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The systematics and ecology of some cirolanid isopods from southern Japan

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Introduction

Recent work on the systematics of isopod crustaceans from Japan has been centred mainly on the *Anthuridae* (Nunomura 1975, 1976 a, 1976 b, 1977) and the *Sphaeromatidae* (Nishimura 1976 a, 1976 b, Nunomura and Nishimura, 1976). The last work that dealt with cirolanid isopods was that of Thielemann (1910) who described six cirolanids from Japanese waters.

In 1977 quantitative and qualitative samples were taken from sand beaches and some rocky areas mainly in the south of Japan (fig. 1) and these, together with collections from museums, reveal the presence of two new species. The ecology of *Cirolana harfordi japonica* Thielemann, is described, but the ecology of *Excirolana chiltoni* Richardson and *Eurydice nipponica* is to be discussed separately by one of the authors (D.A.J.).

Systematics

Family **CIROLANIDAE**

Cirolanidae Hansen, 1890 : 310; Monod, 1930 : 129; Menzies, 1962 : 113; Naylor, 1972 : 24. Eurydicidae Stebbing, 1905 : 10; Barnard, 1914 : 350 a; Hale, 1925 : 129.

Genus *EURYDICE* Leach

Eurydice Leach, 1815 : 370; Hansen, 1890 : 362; 1905 : 340; Richardson, 1905 : 123; Stebbing, 1910 : 95; Barnard, 1914 : 350; 1940 : 387.

Eurydice nipponica sp. nov. (figs. 2 and 3).

MATERIAL EXAMINED: *c.* 200 specimens, ♂♂ and ♀♀ taken from numerous beaches around Kagoshima prefecture. (fig. 1).

MALE. Holotype—mouthparts not differing significantly from those of other members of the genus. Front margin of cephalon indented at point of insertion of antennules (fig. 2 (*b*)).

Antennule short, not extending beyond cephalon (fig. 2 (*d*)); fourth peduncular segment longest, equal to the combined lengths of segments 2 and 3. Flagellum extremely short, composed of two articles: equal to half the length of peduncular segment 3.

Antenna with fourth peduncular segment longer than the combined lengths of segments 2 and 3 (fig. 2 (*c*)); segment 3 bearing a row of eight stout curved setae on

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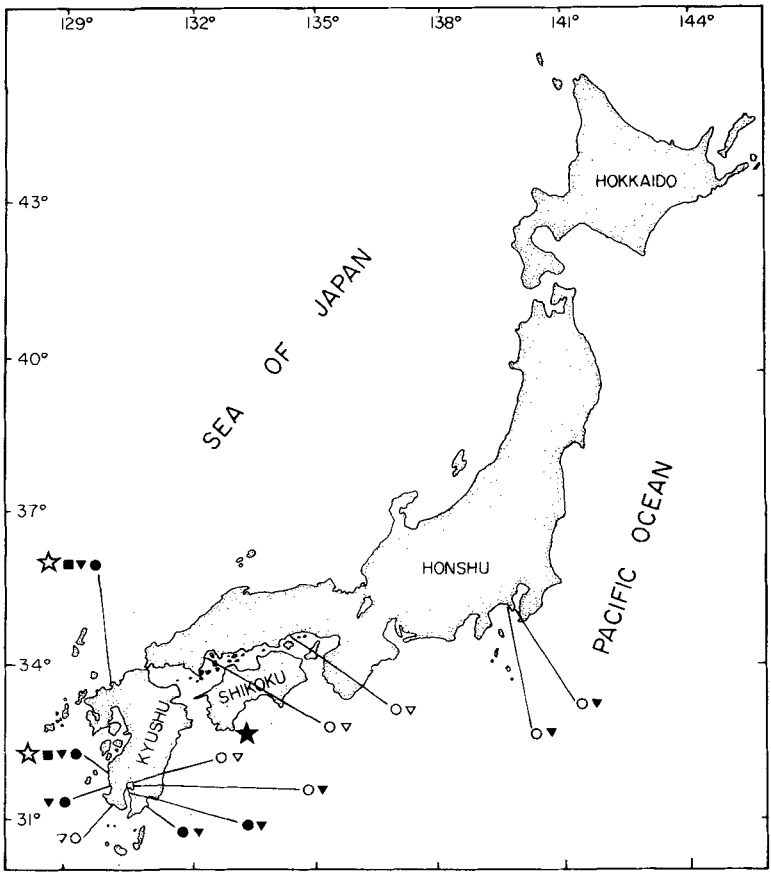

FIG. 1. Map of Japan showing the distribution of cirolanid isopod species and collection sites. *Eurydice nipponica* sp. nov., (● present, ○ absent); *Excirolana chiltoni* (▼ ▽); *Cirolana harfordi japonica* (■ present); *C. australiense* (☆ present); *C. coronata* sp. nov. (★ present).

the outer distal margin. Antennal flagellum long, extending beyond the second pleon segment; flagellum composed of 18 articles with articles 4–17 bearing a plicate process (fig. 2 (*c*)).

Coxae with posterior border becoming progressively more produced (fig. 2 (*a*)); coxae 4–7 terminating in a well developed rounded point (fig. 2 (*f*)).

Peraeopod 1 (fig. 3 (*a*, *b*)) with merus bearing 3 stout spines on posterior border, carpus with a single spine and propodus with 3 spines including a terminal spine which is less than half the length of the opposing dactyl (fig. 3 (*b*)).

Peraeopod 7 large and broad, (fig. 2 (*h*)) ischium slightly longer than segments 3–5 which are subequal in length; basis about 1·5 times as long as ischium. Hind margins of segments 3 and 4 setose; segments 2–4 with spines at posterior distal corner, and segment 3 with an additional spine on the hind margin. Anterior margin with spines arranged in groups of three; propodus with a terminal group of 4 spines.

Telson broad, greatest width about one-third longer than greatest length (fig. 2 (*g*)). Hind margin narrow, about one-fourth of the width of the telson; deeply indented with two prominent lateral teeth and 6 plumose setae.

