuring the length from the epipod tip to the centre (not the often more posterior lateral edge) of its articulation, while width was taken as the widest point anywhere along its length.

The relative length of plumose setae on the exopod of pleopod 2 was derived from the length of the longest plumose seta, and the length of the exopod from the centre of its point of articulation (not its often produced anterolateral lobe) to its distal tip (not including plumose setae).

The relative length of the uropodal endopod was derived from the length of the endopod

(excluding apical claw in *Paralimnoria*), and the length of the peduncle from its most proximal end to the centre of where it articulates with the endopod (not the more posterior tip of the peduncular ventral process which extends between the rami).

### Useful systematic characters

Figs 5–9 (*P. asterosa*) and Figs 23–26 (*L. indica*) show examples of most of the characters discussed below. The relative position of antennae and mouthparts are shown in Fig. 24.

**Uropod.** The uropod is the most important character separating *Limnoria* from *Paralimnoria*. *Paralimnoria* has an apical claw on the endopod; a long claw on the exopod; the exopod claw directed dorsolaterally rather than laterally; the articulation of the exopod ventrolateral to the endopod rather than lateral; and trifid pappose setae on the peduncle. In *Limnoria* the exopod claw may be very small (*L. kautensis*, *L. pfefferi*, *L. clarkae* and *L. torquisa*, or more developed and laterally recurved (most other *Limnoria*). In *P. andrewsi* and *P. asterosa* there are about ten simple setae on the exopod, while in *L. kautensis* there are about eight. Most other species of *Limnoria* have less than six simple setae on the exopod, exceptions are *L. pfefferi*, *L. echidna* and the large species *L. sublittorale* and *L. stephensi*. Also, on the endopod of *Paralimnoria* the row of simple setae are placed apically and distolaterally. In most *Limnoria* the row is only apical, but in *L. kautensis*, *L. andamanensis*, *L. sexcarinata*, and (slightly) *L. pfefferi* the row also has a lateral component which extends well beyond the bases of the most posterior set of brush setae.

Some *Limnoria*, such as *L. tripunctata*, *L. insulae* and *L. lignorum*, have large lateral tubercles on the uropod peduncle (Plate 2a). In these species tubercles are then usually also present laterally on the exopod, and also on the ventral projection on the peduncle between the rami. In some other *Limnoria* only small tubercles are present. Other species (e.g., *L. quadripunctata*, *L. stephensi*) may have many short simple lateral setae instead of tubercles. *P. andrewsi* also has a few tubercles on the peduncle, but these are ventrally placed. Due to the tubular nature of uropods, dissected uropods may roll slightly from an exact ventral view when mounted on a slide. In the figures of the uropods, an estimate of the degree of rolling can be gained from the fact that all setae near the lateral margin of the peduncle should be seen from ventral



view, and not dorsally as is sometimes suggested in the figures (by dashed lines). If rolling has occurred, small lateral tubercles may no longer be in view. For this reason the structure of the uropods of *Limnoria* should also be examined *in situ*.

In some species, the ventral row of proximally bifurcate pappose setae on the peduncle is situated on a crest (e.g. *L. pfefferi*), while in others the peduncle is more flattened in this region (e.g. *L. stephensi*, *L. lignorum*). Small tubercles may also be found between the pappose setae (e.g. *L. indica*, *L. sexcarinata*, and *L. pfefferi*).

The relative length of the endopod and peduncle can also vary between species. Pillai (1961) in particular used this character in his species diagnoses. Although there can be small variations in length between specimens, this character is still useful to a certain degree.

The endopod of *L. torquisa* and *L. glaucinosa* have well developed proximally bifurcate pappose setae ventrally, similar to those found on the peduncle. Other *Limnoria*, and *Paralimnoria*, lack these setae on the endopod.

**Antenna 1.** *Limnoria* and *Paralimnoria* are unusual amongst isopods in that they have a scale which articulates distally on peduncular article 3. The scale was possibly derived from the lost ramus of the plesiomorphic biramous antenna 1 (Calman, 1910). A scale is also found in the cirrolanid *Bathynomus* and cryptoniscan larvae of some Epicaridea (Calman, 1910). All limnoriid species examined in the current study had a scale, which was largest in *P. andrewsi* and *P. asterosa* and smallest in *L. cristata*.

*Paralimnoria* have five flagellar articles on antenna 1 while *Limnoria* have three or four articles. In his diagnosis of *Limnoria*, Menzies (1957) stated that the flagellum has four articles, even though in some species he examined there were three (*L. multipunctata*, *L. platycauda* and *L. insulanae*). However, Menzies (1957) figured the number of flagella on antenna 1 correctly for *L. platycauda* and *L. multipunctata*.

In all species examined there was only one aesthetasc on the third segment of the flagellum. The number of aesthetascs on the second segment can vary greatly between species, and ranged from one in *L. orbellum* to about 13 in *L. indica*. *L. indica* and *L. saseboensis* are unusual in that the aesthetascs on segment 2 arise from two definite groups or tufts, one of which is closer to the mid-length of the segment than usual. For species which only have about two to five aesthetascs, the number of aesthetascs found appears to be fairly constant between specimens. For those species with many aes-

thetasc there is often more variation between specimens, and some of the variation may depend on geographical location and specimen size.

The first segment on the flagellum of antenna 1 is usually very short. For this reason it has often been overlooked in species descriptions. Pillai (1957) stated in his original description of *L. bituberculata* that there were three segments on the flagellum, but later corrected this to four (Pillai, 1961). Kühne (1975) figured only three flagellar articles on antenna 1 for *L. sexcarinata*, but there are four segments. Similarly for *L. clarkae*, only two flagellar articles were described (Kensley and Schotte, 1987), although there are three.

**Antenna 2.** The number of flagellar articles varies between species. *Limnoria* have three to five articles, while *Paralimnoria* have five to six. In most species the number of segments is constant, although the number can vary in some species to a certain degree: *P. andrewsi* (5–6), *L. sexcarinata* (4–5), *L. poorei* (3–4) and *L. simulata* (4–5). When describing *L. sexcarinata*, Kühne (1976) generalised that this character was not particularly reliable, however I found it to be very useful for the remaining species examined.

**Mandibles.** Mandibles of the Limnoriidae lack a molar, although they do have an inner bump or projection which may be a vestigial molar (Pillai, 1957). This projection is present on all *Limnoria* and *Paralimnoria*, although it is further reduced in *L. torquisa*.

The incisor surfaces in some species may be modified so that the left incisor has numerous pointed projections resembling a rasp (Plate 1a), and the right incisor has several parallel ridges resembling a file (Fig. 50c; Cookson and Cragg, 1988; Fig. 3e). The presence or absence of a rasp and file is constant within each species, although in *L. echidna* the rasp may be absent or greatly reduced. I have examined mainly the rasp of the left mandible, as the file of the right mandible was not fully visible in the orientation used to view the lacinia mobilis on prepared slides. The number of grooves in a file can also vary between species. *L. tripunctata* has about three to five grooves while *L. quadripunctata* has about five to eight. However, such overlap in variation probably means that this would not be a useful taxonomic character.

The lacinia mobilis of the left mandible is a short simple spine-like seta. Accompanying the lacinia mobilis is usually two long serrated setae in *Limnoria*, or three in *Paralimnoria*. In some species of *Limnoria* there is only one seta (e.g. *L.*

*uncapedis*), while in others the seta may be greatly reduced (e.g. *L. rugosissima*).

The lacinia mobilis of the right mandible is a useful diagnostic feature which varies only slightly within a species. In *L. indica* it varies in the degree of compactness of the apical teeth. In *L. agrostisa* the apical teeth may be pointed or rounded (possibly from becoming blunt). The number of setae in the spine row tends to be fewer in some species (about four in *L. uncapedis*) than in others, but varies too much to be useful.

The number and size of articles in the mandibular palp is very useful. For most species there are three segments. In other species there may be a slight reduction of article 3 (*L. nonsegnis*, *L. cristata*, *L. chilensis*, *L. poorei*, *L. convexa*), loss of article 3 (*L. segnis*), loss of articles 2 and 3 (*L. unicornis*), or loss of all articles (*L. bituberculata*, *L. uncapedis*, *L. segnoides*, *L. zinovae*). *L. indica* has article 3 elongated and apically pointed. Most *Limnoria* and *Paralimnoria* have one simple true apical seta on articles 1 and 2, but in some species there are several simple setae on article 2 (*L. stephensi*, *L. antarctica*, *L. glaucinosa*).

**Maxilla 1.** There is little variation between species in the form of maxilla 1. In *Paralimnoria* one of the outer smooth spines is shorter than the other spines, while in *Limnoria* the same spine is smaller again or absent. Of the five barbed inner spines on the outer lobe, two usually have more pointed barbs than the other three. The most inner of the bluntly barbed spines can vary slightly in shape. The inner lobe of maxilla 1 also varies little between species, although in *L. uncapedis* the normally long innermost pappose seta is similar in length to the two adjacent pappose setae.

**Maxilla 2.** In most species there are two long comb setae on the outer lobe, three on the middle lobe, and a more variable number on the inner lobe. On the inner lobe all species also have a large mesial inwardly directed comb seta. This inner seta is strongly recurved in *L. uncapedis*, and in some other species it is slightly sinuous (*L. nonsegnis*, *L. convexa*, *L. poorei*).

**Maxilliped.** The palp has five articles. In *L. torquisa* the joint between the basis and first article of the palp appears to be partly fused and is difficult to find in some specimens. In all species examined, the endite has two stout sub-apical setae which may bear a few setules proximally; another stout seta which is short, mesial and without setules; and two distomedial pappose setae which have numerous setules. Lateral to these are five (in *Paralimnoria*) or three (in

*Limnoria*) apical curved pappose setae. Depending on how the endite settled when mounted on a slide, a few other sub-apical ventromesial setae may be visible. Each endite has one coupling hook.

The shape of the epipod is very useful taxonomically. Although the shape is mostly constant within a species, the length can sometimes vary between specimens of certain species (e.g., *L. indica*, *L. raruslima*, *L. saseboensis*, *L. rugosissima*). Simple true setae are found on the epipods of *Paralimnoria* and many *Limnoria*, however they are absent on some species such as *L. kautensis* and *L. lignorum*.

**Clypeus, labrum, labium.** There are only minor variations between species in the form of the clypeus, labrum and labium.

**Pereopods.** The pereopods have been drawn in lateral view, and because pereopods 1-3 are anteriorly directed and pereopods 4-7 posteriorly directed (as in many isopods), this reversal is reflected in the figures. From pereopods 1-4 there is a gradual decrease in size, followed by an increase thereafter. There is also an increase in the number of comb setae found dorsally on the merus of pereopods 4-7. For *Limnoria*, the presence or absence of a comb seta ventrally on the merus and carpus of the pereopods is remarkably variable between species and consistent within a species (Table 3).

The secondary unguis on the first pereopod (and often other pereopods) can be very useful in helping to distinguish certain species. In *Paralimnoria* the unguis is trifold (although in some specimens of *P. andrewsi* the unguis is bifid), in most *Limnoria* it is bifid, while in other species of *Limnoria* there are a variety of modifications (*L. uncapedis*, *L. poorei*, *L. bituberculata*, *L. segnoides*, *L. stephensi*, *L. torquisa*).

The form of the secondary unguis on the seventh pereopod can also vary between species. In *L. kautensis* it is tiny, in *L. orbellum* absent, and in *L. cristata* it is absent on pereopods 2-7.

The number and size of tubercles on the pereopods can vary between species, but these characters appear to vary too greatly between specimens to be useful.

In some species the basis of pereopod 4 may have proximally bifurcate pappose setae. A few short proximally bifurcate pappose setae occur on pereopod 4 in *Paralimnoria*. On *L. sexcarinata* there are many long proximally bifurcate pappose setae which have lost setules. In *L. torquisa* the setae are abundant.

Pereopod 7 is often not directionally aligned with pereopods 4-6, but directed anteromedially. In some species (especially wood-borers)

Table 3. Percopods on which ventral comb seta was present on carpus or merus of species of Limmoriidae.

\*Vestigial comb seta.

L, R, left and right.

<sup>1</sup>From Pillai, 1961.

Species	Collection location	Specimens examined	Carpus	Merus
<i>P. andrewsi</i>	Port Moresby, PNG	3	765432	0
"	Madang, PNG	5	765 32	6*5*4*
"	Christmas Island	3	765 32	5*4*
"	Cocos Islands	5	765 32	0
"	Lorengau, PNG	1	765 32	6*5*
<i>P. asterosa</i>	Kaut, PNG	3	765 32	6*5*
<i>L. kautensis</i>	Kaut, PNG	3	765432	76
<i>L. sexcarinata</i>	Satta Hip, Thailand	3	76 32	76
<i>L. pfefferi</i>	Port Moresby, PNG	3	76 32	76
<i>L. andamanensis</i>	Buka Passage, PNG	2	765 32	76
"	Madang, PNG	3	765 32	76
"	Belize	3	765 32	76
<i>L. platycauda</i>	Curaçao, West Indies	2	765432	7
"	Nelly Bay, Qld	3	765432	7
"	Red Wallis Is, Qld	3	765432	7
<i>L. multipunctata</i>	Kai Is, Banda Sea	2	765432	7
"	Cocos Islands	3	765432	7
"	Green Island, Qld	3	765432	7
<i>L. insulae</i>	Arcadia, Qld	3	7654	7
"	Barrow Island, WA	3	7654	7
"	Tahira, PNG	2	7654	7
<i>L. saseboensis</i>	Sascho, Japan	3	765432	7
<i>L. indica</i>	Bowen, Qld	5	765432	7
"	Lady Musgrave Is, Qld	2	765432	7
"	Lorengau, PNG	2	765432	7
"	India <sup>1</sup>	1	765432	7
<i>L. simulata</i>	Florida	3	765432	7
<i>L. sublittorale</i>	New South Wales	2	765432	7
<i>L. raruslima</i>	West Island, SA	3	765	7
"	Crib Point, Vic.	3	765	7
"	Geelong, Vic.	2	765	7
"	Geelong, Vic.	1	7654*	7
<i>L. unicornis</i>	Port Douglas, Qld	3	765432	0
<i>L. tripunctata</i>	Ulladulla, NSW	3	76 32	7
"	Ulladulla, NSW	1	76 32	76
"	Goat Island, NSW	3	76 32	7
"	California	2	76 32	7
"	England	2	76 32	7
"	England	1	76 32	0
<i>L. tuberculata</i>	"Germany" in aquaria	3	76 32	7
<i>L. orbellum</i>	Cape Don, NT	3	76	0
<i>L. cristata</i>	Singapore	3	76	0
<i>L. lignorum</i>	Canada	2	765432	7
"	Bramley, England	3	765432	7
<i>L. borealis</i>	White Sea	2	765 32	7
<i>L. gibbera</i>	Thistle Cove, WA	2	76	0



<i>L. poorei</i>	West Island, SA	1	76	0
"	Topgallant Is., SA	1	76	0
<i>L. uncapedis</i>	Flinders Island, SA	2	76	0
"	McCluer Island, NT	2	76	0
<i>L. clarkae</i>	Belize	3	765432	0
<i>L. quadripunctata</i>	Brighton, Vic.	3	765432	0
"	Portobello, NZ	2	765432	0
"	Bramley, England	2	765432	0
"	The Snares, NZ	4	7654	0
<i>L. agrostisa</i>	Cliff Head, WA	1L	765	0
"	"	1R	765	7
"	Tiparra Bay, SA	1	765	7
<i>L. echidna</i>	Coles Bay, Tas	1	76	7
"	Ninepin Point, Tas	1	76	7
<i>L. algarum</i>	California	3	765	7
<i>L. rugosissima</i>	Sydney	2	765	7
"	West Island, SA	3	765	7
"	The Snares, NZ	2	765	7
<i>L. loricata</i>	The Snares, NZ	2	76	7
<i>L. glaucinosa</i>	Flinders Island, SA	3	76	7
"	Flinders Island, SA	1	765	7
"	Marengo, Vic.	4	765	7
<i>L. antarctica</i>	Macquarie Island	3	765	7
<i>L. stephensi</i>	Macquarie Island	3	765	7
<i>L. nonsegnis</i>	Variety Bay, Tas.	3	76	0
"	Aireys Inlet, Vic.	2	76	0
"	Port Arthur, Tas.	3	76	0
<i>L. convexa</i>	The Snares, NZ	5	765	0
<i>L. torquisa</i>	Aireys Inlet, Vic.	3	765	0

the merus of pereopod 7 has a marked dorsal projection fringed with a semicircle of comb setae. The carpus also has long distal comb setae, which in some species have thicker comb teeth on the more dorsal comb setae. Both sexes have these comb structures. Possibly they are used for cleaning other appendages, including mouthparts. The relative length of the propodus varies between species.

The dorsal coxal plates, fused on pereonite 1, become progressively pointed posteriorly. There are only slight variations between species in shapes, although coxa 7 in *P. andrewsi*, *P. asterosa* and *L. torquisa* is more rounded posteriorly than in other species.

**Penes.** There is little variation in shape between species, although relative length varies slightly.

**Pleopods.** The pleopods provide many useful characteristics, including: presence (*Paralimnoria*) or absence (*Limnoria*) of plumose setae on pleopod 5, and the length of plumose setae on pleopod 2 (and other pleopods).

The position of the articulation of the appendix masculina is mostly constant for each spe-

cies. Length is also often constant, although it cannot always be relied upon in some species such as *L. tripunctata*, *L. insulae* and *L. raruslima*. In all specimens of *L. tripunctata* examined from Australia, the length was fairly constant so that the appendix masculina reached near the tip of the endopod, however those from England were slightly longer.

In *P. andrewsi*, *P. asterosa*, *L. kautensis*, *L. pfefferi*, *L. andamanensis*, and *L. sexcarinata* the endopod articulation of pleopods 1-5 is posterior to the exopod; but for other species of *Limnoria* the endopod of pleopod 5 is anterior to the exopod.

In *Paralimnoria* and most *Limnoria* the number of coupling hooks on the pleopod peduncles follow the sequence of 32220, but in *L. orbellum* it is 22220, and in *L. sublittorale* it is 33330. *L. reniculus* has 3 coupling hooks on pleopod 2 (Schotte, 1989). In only two specimens of *Limnoria* examined (one *L. multipunctata* and one *L. gibbera*), the peduncle of pleopod 5 was unusually large medially and had 1 or 2 vestigial coupling hooks.

Relative length, and shape especially, of the

endopod of pleopod 5 is useful taxonomically. Laterally on the peduncle of pleopod 5 there may be a comb seta in some species, while in other species the seta may be simple or absent. The lateral seta on *Paralimnoria* appears to be a reduced comb seta which lacks setules, rather than a simple seta. The presence or absence on the endopod of pleopod 5 of small simple setae is also a useful character (found in *L. nonsegnis*, *L. rugosissima* and *L. torquisa*).

**Colour.** Most species are pale yellow or white in colour, and many specimens of certain species (usually wood-borers) also have a faint dark reticulate pattern. *L. glaucinosa* is unusual for its blue-grey colouration.

**Body shape.** Most species are similarly narrow and elongated in shape. Some species such as *L. torquisa*, *L. stephensi*, and *L. nonsegnis* are slightly wider than usual. On the head, the Limnoriidae lack a dorsal occipital groove, which is contrary to the finding of Menzies (1957: Table 1).

**Pleonite 5 and pleotelson.** The relative length of pleonite 5 and the pleotelson is a useful taxonomic character.

The sculpturing of the pleotelson and pleonite 5 presents the most useful specific features. The sculpturing mainly takes shape from the various puncta and carinae. The prominence of the sculpturing can vary between specimens, so that in some specimens the complete pattern may be difficult to detect.

In some species there is a sexual dimorphism in the pleotelson. Males of *L. unicornis* and *L. zinovae* have a much larger median punctum than females. *L. platycauda* males have a longer pleotelson than females (longer posterior to the pleopodal cavity). Some specimens of *L. insulae* have a much deeper cup-shaped pleotelson than females. *L. indica* shows the greatest degree of sexual dimorphism in the arrangement of puncta and carinae on the pleotelson.

**Structure of pleonite 5 and pleotelson dorsal surface.** The microscopic structure of the surface of pleonite 5 and the pleotelson (and probably other segments) is useful taxonomically. However, to see this structure the somites must be brushed clean of most debris. The scanning electron microscope is particularly useful for studying this character. The structures include a smooth surface constructed from scales which bear several fine scale spikes on the posterior fringes (Plate 1e) (e.g., *L. tripunctata*, *L. kautensis* and *L. nonsegnis*). In *Paralimnoria* the fine scale spikes are thickened into stout scale spikes, while in other species of *Limnoria* the scale

spikes remain thin but are greatly elongated (*L. gibbera*). In some species the scales have a single large spike centrally rather than a posterior fringe of small spikes (*L. lignorum*, *L. andamanensis*, *L. pfefferi*). In many species with the large central spike, the scales are apparently fused and cannot be detected as separate entities (e.g., *L. indica*, *L. quadripunctata*, *L. echidna*, *L. rugosissima*).

Many species have pits on the surface, especially on pleonite 5 and the anterior portion of the pleotelson (e.g., *L. rugosissima*, *L. loricata*, *L. unicornis*, *L. indica*, *L. nonsegnis*). This situation occurs mainly in species with fused scales (Plates 2d, 2c).

The dorsal surface structure near the perimeter of the pleotelson varies between species. Some species have a dorsal row of tubercles or scale spikes, or both (as in *L. orbellum*), while in other species these rows may be absent. Few algal-borers have tubercles, although *L. gibbera* and *L. poorei* have on the lateral crests small tubercles with dorsal scale spikes, which are swellings which seem different to the tubercles found on some wood-borers. Tubercles are usually larger on lateral crests of the pleotelson than on the hind margin, and in some species (and specimens of *P. andrewsi*) tubercles are present on crests but absent on the hind margin. The size and number of scale spikes also varies between species. In *L. uncapedis* the spikes are small and numerous. In *L. quadripunctata* they are large. On the lateral crests the scale spikes are larger than on the posterior margin.

On the posterior margin of the pleotelson there are three main types of setae (including false setae). The shortest are the scale spikes which may be thin and in groups of about three to seven (*L. poorei* and *L. orbellum*) (Plate 1c), or thick and often fewer (*L. quadripunctata*, *L. glaucinosa*). In some species the scale spikes are lost (Plate 1b). The second type of setae are long, flexible, basally sheathed setae (Plate 1b). The sheathing can be fairly difficult to see in some species and specimens (Plate 1c). The third type of setae are posteromedial stout unsheathed setae (Plate 1c). Many species have four of these (e.g., *L. tripunctata*, *L. quadripunctata*, *L. indica*, *L. rugosissima*, *L. lignorum*) (Plate 2c), a few may have six (*L. nonsegnis*, *L. convexa*, *L. chilensis*, *L. torquisa*), while *L. stephensi* has a continuous row of stout setae extending from the posterior margin to the lateral crests, and so for this species the number may reach over twenty. *L. platycauda* and *L. insulae* have an intermediate form of unsheathed flexible seta of sim-

ilar size to adjacent sheathed setae. Some species have the sheathed setae between stout setae greatly reduced, and the sheaths on these appear to be lost (*L. orbellum*, *L. stephenseni*, *L. non-segnis*).

**Systematics**

**Limnoriidae White**

Limnoriadae White, 1850: 68.—White, 1857: 226.

Limnoriinae.—Dana, 1853: 716.

Limnoriidae.—Harger, 1879: 161.—Harger, 1880: 371–373.—Pfeffer, 1887: 60.—Stebbing, 1893: 367.—Sars, 1899: 74–75.—Richardson, 1904: 8.—Richardson, 1905: 268.—Stebbing, 1904: 713.—Zirwas, 1910: 86.—Vanhöffen, 1914: 508.—Dahl, 1916: 28.—Shiino, 1950: 334.—Menzies, 1957: 115–121.—Menzies, 1962: 112–113.—Bastida and Torti, 1972: 144.—Kussakin, 1979: 309–310.—Bruce, 1988: 346–353.—Kensley and Schotte, 1989: 193.

*Limnorina* group.—Gerstaecker, 1881–1883: 220.

Limnoriinae.—Hansen, 1905: 98.—Hansen, 1916: 177.—Omer-Cooper and Rawson, 1934: 28–30.

Limnoriidae.—Schultz, 1969: 138.—Brusca, 1980: 233.

*Type genus. Limnoria* Leach, 1814: 433.

*Diagnosis.* Head ovoid in cross section, freely articulating, pereonite 1 overlaps cephalon pos-

teriorly. Coxal plates free and articulating on pereonites 2–7. Pleonite 5 longer than each preceding 4 pleonites, pleonite 1 not extending ventrally as far as other pleonites. Pleotelson posteriorly semi-circular, pleonite 5 and pleotelson in combination circular or oval; pleonite 5 (or pleonite 4) and pleotelson with lateral crests.

Clypeus transversely elongated, with oval labrum inserted ventromedially; without frontal lamina. Labium consisting of 2 anterior lobes and 2 more posterior dissimilar plates. Antennae not contiguous at bases; neither base markedly more anterior than other. Peduncle of antenna 1 with 3 articles, peduncle of antenna 2 with 5 articles. Scale inserted into peduncular article 3 of antenna 1. Mandibles lacking molar process, lacinia mobilis reduced to small seta. Maxilla 1 with 2 lobes; maxilla 2 with 3 non-articulating apical lobes. Maxilliped with epipod, 5-articled palp, and coupling hook on each endite. Pereopod 1 with carpus reduced and nearly concealed dorsally by merus and propodus, with 2 comb setae distally on propodus, dactylus with 2 ungui. Penes articulating and separate. Testes each with one lobe. Gut with 4 digestive caeca. Pleopod 5 with none or fewer plumose setae than on pleopods 1–4. Uropod ventral to pleotelson; rami tubular, not markedly expanded or flattened.

**Key to genera of Limnoriidae**

- 1. Both uropod rami elongate, with apical claw (Fig. 5f). Antenna 1 with 5 flagellar articles (Fig. 6e). Pereopod 1 secondary unguis trifold (Fig. 7b) ..... *Paralimnoria*
- Uropod exopod much shorter than endopod, endopod without apical claw (Fig. 24d). Antenna 1 with 4 or fewer flagellar articles (Fig. 25g). Pereopod 1 secondary unguis bifid (Fig. 26a), or undivided and sometimes with accessory spinules (Fig. 62b) ..... *Limnoria*

**Key to species of *Paralimnoria***

- 1. Pleonite 5 with anterior transverse carina bearing part of ring of radiating setae which continues around pleonite 4 and pleotelson (Fig. 5b) ..... *P. asterosa*
- Pleonite 5 dorsomedially without anterior transverse carina (Fig. 3a) ..... *P. andrewsi*

**Key to species of *Limnoria***

This key contains several triplets. Examples of structures found in figures and plates are not necessarily from the species being referred to in the key.

- 1. Pleonite 5 dorsomedially with opposing horseshoe-shaped carinae, structure of mandibular incisors unknown. Substrate unknown ..... *L. septima*



- Pleonite 5 dorsomedially without opposing horseshoe-shaped carinae, left mandible with well developed rasp (more than 20 teeth) (Fig. 46f). Substrate wood or seagrass . . . . . 2
- Pleonite 5 dorsomedially without opposing horseshoe-shaped carinae, left mandible without rasp (Fig. 16e), or only few small teeth (Fig. 17h). Substrate mainly algae, sometimes wood or seagrass . . . . . 25
2. Antenna 1 with 3 flagellar articles . . . . . 3
- Antenna 1 with 4 flagellar articles . . . . . 7
3. Pleonite 5 with an anterior row of 4 puncta and a posterior row of 2 puncta. Posterior perimeter of pleotelson uneven, with pair of shallow symmetrical notches. Substrate wood . . . . . *L. hicksi*
- Pleonite 5 without puncta or with 3 puncta. Posterior perimeter of pleotelson evenly rounded . . . . . 4
4. Pereopods 2–7 with secondary unguis (Figs 26b–g). Maxillipedal epipod broad (Fig. 33c). Peduncle of pleopod 5 with comb seta laterally (Figs 34c, d) . . . . . 5
- Pereopods 2–7 without secondary unguis (Fig. 39b). Maxillipedal epipod narrowed distally to finger-like projection. Peduncle of pleopod 5 without seta laterally (Fig. 65c). Substrate wood . . . . . *L. cristata*
5. Lacinia mobilis of right mandible well developed (Figs 28h, 43c). Pleotelson may have sexual dimorphism . . . . . 6
- Lacinia mobilis of right mandible reduced (Fig. 33g). Pleotelson without sexual dimorphism. Usually with at least longitudinal tuberculate carina posteromedially. Substrate wood . . . . . *L. multipunctata*
6. Uropod peduncle laterally compressed and broadened (Figs 28f, g). Pleotelson of males may be deeply cup-shaped (Plate 2b). Substrate wood . . . . . *L. insulae*
- Uropod peduncle tubular, not laterally compressed (Fig. 42e). Pleotelson longer in males than females (Figs 42a, f). Substrate wood . . . . . *L. platycauda*
7. Articulation of pleopod 5 endopod posterior to exopod, endopod triangular (Fig. 11f). Maxillipedal epipod broad and oval . . . . . 8
- Articulation of pleopod 5 endopod anterior to exopod, endopod oval (Fig. 65c), elongated (Fig. 34c) or circular (Fig. 37h). Maxillipedal epipod broad and oval (Fig. 40f), triangular (Fig. 46c), or strap-like (Fig. 10c) . . . . . 10
8. Pleotelson dorsally with 1 pair of carinae. Uropodal exopod claw greatly reduced to small knob (Figs 30h, 41d). Basis of pereopod 4 without long setae . . . . . 9
- Pleotelson dorsally with 3 pairs of carinae. Uropodal exopod claw reduced. Basis of pereopod 4 with many long flexible setae (Fig. 57d). Substrate wood . . . . . *L. sexcarinata*
- Pleotelson dorsally with 2 pairs of puncta. Uropodal exopod claw well developed (Fig. 11g). Basis of pereopod 4 without long setae. Substrate wood . . . . . *L. andamanensis*
9. Pleonite 5 dorsomedially with Y-shaped carina (Fig. 40a). Pereopods 4 and 5 without ventral comb seta on carpus. Secondary unguis on pereopod 7 not reduced. Substrate wood . . . . . *L. pfefferi*
- Pleonite 5 dorsomedially without carinae. Pereopods 4 and 5 with ventral comb seta on carpus (Fig. 2d). Uropodal exopod long, half as long as endopod. Secondary unguis on pereopod 7 tiny (Fig. 2f). Substrate wood . . . . . *L. kautensis*
10. Pleotelson dorsomedially with pair of anterior puncta not associated with carinae, may also have more lateral pair of small puncta. Rasp reduced and confined to distal half of right mandibular incisor. Substrate seagrass . . . . . *L. simulata*

- Pleotelson dorsomedially without pair of anterior puncta, or with pair of anterior puncta associated with longitudinal carinae. Rasp well developed and not confined to distal half of right incisor (except in *L. raruslima*, Fig. 50f). Substrate wood or seagrass ..... 11
- 11. Antenna 2 with 3 or 4 flagellar articles ..... 12
- Antenna 2 with 5 flagellar articles ..... 17
- 12. Dorsomedial sculpture on pleotelson with 1 central anterior punctum or carina, which may or may not be followed posteriorly by additional sculpturing (Fig. 64a) ..... 13
- Dorsomedial sculpture on pleotelson with pair of puncta anteriorly, followed posteriorly by carinae bearing another 1 or 2 pairs of puncta (Fig. 46a). Substrate wood ..... *L. carinata*
- 13. Mandibular palp with 3 articles ..... 14
- Mandibular palp with 1 article (Fig. 64f). Substrate wood *L. unicornis*
- 14. Maxillipedal epipod triangular ..... 15
- Maxillipedal epipod broad and apically rounded. Substrate wood ...  
..... *L. magadanensis*
- 15. Pleotelson dorsomedially with anterior punctum and pair of more posterior puncta (Fig. 58a) ..... 16
- Pleotelson dorsomedially with anterior punctum followed posteriorly by another medial punctum. Substrate wood ..... *L. emarginata*
- Pleotelson dorsomedially without puncta, with carina shaped as a short-stemmed inverted Y. Substrate wood ..... *L. lignorum*
- 16. Posterior margin of pleotelson with dorsal row of scale spikes. Substrate wood ..... *L. borealis*
- Posterior margin of pleotelson without dorsal row of scale spikes. Substrate wood (bamboo) ..... *L. japonica*
- 17. Dorsomedial sculpture on pleotelson with anterior central punctum (Fig. 36a). Dorsal structure of pleotelson composed of scales (Fig. 36c), lacking pits ..... 18
- Dorsomedial sculpture of pleotelson with pair of anterior puncta or carinae (Figs 23b, i). Dorsal structure of pleotelson with scales fused, often with pits (Plate 2d) ..... 19
- Pleotelson without dorsomedial sculpture. Dorsal structure of pleotelson unknown, but without pits. Substrate wood ..... *L. bombayensis*
- 18. Dorsomedial puncta on pleotelson not followed by carinae (Fig. 36a). Pleopod 1 with only 2 coupling hooks (Fig. 37c). Pereopod 7 without secondary unguis (Fig. 39b). Endopod of pleopod 5 circular (Fig. 37h). Substrate wood ..... *L. orbellum*
- Dorsomedial puncta on pleotelson each followed by short carina of similar length (Fig. 58a). Pleopod 1 with 3 coupling hooks (Fig. 58h). Pereopod 7 with secondary unguis. Endopod of pleopod 5 circular but produced proximally (Fig. 58g). Substrate wood ... *L. tripunctata*
- Dorsomedial puncta on pleotelson with posterior pair of puncta followed by carinae (bearing tubercles) much longer than carina following anterior punctum (Fig. 59a). Pleopod 1 with 3 coupling hooks. Pereopod 7 with secondary unguis. Endopod of pleopod 5 oval (Fig. 59b). Substrate wood ..... *L. tuberculata*
- 19. Posterior margin and lateral crests of pleotelson with tubercles (Figs 23b, 25i) ..... 20
- Posterior margin and lateral crests of pleotelson without tubercles (Figs 50a, 54b) ..... 21
- 20. Dorsomedial parallel carinae on pleotelson long, with small anterior pair of puncta, carinae rugose when adjacent pits well developed; also with 2 short pairs of more lateral carinae. Substrate wood ... *L. saseboensis*
- Pleotelson with sexual dimorphism; males dorsomedially with 2 pairs of

- well developed puncta, not followed posteriorly by carinae (Fig. 23b); female dorsomedially with parallel carinae each with anterior punctum (Fig. 23i); sexes without lateral carinae and well developed pits. Substrate wood ..... *L. indica*
21. Pleonite 5 with parallel dorsomedial carinae extending full length of pleonite (Fig. 54a) ..... 22
- Pleonite 5 with parallel dorsomedial carinae not extending to anterior margin, U-shaped. Substrate wood ..... *L. reniculus*
- Pleonite 5 with Y- or X-shaped dorsomedial carinae (Figs 10a, 46a) .  
..... 24
22. Pleonite 5 not markedly foveolate ..... 23
- Pleonite 5 markedly foveolate. Substrate unknown ..... *L. foveolata*
23. Pleopods 2-4 with 3 coupling hooks (Fig. 54d). Pleotelson with only 1 pair of carinae dorsomedially (Fig. 54a). Substrate wood .....  
..... *L. sublittorale*
- Pleopods 2-4 with 2 coupling hooks (Fig. 49f). Pleotelson with dorsomedial pair of carinae and 2 more lateral pairs of carinae (Fig. 49a). Substrate seagrass ..... *L. raruslima*
24. Maxillipedal epipod triangular (Fig. 46c). Dorsomedial sculpture on pleotelson includes 2 pairs of puncta (Fig. 46a). Lacinia mobilis of right mandible apically curved, fringed with many small teeth (Fig. 46h). Substrate wood ..... *L. quadripunctata*
- Maxillipedal epipod strap-like (Fig. 10c). Dorsomedial sculpture on pleotelson includes only 1 pair of anterior puncta (Fig. 10a). Lacinia mobilis of right mandible small, straight, with 2-3 apical teeth (Figs 10 h, i). Substrate seagrass ..... *L. agrostisa*
25. Mandibular palp lacking ..... 26
- Mandibular palp with 3 articles (Fig. 55g), third article may be small (Fig. 44d) ..... 29
- Mandibular palp with 2 articles. Substrate algae ..... *L. segnis*
26. Pleonite 5 dorsomedially with Y- or V-shaped carina. Secondary unguis of pereopod 1 bifid (Fig. 26a) or undivided, without spinules ..... 27
- Pleonite 5 dorsomedially without carinae. Secondary unguis of pereopod 1 with several spinules (Fig. 62b) ..... 28
27. Secondary unguis of pereopod 1 bifid. Pleotelson with dorsomedial anterior punctum. Lacinia mobilis of right mandible undivided other than for apical teeth. Substrate seagrass ..... *L. zinovae*
- Secondary unguis of pereopod 1 undivided. Pleotelson with dorsomedial wide elevated anterior region. Lacinia mobilis of right mandible bifid (Fig. 60h). Substrate algae ..... *L. segnoides*
28. Pleotelson dorsomedially without puncta (Fig. 60b). Substrate algae .  
..... *L. uncapedis*
- Pleotelson dorsomedially with 2 puncta joined by transverse carina. Substrate algae ..... *L. bituberculata*
29. Antenna 1 with 3 flagellar articles. Uropodal exopod claw reduced (Fig. 57h) ..... 30
- Antenna 1 with 4 flagellar articles. Uropodal exopod claw well developed ..... 31
30. Pleotelson dorsomedially with pair of parallel carinae. Antenna 2 with 5 flagellar articles. Basis of pereopod 4, and uropodal endopod, without large pappose setae. Secondary unguis of pereopods without accessory spinules. Substrate wood ..... *L. clarkae*
- Pleotelson dorsomedially without carinae or puncta (Fig. 55a). Antenna 2 with 4 flagellar articles. Basis of pereopod 4 (Fig. 57d) and uropodal endopod (Fig. 57h) with several large pappose setae. Secondary unguis of pereopods with accessory spinules (Figs 57b,g). Substrate algae .....  
..... *L. torquisa*



31. Antenna 2 with 3 or 4 flagellar articles ..... 32  
 — Antenna 2 with 5 flagellar articles ..... 37
32. Posterior margin of pleotelson without large stout setae (Fig. 45d). Endopod of pleopod 5 narrowly elongated and oval (Fig. 45c) ..... 33  
 — Posterior margin of pleotelson with at least 4 large stout setae (Figs 13b, 32b). Endopod of pleopod 5 short and oval (Fig. 13i) ..... 34
33. Third article of mandibular palp well developed, with comb setae (Fig. 19j). Secondary unguis of pereopod 1 bifid. Lacinia mobilis of right mandible with apical expansion bearing small teeth (Figs 19k, l). Substrate algae ..... *L. gibbera*  
 — Third article of mandibular palp reduced, without comb setae (Fig. 44d). Secondary unguis of pereopod 1 undivided but with 2 spiky protuberances sub-proximally (Fig. 45f). Lacinia mobilis of right mandible thin and serrated (Fig. 44e). Substrate algae. .... *L. poorei*
34. Third article of mandibular palp well developed, second article with several simple true setae (Fig. 53f) ..... 35  
 — Third article of mandibular palp reduced, second article with 1 apical simple true seta (Fig. 35d) ..... 36
35. Pleotelson and pleonite 5 with carinae dorsomedially (Fig. 13a). Secondary unguis of pereopod 1 bifid. Posterior margin of pleotelson with 4 or 6 stout setae. Substrate algae ..... *L. antarctica*  
 — Pleotelson and pleonite 5 without carinae dorsomedially (Fig. 53a). Secondary unguis of pereopod 1 bifid, but ventral branch tiny (Fig. 53j). Pleotelson margin with stout setae both posteriorly and laterally. Substrate algae ..... *L. stephenseni*
36. Pleonite 5 dorsomedially with V-shaped carina. Substrate algae .....  
 ..... *L. chilensis*  
 — Pleonite 5 dorsomedially with longitudinal carina, or at least a raised longitudinal area (Fig. 35a). Substrate algae ..... *L. nonsegnis*  
 — Pleonite 5 dorsomedially smoothly convex, without carinae (Fig. 14a). Substrate algae ..... *L. convexa*
37. Pleonite 5 pale yellow or white in colour, with carinae. Second article of mandibular palp with 1 simple seta ..... 38  
 — Pleonite 5 blue-grey in colour, without carinae (Fig. 20a). Second article of mandibular palp with several simple setae (Fig. 21f). Substrate algae ..... *L. glaucinosa*
38. Pleonite 5 dorsomedially with Y- or X-shaped carina. Lacinia mobilis of right mandible serrated apically only, may also be divided or expanded apically ..... 39  
 — Pleonite 5 dorsomedially with pair of longitudinal carinae which converge posteriorly. Lacinia mobilis of right mandible serrated apically and laterally, undivided (Fig. 44e). Substrate algae ..... *L. algarum*
39. Mandibular incisor of right mandible without deep cleft apically (Fig. 32i). Pleopod 5 without simple seta on endopod (Fig. 32g) ..... 40  
 — Mandibular incisor of right mandible with deep cleft apically (Fig. 51g). Pleopod 5 with simple seta on endopod (Fig. 52b). Substrate algae ..  
 ..... *L. rugosissima*
40. Pleonite 5 dorsally markedly foveolate, with X-shaped carina with axes joined near mid-length of pleonite (Fig. 32a). Lacinia mobilis of right mandible with long apical serrations (Fig. 32j). Substrate algae. ....  
 ..... *L. loricata*  
 — Pleonite 5 dorsally not markedly foveolate, with X-shaped carina with axes joined near posterior margin of pleonite (Figs 17a, 18a). Lacinia mobilis of right mandible with apical expansion fringed by short teeth (Fig. 17g). Substrate algae ..... *L. echidna*

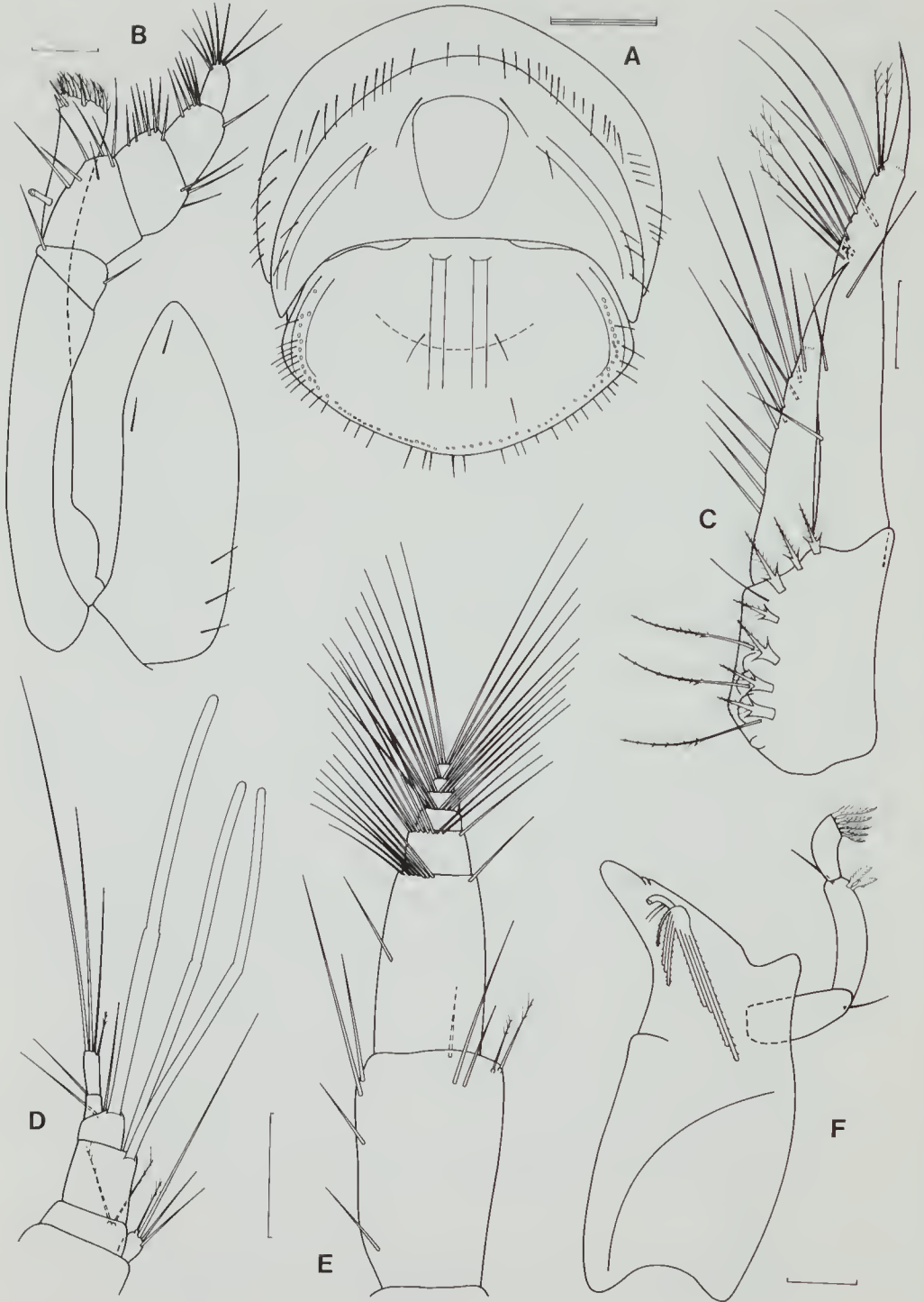


Figure 3. *Paralimnoria andrewsi* (Calman). A–E, male, AM P38919: A, pleonite 4, 5 and pleotelson, dorsal view; B, maxilliped; C, uropod, ventral view; D, flagellum of antenna 1; E, peduncle article 5 and flagellum of antenna 2. F, male, NMV J15473, right mandible.

**Paralimnoria Menzies**

*Paralimnoria* Menzies, 1957: 147–148.—Kensley and Schotte, 1989: 199.

*Type species. Limnoria andrewsi* Calman, 1910 (original designation).

*Diagnosis.* Flagellum of antenna 1 with 5 articles. Flagellum of antenna 2 with 5–6 articles. Left mandible with “rasp” and right mandible with “file” incisor surface. Spine row of left mandible of 3 serrated setae. Exopod of uropod long, more than half as long as endopod, both rami with long apical claws; exopod ventrolateral to endopod; peduncle with trifurcate pappose setae ventrally. Peduncles of pleopods 1–4 with medial lobe; appendix masculina articulating proximally; both rami of pleopod 5 with few plumose setae; pleopod 5 nearly as large as other pleopods. Pleonite 5 and pleotelson similar in length. Outer lobe of maxilla 1 with 5 smooth outer spines of which 4 are similar length and 1 is more than half this length. Maxillipedal endites with 5 apical curved pappose setae of similar form. Secondary unguis of pereopod 1 usually trifid, occasionally bifid.

**Paralimnoria andrewsi** (Calman)

Figures 3, 4

*Limnoria andrewsi* Calman, 1910: 184–186, pl. V figs 7–14.—Chilton, 1914a: 382–387.—Miller, 1924: 159–164, figs 3–5.—Atwood et al., 1924: 24–25, pl. I figs 3–5.—Shiino, 1944: 1–19.—Holthuis, 1949: 170.—Shiino, 1950: 341–358, figs 4–6.

*Paralimnoria andrewsi.*—Menzies, 1957: 148–151, figs 7, 22–24.—Menzies, 1959: 14.—Mohr, 1959: 88.—Menzies and Robinson, 1960: 132–137.—Menzies and Glynn, 1968: 50, figs 21A–B.—Schultz, 1969: 139, fig. 204.—Kühne, 1971: 67, 70.—Jones et al., 1972: 105, 109.—Kühne, 1975: 452.—Barnacle and Ampong, 1975: 289–310.—Kühne, 1976: 550, fig. 11.—Barnacle, 1976: 59.—Ampong and Asare-Nuadu, 1985: 2.—Eaton et al., 1989: 63.—Kensley and Schotte, 1989: 199–201, fig. 88C–D.

*Material examined.* Syntypes: Flying Fish Cove, Christmas Islands (10°30'S, 105°44'E), timber piles, C.W. Andrews, 1908, British Museum (Natural History) 1909.5.19: 335–339 (3 males, 1.6–1.7 mm, 3 juvs., 1.15–1.6 mm).

Other material: PNG, Madang, low tide, pine bait block no. 27 after 2 months, R.D. Turner, J.V. Marshall and J. Beesley, 30 Aug 1970, AM P38919 (male, 2.6 mm, 0.7 mm wide pleotelson, with 1 slide),

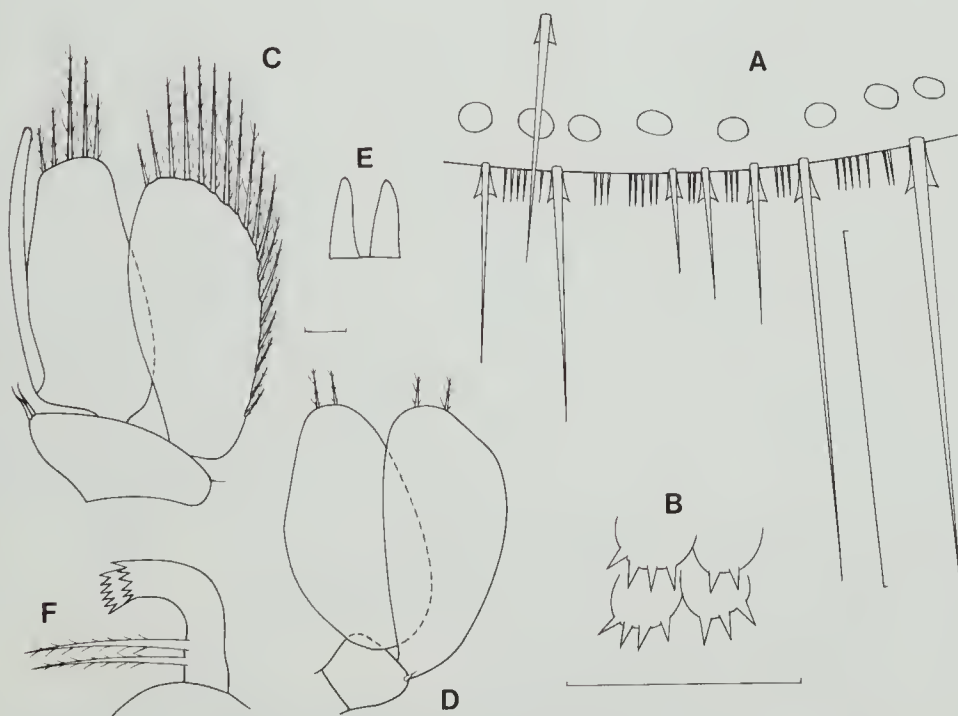


Figure 4. *Paralimnoria andrewsi* (Calman). A–E, male, AM P38919: A, posterior margin of pleotelson, dorsal view; B, dorsal structure of pleotelson; C, pleopod 2; D, pleopod 5; E, penes. F, male NMV J15473, lacinia mobilis of right mandible.



AM P38918 (3 non-ovig. females, 2.7, 2.8, 2.9 mm, 2 juvs., 2.2, 2.5 mm). Port Moresby, Harbour, S.M. Rayner, Oct 1972, NMV J15473 (male, 2.5 mm, with 1 slide), NMV J15474 (non-ovig. female, 2.9 mm, with 2 slides), NMV J15472 (5 males, 2.3–2.5 mm, 3 non-ovig. females, 2.7, 3.0, 3.1 mm, 2 ovig. females, 2.5, 2.7 mm, juv. 1.8 mm). Lorengau, Admiralty Islands, S.M. Rayner, 10 Oct 1970, NMV J15489 (2 males, 1.8, 2.0 mm).

Cocos Islands, pine bait block no. 242 after 5 months, J.D. Turner, J.V. Marshall and J. Beesley, Nov 1970, AM P38920 (5 males, 6 females).

*Types.* All types held by the British Museum (Natural History).

*Diagnosis* (based on Madang specimens). Pleonite 5 dorsomedially with depressed triangular area, with lateral crests. Pleotelson with dorsomedial pair of long longitudinal parallel carinae slightly raised anteriorly as puncta. Pleonite 5 0.85 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with several thick scale spikes. Dorsal row of tubercles extend from lateral crests to posterior margin of pleotelson; posterior margin fringed with thin scale spikes and short-sheathed setae, lacking stout setae.

Antenna 1 with 5 flagellar articles; second article with 2 aesthetascs. Flagellum of antenna 2 with 5–6 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible tubular, recurved, with apical perimeter of teeth. Epipod of maxilliped broad, apically pointed, 3 times as long as wide, reaching beyond palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 trifold. Ventral comb seta on merus of pereopods 4, 5 and 6 vestigial (none present in Port Moresby specimens), present on carpus of pereopods 2, 3, 5, 6 and 7 (and pereopod 4 in Port Moresby specimens). Uropod peduncle without tubercles on lateral margin, with ventrolateral tubercles; endopod 1.6 times as long as (claw not included) peduncle.

Pleopod 2 with short plumose setae, up to 0.5 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximally. Endopod of pleopod 5 posterior to exopod, oval-slightly triangular, 0.9 times shorter than endopod of pleopod 2; peduncle of pleopod 5 with vestigial comb seta laterally.

*Additional characters.* Body length up to 3.1 mm. Colour in alcohol white to pale yellow with dark reticulate pigment.

*Distribution.* Flying Fish Cove, Christmas Islands (type locality) (Calman, 1910); Samoa; Hawaii (Miller, 1924); Japan (Shiino, 1950; Kühne, 1976); Florida; Caribbean; Philippines (Menzies, 1957); Puerto Rico (Menzies and Glynn, 1968); Ghana (Barnacle and Ampong, 1975); Papua New Guinea (Kühne, 1976; current study); Cocos Islands (current study). 0–4 m depths (Barnacle and Ampong, 1975).

*Substrates.* Timber piles (Calman, 1910), *Chlorophora excelsa* (Welw.) Benth. piles (Barnacle and Ampong, 1975), pine blocks (current study).

*Remarks.* Menzies (1957) described three forms of *P. andrewsi*, which were not subspecies but only morphological variations that could be found together within certain populations, and in others were so mixed that a precise assignment was not possible (Menzies, 1957). Some of the morphological variations found in *P. andrewsi* are: the depressed triangular area on pleonite 5 may be absent, although the dorsomedial area is still flat; the longitudinal carinae on the pleotelson may be shorter than indicated in Fig. 3, or even absent (Menzies and Glynn, 1968); the degree of tuberculation on the lateral crests and posterior margin of the pleotelson can vary; and the occurrence of ventral comb seta on the various pereopods of *P. andrewsi*, unlike *Limnoria* species, is variable.

Normally the secondary unguis on pereopod 1 is trifold, however one of the male syntypes examined had a bifid secondary unguis as is typically found in *Limnoria*. One male from the Cocos Islands had a trifold unguis on the left pereopod, but a bifid unguis on the right.

Of the dissected specimens examined, all had five flagellar articles on antenna 2. However, some specimens may have six articles (Menzies, 1957). It cannot be certain that the *Paralimnoria* examined by Shiino (1950) were *P. andrewsi*, as he noted only four flagellar articles on antenna 2. Also, the maxillipedal epipodite was triangular (Shiino, 1950), which is different from the broad shape found in the syntypes of *P. andrewsi*.

### *Paralimnoria asterosa* Cookson and Cragg

Figures 5–9

*Paralimnoria asterosa* Cookson and Cragg, 1988: 1512–1515, figs 4, 5.