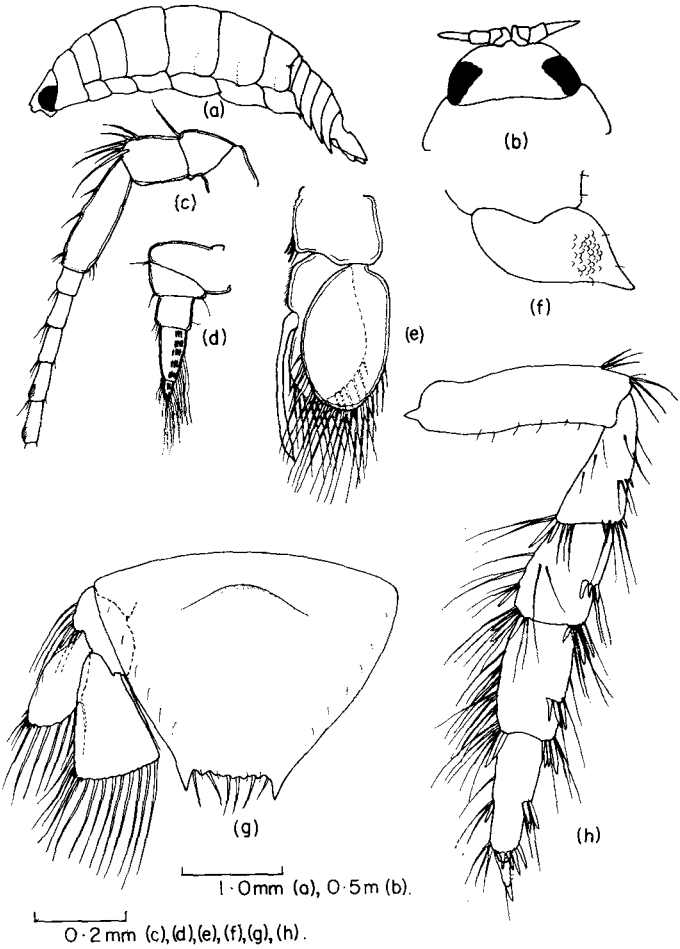

FIG. 2. *Eurydice nipponica* sp. nov., (*a*) lateral view (*b*) dorsal view of cephalon (*c*) antenna (*d*) antennule (*e*) pleopod 2 (*f*) coxa 7 (*g*) telson and uropod (*h*) peraeopod 7.

Uropods not exceeding hind margin of telson; exopod narrow, less than half the width of endopod and half the length of the endopod.

Pleopod 2 with *appendix masculina* arising from centre of inner margin (fig. 2 (*e*)) and exceeding the hind margin of the pleopod by one half of its length. *Appendix masculina* slender (fig. 3 (*d*)), becoming broader distally and terminating in an acute point.

COLOUR: White to pale brown in formalin and alcohol; with brown to black chromatophores.

LENGTH: 3·0 mm.

FEMALE. As the male, but with *appendix masculina* on pleopod 2 absent, also lacks the plicate process on the antennal flagellum. The body is more convex than for the male, maximum size ca. 5·0 mm.

TYPES: 1 ♂ holotype B.M.(N.H.) registration number 1978:133:1. 2 ♂♂ 4 ♀♀ paratypes B.M.(N.H.) registration number. 1978:134:8. Additional material in the authors' collections.

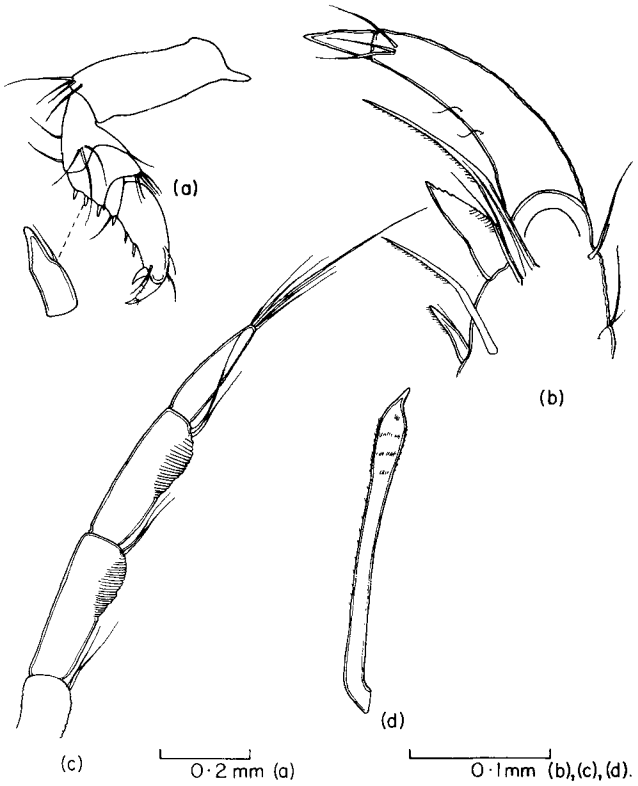

FIG. 3. *Eurydice nipponica* sp. nov., (*a*) peraeopod 1 (*b*) detail of dactyl of peraeopod 1 (*c*) antennal flagellum—distal portion (*d*) *appendix masculina*.

TYPE LOCALITY: Fukiage beach, Kyushu, Japan 12.8.78.

REMARKS: The configuration of the hind margin of the telson separates *E. nipponica* sp. nov. from most other members of the genus with the exception of *E. orientalis* Hansen and *E. grimaldii* Dollfus. *E. orientalis* may be distinguished by having longer antennules, broader uropodal exopods and a shorter *appendix masculina* (Hansen 1890). *E. grimaldii* is a pelagic Atlantic species, (Jones and Naylor 1967) and has a broader hind margin to the telson (Hansen 1890).

DISTRIBUTION: In intertidal and sublittoral sand along the coast of Japan as far north as Fukuoka, northern Kyushu (fig. 1).

Genus ***EXCIROLANA*** Richardson

Excirolana Richardson, 1912 : 201; Hale, 1925 : 156; Monod, 1930 : 174; Nierstrasz, 1931 : 148; Barnard, 1940 : 387.

Excirolana chiltoni Richardson

(Figs. 4, 5, 6 (*a*)–(*d*).)

Cirolana chiltoni: Richardson, 1905 : 91–92, fig. 73.

Cirolana chiltoni sub sp. *japonica:* Thielemann, 1910 : 15–18, figs. 8–11.

Excirolana chiltoni: Richardson, 1912 : 201.

Excirolana japonica: Richardson, 1912 : 201.

Cirolana chiltoni var *vancouverensis:* Fee, 1927 : 12–13, plate 1, figs. 13, 14.
Excirolana japonica: Monod, 1930 : 180.
Excirolana chiltoni: Monod, 1930 : 180.
Cirolana kincaidi: Hatch, 1947 : 208, fig. 163 (not seen).
Excirolana japonica: Kussakin 1955 : 232–234, fig. 4.
Excirolana (*Pontogeroides*) *japonica:* Shiino, 1965 : 541. fig. 717. (subgeneric misspelling).
Excirolana chiltoni: Schultz, 1969 : 175, fig. 270.
Excirolana kincaidi: Schultz, 1969 : 176, fig. 271.
Excirolana vancouverensis: Schultz, 1969 : 176, fig. 272.
Excirolana kincaidi: Monod, 1976 : 140–148, figs. 27–73.