*Material examined.* Holotype: PNG, Kaut, New Ireland Province (2°46'03''S, 150°54'28''E), 8 m, dense rainforest log, SCUBA, S.M. Cragg, 10 Oct

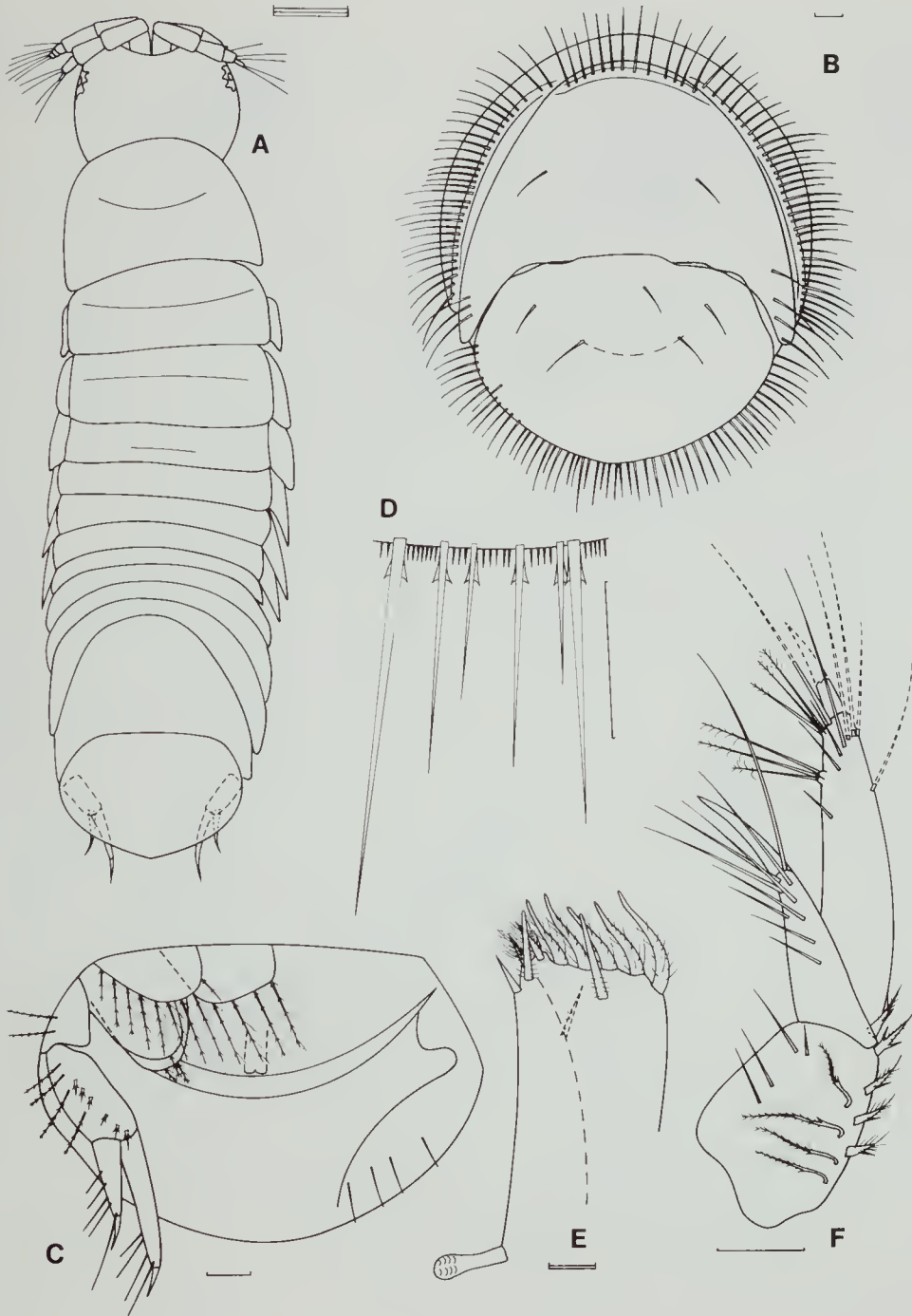


Figure 5. *Paralimnoria asterosa* Cookson and Cragg. A-F, juvenile, NMV J14779, holotype: A, dorsal view, most setae omitted; B, pleonites 4, 5 and pleotelson, dorsal view; C, pleotelson, left uropod and pleopods removed, ventral view; D, posterior margin of pleotelson, dorsal view; E, endite of maxilliped; F, uropod, lateral view.

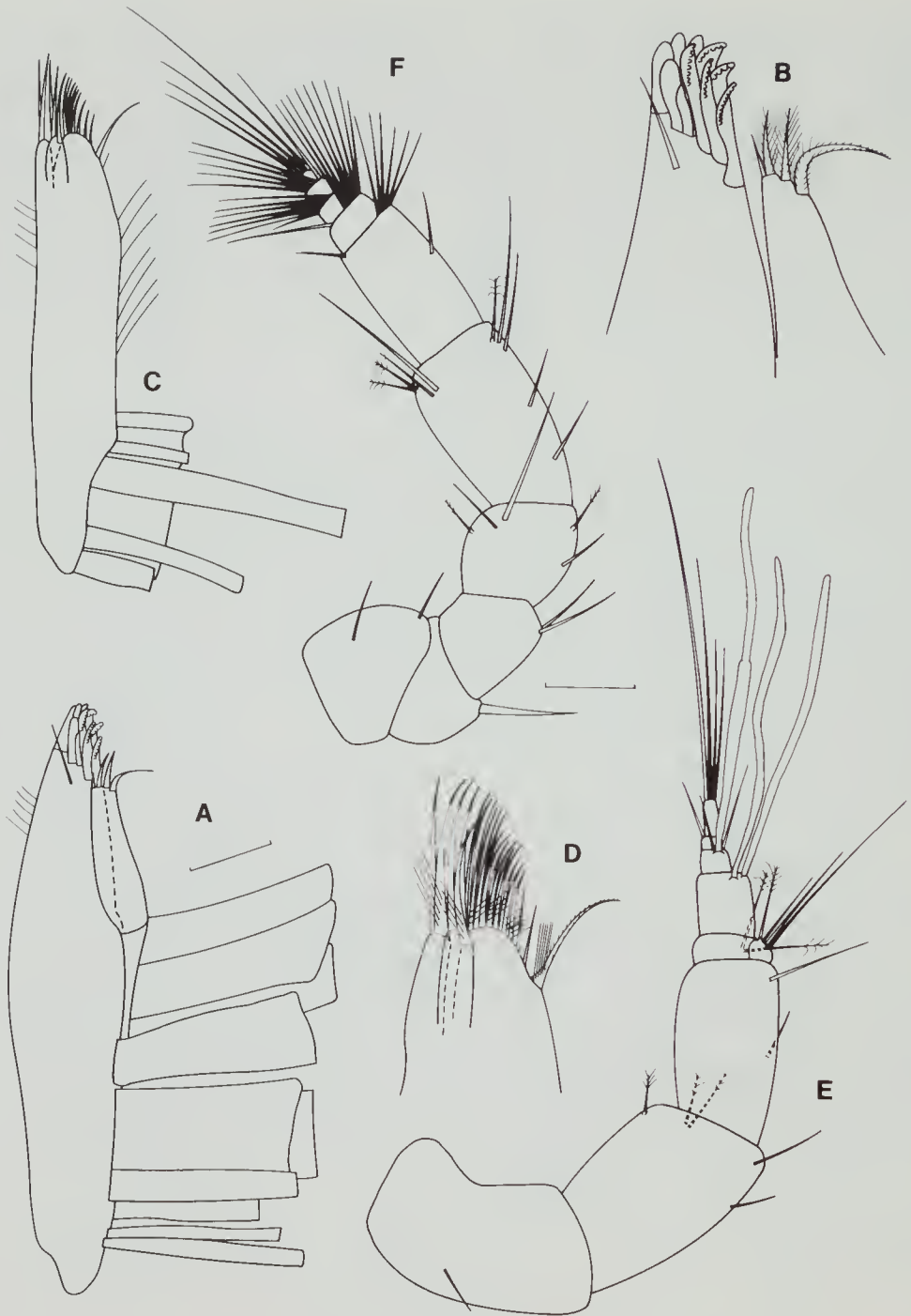


Figure 6. *Paralimnoria asterosa* Cookson and Cragg. A-F, juvenile, NMV J14779, holotype: A, maxilla 1 with associated muscle; B, distal portion of maxilla 1; C, maxilla 2 with associated muscle; D, distal portion of maxilla 2; E, antenna 1; F, antenna 2.



1985, NMV J14779 (juv., 2.2 mm, 0.5 mm wide pleotelson, with 1 slide).

Paratypes: Type locality, NMV J14780 (ovig. female damaged at perconite 1-cephalon juncture, 2.7 mm, with 3 slides), NMV J14781 (juv., 1.9 mm).

**Diagnosis.** Pleonite 5 dorsomedially with anterior transverse carina; with very short lateral crests as pleonite dorsolaterally mostly surrounded by lateral crests of pleonite 4; without central depressed area, but central area flattened. Pleotelson without dorsomedial carinae and puncta. Pleonite 5 0.9 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with several thick scale spikes. With continuous ring of radially directed, short-sheathed setae on lateral carinae of pleonite 4, anterior transverse carina of pleonite 5, and lateral crests and posterior margin of pleotelson. Posterior margin of pleotelson also fringed with thin scale spikes, without stout setae; posterior margin and lateral crests without dorsal row of tubercles or scale spikes.

Antenna 1 with 5 flagellar articles; second article with 2 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible tubular, recurved, with perimeter of apical teeth. Epipod of maxilliped broad, apically pointed, 3 times as long as wide, reaching beyond palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 trifold. Ventral comb seta on merus of pereopods 5 and 6 vestigial, seta present on carpus of pereopods 2, 3, 5, 6 and 7. Uropod peduncle without tubercles laterally or ventrally; endopod 1.6 times as long as (not including claw) peduncle.

Pleopod 2 with plumose setae up to 0.6 times as long as exopod. Characteristics of appendix masculina unknown. Endopod of pleopod 5 posterior to exopod, oval-slightly triangular, same length as endopod of pleopod 2; peduncle of pleopod 5 with vestigial comb seta laterally.

**Additional characters.** Body length up to 2.7 mm. Colour in alcohol white, with faint dark reticulate pigment.

**Distribution.** Kaut, Papua New Guinea (type locality). 8 m depth.

**Substrate.** Dense log.

**Remarks.** The species is re-illustrated here in more detail than in the original description. *P. asterosa* differs from *P. andrewsi* in having a transverse anteromedial carina on pleonite 5. *P. asterosa* also lacks the central depressed area on

pleonite 5 often found in *P. andrewsi*. Unlike *P. andrewsi*, the lateral crests on pleonite 4 of *P. asterosa* surround most of the lateral margin of pleonite 5, so that pleonite 5 is mostly without lateral crests. Its pleotelson lacks the two parallel medial carinae found on *P. andrewsi*. Though *P. andrewsi*, like *P. asterosa*, has sheathed setae, these are shorter, less numerous, are not situated on carinae on pleonites 4 and 5, and do not cross medially as a row from pleonite 4 to 5. Also they are not so distinctly radially orientated. *P. andrewsi* has tubercles on the lateral crests and posterior margin of the pleotelson and on the uropod peduncle while *P. asterosa* does not.

### Limnoria Leach

*Limnoria* Leach, 1814: 433.—Coldstream, 1836: 316–334.—Bate and Westwood, 1868: 351.—Harger, 1880: 373.—Hoek, 1893: 1–97.—Sars, 1899: 75.—Richardson, 1905: 269–270.—Nierstrasz and Schuurmans Stekhoven, 1930: 79.—Kussakin, 1979: 315.—Kensley and Schotte, 1989: 194.

*Limnoria* (*Limnoria*).—Menzies, 1957: 121–122.—Menzies, 1959: 12–14.—Pillai, 1961: 20.—Rao and Ganapati, 1969: 225–226.

*Limnoria* (*Phycolimnoria*) Menzies, 1957: 144, 146.—Pillai, 1957: 149–150.—Menzies, 1959: 13–14.

*Phycolimnoria*.—Kussakin, 1963: 281.—Kussakin, 1979: 310.—Kensley and Schotte, 1987: 226.—Kensley and Schotte, 1989: 201.

*Limnoria*.—Humphreys, 1845: 22 (lapsus).

*Lunovia*.—Fox and Boulton, 1877: 189–194 (lapsus).

**Type species.** *Limnoria terebraus* Leach, 1814: 433 (= *Cymothoa lignorum* Rathke, 1799) (monotypy).

**Diagnosis.** Flagellum of antenna 1 with 3–4 articles. Flagellum of antenna 2 with 3–5 articles. Mandibular incisors with or without “rasp” and “file”; mandibular palp with 0–3 articles; spine row of left mandible of 2 or fewer serrated setae. Exopod of uropod much shorter than endopod, provided with apical claw or knob; apex of endopod blunt, without claw; exopod lateral to endopod. Pleopod 5 lacking plumose setae; rami nearly as long, or smaller than on other pleopods; peduncle of pleopods 1–4 without inner lobe; appendix masculina articulating sub-proximally to sub-apically. Outer lobe of maxilla 1 with 5 smooth outer spines of which 4 are similar length and 1 is less than half this length or absent. Maxilliped endite with 3 apical curved pappose setae of similar form. Pleotelson often much longer than pleonite 5. Secondary unguis of pereopod 1 bifid or variable.

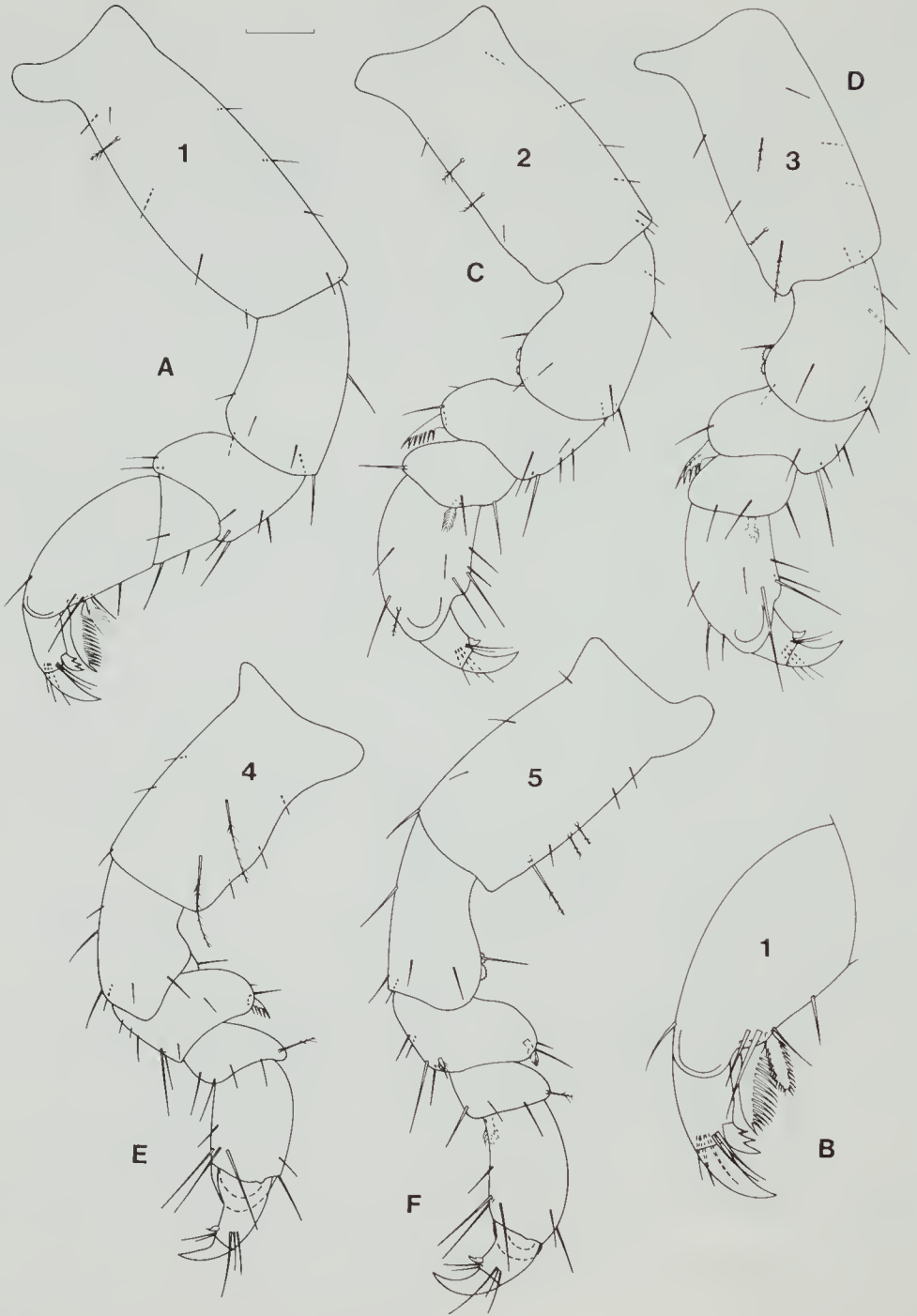


Figure 7. *Paralimnoria asterosa* Cookson and Cragg. A-F, juvenile, NMV J14779, holotype: A, pereopod 1, lateral view; B, propodus and dactylus of pereopod 1, lateral view; C-F, pereopods 2-5, lateral views.

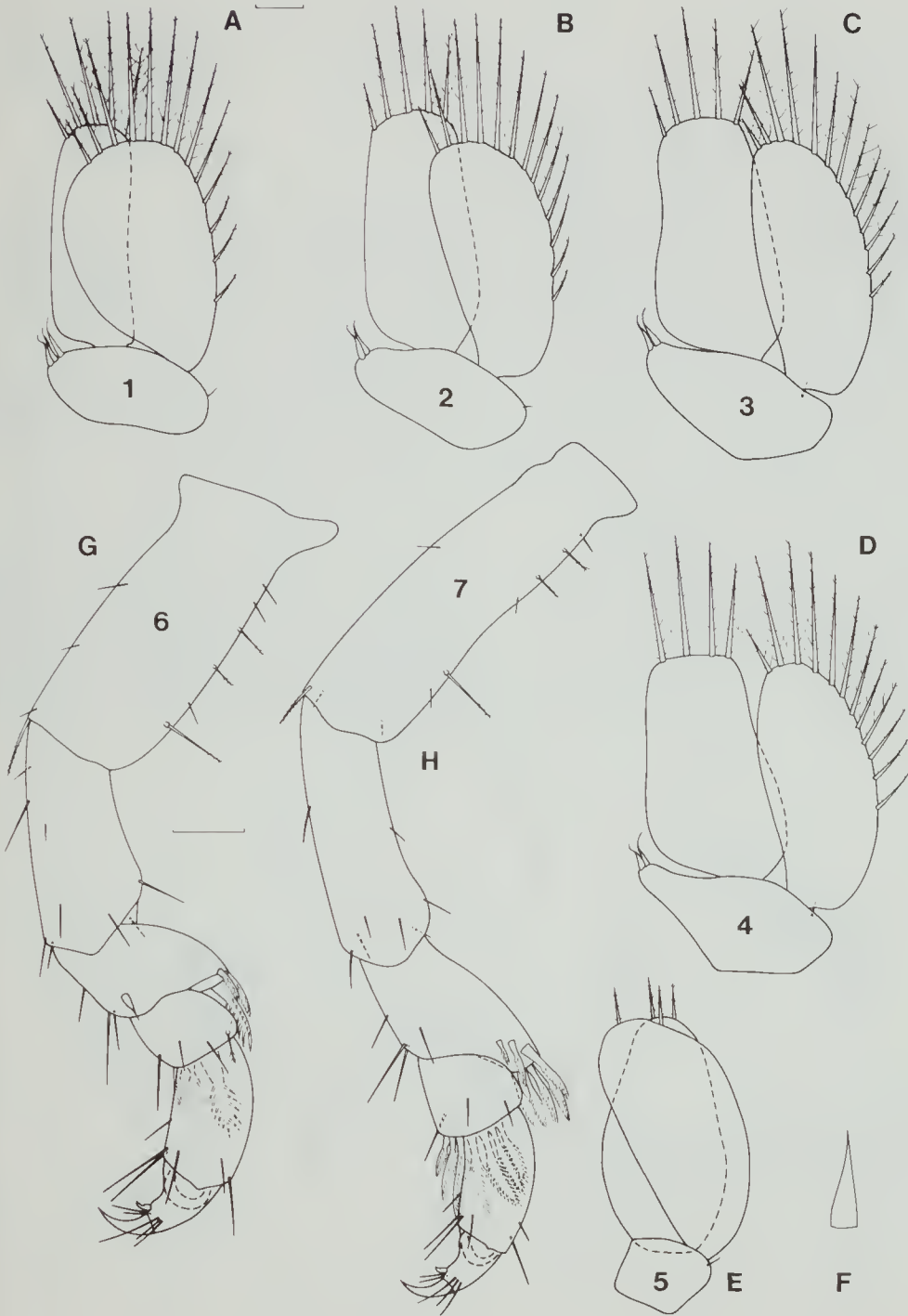


Figure 8. *Paralomnoria asterosa* Cookson and Cragg. A-H, juvenile, NMV J14779, holotype: A-E, pleopods 1-5; F, vestigial comb seta on peduncle of pleopod 5; G, pereopod 6, lateral view; H, pereopod 7, lateral view.



*Remarks.* For the full description of a species of *Limnoria*, see *L. indica*.

Although specimens of *L. lignorum* from England were examined, this species has not been described here because it is not an Australasian species. Also, type material for the species is not known to exist, although new specimens collected from the type locality in Norway would suffice in such a description.

Menzies (1957) erected the subgenus *Limnoria* (*Phycolimnoria*). Kussakin (1963) later raised *Phycolimnoria* to generic status, using the characters determined by Menzies (1957) of the lack of mandibular rasp and file, and an algal habitat. It is now known that these two characters are not always correlated. Two species which lack a rasp and file are not algal dwellers. *L. zinovae* is a seagrass-borer, and *L. clarkae* bores into soft mangrove wood. These may be examples of habitat induced convergence.

The rasp and file can no longer be used to clearly separate species. Intermediate states, where the rasp is reduced, can be found in *L. raruslima*, *L. simulata* and *L. echidna*. For the two known specimens of *L. echidna*, one lacks a rasp and the other has about 11 small teeth. *L. echidna* is most similar to the wood-borer *L.*

*quadripunctata*. Also, no additional character was found that supported the division of species according to rasp and file. For these reasons, *Phycolimnoria* is synonymised with *Limnoria*.

### *Limnoria agrostisa* sp. nov.

#### Figure 10

*Material examined.* Holotype: WA, 300 m offshore near Cliff Head, 30 km south of Dongara (29°32'S, 114°59'E), 2 m, in rhizomes at edge of *Posidonia* bed, SCUBA, G.C.B. Poore and H.M. Lew Ton, 22 Apr 1986 (stn SWA 85), NMV J14972 (juv., 2.8 mm, 0.6 mm wide pleotelson, with 1 slide).

Paratype: SA, Coal Reef, Tiparra Reef, Tiparra Bay (34°4'S, 137°23'E), 5 m, dead seagrass in sand and grit, SCUBA, G.C.B. Poore and H.M. Lew Ton, 15 Mar 1985 (stn SA 13), NMV J14973 (male, 2.1 mm, 0.5 mm wide pleotelson, with 1 slide).

*Diagnosis.* Pleonite 5 dorsomedially with X-shaped carina, anterior axes longer than posterior axes, posterior axes without depression between them. Pleotelson with 2 dorsomedial parallel carinae slightly raised anteriorly as puncta; carinae followed laterally by another short pair of carinae and long pair of carinae, as well as lateral crests. Pleonite 5 0.6 times as long

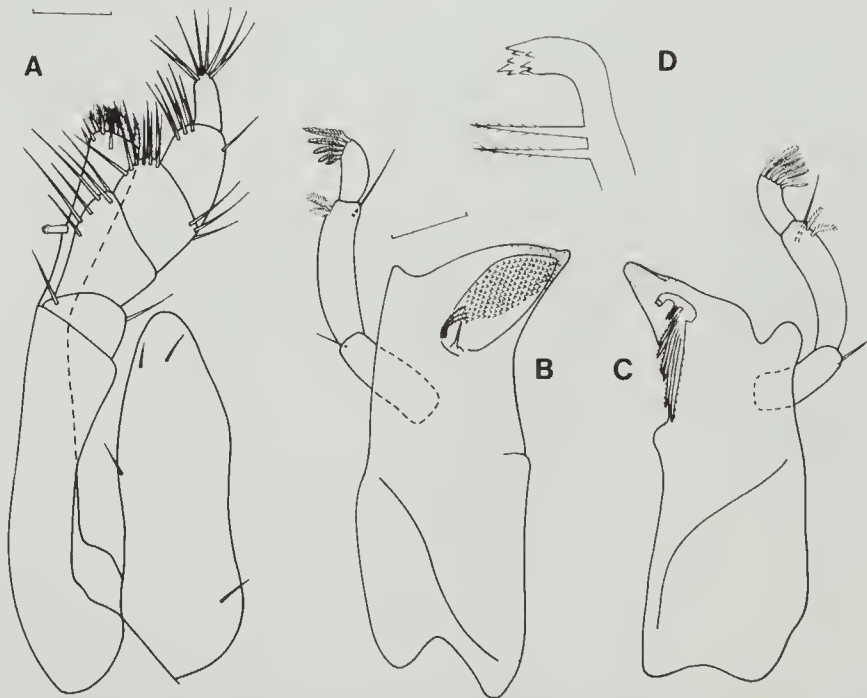


Figure 9. *Paralimnoria asterosa* Cookson and Cragg. A–D, juvenile, NMV J14779, holotype: A, maxilliped; B, left mandible; C, right mandible; D, lacinia mobilis of right mandible.

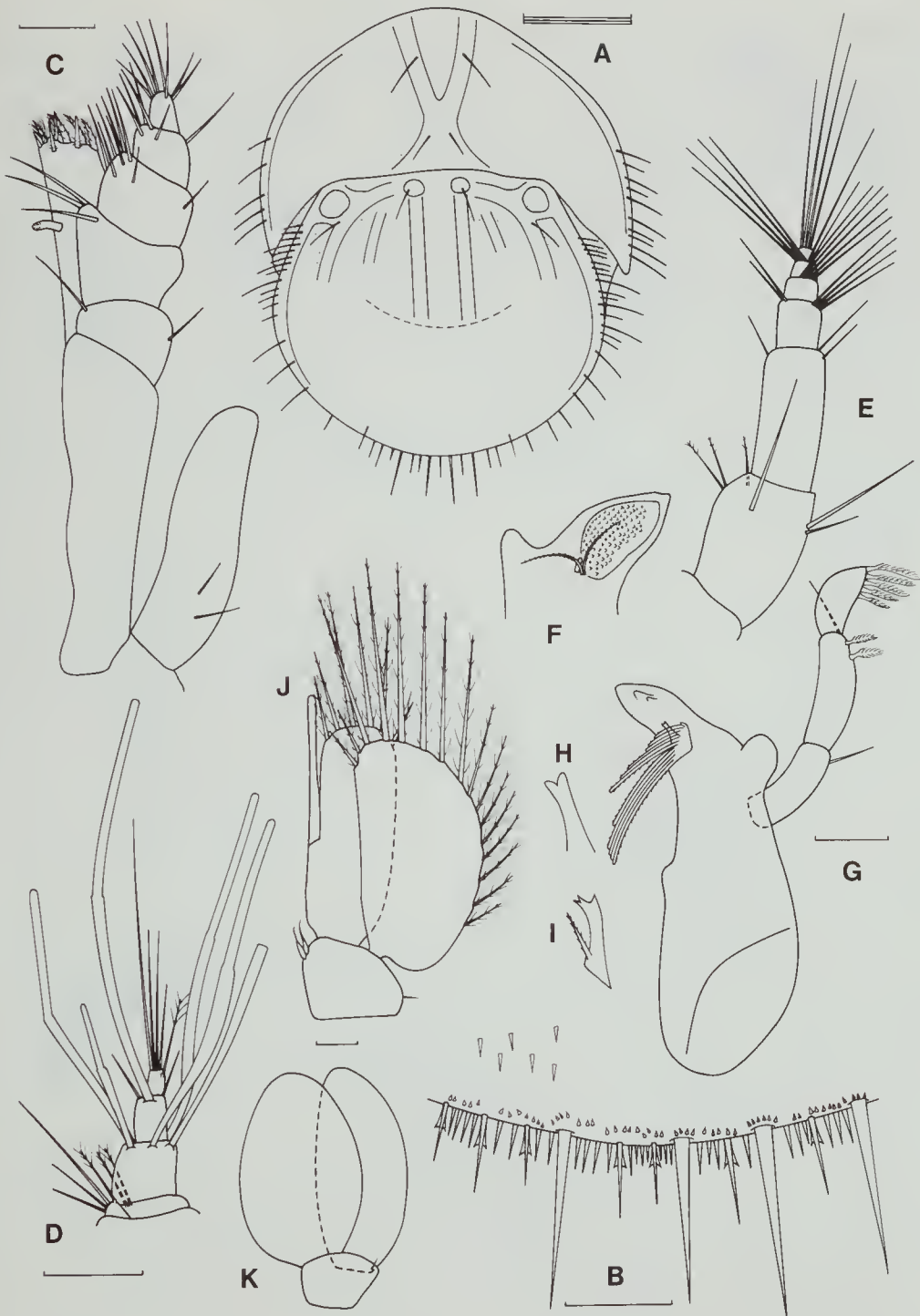


Figure 10. *Limnoria agrostisa* sp. nov. A-H, juvenile, NMV J14972, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; D, flagellum of antenna 1; E, peduncle article 5 and flagellum of antenna 2; F, incisor of left mandible; G, right mandible; H, lacinia mobilis of right mandible. I-K, male, NMV J14973, paratype: I, lacinia mobilis of right mandible; J, pleopod 2; K, pleopod 5.

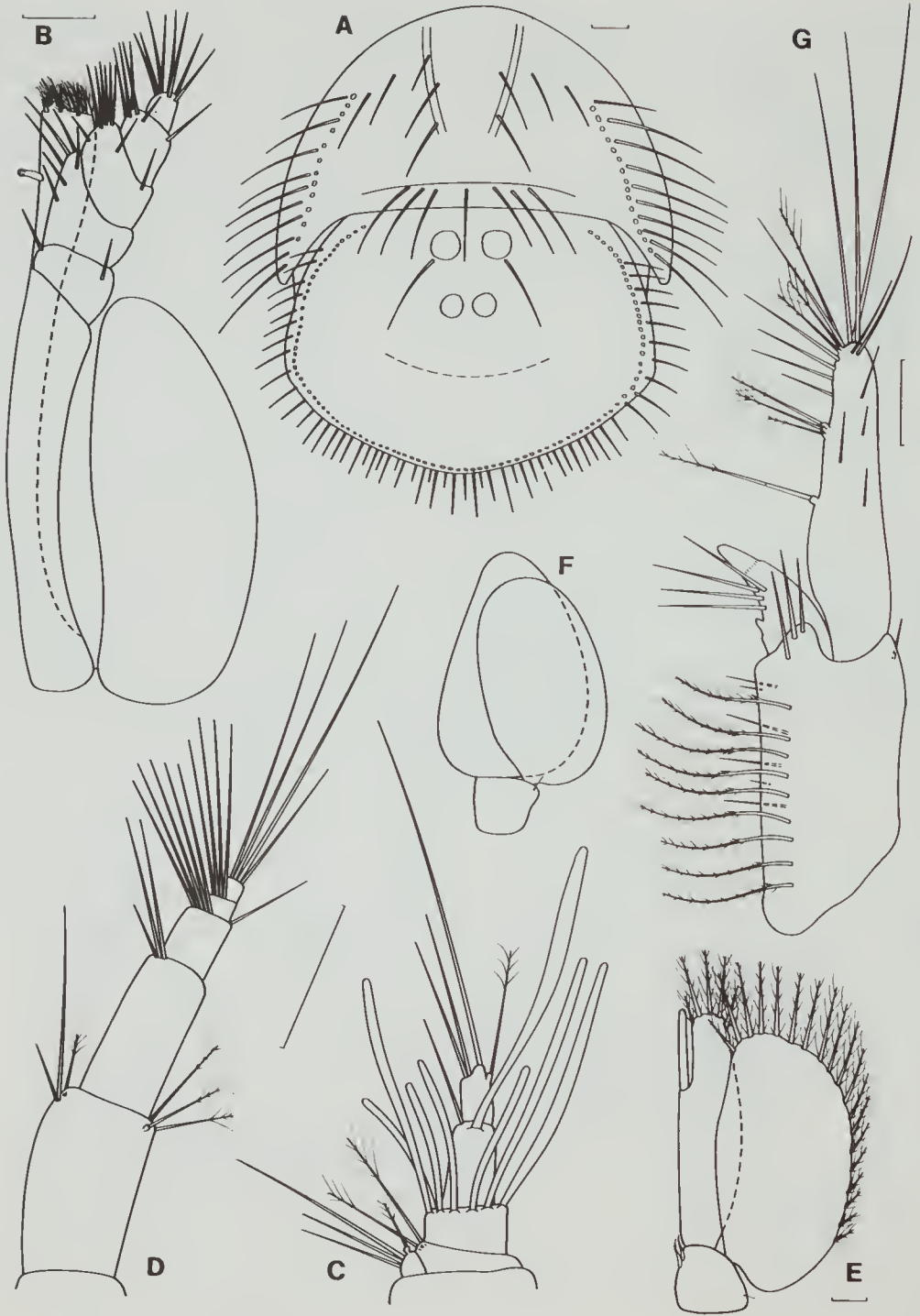


Figure 11. *Limnoria andamanensis* Rao and Ganapati. A, E, F, male, NMV J15468: A, pleonite 5 and pleotelson, dorsal view; E, pleopod 2; F, pleopod 5. B–D, G, male, NMV J15469: B, maxilliped; C, flagellum of antenna 1; D, peduncle article 5 and flagellum of antenna 2; G, uropod, ventral view.



as pleotelson. Dorsal surface of pleotelson with scales fused, covered with solitary scale spikes, surface pitted. Posterior margin of pleotelson with dorsal row of small scale spikes clustered into groups of 2–6; posterior margin with 4 stout setae between which are short-sheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 4–5 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible short, straight, with 2–3 sharp or blunt apical teeth. Epipod of maxilliped strap-like, 3.7 times as long as wide, just reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 5, 6 and 7. Uropod peduncle with small lateral tubercles; endopod 0.8 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.8 times length of exopod. Appendix masculina reaching beyond endopod tip, articulating just proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.9 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Body length up to 2.8 mm. Colour in alcohol pale yellow.

*Etymology.* From *agrostis*, Latin for couch-grass.

*Distribution.* South Australia and southern Western Australia. 2–5 m depths.

*Substrates.* Seagrass rhizomes such as those from *Posidonia*.

*Remarks.* The rasp on the left mandible is not absent or reduced as it is in the other seagrass borers *L. zinovae*, *L. simulata* and *L. rarus-lima*.

*L. agrostisa* is most similar to *L. quadripunctata* in the ornamentation on pleonite 5 and the pleotelson, possession of a rasp and file, possession of a dorsal row of scale spikes on the posterior margin of the pleotelson, and the shape of the pleopods. *L. agrostisa* may be distinguished from *L. quadripunctata* by the shapes of the maxillipedal epipod, lacinia mobilis of the right mandible, and carina on pleonite 5. Further, *L. agrostisa* lacks a posterior pair of puncta on the pleotelson, and has scale spikes dorsally on the posterior margin of the pleotelson which are small and divided into groups of 2–6.

### *Limnoria andamanensis* Rao and Ganapati

Figures 11, 12, Plate 1f

*Limnoria (Limnoria) andamanensis* Rao and Ganapati, 1969: 225–230, figs 1–21.—Nair, 1984: 208.

*Material examined.* PNG. Buka Passage, Bougainville, S.M. Rayner, NMV J15468 (male, 2.3 mm, 0.53 mm wide pleotelson, with 1 slide), NMV J15469 (male, 2.6 mm, with 1 slide), NMV J15470 (3 males, 2.2, 2.4, 2.4 mm, 3 ovig. females, 2.2, 2.3, 2.5 mm). Rabaul, timber piles from main wharf, S.M. Cragg, 15 Nov 1982, NMV J15482 (male, ovig. female). Alotau, Milne Bay Province, S.M. Rayner, Aug 1971, NMV J15476 (2 males, 2 ovig. females). Madang, low tide, pine bait block no. 27 after 2 months, R.D. Turner, J.V. Marshall and J. Beesley, 30 Aug 1970, AM P38917 (2 males, non-ovig. female). Belize, Twin Cays, 1 m, rotting wood, B. Kensley, 12 Dec 1986, NMV J15440 (11 specimens).

*Types.* Zoology Museum, Andhra University, Waltair, India. Attempts to obtain the types have been unsuccessful.

*Diagnosis.* Pleonite 5 dorsomedially with 2 longitudinal carinae of very low elevation which converge posteriorly; with prominent postero-transverse ridge bearing 7–10 long setae. Pleotelson with 2 pairs of anteromedial puncta, posterior pair closer together than anterior pair. Pleonite 5 0.75 times as long as pleotelson. Dorsal surface of pleotelson composed of scales bearing central spike. Dorsal row of laterally compressed tubercles extend from lateral crests to posterior margin of pleotelson; some tubercles with row of tiny spikes at apex. Posterior margin of pleotelson fringed with long-sheathed setae, without stout setae or scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 7 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible short, curved, with row of small teeth. Epipod of maxilliped broad, oval, 2.5 times as long as wide, reaching past palp articulation; epipod lacking simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopods 6 and 7, and carpus of pereopods 2,3,5,6 and 7. Uropod peduncle with small lateral tubercles; endopod 1.1 times as long as peduncle; endopod with apical row of simple setae extending laterally.

Pleopod 2 with short plumose setae, up to 0.3 times length of exopod. Appendix masculina short, reaching endopod tip, articulating distal to midlength of endopod. Endopod of pleopod 5 posterior to exopod, triangular, similar length to

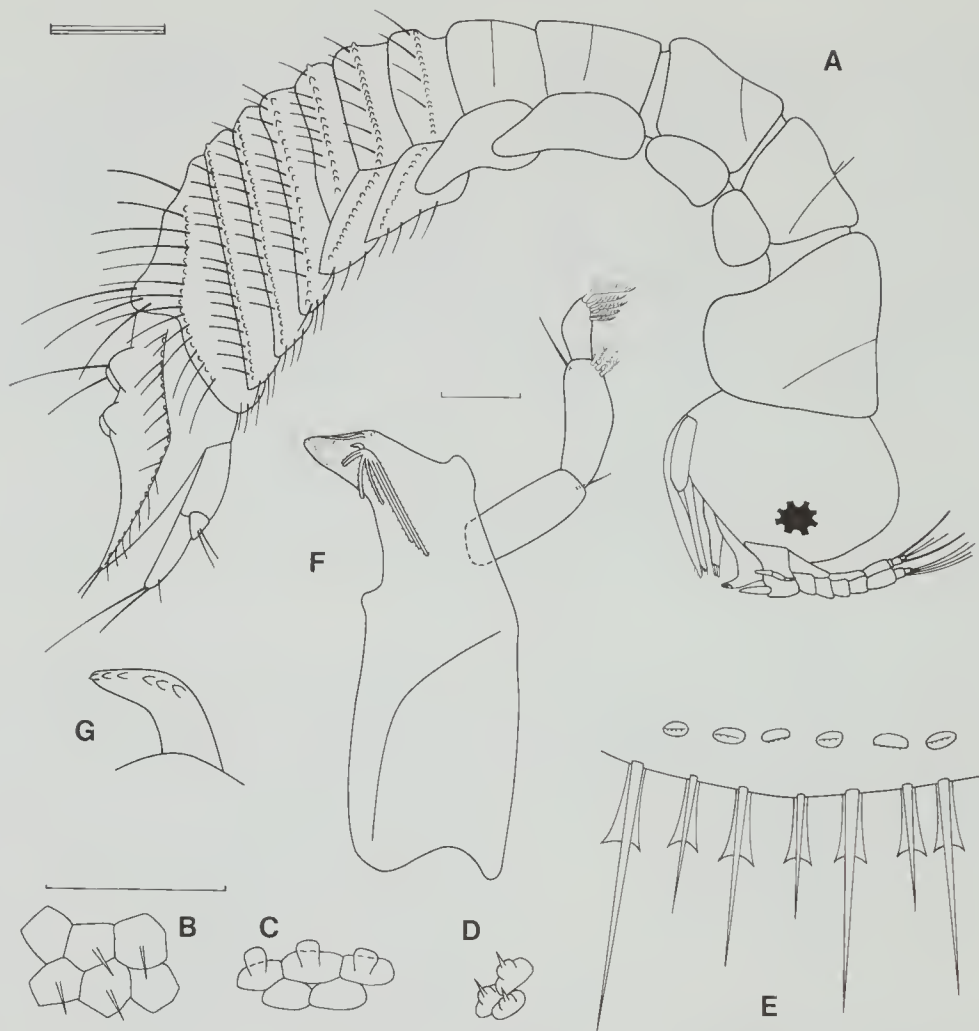


Figure 12. *Limnoria andamanensis* Rao and Ganapati. A–E, male, NMV J15468: A, lateral view; B, dorsal structure of pleotelson; C, dorsal tubercles on pleonite 2; D, dorsal tubercles on lateral crests of pleotelson; E, posterior margin of pleotelson, dorsal view. F, G, male, NMV J15469: F, right mandible; G, lacinia mobilis of right mandible.

endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Somites pereonite 6 to pleonite 4 with transverse row of dorsal tubercles, most prominent on pleonites 1 and 2; pleonites 3 and 4 with tuberculate row near posterior margins, row becomes more centrally located on more anterior somites. Exopod of uropod with two lateral tubercles. Body length up to 2.6 mm. Colour in alcohol pale yellow, with dark reticulate pigment.

*Distribution.* Andaman Islands, Indian Ocean (type locality) (Rao and Ganapati, 1969); Papua New Guinea; Belize. 1 m depth (current study).

*Substrates.* Log (Rao and Ganapati, 1969), rotting wood, pine bait blocks (current study).

*Remarks.* The subparallel longitudinal carinae on pleonite 5 are indistinct, and on most specimens not detectable. When present, these carinae have a similar position to two sides of the depressed triangular area found on *P. andrewsi*. The hind pair of puncta on the pleotelson vary in the degree with which they are separated – in some specimens they are joined together (although still distinct puncta). The apical teeth on the lacinia mobilis of the right mandible (Plate 1f) are difficult to detect with the light microscope, and so may have been over-

looked in the specimens examined by Rao and Ganapati (1969), where the lacinia mobilis was described as pointed, smooth and curved.

The specimens from Papua New Guinea and Belize differ slightly from the original description (Rao and Ganapati, 1969), in that they have a row of modified tubercles on the posterior margin of the pleotelson. In the original description it was stated that the distal border was without tubercles. However, due to the possibility that these were overlooked, the specimens from Papua New Guinea and Belize cannot be separated as a different species (or subspecies) without examining the types. The rather prominent tubercles on pereonites 6 to pleonite 5 were also not noted by Rao and Ganapati (1969).

*L. andamanensis* is most similar to *L. pfefferi*, for the reasons listed with that species.

### *Limnoria antarctica* Pfeffer

#### Figure 13

*Limnoria antarctica* Pfeffer, 1887: 96–102, pl. 2 figs 12–13, pl. 5 figs 2–22.—Pfeffer, 1890: 504.—Vanhöffen, 1914: 509–510.—Chilton, 1914a: 382–388, pl. 17 fig. 8.—Holthuis, 1949: 170.

*Limnoria (Phycolimnoria) antarctica*.—Menzies, 1957: 180–182, fig. 36.—Pillai, 1957: 150.—Menzies, 1959: 29.

*Phycolimnoria antarctica*.—Edgar, 1987: 607.

Not *Limnoria antarctica*.—Richardson, 1913: 8.—Chilton, 1914b: 448 (possible).—Hale, 1937: 21–23, fig. 6 (= *Limnoria stephenseni*).

*Material examined.* Macquarie Island. Large rock on SW side of Caroline Cove, 8 m, *Macrocystis pyrifera* holdfasts, SCUBA, J.K. Lowry, 15 Jan 1978 (stn MA 298), NMV J15399 (male, 3.3 mm, 0.9 mm wide pleotelson, with 1 slide), NMV J15398 (male, 2.7 mm, with 1 slide), NMV J15397 (13 males, 2.1–3.4 mm, 2 non-ovig. females, 2.6, 2.9 mm, 4 ovig. females, 3.3–4.2 mm, 11 juvs., 1.2–2.0 mm). 3 rocks at mouth of Caroline Cove, 13–18 m, red algae from dense *Macrocystis* bed, SCUBA, J.K. Lowry, 16 Jan 1978 (stn MA 307), NMV J15393 (4 males); 13 m, *M. pyrifera* holdfasts (stn MA 306), NMV J15394 (6 males, 2 non-ovig. females, 2 ovig. females, 6 juvs.). Green Gorge, 18 m, *M. pyrifera* holdfasts on platform with rocky gravel bottom and boulders, SCUBA, J.K. Lowry, 8 Jan 1978 (stn MA 250), NMV J15391 (male, ovig. female, 10 juvs.); 15 m, *M. pyrifera* holdfasts on rocks on sandy gravel bottom, SCUBA, D.S. Horning, 13 Jan 1978 (stn MA 294), NMV J15392 (12 males, 2 non-ovig. females, 6 juvs.). Garden Bay, 8 m, *M. pyrifera* holdfasts, SCUBA, D.S. Horning, 7 Dec 1977 (stn MA 91), NMV J15396 (ovig. female, 4.7 mm).

South Orkney Islands, "Scotia" Expedition, 1903, determined C. Chilton, Canterbury Museum (ovig. female, 4.2 mm, pleotelson).

*Types.* Hamburg Museum, not examined.

*Diagnosis.* Pleonite 5 dorsomedially with 2 transverse carinae. Pleotelson with 2 dorso-medial puneta joined by transverse carina, followed posteriorly by 2 parallel carinae; laterally with 2 more pairs of short carinae and lateral crests. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson composed of indistinct partly fused scales with single scale spike, surface anteriorly with small pits. Posterior margin of pleotelson with dorsal row of scale spikes; margin fringed with 4 or 6 stout setae between which are short unsheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 6 aesthetases. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors without rasp and file. Lacinia mobilis of right mandible unbranched, apically serrated. Epipod of maxilliped strap-like, 4.4 times as long as wide, reaching articulation of articles 1 and 2 of palp; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 5, 6 and 7. Uropod peduncle with short lateral spike setae, some setae on small elevations, without prominent tubercles; endopod 0.55 times as long as peduncle.

Pleopod 2 with long plumose setae up to length equal to exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.7 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Article 2 of mandibular palp with more than 1 simple seta. Mandibular incisor of right mandible with 3 cusps. Body length up to 4.7 mm. Colour in alcohol pale yellow.

*Distribution.* South Georgia Island (type locality) (Pfeffer, 1887); South Orkney Islands (Chilton, 1914a); Kerguelen (Menzies, 1957); Macquarie Island. 8–18 m depths (current study).

*Substrates.* *Macrocystis*, and algae under stones (Pfeffer, 1887); *M. pyrifera* holdfasts, red algae amongst a dense *Macrocystis* bed (present study).

*Remarks.* *L. antarctica* is most similar to *L. stephenseni* for the reasons listed with that species. *L. antarctica* may have arisen from an



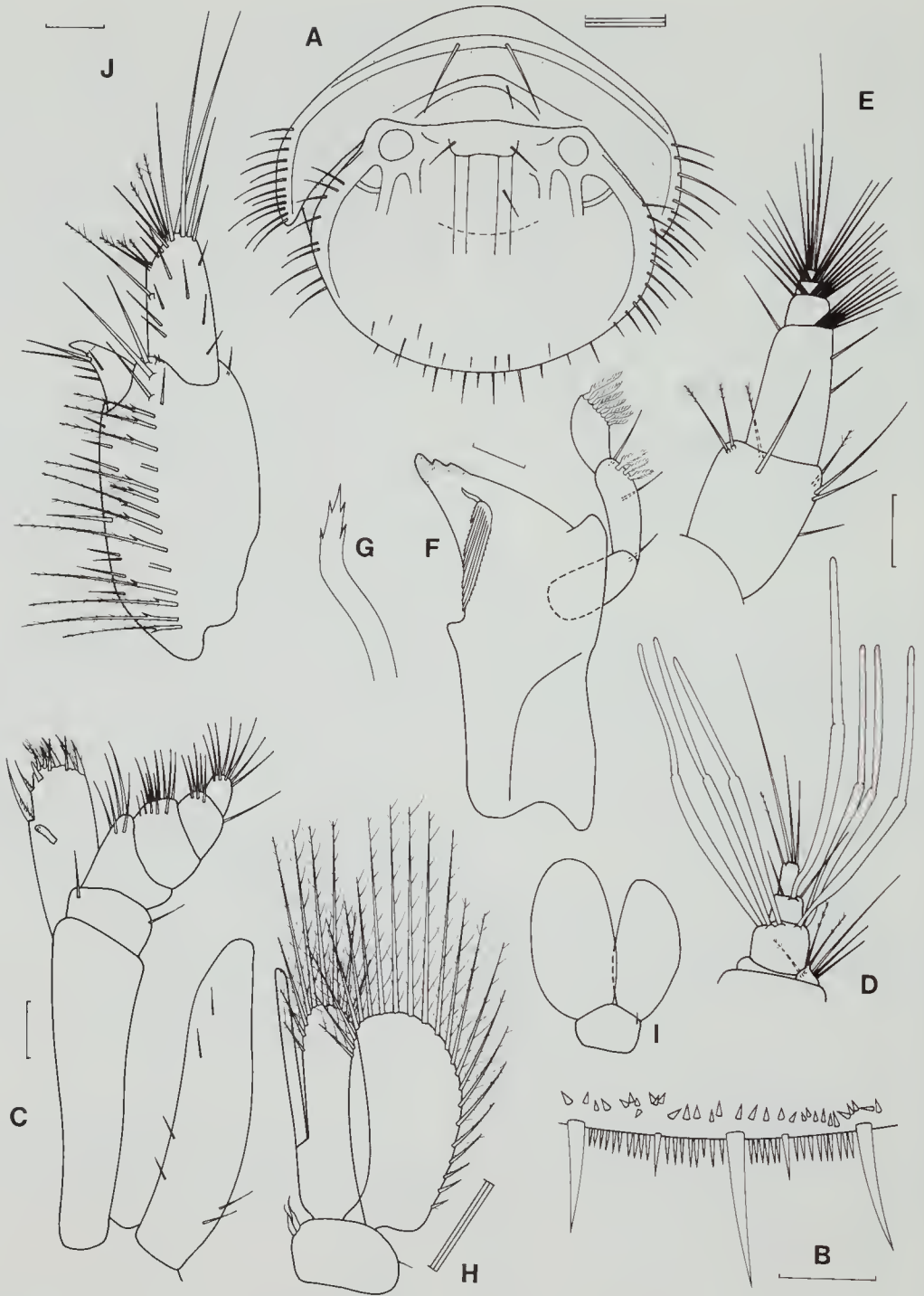


Figure 13. *Limnoria antarctica* Pfeffer. A-I, male, NMV J15399: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; D, flagellum of antenna 1; E, peduncle article 5 and flagellum of antenna 2; F, right mandible; G, lacinia mobilis of right mandible; H, pleopod 2; I, pleopod 5. J, male, NMV J15398, uropod, ventral view.

ancestor similar to *L. glaucinosa* and *L. loricata*. All are large cold-water algal-borers with strap-like maxillipedal epipods, and similar pleopods with long appendix masculina and long plumose setae. *L. glaucinosa* also has more than one simple seta on article 2 of the mandibular palp. The carinae on the pleotelson of *L. loricata* and *L. antarctica* are of similar form, while the transverse carinae on pleonite 5 of *L. antarctica* could have arisen from the broad X-shaped carina on *L. loricata*. Also, some specimens of *L. antarctica* have fine carinae around the surface pits on pleonite 5 as in *L. loricata*. A male *L. antarctica* specimen from lot NMV J15397 had a discernible anterior and posterior pair of puncta on the dorsomedial carinae; therefore, a sculpture pattern approaching *L. quadripunctata* and *L. echidna* was apparent.

Menzies (1957) thought the specimens from South Orkney Islands might be *L. stephensi*, based on the proportions of the uropod figured by Chilton (1914a). However, examination of the remaining intact specimen showed it to be *L. antarctica*.

#### *Limnoria convexa* sp. nov.

Figures 14–16

*Material examined.* Holotype: New Zealand, The Snares islands, Station Point (48°07'S, 166°38'E), low intertidal zone, *Durvillaea* holdfast, K.J. Sainsbury, 3 Feb 1972, NMNZ Cr.6467 (male, 1.6 mm, 0.5 mm wide pleotelson, with 1 slide).

Paratypes: Type locality, NMV J15449 (ovig. female, 2.2 mm, with 1 slide), NMV J15450 (2 males, 1.3, 1.5 mm). The Snares, NW corner of Ho Ho Bay, 14 m, among clumps of concentric crustose coralline algae, G.D. Fenwick, 19 Dec 1976 (stn SA 3459), NMV J15447 (ovig. female, 2.1 mm, with 1 slide); Cod Cavern, Gutway, 12–15 m, red algae, D.S. Horning, 24 Jan 1975 (stn SA 902), AM P38915 (male, 1.4 mm), AM P30750 (non-ovig. female, 2.0 mm, with 1 slide); south side of Ho Ho Bay, 5 m, algae on vertical rock face, D.S. Horning, 23 Dec 1974 (stn SA 795), NMNZ Cr. 6458 (male, 1.5 mm, non-ovig. female, 1.4 mm).

Other material: NZ, The Snares, north side of Boat Harbour, from *D. antarctica* holdfast in upper *Durvillaea* zone, G.D. Fenwick, 13 Nov 1976 (stn SA 3386), NMNZ Cr. 6460 (ovig. female, 2.6 mm, pleonite 5 damaged, left uropod and antennae missing).

*Diagnosis.* Pleonite 5 dorsomedially smoothly convex, without sublateral depressions; pleonite 5 with posterolateral extensions reaching as far as widest part of lateral margins of pleotelson. Pleotelson with 2 short dorsomedial longitudinal carinae. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson composed of

scales fringed posteriorly with fine scale spikes. Posterior margin of pleotelson with dorsal row of scale spikes; margin fringed with 6 long stout setae between which are short unsheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 3 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles, article 3 reduced, with 1 or 2 apical comb setae. Mandibular incisors without rasp and file. Lacinia mobilis of right mandible unbranched, curved near midlength and serrated. Epipod of maxilliped strap-like, apically round, 4.5 times as long as wide, reaching beyond palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta absent on merus of pereopods, present on carpus of pereopods 5, 6 and 7. Uropod peduncle with few small lateral tubercles bearing short spikes; endopod 0.75 times as long as peduncle.

Pleopod 2 with long plumose setae up to 0.9 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.6 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Large medial seta on maxilla 2 sinuous. Lacinia mobilis of left mandible accompanied by only 1 serrated seta in spine row. Body length up to 2.2 mm. Colour in alcohol white.

*Etymology.* From the Latin *convexa*, relating to the convex nature of pleonite 5 which is the main feature distinguishing it from *L. nonsegnis*.

*Distribution.* The Snares, New Zealand, 0–15 m depths.

*Substrates.* *Durvillaea* holdfasts, among coralline algae, red algae.