This species was summarily described by Richardson (1905) with one figure of the telson and uropods and one of the cephalon. Although the biology and physiology of this species has been studied (Enright 1976, Klapow 1970, 1976), there appears to have been no further description or report of material designated as this species. Thielemann (1910) described the subspecies *japonica* of *E. chiltoni* from Hokkaido, Japan, and this was subsequently given specific status by Richardson (1912) without any discussion. *Excirolana japonica* appears to have been accepted by subsequent authors (Kussakin 1955, 1975, Monod 1930, Shiino 1965) although the subspecies was based on a single specimen (*ex pisce*) and Thielemann himself suggested that his specimen was but a geographic variety.

Fee (1927) described a further variety as *Cirolana chiltoni* var *vancouverensis* from Departure Bay, Vancouver Island. This variety has received the same treatment as the subspecies described by Thielemann. Schultz (1969) transferred it to the genus *Excirolana* and at the same time elevated it to specific status without discussion. Yet another sand beach species was described by Hatch (1947) as *Cirolana kincaidi*, from Washington, U.S.A. This species was also later transferred to the genus *Excirolana* by Schultz (1969). Monod (1976) redescribed this species giving excellent illustrations, but did not comment on its systematic position in the genus. His figures allow ready identification of the species as a synonym of *E. chiltoni*.

The confusion surrounding this species is attributable both to authors describing new species without adequate recourse to prior literature, and to the elevation of varieties or subspecies to specific rank without explanation. In view of this, material from Japan is redescribed, as *Excirolana chiltoni* and comparison made with *E. chiltoni* obtained from California. The relationships of the various forms of this species are fully discussed under the appropriate section.

MATERIAL EXAMINED: *c.* 200 ♂♂ and ♀♀ from various sandy beaches from Kyushu and Honshu Islands, Japan (fig. 1). For comparison *c.* 35 specimens, Pillar Point Harbour, Half Moon Bay, California, 5·7 : 1971 Coll. E. Iverson and O. Behrens, U.S.N.M. Acc. No. 297393.

MALE: Body 2·5–2·75 times as long as broad (fig. 4 (*a*)), surface smooth with a few scattered pits; rostral point expands distally and projects beyond the base of the antennules and is united with the frontal lamina. Frontal lamina is overlapped at its base by the clypeus, which is very short, about 8 times broader than long, and has a small median projection (fig. 4 (*b*)). Eyes of moderate size, twice as broad as long with distinct facets (fig. 4 (*h*).

Peraeon segments 1, 4 and 7 subequal in length; segments 2 and 3 subequal in length and shortest; segments 5 and 6 are subequal in length and are the longest. Coxae on segments 2–7 distinct (fig. 4 (*h*)); those on segments 4–7 with posterior edge

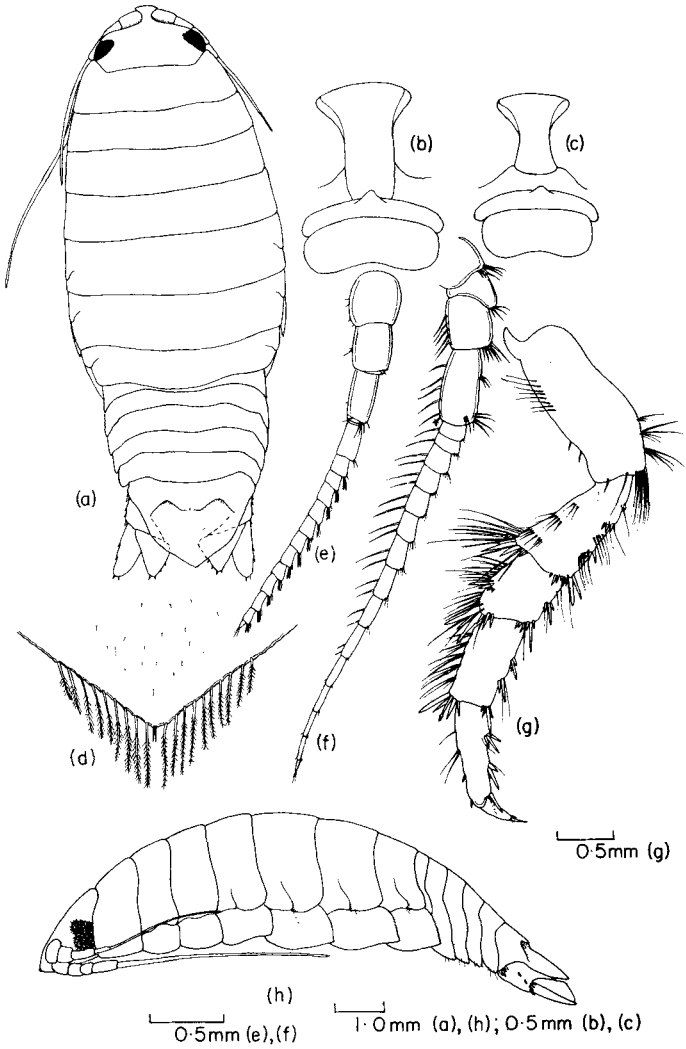

FIG. 4. *Excirolana chiltoni* Richardson, (*a*) dorsal view ♀ from Japan (*b*) frontal lamina and clypeus ♀ Japan (*c*) frontal lamina and clypeus ♀, California. (*d*) hind margin of telson (*e*) antennule (*f*) antenna (*g*) paraeopod 7 (*h*) lateral view, ♀ Japan. All ♂ except where otherwise stated.

rounded and only slightly extended backwards. Lateral carinae present on segments 4–7, but on none of the coxae. A pair of papilliform penes open on the posterior of sternite 7. Pleon with segment 1 largely concealed by peraeon segment 7; segment 5 with lateral margins free. Segments 1–4 are subequal in length, segment 5 half as long again as segment 4.

Antennule with peduncular articles 1 and 2 subequal in length (fig. 4 (*e*)) and segment 3 only slightly longer. Proximal article of flagellum is about twice the length of the other articles; all articles with the exception of first and terminal articles with a pair of short aesthetascs. Flagellum extends to the hind margin of peraeon segment 3.

Antenna long, flagellum extending to the posterior border of peraeon segment 5. Segments 1 and 2 short and subequal in length; segment 4 about one and a half times the length of segment 3, which is about one and a half times the maximum length of segment 2 (fig. 4 (*f*)). The posterior margins of segments 3 and 4 and all flagellar articles excluding the last 6 are furnished with long plumose setae; 5 setae are present on segments 3 and 4 and 2 setae on each flagellar article.

MOUTHPARTS: Mandibles with usual tricuspidate incisor process (fig. 5, (*a*), (*c*)); condyles prominent, one smooth and pointed, the other rounded with minute spinules on its surface; spine row with *c*. 13 teeth of unequal size; molar process with *c*. 30 teeth. Palp with 2 segments, segment 2 being half as long again as segment 1. 5–6 setae are present on segment 1 and segment 2 boasts 7–8 setae on the lateral border and 2 long and 2 short setae at the apex. Maxillule (fig. 5 (*d*)) with 12 spines on the gnathal surface of the exopod, and endopod with 3 stout plumose spines. Maxilla (fig.