*Remarks.* This species is very similar to *L. nonsegnis*, but differs slightly in that for *L. convexa*: the epipod of the maxilliped is not club-shaped; pleonite 5 is convex and lacks depressions on either side of the median region; body size is smaller; the food substrate is different; the lacinia mobilis of the right mandible is undivided; the endopod on pleopod 5 lacks a simple seta; the lateral margin on pleonite 5 is longer posteriorly giving a more circular appearance to pleonite 5 and the pleotelson; the lacinia mobilis of the left mandible is accompanied by one not

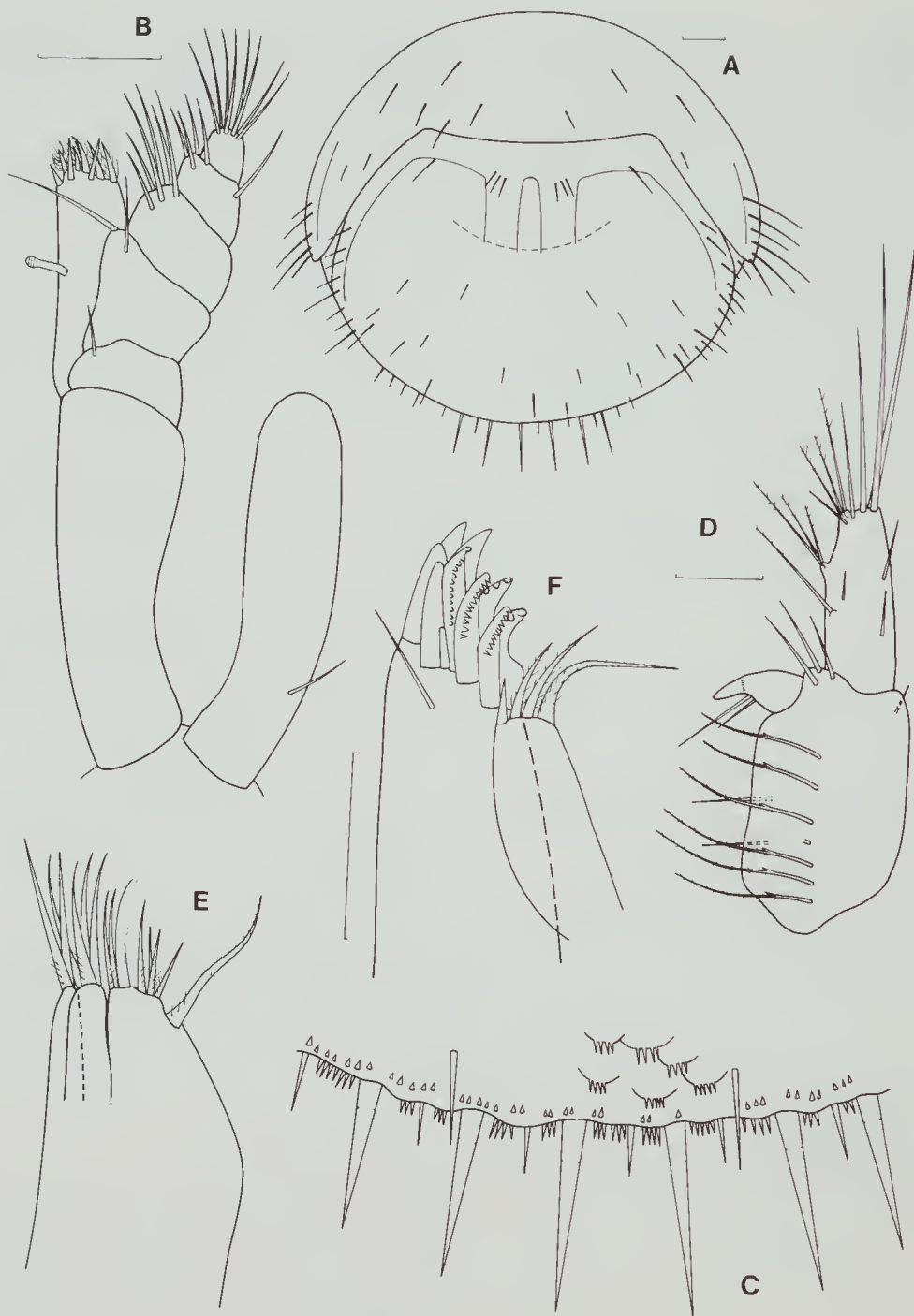


Figure 14. *Limnoria convexa* sp. nov. A-F, male, NMNZ Cr.6467, holotype: A, pleonite 5 and pleotelson, dorsal view; B, maxilliped; C, posterior margin of pleotelson, dorsal view; D, uropod, ventral view; E, maxilla 2; F, maxilla 1.



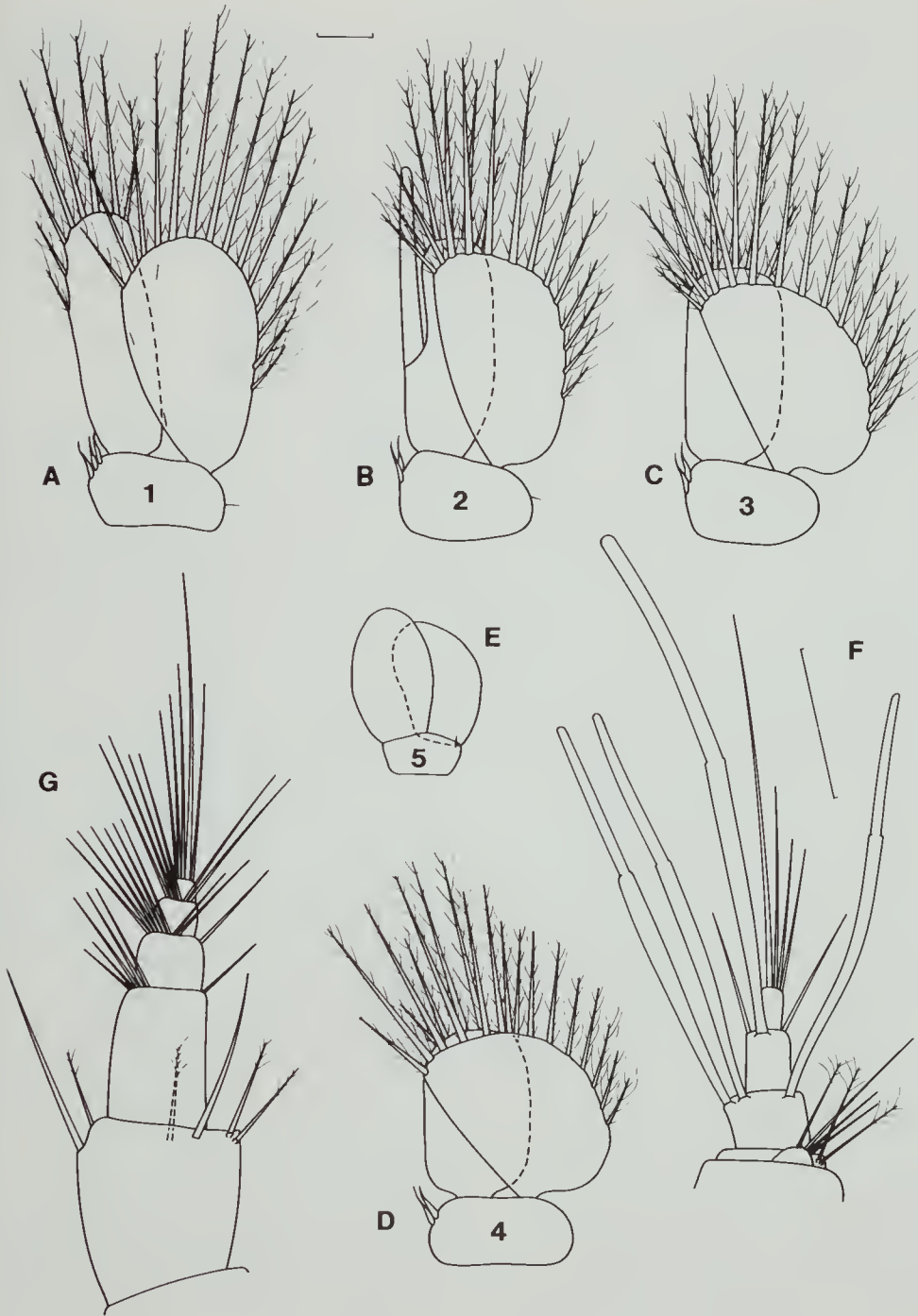


Figure 15. *Limnoria convexa* sp. nov. A-G, male, NMNZ Cr.6467, holotype: A-E, pleopods 1-5; F, flagellum of antenna 1; G, peduncle article 5 and flagellum of antenna 2.

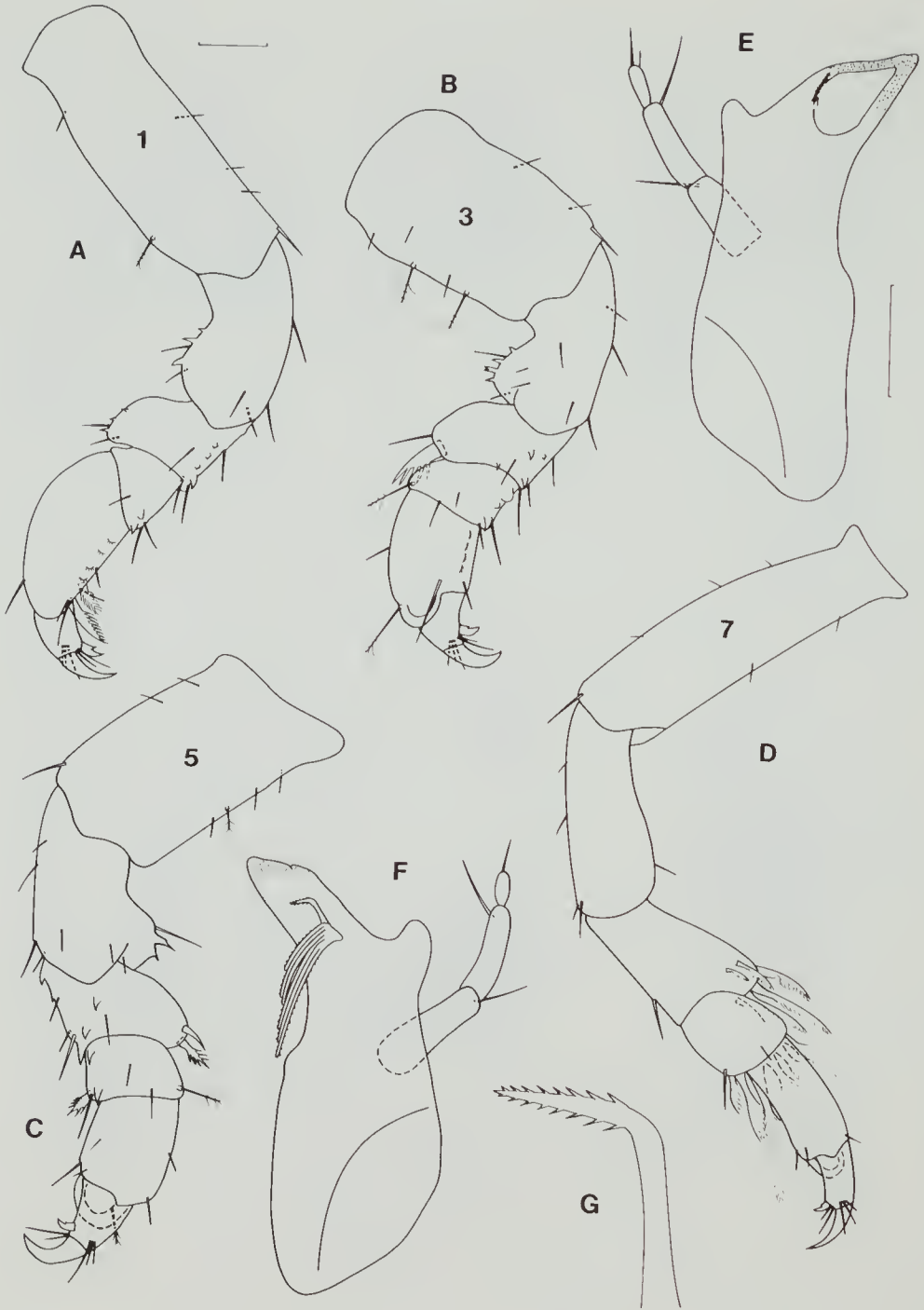


Figure 16. *Limnoria convexa* sp. nov. A-G, male, NMNZ Cr.6467, holotype: A-D, pereopods 1, 3, 5 and 7, lateral views; E, left mandible; F, right mandible; G, lacinia mobilis of right mandible.

two serrated setae; and a ventral comb seta is present on the carpus of pereopod 5.

Edgar (1987) suggested that floating seaweed would rarely be able to cross the Tasman Sea, as it would not maintain buoyancy or growth due to low dissolved nitrate levels in seawater. Therefore there would be little gene flow between The Snares and Tasmanian populations, allowing speciation of *L. nonsegnis* and *L. convexa*.

### *Limnoria echidna* sp. nov.

Figures 17, 18

*Material examined.* Holotype: Tas. Coles Bay, near boat ramp (42°7'S, 148°17'E), 1 m, red algae and invertebrates on vertical rock wall, airlift, R.S. Wilson, 21 Apr 1985 (stn TAS 17), NMV J14782 (male, 2.1 mm, 0.55 mm wide pleotelson, with 1 slide).

Paratype: Tas. Ninepin Point (43°17'S, 147°15'E), 1–2 m, washings from red, green, and some brown algae, some freshwater input to site apparent, G.C.B. Poore and H.M. Lew Ton, 20 Mar 1988 (stn TAS 69), NMV J15467 (male, 2.6 mm, with 1 slide).

*Diagnosis.* Pleonite 5 dorsomedially with X-shaped carina, anterior axes diverging laterally near pleonite margins. Pleotelson with 2 long parallel dorsomedial carinae, carinae with 2 pairs of tiny or large anterior and subanterior puncta; carinae followed laterally by pair of short less distinct or even absent carinae, and further pair of lateral carinae as long as medial pair. Pleonite 5 0.6 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with solitary scale spikes, anterior surface slightly pitted. Posterior margin of pleotelson without dorsal row of scale spikes or tubercles; posterior margin fringed with 4 stout setae between which are short-sheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 5–8 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisor of left mandible with rasp vestigial or absent. Lacinia mobilis of right mandible enlarged apically, fringed by row of small teeth. Epipod of maxilliped subtriangular, 3.1 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 6 and 7. Uropod peduncle with small lateral tubercles; epipod 0.9 times as long as peduncle.

Pleopod 2 with long plumose setae up to 1.1 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.7 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Body length up to 2.6 mm. Colour in alcohol pale yellow.

*Etymology.* Named after the Australian monotreme, the echidna, alluding to the covering of the body with spikes.

*Distribution.* Tasmania. 1–2 m depths.

*Substrate.* Possibly red algae.

*Remarks.* When the holotype was first examined it was white, and the small puncta on the pleotelson were not detected. The specimen has since become more transparent, possibly due to examinations in glycerine, and the tiny puncta became noticeable. On the paratype the puncta on the pleotelson are prominent, to the degree found in *L. quadripunctata*. Like the holotype, the paratype lacks a dorsal row of scale spikes on the posterior margin of the pleotelson. Although the dorsal surface of the pleotelson was generally covered by more scale spikes than the holotype, and although some of these scale spikes were near the hind perimeter of the pleotelson, they did not form a regular row. The left mandible on the holotype was slightly distorted after mounting and placement of the coverslip, which is why the incisor was drawn as being partially concealed. The paratype had no small teeth or vestigial rasp on the incisor of the left mandible.

*L. echidna* has a similar pleotelson ornamentation to *L. quadripunctata*, *L. agrostisa* and *L. rugosissima*. It seems most similar to *L. quadripunctata* as both species have four dorsomedial puncta on the pleotelson, and similar lacinia mobilis of the right mandible (also similar to the lacinia mobilis on *L. rarulima*).

*L. echidna* may be distinguished from *L. quadripunctata* by: longer carinae (especially the lateral carinae) on the pleotelson, slightly different carinae on pleonite 5, more tuberculate lateral margin on the uropod peduncle, greatly reduced or absent rasp, slightly larger right mandibular lacinia mobilis, more apically rounded maxillipedal epipod, absence of a dorsal row of scale spikes on the posterior margin of the pleotelson, and different ventral comb setal sequence on the pereopods.



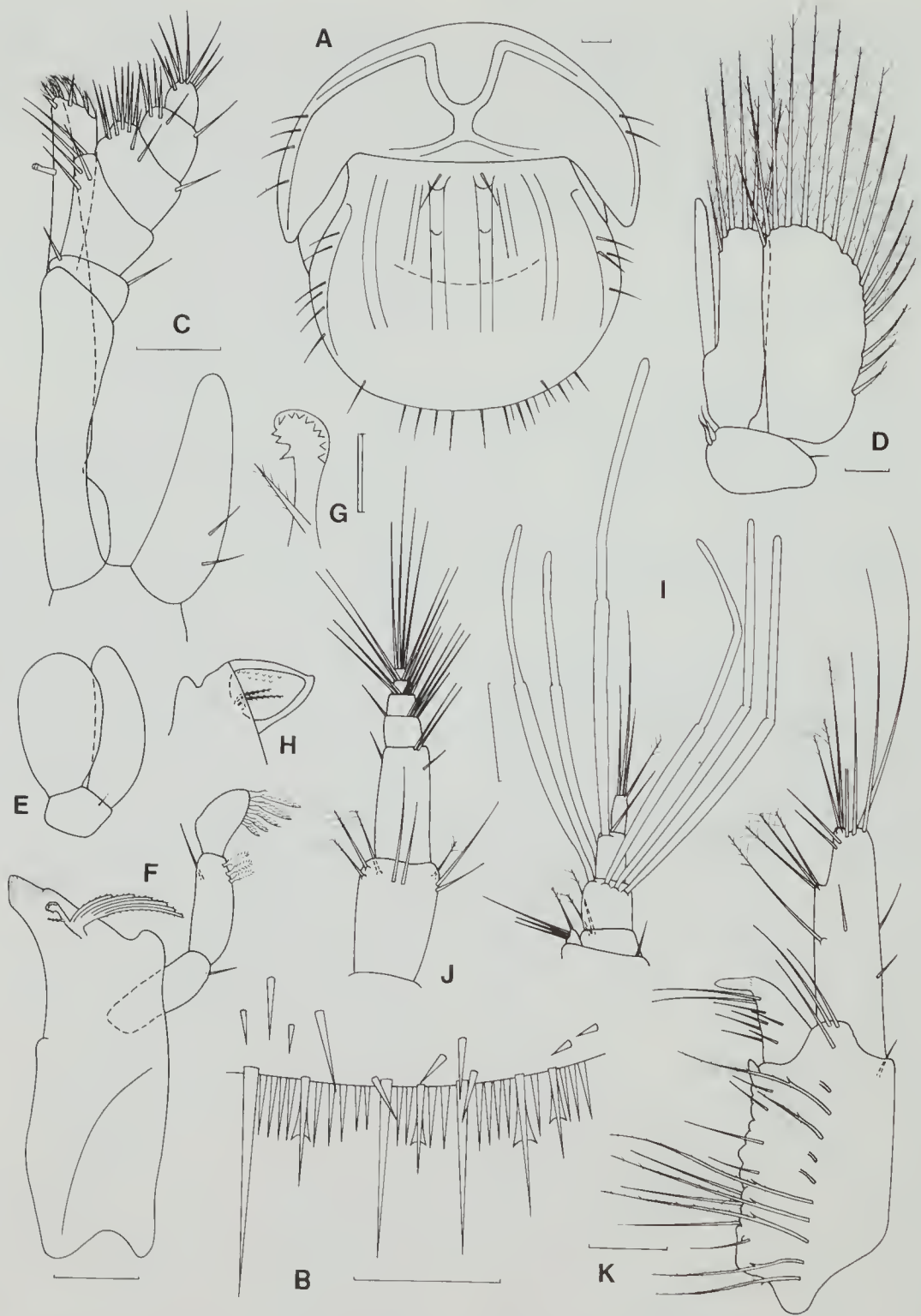


Figure 17. *Limnoria echidna* sp. nov. A–K, male, NMV J14782, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; D, pleopod 2; E, pleopod 5; F, right mandible; G, lacinia mobilis of right mandible; H, ineisor of left mandible; I, flagellum of antenna 1; J, peduncle of antenna 2; K, uropod, ventral view.

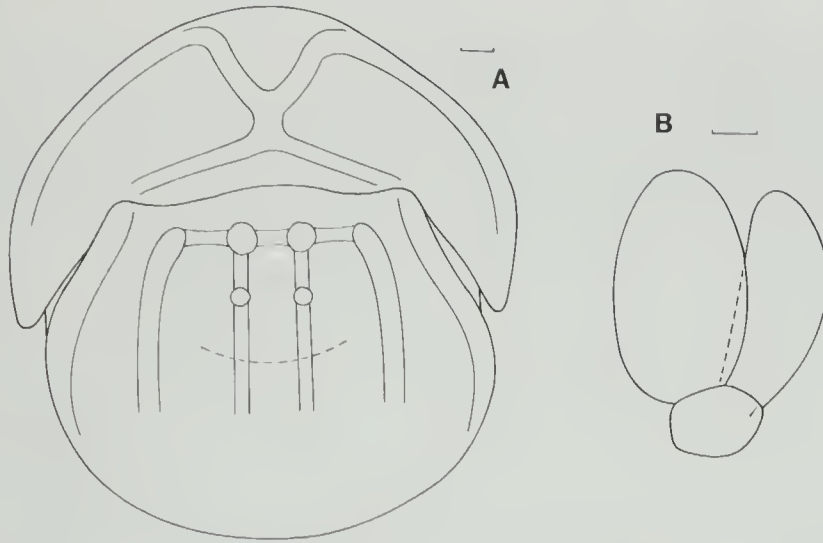


Figure 18. *Limnoria echidna* sp. nov. A, B, Male, NMV J15467, paratype: A, pleonite 5 and pleotelson, dorsal view, setae omitted; B, pleopod 5.

***Limnoria gibbera* sp. nov.**

Figure 19

*Material examined.* Holotype: WA, eastern end of Thistle Cove (34°0'S, 122°12'E), 7 m, red algae, SCUBA, G.C.B. Poore and H.M. Lew Ton, 11 Apr 1984 (stn SWA 27), NMV J15339 (male, 2.0 mm, 0.55 mm wide pleotelson, with 1 slide).

Paratypes: Type locality, NMV J15340 (non-ovig. female, 2.2 mm, with 1 slide). WA, NE end of Vancouver Peninsula (35°3.4'S, 117°56.2'E), 10 m, red algae, SCUBA, G.C.B. Poore and H.M. Lew Ton, 8 Apr 1984 (stn SWA 24), NMV J15341 (non-ovig. female, 1.9 mm).

SA, north side of West Island (35°37'S, 138°36'E), 5 m, sandy sediment, SCUBA, G.C.B. Poore and H.M. Lew Ton, 21 Mar 1985 (stn SA 46), NMV J15342 (male, 1.6 mm).

*Diagnosis.* Pleonite 5 dorsomedially lacking carinae and puncta, with many long setae. Pleotelson with broad raised dorsomedial area, with pair of lateral carinae. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson with scales bearing fine spikes posteriorly, spikes long on anterior scales. Posterior margin of pleotelson with dorsal row of scale spikes, lateral crests with tubercles each bearing dorsal row of scale spikes; posterior margin fringed with scale spikes and short-sheathed setae, lacking stout setae.

Antenna 1 with 4 flagellar articles; second article with about 4 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors lacking rasp and

file. Lacinia mobilis of right mandible with apical expansion with regular or irregular row of small teeth. Epipod of maxilliped almost strap-like, but broad at midlength, 2.7 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta absent on merus, present on carpus of pereopods 6 and 7. Uropod peduncle with few small proximolateral tubercles; endopod as long as peduncle.

Pleopod 2 with long plumose setae up to 0.9 times length of exopod. Appendix masculina reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, elongated, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Secondary unguis on all pereopods clearly bifid. Endopod of uropod with 2 small vestigial proximally bifurcate pappose setae similar to those found on peduncle. Lacinia mobilis of left mandible accompanied by only 1 long serrated seta. Body length up to 2.2 mm. Colour in alcohol red-brown due to colour of gut and surface debris; NMV J15342 specimen pale yellow.

*Etymology.* From the Latin for hump, *gibber*. Relates to the pleotelsonal shape.

*Distribution.* Southern Western Australia and South Australia. 5–10 m depths.

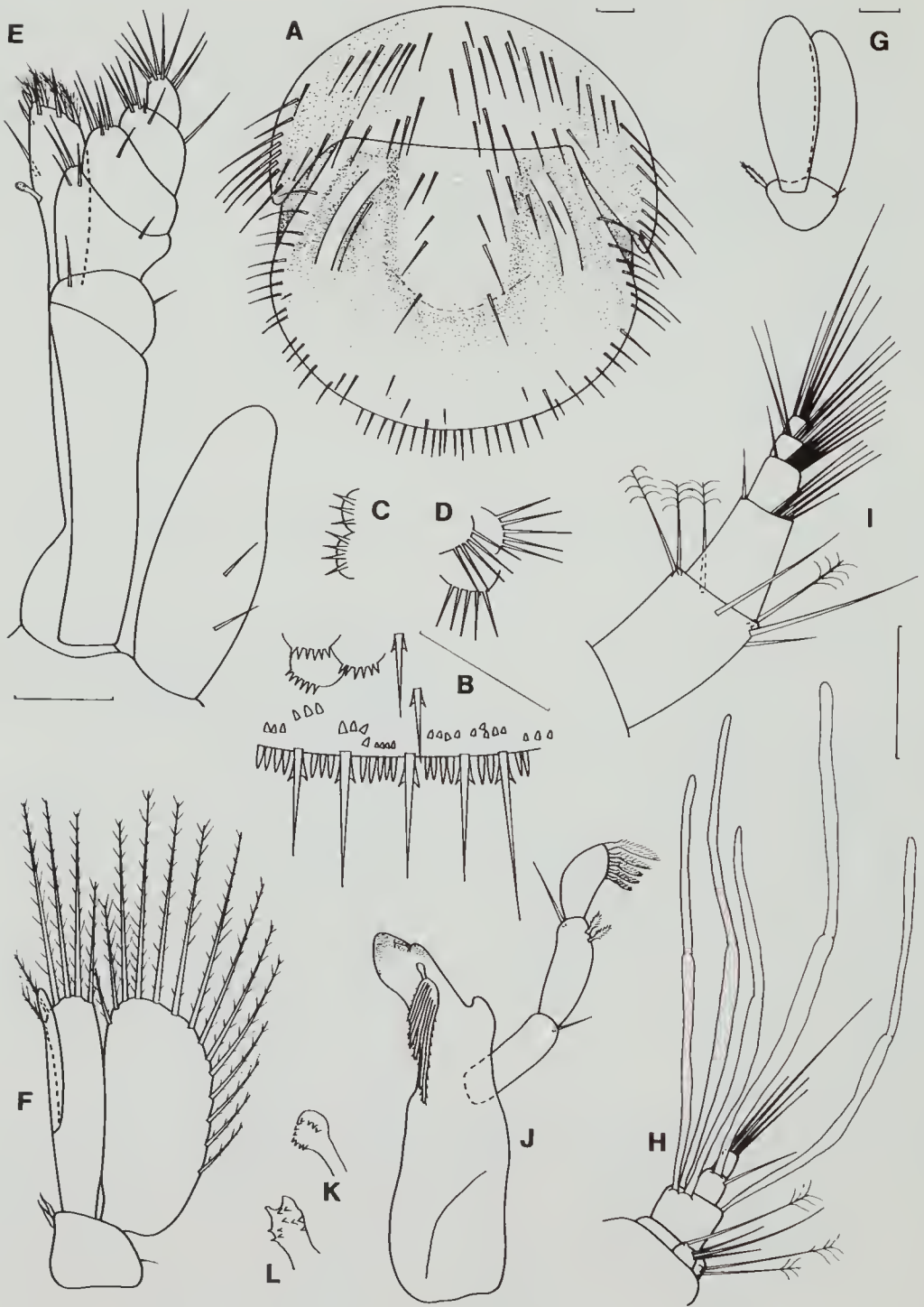


Figure 19. *Limnoria gibbera* sp. nov. A -G, J, L, male, NMV J15339, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, tubercles on lateral crests of pleotelson; D, dorsal structure of anterior region of pleotelson; E, maxilliped; F, plcopod 2; G, pleopod 5; H, flagellum of antenna 1; I, peduncle article 5 and flagellum of antenna 2; J, right mandible; K, lacinia mobilis of right mandible; L, lacinia and flagellum of antenna 2.



*Substrate.* Red algae.

*Remarks.* The peduncle on pleopod 5 in the holotype is broader than in the paratypes, and has what may be a vestigial coupling hook which also is not found in the paratypes.

The carinae on the pleotelson of *L. gibbera* have similarities to those found on *L. echidna*. The central humped area may have arisen from a merging of the area between two parallel medial carinae. The lacinia mobilis of the right mandible has similarities to that found on *L. echidna*, *L. rarulima* and *L. quadripunctata*.

*L. gibbera* may be most similar to *L. poorei*. Both species have been collected from red algae, have broad maxillipedal epipods (only slightly broad in *L. gibbera*), four flagellar articles on antenna 2, elongated rami on pleopod 5, similar pleopod 2 shapes, lack stout setae on the posterior margin of the pleotelson, and lack carinae on pleonite 5. *L. gibbera* does not have the reduction in the mandibular palp or modification of the secondary unguis found in *L. poorei* or the related species: *L. nuncapedis*, *L. bituberculata* and *L. segnoides*. *L. gibbera* appears to have evolved before the ancestor to the latter species.

### *Limnoria glaucinosa* sp. nov.

Figures 20–22

*Phycolimnoria* spp. Edgar, 1987: 599–610.

*Material examined.* Holotype: SA, "Hotspot" reef, 5 nautical miles W of north end of Flinders Island (33°40.5'S, 134°22'E), 17 m, assorted large brown, green and red algae, SCUBA, S.A. Shepherd, 19 Apr 1985 (stn SA 65), NMV J14974 (male, 3.9 mm, 1.05 mm wide pleotelson, with 1 slide).

Paratypes: Type locality, NMV J14975 (ovig. female, 4.0 mm, with 1 slide), NMV J14976 (male, 3.3 mm, non-ovig. female, 3.1 mm). Vic. Marengo, near Apollo Bay (38°46'S, 143°44'E), W.F. Seed, 28 Dec 1970, NMV J15376 (male, 5.6 mm, with 1 slide), NMV J15375 (65 males, 2.7–6.8 mm, 32 non-ovig. females, 3.3–7.5 mm, 15 ovig. females, 3.6–6.2 mm, 60 juvs., 1.9–3.3 mm).

Other material: SA, NE side of Topgallant Island (33°43'S, 134°36.6'E), 16 m, *Cystophora*, SCUBA, S.A. Shepherd and G.C.B. Poore, 21 Apr 1985 (stn SA 84), NMV J14977 (male); 7 m, *Acrocarpia aniculata* and red algae, 22 Apr 1985 (stn SA 83), NMV J14978 (male, intersex, non-ovig. female, juv.).

Vic. NE shore of Cape Wellington, Wilsons Promontory (39°3.5'S, 146°28.7'E), 0–15 m, various substrates, SCUBA, G. Smith and L. Rubelman, 2 Sep 1982 (stn WPNP 36), NMV J15368 (male, 4 juvs.). Southwestern Bass Strait (39°32.8'S, 144°16'E), 18 m, fine sand, epibenthic sled, G.C.B. Poore on FV

"Sarda", 1 Nov 1980 (stn BSS 107), NMV J15369 (non-ovig. female), 1 km E of Harmers Haven, 300 m offshore (38°34'S, 145°40'E), 6 m, algal turf on rocks, SCUBA, R. Wilson and C. Larsen, 6 Mar 1982 (stn CPA 15), NMV J12881 (2 juvs.); 500 m offshore, 11 m, algal turf on rocks, C. Larsen and G. Barber (stn CPA 14), NMV J12882 (2 males, non-ovig. female), Shack Bay, Venus Bay (38°40'S, 145°40'E), 12 m, rocky habitat, SCUBA, C. Larsen, G. Barber, M. MacDonald et al., 4 Mar 1982 (stn CPA 4), NMV J12889 (juv.). The Oaks, Bunurong Coast (38°40'S, 145°38'E), algae in LWM rock pools, G.C.B. Poore, 5 Mar 1982 (stn CPA 21), NMV J12891 (intersex). Apollo Bay, rock pools, W.F. Seed, 22 Dec 1970, NMV J13894 (4 males, 2 juvs.). Shoreham, Western Port Bay, W.F. Seed, 28 Feb 1959, NMV J13896 (2 males, 2 non-ovig. females, 2 juvs., blue-grey colour, now white).

Tas. Variety Bay (43°12'S, 147°24'E), 6.8 m, *Macrocystis* holdfast, G. Edgar, 1984, NMV J15370 (2 males, non-ovig. female, ovig. female).

*Diagnosis.* Pleonite 5 without sculpturing dorsomedially, slightly convex, not concave laterally. Pleotelson flat, not concave, semicircular as lateral margins begin to converge posteriorly from proximal end; with 4 small and short dorsomedial anterior carinae, 2 longitudinal and 2 oblique; with pair of oblique grooves. Pleonite 5 0.4 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with solitary scale spikes, without pits. Posterior margin of pleotelson with dorsal row of scale spikes; fringed with 4 large stout setae between which are many short-sheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 7 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors without rasp and file. Lacinia mobilis of right mandible long, with several blunt apical teeth. Epipod of maxilliped strap-like, 4.2 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 5 (sometimes), 6 and 7. Uropod peduncle with small tubercles on lateral margin; endopod 1.3 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.7 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.7 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Second article of mandibular palp with more than 1 simple seta. Lacinia

mobilis of left mandible without accompanying pair of serrated setae in spine row. Body length up to 7.5 mm. Colour in alcohol, blue-grey with irregular patches of pale yellow, on cephalon, pereonites 1–3 and 7, pleonites 1–5 and pleotelson; pereonites 4–6 mostly pale yellow. Blue-grey colour is closest to colour given in plate 30, square a6, by Maerz and Paul (1950).

*Etymology.* From the Greek for bluish-grey, *glauinos*.

*Distribution.* Victoria, Tasmania and South Australia. 0–18 m depths, and rock pools.

*Substrates.* *Macrocystis* holdfasts (Edgar, 1987), *Cystophora*, assorted red brown and green algae, algal turf, and *Acrocarpia aniculata* or red algae (present study).

*Remarks.* The range of substrates for this borer seems quite large, it bores into holdfasts of kelps, and may also live under or on algal turf in rock-pools. *L. glaucinosa* is the only brightly coloured limnoriid species known. It may be relevant that some *Macrocystis* haptera have a purple appearance due to an iron-tannin complex (Jones, 1971).

Many specimens had pleopods 1–4 pointing anteriorly. Possibly this was due to, or allowed, the presence of commensals, mainly ostracods, between pleopods 4 and 5.

The dissected specimen from Marengo had 14–15 aesthetascs on flagellar article 2 on antenna 1. Although there was only one simple seta on article 2 on the right mandibular palp of the holotype, there were two on the left mandible. Other specimens collected with the holotype also had the two simple setae on article 2 on both the left and right mandibular palps. Four paratypes examined from Marengo had a ventral comb seta on the carpus of pereopods 5, 6 and 7, as did a male paratype from near Flinders Island; however, the holotype and two other paratypes from near Flinders Island had the comb seta present on pereopods 6 and 7 only.

The shape of the maxillipedal epipod and presence of several simple setae on article 2 of the mandibular palp suggest a similarity of *L. glaucinosa* to *L. antarctica* and *L. stephensi*. However, the later two species have only four flagellar articles on antenna 2, and very short uropodal endopods. Both *L. torquisa* and *L. glaucinosa* have pappose setae on the uropodal endopod, but the two species have few other similarities.

*L. glaucinosa* may be most similar to *L. loricata* and *L. rugosissima* as all have five flagellar

articles on antenna 2, similar setal structure on the posterior margin of the pleotelson, similar pleopod 2 shapes, and similar ventral comb setal arrangement on the pereopods. The faint pleotelsonal earinae found on *L. glaucinosa* may be derived from well developed carinae similar to those found on *L. loricata* and *L. rugosissima*. Both the maxillipedal epipod, and the setal arrangement adjacent to the lacinia mobilis of the left mandible, are also similar to those found in *L. rugosissima*. The lacinia mobilis of the right mandible has some similarities to that found in *L. loricata*.

*L. glaucinosa* is most readily distinguished by its large patches of blue-grey colouration. Also useful are the setal arrangements on both the left and right mandibular palps, and the shapes of the pleotelson (perimeter outline) and lacinia mobilis of the right mandible.

### *Limnoria indica* Becker and Kampf

Figures 23–26

*Limnoria (Limnoria) indica* Becker and Kampf, 1958: 1–9, figs 2–4.—Becker and Kampf, 1959: 12–17, figs 2–4.—Ganapati and Rao, 1960: 275–276.—Pillai, 1961: 23, 25, pl. II figs 4–5, text-figs 11–12.—Rao and Ganapati, 1969: 226.—Kühne, 1975: 453.—Kühne, 1976: 546, figs 3–4.—Santhakumaran, 1976: 238.—Krishnan et al., 1980: 20.—Kensley and Schotte, 1987: 222, fig. 4.

*Limnoria indica*.—Jones et al., 1972: 105, 109–110.—Karande, 1978: 41, 43.—Nair, 1984: 208–209.—Barnaale et al., 1986: 10–11.—Cookson, 1987a: 1–14.—Cookson, 1987b: 85–89, figs 1–8.—Cookson and Barnaale, 1987b: 287–293.—Cookson et al., 1989: 1–8.—Kensley and Schotte, 1989: 194, fig. 86A–B.

*Limnoria simulata*.—McCoy-Hill, 1964: 46 (possible).—Müller, 1988: 397–403 (*L. indica* material only).

*Material examined.* Holotype: India, Mandapam Camp (9°18'N, 78°8'E), palm log in shallow water, G. Becker, 30 Oct 1956, Bundesanstalt für Materialprüfung, Berlin (male).

Allotype: Type locality, Bundesanstalt für Materialprüfung, Berlin (female).

Other material. Qld. Bowen, 1 m, untreated turpentine pile C20 heartwood, L.J. Cookson, 4 Jul 1985, NMV J15495 (male, 3.0 mm, 0.8 mm wide pleotelson, with 1 slide), NMV J15301 (male, 3.0 mm), NMV J15299 (intersex, 3.1 mm, with 1 slide), NMV J15298 (non-ovig. female, 2.9 mm, with 1 slide), NMV J15297 (35 males, 1.9–3.1 mm, 16 non-ovig. females, 2.0–2.8 mm, 18 ovig. females, 2.6–3.0 mm, 12 juvs., 1.5–2.1 mm); 0–4 m, turpentine heartwoods, NMV J15297 (51), NMV J14994 (23), NMV J15289 (94), NMV J15291 (240); 4 m, turpentine bark at mud-line, NMV

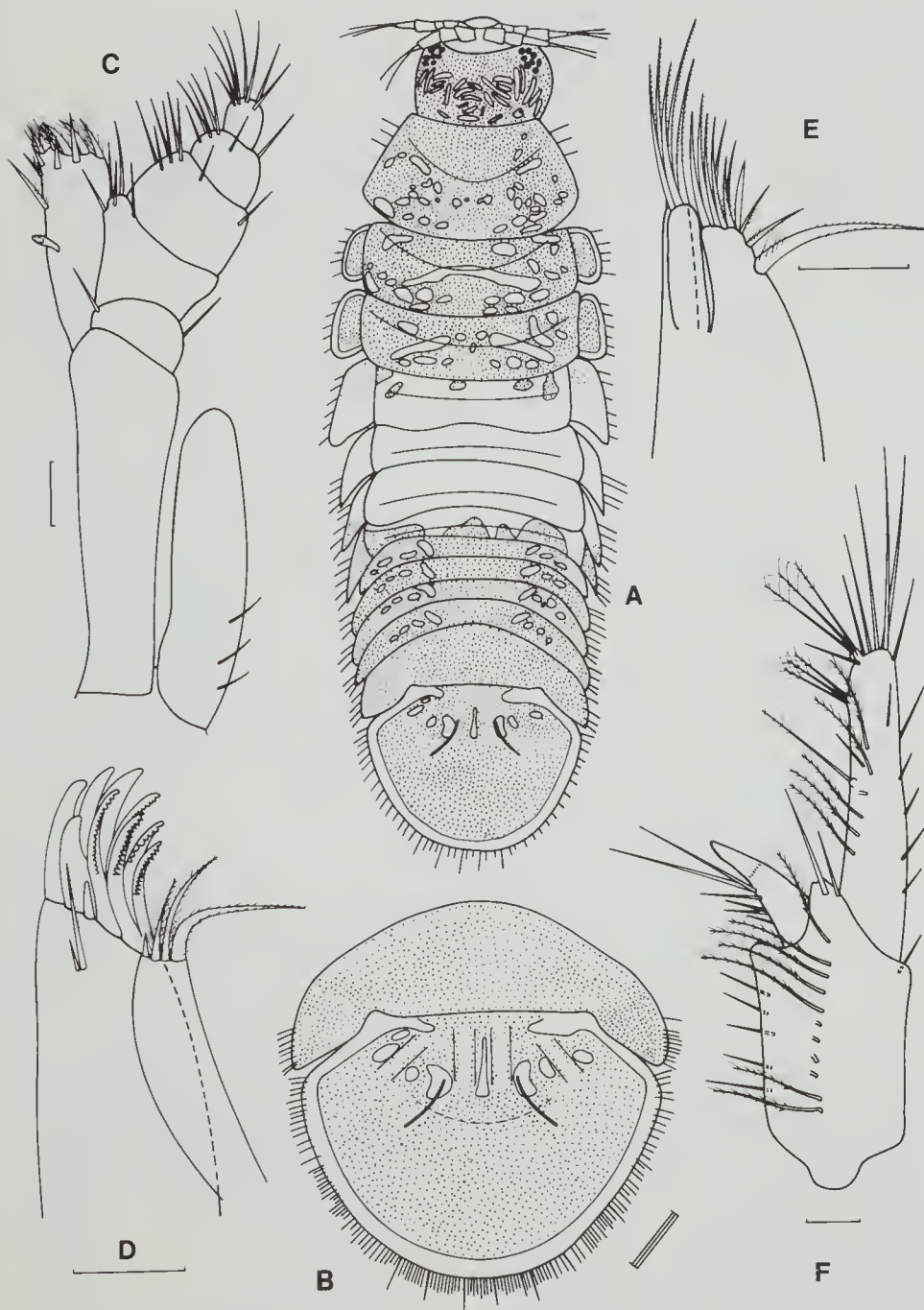


Figure 20. *Limnoria glaucinosa* sp. nov. A-F, male, NMV J14974, holotype: A, dorsal view; B, pleonite 5 and pleotelson, dorsal view; C, maxilliped; D, maxilla 1; E, maxilla 2; F, uropod, ventral view.



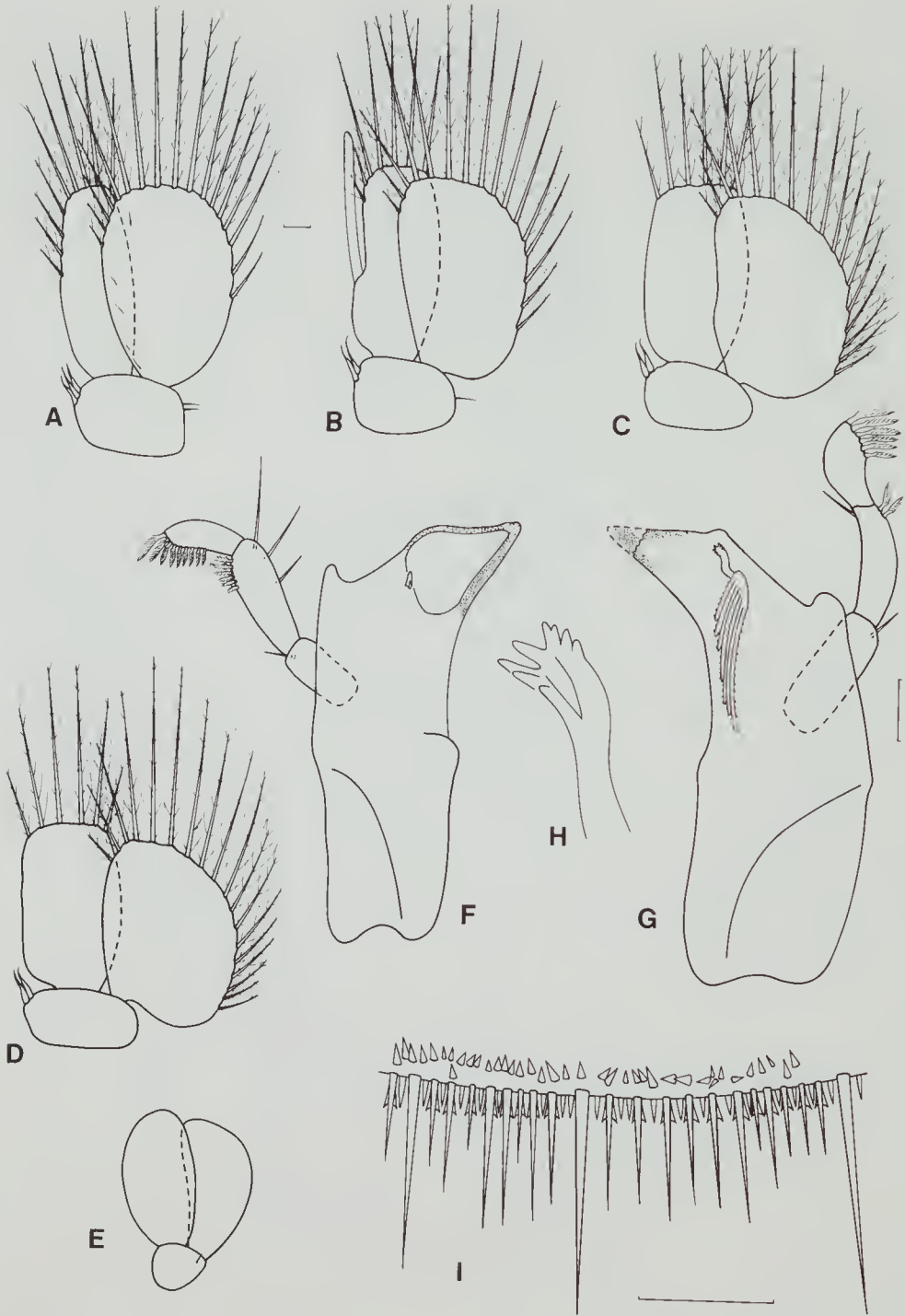


Figure 21. *Limnoria glaucinosa* sp. nov. A-E, G-I, male, NMV J14974, holotype: A-E, pleopods 1-5; G, right mandible; H, lacinia mobilis of right mandible; I, posterior margin of pleotelson. F, male, NMV J15376, left mandible.

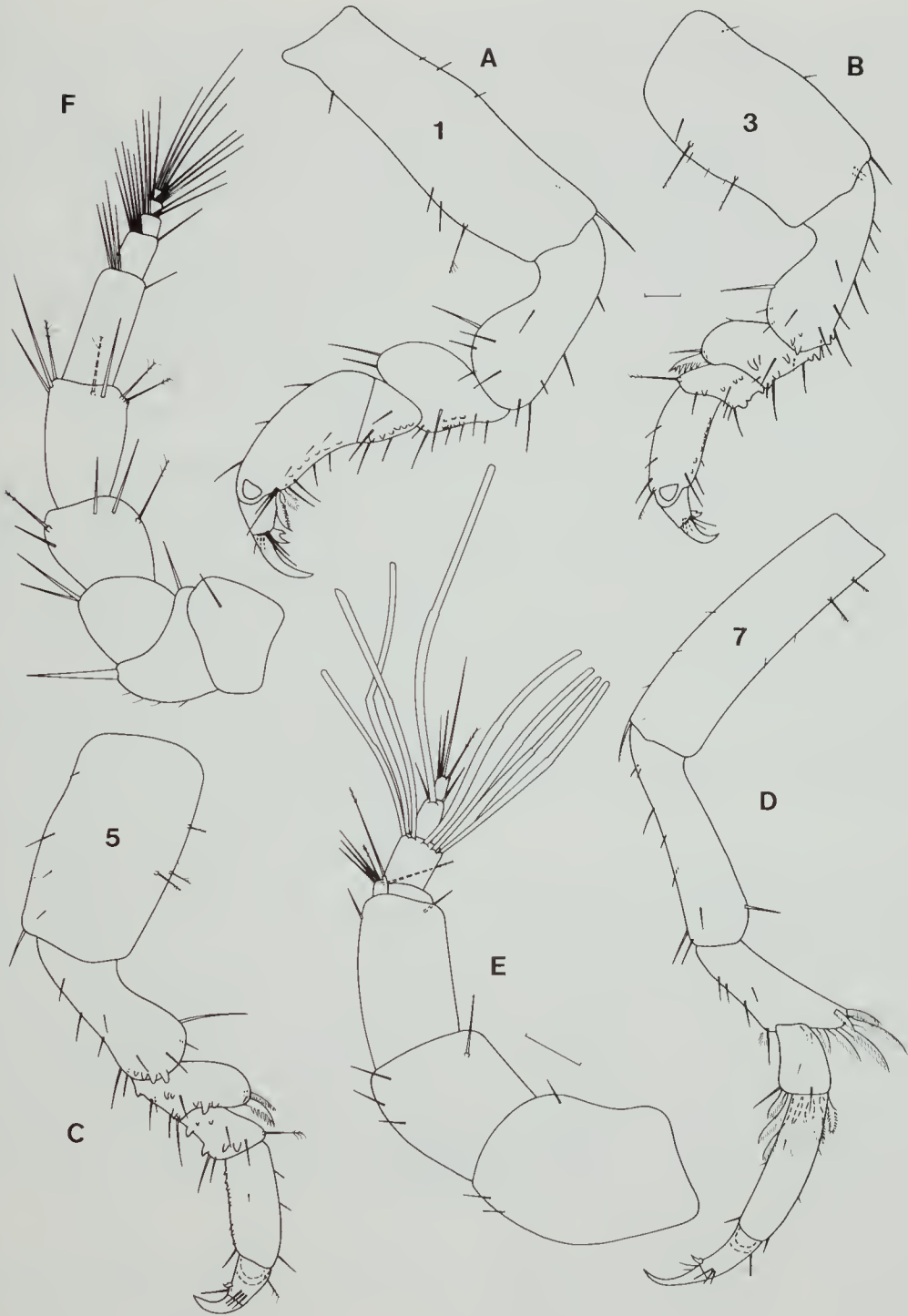


Figure 22. *Limnoria glaucinosa* sp. nov. A-F, male, NMV J14974, holotype: A-D, pereopods 1, 3, 5 and 7, lateral views; E, antenna 1; F, antenna 2.

J15288 (6); 0–3 m, sapwood of CCA-treated turpentine pile C18, NMV J15290 (85); 0.5 m, pine bait block no. 154 after 5.5 months, R.D. Turner, J.V. Marshall and J. Beesley, 29 Sep 1970, AM P37043 (1). Lady Musgrave Island, Capricorn-Bunker group, 3 m, *Melaleuca* block from shipwreck, L.J. Cookson and P. Gestner, 25 May 1986, NMV J15231 (3). Mackay, 1 m, *P. radiata* bait block after 4 months, L.J. Cookson, 21 Apr 1987, NMV J15208 (11). Townsville, Port, 4 m, dry turpentine pile heartwood on jetty, L.J. Cookson, 17 Dec 1987, NMV J15207 (8); berth 8, 0.3 m, *P. radiata* bait blocks after 8 months, L.J. Cookson, 21 Sep 1988, NMV J15455 (3). Cairns, 1 m, arsenical creosoted *Eucalyptus pilularis* Sm. stake 1685, J.E. Barnacle, 19 May 1986, NMV J14982 (1); 2 m, sapwood of double-treated *E. maculata* Hook stake 8544, L.J. Cookson, 16 Dec 1987, NMV J15204 (4); sapwood of arsenical creosoted *E. maculata* stake 1981, NMV J15205 (1); sapwood-heartwood boundary of double-treated *E. pilularis* stake 8542, NMV J15206 (18). Green Island, 10 m from jetty, 2 m, hardwood plank on sand, L.J. Cookson, 19 Sep 1988, NMV J15454 (76). Port Douglas, 0.5–1 m, untreated turpentine pile 6, J.E. Barnacle, 29 May 1984, NMV J15235 (71); 0 m, 19 May 1986, NMV J14979 (3); 4 m, sapwood at mud-line of turpentine pile 6, L.J. Cookson, 15 Dec 1987, NMV J15212 (33); 1.5 m, sapwood and heartwood of turpentine pile 5, NMV J15213 (68); 2 m, sapwood and heartwood of CCA-treated turpentine pile 1, 16 Dec 1987, NMV J15214 (41); 3.5 m, NMV J15215 (26).

PNG. Lorengau, Admiralty Islands, S.M. Rayner, 10 Oct 1970, NMV J15491 (male, 3.1 mm, with 1 slide), NMV J15490 (4 males, 1.9–2.8 mm, 2 non-ovig. females, 2.1–2.4 mm).

*Diagnosis* (male). Pleonite 5 dorsomedially with 2 subparallel longitudinal carinae which converge slightly posteriorly. Pleotelson with 2 pairs of anteromedial puncta, one pair directly behind other, without carinae behind posterior pair of puncta, with another anterolateral pair of puncta or long setae. Pleonite 5 0.6 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with many solitary scale spikes, slightly pitted anteriorly. Dorsal row of tubercles extend from lateral crests to posterior margin of pleotelson; posterior margin fringed with 4 large stout setae between which are scale spikes and short-sheathed setae.

Antenna 1 with 4 flagellar articles; second article with about 13 aesthetases arising from 2 tufts. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles, article 3 elongated apically, with large terminal comb seta anterior to row of other comb setae. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible straight, apex with several compact or separate teeth. Epipod of maxilliped

triangular, 3.5 times as long as wide, not reaching palp articulation; epipod with true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta present on merus of pereopod 7 and carpus of pereopods 2, 3, 4, 5, 6 and 7. Uropod peduncle laterally with many short simple setae, few on small tubercles; with small tubercles between plumose setae; endopod 0.8 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.6 times length of exopod. Appendix masculina reaching or nearly reaching apex of endopod of pleopod 2, articulating just proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, broadly oval, 0.7 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* With sexual dimorphism of pleotelson sculpturing; female with pair of anteromedial puncta followed posteriorly by long carinae, pleotelson without other puncta, posterior margin of ventral pleopodal cavity more posterior than in males. Body length up to 3.3 mm. Colour in alcohol pale yellow.

*Full description of male* (NMV J15495). Body 3.8 times as long as wide; pale yellow colour. Cephalon oval, partly covered dorsoposteriorly by pereonite 1; without dorsal occipital groove. Pereonites 2–7 and pleonites 1–4 all similar width, pleonite 5 and pleotelson slightly narrower. Pereonite 1 2.4 times as long as other pereonites, coxal plates fused, centrally slightly depressed transversely. Pereonites 2–5 anteriorly slightly depressed transversely, longer than pereonites 6 and 7. Pereonites 2–7 coxal plates all overlap bases of pereopods; coxa 2 rectangular, not overlapping coxa 3; coxa 3 rectangular but more rounded posteriorly and just overlapping coxa 4; remaining coxae increasingly pointed distoposteriorly, overlapping following coxae posteriorly; coxae 5–7 with row of small tubercles. Pleonites 1–4 similar in length; pleonite 1 shorter ventrolaterally than other segments. Pleonites 5 about 7 times as long as other pleonites, pleotelson 1.7 times as long as pleonite 5.

Pleonite 5 and pleotelson with lateral crests. Pleonite 5 with pair of longitudinal subparallel dorsomedial carinae, reaching from anterior to posterior margins, converging slightly posteriorly; dorsal surface between carinae and lateral crests slightly concave. Pleotelson with 2 pairs of proximal puncta dorsomedially, one pair directly behind other, with long seta near base of each anterior puncta; with another pair of long



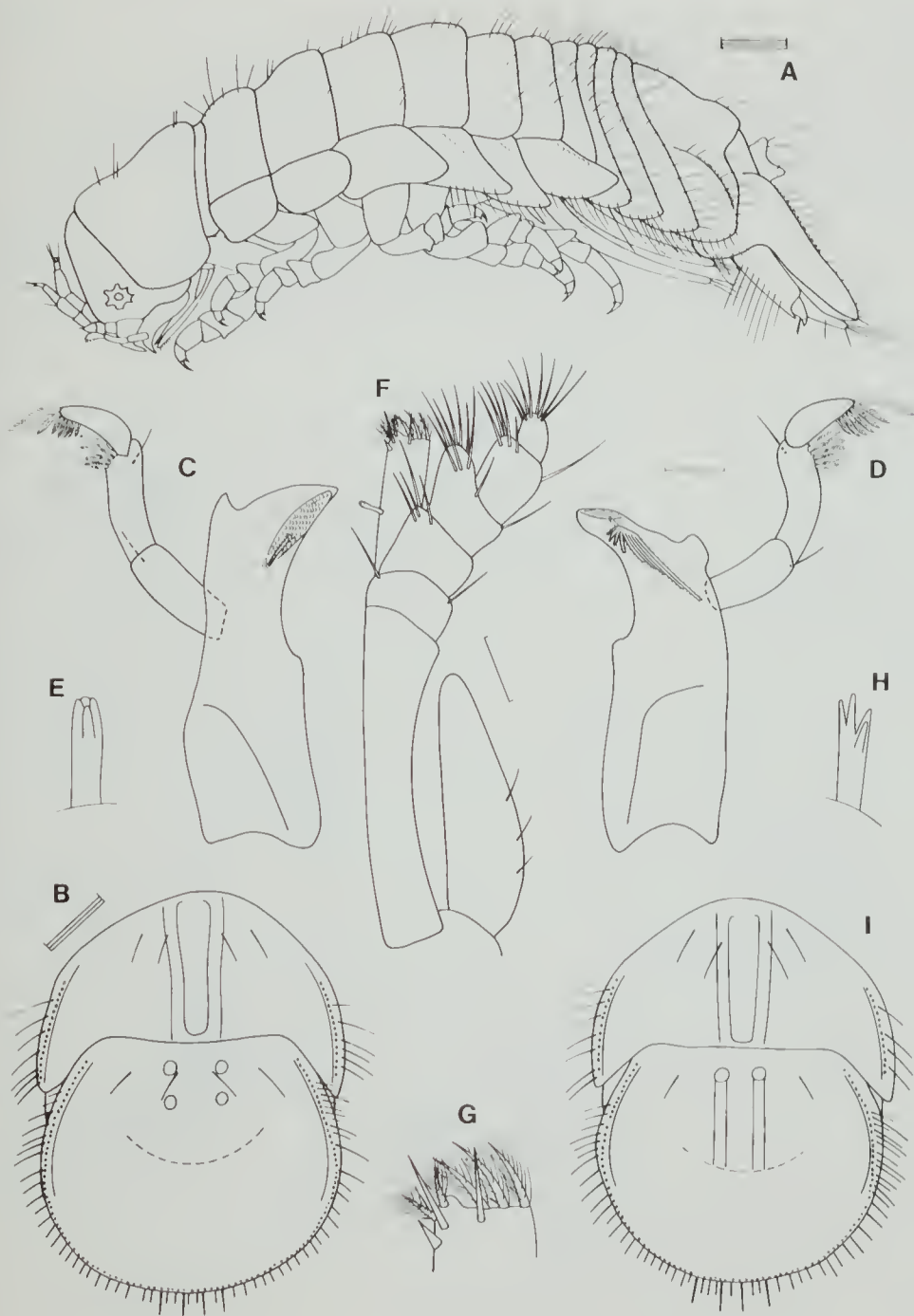


Figure 23. *Limnoria indica* Becker and Kampf. A-G, male, NMV J15495: A, lateral view; B, pleonite 5 and pleotelson, dorsal view; C, left mandible; D, right mandible; E, lacinia mobilis of right mandible; F, maxilliped; G, distal portion of maxillipedal endite. H, male, NMV J15299, lacinia mobilis of right mandible. I, female, NMV J15300, pleonite 5 and pleotelson, dorsal view.

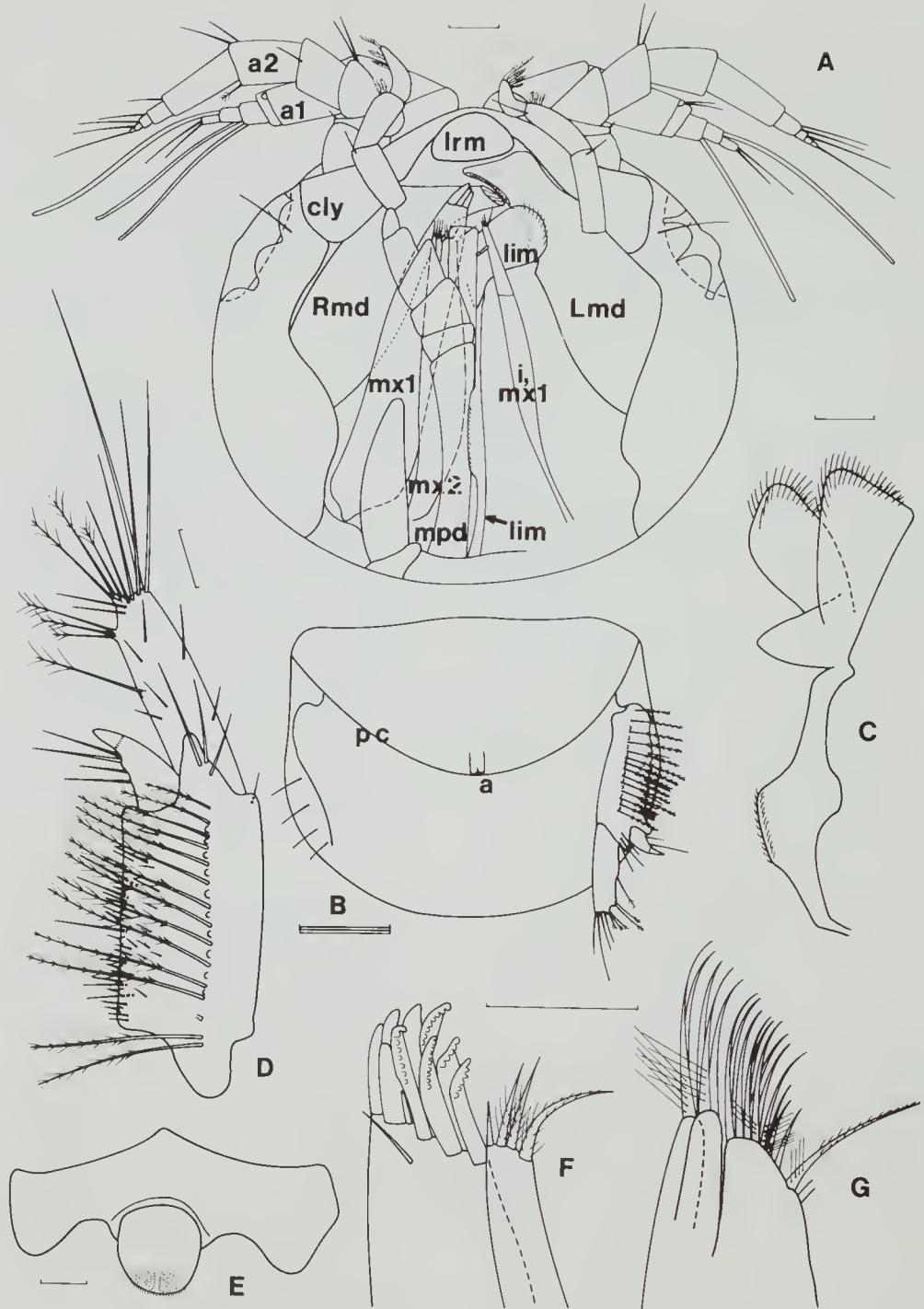


Figure 24. *Limnoria indica* Becker and Kampf. A, male, NMV J15301, cephalon, ventral view: a1 = antenna 1; a2 = antenna 2; lrm = labrum; cly = clypeus; Rmd = right mandible; Lmd = left mandible; lim = labium; mx1 = maxilla 1; i, mx1 = inner lobe and muscle of maxilla 1; mx2 = maxilla 2; mpd = maxilliped. B, male, NMV J15299, NMV J15495: D, uropod, ventral view; E, clypeus and labrum, anterior view; F, maxilla 1; G, maxilla 2.

setae (position of lateral puncta in some specimens) lateral to anterior puncta. Area between medial puncta and lateral crests concave. Posterior margin of ventral pleopodal cavity extends to midlength of pleotelson.

Dorsal surface of pleotelson without scale structure, scales fused, with slight pitting anteriorly, surface covered with solitary scale spikes, abundant on lateral crests and bases of puncta. Pleotelson with row of tubercles extending from lateral crests to posterior margin. Posterior margin of pleotelson with 4 stout setae between which are 2–3 short-sheathed setae and many scale spikes.

Antennae similar length. Peduncle article 2 on antenna 1 with several distal simple setae and brush setae; both small scale and article 1 of flagellum inserted into peduncle; scale small, with 3 simple setae and 1 brush seta apically. Flagellum of antenna 1 with 4 articles; article 1 short, with 2 brush setae ventral and opposite to scale; article 2 with 2 groups of aesthetascs totaling 13 aesthetascs; article 3 narrow, with 1 long aesthetasc and 2 simple setae; article 4 small, with 3 simple setae and 1 brush seta apically. Peduncle article 2 on antenna 2 with large stout seta directed anteriorly and smaller seta opposite; article 3 with 2 inner simple setae directed anteriorly; articles 4 and 5 with simple and brush setae. Flagellum of antenna 2 with 5 articles; article 1 of flagellum and article 5 of peduncle similar in length; articles 2–5 of flagellum each with 4–6 long simple setae.

Clypeus expanded laterally; labrum circular plate articulating ventromesially with clypeus. Labium bilobed anteriorly, posteriorly with single plate positioned between inner lobes of maxilla 1, larger more posterior plate positioned to partly protrude between bases of maxillipedal endopods.

Left mandible with rasp, right mandible with file incisor surfaces. Left mandible with short pointed distolateral projection; with small lacinia mobilis flanked by 2 longer serrated setae in spine row. Palp with 3 articles, articles 1 and 2 similar length, with outer distal simple seta, article 2 with 4 distolateral comb setae; article 3 shorter than articles 1 and 2, narrowed apically, with about 7 distolateral comb setae, of which largest at apex is anterior (outer) to row of 6 comb setae. Right mandible with lacinia mobilis bearing 4 apical teeth closed together; spine row with 9 serrated setae; mandible with squarish distolateral projection; palp similar to palp of left mandible.

Inner lobe of maxilla 1 with long curved mesial pappose seta, 2 straighter pappose setae

and shorter non-pappose seta; outer lobe with 5 outer smooth spines, with one only 0.4 times length of others; outer lobe also with 5 inner serrated spines. Inner lobe of maxilla 2 large, with about 13 setae, medial seta largest; medial lobe with 3 and outer lobe with 2 distal setae.

Articles 2–4 of maxillipedal palp with 4–7 distomesial setae, article 5 with 8 apical setae; endite with 8 distal setae of 4 different types: 3 apicolateral curved pappose setae, 2 straighter apicomедial pappose setae with many setules, 1 medial short stout simple seta subapically, and 2 subapical simple setae; epipod triangular, 3.5 times as long as wide, not reaching palp articulation, with 2–3 short lateral simple setae.

Pereopod 4 overlaps pereopods 3 and 5 basally; pereopod 4 smallest, pereopods increasing length from pereopods 4–1 and 4–7; pereopod 1 about 1.5 times as long, and pereopod 7 about 2.9 times as long, as pereopod 4. Dactylus of pereopod 1 with claw-like primary unguis and shorter bifid secondary unguis; lacking comb setae on merus and carpus. Pereopods 2–7 without comb setae on propodus; pereopods 2 and 3 with 1 comb seta dorsally on merus and ventrally on carpus; pereopods 4 and 5 with 2 comb setae dorsally on merus and 1 ventrally on carpus; merus of pereopods 6 and 7 increasingly enlarged dorsally, with 4 comb setae dorsally on pereopod 6 and 8 on pereopod 7, both pereopods with ventral comb seta; carpus of pereopod 6 with 4 inner comb setae of various length, more dorsal comb with comb teeth broader than other combs; carpus of pereopod 7 with 6 inner comb setae of various length, more dorsal combs with comb teeth increasingly broad. Secondary unguis of pereopods 2–6 undivided, slightly bifid on pereopod 7.

Endopods of pleopods 1–4 anterior to exopods, reversed for pleopod 5. Pleopods 1–4 with plumose setae up to 0.6 times length of rami; exopods increasingly lobate lateroproximally; endopods longer, from point of articulation, than exopods. Peduncles without inner lobes, coupling hook sequence 32220. Pleopod 1 with several thin true setae on exopod. Appendix masculina slightly medially curved, articulating just proximal to midlength of endopod, nearly reaching apex of endopod. Pleopod 5 without plumose setae, endopod shorter than exopod, 0.7 times as long as endopod of pleopod 2; endopod oval; peduncle small, with simple seta laterally.

Uropod tubular, not flattened or compressed, covered dorsally by pleotelson, inserted laterally just anterior to midlength of pleotelson. Exopod inserted laterally to endopod, points of articulation



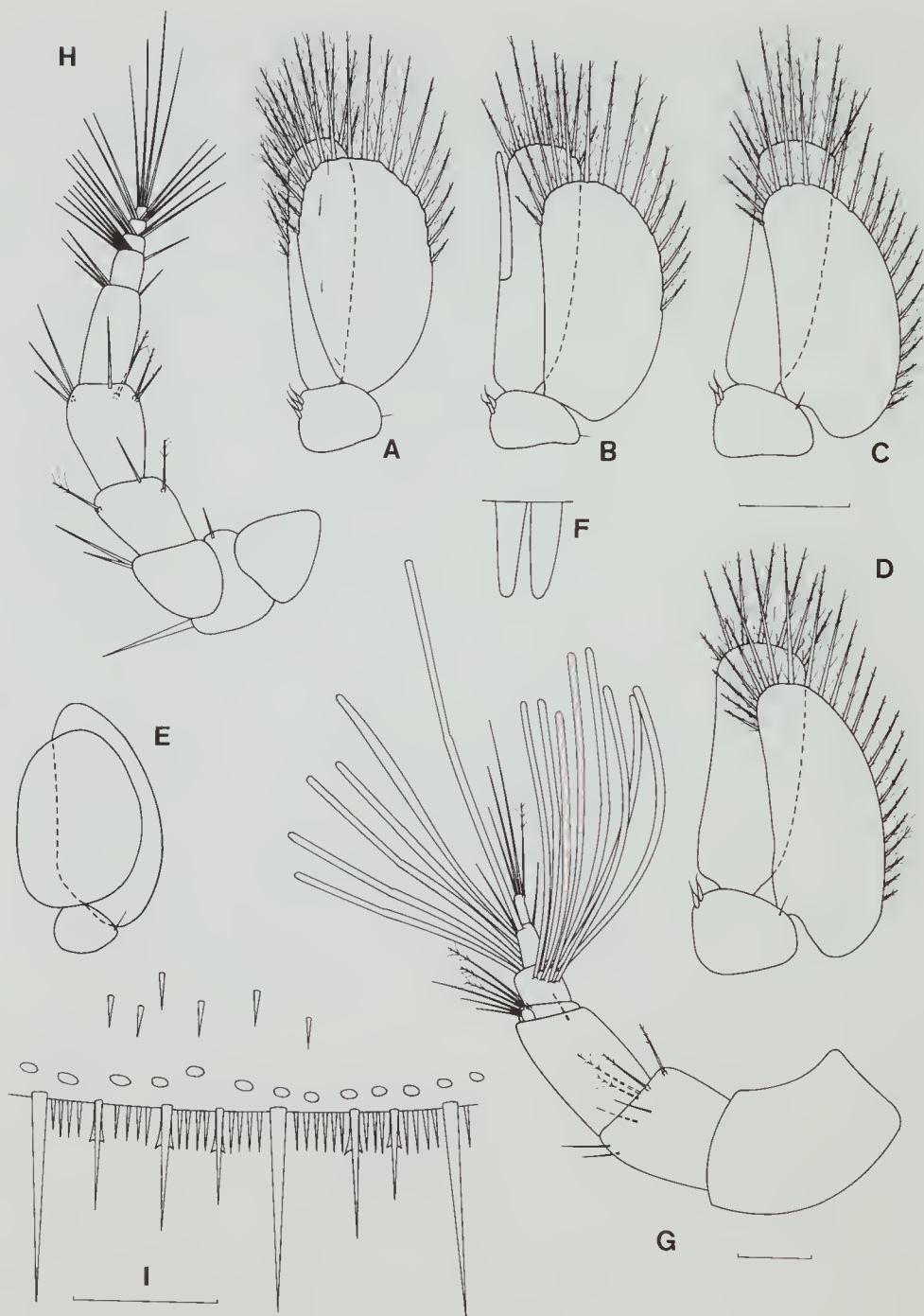


Figure 25. *Limnoria indica* Becker and Kampf. A-F, I, male, NMV J15495: A-E, pleopods 1-5; F, penes; I, posterior margin of pleotelson, dorsal view. G, H, female, NMV J15300: G, antenna 1; H, antenna 2.

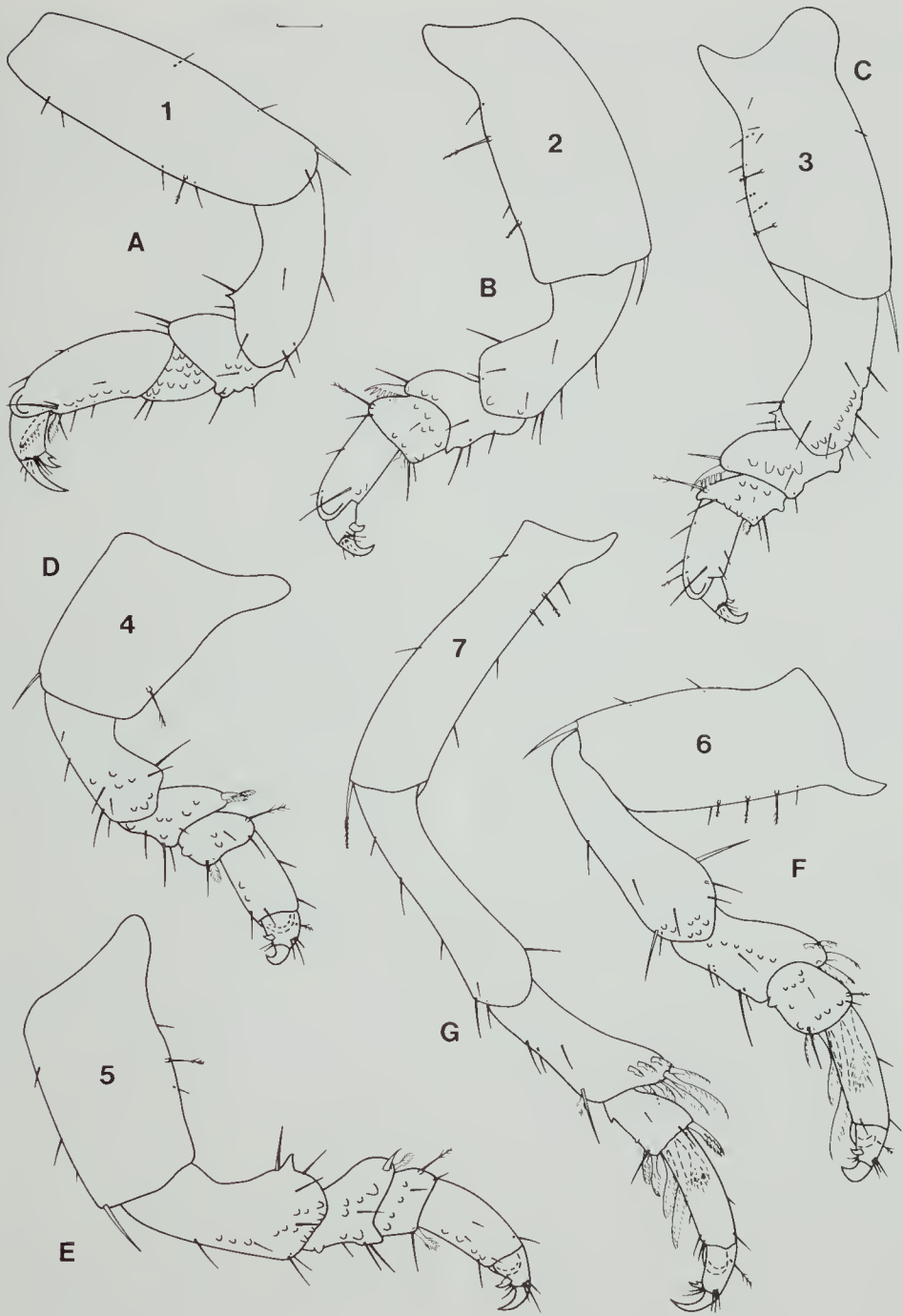


Figure 26. *Limnoria indica* Beeker and Kampf. A-G, male, NMV J15495, pereopods 1-7, lateral views.

lation at similar level on peduncle; endopod 0.6 times as long as peduncle, exopod 0.3 times as long as peduncle. Exopod with laterally curved apical claw, with 4 lateral simple setae. Endopod apically truncate, without claw, with row of 6 ventral simple setae and long dorsal simple seta; endopod with 3 groups of brush setae. Peduncle with mesial projection between rami, projection with 3 simple setae; peduncle with ventral row of about 15 proximally bifurcate pappose setae, with small tubercles between pappose setae; with many short lateral simple setae, some raised on small tubercles.

*Distribution.* Mandapam Camp, India (type locality) (Becker and Kampf, 1958); Andaman Islands (Ganapati and Rao, 1960); Hong Kong; Manila, Philippines (Kühne, 1976); Koniya, Japan (Kühne, 1975); Penang, Malaysia (Jones et al., 1972); Belize (Kensley and Schotte, 1987); Admiralty Islands; Queensland; 0–4 m depths (current study).

*Substrates.* Red mangrove roots (Kensley and Schotte, 1987); various untreated timbers, especially turpentine (*Syncarpia glomulifera* (Sm.) Niedenzu) (Cookson and Barnacle, 1987b); and preservative-treated timbers (current study).

*Remarks.* The sculpturing on the male pleotelson is variable. In most males examined, the lateral pair of puncta are either small, or absent and represented by only a long simple seta. Also, in most males, and the holotype, the posterior pair of puncta are directly behind the anterior pair. However, some specimens do have one or both hind puncta slightly more lateral than the anterior pair of puncta, although not to the degree shown by Becker and Kampf (1958). Juveniles have the same pleotelsonal sculpture found in females. Some small males also have the pleotelsonal carinae and puncta found in females, but with an extra pair of small more posterior puncta on the carinae. In fully developed males the two medial pair of puncta are larger and the posterior carinae lost.

Pillai (1961) drew pereopods 1–7 of a specimen of *L. indica* from India. The ventral comb setal sequence drawn matches the sequence found in Australian specimens. Pillai did not find a dorsal row of tubercles on the posterior margin of the pleotelson in a male specimen he examined, although it was present in a female specimen. This row of tubercles was present in ten males and ten females examined from the Australian material.

*L. indica* appears to be similar to *L. simulata* and most similar to *L. saseboensis*. Both *L.*

*indica* and *L. saseboensis* have similarly shaped carinae on pleonite 5, a maxillipedal epipod which tapers apically, five flagellar articles on antenna 2, aesthetascs which arise from two tufts on antenna 1, similar pleopod 2 shapes, rounded endopods on pleopod 5, similar setal and tuberculate structure on the posterior margin of the pleotelson, and similar ventral comb setal sequence on the pereopods. The species differ in that *L. saseboensis*: has prominent pits on pleonite 5 which are bordered by fine carinae, lacks a tapered third article on the mandibular palp, has a much rounder endopod on pleopod 5, and lacks sexual dimorphism in the sculpturing on the pleotelson in that both sexes have equally long dorsomedial carinae. The sculpturing on the pleotelson of the female *L. indica* specimen is closer to *L. saseboensis* than the male; however, *L. indica* lacks the short lateral carinae found on the pleotelson of *L. saseboensis*.

Müller (1988) suggested that *L. indica* was a junior synonym of *L. simulata*, based on the observation that the sexual dimorphism found in *L. indica* also occurs in the types of *L. simulata* and in *L. simulata* collected from the seagrass *Thalassia testudinum* in Colombia. However, three specimens of *L. simulata* (identified originally by Menzies) collected from the leaves of *Thalassia* at Tarpon Springs, Florida (USNM 103005) and both Menzies' (1957) and Müller's (1988) drawings show several differences. Unlike *L. indica*, *L. simulata*: lacks a dorsal row of tubercles on the posterior margin of the pleotelson (although sometimes present on the lateral crests); lacks the covering of solitary scale spikes on a fused dorsal surface of the pleotelson, but has groups of smaller scale spikes on partially fused scales; has much weaker or even absent longitudinal carinae on pleonite 5; does not always have the posterior pair of dorsomedial puncta on the pleotelson (the presence of the lateral pair of puncta is variable in both species); has longer and more numerous setae dorsomedially on pleonite 5; does not have the aesthetascs on flagellar article 2 of antenna 1 arising from two separate tufts; has the right mandibular rasp confined to the distal half of the incisor; has much longer plumose setae on pleopod 2 (up to 0.9 times as long as exopod); and has the appendix masculina extending beyond the endopod tip. Also, the substrate is seagrass not wood. In the Limnoriidae such variability in habitat is uncommon, although *L. quadripunctata* occurs both in wood and occasionally among algae under rocks.

Unlike the type specimens of *L. simulata* described by Menzies (1957), both the Colombia



(Müller, 1988) and Florida specimens had five not four flagellar articles on antenna 2. The Florida male specimen only had a pair of anterior dorsomedial puncta on the pleotelson. Another species which appears to sometimes have a sexual dimorphism similar to *L. indica* is *L. saseboensis* (unpublished). I have yet to examine the types of *L. simulata*, but would caution against synonymy with *L. indica*.

### *Limnoria insulae* Menzies

Figures 27, 28, Plates 2a, b

*Limnoria (Limnoria) insulae* Menzies, 1957: 178–180, fig. 35.—Menzies, 1959: 19.—Ganapati and Rao, 1960: 275–276.—Rao and Ganapati, 1969: 226.

*Limnoria insulae*.—McCoy-Hill, 1964: 46.—Nair, 1984: 208.—Cookson, 1987a: 3, 7.—Cookson et al., 1989: 1–8.—Kensley and Schotte, 1989: 195, fig. 86C.

*Material examined*. Qld. Magnetic Island, Arcadia, low tide, turpentine pile stump, J.E. Barnacle and L.J. Cookson, 12 Jul 1985, NMV J15222 (male, 2.7 mm, 0.65 mm wide pleotelson, with 1 slide), NMV J15223 (male, 2.7 mm, with 1 slide), NMV J15224 (male, 2.7 mm, with 1 slide), NMV J15225 (male, 2.7 mm, with 3 slides), NMV J15226 (non-ovig. female, 3.3 mm, with 2 slides); NMV J15221 (11 males, 2.3–2.8 mm, 11 non-ovig. females, 2.4–2.8 mm, 5 ovig. females, 2.6–3.0 mm, 3 juvs., 1.6–2.1 mm); dry pulled turpentine pile on beach, J.E. Barnacle, NMV J15228 (9); Geoffrey Bay, tidal zone, turpentine pile in jetty, L.J. Cookson and J.E. Barnacle, NMV J15227 (7 males, 2.0–2.8 mm, 12 non-ovig. females, 2.5–3.2 mm, ovig. female, 3.2 mm, 7 juvs., 1.7–2.2 mm). Port Douglas, low tide, turpentine pile, J.E. Barnacle, 29 May 1986, NMV J14980 (3 pleotelsons).

WA. Barrow Island, sawn jarrah piles after 4 years, L.J. Cookson and S. Gorjy, Mar 1986, NMV J14956 (male, 3.4 mm, with 1 slide), NMV J14957 (130).

NT. Cape Don, Cobourg Peninsula (11°18'S, 131°46'E), R.D. Turner and J.V. Marshall, 26 Oct 1970, AM P35426 (male, 3.3 mm, 4 intersexes, 2.8–3.9 mm).

PNG. Fairfax Harbour, S.M. Rayner, Aug 1971, NMV J15487 (male, 1.9 mm, with 1 slide), NMV J15475 (3 males, 2.1, 2.2, 2.7 mm, non-ovig. female, 2.2 mm, ovig. female, 2.5 mm, juv., 1.3 mm); Alotau, Milne Bay Province, NMV J15477 (non-ovig. female). Motupore Island, Central Province, S.M. Cragg, 8 Jun 1984, NMV J15492 (male, 2.3 mm); Tahira, Bootless, 3 Oct 1983, NMV J15479 (male, 4.0 mm, with 1 slide), NMV J15480 (male, ovig. female).

Cocos Islands. Pine bait block no. 242 after 5 months, R.D. Turner, J.V. Marshall and J. Beesley, Nov 1970, AM P38924 (male pleotelson, ovig. female).

*Types*. USNM.

*Diagnosis*. Pleonite 5 dorsally with slightly raised transverse carina near anterior margin, with shorter transverse carina near posterior margin; with or without pronounced medial hump or carina between transverse carinae. Pleotelson without distinctive carinae or tubercles, but some males with pleotelson deeply cup-shaped and lateral crests well developed; pleotelson slightly raised to anterior dorsomedial point. Pleonite 5 0.3 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with fine spikes. Perimeter of pleotelson with dorsal row of tubercles; posterior margin fringed with 4 unsheathed setae between which are shorter long-sheathed setae, lacking scale spikes.

Antenna 1 with 3 flagellar articles; second article with about 8 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible with 2 curved pointed apical branches. Epipod of maxilliped broad, 3.1 times as long as wide, reaching past palp articulation; epipod lacking true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 4, 5, 6 and 7. Uropod peduncle laterally compressed, with prominent claw-like tubercles; endopod 1.7 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.8 times length of exopod. Appendix masculina may or may not reach beyond endopod tip, articulating distal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.7 times as long as endopod of pleopod 2; peduncle of pleopod 5 with comb seta laterally.

*Additional characters*. Body length up to 4.0 mm. Colour in alcohol pale yellow, with dark reticulate pigment.

*Distribution*. Serua, Fiji (type locality); Guam Island; Palmyra Island; Ponape, Caroline Islands (Menzies, 1957); Andaman Islands (Ganapati and Rao, 1960); Kilindini, Kenya (McCoy-Hill, 1964); Cocos Islands; Northern Territory; Barrow Island, WA; Queensland; Papua New Guinea. So far only recorded from tidal zone (current study).

*Substrates*. Coconut tree trunk (Menzies, 1957); wooden plank (Ganapati and Rao, 1960); *Pinus*, sawn jarrah heartwood (*E. marginata* Donn ex Sm.), and turpentine (present study).

*Remarks*. This species varies considerably in some characters. None of the specimens from

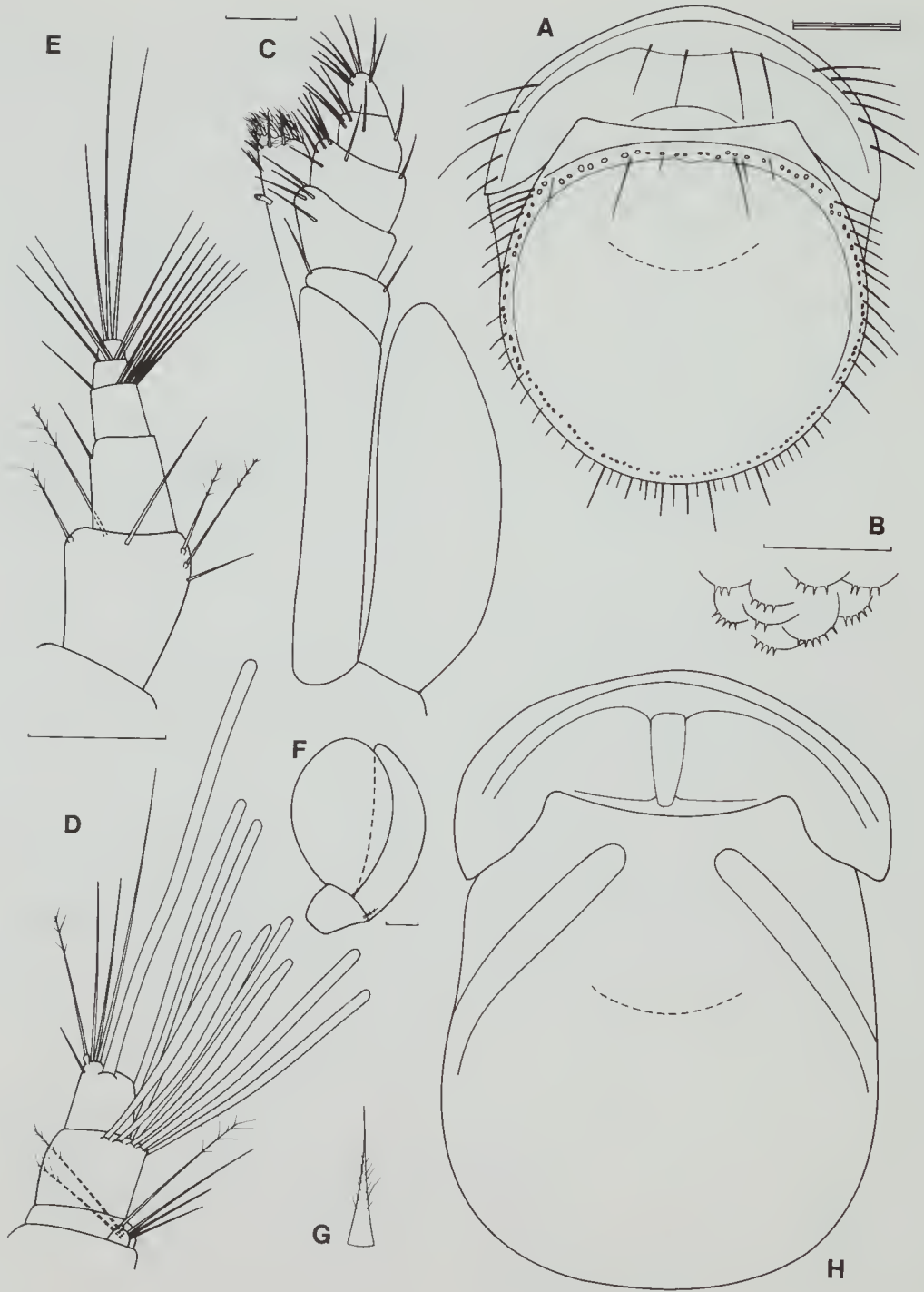


Figure 27. *Limnoria insulae* Menzies. A-G, male, NMV J15222: A, pleonite 5 and pleotelson, dorsal view; B, dorsal structure of pleotelson; C, maxilliped; D, flagellum of antenna 1; E, peduncle article 5 and flagellum of antenna 2; F, pleopod 5; G, comb seta on peduncle of pleopod 5. H, male, NMV J15479, pleonite 5 and pleotelson, setae omitted, dorsal view.

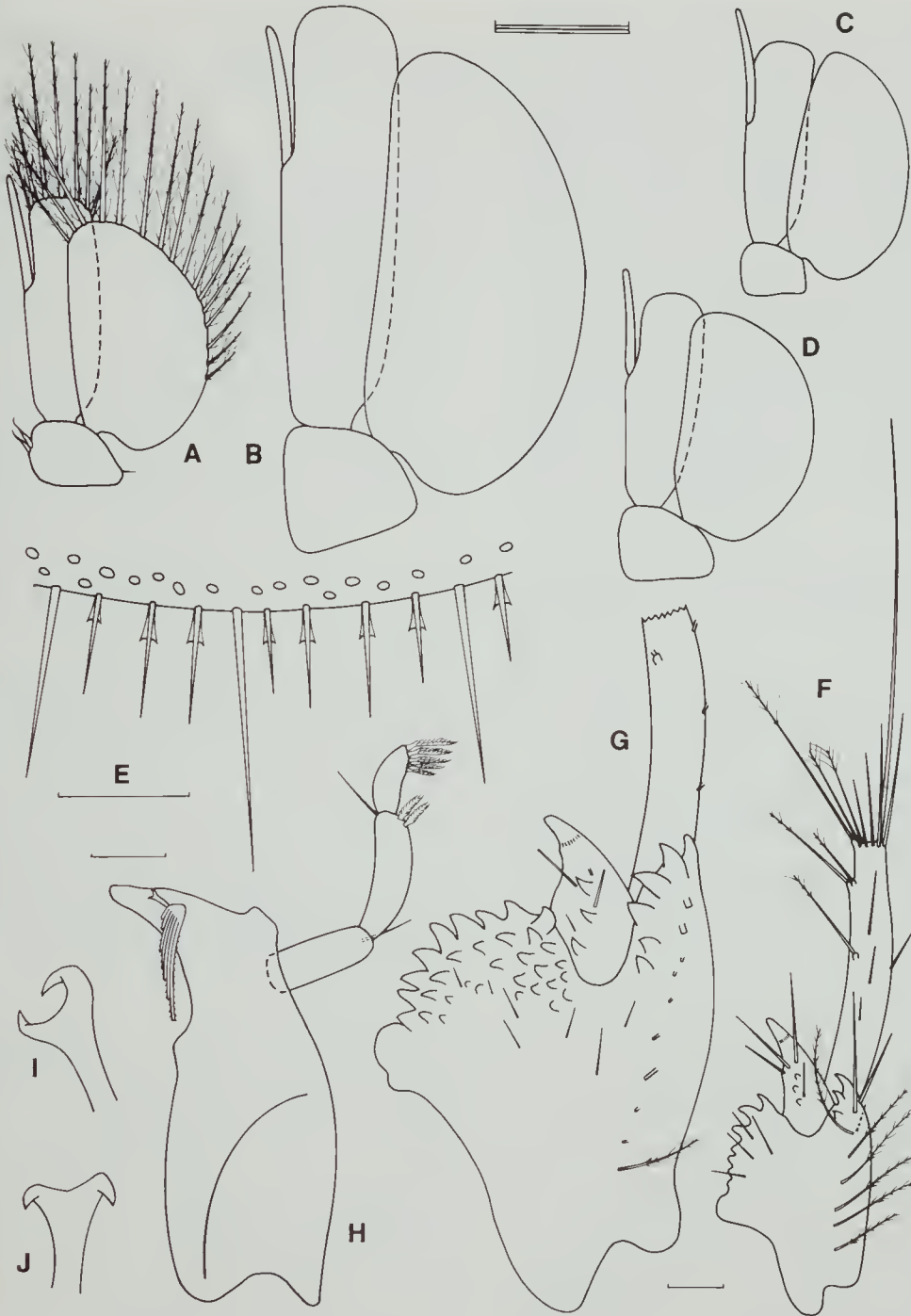


Figure 28. *Limnoria insulae* Menzies. A, E, F, J, male, NMV J15222: A, pleopod 2; E, posterior margin of pleotelson, dorsal view; F, uropod, ventrolateral view; J, lacinia mobilis of right mandible. B, G, male, NMV J15479: B, pleopod 2, setae omitted; G, uropod, endopod broken, ventrolateral view. C, male, NMV J15487, pleopod 2, setae omitted. D, male, NMV J14956, pleopod 2, setae omitted. H, I, male, NMV J15223: H, right mandible; I, lacinia mobilis of right mandible.



Barrow Island or Queensland had the deep cup-shaped pleotelson found in some specimens from Papua New Guinea (Plates 2a, b). However, some males from Fairfax Harbour, Papua New Guinea, from the deep cup-shape forms, to the slightly concave forms also commonly found in Australia. Females did not have the deeply cup-shaped pleotelson. Associated with increased cupping of the pleotelson was increased prominence of the medial carina hump on pleonite 5. Menzies did not mention such variation and his figure shows a male pleotelson with the deep cup-shaped form.

Specimens from Magnetic Island which have been kept since July 1985 in laboratory aquaria at 27–28°C did not produce any forms with the deep cup-shaped pleotelson when examined bimonthly. This situation may change if certain culture parameters were to be altered in the aquaria.

A male from Barrow Island (NMV J14956) had a 3-articled flagellum on antenna 2. The number of claw-like tubercles on the uropod peduncle shown in Plate 2a was fewer than sometimes found in other specimens from Magnetic Island. Uropods with most tubercles were found on males from Papua New Guinea which also had deeply cup-shaped pleotelsons. The relative size, and articulation position of the appendix masculina, also differed between specimens – those with a large body size (and deep cup-shaped pleotelson) had relatively short and distally articulating appendix masculina, as well as short plumose setae. The male figured by Menzies (1957) follows this pattern.

*L. insulae* is most similar to *L. platycauda* and *L. multipunctata*. *L. insulae* may be distinguished most readily by its laterally compressed uropod peduncle, and the form of the lacinia mobilis of the right mandible. The deep cup-shape of the pleotelson is also useful, when this character is developed.

### *Limnoria kautensis* Cookson and Cragg

Figures 2, 29–31

*Limnoria kautensis* Cookson and Cragg, 1988: 1508–1512, figs. 1–3.

*Material examined.* Holotype: PNG, Kaut Harbour, New Ireland Province (2°46'03"S, 150°54'28"E), 8 m, dense log, S.M. Cragg, 10 Oct 1985, NMV J14773 (male, 2.9 mm, with 1 slide).

Paratypes: Type locality, NMV J14774 (non-ovig. female, 2.8 mm, = allotype), NMV J14775 (3 non-ovig. females, 2.3–2.6 mm, juv., 1.3 mm); 9 m, 20 Nov 1982, NMV J14776 (non-ovig. female, 2.6 mm, with 1

slide), NMV J14777 (male, 2.6 mm, with 1 slide), NMV J14778 (5 males, 2.1–2.5 mm, 3 non-ovig. females, 2.7–3.0 mm, 2 ovig. females, 2.9, 3.1 mm, juv.), PNGNM (3 males, 2.2–2.7 mm, 2 non-ovig. females, 2.7, 2.9 mm, ovig. female, 2.8 mm, juv., 1.4 mm).

*Diagnosis.* Pleonite 5 lacking carinae and tubercles dorsomedially. Pleotelson with long horse-shoe-shaped dorsomedial carina. Pleonite 5 0.7 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with fine spikes. Dorsal row of tubercles extend from lateral crests to posterior margin of pleotelson; margin fringed with long-sheathed setae, without scale spikes and stout setae.

Antenna 1 with 4 flagellar articles; second article bears 3–4 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible bilobed, each lobe bears 3–4 teeth. Epipod of maxilliped broad, oval, 2.5 times as long as wide, reaching past palp articulation; epipod lacking simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopods 6 and 7 and carpus of pereopods 2–7. Uropod peduncle with few small lateral tubercles; endopod as long as peduncle.

Pleopod 2 with short plumose setae, up to 0.3 times length of exopod. Appendix masculina short, not reaching beyond endopod of pleopod, articulating distal to midlength of endopod. Endopod of pleopod 5 posterior to exopod, triangular, 0.9 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Secondary unguis of pereopod 7 small. Exopod of uropod with small apical claw, exopod with row of about 8 long setae, exopod long. Body length up to 3.1 mm. Colour in alcohol white with dark reticulate pigment.

*Distribution.* Kaut, Papua New Guinea (Type locality). 8–9 m depths.

*Substrate.* Dense log.

*Remarks.* The species is re-illustrated here in more detail than in the original description. *L. kautensis* has more plesiomorphic characters than any other species of *Limnoria*. It has: the longest uropodal exopod, although not as long as the exopod of *P. andrewsi*, many simple setae on the uropodal exopod and endopod, relatively long pleonite 5, large pleopod 5 with endopod

posterior to exopod, absence of stout setae on the posterior margin of the pleotelson, and broad maxillipedal epipod. However, *L. kautensis* has a four rather than five segmented flagellum on antenna 2.

*L. kautensis* is most similar to *L. pfefferi* as both species have two longitudinal carinae on the pleotelson, small uropodal exopod claws, similar pleopods, lack stout setae and scale spikes on the posterior margin of the pleotelson, have similar maxillipedal epipods, and four flagellar articles on both antennae. Unlike *L. kautensis*, *L. pfefferi* has a Y-shaped carina on pleonite 5, a distally undivided lacinia mobilis on the right mandible, a more distally rounded maxillipedal epipod, longer first article on the flagellum of antenna 2, longer uropodal peduncle, and pappose setae on the uropod peduncle which arises from a ridge.

### *Limnoria loricata* sp. nov.

Figures 1, 32

*Limnoria quadripunctata* Holthuis.—Poore, 1981: 342 (stn SA 3369).

*Material examined.* Holotype: NZ, The Snares, Senecio Pool (48°07'S, 166°38'E), 1.5 m, from *Lessonia variegata* holdfast, G.D. Fenwick, 6 Jan 1977 (stn SA 3369), NMNZ Cr. 6456 (male, 3.2 mm, 0.9 mm wide pleotelson with 1 slide).

Paratypes: Type locality, NMNZ Cr. 6457 (male, 3.1 mm, with 1 slide, male, without cephalon or uropods, 4.7 mm [allowing for head length]).

*Diagnosis.* Pleonite 5 dorsomedially with X-shaped carina, with anterior axes not reaching anterior pleonite margin but diverging laterally to join lateral crests, posterior axes reaching posterior pleonite margin, following margin laterally. Pleotelson with 2 subparallel dorsomedial carinae which diverge posteriorly, each carina with small anterior punctum; with 2 pairs of more lateral carinae, followed by lateral crests. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with solitary scale spikes, surface with pits bordered by carinae on pleonite 5 and anterior portion of pleotelson. Dorsal row of short scale spikes extend from lateral crests to posterior margin of pleotelson; posterior margin with 4 large stout setae between which are scale spikes and short-sheathed setae.

Antenna 1 with 4 flagellar articles; second article with about 8 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors without rasp and file. Lacinia mobilis of right mandible with 2

apical branches with long serrations. Epipod of maxilliped subtriangular, 3.1 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 6 and 7. Uropod peduncle without lateral tubercles; endopod 0.8 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.7 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Lacinia mobilis of left mandible long. Body length up to 4.7 mm. Colour in alcohol pale yellow.

*Etymology.* From the Latin for mail-clad, *loricata*, describing the rings of small carinae on pleonite 5.

*Distribution.* The Snares, southern New Zealand. 1.5 m depth.

*Substrate.* Holdfast of *Lessonia variegata*.

*Remarks.* *Limnoria* has also been found in floating (adrift) *Lessonia* near the Auckland Islands, New Zealand (Hale, 1937) and were later identified by Menzies (1957), using Hale's figures, as *L. stephenseni*. The specimens could not have been *L. loricata* as the uropod drawn by Hale (1937) is similar to that found in *L. stephenseni* and *L. antarctica*.

*L. loricata* is most similar to *L. rugosissima*. Both species have a rugose appearance (more so in *L. loricata*), generally similar carinae on pleonite 5 and the pleotelson, similar pleopodal shapes, an almost strap-like maxillipedal epipod, and absence of a rasp and file. However, these species can be separated by finer details of the shape of the maxillipedal epipod, ornamentation on pleonite 5 and the pleotelson, and structure of the lacinia mobilis on the right mandible. Also, unlike *L. loricata*, *L. rugosissima* has a simple seta on the endopod of pleopod 5, cleaved incisor on the right mandible, and reduced spine row of the left mandible.

### *Limnoria multipunctata* Menzies

Figures 33, 34

*Limnoria (Limnoria) multipunctata* Menzies, 1957: 170–173, figs 30–31.—Menzies, 1959: 19.—Kühne,

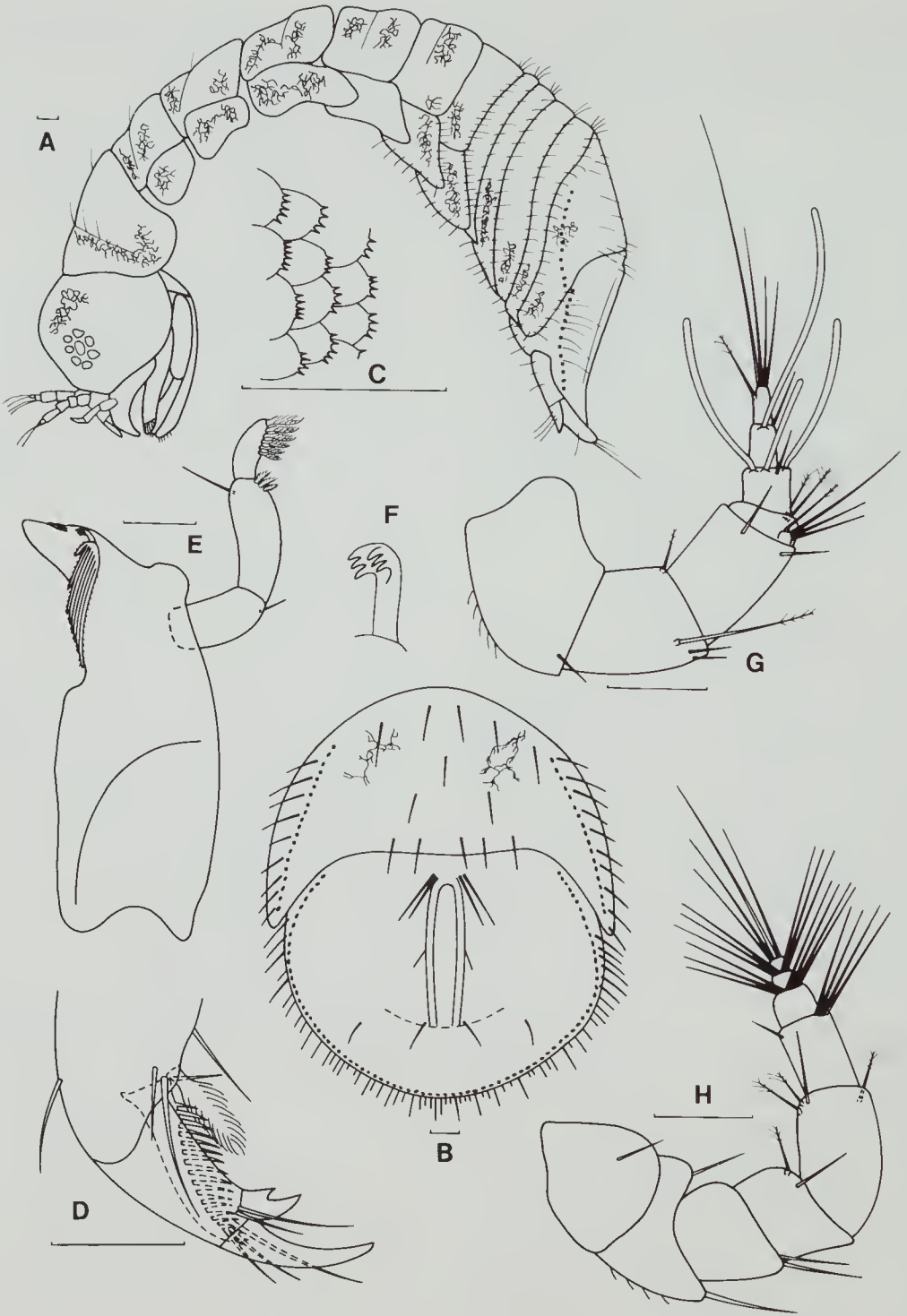


Figure 29. *Limnoria kautensis* Cookson and Cragg. A-D, male, NMV J14773, holotype: A, lateral view; B, pleonite 5 and pleotelson, dorsal view; C, dorsal structure of pleotelson; D, distal articles of pereopod 1, lateral view. E,F, male, NMV J14777, paratype: E, right mandible; F, lacinia mobilis of right mandible. G,H, female, NMV J14776, paratype: G, antenna 1; H, antenna 2.



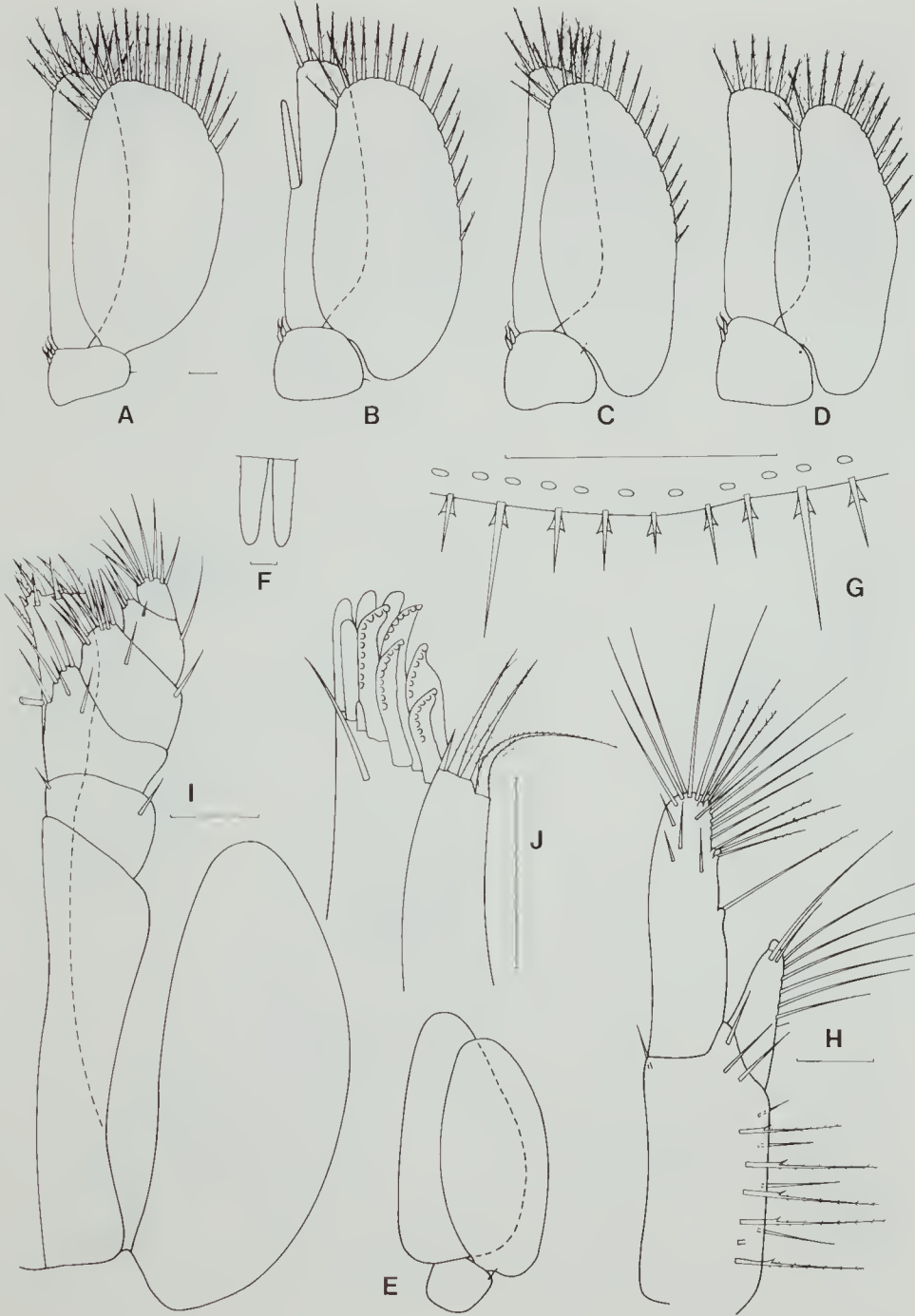


Figure 30. *Limnoria kautensis* Cookson and Cragg. A-H, male, NMV J14773, holotype: A-E, pleopods 1-5; F, penes; G, posterior margin of pleotelson, dorsal view; H, uropod, ventral view. I, J, female, NMV J14776, paratype: I, maxilliped; J, maxilla 1.