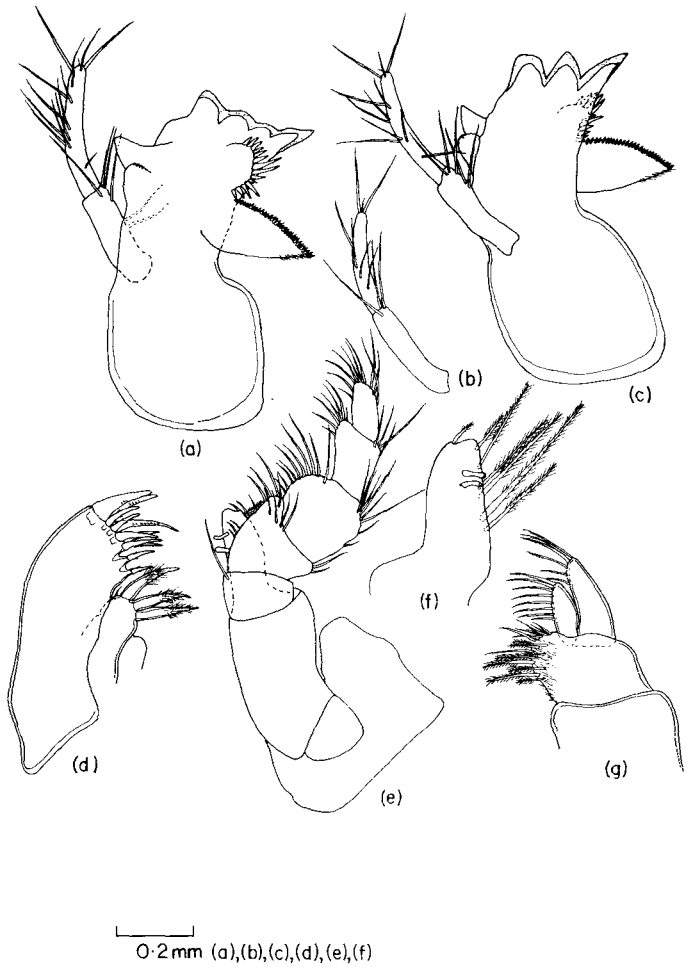

FIG. 5. *Excirolana chiltoni* Richardson, (*a*) mandible, (*b*) mandibular palp ♂, California, (*c*) Mandible (*d*) maxillule (*e*) maxilliped (*f*) endite of maxilliped of ♀ (*g*) maxilla.

5 (*g*)) with 6 and 8 fringed setae on the palp and exopod respectively; endopod with 8 large setae and *c*. 9 simple setae; and with numerous setules on the endopod surface. Maxilliped (fig. 5 (*e*)) with numerous simple setae on palp segments: segment 2 of palp with a row of 5 setae inside the distal border and segment 1 with a single seta at the medial distal corner. The endite bears two stout coupling hooks (fig. 5 (*f*)) and 6 long plumose setae, a further short plumose seta is situated at the apex.

Peraeopods 1–3 are short and prehensile whilst 4–7 are ambulatory. The propodus of peraeopod 1 (fig. 6 (*a*)) is a little greater than half the length of the basis, and the ischium and merus have their distal anterior external angles produced with numerous long setae on the apical and external margins. The merus bears 8 spines on the posterior border; carpus 3 spines, and both bear a single seta amongst the spines on the posterior border. Propodus with 6 spines and a seventh serrated spine opposing the dactyl on the posterior border, and 8 stout curved setae on anterior margin. Peraeopod 7 with numerous long setae on the posterior margins of the ischium, merus, and carpus (fig. 4 (*g*)). The basis with 3 groups of setae on the anterior distal margin, and a large group of setae at the antero-distal corner and a line of setae present in the posterior proximal region, running parallel to the posterior border. The ischium is armed with 3 groups of spines on the anterior margin and a fourth group of *c*. 12 spines on the antero-distal corner, the posterior distal corner also bears a group of large spines. Merus with 4 groups of spines, group at each distal corner and a group midway along each margin. Carpus with a group of spines at each distal corner and a further 2 groups along the anterior margin. Propodus with a pair of spines opposing the dactyl, and 2 groups of 3 spines along the anterior margin also 2 spines are present on the posterior margin.

Pleopods, do not differ from the figures given by Monod (1976) for *Excirolana kincaidi*. *Appendix masculina* short, broad and recurved (fig. 6 (*d*)).

Telson one and half times as broad as maximum length (fig. 4 (*a*)) with a rounded triangular apex coming to a blunt point. The posterior margin is slightly serrated, armed 16–20 plumose setae (fig. 4 (*d*)), and a terminal pair of short simple setae. Surface with minute setules scattered over it. A carina is present, forming 2 distinct impressions and separating the telson into opaque anterior and transparent posterior parts. Uropods with endopod broad, obliquely truncate and distinctly triangular (fig. 6 (*b*)). The endopod exceeds the posterior margin of the peduncle by a third of the length of its inner margin. Exopod narrowly rounded and slightly longer than the endopod. The lateral corner of the telson is armed with 4 stout spines, and the peduncle of the uropod with 2 single spines on the lateral edge, and 4 on the lateral distal corner; inner margin bears 5 plumose setae, and posterior margin bears 2 plumose setae. Exopod with 2 deep set spines on the exterior margin and spines at the distal corner, fringed with *c*. 18 plumose setae. Endopod with 2 spines on the inner margin and 2 at the distal corner; inner margin fringed with *c*. 20 long plumose setae and lateral margin with 6 pairs of setae, the distal seta of each pair being short.

SIZE: Largest about 8 mm.

FEMALE: As the male, but differs other than in just the sexual characters. Females tend to a larger body size; the plumose setae on the antenna are longer, and occur at 3 per flagellar article. Peraeopod 7 tends to be broader, and also has more spines, (the merus for example has a total of 6 groups of spines, while the male has four).

SIZE: Largest reaching 14 mm.

DISPOSITION OF MATERIAL: British Museum (N.H.) and United States National Museum.

Additional material contained in the authors' personal collections.

REMARKS: As several varieties of this species have been described, they will be discussed in chronological order.

Material from California differs from Japanese specimens in that the clypeus does not overlap the frontal lamina. (fig. 4 (*c*)) and the *appendix masculina* is slightly longer and more attenuated (fig. 6 (*c*)). A further difference is that the plumose setae of the antennae extend the entire length of the flagellum and are slightly longer. However, these differences are relative and the basic form and proportions of the structures concerned remains identical so that present authors consider *E. chiltoni* Richardson and *E. japonica* Richardson to be the same species. Differences that have been utilized previously to distinguish *E. chiltoni* were the size of the eyes and the proportions of the rostral point. Comparison of Japanese and Californian material reveals that there is no difference in these structures, the rostral point was measured and in all cases found to conform to the ratio minimum width : maximum width : length = 1 : 2 : 2·5. The relative proportions of the rostral point and eyes differ depending upon the viewing perspective and the figure given by Richardson (1905, fig. 73 (*a*)) is certainly not representative.