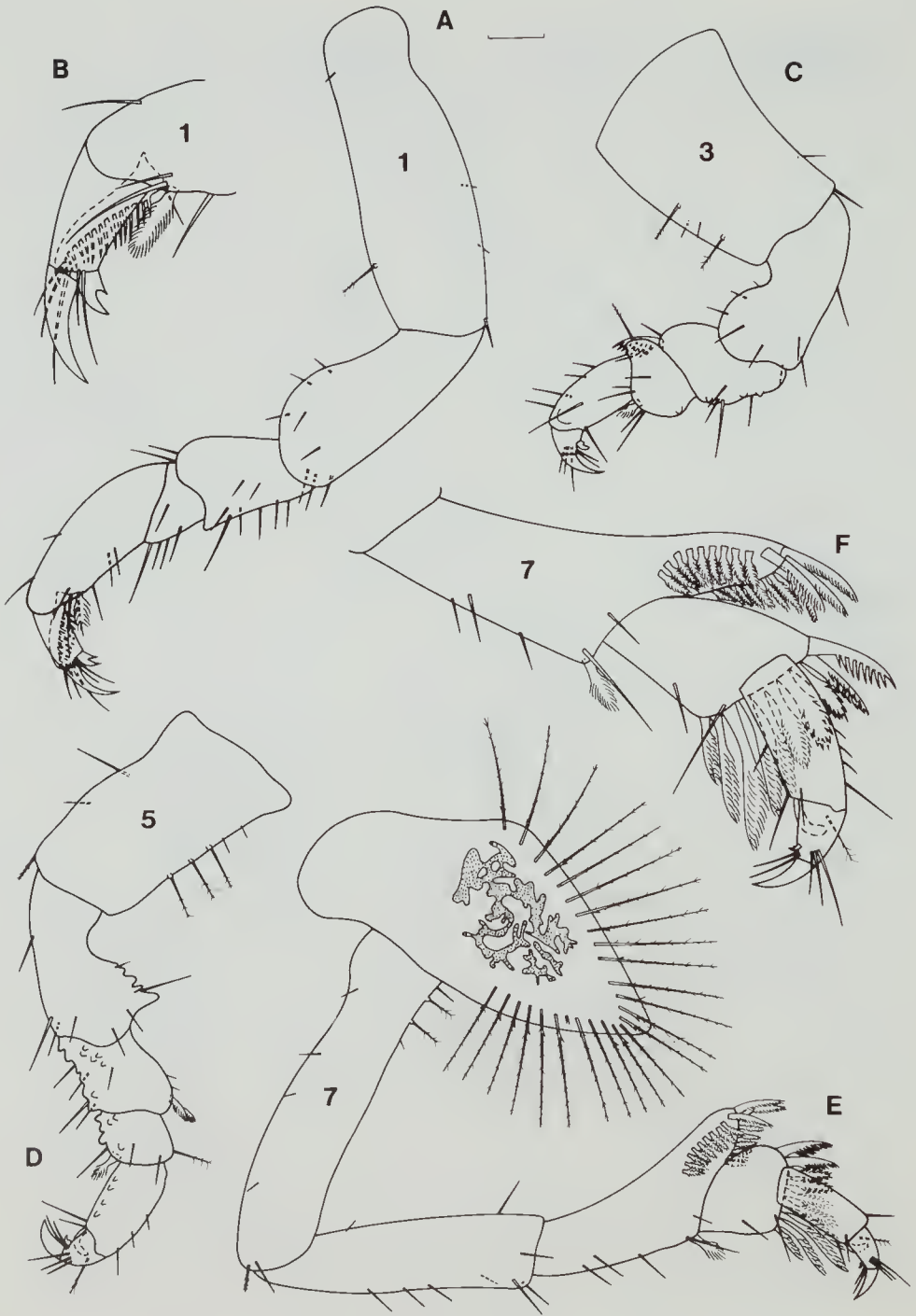


Figure 31. *Limnoria kautensis* Cookson and Cragg. A-F, male, NMV J14773, holotype: A, pereopod 1; B, daetylus of pereopod 1; C, pereopod 3; D, pereopod 5; E, pereopod 7 with coxa; F, distal articles of pereopod 7; all lateral views.



Figure 32. *Limnoria loricata* sp. nov. A–J, male, NMNZ Cr. 6456, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; D, flagellum of antenna 1; E, peduncle article 5 and flagellum of antenna 2; F, pleopod 2; G, pleopod 5; H, incisor of left mandible; I, right mandible; J, lacinia mobilis of right mandible.



1975: 453.—Kühne, 1976: 548, figs 8–9.—Kensley and Schotte, 1987: 222, fig. 5.

*Limnoria multipunctata*.—Jones et al., 1972: 105, 109.—Jones et al., 1976: 122, 134.—Kensley and Schotte, 1989: 196–197, figs 86D, 87A.

*Material examined*. Holotype: near Kai Islands (15°–6'5"S, 131°5'–133°15'E), 13 m, 12 Jun 1922, Zoologisk Museum, Copenhagen (male, 1.9 mm).

Paratypes: Type locality. Zoologisk Museum, Copenhagen (non-ovig. female, 2.0 mm, = allotype, male, 1.8 mm, with 1 slide, non-ovig. female, without cephalon and uropods, juv., without cephalon and right uropod).

Other material. Cocos Islands, pine bait block no. 242 after 5 months, R.D. Turner, J.V. Marshall and J. Beesley, Nov 1970, AM P38923 (male, 2.9 mm, 0.7 mm wide pleotelson, with 1 slide), AM P38922 (male, 2.5 mm, with 1 slide), AM P38921 (male, 2.2 mm, with 2 slides), AM P35429 (15 males, 2.2–2.7 mm, 10 non-ovig. females, 2.5–3.1 mm, 9 ovig. females, 2.8–3.2 mm).

Qld. Green Island, 10 m from jetty, 2 m. hardwood sawn plank on sand, L.J. Cookson, 16 Sep 1988, NMV J15452 (male, 2 juvs.).

PNG. Alotau, Milne Bay Province, S.M. Rayner, Aug 1971, NMV J15478 (male, 6 non-ovig. females).

*Types*. Zoologisk Museum, Copenhagen; USNM (not examined).

*Diagnosis*. Pleonite 5 dorsomedially convex, without carinae and puncta; lateral crests slightly developed on pleonite 4. Pleotelson with longitudinal distal row of dorsomedial puncta and tubercles. Pleonite 5 0.4 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with fine spikes. Dorsal row of tubercles extend from lateral crests to posterior margin of pleotelson; margin fringed with 4 unsheathed setae between which are long-sheathed setae, lacking scale spikes.

Antenna 1 with 3 flagellar articles; second article with about 8 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible very short, without teeth or serrations. Epipod of maxilliped broad, 2.8 times as long as wide, reaching past palp articulation; epipod lacking true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and earpus of pereopods 2, 3, 4, 5, 6 and 7. Uropod peduncle with few small distolateral tubercles, median projection between rami tuberculate; endopod 1.1 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.7 times length of exopod. Appendix masculina reaching

beyond endopod tip, articulating just distal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, elongated, oval, 0.7 times as long as endopod of pleopod 2; peduncle of pleopod 5 with comb seta laterally.

*Additional characters*. Exopod of uropod with 2 sometimes pointed tubercles. Body length up to 3.2 mm. Colour in alcohol pale yellow, with dark reticulate pigment.

*Distribution*. Near the Kai Islands (type locality); Saipan Island; Guam Island; Canton Island (Menziés, 1957); Puerto Rico; Jamaica; Koniya, Japan (Kühne, 1976); Belize (Kensley and Schotte, 1987); Milne Bay, PNG; Cocos Islands; Green Island, Qld (current study). 2–13 m depths (Menziés, 1957; current study).

*Substrates*. *Teredo* infested wood (Menziés, 1957), dead red mangrove wood (Kensley and Schotte, 1987), *Pinus sylvestris* L. (Jones et al., 1972), hardwood plank. *Pinus* (present study).

*Remarks*. The vestigial coupling hooks found on the pleopod 5 peduncle in a male paratype (Fig. 34) were not found in the other four dissected specimens. The male specimen from the Cocos Islands (AM P38923) had 21 rather than 8 aesthetascs on article 2 of the flagellum on antenna 1.

The sculpturing of the pleotelson varied within populations. In some specimens such as the paratype figured by Menziés (1957), there were two pairs of anterior puncta, as well as the longitudinal medial tuberculate ridge similar to that shown in Fig. 33. These puncta were most developed in the holotype, although still not with the prominence suggested in Menziés' figure. In the other types the two pairs of anterior puncta were absent, or represented by slightly raised blunt humps. In some specimens from Milne Bay and the Cocos Islands, no sculpturing on the pleotelson was found, although in most specimens there was at least a ridge or tuberculate ridge medially. The most anterior pair of puncta were more often found than the posterior pair. These variations did not appear to be due to sexual dimorphism. The anterior pairs of puncta were also absent in specimens from Belize (Kensley and Schotte, 1987), Puerto Rico and Jamaica (Kühne, 1976).

The degree of variation in pleotelsonal sculpturing led Kühne (1976; see also Jones et al., 1976) to suggest that *L. platycauda* was just a transitional stage or variety of *L. multipunctata*. However, there are several other important differences between the species. *L. multipunctata*

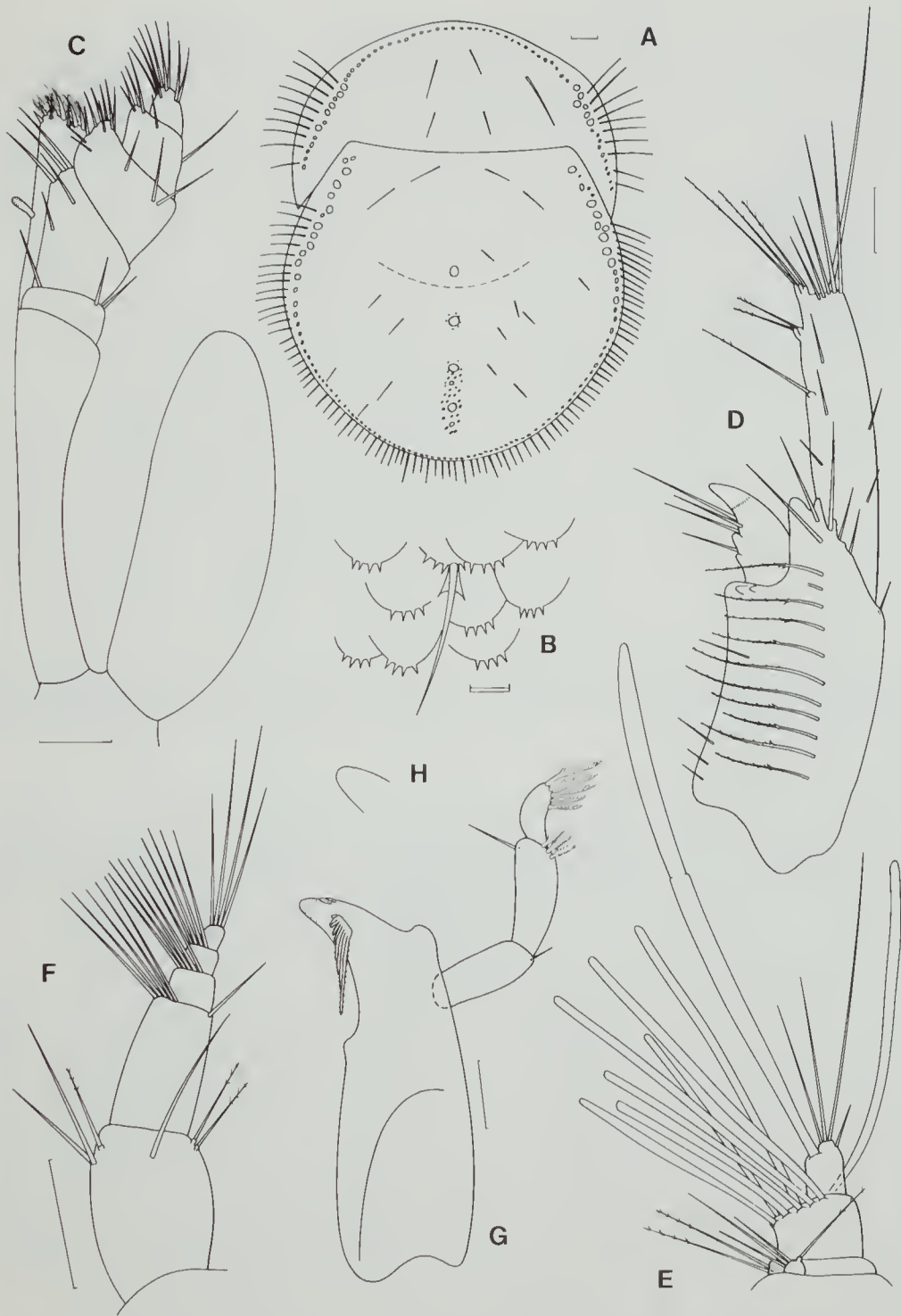


Figure 33. *Limnoria multipunctata* Menzies. A–D, F–H, male, AM P38923: A, pleonite 5 and pleotelson, dorsal view; B, dorsal structure of pleotelson; C, maxilliped; D, uropod, ventral view; F, peduncle article 5 and illagellum of antenna 2; G, right mandible; H, lacinia mobilis of right mandible. E, male, AM P38921, illagellum of antenna 1.

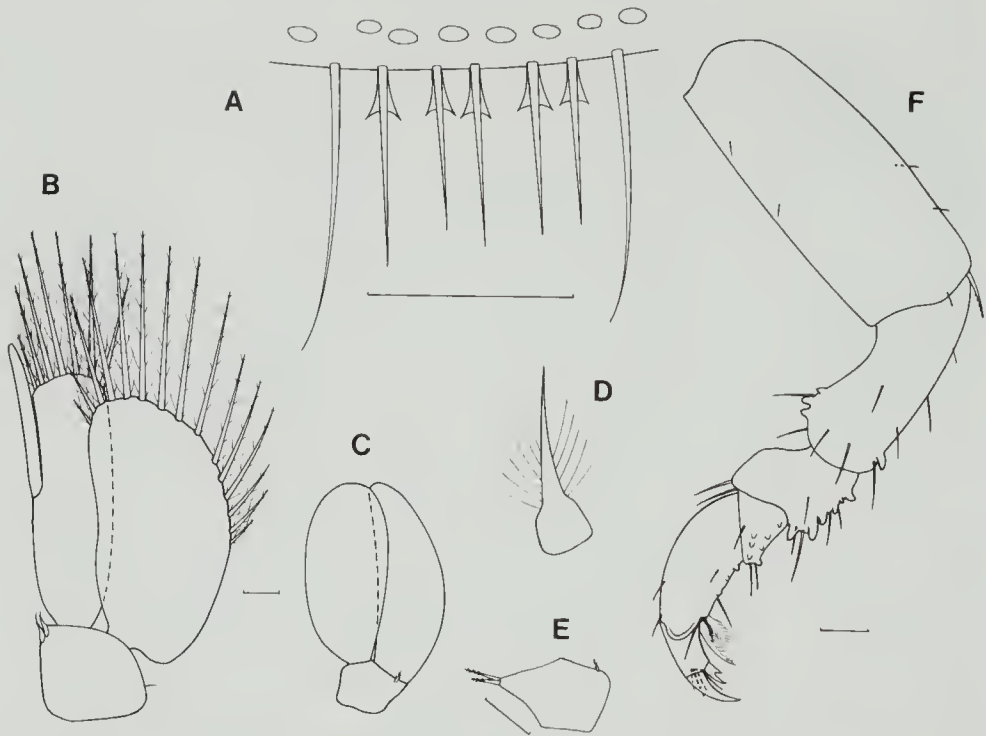


Figure 34. *Limnoria multipunctata* Menzies. A–D, F, male, AM P38923: A, posterior margin of pleotelson, dorsal view; B, pleopod 2; C, pleopod 5; D, lateral seta on peduncle of pleopod 5; F, pereopod 1, lateral view. E, male, paratype, peduncle of pleopod 5.

lacks sexual dimorphism in the pleotelson; the lacinia mobilis of the right mandible is quite different in shape; and pleonite 5 is dorsomedially convex whereas in *L. platycauda* there is at least a median elevation or inflection.

### *Limnoria nonsegnis* Menzies

#### Figure 35

*Limnoria* (*Phycolimnoria*) *nonsegnis* Menzies, 1957: 186, fig. 39.—Pillai, 1957: 150.—Menzies, 1959: 29.

*Phycolimnoria nonsegnis*.—Edgar, 1987: 599–610.

*Material examined*. Paratypes: Tas. Port Arthur (43°8'S, 147°50'E), *Macrocyctis* holdfast, A.B. Cribb, Jun 1951, AM P38931 (4 non-ovig. females, 3.3–3.9 mm, 8 ovig. females, 3.0–4.0 mm).

*Other material*. Tas. Variety Bay (43°12'S, 147°24'E), 6.8 m, *Macrocyctis* holdfast, G. Edgar, 1984, NMV J15359 (male, 2.7 mm, 0.8 mm wide pleotelson, with 1 slide), NMV J15357 (ovig. female, 4.1 mm, with 1 slide), NMV J15358 (juv., 2.2 mm, with 1 slide), NMV J15356 (male, 3.0 mm, 7 non-ovig. females, 2.3–3.5 mm, 2 ovig. females, 3.5–4.0 mm, juv., 1.3 mm). Maria Island, 500 m west of Darlington (42°35'S, 148°2'E), 30 m, algal and drift holdfast,

trawl, R.S. Wilson, 23 Apr 1985 (stn TAS 27), NMV J15371 (male, 2.7 mm).

Vie. Aireys Inlet, drift *Macrocyctis* holdfast on beach, L.J. Cookson, 30 Mar 1988, NMV J15322 (male, 2.1 mm, with 1 slide), NMV J15321 (juv., 2.1 mm, with 1 slide), NMV J15320 (4 juvs., 1.7–2.0 mm).

*Diagnosis*. Pleonite 5 dorsomedially elevated, with depressed zones sublaterally, with oblique carinae laterally. Pleotelson with anterior raised dorsomedial region followed posteriorly by 2 parallel carinae and laterally by pair of short oblique carinae and lateral crests. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with fine scale spikes, surface anteriorly slightly pitted. Posterior margin of pleotelson with dorsal row of scale spikes; margin fringed with 6 long stout setae between which are short unsheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 6 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles, article 3 reduced, with several apical comb setae. Mandibular incisors without rasp



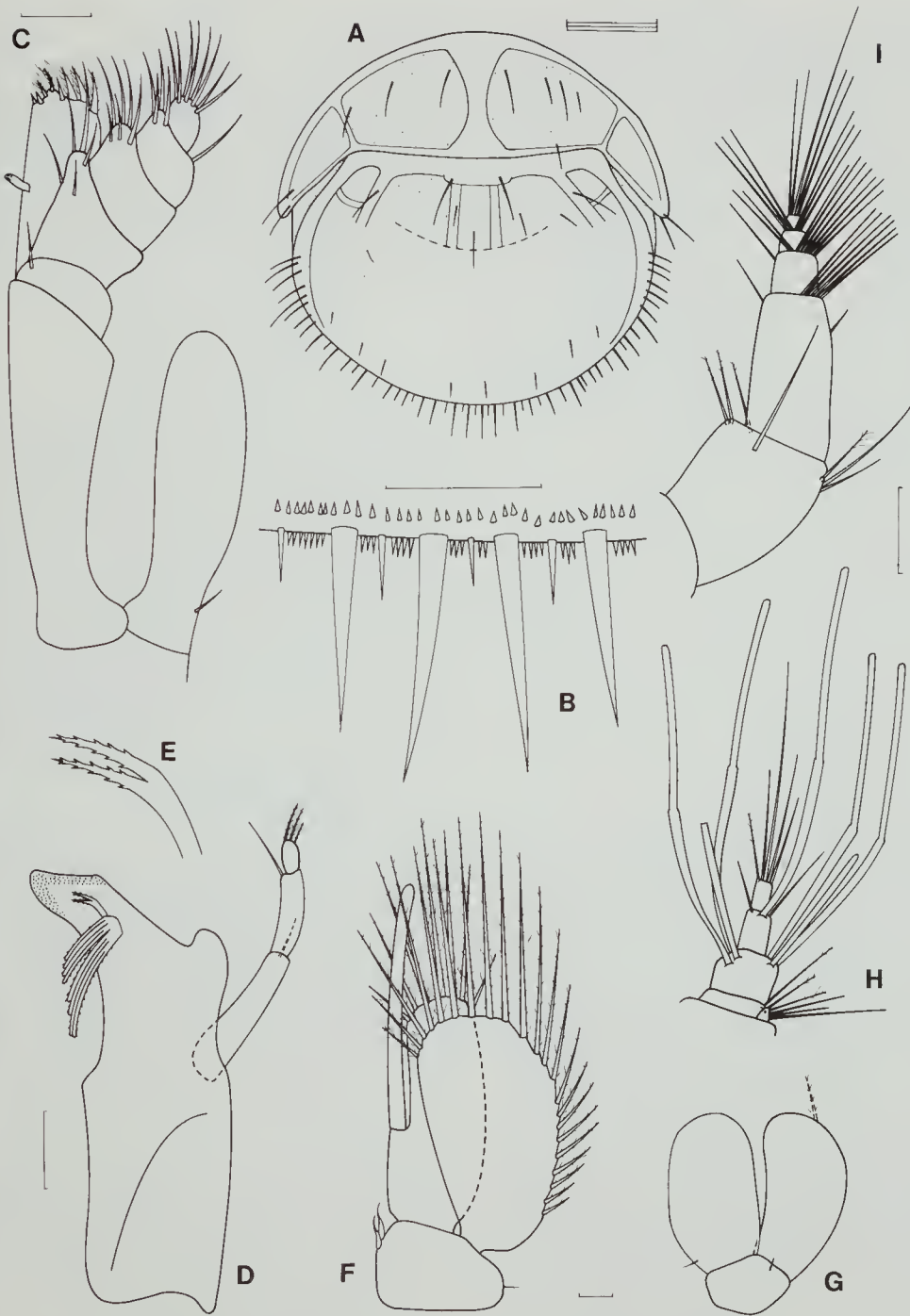


Figure 35. *Limnoria nonsegnis* Menzies. A-I, male, NMV J15359: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; D, right mandible; E, lacinia mobilis of right mandible; F, pleopod 2; G, pleopod 5 (dashed plumose seta found only on female NMV J15357); H, flagellum of antenna 1; I, peduncle article 5 and flagellum of antenna 2.

and file. Lacinia mobilis of right mandible branched at midlength, branches serrated. Epipod of maxilliped club-shaped, apically rounded, 3.6 times as long as wide, reaching beyond palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta absent on merus, present on carpus of pereopods 6 and 7. Uropod peduncle with few small lateral tubercles bearing short spikes; endopod 0.75 times as long as peduncle.

Pleopod 2 with long plumose setae up to 0.9 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.65 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Large medial seta on maxilla 2 sinuous. Body length up to 4.1 mm. Colour in alcohol pale yellow.

*Distribution.* Port Arthur, Tasmania (type locality) (Menzies, 1957; current study); Tasmania; Aireys Inlet, Victoria. 0–30 m depths (current study).

*Substrates.* *Macrocyctis* holdfasts (Menzies, 1957; current study).

*Remarks.* The prominence of the sculpturing on pleonite 5 and the pleotelson varies, and in some specimens is so indistinct as to look like the sculpture on *L. convexa*, although these specimens at least still have the sublateral depressions or concavity on pleonite 5. The plumose seta drawn on pleopod 5 (Fig. 35) was not found on other specimens. Menzies (1957) described the maxillipedal epipod as strap-like, although his figure of the epipod has a club-shaped appearance. Other types and specimens examined by me had club-shaped maxillipedal epipods.

*L. nonsegnis* is most similar to *L. convexa*, for the reasons given with that species. *L. nonsegnis* is also similar to *L. antarctica* in the form of the sculpturing on the pleotelson. The setal structure on the posterior margin of the pleotelson is also similar: both species have lost sheathing on the "sheathed" setae, and *L. nonsegnis* has six stout setae while *L. antarctica* may have four or six stout setae. The club-shaped maxillipedal epipod may have arisen from a strap-shaped epipod (strap-shape retained in *L. convexa*). Both *L. nonsegnis* and *L. antarctica* have four flagellar articles on antenna 2, similar pleopods, and a large oval body shape. Based on the reduction of

the mandibular palp, *L. nonsegnis* evolved after *L. antarctica*.

*L. nonsegnis* also is similar to *L. poorei*, both have: similar mandibular palp, slightly sinuous inner seta on maxilla 2, and similar ventral comb setal sequence on the pereopods. But *L. poorei* lacks stout setae on the posterior margin of the pleotelson, has a much broader maxillipedal epipod, elongated pleopod 5 shape, small size, and modified secondary unguis on pereopod 1.

### *Limnoria orbellum* sp. nov.

Figures 36–39, Plate 2c

*Material examined.* Holotype: NT. Cape Don, Cobourg Peninsula (11°18'S 131°46'E), R.D. Turner and J.V. Marshall, 26 Oct 1970, AM P38926 (male, 2.2 mm, 0.5 mm wide pleotelson, with 1 slide).

Paratypes: Type locality. AM P38927 (male, 2.1 mm, with 2 slides), AM P38928 (non-ovig. female, 2.3 mm, 0.55 mm wide pleotelson, with 1 slide), AM P38929 (damaged juv. and ovig. female, with 1 slide), AM P38925 (12 males, 1.3–2.0 mm, 20 non-ovig. females, 2.0–2.45 mm, 7 ovig. females, 2.1–2.45 mm, 6 juvs., 1.2–1.9 mm), NMV J15451 (4 males, 1.6–2.0 mm, 4 non-ovig. females, 2.2–2.4 mm, ovig. female, 2.2 mm, juv. 1.3 mm); separate collection, AM P35425 (male, 2.0 mm, 2 non-ovig. females, 2.4, 2.45 mm, ovig. female, 2.4 mm). It is not known how the two collections differ, presumably they were from different timbers or positions on timbers.

*Diagnosis.* Pleonite 5 without dorsomedial earinae and tubercles. Pleotelson with antero-medial punctum followed posteriorly by pair of puncta. Pleonite 5 0.75 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with fine spikes. Dorsal row of tubercles extend from lateral crests to posterior margin of pleotelson, each tubercle with row of several short dorsal spikes. Posterior margin of pleotelson with 4 large stout setae between which are short unsheathed setae and thin scale spikes.

Antenna 1 with 4 flagellar articles; second article with 1 aesthetasc. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible with several apical teeth. Epipod of maxilliped triangular, 2.6 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta absent on merus, present on carpus of pereopods 6 and 7. Uropod peduncle with many small lateral tubercles; endopod 1.4 times as long as peduncle.



Figure 36. *Limnoria orbellum* sp. nov. A-C, F-H, male, AM P38926, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, dorsal structure of pleotelson; F, left mandible; G, right mandible; H, lacinia mobilis of right mandible. D, E, I, K, male, AM P38927, paratype: D, maxilliped; E, endite of maxilliped; I, lacinia mobilis of right mandible; K, uropod, ventrolateral view. J, female, AM P38928, paratype, lacinia mobilis of right mandible.



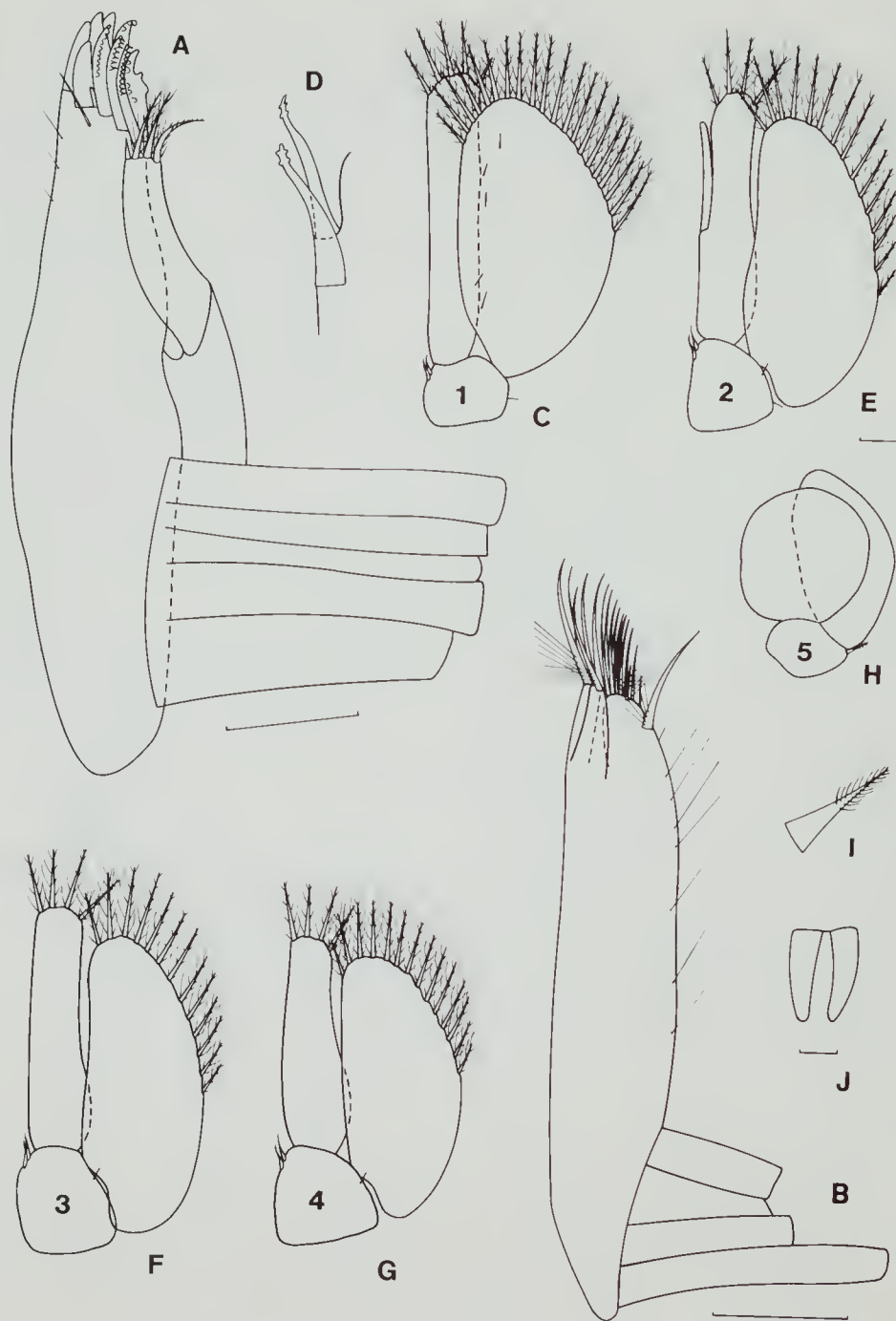


Figure 37. *Limnoria orbellum* sp. nov. A-l, male, AM P38926, holotype: A, maxilla 1 and associated muscle; B, maxilla 2 and associated muscle; C, pleopod 1; D, coupling hooks on pleopod 1; E-H, pleopods 2-5; I, comb seta on pleopod 5. J, male, AM P38927, paratype, pencils.

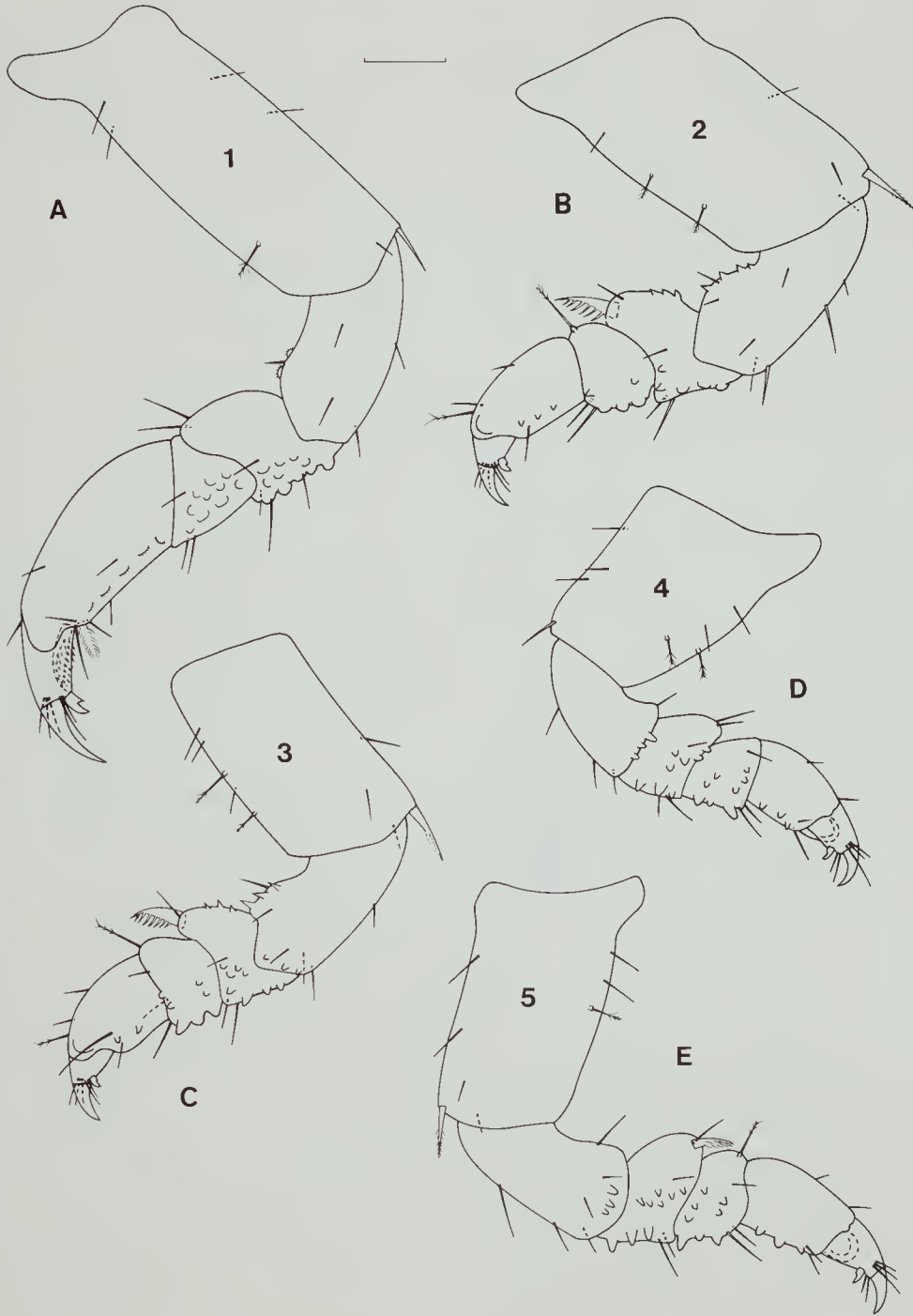


Figure 38. *Limnoria orbellum* sp. nov. A-E, male AM P28926, holotype: A-E, pereopods 1-5, lateral views.



Figure 39. *Linnoria orbellum* sp. nov. A-E, male, AM P38926, holotype: A, pereopod 6, lateral view; B, pereopod 7, lateral view; C, dactylus of pereopod 7, lateral view; D, antenna 1; E, antenna 2.



Pleopod 2 with short plumose setae up to 0.3 times length of exopod. Appendix masculina short, not reaching endopod tip, articulating slightly proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, circular, 0.5 times as long as endopod of pleopod 2; peduncle of pleopod 5 with comb seta laterally.

*Additional characters.* Pleopod 1 with only 2 coupling hooks. Pereopod 7 without secondary unguis. Body length up to 2.5 mm. Colour in alcohol pale yellow, with dark reticulate pigment.

*Etymology.* Derived from *orbis*, Latin for circle, and *flabellum*, Latin for fan and describes the almost perfectly round endopod on pleopod 5.

*Distribution.* Cape Don, Northern Territory. Precise depths unknown, shallow water.

*Substrates.* Although no data was provided, the specimens were collected during an Australia-wide teredinid survey, when borers were collected from pine bait panels or submerged timbers. Baits were not sent to Cape Don, and so the timber must have been a local pile or log. *L. orbellum* was collected with *L. insulae*, a known wood-borer.

*Remarks.* *L. orbellum* is similar to *L. tripunctata*, *L. japonica*, *L. borealis* and *L. magadanensis* in that all species possess three puncta on the pleotelson, while both *L. orbellum* and *L. magadanensis* also do not have carinae connected to the puncta. *L. orbellum* seems most similar to *L. tripunctata*. Both species have five flagellar articles on antenna 2, a triangular maxillipedal epipod, and a circular endopod on pleopod 5. However, *L. orbellum* also has affinities with *L. kautensis*: both have short pleopodal plumose setae and appendix masculina, long pleonite 5 segment, and reduced or absent secondary unguis on pereopod 7.

*L. orbellum* is most readily distinguished by pleotelsonal sculpturing, presence of scale spikes on the dorsal row of tubercles near the posterior margin of the pleotelson, almost perfectly round pleopod 5 endopod, lack of a secondary unguis on pereopod 7, and presence of only two coupling hooks on pleopod 1.

### *Limnoria pfefferi* Stebbing

Figures 40, 41

*Limnoria pfefferi* Stebbing, 1904: 714–715, pl. LIIIa.—Chilton, 1914a: 382, 387.—Moll, 1915: 184–185, 188, fig. 7.—Kofoid and Miller, 1927: 309.—

Holthuis, 1949: 170.—Menzies and Becker, 1957: 87, fig. 1.—McCoy-Hill, 1964: 46.—Nair, 1984: 208.—Kensley, 1988: 41.—Kensley and Schotte, 1989: 198, fig. 87B.

*Limnoria (Limnoria) pfefferi*.—Menzies, 1957: 135–137, fig. 15.—Becker and Kampf, 1958: fig. 4.—Becker and Kampf, 1959: fig. 4.—Menzies, 1959: 18.—Ganapati and Rao, 1960: 275–276.—Pillai, 1961: 25, text-fig. 13.—Menzies and Glynn, 1968: 48, fig. 21E.—Rao and Ganapati, 1969: 226, 229.—Schultz, 1969: 144, fig. 212.—Kühne, 1975: 454.—Kühne, 1976: 547–548, fig. 7.—Krishnan et al., 1980: 20.—Kensley and Schotte, 1987: 222–224.

Not *Limnoria pfefferi*.—Stephensen, 1927: 361–362 (= *Limnoria stephensi*).

*Material examined.* Syntypes: Minikoi Atoll, Indian Ocean, in rotten log in lagoon, S. Gardiner, British Museum (Natural History) 1928.12.1: 1275–80 (male, 2 non-ovig. females).

Other material. PNG. Rabaul, timber piles from main wharf, S.M. Cragg, NMV J15485 (male, 4.7 mm, 1.1 mm wide pleotelson, with 1 slide), NMV J15486 (male, 4.6 mm, with 2 slides), NMV J15484 (20 males, 2.7–4.7 mm, 9 non-ovig. females, 3.8–4.7 mm, 3 ovig. females, 3.8, 4.0, 4.0 mm, juv., 1.6 mm); 15 Nov 1982, NMV J15483 (6 males, 4 females), Port Moresby, harbour, S.M. Rayner, Jan 1973, NMV J15471 (4 ovig. females); timber piles, S.M. Cragg, 20 Jun 1983, NMV J15494 (3 males, 4 non-ovig. females, juv.), Tahira, Bootless, S.M. Cragg, 3 Oct 1983, NMV J15481 (7). Madang, low tide, pine bait block no. 27 after 2 months, R.D. Turner, J.V. Marshall and J. Beesley, 30 Aug 1970, AM P35430 (10 males, 5 non-ovig. females, 2 ovig. females, 3 juvs.).

Cocos Islands, pine bait block no. 242 after 5 months, R.D. Turner, J.V. Marshall and J. Beesley, Nov 1970, AM P38916 (3 males, non-ovig. female, ovig. female).

Qld. Green Island, 10 m from jetty, 2 m, hardwood sawn plank on sand, L.J. Cookson, 19 Sep 1988, NMV J15453 (112).

*Types.* British Museum (Natural History).

*Diagnosis.* Pleonite 5 dorsomedially with Y-shaped longitudinal carina. Pleotelson with 2 dorsomedial parallel carinae. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson composed of scales, most with single central spike. Dorsal row of tubercles extend from lateral crests to posterior margin of pleotelson; margin fringed with long-sheathed setae, without scale spikes and stout setae.

Antenna 1 with 4 flagellar articles; second article with 5–6 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible short, rounded apically, with fringe of small teeth. Epipod of maxilliped broad, clavate, 2.4 times as long as wide,



Figure 40. *Limnoria pfefferi* Stebbing. A-H, male NMV J15485: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, tubercles on lateral crests of pleotelson; D, lacinia mobilis of right mandible; E, lacinia mobilis of right mandible; F, maxilliped; G, flagellum of antenna 1; H, peduncle of antenna 2 and flagellum of antenna 2.

reaching past palp articulation; epipod without simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopods 6 and 7, and carpus of pereopods 2, 3, 6 and 7. Uropod peduncle with small lateral tubercles, with small tubercles between pappose setae, pappose setae situated on ridge; endopod 0.75 times as long as peduncle.

Pleopod 2 with short plumose setae, up to 0.3 times length of exopod. Appendix masculina short, not reaching beyond endopod, articulating distal to midlength of endopod. Endopod of pleopod 5 posterior to exopod, subtriangular, 0.9 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Exopod of uropod with small apical claw; exopod with row of about 7 long setae. Body length up to 4.7 mm. Colour in alcohol pale yellow.

*Distribution.* Minikoi Atoll, Indian Ocean (type locality) (Stebbing, 1904); Andaman Islands (Ganapati and Rao, 1960); Miami, Florida (Menzies, 1957); Aldabra Atoll (Kensley, 1988); Belize (Kensley and Schotte, 1987); Puerto Rico

(Menzies and Glynn, 1968; Kühne, 1976); Papua New Guinea; Philippines; Panama (Kühne, 1976); Cocos Islands; PNG; Green Island, Qld (current study). 0-3 m depths (Kensley and Schotte, 1987).

*Substrates.* Rotten wood (Stebbing, 1904); wooden plank (Ganapati and Rao, 1960); palm pile (Menzies and Glynn, 1968); red mangrove wood, algal mat under red mangrove roots (Kensley and Schotte, 1987); decayed wood (Kensley, 1988); pine blocks, hardwood plank (current study).

*Remarks.* Menzies (1957) stated that the lateral crests and posterior margin of the pleotelson were devoid of tubercles. However, they were present on all material examined here, although slightly smaller in the syntypes. It is possible they were absent on the "cotype" (= syntype) figured by Menzies (1957), and so this character may be variable. The tubercles on the pleotelson's lateral crests on some Papua New Guinea material bear a row of tiny spikes, which may have arisen from spikes which posteriorly fringe the dorsal scales of the pleotelson found in some other species. The lacinia mobilis of the right mandible on the figured specimen is bifid, in

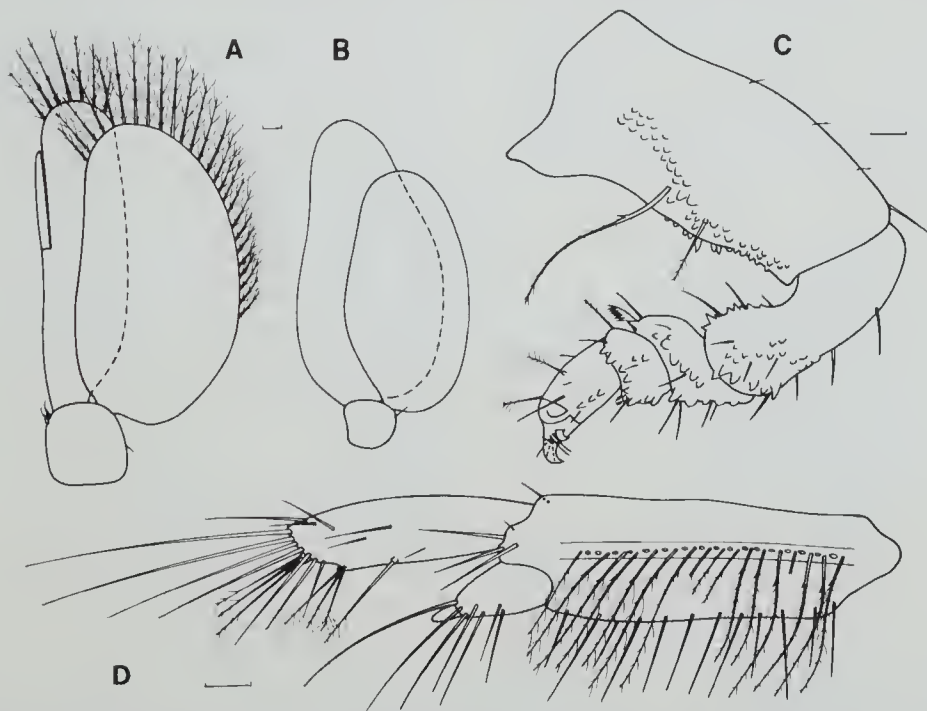


Figure 41. *Limnoria pfefferi* Stebbing. A-C, male, NMV J15485: A, pleopod 2; B, pleopod 5; C, pereopod 3, lateral view. D, male, NMV J15484, uropod, ventral view.



most specimens it is undivided as described in the diagnosis. Menzies (1957) stated that the lacinia mobilis had five denticles, but the number is more variable than this.

In the original description, Stebbing (1904) figured uropods which were similar to those of *Paralimnoria*, leading Menzies (1957) to suggest that Stebbing had a mixture of two species. Specimens from the Auckland Islands identified by Stephensen (1927) as *L. pfefferi*, with uncertainty, were actually *L. stephenseni* (Menzies 1957).

*L. pfefferi* is most similar to *L. sexcarinata* and *L. andamanensis*. These species have similar pleopods and maxillipedal epipods, four flagellar articles on antennae 2 (sometimes five in *L. sexcarinata*) and 1, similar lacinia mobilis of the right mandible, and similar scale structure on the dorsal surface of the pleotelson. *L. andamanensis* differs from *L. pfefferi* mainly by the sculpturing on the pleotelson and pleonite 5, presence of dorsal rows of tubercles on somites pereonite 6 to pleonite 4, comparatively short uropod peduncle, comparatively large uropod exopod claw, and lack of a median ridge on the uropod peduncle. *L. sexcarinata* differs from *L. pfefferi* as the Y-shaped carina on pleonite 5 has a much shorter stem than on *L. pfefferi*. Also, *L. sexcarinata* has a transverse carina on the posterior margin of pleonite 5 (part of splayed base of Y-shaped carina) which is almost as well developed as in *L. andamanensis*. *L. sexcarinata* also has many long flexible vestigial proximally bifurcate pappose setae on the basis of pereopod 4, similar to those found in *L. torquisa*.

### *Limnoria platycauda* Menzies

Figures 42, 43

*Limnoria (Limnoria) platycauda* Menzies, 1957: 139–141, fig. 17.—Menzies, 1959: 20.—Menzies and Glynn, 1968: 48, fig. 21F.—Schultz, 1969: 143, fig. 211.—Rao and Ganapati, 1969: 226.—Kühne, 1975: 452–453.—Kühne, 1976: 548.—Ortiz, 1983: 7.—Kensley and Schotte, 1987: 224.

*Limnoria platycauda*.—Jones et al., 1976: 122, 134.—Nair, 1984: 208.—Kensley, 1988: 41.—Kensley and Schotte, 1989: 198, fig. 87C.

*Material examined*. Paratypes: West Indies, mouth of Curaçao Harbour (12°12'N, 68°56'W), in greenheart timber, J.W. Gonggrip, 1923, USNM 91747 (12 males, 16 females, 7 juvs., with 2 slides prepared from a male, 2.0 mm).

Other material. Qld. Maekay, 1 m, *P. radiata* bait block after 4 months under jetty, L.J. Cookson, 21 Apr 1987, NMV J15425 (male, 2.8 mm, 0.7 mm wide pleotelson, with 1 slide), NMV J15426 (male, 2.8 mm, with

1 slide), NMV J15427 (non-ovig. female 2.8 mm, 0.55 mm wide pleotelson, with 1 slide); NMV J15424 (92 males, 1.8–3.0 mm, 27 non-ovig. females, 2.1–3.1 mm, 27 ovig. females, 2.3–3.5 mm, 2 juvs., 1.9, 2.2 mm). Red Wallis Island, 0.5 m, turpentine fender piles after 7 years, P. Pink, Jul 1986, NMV J15233 (male, 2.0 mm, with 1 slide), NMV J15234 (male, 2.0 mm, with 1 slide), NMV J15232 (9 males, 1.9–2.1 mm, 10 non-ovig. females, 1.9–2.0 mm, 4 juvs., 0.9–1.9 mm). Magnetie Island, Nelly Bay, *P. taeda* bait block after 2.5 months, J.V. Marshall, 15 Oct 1971, AM P38912 (male, 2.6 mm, with 1 slide), AM P38913 (male, 2.6 mm, with 1 slide), AM P38914 (non-ovig. female, 2.8 mm, with 1 slide), AM P35401 (3 males, 2.5–3.0 mm, 5 non-ovig. females, 3.0–3.2 mm, 2 juvs., 1.8, 2.1 mm). Magnetie Island, Areadia, low tide, turpentine pile stump, J.E. Barnaele, 12 Jul 1985, NMV J15219 (2); dry pulled turpentine piles on beach, NMV J15220 (6). Lady Musgrave Island, Capricorn-Bunker group, 3 m, *Melaleuca* wood block from shipwreck, L.J. Cookson and P. Gestner, 25 May 1986, NMV J15230 (ovig. female, 2.6 mm, with 1 slide), NMV J15229 (9). Wreck Reef, Cato shipwreck of 1803 (22°11'S, 155°15'E), 12 m, *Casuarina* wood wedged in reef, L.J. Cookson and W. Delany, 18 May 1988, NMV J15211 (54).

*Types*. USNM.

*Diagnosis*. Pleonite 5 dorsomedially slightly elevated longitudinally; lateral crests slightly developed on pleonite 4. Pleotelson with short dorsomedial longitudinal elevation anteriorly. Pleonite 5 0.3–0.4 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with fine spikes. Dorsal row of tubercles extend from lateral crests to posterior margin of pleotelson; margin fringed with 4 unsheathed setae between which are shorter long-sheathed setae, lacking scale spikes.

Antenna 1 with 3 flagellar articles; second article with about 18 aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible long, thin, apically recurved and fringed with several teeth. Epipod of maxilliped broad, narrowed distally, 2.6 times as long as wide, just reaching palp articulation; epipod lacking true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta present on merus of pereopod 7 and carpus of pereopods 2, 3, 4, 5, 6 and 7. Uropod peduncle with anterolateral tubercles; endopod 1.2 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.7 times length of exopod. Appendix masculina reaching tip of endopod, articulating just proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.65 times as long as

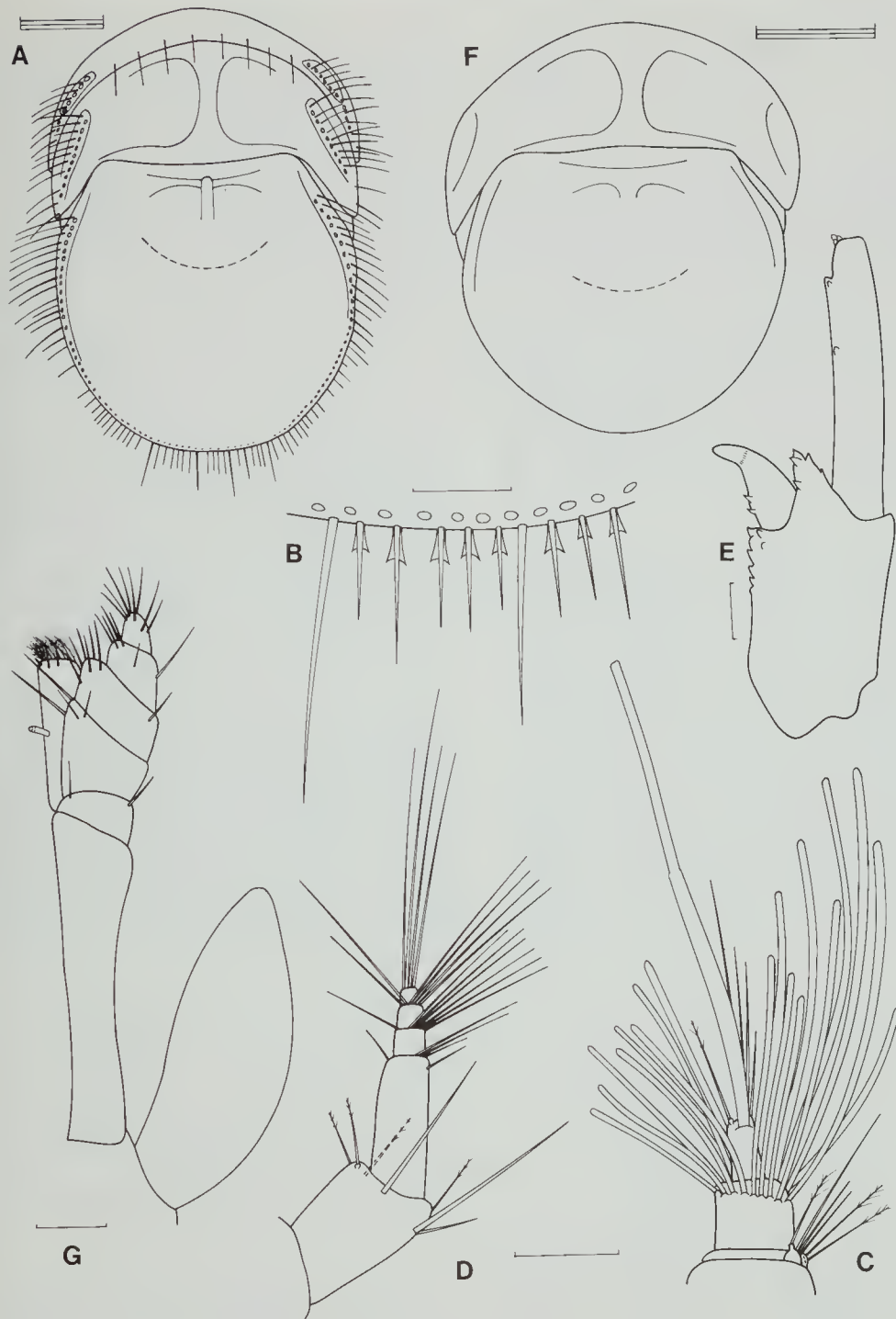


Figure 42. *Limnoria platycauda* Menzies. A-E, male, NMV J15426: A, pleonites 4, 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, flagellum of antenna 1; D, peduncle article 5 and flagellum of antenna 2; E, uropod, ventral view, setae omitted. F, G, female, NMV J15427: F, pleonite 5 and pleotelson, dorsal view, setae omitted; G, maxilliped.

endopod of pleopod 2; peduncle of pleopod 5 with comb seta laterally.

*Additional characters.* Dorsal surface of pleotelson without true setae other than near perimeter of pleotelson. Pleotelson with sexual dimorphism, region posterior to hind margin of ventral pleopodal cavity longer in males than females. Body length up to 3.5 mm. Colour in alcohol pale yellow, with dark reticulate pigment.

*Distribution.* Curaçao, West Indies (type locality); Puerto Rico (Menzies, 1957; Menzies and Glynn, 1968); Andaman Islands (Ganapati and Rao, 1960); Aldabra Atoll (Kensley, 1988); Koniya, Japan; Satta Hip, Thailand (Kühne, 1975); Admiralty Islands (Kühne, 1976); Belize (Kensley and Schotte, 1987); Cuba (Ortiz, 1983); Queensland. 0–12 m depths (current study).

*Substrates.* Greenheart timber (Menzies, 1957); mangrove root (Menzies and Glynn, 1968); wooden plank (Rao and Ganapati, 1969); red mangrove wood (Kensley and Schotte, 1987); decayed wood (Kensley, 1988); *Pinus*, *P. radiata*, *Syncarpia*, *Melaleuca*, *Casuarina* (present study).

*Remarks.* In Fig. 42 the sexual dimorphism of the pleotelson is best judged in relation to pleotelson width. In most males examined pleonite 5 is 0.3 times as long as the pleotelson. The prominence of the elevations on pleonite 5 and the pleotelson varies, in some specimens they appear as slightly raised carinae, in others as ele-

vations which gradually merge with the general surface. The epipod of the maxilliped appears longer in the figure given by Menzies (1957) than in most material examined here, including the dissected male paratype. However, the maxillipedal epipod is similarly long in some Australian specimens (e.g., NMV J15233 from Red Wallis Island). The maxillipedal epipod is also more apically rounded in some specimens.

There were some other small variations in characters between specimens. The endopod of the uropod was found to vary between 1.05–1.3 times the length of the peduncle. Plumose setae on pleopod 2 were up to 0.7–0.8 times the length of the exopod. The appendix masculina on specimens from Red Wallis Island reached beyond the endopod, and articulated just distal to the midlength of the endopod; in the dissected male paratype the appendix masculina was level with the endopod tip, and articulated midlength to the endopod. The number of aesthetascs on the second flagellar article of antenna 1 varied from 13 (paratype, some Magnetic Island specimens) to 3 (some Red Wallis Island specimens).

Menzies (1957) noted that the underlying structure of the scales on the dorsal surface of the pleotelson appeared to be hexagonal units, which were not obscured by scale spikes. In the Australian specimens, except those from Lady Musgrave Island, the scales were fringed with scale spikes. Of the 34 paratypes examined, scale spikes were present on only three specimens.

*L. platycauda* is most similar to *L. multipunctata* and *L. insulae*. These species have three

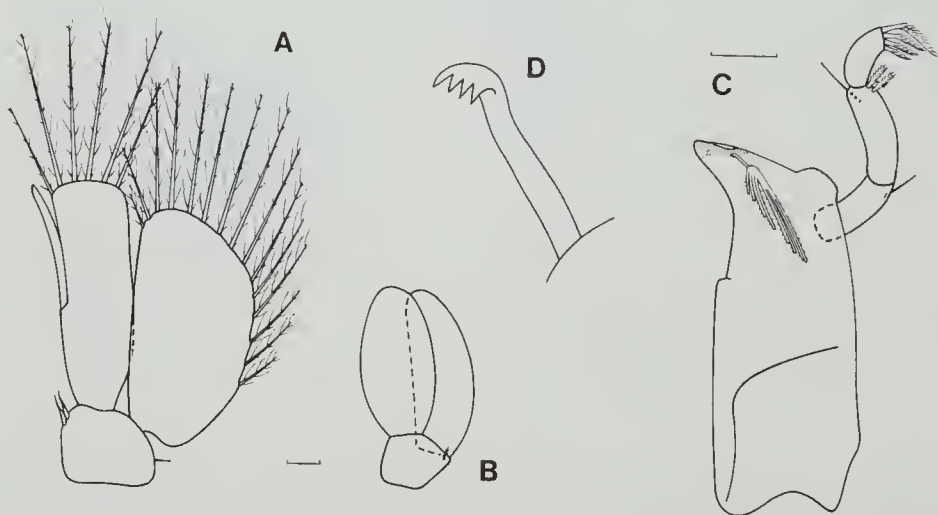


Figure 43. *Limnoria platycauda* Menzies. A–D, male, NMV J15426: A, pleopod 2; B, pleopod 5; C, right mandible; D, lacinia mobilis of right mandible.



flagellar articles on antenna 1, and four flagellar articles on antenna 2; broad maxillipedal epipods which lack true setae; similar structure on the posterior margin of the pleotelson; uropod peduncles with tubercles on the median projection between both rami; comb setae on the peduncle of pleopod 5; and, at least in some specimens, a single median carina or tuberculate row on the pleotelson or pleonite 5. The pleopods of *L. multipunctata* and *L. platycauda* are also similar.

### *Limnoria poorei* sp. nov.

Figures 44, 45

*Material examined.* Holotype: SA. NE end of West Island (35°37'S, 138°36'E). 12 m, red algae, SCUBA, G.C.B. Poore and H.M. Lew Ton, 20 Mar 1985 (stn SA 39), NMV J15337 (male, 2.1 mm, 0.45 mm wide pleotelson, with 1 slide).

Paratype: SA. NE side of Topgallant Island, Topgallant Island, Investigator Group (33°43'S, 134°36.6'E). 16 m, *Cystophora*, SCUBA, S. Shepherd and G.C.B. Poore on FV "Limnos", 22 Apr 1985, NMV J15338 (male, 1.9 mm, broken between pleonite and pereonite, with 1 slide).

*Diagnosis.* Both pleonite 5 and pleotelson lacking carinae and puncta dorsomedially; pleonite 5 0.6 times as long as pleotelson. Dorsal surface of pleotelson with scales bearing fine spikes posteriorly. Lateral crests with tuberculate swellings, tubercles with dorsal rows of scale spikes. Posterior margin of pleotelson with dorsal row of small scale spikes; margin fringed with thin scale spikes and short-sheathed setae, lacking stout setae.

Antenna 1 with 4 flagellar articles; second article with about 15 aesthetascs. Flagellum of antenna 2 with 3–4 articles. Mandibular palp with 3 articles, third article reduced, palp without comb setae. Mandibular incisors without rasp and file. Lacinia mobilis of right mandible straight, serrated. Epipod of maxilliped broad, narrowed to blunt apical point, 1.9 times as long as wide, reaching articulation of articles 1 and 2 of palp; epipod with simple true seta.

Secondary unguis of pereopod 1 undivided, with 2 spiky protuberances subproximally. Ventral comb seta absent on merus, present on carpus of pereopods 6 and 7. Uropod peduncle with small lateral tubercles, not prominent; endopod 0.9 times as long as peduncle.

Pleopod 2 with long plumose setae up to 1.2 times longer than exopod. Appendix masculina long, reaching beyond endopod tip, articulating

proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, elongated, 0.9 times as long as endopod of pleopod 2; peduncle of pleopod 5 may be without simple seta laterally.

*Additional characters.* Inner lobe of maxilla 2 with slightly sinuous medial seta. Left mandible with small lacinia mobilis, without accompanying spine row. Apical simple setae on articles 1 and 2 of mandibular palp long. Body length up to 2.1 mm. Colour in alcohol pale yellow.

*Etymology.* Named for Dr Gary C. B. Poore, Museum of Victoria, who collected this and many other species of *Limnoria*.

*Distribution.* South Australia. 12–16 m depths.

*Substrates.* Red algae, and the brown alga *Cystophora*.

*Remarks.* Although the peduncle of pleopod 5 was damaged when dissected, the lateral seta appears to be absent. The flagellum of antenna 2 has three segments in the holotype and four in the paratype.

*L. poorei* can be easily placed in the evolutionary sequence between *L. gibbera* and the group of species which have completely lost the mandibular palp, *L. uncapedis*, *L. segnoides*, and *L. bituberculata*. *L. poorei* seems most similar to *L. uncapedis*, which is also found in red algae. Both species have broad maxillipedal epipods, reduced mandibular palps, modified secondary unguis, modified (curved or sinuate) inner seta on maxilla 2, lack sculpturing on pleonite 5 and the pleotelson, and lack stout setae on the posterior margin of the pleotelson.

*L. nonsegnis* is similar to *L. poorei* in that both have a reduced mandibular palp. However, *L. nonsegnis* differs by having a narrower maxillipedal epipod, and well developed stout setae posteriorly on the pleotelson.

### *Limnoria quadripunctata* Holthuis

Figures 46–48, Plate 2d

*Limnoria quadripunctata* Holthuis, 1949: 167–172, fig. 2.—Menzies and Mohr, 1952: 81–86.—Ralph and Hurley, 1952: 15–16.—Menzies and Becker, 1957: 85–92, fig. 1.—Eltringham and Hockley, 1958: 1659–1660.—Mohr, 1959: 88–89.—McQuire, 1964: 35–44.—McQuire, 1965: 34, 36, 39.—Hall and Saunders, 1967: 1–17.—Jones et al., 1972: 105, 108–109.—Jones et al., 1976: 122, 134.—Kussakin, 1979: 316–322, figs 183–186.—Rutherford et al., 1979: 527–530.—Bultman et al., 1980: 201.—Poore, 1981: 342.—Haderlie, 1983: 182–184.—Cookson, 1987b:

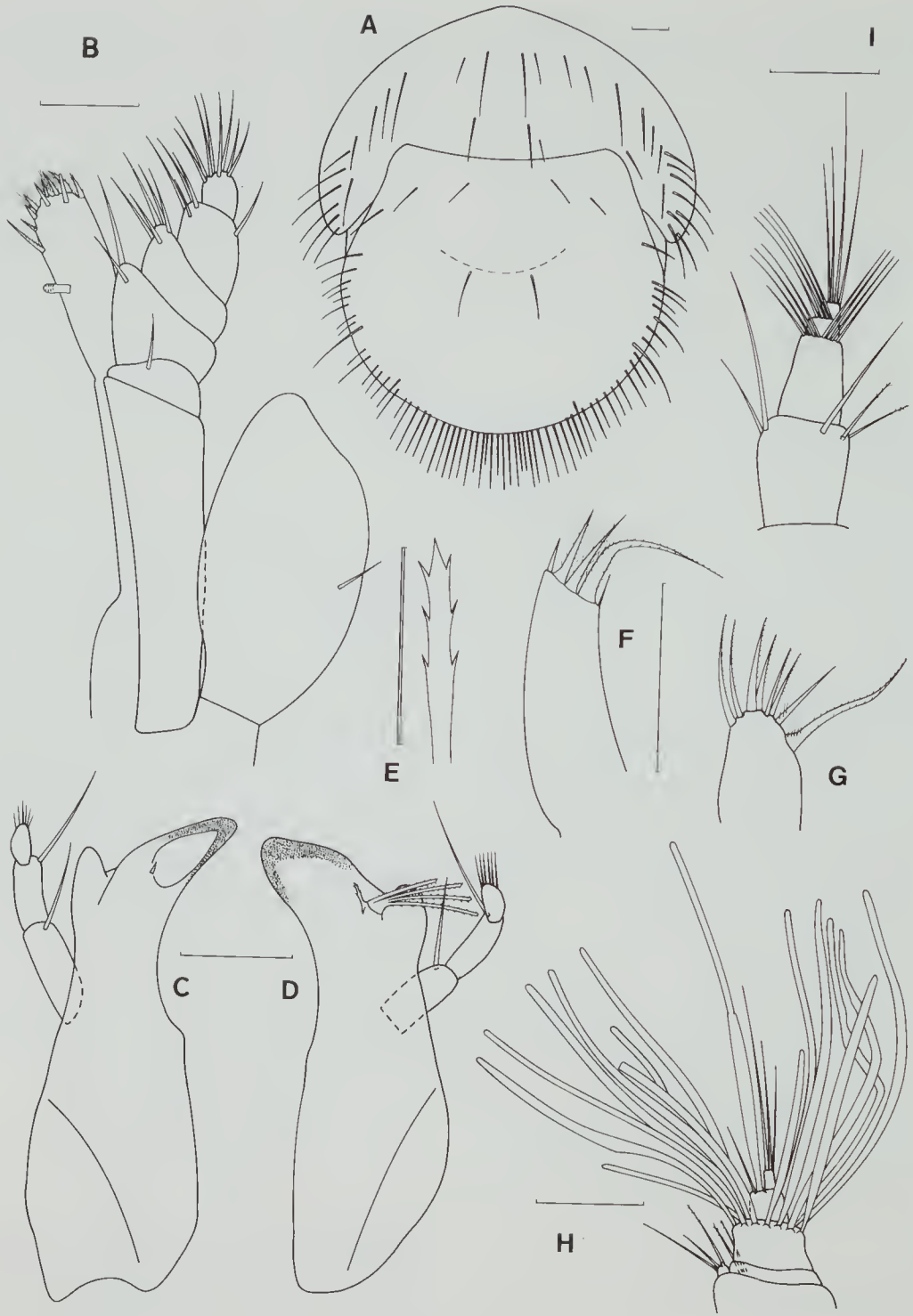


Figure 44. *Limnoria poorei* sp. nov. A, B, F-I, male, NMV J15337, holotype: A, pleonite 5 and pleotelson, dorsal view; B, maxilliped; F, inner lobe of maxilla 1; G, inner lobe of maxilla 2; H, flagellum of antenna 1; I, peduncle of antenna 2. C-E, male, NMV J15338, paratype: C, left mandible; D, right mandible; E, lacinia mobilis of right mandible.

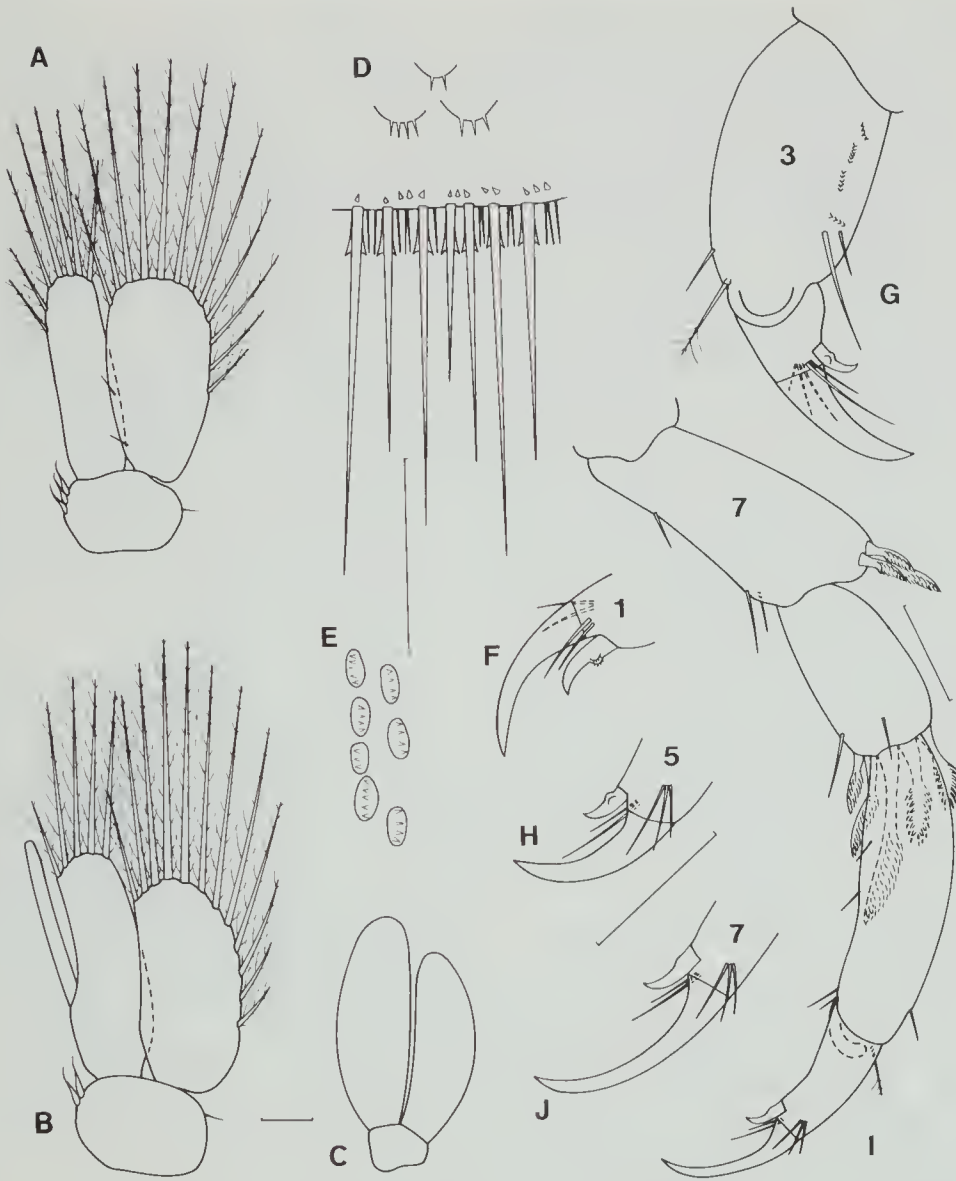


Figure 45. *Limnoria poorei* sp. nov. A-J, male, NMV J15337, holotype: A-C, pleopods 1, 2 and 5; D, posterior margin and dorsal structure of pleotelson; E, tubercles on lateral crest of pleotelson; F, unguis of pereopod 1; G, propodus and dactylus of pereopod 3; H, unguis of pereopod 5; I, distal articles of pereopod 7; J, unguis of pereopod 7; pereopods all lateral views.

85-89.—Eaton, 1988: 4.—Hicks, 1988: 646, 675.—Eaton et al., 1989: 63.  
*Limnoria (Limnoria) quadripunctata*.—Menzies, 1957: 127-133, figs 10-14 (synonymy).—Menzies, 1959: 25.—Hurley, 1961: 266, 283.—Oliver, 1962: 32-91, figs 2, 4.—Menzies et al., 1963: 97-120.—Antezana, 1968: 293-301, figs 1-3.—Schultz, 1969: 143, fig. 210.—Kühne, 1971: 71, figs 2, 6-7.—Kühne, 1975: 454.—Kühne, 1976: 545.—Barnacle et al., 1983: 1-10.

*Limnoria carinata*.—Hicks, 1988: 654, 668, 669 (probable).  
*Biology and wood preservation literature.*  
 Hoehman et al., 1956: 1-37, fig. 13.—Vind et al., 1957: 35-48, fig. 10.—Drisko and Hoehman, 1957: 325-329.—Hoehman, 1959: 45-48, fig. 5.—Eltringham, 1961a: 512-513.—Eltringham, 1961b: 785-797.—Eltringham and Hockley, 1961: 467-482.—Vind and Hochman, 1961: 1-17, fig. 1.—Jones, 1963: 589-603.—Eltringham, 1964: 675-



683.—Eltringham, 1965a: 149–157.—Eltringham, 1965b: 145–152.—Schafer, 1966: 109–115.—Anderson and Reish, 1967: 56–59.—Eltringham, 1967: 521–529.—Hochman, 1967: 138–150.—Kühne, 1968: 107–118.—Reish and Hetherington, 1969: 137–139.—Hochman, 1970: 38–42.—Eltringham, 1971: 61–67.—Hochman, 1973a: 254–255.—Cookson and Barnacle, 1985: 8.—Eaton, 1986: 356, 361.—Barnacle, 1987: 7–23.—Cookson, 1987a: 1–14.—Cookson and Barnacle, 1987a: 139–160.—Cookson and Barnacle, 1987b: 287–293.

*Material examined.* Vic, Port Phillip Bay, Brighton, pier, 0–3 m, heartwood of pulped river red gum pile, L.J. Cookson, 31 May 1983, NMV J14971 (male, 2.5 mm, 0.75 mm wide pleotelson, with 1 slide), NMV J14969 (male, 2.9 mm, with 1 slide), NMV J14970 (non-ovig. female, 2.6 mm, with 1 slide), NMV J14968 (9 males, 1.8–2.9 mm, 11 non-ovig. females, 2.1–3.3 mm, ovig. female, 2.8 mm, 14 juvs. 1.4–2.3 mm). Various depths, collectors, dates; St Kilda, *E. obliqua* L'Herit. crossbrace, NMV J15240 (262); St Kilda, eucalypt pile NMV J15238 (24); Ellwood, *E. obliqua* pile, NMV J14993 (18); Sandringham, *E. pilularis* crossbrace, NMV J14965 (25); Sandringham, river red gum pile, NMV J14901 (20); Melbourne, pine, AM P35410 (5); Williamstown, pine, AM P35411 (24); Williamstown, cellery top pine, NMV J14907 (3); South Channel Light, river red gum and jarrah piles, NMV J14898 (46); Geelong, ironbark pile, NMV J15247 (4); Point Cook, eucalypt pile, NMV J14986 (45); Seabird shipwreck, NMV J14988 (8); Queenscliff, *P. radiata* bait, NMV J15236 (26); Queenscliff, yellow stringybark piles, NMV J15237 (53); Port Arlington, river red gum piles, NMV J14908 (32); Rye, eucalypt pile, NMV J14895 (3).

Vic., west of Port Phillip Bay. Various depths, collectors, dates; Lorne, driftwood, NMV J14894 (133); Wye River, log, NMV J14990 (26); Warrnambool, *P. radiata* bait, NMV J15201 (20); Portland, pine bait, AM P35416 (28); Portland, *P. radiata* bait, NMV J14960 (42). Western Port: various depths, collectors, dates; Rhyll, *E. obliqua* pile, NMV J15255 (9); Hastings, grey gum pile, NMV J14904 (15); HMAS Cerberus, eucalypt pile, NMV J14900 (11); Sunday Island, eucalypt pile, NMV J14897 (15). E of Western Port: various depths, collectors, dates, eucalypt piles; Cape Woolamai, NMV J15246 (9); Inverloch, NMV J15202 (25); Corner Inlet, NMV J14903 (10); Port Welshpool, *E. obliqua* pile, NMV J14902 (12); Port Albert, eucalypt pile, NMV J14950 (18); Port Albert, *E. regnans* pile, NMV J14896 (28); Lakes Entrance, pine bait, AM P35409 (16); Lakes Entrance, boat, NMV J14899 (17).

Tas. Various depths, collectors, dates, pine baits; King Island, Currie, NMV J14917 (17); Deal Island, AM P35404 (7); Stanley, NMV J14916 (36); Burnie, NMV J14913–15 (131); Devonport, NMV J14911, J14912 (85); Launceston, AM P35400 (45); Port Huon, AM P35428 (18), AM P35431 (302); Hobart, CCA-treated *E. obliqua* pile, NMV J14909 (15); Hobart, *E. globulus* Labill. pile, NMV J14910 (21); Hobart, timber, TM G1063 (9); D'Entrecasteaux Channel, wood, TM G926 (2).

SA. Various depths, collectors, dates; Robe, wooden cable reel, AM P35412 (69); Port Adelaide, *P. radiata* bait, NMV J15243–44 (11); Port Lincoln, jarrah cross-brace, NMV J14989 (8); Port Lincoln, identified as *L. lignorum* by H. Hale, SAM C4199 (5 on slide); Port Lincoln, pine bait, AM P37026 (5).

WA. Various depths, collectors, dates, pine baits; Esperance, AM P37031 (8); Albany, NMV J14918–J14920 (8), NMV J14922 (1); Bunbury, NMV J14940 (1); Bunbury, AM P37027–P37030 (61), AM P37032 (26).

NSW. Various depths, collectors, dates; Eden, pine baits, AM P37023–P37025 (16); Pambula, black wattle post, NMV J14985 (12); Merimbula, eucalypt pile, NMV J14983 (56); Wallagoot Lake, log, NMV J14984 (21); Marks Point, near Newcastle, *P. taeda* bait, AM P35397 (25). Sydney Harbour: various depths, collectors, dates, pine baits; Watsons Bay, AM P35376 (1), AM P37014–P37016 (87); Rose Bay, AM P37017 (3); Cabarita, AM P35391 (12); Bantry Bay, AM P35380 (2). Goat Island, many substrates including pine, eucalypt, turpentine, *Acacia*, AM P37018–P37021 (74), AM P37033 (1), NMV J15318 (7), J15256 (12), J15261–J15262 (18), J15267 (7), J15269 (26), J15273 (55), J15277 (50).

NZ. Portobello, *P. radiata* bait block near mud-line, J.E. Barnacle and L.J. Cookson, 24 Mar 1987, NMV J14992 (male, with 1 slide), NMV J15323 (male, 3.2 mm, with 1 slide), NMV J15324 (non-ovig. female, 3.7 mm, with 1 slide), NMV J14991 (58). Auckland Harbour, from piles, determined R.J. Menzies, AM P12767 (7). Auckland Harbour, H. Larkin, 1913, AM P3865 (9). The Snares islands, Station Cove, 0.5 m, from algae in pool, C.E. Holmes, 23 Jan 1975 (stn SA 3369), NMV J678 (male, female, with 2 slides); Mollymawk Bay, 24–27 m, algae, D.S. Horning, 6 Dec 1974 (stn SA 676), NMNZ Cr. 6461 (1); Ho Ho Bay, 30 m, under algae-covered boulders on coarse shelly sand, G.D. Fenwick, 16 Jan 1977 (stn SA 3497), NMNZ Cr. 6462 (1).

England. Southsea Beach, Bramley, driftwood on beach, S.M. Cragg, Jan 1988, NMV J15296 (male, 2.9 mm, with 1 slide), NMV J15295 (3).

*Types.* USNM and Rijksmuseum van Natuurlijke, Leiden.

*Diagnosis.* Pleonite 5 dorsomedially with X-shaped earina, anterior axes longer than posterior axes. Pleotelson with 2 subparallel antero-medial earinae converging slightly posteriorly, earinae with pair of anterior and subanterior puneta; with 2 pairs of more lateral short earinae, followed by lateral crests. Pleonite 5 0.6 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with solitary scale spikes, surface pitted on pleonite 5 and anteriorly on pleotelson. Dorsal row of short scale spikes extend from lateral crests to posterior margin of pleotelson. Posterior margin with 4 large stout setae between which are short-sheathed setae and scale spikes.

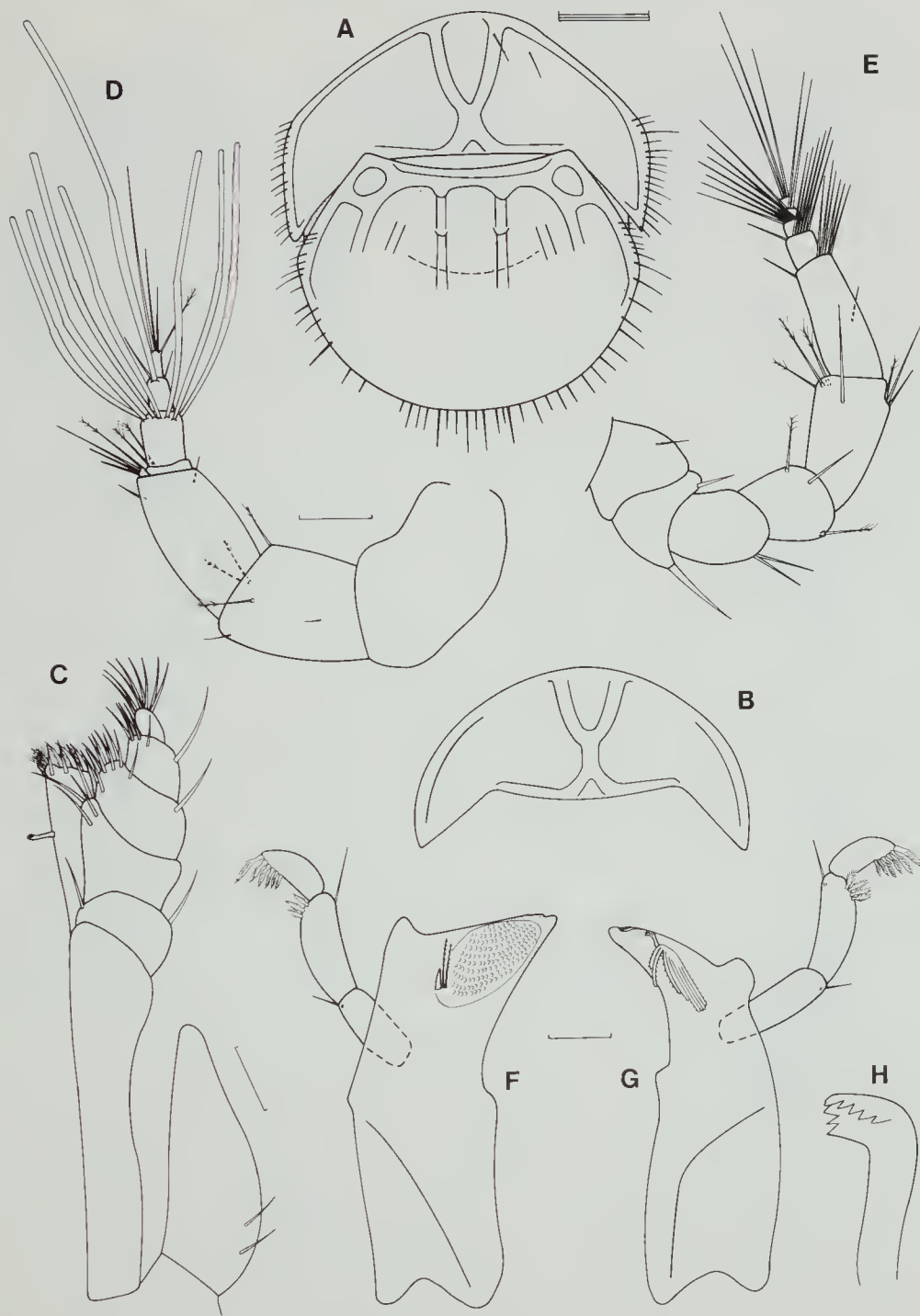


Figure 46. *Limnoria quadripunctata* Holthuis. A, C-H, male, NMV J14971: A, pleonite 5 and pleotelson, dorsal view; C, maxilliped; D, antenna 1; E, antenna 2; F, left mandible; G, right mandible; H, lacinia mobilis of right mandible. B, female, NMV J14970, pleonite 5, dorsal view, setae omitted.

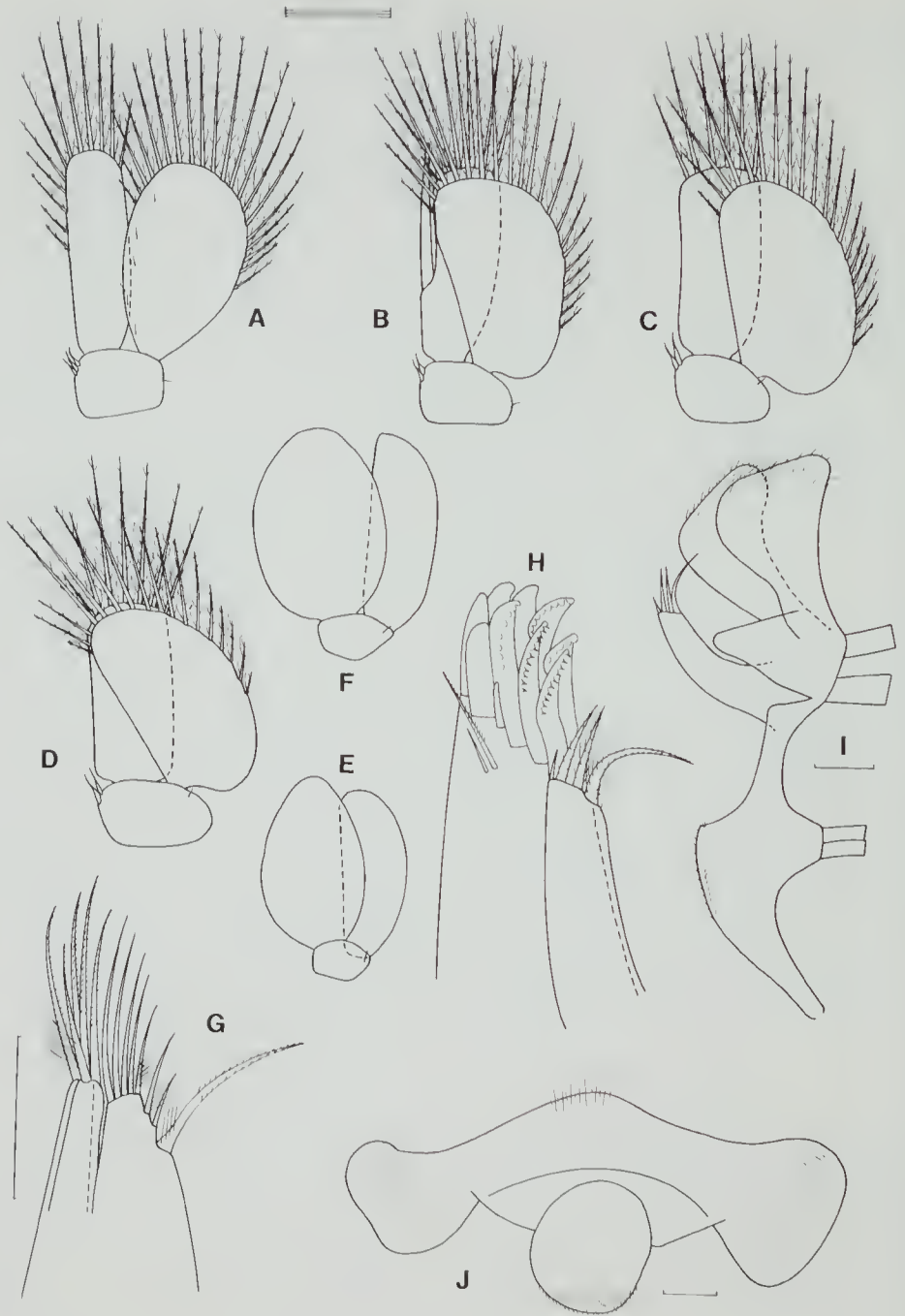


Figure 47. *Limnoria quadripunctata* Holthuis. A-E, G, H, male, NMV J14971: A-E, pleopods 1-5; G, maxilla 1; H, maxilla 2. F, male, NMV J678, pleopod 5. I, labium, with associated muscle, lateral view, also showing position of inner lobe of maxilla 1. J, male, NMV J14992, labrum and clypeus, anterior view.



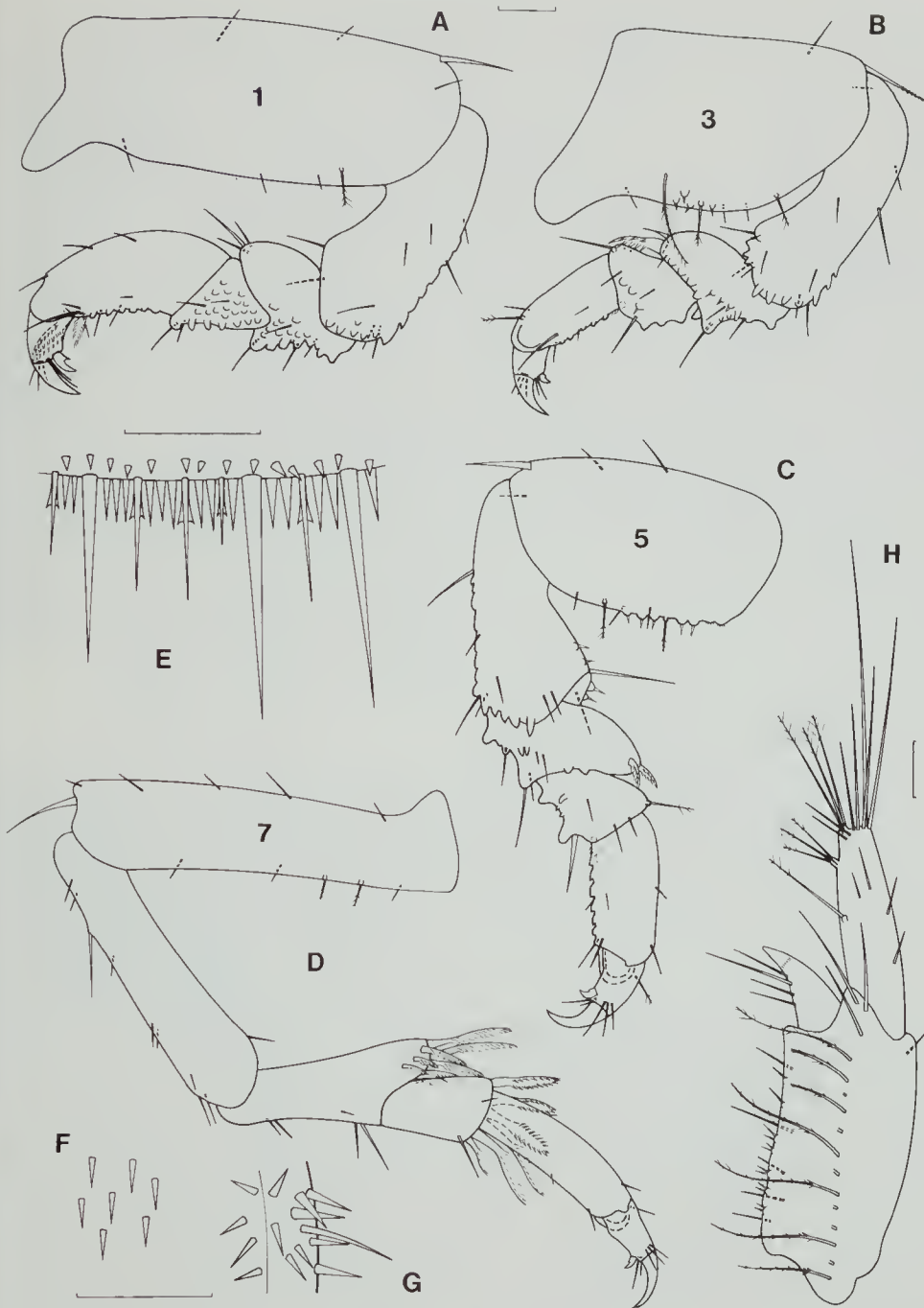


Figure 48. *Limnoria quadripunctata* Holthuis. A-H, male, NMV J14971: A-D, pereopods 1, 3, 5 and 7, lateral views; E, posterior margin of pleotelson, dorsal view; F, dorsal surface of pleotelson; G, lateral crest of pleotelson, dorsal view; H, uropod, ventral view.

Antenna 1 with 4 flagellar articles; second article with about 7 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible with fringe of teeth on apical curved process. Epipod of maxilliped triangular, 2.8 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta absent on merus, present on carpus of pereopods 2,3,4,5,6 and 7. Uropod peduncle without prominent lateral tubercles; endopod 0.8 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.8 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.85 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Body length up to 4.0 mm (Antezana, 1968). Colour in alcohol pale yellow.

*Distribution.* Widespread cool temperate distribution including: North Sea coast of Zuid-Holland near Leiden, Holland (type locality) (Holthuis, 1949); New Zealand (McQuire, 1964); California, USA (Menzies, 1957); Chile (Antezana, 1968); France (Jones et al., 1972); Trieste, Italy (Menzies and Becker, 1957); England (Jones, 1963); Tasmania, Victoria, SA, WA as far west as Bunbury, NSW north to Marks Point. 0–5 m depths; material from The Snares to 30 m (current study).

*Substrates.* Algae covered piece of driftwood (Holthuis, 1949); *P. sylvestris* (Jones et al., 1972); oak and Douglas fir (Haderlie, 1983); *P. radiata* (McQuire, 1964); CCA-treated *P. radiata* piles (Barnacle, 1987); CCA-treated wood (Barnacle et al., 1983); various untreated eucalypts, pines, *Acacia*; algae in pool and under boulders at The Snares (current study).

*Remarks.* Menzies and Becker (1957) stated that unlike *L. carinata*, the pleotelson surface of *L. quadripunctata* was not foveolate; however, SEM photographs of *L. quadripunctata* paratypes taken by M. Schotte (pers. comm.) show foveolate patterns on the pleotelson. Australian specimens also show foveolate patterns, although the degree can vary slightly within a population (Plate 2d). In some specimens, including some from The Snares (Station Cove and Mollymawk Bay), the pits are bordered by

small carinae, almost to the degree found in *L. loricata*. This character can vary within a population (such as at St Kilda, Victoria). The exact shape of the X-shaped carina on pleonite 5 can vary slightly between specimens, depending on where adjacent pits are situated.

On most specimens within a population, the anterior pair of puncta on the pleotelson are separated slightly more than the posterior pair. This situation did not occur on the figured specimen, but it was the case for most other specimens from Brighton.

The four specimens from The Snares found under rocks and amongst algae were without the attached wood debris usually associated with *L. quadripunctata*. Unlike other specimens of *L. quadripunctata* examined, The Snares specimens: lack ventral comb setae on the carpus of pereopods 2 and 3, have slightly wider than usual endopod on pleopod 5, and the dorsal row of short scale spikes on the posterior margin of the pleotelson are broader than usual. However these differences are not enough to constitute a new species, especially when so few specimens were available for examination.

#### *Limnoria raruslima* sp. nov.

Figures 49, 50

*Material examined.* Holotype: SA. North side of West Island (35°37'S, 138°36'E), 5 m, sediment at base of *Heterozostera*, SCUBA, G.C.B. Poore and H.M. Lew Ton, 21 Mar 1985 (stn SA 49), NMV J15363 (male, 3.5 mm, 0.85 mm wide pleotelson, with 1 slide).

Paratypes: Type locality. NMV J15364 (non-ovig. female, 3.5 mm, 0.8 mm wide pleotelson, with 1 slide), NMV J15365 (male, 3.6 mm, with 1 slide), NMV J15374 (male, 3.6 mm, with 1 slide), NMV J15366 (7 males, 3.2–4.5 mm, 5 non-ovig. females, 2.8–4.3 mm, 3 ovig. females, 4.0, 4.2, 4.5 mm, 3 juvs., 2.8 mm); 4 m, sand patch in *Heterozostera* meadow (stn SA 48), NMV J15367 (3 males, 2.5, 3.0, 3.5 mm, 3 non-ovig. females, 2.5, 3.1, 3.2 mm, ovig. female, 4.2 mm, 3 juvs., 1.9 (with 1 slide), 2.1, 2.2 mm).

Other material: SA. NE end of West Island (35°37'S, 138°36'E), 12 m, red algae, SCUBA, G.C.B. Poore and H.M. Lew Ton, 20 Mar 1985 (stn SA 39), NMV J15362 (non-ovig. female), Tiparra Reef, Tiparra Light, Tiparra Bay (34°4'S, 137°23'E), 5 m, *Amphibolis* and sand, SCUBA, G.C.B. Poore and H.M. Lew Ton, 15 Mar 1985 (stn SA 16), NMV J15360 (male, 2 females), Salt Creek Bay, southern shore (35°3'S, 137°44'E), low tide, sandy patches between *Posidonia* beds, dredge, G.C.B. Poore and H.M. Lew Ton, 19 Mar 1985 (stn SA 31), NMV J15361 (female).

Small forms: Vic. Western Port, (38°15.31'S, 145°22.38'E), 0 m, in sandy clay, Smith-McIntyre grab, N. Coleman et al., 8 Jan 1974 (stn WBES 1706), NMV J15388 (male, 2.0 mm, with 1 slide), NMV

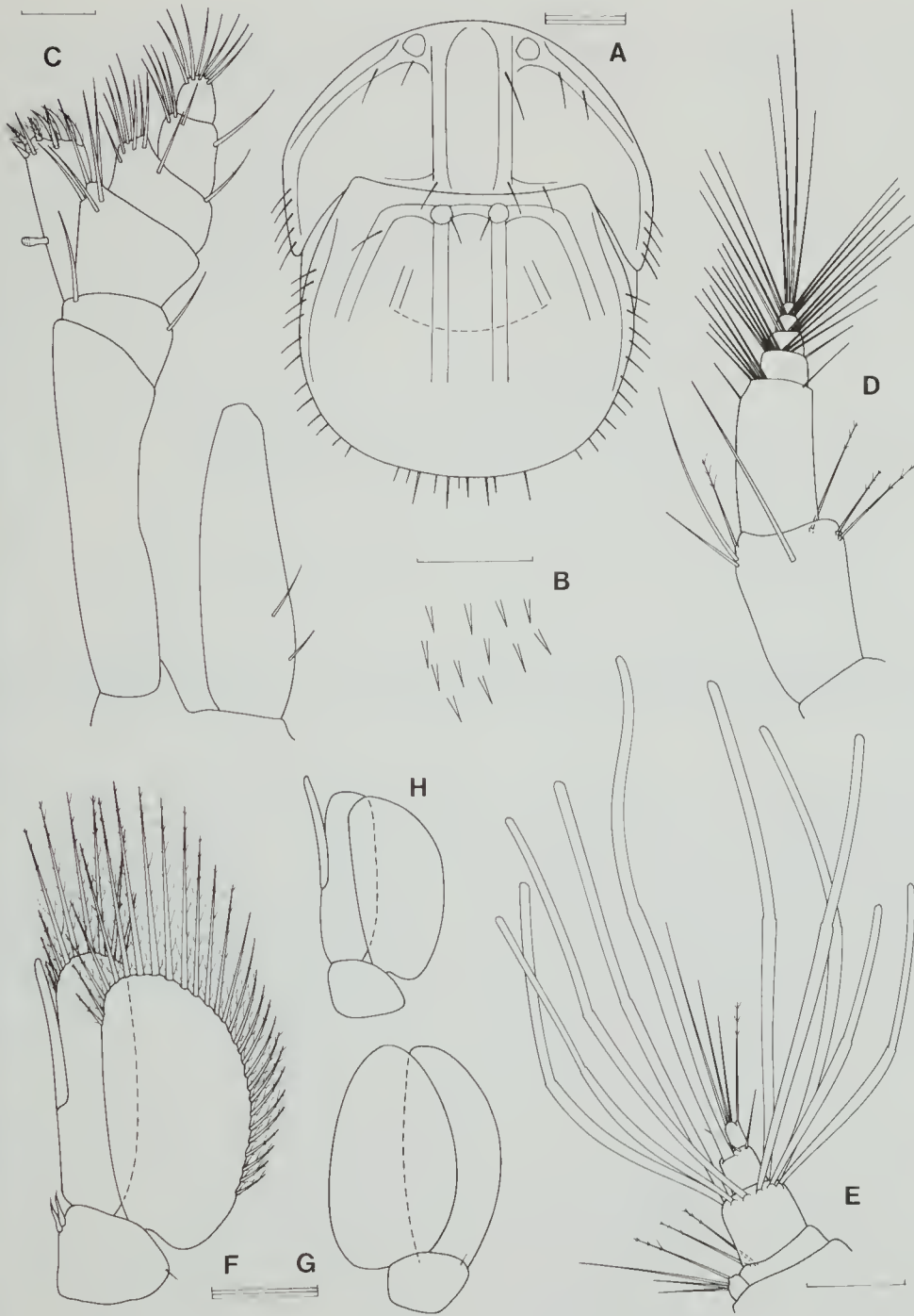


Figure 49. *Limnoria raruslima* sp. nov. A-G, male, NMV J15363, holotype: A, pleonite 5 and pleotelson, dorsal view; B, dorsal structure of pleotelson; C, maxilliped; D, peduncle of antenna 2; E, flagellum of antenna 1; F, pleopod 2; G, pleopod 5. H, male, NMV J15389, pleopod 2, setae omitted.



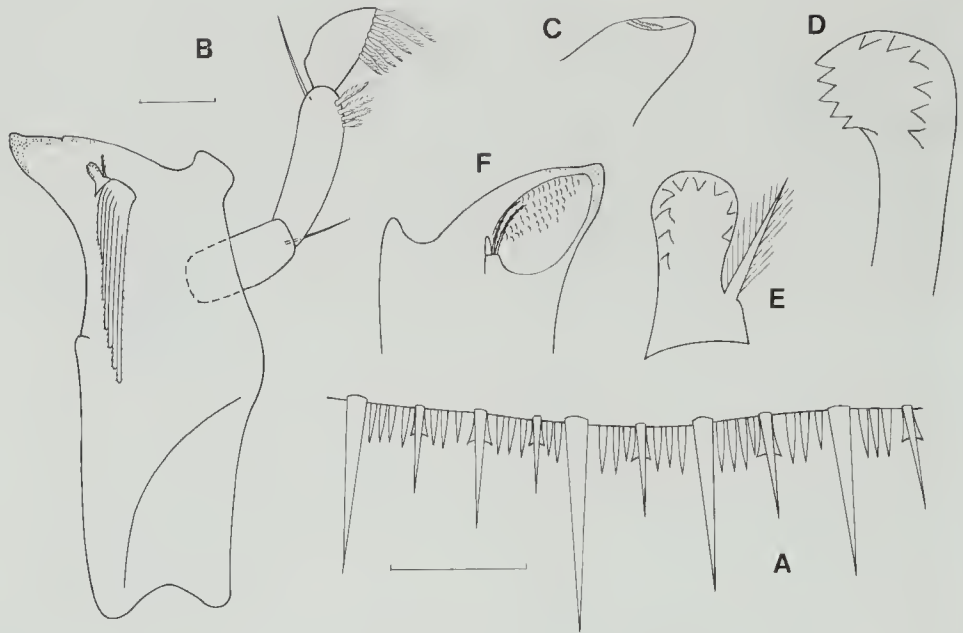


Figure 50. *Limnoria varuslima* sp. nov. A, B, E, F, male, NMV J15363, holotype: A, posterior margin of pleotelson, dorsal view; B, right mandible; E, lacinia mobilis of right mandible; F, incisor of left mandible. C, male, NMV J15374, paratype, incisor of right mandible. D, male, NMV J15365, paratype, lacinia mobilis of right mandible.

J15389 (male, 2.6 mm, with 1 slide), NMV J15390 (non-ovig. female, 1.7 mm, with 1 slide), NMV J4250 (12); (38°21.65'S, 145°15.21'E), 2 m, in sandy mud, S-M grab, A.J. Gilmour, 13 Apr 1965 (stn CPBS-S 03), NMV J15387 (male, 2.8 mm, with 1 slide), NMV J4245 (4); (38°21.17'S, 145°13.15'E), 2 m, sandy mud, S-M grab, A.J. Gilmour, 6 Apr 1965 (stn CPBS 000), NMV J4243 (2); (38°20.56'S, 145°15.08'E), 2 m, S-M grab, A.J. Gilmour, 5 Apr 1965 (stn CPBS 03N), NMV J4244 (2); (38°20.15'S, 145°15.0'E), 3 m, fine sand mud, S-M grab, A.J. Gilmour, 5 Apr 1965 (stn CPBS 10E), NMV J4246 (non-ovig. female, 3.7 mm); (38°19.98'S, 145°15.13'E), 2 m, mud and *Zostera*, S-M grab, A.J. Gilmour, 16 Mar 1965 (stn CPBS 12N), NMV J4247 (ovig. female); (38°25.53'S, 145°20.38'E), 0 m, sand, S-M grab, N. Coleman et al., 10 Jan 1974 (stn WBES 1717), NMV J4248 (crushed male); (38°25.45'S, 145°20.45'E), 0 m, silty clay, S-M grab, N. Coleman et al., 10 Jan 1974 (stn WBES 1716), NMV J4249 (2 females). Geelong Arm of Port Phillip Bay (38°9.3'S, 144°42.7'E), 3 m, sand and seagrass, S-M grab, G.C.B. Poore et al., 11 Jun 1971 (stn PPBES 953) NMV J15380 (non-ovig. female, 2.3 mm, with 1 slide), NMV J15381 (male, 3.6 mm, with 1 slide), NMV J15382 (male, 2.6 mm, with 1 slide), NMV J15383 (male, 2.7 mm, with 1 slide), NMV J13891 (4 males, 5 non-ovig. females, ovig. female), NMV J15384 (male, 2.7 mm, with 1 slide), NMV J15385 (male, 2.4 mm, with 1 slide), NMV J15386 (non-ovig. female, 2.8 mm,

with 1 slide), NMV J13890 (5 males, 6 non-ovig. females, 2 juvs.), NMV J13892 (non-ovig. female, 2.5 mm with 1 slide, juv., 1.6 mm, with 1 slide).

*Diagnosis.* Pleonite 5 dorsomedially with pair of longitudinal parallel carinae. Pleotelson with longitudinal parallel pair of long dorsomedial carinae, produced slightly anteriorly as puncta; carinae followed laterally by pair of short carinae and pair of longer carinae, as well as lateral crests. Pleonite 5 0.6 times as long as pleotelson. Dorsal surface of pleotelson composed of partly fused scales, covered with solitary scale spikes. Posterior margin of pleotelson with or without dorsal row of scale spikes; margin fringed with 4 stout setae between which are short-sheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 9 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with reduced rasp and file. Lacinia mobilis of right mandible short, apically circular, fringed with teeth. Epipod of maxilliped subtriangular, not apically pointed, 3.5 times as long as wide, just short of palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 5, 6 and 7. Uropod peduncle with small lateral tubercles; endopod 0.7 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.8 times length of exopod. Appendix masculina reaching endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, subtriangular, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Body length up to 4.5 mm. Colour in alcohol white.

*Etymology.* From the Latin for scanty (*rarus*) and file (*lima*).

*Distribution.* South Australia and Victoria. 0–12 m depth.

*Substrates.* Rhizomes of the seagrasses *Heterozostera*, *Zostera*, *Posidonia* and *Amphibolis*. Red alga also listed.

*Remarks.* The small forms of *L. raruslima* from Victoria also differ from the type material by having: an appendix masculina of variable length, which may or may not reach beyond the endopod tip; a maxillipedal epipod of variable length, although always shorter than the palp articulation; and 2–7 aesthetascs on flagellar article 2 of antenna 1, rather than about 9. Size is not sufficient to suggest a separate species as it may merely reflect slightly different habitats or food substrates. Nearly all specimens examined, including the types, were without a dorsal row of scale spikes on the posterior margin of the pleotelson; however, a few specimens were found which possessed patches of a dorsal row of scale spikes.

*L. raruslima* seems most similar to *L. sublittorale*. Both species have strongly developed longitudinal carinae on pleonite 5 and the pleotelson. Also, the pleopods are fairly similar, other than for the coupling hook sequence. A few specimens of *L. raruslima* have an interrupted row of dorsal scale spikes on the pleotelson hind margin, which approaches the condition found in *L. sublittorale*. *L. raruslima* also has similarities to *L. simulata*. Both species are seagrass-borers with reduced rasp.

*L. raruslima* may be distinguished from *L. sublittorale* by the details of the shapes of the maxillipedal epipod, endopod of pleopod 5, and the lacinia mobilis of the right mandible. Other differences are that *L. raruslima* has: a pleopod

coupling hook sequence of 32220, lateral carinae on the pleotelson, a reduced rasp and file, relatively longer pleonite 5 segment, and a different sequence of ventral comb setae on the pereopods.

### *Limnoria rugosissima* Menzies

Figures 51, 52

*Limnoria (Phycolimnoria) rugosissima* Menzies, 1957: 189, fig. 40.—Pillai, 1957: 150.—Menzies, 1959: 30.

*Limnoria quadripunctata* Holthuis.—Poore, 1981: 342 (stns SA 3459 and 893).

*Material examined.* Holotype: NSW, Port Jackson, Sydney Harbour (33°50'S, 151°15'E), C. Chilton collection, Canterbury Museum, New Zealand (male, 2.0 mm, 0.55 mm wide pleotelson).

Paratypes: Type locality, Canterbury Museum (ovig. female, 1.9 mm, 0.5 mm wide pleotelson = allotype, male dissected and figured by R.J. Menzies, 2.0 mm, male, 1.9 mm, dissected by L.J. Cookson, with 1 slide, 3 males 1.9, 1.9, 2.3 mm, 2 non-ovig. females, 2.2, 2.6 mm, 3 juvs. 1.6, 1.6, 1.7 mm).