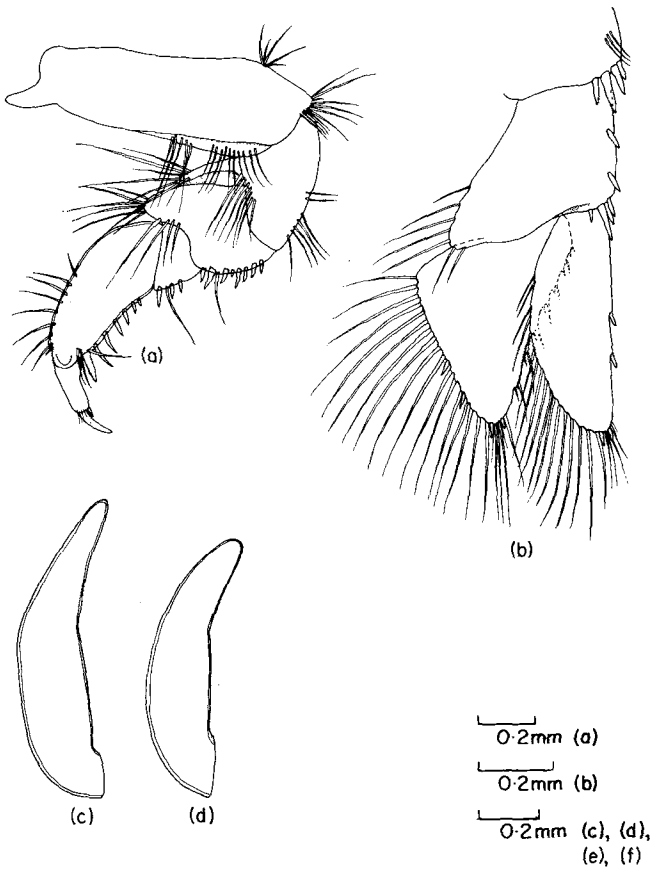

FIG. 6. *Excirolana chiltoni* Richardson (*a*) peraeopod 1 (*b*) uropod in ventral view (*c*) *appendix masculina*, California (*d*) *appendix masculina*, Japan.

Fee (1927) separated a variety of *E. chiltoni* on the relative proportions of the peduncular articles of the antennule, as the second segment was shorter than the first and third. This difference is also present in *E. kincaidi* described by Monod (1976). The Japanese and Californian specimens have an antennule peduncle with the segments sub-equal, or with segment 3 very slightly longer.

E. kincaidi Hatch (Monod 1976) differs in only two respects from the Japanese material, firstly the relative size of antennule segment 2 and also in having fewer setae on the mandibular palp, a feature also seen in Californian specimens of *E. chiltoni*.

The variations present in this species of *Excirolana* are relatively few over such a vast geographic area (fig. 7), and are not considered to be of significance. Furthermore they are not evenly distributed. Thus *E. kincaidi* approximates to *E. vancouverensis* on the basis of the antennule; is close to *E. japonica* on the basis of the *appendix masculina*, and is close to *E. chiltoni* (California) on the basis of the mandibular palp. *Eurydice caudata* Richardson is another widely distributed species, and there is variation present in the *appendix masculina* of otherwise similar specimens (Bowman 1977).

In the opinion of the present authors, the differences referred to above do not merit the erection to specific status of the described subspecies and varieties of *E. chiltoni*, and *Excirolana kincaidi* Hatch is the junior synonym of *Excirolana chiltoni* Richardson.

Distribution: (figs. 1 and 7) *E. chiltoni* appears to be a temperate N. Pacific species occurring widely in Japan, South Kuriles (Kussakin 1975), and Eastern Russia (Kussakin 1955), and also along the Pacific coast of N. America from San Diego (Klapow 1970), San Francisco (Richardson 1905), to Washington (Monod 1976), and Vancouver Island (Fee 1927). Thus it appears to be the only member of the genus with a northern distribution extending into temperate waters, as all other known species occur in sub-tropical or tropical waters.

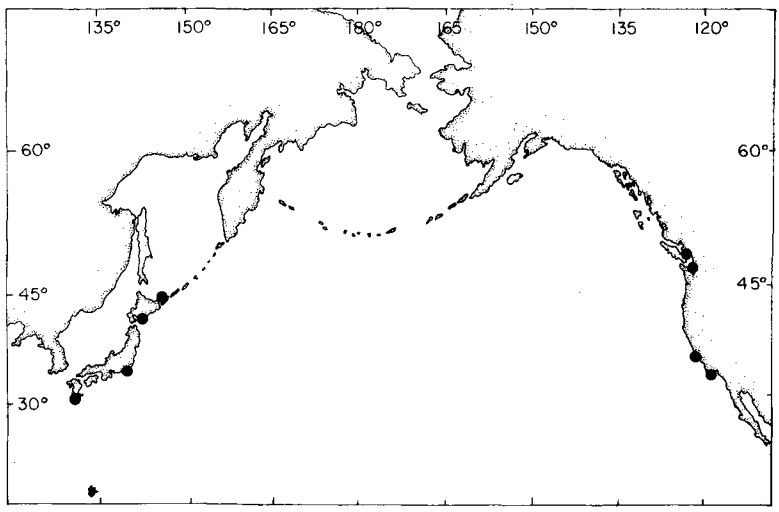

Fig. 7. Map showing distribution of *Excirolana chiltoni* in the North Pacific: (● recorded locality).

Cirolana harfordi japonica Thielemann (fig. 8).

Cirolana harfordi harfordi Lockington *japonica* Thielemann, 1910 : 11–14, figs. 5–7; *Cirolana harfordi japonica:* Shiino, 1965 : 541, fig. 716.

MATERIAL EXAMINED: *c.* 1500 specimens, ♂♂ and ♀♀ were collected from rock crevices bordering a sand beach at Sendai Kyushu, Japan. Large ♂♂ and ♀♀ and a size range of immature specimens were selected for study. Also for comparison 25 specimens, ♂♂ and ♀♀ *Cirolana harfordi harfordi* Lockington from California (USNM Catalogue No. 22888).

Thielemann (1910) erected *C. harfordi japonica* as a subspecies of *C. harfordi harfordi* Lockington using the brief description of this species given by Richardson (1905) as a basis for comparison. The main distinction between the two forms was the presence of tubercules on the dorsal surface of the telson in the Japanese form (Thielemann 1910, fig. 7). Richardson (1905) described *C. harfordi harfordi* from small specimens which did not show tubercules but observed that larger specimens did not differ in this respect.