Other material: NSW, Port Jackson, Sydney Harbour, W.A. Haswell, 1918, C. Chilton collection, identified as *L. pfefferi* by C. Chilton, Canterbury Museum (male, 2.8 mm, with 1 slide, 6 males, 2.1–2.6 mm, 4 non-ovig. females, 1.9–3.3 mm, 4 ovig. females, 2.6–3.3 mm, 2 juvs., 2.0, 2.2 mm).

SA. North side of West Island, SA (35°37'S, 138°36'E), 4 m, *Ecklonia* holdfasts, SCUBA, G.C.B. Poore and H.M. Lew Ton, 21 Mar 1985 (stn SA 45), NMV J15344 (male, 2.4 mm 0.65 mm wide pleotelson, with 1 slide), NMV J15345 (male, 2.0 mm, with 1 slide), NMV J15346 (non-ovig. female, 2.5 mm, with 1 slide), NMV J15343 (53 males, 1.7–2.6 mm, 22 non-ovig. females, 1.8–2.8 mm, 11 ovig. females, 2.3–3.1 mm, 5 juvs., 1.4–1.6 mm). "The Hotspot", reef 5 n. miles W of north end of Flinders Island (33°40.5'S, 134°22'E), 17 m, *Cystophora* holdfasts on exposed rock bottom, G.C.B. Poore, 19 Apr 1985 (stn SA 61), NMV J15439 (non-ovig. female, 2.2 mm, with 1 slide).

Vic. Aireys Inlet, in tan coloured haptera (not old dark brown or fresh green haptera) of *Ecklonia radiata* holdfast drift on beach, L.J. Cookson, 30 Mar 1988, NMV J15319 (male, 1.9 mm, juv., 0.9 mm).

Tas. Maria Island, 500 m W of Darlington (42°35'S, 148°2'E), 30 m, algal and drift holdfast epifauna, trawl, R.S. Wilson, 23 Mar 1985 (stn TAS 27), NMV J15348 (male, 2.8 mm, with 1 slide), NMV J15349 (male, 2.5 mm, with 1 slide), NMV J15350 (non-ovig. female, 2.4 mm, with 1 slide), NMV J15347 (male, 2.6 mm, 2 non-ovig. females, 2.2, 2.5 mm).

NZ. The Snares. NW corner of Ho Ho Bay, 14 m, among clumps of concentric crustose coralline algae, G.D. Fenwick, 19 Dec 1976 (stn SA 3459), NMV J677 (2 males, 2.4, 2.6 mm, with 1 slide of 2.6 mm specimen). E end of Seal Point, 2–4 m, brown algae, D.S.

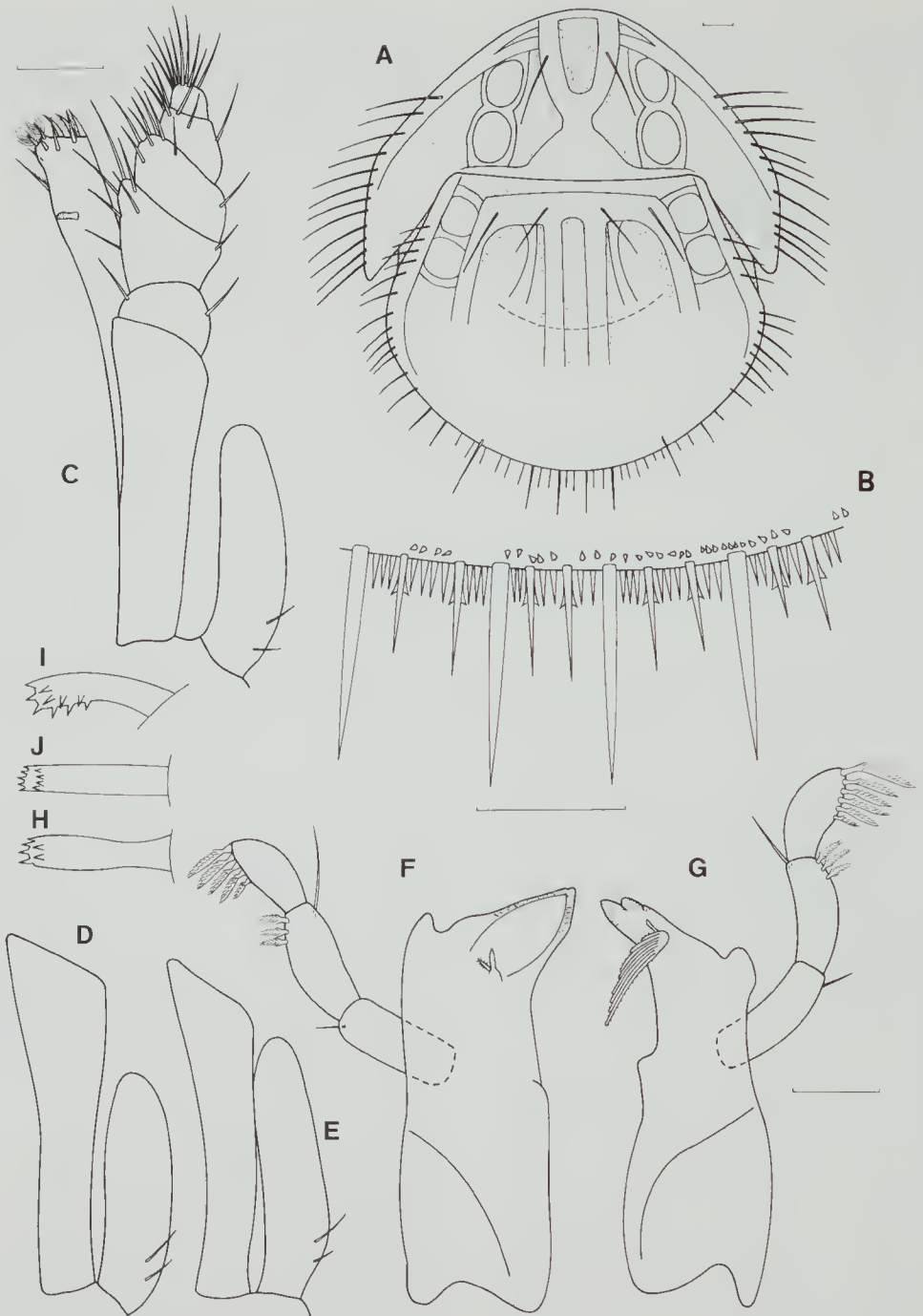


Figure 51. *Limnoria rugosissima* Menzies. A–C, F–H, male, NMV J15344: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; F, left mandible; G, right mandible; H, lacinia mobilis of right mandible. D, J, male, NZNM: D, epipod and basis of endopod of maxilliped; J, lacinia mobilis of right mandible. E, I, male, Canterbury Museum, paratype: E, epipod and basis of endopod of maxilliped; I, lacinia mobilis of right mandible.



Horning, 1 Feb 1975 (stn SA 893), NMNZ Cr. 6459 (juv., 1.6 mm, with 1 slide).

**Diagnosis.** Pleonite 5 dorsomedially with Y-shaped carina with splayed base, with less distinct figure 8-shaped carinae more laterally. Pleotelson with pair of longitudinal parallel dorsomedial carinae, followed laterally by 2 pairs of short carinae, and lateral crests. Pleonite 5 0.6 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with solitary scale spikes, with pits anteriorly. Posterior margin of pleotelson with dorsal row of scale spikes; margin fringed with 4 large stout setae between which are short-sheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 12 aesthetases. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors without rasp and

file; incisor of right mandible deeply cleaved. Lacinia mobilis of right mandible small, with small apical teeth. Epipod of maxilliped strap-like, 3.7 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 5, 6 and 7. Uropod peduncle with small lateral tubercles; endopod 1.1 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.8 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval but produced medially, 0.85 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

**Additional characters.** Lacinia mobilis of left

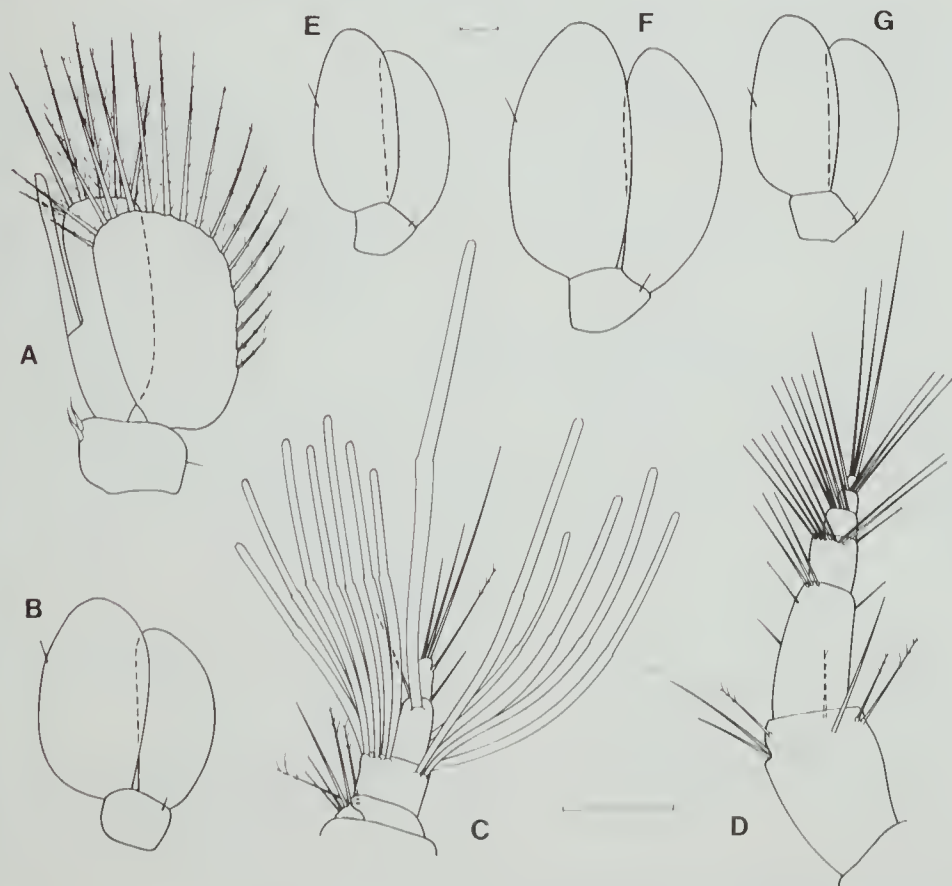


Figure 52. *Limnoria rugosissima* Menzies. A-D, male, NMV J15344: A, pleopod 2; B, pleopod 5; C, flagellum of antenna 1; D, peduncle article 5 and flagellum of antenna 2. E, male, NMV J677, pleopod 5. F, male, NMV J15348, pleopod 5. G, male, paratype, pleopod 5.

mandible accompanied by only 1 very short serrated seta. Endopod of pleopod 5 with medial simple seta near midlength. Body length up to 3.3 mm. Colour in alcohol pale yellow, some specimens with small amount of brown-blue reticulation (approaching condition of *L. glaucinosa*).

*Distribution.* Port Jackson, NSW (type locality) (Menzies, 1957); SA, Victoria, Tasmania; The Snares, New Zealand. 0–30 m depths (current study).

*Substrates.* *Ecklonia* holdfasts, *Cystophora* holdfasts, coralline algae (present study).

*Remarks.* The sculpture on pleonite 5 and the pleotelson of *L. rugosissima* is more regular in pattern than indicated by Menzies (1957). The distinctiveness of the sculpturing can vary between populations and individuals within a population. On specimen NMV J15439, the carinae on pleonite 5 cannot be clearly seen. The types are not in good condition, however accompanying specimens collected from Sydney Harbour, possibly from the same original lot, are in good condition and the sculpture pattern very clear.

Menzies (1957) did not know the substrate of *L. rugosissima*, however he correctly surmised, based on the lack of a rasp and file, that it was algae.

*L. rugosissima* appears most similar to *L. eclidna*. *L. rugosissima* may be distinguished by finer details of the sculpturing on pleonite 5 and the pleotelson, shape of the lacinia mobilis of the right mandible, cleaved incisor on the right mandible, presence of a dorsal row of scale spikes on the posterior margin of the pleotelson, reduced spine row on left mandible, and the presence of a simple seta on the endopod of pleopod 5.

### *Limnoria stephensi* Menzies

#### Figure 53

*Limnoria antarctica* Pfeffer.—Halc, 1937: 21–23, fig. 6.

?*Limnoria pfefferi* Stebbing.—Stephensen, 1927: 361–362.

*Limnoria (Phycolimnoria) stephensi* Menzies, 1957: 189–191, figs 41–42.—Pillai, 1957: 150.—Menzies, 1959: 27.

*Limnoria stephensi*.—Hicks, 1990: 451–456.—Wolff, 1990: 311–318.

*Material examined.* Lectotype (selected by Wolff, 1990): 1 mile east of Auckland Island, NZ (50°35'S, 166°E), in floating "*Lessonia*", T. Mortensen expedition, 28 Nov 1914, Zoologisk Museum, Copenhagen (male, 6.9 mm).

Paralectotypes: Type locality, NMV J17240 (male, 4.3 mm, non-ovig. female, 4.5 mm).

Other material. Macquarie Island. Handspike Point, intertidal holdfasts of *Durvillaea antarctica*, D.S. Horning and J.K. Lowry, 21 Dec 1977 (stn MA 135), NMV J15421 (male, 5.0 mm, 1.8 mm wide pleotelson, with 1 slide), NMV J15422 (male, 6.2 mm, with 2 slides), NMV J15423 (ovig. female, 8.5 mm, with 1 slide), NMV J15400 (122 males, 3.7–8.7 mm, 91 non-ovig. females, 5.0–7.5 mm, 12 ovig. females, 7.0–7.5 mm, 62 juvs., 2.0–4.5 mm), SE corner of Gorilla Head Rock, 8 m, small exposed *D. antarctica* holdfast, SCUBA, J.K. Lowry, 23 Dec 1977 (stn MA 147), NMV J15395 (male), 19 Oct 1983 (stn CI 1), NMV J15445 (12 males, 5 non-ovig. females, 3 ovig. females up to 8.7 mm, 6 juvs.), 19 Oct 1983 (stn CI 6), NMV J15446 (11 males, 9 non-ovig. females, 5 ovig. females). Kelp root washing, R. Kenny, 7 Feb 1949, WAM (1). Roots of kelp, SAM C4104 (ovig. female, 10 juvs., incorrectly identified as *L. antarctica* by H. Hale). Roots of kelp, Aug 1913, SAM C4105 (4 males, 3 females).

Marion Island (46°54'S, 37°45'E), intertidal, holdfasts of *Durvillaea antarctica*, P.G. Haxen, 4 Aug 1979, NMV J17241 (5).

*Types.* Zoologisk Museum, Copenhagen, and NMV.

*Diagnosis.* Pleonite 5 convex dorsomedially, both pleonite 5 and pleotelson without dorsomedial carinae and puncta. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson composed of indistinct partly fused scales which bear single scale spike; with 2 groups of irregular patches clear of scale spikes located submedially just proximal to midlength of pleotelson. Posterior margin of pleotelson with dorsal row of short blunt scale spikes in clusters of 2–5; margin fringed with more than 20 stout setae between which are small unsheathed (vestigial sheathed) setae and thin scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 9 short aesthetascs. Flagellum of antenna 2 with 4 articles. Mandibular palp with 3 articles. Mandibular incisors without rasp and file. Lacinia mobilis of right mandible with 2 serrated branches. Epipod of maxilliped strap-like, 4.2 times as long as wide, reaching beyond palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid, ventral branch very short; with small seta near branching point. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 5, 6 and 7. Uropod peduncle without lateral tubercles; endopod 0.8 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.5 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 without seta laterally.

*Additional characters.* Articles 1 and 2 of mandibular palp with more than 1 simple seta. Incisor of right mandible with 3 cusps. Body length up to 9.8 mm. Colour in alcohol pale yellow.

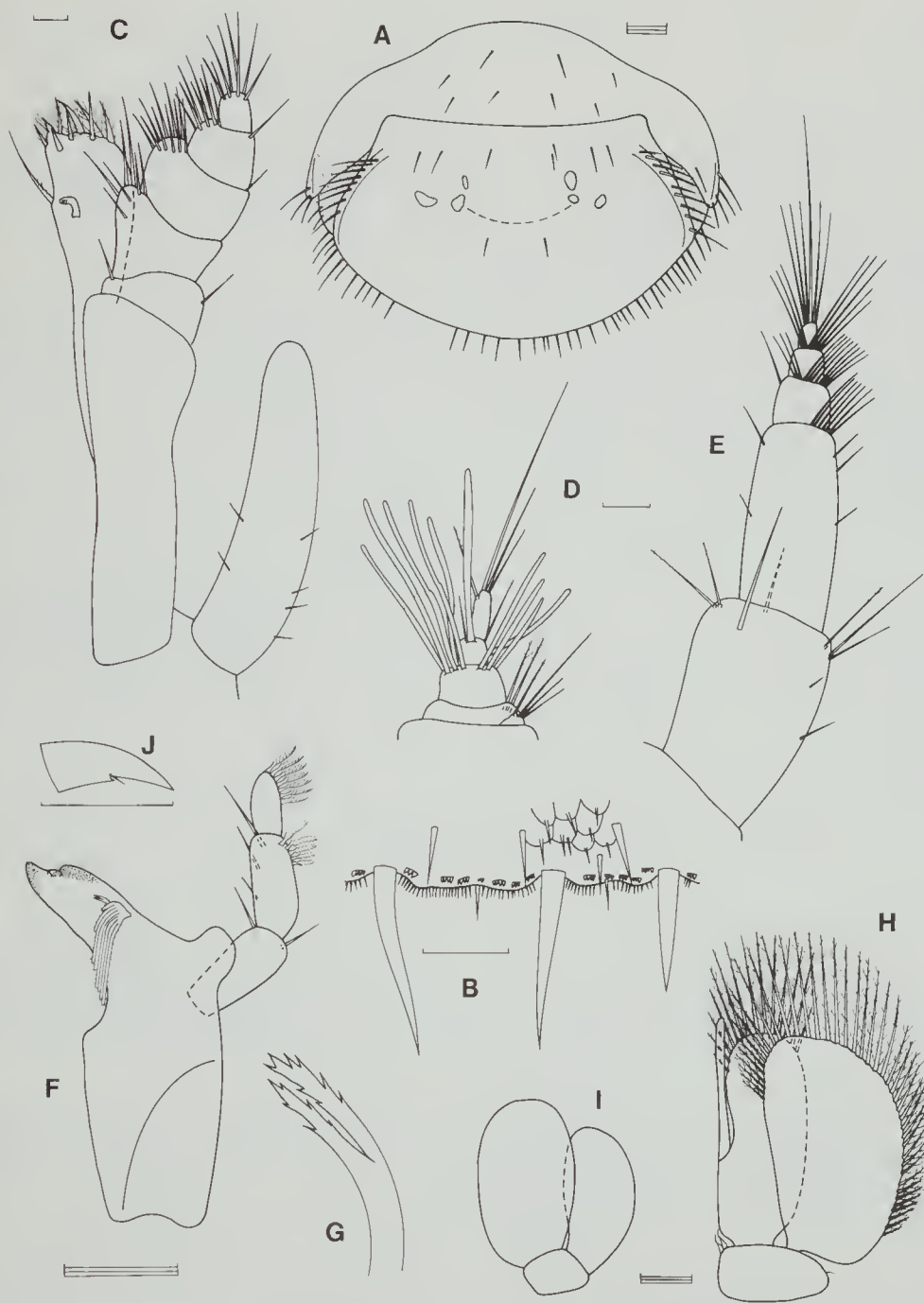


Figure 53. *Limnoria stephenseni* Menzies. A-J, male, NMV J15421: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; D, flagellum of antenna 1; E, peduncle of antenna 2 and flagellum of antenna 2; F, right mandible; G, lacinia mobilis of right mandible; H, pleopod 2; I, pleopod 5; J, secondary unguis of pereopod 1.



*Distribution.* Auckland Islands (type locality); Macquarie Island (Menzies, 1957; current study); Marion Island (Wolff, 1990). 0–8 m depths (current study).

*Substrates.* Floating *Lessonia* (Stephensen, 1927), *Macrocystis* holdfasts (Hale, 1937); *Durvillaea antarctica* holdfasts (Wolff, 1990; present study).

*Remarks.* The longest specimen examined by Menzies (1957) was an 8.0 mm female. From Macquarie Island there is a male 8.7 mm long. From Marion Island there is a male 9.8 mm long (Wolff, 1990). Previously the largest limnoriid species known was *L. magadanensis* at 8.5 mm (Jesakova, 1961).

Menzies (1957) did not mention the dorsal row of scale spikes on the posterior margin of the pleotelson, although the fringing posteriorly directed stout setae with small scale spikes between them were noted. This dorsal row was found on all specimens examined here, although on the types the row was absent in patches. The lacinia mobilis of the right mandible was also stated to be undivided (Menzies, 1957) rather than bifid. The lacinia mobilis of the male paralectotype was bifid, although the branches were closed together.

Menzies (1957) assigned the specimens identified as *L. antarctica* by Chilton (1914a) and Hale (1937) to *L. stephenseni*, based on their figures of uropods which showed a shorter exopod than Menzies found on *L. antarctica*. However, uropod length can be variable and the exopod of *L. antarctica* in Fig. 13 is 0.5 times the endopod length, a condition Menzies thought belonged to *L. stephenseni*. The specimens identified by Chilton (1914a) were *L. antarctica*, while Hale's specimens were *L. stephenseni*. Menzies (1957) noted that specimens from the Deception and South Shetland Islands also may not be *L. antarctica* as was determined by Richardson (1913).

*L. stephenseni* is most similar to *L. antarctica*. The similarities are: the strap-like maxillipedal epipod, four flagellar articles on antennae 1 and 2, strongly indented incisors on the right mandible, article 2 of the mandibular palp with more than one simple seta (*L. glaucinosa* also), short uropodal endopods, lack of sheathed setae on the posterior margin of the pleotelson, similar pleopod 5 shapes, large relatively oval bodies, and antarctic habitats. *L. stephenseni* has more apomorphic characters than *L. antarctica* as it has lost the sculpturing on the abdominal segments, has a modified secondary unguis on pereopod 1 (as does *L. segnis* and *L. chilensis*), and stout setae have replaced sheathed setae along the entire hind perimeter of the pleotelson.

In some specimens the pleotelson also has oblique grooves near the patches that lack large scale spikes, grooves similar to those found in *L. glaucinosa*.

### *Limnoria sublittorale* Menzies

#### Figure 54

*Limnoria (Limnoria) sublittorale* Menzies, 1957: 175–178, fig. 34.—Menzies, 1959: 23.

*Material examined.* Holotype: NSW. Off coast, 110 m, from Oregon fir timber forming part of the frame of otter board of otter fish trawl net, retrieved by trawler, F.A. McNeill, AM P12765 (male, 5.0 mm, 1.3 mm wide pleotelson).

Paratype: Type locality, AM P38932 (male, 4.0 mm, cephalon and uropod previously dissected and now missing, with 1 slide of pleopods). Description of mandibular incisors and lacinia mobilis based on Menzies (1957).

*Diagnosis.* Pleonite 5 dorsomedially with pair of parallel longitudinal carinae. Pleotelson with pair of parallel longitudinal dorsomedial carinae, with small anterior puncta. Pleonite 5 0.45 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, covered with solitary scale spikes, surface not pitted. Posterior margin of pleotelson with dorsal row of scale spikes; margin fringed with 4 stout setae between which are short-sheathed setae and scale spikes.

Antenna 1 with 4 flagellar articles. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible with 2 recurved apical teeth. Epipod of maxilliped triangular, 3.1 times as long as wide, reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 2, 3, 4, 5, 6, and 7. Uropod peduncle with small lateral tubercles; endopod 0.9 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.6 times length of exopod. Appendix masculina reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Pleopods 1–4 each with 3 coupling hooks. Body length up to 5.0 mm. Colour in alcohol pale yellow.

*Distribution.* Off the NSW coast (type locality). 110 m depth.

*Substrate.* Oregon (*Pseudotsuga menziesii* (Mirb.) Franco).

*Remarks.* Only two specimens of *L. sublittorale* are known. *L. sublittorale* may be restricted to deeper waters off NSW. It has not been collected from the many timbers sampled on the NSW coast at 0–3 m depths.

Menzies' (1957) figure of the setae on the posterior margin of the pleotelson did not indicate

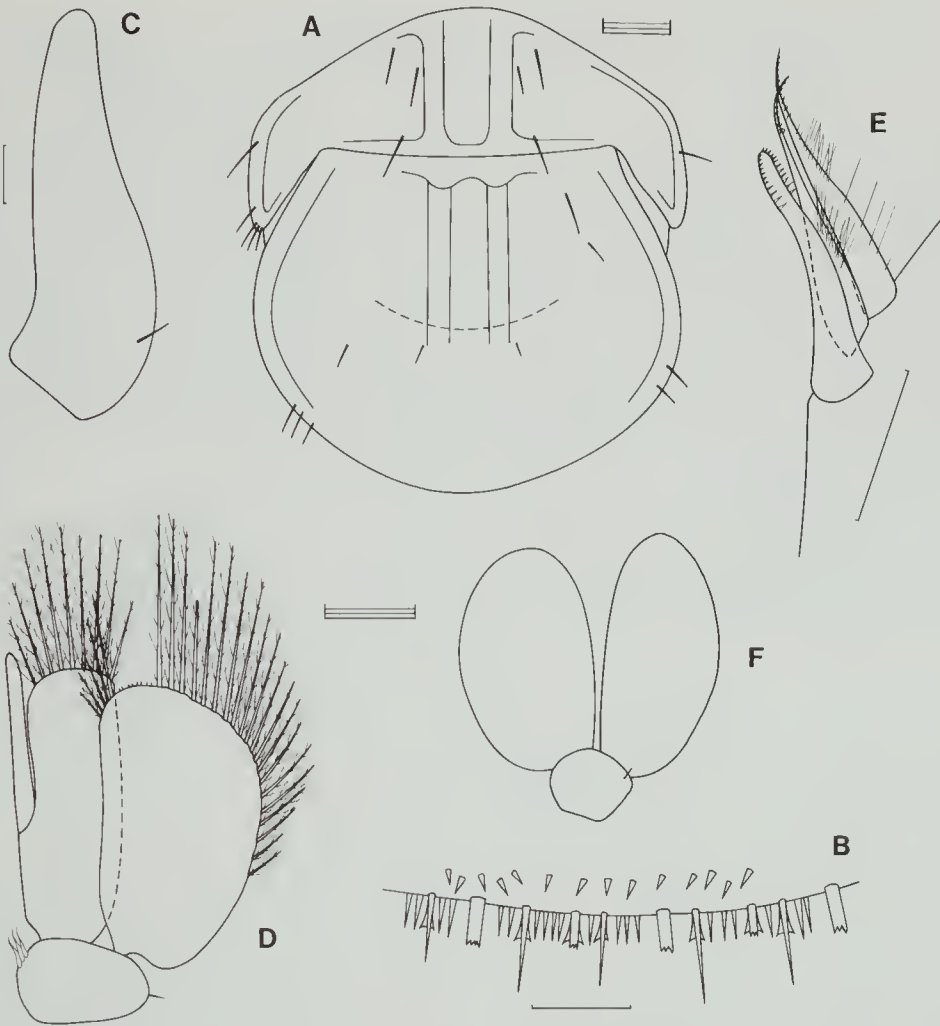


Figure 54. *Limnoria sublittorale* Menzies. A, B, D–F, male, AM P38932, paratype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, stout setae broken, dorsal view; D, pleopod 2; E, coupling hooks on pleopod 2; F, pleopod 5. C, male, AM P12765, holotype, epipod of maxilliped.

that some of the setae were sheathed. The presence of three coupling hooks on pleopods 1–4, on both specimens, was also not noted.

*L. sublittorale* is similar to *L. raruslima*, *L. reniculus*, *L. indica* females, *L. saseboensis* and *L. foveolata* in that all species have a longitudinal pair of carinae on both pleonite 5 and the pleotelson, and a triangular or subtriangular maxillipedal epipod. *L. sublittorale*, *L. reniculus*, *L. indica*, *L. saseboensis* and *L. foveolata* also have a similar lacinia mobilis of the right mandible, as they have two or several large apical teeth. *L. sublittorale*, *L. reniculus*, *L. foveolata* and *L. raruslima* all lack tubercles on the margins of the pleotelson. *L. sublittorale* seems

most similar to *L. reniculus* as both species also have three coupling hooks on pleopod 2, and are large deep-sea wood-borers from the Tasman Sea. The two species may be most readily separated by sculptural differences on pleonite 5 and the pleotelson.

#### *Limnoria torquisa* sp. nov.

Figures 55–57

*Material examined.* Holotype: Vic. Aireys Inlet (38°28'S, 144°6'E), extracted from *Hormosira banksii* with Pronoxfish (rotenone), W.F. Seed, 23 Jan 1968, NMV J15377 (male, 2.2 mm, 0.55 mm wide pleotelson, with 1 slide).

Paratypes: Type locality, NMV J15378 (male, 2.3 mm, with 1 slide), NMV J15379 (ovig. female, 3.0 mm, with 1 slide), NMV J13895 (5 males, 1.8–2.1 mm, 3 non-ovig. females, 1.9, 2.0, 2.1 mm, 2 ovig. females, 2.1, 2.2 mm).

Other material: Vic. Bunurong Coast, The Oaks (38°40'S, 145°38'E), algae in LWM rock pools, G.C.B. Poore, 5 Mar 1982 (stn CPA 21), NMV J15372 (male, 2.0 mm); algae in rock pools, NMV J12892 (male, juv.); Harmers Haven (38°40'S, 145°35'E), algae on LWM rocks, G.C.B. Poore, 6 Mar 1982 (stn CPA 23), NMV J12888 (non-ovig. female, 2.5 mm). Eagles Nest, Venus Bay (38°40'S, 145°40'E), from algae on rocks at low tide, G.C.B. Poore, 5 Mar 1982 (stn CPA 19), NMV J12884 (male, 1.6 mm). 75 m SW of Eagles Nest, Venus Bay (38°40'S, 145°40'E), 8 m, rocky habitat, SCUBA, R. Wilson and G. Barber, 5 Mar 1982 (stn CPA 3), NMV J12886 (crushed juv.). Apollo Bay, rock pools, W.F. Seed, 22 Dec 1970, NMV J15373 (male). Marengo, near Apollo Bay, W.F. Seed, 28 Dec 1970, NMV J13897 (2 males, 4 non-ovig. females, 2 ovig. females). Shoreham, from old and living colonies of *Galeolaria*, W.F. Seed, 28 Feb 1957, NMV J13893 (male, 1.8 mm, non-ovig. female 2.8 mm); under encrusting calcareous algae, W.F. Seed, 28 Feb 1959, NMV J13898 (male).

**Diagnosis.** Pleonite 5 and pleotelson dorso-medially without carinae and tubercles. Pleonite 5 0.7 times as long as pleotelson. Dorsal surface of pleotelson composed of scales fringed posteriorly with fine scale spikes. Posterior margin of pleotelson with dorsal row of small scale spikes; margin fringed with 6 very long stout setae between which are short-sheathed and scale spikes.

Antenna 1 with 3 flagellar articles; second article with about 8 aesthetascs. Flagellum of antenna 2 with 4 articles, article 4 very short. Mandibular palp with 3 articles. Mandibular incisors without rasp and file. Lacinia mobilis of right mandible unbranched, bent at midlength, serrated. Epipod of maxilliped club-shaped, 3.9 times as long as wide, reaching beyond palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 long, bilid, but ventral branch with 2 small branches. Ventral comb seta absent on merus, present on carpus of pereopods 5, 6 and 7. Uropod peduncle without lateral tubercles; endopod as long as peduncle.

Pleopod 2 with long plumose setae up to 0.9 times length of exopod. Appendix masculina long, reaching beyond endopod tip, articulating proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.6 times as long as endopod of pleopod 2; peduncle of pleopod 5 without setae laterally.

**Additional characters.** Body shape wide. On maxilliped, articulation of palp with basis of endopod indistinct, suggesting partial fusion. Lacinia mobilis of left mandible accompanied by only 1 serrated seta in spine row. Endopod of pleopod 5 with proximomedial simple seta. Endopod of uropod with 4–5 well developed proximally bifurcate pappose setae. Some paratypes with uropod exopod claw smaller than figured, even absent. Basis of pereopod 4 with many well developed proximally bifurcate pappose setae. Secondary unguis on all pereopods with accessory branches or spinules. Pereopods, especially pereopod 4, with many spines and spikes; pereopods 2–6 with large ventral apical spine seta on propodus opposing secondary unguis. Body length up to 3.0 mm. Colour in alcohol white.

**Etymology.** From the latin *torquis*, necklace, named for one of the host plants, Neptune's necklace (*Hormosira banksii*).

**Distribution.** Victoria. Mainly rock pools in tidal zone on beaches, also at 8 m depth.

**Substrates.** May feed on algal surfaces and films without boring, found on *Hormosira*, *Galeolaria*, and under encrusting algae.

**Remarks.** *L. torquisa* was often found with *L. glaucinosa*.

The pereopods of *L. torquisa*, especially pereopod 4, have many spines and appear well suited for clinging to various substrates in the tidal zone. This would be important if it was not enclosed in a burrow. The body shape is wider than the tubular shape commonly found for burrow dwelling species. An exposed habitat may also explain the presence of the pappose (possibly sensory) setae on pereopod 4 and the uropod peduncle. The well developed spines on the propodus of the pereopods in some ways parallel the barbs found on the propodus of *L. uncapedis*, although in *L. torquisa* the spines have developed from setae while in *L. uncapedis* the barbs are projections of the integument.

*L. torquisa* is most similar to *L. nonseguis*, although with more plesiomorphic characters such as a fully developed mandibular palp and relatively longer pleonite 5. Both species are similar in that they have six stout setae on the posterior margin of the pleotelson, although these are much longer in *L. torquisa* where they may no longer be required for bracing the pleotelson in burrows. Both species also have a club-shaped maxillipedal epipod, similarly serrated lacinia mobilis of the right mandible, and simi-



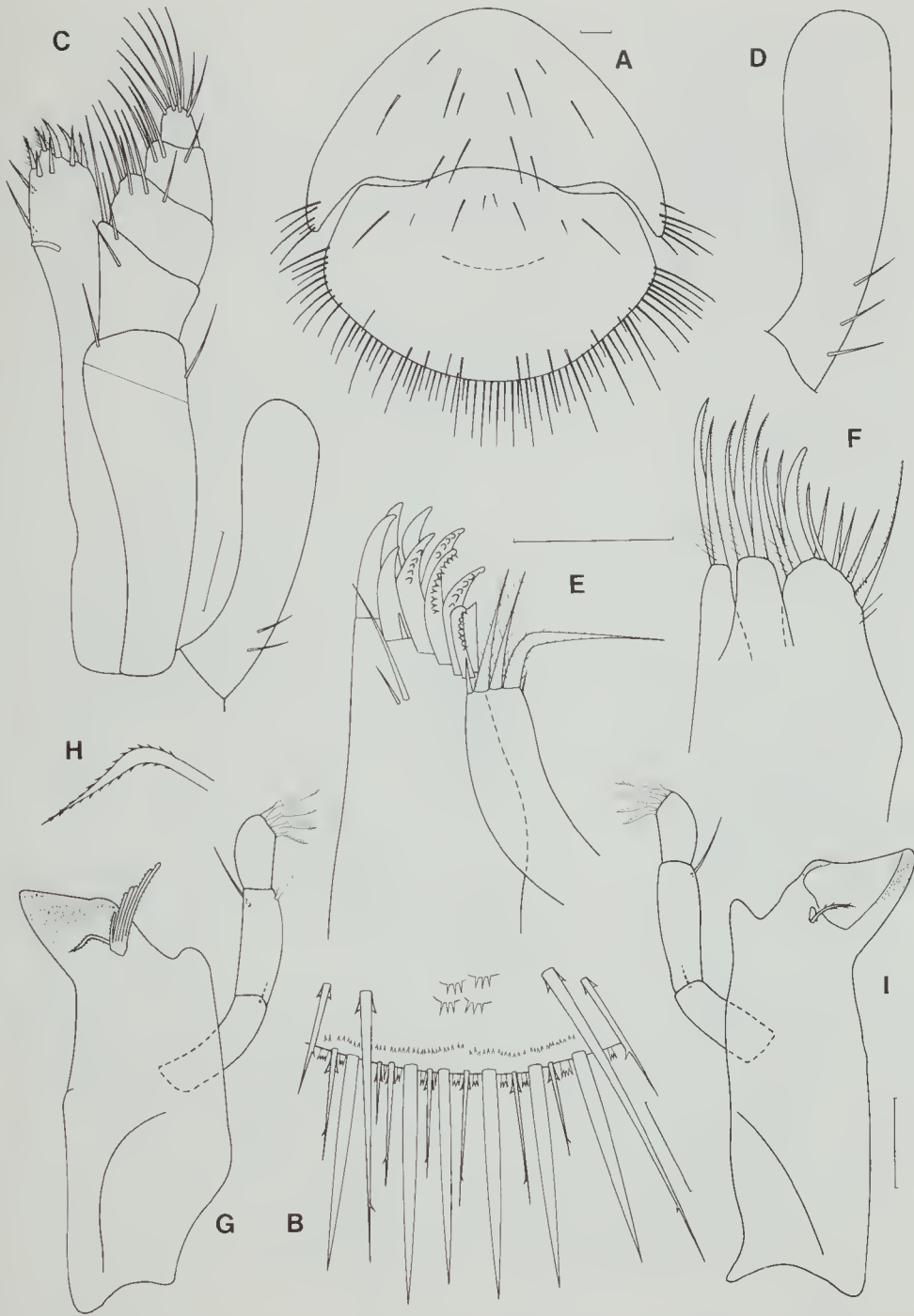


Figure 55. *Limnoria torquisa* sp. nov. A-C, E-I, male, NMV J15377, holotype: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped; E, maxilla 1; F, maxilla 2; G, right mandible; H, lacinia mobilis of right mandible; I, left mandible. D, female, NMV J15379, paratype, epipod of maxilliped.

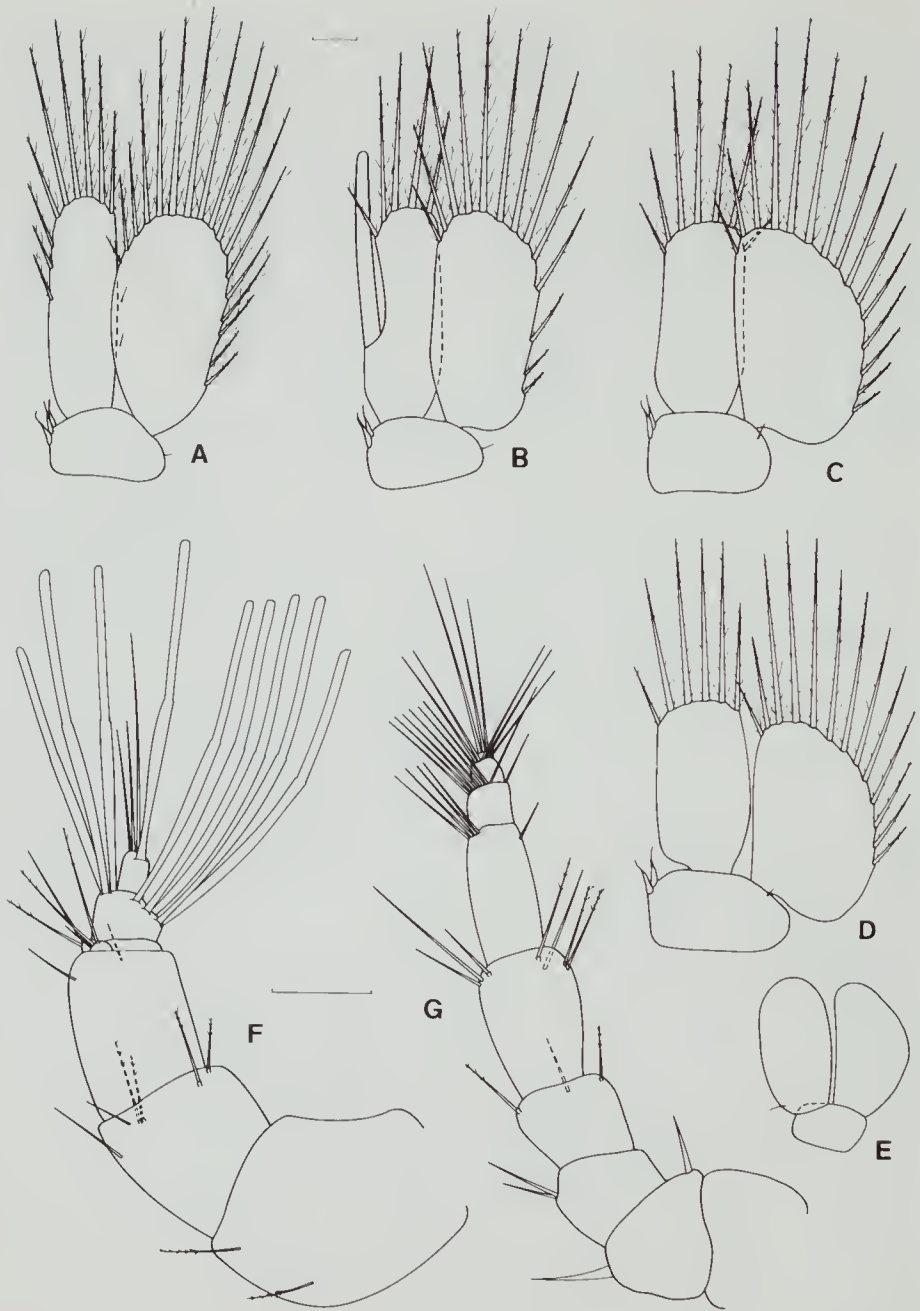


Figure 56. *Limnoria torquisa* sp. nov. A-G, male, NMV J15378, paratype: A-E, pleopods 1-5; F, antenna 1; G, antenna 2.



Figure 57. *Limnoria torquisa* sp. nov. A-H, male, NMV J15377, holotype: A, pereopod 1, lateral view; B, secondary unguis of pereopod 1; C, pereopod 3, lateral view; D, pereopod 4, lateral view; E, pereopod 5, lateral view; F, pereopod 7, lateral view; G, secondary unguis of pereopod 7; H, uropod, ventral view.



lar pleopods, even to the point of having a simple seta on the endopod of pleopod 5. However, *L. torquisa* has only three flagellar articles on antenna 1, a situation also found in *L. platycauda*.

*L. torquisa* may be easily distinguished by the spines on the pereopods, the well developed papose setae on pereopod 4 and uropod peduncle, the number of flagellar articles on antenna 1, shape of the maxillipedal epipod, and the shape and lack of sculpturing on the abdominal segments.

### *Limnoria tripunctata* Menzies

Figures 58, Plates 1a, b, d, e

*Limnoria tripunctata* Menzies, 1951b: 86–88. pl. 36.—Menzies, 1951a: M1–M7.—Menzies and Becker, 1957: 86–91, fig. 1.—Eltringham and Hockley, 1958: 1659–1660.—Jones, 1963: 589–603.—McCoy-Hill, 1964: 46.—McQuire, 1964: 35–44.—McQuire, 1965: 34, 36, 39.—Hall and Saunders, 1967: 1–17.—Fougerousse, 1968: 81–94.—Baechler et al., 1970: 47–64.—Menzies, 1972: 149–157, figs 1–2.—Jones et al., 1972: 105, 108–110.—Haderlie, 1974: 57–59.—Jones et al., 1976: 122, 134.—Cook, 1977: 105–106.—Schultz, 1978: 9, fig. 4c.—Krishnan et al., 1980: 20.—Bultman et al., 1980: 201.—Barnacle et al., 1983: 1–10.—Gambetta and Orlandi, 1983: 27–37.—Nair, 1984: 208–209.—Barnacle et al., 1986: 12.—Cookson, 1987b: 85–89.—Cookson and Barnacle, 1987a: 139–160.—Cookson and Barnacle, 1987b: 287–293.—Eaton, 1989: 63.

*Limnoria (Limnoria) tripunctata*.—Menzies, 1957: 137–139, fig. 16 (synonymy).—Becker and Kampf, 1958: 3, 8, fig. 4.—Becker and Kampf, 1959: 13, 15, fig. 4.—Menzies, 1959: 22.—Pillai, 1961: 29, text-fig. 15.—Jesakova, 1961: 183–184, fig. 3.—Olivier, 1962: 32–91, figs 3–4.—Menzies et al., 1963: 97–120.—Menzies and Glynn, 1968: 49.—Santhakumaran, 1969a: 7–11.—Rao and Ganapati, 1969: 226.—Schultz, 1969: 142, fig. 209.—Bastida and Torti, 1972: 143–153, figs 1–4.—Kühne, 1971: 74, figs 3–5, 7.—Kühne, 1975: 453.—Barnacle and Ampong, 1975: 289–310.—Kühne, 1976: 545–546.—Kensley and Schotte, 1987: 224–225.

#### *Biology and timber preservation literature.*

Menzies, 1954: 363–388.—Menzies and Widrig, 1955: 149–152.—Barnard, 1955: 87–98.—Johnson and Menzies, 1956: 54–68.—Hochman et al., 1956: 1–37, fig. 12.—Beckman et al., 1957: 162t–164t.—Vind et al., 1957: 35–48, fig. 9.—Meyers and Reynolds, 1957: 969.—Kampf, 1957: 359–375, fig. 1.—Schafer and Lane, 1957: 289–296.—Drisko and Hochman, 1957: 325–329.—Kohlmeier et al., 1959: 457–489.—Wakeman and Whiteneck, 1959: 37–39.—Lane, 1959: 34–45.—Becker, 1959a: 62–83.—Mohr, 1959: 88.—Becker, 1959b: 443–450.—Hochman, 1959: 45–48, figs 4–5.—Becker and Kampf, 1960: 301–307.—Beckman and Menzies, 1960: 9–16.—Eltringham and

Hockley, 1961: 467–482.—Vind and Hochman, 1961: 1–17, fig. 1.—Eltringham, 1961a: 512–513.—Becker and Kühne, 1961: 1352–1356.—Eltringham, 1961b: 785–797.—Vind and Hochman, 1962: 170–178.—Eltringham, 1964: 675–683.—Hochman, 1964: 1–13.—Eltringham, 1965a: 149–157.—Eltringham, 1965b: 145–152.—Walden and Trussel, 1965: 14–15.—Schafer, 1966: 109–115.—Wakeman and Steiger, 1966: 6–7, 24–25.—Colley, 1967: 151–162.—Hochman, 1967: 138–150.—Anderson and Reish, 1967: 56–59.—Eltringham, 1967: 521–529.—Kühne, 1968: 107–118.—Menzies, 1968: 802–803.—Anderson and Stephens, 1969: 243–249.—Coull and Lindgren, 1969: 73–75.—Reish and Hetherington, 1969: 137–139.—Kühne and Becker, 1970: 307–319.—Hochman, 1970: 38–41.—Richards, 1971: 144–146.—Eltringham, 1971: 61–67.—Jones, 1971: 360.—Southwell and Bultman, 1971: 100–102.—Colley, 1972: 44–58.—Richards et al., 1972: 143–146.—Southwell and Bultman, 1972: 49–60.—Kühne, 1973: 814–820.—Sleeter and Coull, 1973: 97–102.—Hochman, 1973a: 254–255.—Hochman, 1973b: 31–36.—Montemartini, 1975: 227–237.—Richards and Webb, 1975: 30–35.—McCarthy, 1975: 902.—Sargent and Domnas, 1976: 317.—Kalinins, 1976: 250–262.—Barnacle, 1976: 57–66.—Fish and Webb, 1978: 260–267.—Sleeter et al., 1978: 329–336.—Bultman, 1978: 12, 15.—Boyle and Mitchell, 1978: 1157–1159.—Parrish and Bultman, 1978: 92–98.—Zachary and Colwell, 1979: 716–717.—Montemartini, 1979: 297–325.—Parrish and Bultman, 1979: 1–12.—Helsing, 1979: 20.—Rutherford et al., 1979: 527–530.—Serpa, 1980: 42–44.—Geyer and Becker, 1980: 53–78.—Boyle and Mitchell, 1980: 179–186.—Webb and Baldwin, 1981: 152–155.—Johnson and Gutzmer, 1981: 1–14.—Johnson, 1982: 704–705.—Richards, 1982: 267–268.—Kühne, 1982: 58.—Geyer, 1982: 77–89.—Zachary et al., 1983: 1–8.—Parrish et al., 1983: 1–17.—Gambetta and Orlandi, 1983: 1–4.—Bultman et al., 1983: 42.—Webb et al., 1984: 41–44.—Johnson and Gutzmer, 1984: 1–23.—Cookson and Barnacle, 1985: 8.—Ampong and Asare-Nyadu, 1985: 2.—Eaton, 1985: 157–191.—Eaton, 1986: 355–365.—Gambetta and Orlandi, 1986: 1–8.—Pendleton and O'Neill, 1986: 1–23.—Cookson, 1987a: 1–14.—Hong and Reish, 1987: 884–888.—Gambetta et al., 1988: 64, 76.—Johnson and Rowell, 1988: 147–156.—Lebow and Morrell, 1988: 25–30.

*Limnoria tuberculata* Sowinsky.—Geldiay and Kocates, 1972: 23 (possible).—Kussakin, 1979: figs 189–190.—Kensley and Schotte, 1987: 224–225 (probable).—Kensley and Schotte, 1989: 199, fig. 87F.

*Material examined.* Paratypes: USA, California, San Diego, Mission Bay (32°45'N, 117°10'W), R.J. Menzies, 23 Dec 1948, British Museum (Natural History) 1951.4.20: 6–9 (male, 2.4 mm, non-ovig. female, 2.5 mm).

Other material: USA, San Diego, H. Hemphill, AM P8371 (2, identified as *L. lignorum* by H. Richardson).

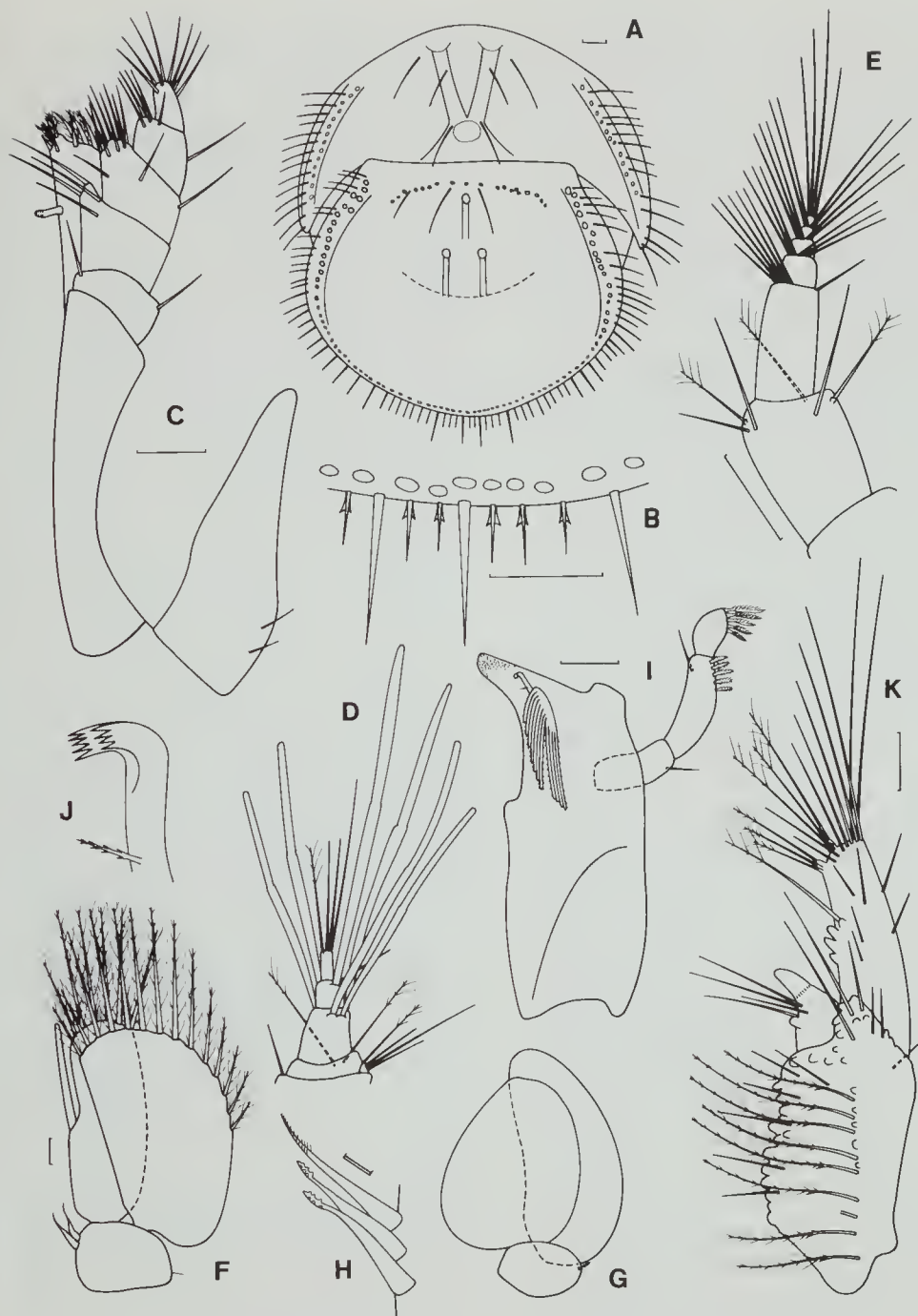


Figure 58. *Limnoria tripunctata* Menzies. A, B, F-K, male, NMV J15429: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; F, pleopod 2; G, pleopod 5; H, coupling hooks on pleopod 1; I, right mandible; J, lacinia mobilis of right mandible; K, uropod, ventral view. C, male, NMV J15431, maxilliped. D, E, male, NMV J15430: D, flagellum of antenna 1; E, peduncle article 5 and flagellum of antenna 2.

UK. Probably Southsea, aquaria at Portsmouth Polytechnic, S.M. Cragg, 8 May 1986, NMV J15293 (male, 2.2 mm, with 1 slide), NMV J15294 (male, 2.0 mm, with 1 slide), NMV J15292 (19).

PNG. Lorengau, Admiralty Islands, S.M. Rayner, 14 Jul 1971, NMV J15488 (juv., with 1 slide).

Vic. Port Phillip Bay: various depths, collectors, dates; Sandringham, *Eucalyptus pilularis* crossbrace, NMV J14893 (48); St Kilda, *E. obliqua* crossbrace, NMV J15239 (122); Williamstown, timber, 17 Jul, 1935, NMV J14889 (14); Williamstown, pine bait, AM P37038 (19), NMV J14890 (12); Williamstown, oregon, NMV J14887 (55); Williamstown, eucalypt, NMV J14888 (31). Western Port: various depths, collectors, dates; Sunday Island, eucalypt pile, NMV J14892 (1); Flinders Naval Base, AM P35413 (1); HMAS Cerberus, eucalypt pile, NMV J14891 (41); Rhyll, *E. obliqua* pile, NMV J15254 (4). Port Albert, *E. obliqua* pile, NMV J15253 (1); Port Albert, AM P35415 (24); Wangan Inlet, AM P35414 (6).