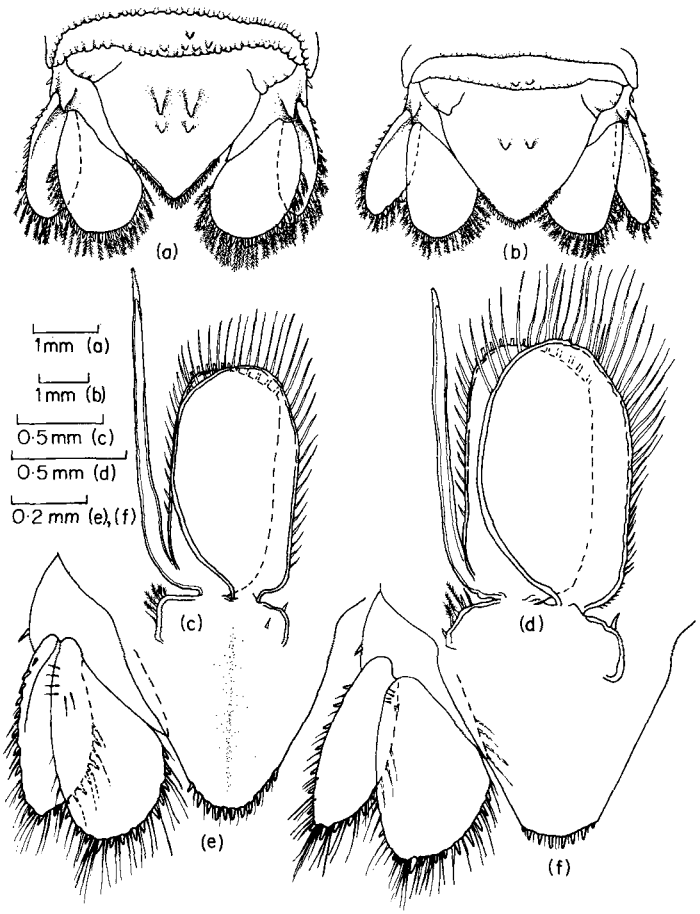

FIG. 8. *Cirolana harfordi japonica* Thielemann, (*a*) telson and uropods (*d*) *appendix masculina*, (*e*) telson and uropods juvenile (6 mm); *Cirolana harfordi harfordi* Lockington (*b*) telson and uropod (*c*) *appendix masculina; Cirolana australiense* Naylor (*f*) telson and uropod (6 mm).

Present collections from Japan show that juvenile and immature specimens of *C. harfordi japonica* cannot be separated from *C. harfordi harfordi* on the basis of the description given by Richardson (1905) (fig. 8 (*e*)). In agreement with Thielemann (1910) adult specimens (*c.* 7–8 mm) of both sexes possess tubercules on the telson and last pleon segment and denticulate hind margins on pleon segments 3–5 (fig. 8 (*a*)). Examination of *C. harfordi harfordi* from California reveals that adult males in excess of 14 mm also possess tubercules on the telson and on the hind margin of pleon segments 4–5 (fig. 8 (*b*)). These features are absent in all female specimens examined (size range 10–13 mm including ovigerous animals). Thus it appears that the similarity between *C. harfordi harfordi* and *C. harfordi japonica* is even closer than was previously thought. However it is decided to retain the subspecies *japonica* as detailed examination of present material reveals the following criteria which may be used to separate the two forms.

Antenna composed of 30 flagellar articles in adult *C. harfordi harfordi* and reaching to the hind border of peraeon segment 4. Antenna composed of 32–33 flagellar articles in adult *C. harfordi japonica* and reaching to the hind border of peraeon segment 5. *C. harfordi harfordi* with the endite of the maxilliped bearing 2 coupling hooks of equal size; endite of maxilliped of *C. harfordi japonica* bearing a single coupling hook, occasionally with a second very much reduced. Tubercules and denticulate hind margins of pleon segments 4–5 only present in male *C. harfordi harfordi* larger than 14 mm, absent in females of all sizes. Denticulate hind margins of pleon segments 3–5 and tubercules present in both male and female *C. harfordi japonica* larger than 7–8 mm, more pronounced in males. *Appendix masculina* in male *C. harfordi harfordi* extends beyond the endopod of pleopod 2 by one third of its length (fig. 8 (*c*)). *Appendix masculina* in male *C. harfordi japonica* extends beyond the endopod of pleopod 2 by one fifth of its length (fig. 8 (*d*)). In addition the maximum size of male and female *C. harfordi harfordi* is 22 mm and 13 mm respectively (see also Johnson (1976)), whereas maximum size of *C. harfordi japonica* males and females is 10 mm.

DISTRIBUTION. *C. harfordi japonica*, Sagami Bay, Japan, and Penang, Malaysia (Thielemann 1910). Present material from Shikanoshima and Sendai, Japan. *C. harfordi harfordi*, British Columbia to Baja California (Richardson 1905). Present material from Monterey Bay, California.

Cirolana coronata sp. nov. (figs. 9–11)

MATERIAL EXAMINED: 1 ♀, 10·0 mm, taken off Tosa-shimuzi, Kochi Prefecture, Shikoku Island at a depth of 90 m. 27.3.1961. Coll. K. Kurohara.

FEMALE HOLOTYPE: body elongate, about 3 times as long as greatest width (fig. 9 (*a*)), heavily calcified and coarsely punctate. Cephalon 3 times as broad as greatest width, deeply inserted into first peraeon segment; anterior margin raised into a ridge forming a series of projections, the median projection being distinct from the others. A further pair of processes are centrally disposed either side of the mid line of the cephalon, and the hind margin also raised. Eyes are relatively small and deep set covered by a calcified layer of exoskeleton; facets not distinct. Frontal lamina twice as long as greatest width with a central constriction and coming to a point; freely projecting and not visible from above. (fig. 9 (*c*)).

Paraeon segment 1 twice length of segment 2; segments 2–4 subequal in length and slightly shorter than segments 5–7 which are also subequal in length. Coxae 2

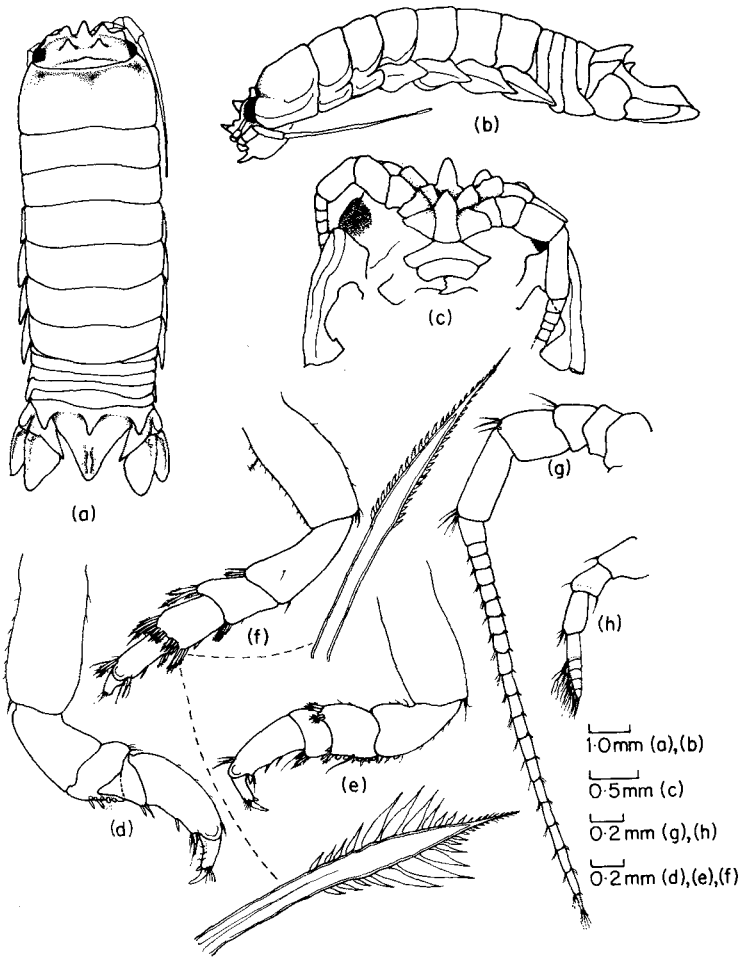

FIG. 9. *Cirolana coronata* sp. nov., holotype (*a*) dorsal view (*b*) lateral view (*c*) cephalon in ventral view (*d*) peraeopod 1 (*e*) peraeopod 2 (*f*) peraeopod 7 (*g*) antenna (*h*) antennule.

and 3 are blunt, not produced and with horizontal carina. Coxae 4–7 become progressively more produced and acute, and all bear a diagonal carina; coxae 4–7 visible dorsally; coxae 5–7 with posterior borders setose.

Pleon segment 1 almost entirely concealed by peraeon segment 7; pleon segment 5 with lateral margins overlapped by the epimera of segment 4 which are posteriorly produced. No epimera present on segments 1, 2 and 5 and the posterior region of epimera 3 and 4 setose.

Antennule short, not extending beyond peduncular segment 3 of antenna (fig. 9, (*a*), (*h*)); segments 1 and 3 subequal in length and slightly longer than segment 2, flagellum composed of 5 articles, article 1 almost as long as the combined length of all other articles. Antenna extending beyond the hind margin of peraeon segment 4 (fig. 9 (*b*), (*g*)); peduncular segment 5 longest, equal in length to the combined lengths of segments 3 and 4; segment 3 about half as long as segment 4; segments 1 and 2 short and subequal in length. Flagellum composed of 20 articles, each bearing two pairs of setae distally.

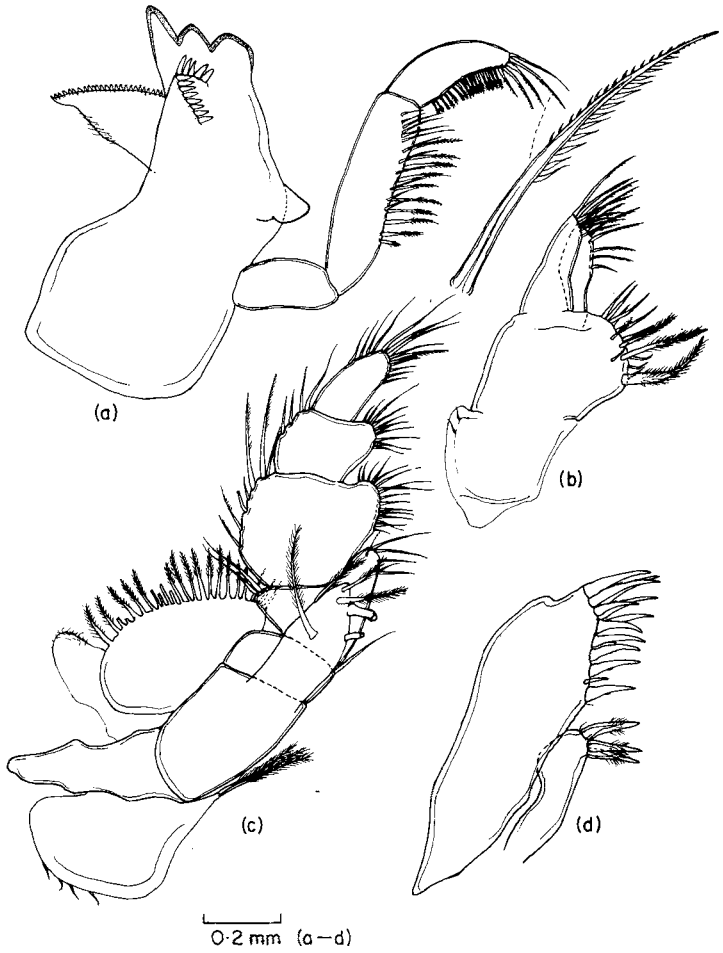

FIG. 10. *Cirolana coronata* sp. nov., holotype (*a*) mandible (*b*) maxilla (*c*) maxilliped (*d*) maxillule.

MOUTHPARTS: mandible with tricuspid incisor (fig. 10 (*a*)); molar process with *c.* 25 teeth and setules on undersurface; spine row of 13 stout spines arranged in a semicircle. Palp large, segment 1 short; segment 2 long, equal in length to the combined lengths of segments 1 and 3. Segment 2 with 10 plumose and *c.* 12 simple setae on the lateral margin, segment 3 with *c.* 18 short plumose setae and four longer fringed setae distally and a long simple terminal seta. Maxillule with 12 stout non-serrate spines on gnathal surface of exopod, endopod with 3 robust plumose spines. Maxilla with 6 and 8 long fringed setae on the palp and exopod respectively (fig. 10 (*b*)), endopod with 3 large plumose setae, and 11 shorter setae on the surface. Maxilliped with numerous setae although only those on the lateral margin of segment 3 of the palp are fringed (fig. 10 (*c*)): endite with 2 coupling spines and four plumose setae.