SA. Various depths, collectors, dates; Port Adelaide, *P. radiata* bait, NMV J15245 (42); Cowell, K55 creosoted *P. radiata* pile, NMV J14883 (27), NMV J14885 (19); Cowell, jarrah crossbrace, NMV J14884 (3); Port Lincoln, AM P6116 (12, identified as *L. lignorum* by Baker); Port Lincoln, pine bait, AM P35403 (17); Port Lincoln, K55 creosoted *P. radiata*, NMV J14879 (34), NMV J14881–J14882 (51); Port Lincoln, jarrah crossbrace, NMV J14880 (11); Tumby Bay, *P. radiata* bait, NMV J15242 (1); Arno Bay, *P. radiata* bait, NMV J15241 (2); Streaky Bay, pine bait, AM P35402 (59); Thevenard, K55 creosoted *P. radiata*, NMV J14886 (14).

WA. Various depths, collectors, dates, pine baits; Esperance, AM P35420 (7); Albany, NMV J14921 (12), NMV J14923–J14925 (25); Bunbury, NMV J14937–J14939 (5), AM P35421 (307), AM P35405–P35408 (801); Kwinana, CCA-*P. radiata*, NMV J14954 (20); Kwinana, NMV J14955 (33); Geraldton, NMV J14941–J14947 (178), AM P35422–P35423 (24); Carnarvon, K55 creosoted *P. radiata*, NMV J14935 (51); Carnarvon, NMV J14936 (31), AM P35424 (40); Point Samson, jarrah pile, NMV J15248 (1); Point Samson, CCA eucalypt pile, NMV J15249 (133); near Roebourne, NMV J14929–J149233 (11); Port Hedland, NMV J14928 (1).

NSW. Ulladulla, untreated *E. obliqua* pile heartwood after 5 years, L.J. Cookson and A. Maling, 23 Jul 1986, NMV J15429 (male, 2.7 mm, 0.7 mm wide pleotelson, with 1 slide), NMV J15430 (male, 2.9 mm, with 1 slide), NMV J15431 (male, 2.6 mm, with 1 slide), NMV J15432 (non-ovig. female, 2.9 mm, with 1 slide), NMV J15428 (28 males, 1.7–2.7 mm, 71 non-ovig. females, 2.0–3.3 mm, ovig. female, 3.4 mm, 20 juvs., 1.4–2.4 mm). Various depths, collectors, dates, pine baits; Eden, AM P35393–P35395 (138); Marks Point, AM P37038–P37040 (344); Forster, AM P35396 (7); Coffs Harbour, NMV J15250 (101). Port Stephens, Taylors Beach, 0.2 m, various collectors, dates, pine, eucalypts, creosoted eucalypts; NMV J15307–J15315 (247).

NSW. Sydney Harbour. Various depths, collectors, dates, pine baits; Darling Harbour, oregon, AM P9062

(10); Watsons Bay, AM P37037 (9), P35377 (58), P37035 (50), P35379 (102); Rose Bay, AM P35382 (5); Cabarita, AM P35392 (79); Cammeray, AM P35383 (6), P37036 (27); Bantry Bay, AM P37041 (7), P35381 (11); Goat Island, NMV J15272 (54), AM P35386–P35388 (458), P37034 (6); Goat Island, *Acacia*, NMV J15316 (92); Goat Island, creosoted *P. radiata*, NMV J15275 (33), J15279 (7); Goat Island, turpentine pith, NMV J15270 (10); Goat Island, eucalypt bait, NMV J15278 (13).

Qld. Various depths, collectors, dates, pine baits; Mooloolaba, NMV J14966 (52); Mackay, NMV J15209 (27); Townsville, NMV J15456, J15457 (345); Nelly Bay, AM P35401 (10); Cooktown, NMV J15202 (45); Bowen, AM P35419 (39); Bowen, CCA slash pine pile, NMV J15280 (81), J15284 (54); Bowen, turpentine sapwood, NMV J15281 (31); Bowen, turpentine, NMV J15283 (18), J15286 (19); Bowen, double-treated *P. radiata* pile, NMV J15282 (58), J15285 (35); Maryborough, turpentine pile, NMV J14998 (8); Cairns, creosoted eucalypts, NMV J14981 (7), J15218 (5).

*Types.* USNM, British Museum (Natural History) and Rijksmuseum van Natuurlijke Historie, Leiden.

*Diagnosis.* Pleonite 5 dorsomedially with anterior pair of nodes, followed by carinae which converge posteriorly to single node. Pleotelson with anterior dorsomedial punctum followed posteriorly by pair of puncta, each puncta followed posteriorly by carina. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson composed of scales, some with posterior row of thin spikes. Dorsal row of tubercles follows entire perimeter of pleotelson; posterior margin with 4 large stout setae between which are long-sheathed setae, lacking scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 5 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible curved, bifid, with apical teeth. Epipod of maxilliped triangular, 2.9 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 2, 3, 6 and 7. Uropod peduncle with prominent, blunt lateral tubercles; endopod with 3 tubercles near midlength, endopod 0.9 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.6 times length of exopod. Appendix masculina reaching beyond endopod tip, articulating near mid-length of endopod. Endopod of pleopod 5 anterior to exopod, circular, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 with comb seta laterally.



*Additional characters.* Body length up to 3.4 mm. Colour in alcohol pale yellow, with dark reticulate pigment.

*Distribution.* Numerous temperate and tropical locations, including: Mission Bay, California (type locality); USA and central America (Menziés, 1957); Ghana (Barnacle and Ampong, 1975); Hawaii (Cook, 1977); Argentina (Bastida and Torti, 1972); southern England (Jones 1963); Mediterranean (unless confused with *L. tuberculata*) (Menziés and Becker, 1957); Madras, India (Becker and Kampf, 1958); Auckland, New Zealand (McQuire, 1964); Admiralty Islands; Australia, except Tasmania. 0–7 m depths (current study).

*Substrates.* Various treated and untreated timbers, including: creosote-treated softwoods (Menziés, 1957); pine baits (McQuire, 1964; Jones et al., 1972); red mangrove wood (Kensley and Schotte, 1987); TBTO-treated *P. sylvestris* (Gambetta et al., 1988); CCA- and CCB-treated timbers (Cookson and Barnacle, 1985); various eucalypts, pines and treated timbers (current study).

*Remarks.* Menziés (1957) did not mention or figure the row of small tubercles near the anterior margin of the pleotelson. This row was present in all material examined, including the paratypes. It was also present in specimens from Argentina (Bastida and Torti, 1972). The sculpture pattern on pleonite 5 described by Menziés (1951b) was incorrect (Menziés, 1957). The lacinia mobilis of the right mandible can vary slightly in shape, generally it is apically curved and has a serrated fringe, however the serrated fringe may also be produced as two branches.

For Australia it is noteworthy that *L. tripunctata* does not appear to normally occur in Tasmania. Therefore, creosote-treated softwoods should provide long service lives in this region (Cookson, 1987a). Similarly, *L. tripunctata* has not yet been found on the coast of Victoria west of Port Phillip Bay. Although *L. tripunctata* can be found on the eastern coast of Victoria, it appears to be partly confined to the more sheltered locations of Westernport Bay and Port Phillip Bay.

*L. tripunctata* is very similar to *L. tuberculata*. Another species with similarities to *L. tripunctata* is *L. orbellum*, for reasons given in the discussion with that species.

### *Limnoria tuberculata* Sowinsky

Figure 59

*Limnoria terebrans* var. *tuberculata* Sowinsky 1884: 264, pl. 6 figs 31–34, pl. 7 figs 37–47.—Sowinsky, 1898: 505.—Sowinsky, 1904: 108–109.

*Limnoria tuberculata*.—Menziés and Becker, 1957: 86.—Jesakova, 1965: 456–458, figs 1–2.—Menziés, 1972: 149–157.—Geldiay and Koeatas, 1972: 23 (possible).—Jones et al., 1976: 122, 134.—Kussakin, 1979: 322–325, figs 187–188.—Richards, 1983: 192.

Not *Limnoria tuberculata*.—Menziés and Glynn, 1968: 49.—Kussakin, 1979: figs 189–190.—Kensley and Schotte, 1987: 224–225.—Kensley and Schotte, 1989: 199, fig. 87F (= *Limnoria tripunctata*).

*Material examined:* Origin of culture unknown, from aquaria at the Bundesanstalt für Materialprüfung, West Germany, S.M. Cragg, May 1988, NMV J15326 (non-ovig. female, 2.8 mm 0.7 mm wide pleotelson, with 1 slide), NMV J15327 (non-ovig. female, 2.8 mm, with 1 slide), NMV J15325 (4 non-ovig. females, 2.4–2.7 mm, 2 ovig. females, 2.7, 2.5 mm).

*Types.* Not known to exist.

*Diagnosis.* Pleonite 5 dorsomedially with anterior pair of nodes, followed by carinae which converge posteriorly at single node. Pleotelson with anterior dorsomedial punctum followed posteriorly by pair of puncta, posterior puncta followed by long diverging carinae bearing tubercles, anterior punctum followed posteriorly by shorter carina. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson composed of scales, some with posterior row of thin spikes. Dorsal row of tubercles follows entire perimeter of pleotelson; posterior margin with 4 large stout setae between which are long-sheathed setae, lacking scale spikes.

Antenna 1 with 4 flagellar articles; second article with about 8 aesthetascs. Flagellum of antenna 2 with 5 articles. Mandibular palp with 3 articles. Mandibular incisors with rasp and file. Lacinia mobilis of right mandible curved, with fringe of small apical teeth. Epipod of maxilliped triangular, 2.9 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta on merus of pereopod 7 and carpus of pereopods 2, 3, 6 and 7. Uropod peduncle with prominent, blunt lateral tubercles; endopod with 3 tubercles near midlength, endopod 1.1 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.7 times length of exopod. Structure of appendix masculina unknown. Endopod of pleopod 5 anterior to exopod, oval, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 with comb seta laterally.



*Additional characters.* Body length up to 2.8 mm. Colour in alcohol pale yellow, with dark reticulate pigment.

*Distribution.* Sevastopol Bay, Black Sea (type locality) (Sowinsky, 1884). Possibly Massachusetts, southern England (Menzies, 1972), and the Aegean Sea (Geldiay and Kocatas, 1972).

*Substrate.* Wood.

*Remarks.* The figure of the pleotelson of *L. tuberculata* from the Black Sea given by Jesakova (1965) is very similar to the pleotelson of the specimen figured here. The shape of the carinae on the pleotelson of *L. lignorum* is similar to the shape on *L. tuberculata*, except that in *L. tuberculata* the carinae also bear tubercles and puncta.

Menzies (1951b) described *L. tripunctata*, unaware of Sowinsky's (1884) description of *L. terebrans* var. *tuberculata*. He later suggested the two may be synonymous (Menzies and Becker, 1957; Menzies and Glynn, 1968). Jesakova (1965) synonymised the species accordingly. Menzies (1972) conducted breeding experiments between so-called *L. tuberculata* from Massachusetts and *L. tripunctata* from several other locations in the USA. He found that viable offspring were not produced, thus concluding that the species were separate. In the same experiment, viable offspring were produced in crosses between different populations of *L. tri-*

*punctata*. Menzies (1972) did not draw or describe the pleotelson of his *L. tuberculata* specimens from Massachusetts, other than to say there were a few additional tubercles to the pattern found on *L. tripunctata*. Whether these tubercles were as numerous as shown in the figure given by Jesakova (1965) of a specimen of *L. tuberculata* from the Black Sea is not known.

Menzies (1972) also stated that *L. tuberculata* could be found in southern England, and these also had a few more tubercles than found in the pattern for *L. tripunctata*. Of the specimens from southern England which I examined, only one specimen had extra puncta, but I still consider them all to be *L. tripunctata* as the posterior pair of carinae were not long or tuberculate. The extra puncta on the specimen mentioned were only an extra pair of puncta found immediately behind and partly fused to the normal posterior pair of puncta. More comparisons are required of specimens from different geographical locations to determine the variations. Also, any extra puncta found on *L. tripunctata/L. tuberculata* forms should be described or drawn in detail.

Unfortunately the origin of the specimens from the BAM is unknown. These specimens were received, incorrectly labelled as *L. tripunctata*. As well as the long tuberculate carinae on the pleotelson of *L. tuberculata* which distinguishes it from *L. tripunctata*, may be added a difference in the fifth pleopod. The specimens

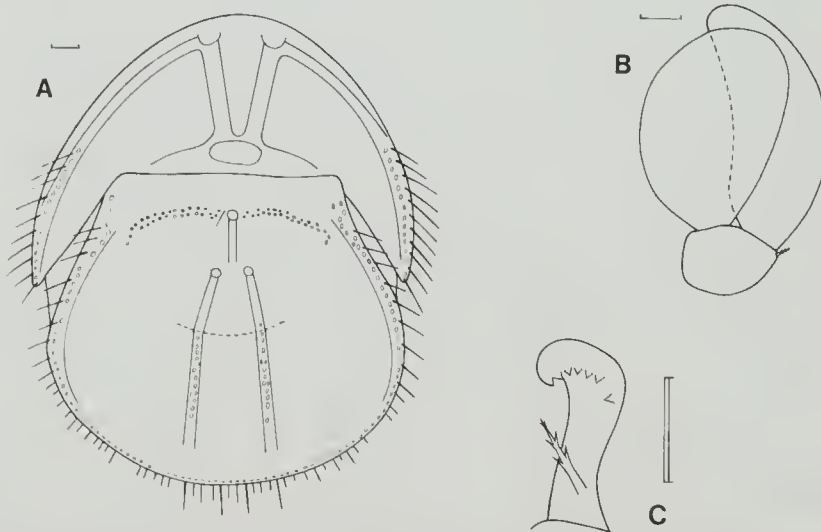


Figure 59. *Limnoria tuberculata* Sowinsky. A, B, female, NMV J15327: A, pleonite 5 and pleotelson, dorsal view; B, pleopod 5. C, female, NMV J15326, lacinia mobilis of right mandible.

from BAM had a less circular shape in the endopod of pleopod 5 than in *L. tripunctata*. In *L. tripunctata*, including the paratypes and the specimens from southern England, the endopod was more produced proxomedially.

Citing unpublished research by Gonor, Richards (1983) stated that unlike *L. tripunctata*, *L. tuberculata* did not attack creosote-treated wood. But this research has not been done (Gonor, pers. comm., 1988).

### *Limnoria uncapedis* sp. nov.

Figures 60–63

*Material examined.* Holotype: SA, NE side of Topgalant Island, Investigator Group (33°43'S, 134°36.6'E), 7 m, *Acrocarpia aniculata* and red algae, SCUBA, S. Shepherd and G.C.B. Poore, 22 Apr 1985 (stn SA 83). NMV J15330 (male, 1.75 mm, 0.45 mm wide pleotelson, with 1 slide).

Paratypes: Type locality, NMV J15331 (non-ovig. female, 1.6 mm); 12 m, algae, bryozoa and sponges (stn SA 81), NMV J15328 (male, 2.1 mm). "The Hotspot" reef, 5 n. miles W of Flinders Island (33°40.8'S, 134°22.5'E), 21 m, tufted red algae and soft erect bryozoa, SCUBA, G.C.B. Poore, 20 Apr 1985 (stn SA 72), NMV J15333 (male, 1.7 mm, with 1 slide), NMV J15332 (male, 1.6 mm, non-ovig. female, 1.8 mm, juv., 1.1 mm). Tiparra reef, Tiparra Bay (34°4'S, 137°23'E), 11 m, algae on sponges and ascidians, SCUBA, G.C.B. Poore and H.M. Lew Ton, 15 Mar 1985 (stn SA 18), NMV J15334 (non-ovig. female, 1.9 mm).

WA, SW corner of Breaksea Island (35°3.9'S, 118°2.5'E), 15 m, *Ecklonia* holdfast, SCUBA, G.C.B. Poore and H.M. Lew Ton, 7 Apr 1984 (stn SWA 13), NMV J15329 (non-ovig. female, 2.2 mm, with 1 slide). NE end of Vancouver Peninsula (35°3.4'S, 117°56.2'E), 10 m, red algae, SCUBA, G.C.B. Poore and H.M. Lew Ton, 8 Apr 1984 (stn SWA 24), NMV J15305 (2 non-ovig. females, 1.6–1.8 mm); 3 m, tufted red algae, soft coral and sponges (stn SWA 22), NMV J15306 (non-ovig. female, 1.6 mm). Eastern end of Thistle Cove (34°S, 122°12'E), 8 m, brown algae, SCUBA, G.C.B. Poore and H.M. Lew Ton, 11 Apr 1984 (stn SWA 28), NMV J15303 (male, 1.6 mm, non-ovig. female, 1.8 mm); brown algae and corallines (stn SWA 32), NMV J15304 (non-ovig. female, 1.7 mm). Seven Mile beach, north of Dongara (29°12'S, 114°53'E), 1 m, *Padina* and seagrass detritus on sand, G.C.B. Poore and H.M. Lew Ton, 24 Apr 1986 (stn SWA 88), NMV J15335 (non-ovig. female, 2.0 mm, with 1 slide).

Other material: WA, Rat Island, Abrolhos Islands (16°24'S, 123°7'E), reef crest rubble, P.A. Hutchings, 24 Aug 1981, NMV J12877 (juv., 1.7 mm, with 1 slide).

NT, McCluer Island, NW end of Bommies (11°2'S, 132°58'E), 8 m, brown algae, G.C.B. Poore, 16 Oct 1982 (stn NT 32), NMV J12878 (ovig. female, 1.7 mm, with 1 slide), NMV J15336 (ovig. female, 1.8 mm).

*Diagnosis.* Pleonite 5 and pleotelson dorso-medially without carinae and puncta. Pleotelson slightly raised anteromedially. Pleonite 5 0.6 times as long as pleotelson. Dorsal surface of pleotelson with scales bearing fine spikes posteriorly. Posterior margin of pleotelson with dorsal row of small scale spikes; margin fringed with thin scale spikes and long short-sheathed setae, lacking stout setae.

Antenna 1 with 4 flagellar articles; second article bears about 7 aesthetases. Flagellum of antenna 2 with 4 articles. Mandibular palp absent, replaced by simple seta. Mandibular incisors lack rasp and file. Lacinia mobilis of right mandible with 2 serrated branches. Epipod of maxilliped clavate, 2.2 times as long as wide, reaching articulation of articles 1 and 2 of palp; epipod with simple true setae.

Secondary unguis of pereopod 1 undivided, with about 7 ventral spinules. Ventral comb seta absent on merus, present on carpus of pereopods 6 and 7. Uropod peduncle with few very small lateral tubercles; endopod 0.8 times as long as peduncle.

Pleopod 2 with long plumose setae up to 1.3 times length of exopod. Appendix masculina long, reaching beyond endopod, articulating just proximal to midlength of endopod. Endopod of pleopod 5 anterior to exopod, elongated, oval, 0.75 times as long as endopod of pleopod 2; peduncle of pleopod 5 with simple seta laterally.

*Additional characters.* Inner lobe of maxilla 1 with 3 pappose setae similar in length. Inner lobe of maxilla 2 with strongly recurved medial seta. Lacinia mobilis of left mandible accompanied by only 1 thick serrated seta. Propodus of pereopods 2–4 with prominent barbed projection opposing secondary unguis of dactyl; projection reduced on pereopod 5, absent on pereopods 1, 6 and 7. Secondary unguis of all pereopods with undivided claw fringed by several spinules. Body length up to 2.2 mm. Colour in alcohol pale yellow.

*Etymology.* From the latin for *uncus* (barb) and *pedis* (foot), relating to the barbed projection on the propodus of some pereopods.

*Distribution.* South Australia, southern Western Australia, and Northern Territory. 1–21 m depths.

*Substrates.* A variety of red and brown algae, and possibly bryozoans and sponges.

*Remarks.* The specimens from the Northern Territory and Abrolhos Islands had all typical

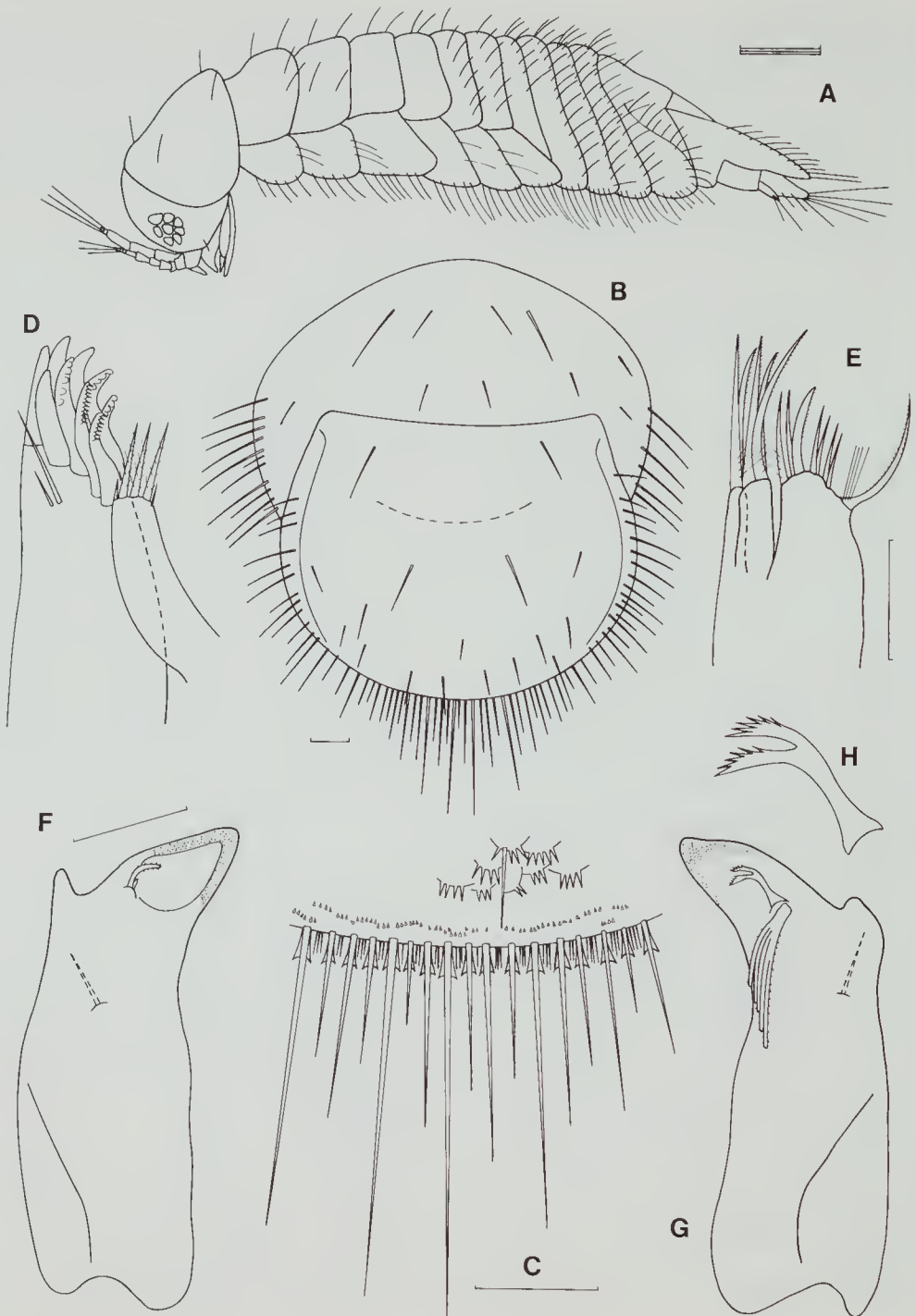


Figure 60. *Limnoria uncapedis* sp. nov. A–H, male, NMV J15330, holotype: A, lateral view; B, pleonite 5 and pleotelson, dorsal view; C, posterior margin of pleotelson, dorsal view; D, maxilla 1; E, maxilla 2; F, left mandible; G, right mandible; H, lacinia mobilis of right mandible.



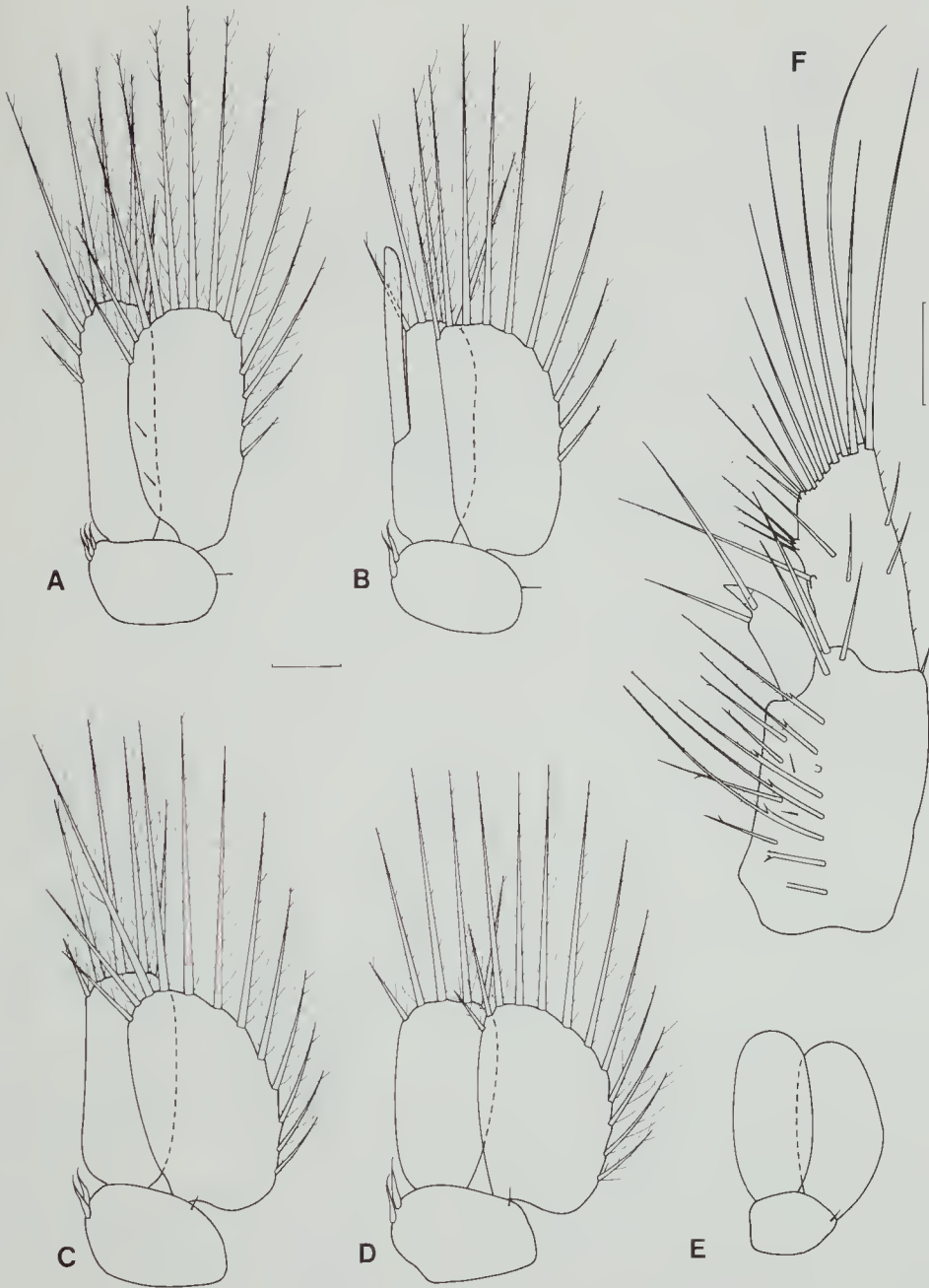


Figure 61. *Limnoria uncapedis* sp. nov. A-E, male, NMV J15333, paratype: A-E, pleopods I-5. F, male, NMV J15330, holotype, uropod, ventral view.

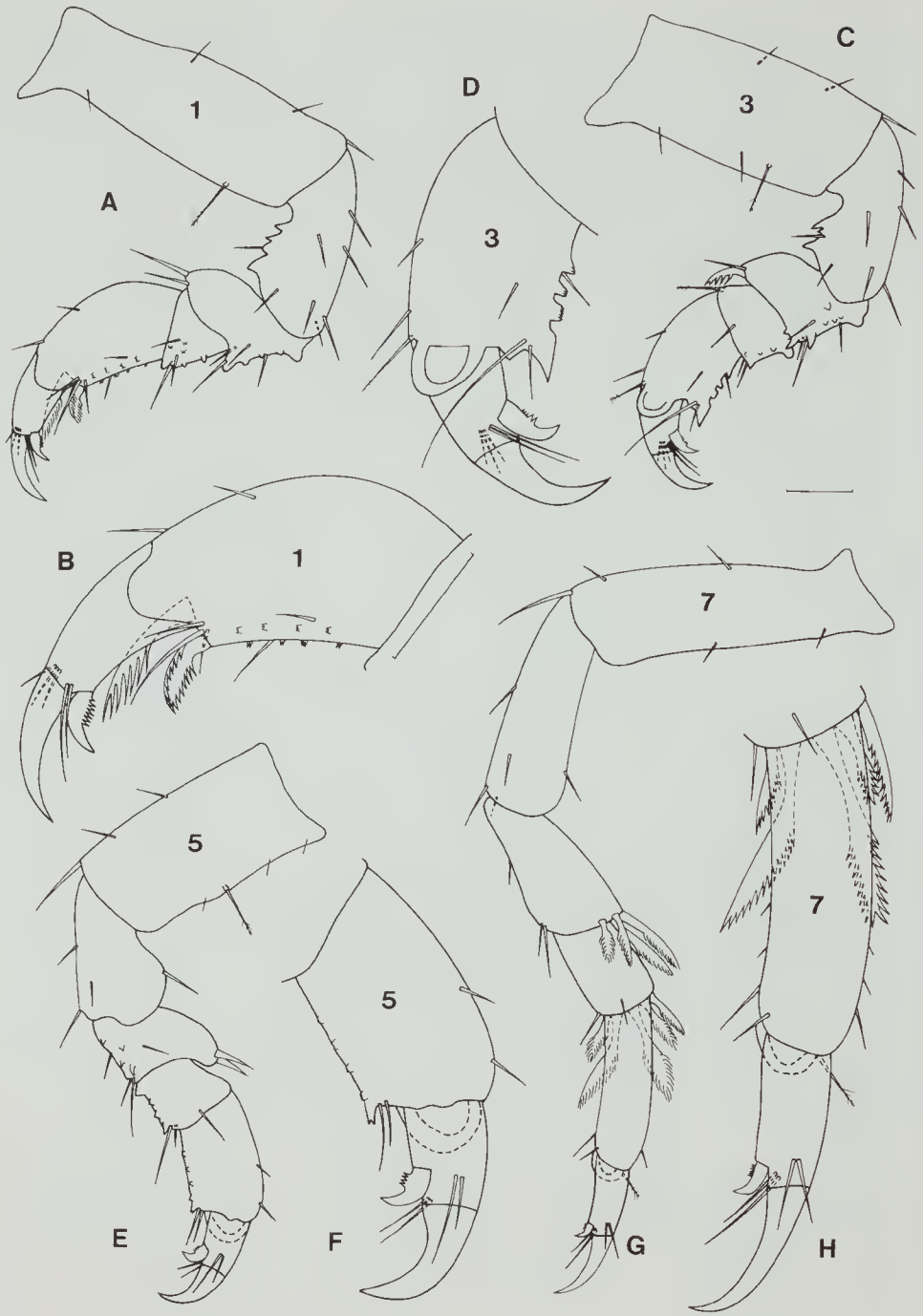


Figure 62. *Limnoria uncapedis* sp. nov. A-H, male, NMV J15330, holotype: A, pereopod 1; B, propodus and dactylus of pereopod 1; C, pereopod 3; D, propodus and dactylus of pereopod 3; E, pereopod 5; F, propodus and dactylus of pereopod 5; G, pereopod 7; H, propodus and dactylus of pereopod 7; all lateral views.

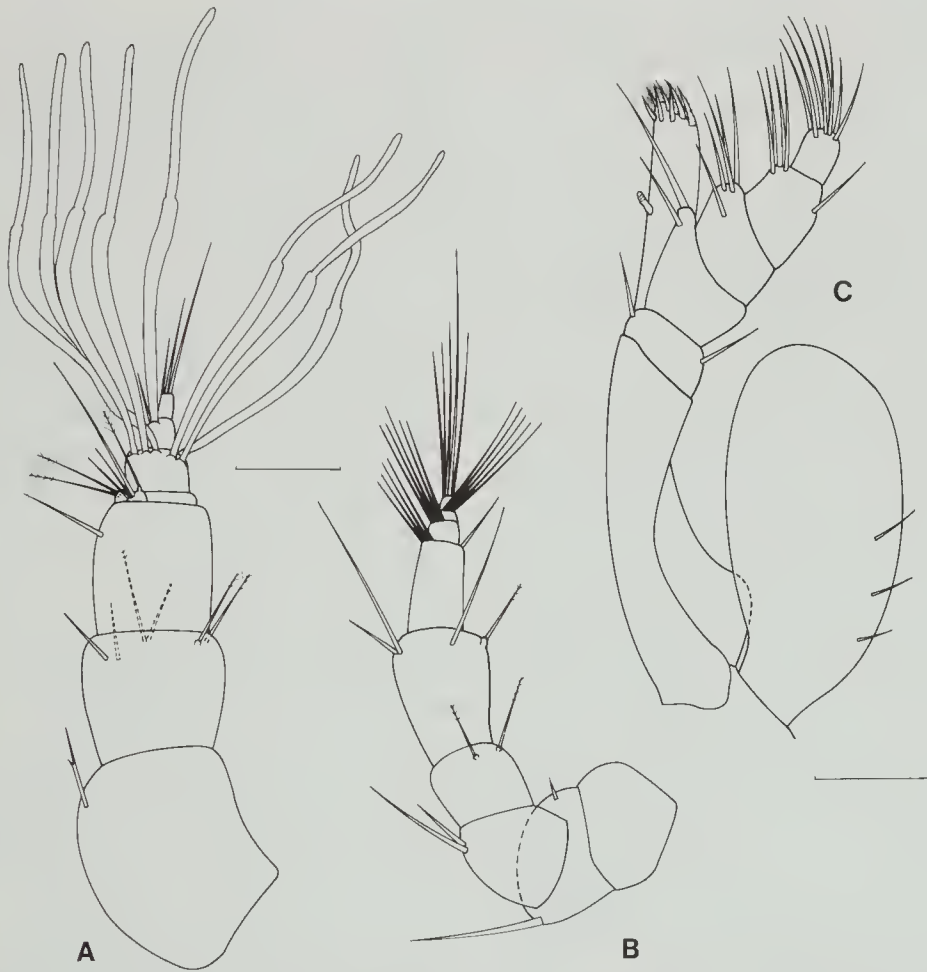


Figure 63. *Limnoria uncapedis* sp. nov. A-C, male, NMV J15330, holotype: A, antenna 1; B, antenna 2; C, maxilliped.

features, except that they lacked the dorsal row of scale spikes on the posterior margin of the pleotelson, although NMV J15336 from the Northern Territory had a row of scale spikes in one small area.

*L. uncapedis*, *L. segnoides* and *L. bituberculata* all share the following features: broad maxillipedal epipod, loss of mandibular palp, similar shape of the lacinia mobilis of the right mandible, and modification of the secondary unguis on pereopod 1. *L. bituberculata* also appears to have a recurved inner seta on maxilla 2 (Pillai, 1961), and strong barbed projections on the propodus of at least pereopod 2 similar to those found in *L. uncapedis*. *L. uncapedis* can be separated from *L. segnoides* by the lack in *L. segnoides* of accessory spinules on the secondary unguis of pereopod 1. Also, *L. segnoides* has

distinctive sculpturing on pleonite 5 and the pleotelson while *L. uncapedis* does not. *L. bituberculata* differs by having two puncta joined by an arcuate carina on the pleotelson, fewer spinules (four) on the secondary unguis of pereopod 1 (*L. uncapedis* has about seven), and by lacking a dorsal row of scale spikes on the posterior margin of the pleotelson (although this is also found in *L. uncapedis* from the Northern Territory and Aboholhos Islands). Without examining some type specimens of *L. bituberculata*, the most reliable difference between the two species appears to be the pleotelsonal ornamentation on *L. bituberculata*. *L. bituberculata* was collected from the holdfast of *Sargassum* rather than red algae.

*L. uncapedis* lives on small seaweeds and fragile substrates and so may be relatively exposed.



It may have developed the pereopodal barbs to help maintain a firm grip on substrates.

### *Limnoria unicornis* Menzies

Figures 64, 65, Plates 1c, 2e, f

*Limnoria (Limnoria) unicornis* Menzies, 1957: 173–175, fig. 32.—Ganapati and Rao, 1960: 275–276.—Rao and Ganapati, 1969: 226.

*Limnoria unicornis*.—Nair, 1984: 208.—Kensley and Schotte, 1987: 225–226, fig. 6.—Cookson, 1987a: 3, 7.—Cookson et al., 1989: 1–8.—Kensley and Schotte, 1989: 199, fig. 88A, B.

*Material examined.* Qld. Port Douglas, tidal zone, sapwood of CCA-treated turpentine pile, J.E. Barnacle and L.J. Cookson, 29 May 1986, NMV J15352 (male, 2.5 mm, 0.7 mm wide pleotelson, with 1 slide), NMV J15353 (male, 2.6 mm, with 1 slide), NMV J15354 (male, 2.4 mm, with 1 slide), NMV J15355 (male, 1.9 mm, with 1 slide), NMV J15351 (57 males, 1.5–2.9 mm, 54 non-ovig. females, 1.5–2.8 mm, 32 ovig. females, 2.2–3.2 mm, 7 juvs. 1.0–1.4 mm); 0.5 m, turpentine pile, J.E. Barnacle, 29 May 1984, NMV J14958 (1); 0 m, sapwood of CCA-treated turpentine pile, J.E. Barnacle, 29 May 1984, NMV J14967 (5); 1.5 m, sapwood and heartwood of turpentine pile no 5, L.J. Cookson, 15 Dec 1987, NMV J15216 (4); tidal zone, sapwood of CCA-treated turpentine pile no 1, L.J. Cookson, 16 Dec 1987, NMV J15217 (47).

WA. Point Samson, low tide near mud-line, untreated eucalypt pile, J.E. Barnacle and L.J. Cookson, 15 Sep 1985, NMV J14963 (45); sapwood of CCA-treated eucalypt, NMV J14964 (6). Port Hedland, midtide, jarrah pile stump, L.J. Cookson and R. Morrison, 26 Jun 1986, NMV J14953 (13). Broome, 0.5 m, untreated sawn jarrah alter 2 years, L.J. Cookson, 26 Sep 1986, NMV J14952 (17).

PNG. Lae, sapwood of CCA-treated *E. maculata* CSIRO test stake. S.M. Rayner, NMV J15302 (male, non-ovig. female). Wewak, tidal zone, CCA-treated *Diospyros papuana* pile in wharf, S.M. Cragg, 1985, NMV J15493 (5 males, 1.7–2.0 mm, 2 non-ovig. females, 1.7, 1.9 mm, 2 ovig. females, 1.8, 1.9 mm, juv., 0.8 mm).

*Types.* Returned to Dr C.H. Edmondson at Bernice P. Bishop Museum, Honolulu, by Menzies.

*Diagnosis.* Pleonite 5 dorsomedially with Y-shaped carina. Pleotelson with large anterior dorsomedial punctum. Pleonite 5 0.5 times as long as pleotelson. Dorsal surface of pleotelson with scales fused, surface pitted, covered with sparsely distributed solitary scale spikes. Posterior margin of pleotelson without dorsal row of tubercles or scale spikes; margin fringed with 4 large stout setae between which are short short-sheathed setae and thin scale spikes.

Antenna 1 with 4 flagellar articles; second article with 3 long aesthetascs. Flagellum of an-

tenna 2 with 4 articles. Mandibular palp with 1 reduced article, without comb setae but with 2 long apical simple setae. Mandibular incisors with a rasp and file. Lacinia mobilis of right mandible very short, without teeth or serrations. Epipod of maxilliped triangular, 3.0 times as long as wide, not reaching palp articulation; epipod with simple true setae.

Secondary unguis of pereopod 1 bifid. Ventral comb seta absent on merus of pereopods, present on carpus of pereopods 2, 3, 4, 5, 6 and 7. Uropod peduncle with few small lateral tubercles; endopod 0.8 times as long as peduncle.

Pleopod 2 with plumose setae up to 0.7 times length of exopod. Appendix masculina reaching tip of endopod, articulating proximal to mid-length of endopod. Endopod of pleopod 5 anterior to exopod, oval, 0.8 times as long as endopod of pleopod 2; peduncle of pleopod 5 without seta laterally.

*Additional characters.* Pleotelson with sexual dimorphism, medial punctum much larger in males than females. Body length up to 3.2 mm. Colour in alcohol pale yellow.

*Distribution.* Ponape, Caroline Islands (type locality) (Menzies, 1957); Andaman Islands (Ganapati and Rao, 1960); Palau; Huahine Island, Society Islands; San Salvador; Belize (Kensley and Schotte, 1987); PNG; northern Western Australia; Port Douglas, Queensland. 0–1.5 m depths (current study).

*Substrates.* Wooden test sample (Menzies, 1957), wooden plank (Ganapati and Rao, 1960), red mangrove wood and roots, (Kensley and Schotte, 1987), jarrah, CCA-treated hardwoods (*E. marginata*, *S. glomulifera*, *E. maculata*, *Diospyros papuana*) (present study).

*Remarks.* Menzies (1957) had only one male specimen and a male pleotelson when describing this species, and so was unaware of the sexual dimorphism. Some of the setae which fringe the posterior margin of the pleotelson are sheathed, which was not indicated by Menzies' (1957) figure. Also, Menzies (1957) thought the lacinia mobilis of the right mandible was simple and apically spinulate. However, in the specimens examined here, the lacinia mobilis is a reduced blunt knob (Plate 2f). As Menzies had only one right mandible to examine, which was apparently mounted in a way that does not give the best view of the lacinia mobilis, it is likely the most apical seta in the spine row was mistaken for the lacinia mobilis.

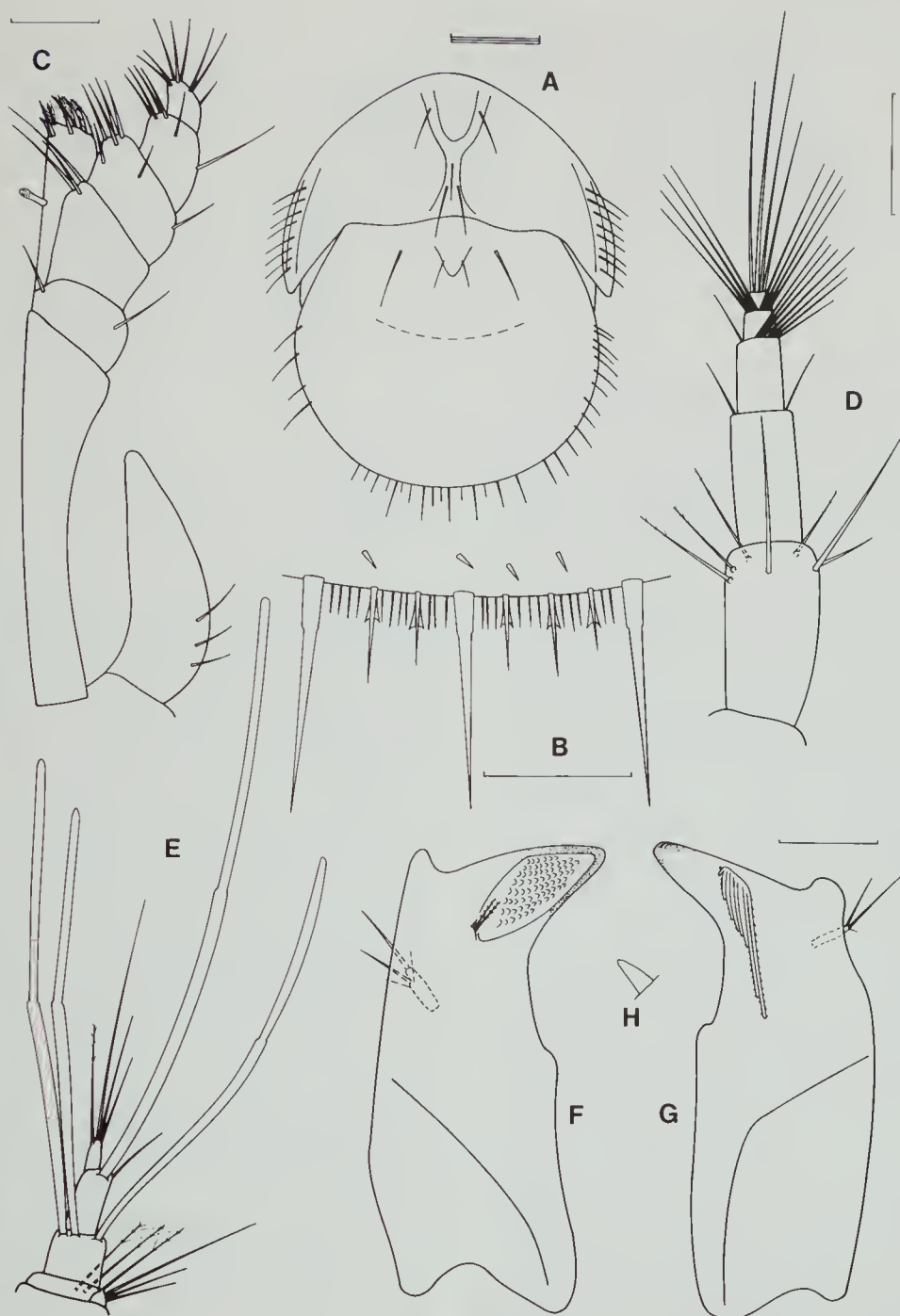


Figure 64. *Limnoria unicornis* Menzies. A-C, male, NMV J15352: A, pleonite 5 and pleotelson, dorsal view; B, posterior margin of pleotelson, dorsal view; C, maxilliped. D,E, male, NMV J15355: D, peduncle article 5 and flagellum of antenna 1; E, flagellum of antenna 2. F-H, male, NMV J15353: F, left mandible; G, right mandible; H, lacinia mobilis of right mandible.

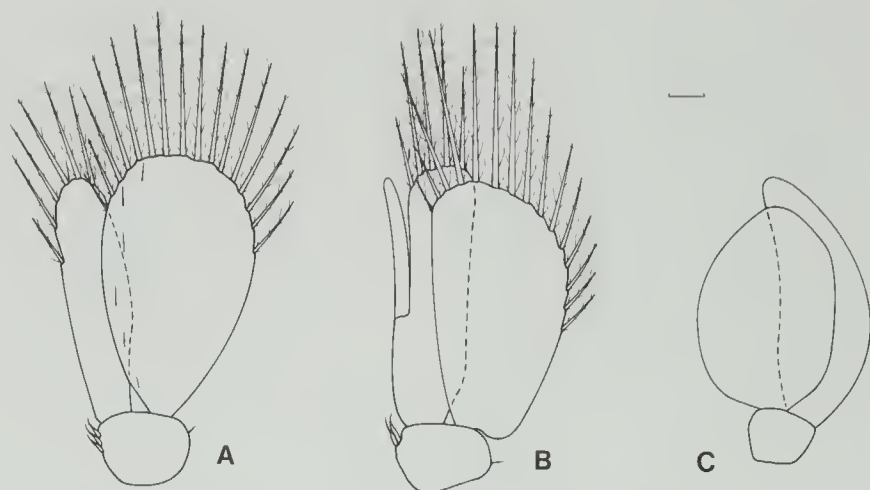


Figure 65. *Linnoria unicornis* Menzies. A–C, male, NMV J15352: A–C, pleopods 1, 2 and 5.

This species does not have obvious affinities with any other species, except possibly the sea-grass-borer *L. zinovae*. Both species have one medial punctum on the pleotelson, the size of which is sexually dimorphic (Plate 2e); a Y-shaped carina on pleonite 5; four flagellar articles on antenna 2; and a reduced mandibular palp. The only other known wood-borer with a (slightly) reduced mandibular palp is *L. cristata*, which, like *L. unicornis*, has a triangular maxillipedal epipod, no dorsal row of tubercles or scale spikes on the posterior margin of the pleotelson (Plate 1c), and a similar arrangement of setae fringing the posterior margin of the pleotelson.

Menzies (1957) thought that *L. unicornis* was similar to *L. segnis* and *L. segnoides*. However, the pleotelsonal ornamentation on these species has a bilateral pattern (although joined anteriorly by a broad raised area), rather than one with an anterior medial punctum. Also in these particular species of algal-borers, the shape of the maxillipedal epipod is not triangular, and the ventral branch of the secondary unguis on pereopod 1 is reduced.

*L. unicornis* is most readily distinguished by the sculpturing on pleonite 5 and the pleotelson, and the possession of only one article on the mandibular palp.

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## Plates

## Plate 1a.

Rasp incisor on left mandible of *Limnoria tripunctata* collected from Ulladulla, NSW. Partly concealed lacinia mobilis is left of two accompanying serrated setae. Scale = 10  $\mu\text{m}$ .

## Plate 1b.

*Limnoria tripunctata* collected from Goat Island, Sydney Harbour. Long-sheathed setae and dorsal row of tubercles on posterior margin of pleotelson. Dorsal view. Scale = 3  $\mu\text{m}$ .

## Plate 1c.

*Limnoria unicornis* collected from Port Douglas, Queensland. Posterior margin of pleotelson. Note the lack of a regular dorsal row of scale spikes. Shows a large stout seta (left), two short-sheathed setae (middle and right), and thin scale spikes. Scale = 5  $\mu\text{m}$ .

## Plate 1d.

*Limnoria tripunctata* collected from Goat Island, Sydney Harbour. Puncta found dorsomedially on pleotelson. Note scale structure of pleotelson. Scale = 10  $\mu\text{m}$ .

## Plate 1e.

*Limnoria tripunctata* collected from Goat Island, Sydney Harbour. Nodes found dorsomedially on pleonite 5. Note scale structure. In this specimen, only the posterior scales were fringed posteriorly with thin spikes. Scale = 20  $\mu\text{m}$ .

## Plate 1f.

*Limnoria andamanensis* collected from Buka Passage, Papua New Guinea. Lacinia mobilis of right mandible. Scale = 1  $\mu\text{m}$ .

## Plate 2a.

*Limnoria insulae* collected from Magnetic Island, Queensland. Pleonite 5 and pleotelson. Note claw-like tubercles on uropod peduncle. Scale = 100  $\mu\text{m}$ .

## Plate 2b.

*Limnoria insulae* collected from Tahira, Papua New Guinea. Pleonite 5 and pleotelson. Shows deep cup-shaped pleotelson. Scale = 100  $\mu\text{m}$ .

## Plate 2c.

*Limnoria orbellum* sp. nov. Pleonite 5 and the pleotelson. Note both the scale structure, and the four stout setae on the posterior margin of the pleotelson. Scale = 100  $\mu\text{m}$ .

## Plate 2d.

*Limnoria quadripunctata* collected from Sandringham, Victoria. Pleonite 5 and pleotelson. Note pitted structure. Scale = 100  $\mu\text{m}$ .

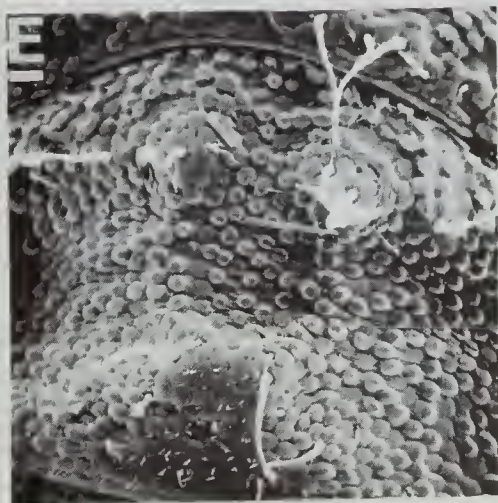
## Plate 2e.

*Limnoria unicornis*, male, collected from Port Douglas, Queensland. Pleotelson and pleonite 5. Note pitted structure. Scale = 100  $\mu\text{m}$ .

## Plate 2f.

*Limnoria unicornis* collected from Port Douglas. Lacinia mobilis, and setal row, of right mandible. Scale = 3  $\mu\text{m}$ .





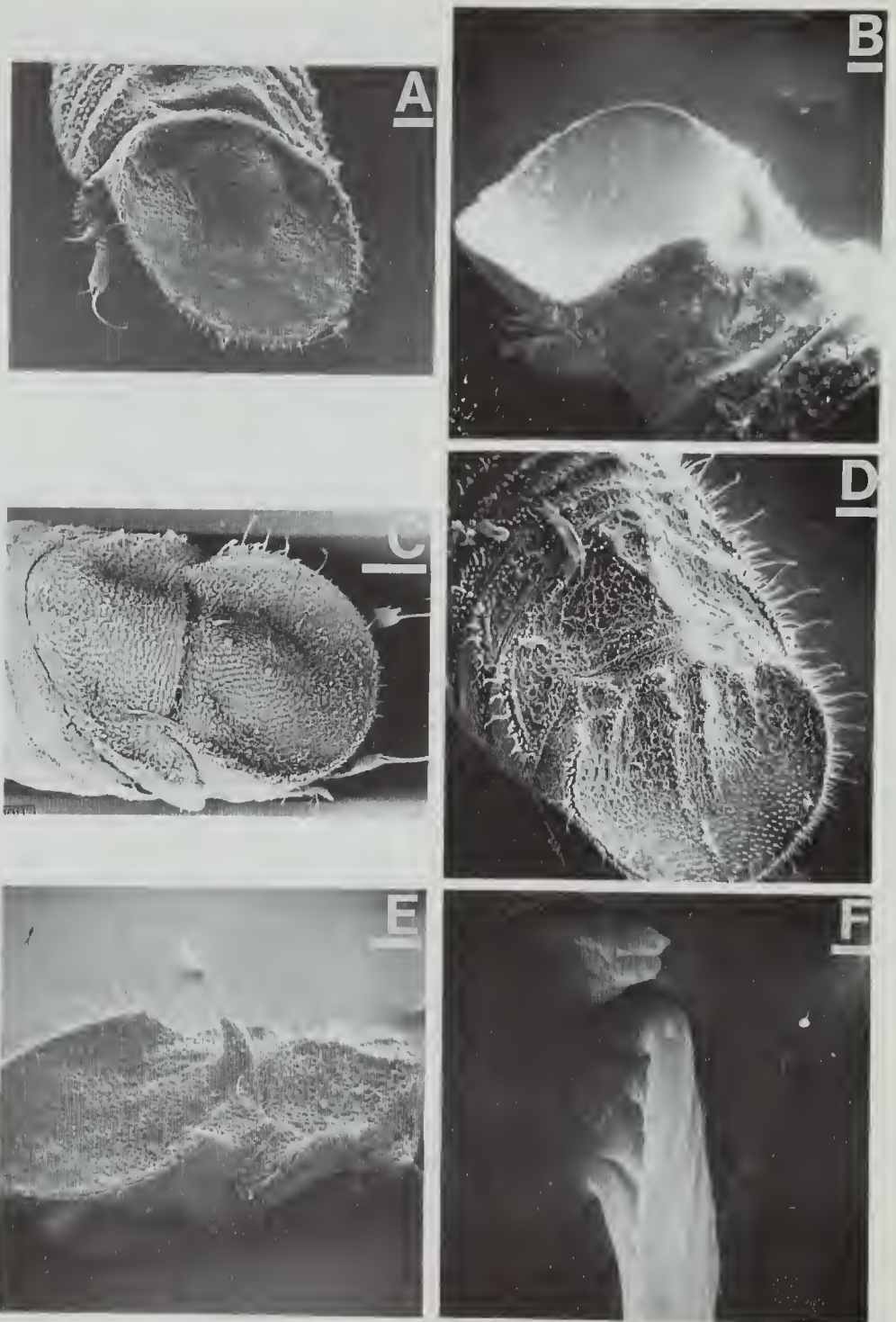


PLATE 2