Peraeopods relatively small and all with biangulate dactyls (fig. 9 (*d,f*). Peraeopods 1–3 prehensile and 4–7 ambulatory. Peraeopod 1 with 5 short blunt spines and 2 acute spines on the posterior margin of the merus: carpus short with 2

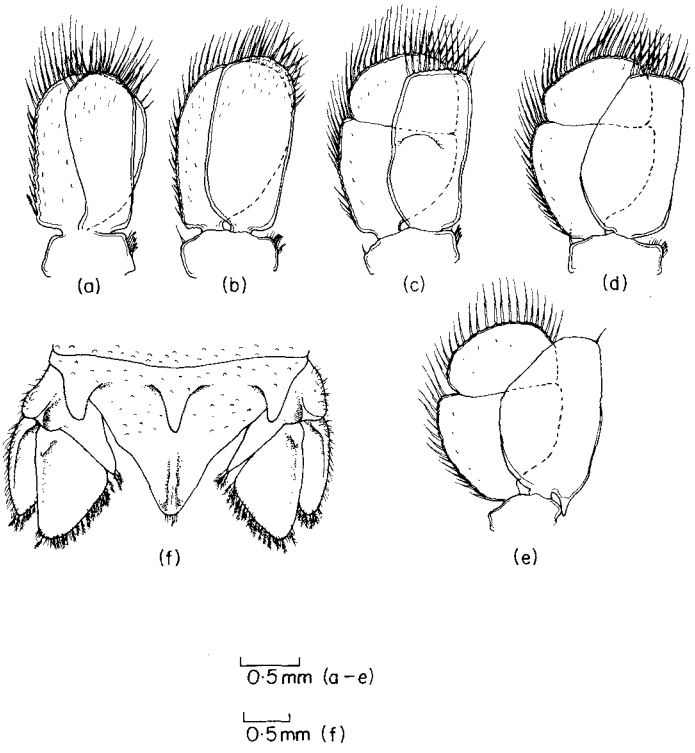

FIG. 11. *Cirolana coronata* sp. nov., holotype (*a–e*) pleopods 1–5 respectively (*f*) telson and uropods.

acute spines on the posterior margin; propodus with 2 spines on the posterior margin, of which one opposes the dactyl. Peraeopod 2 less robust than peraeopod 1; ischium with 1 blunt and 2 acute spines; merus with an additional 5 acute spines on the posterior margin, and a group of spines at the anterior distal corner; carpus longer, with a group of 5 spines at the posterodistal angle; propodus with an additional spine on the posterior margin. Peraeopod 7 with pair of spines at the posterior distal angle of the ischium; carpus with a group of spines at each distal angle; merus with numerous spines, mostly with serrations, along the distal extremity (fig. 9 (*f*)); propodus with a pair of serrate spines at the distal posterior angle; anterior margin with 2 proximal and 1 medial spine. Pleopods with fringe of plumose setae on the exterior and distal margins of the exopods (fig. 11 (*a–e*)); exopod of pleopod 1 with stout serrated spine proximally (fig. 11 (*a*)). Endopods with a fringe of plumose setae along distal borders with the exception of pleopod 5 which is glabrous but for a single simple seta. Endopod of pleopod 3 with a fleshy lobe. Peduncles of pleopods 1 and 2 with 5 coupling hooks and the peduncle of pleopods 3 and 4 with 4 hooks; exopod of pleopods 3–5 with a complete pleat. Telson slightly more than twice as wide as long; sides converging to a narrow rounded point (fig. 11 (*f*)); 3 large prominent tubercules present anteriorly, and a conspicuous median ridge which arises midway and runs to the tip of the telson. Uropods reach well beyond the telson; endopod triangular with posterior margin fringed with plumose setae: and a small projection present at the anterior lateral angle. Exopod narrower, shorter than endopod by one-third the

length of the lateral margin. Peduncle robust, with a dorsal ridge and a lateral margin bearing numerous setae.

COLOUR: White in alcohol.

LENGTH: 10 mm.

TYPE: ♀ holotype. B.M.(N.H.) registration number 1978:138:1.

TYPE LOCALITY: Tosa-shimuzu, Kochi Prefecture, Shikoku Island, Japan. 90 m. 27.3.1961.

REMARKS: This species can at once be separated from all other species of the genus by the unique adornment of the cephalon and telson. *Cirolana willeyi* Stebbing (1904) has similar projections on the cephalon, but these are less pronounced and arranged differently. *C. willeyi* also lacks the sculptured telson seen in *C. coronata* sp. nov. Until the male is known, it will be difficult to ally this species with others within the genus. Typically, males have even more elaborate surface sculpturing than females, if this is so for *C. coronata* it will be placed in the subgroup which includes all species with a sculptured hind margin of peraeon and pleon segments and telson. (Jones 1976).

Cirolana australiense Naylor (fig. 8)

Cirolana cranchii Leach var. *australiense* Hale, 1925:141, fig. 7; 1929:248, fig. 241; Nierstrasz, 1931:158, *Cirolana australiense* Naylor, 1961:14, fig. 5; 1966:184.

MATERIAL EXAMINED: 1 ♀ 10 mm, 4 juveniles 5–7 mm. This species can be referred to *C. australiense* Naylor rather than *C. cranchii* Hansen for reasons given by Hale (1925) and reiterated by Naylor 1961. Unfortunately no adult male was in the present material.

Comparison of this species with *C. harfordi japonica* reveals a very close affinity and juveniles are virtually impossible to separate, for it is only at a size of 6–7 mm that the diagnostic characters of the telson and uropods, and of the maxilliped are developed.

C. australiense may be separated from *C. harfordi japonica* by the more broadly rounded apex of the telson (fig. 8 (*f*)), the reduced number of spines on the telson (8 on the large ♀), the slightly narrower coxae and the reduced number of setae present on the uropods. The maxilliped differs in having fewer setae on the 3rd segment of the palp, and also the endite has 2 coupling hooks and 3 lateral setae; segments 4 and 5 of the palp are shorter than in *C. harfordi japonica*. Peraeopod 7 lacks the group of setae on the posterior distal angle of the basis; peraeopod 2 has the posterior border of the merus indented. The peduncle of pleopod 1 has 5 coupling hooks, not 4 as in *C. harfordi japonica*.

This species is also clearly allied to *Cirolana harfordi harfordi*, from which it can be separated by details of the hind border of the telson and the shape of the uropods.

DISTRIBUTION: New South Wales, South Australia and Victoria (Hale 1925), Chatham Islands, N.Z. (Naylor 1961, 1966) Kagoshima, Kyushu Island, Japan.

Ecology

Of the species collected only *C. coronata*, represented by a single specimen taken from 90 m, is likely to be exclusively sub-littoral in habit. *E. chiltoni* has been collected from intertidal sand beaches over an extensive geographical area (fig. 7), and occupies a similar habitat, together with *Eurydice nipponica*, in Japan. The zonation and ecology of these species on Japanese beaches is described elsewhere (Jones in preparation).

C. harfordi japonica and *C. australiense* appear to be restricted to intertidal rocky shores, although few specimens of the latter species were found in present samples. *C. harfordi japonica* appears to have a vertical range from HWN to LWN with peak abundances at the lower end of this range. It was found amongst the dead shells of *Balanus tintinnabulum* Pilsby and *Tetraclita squamosa japonica* Pilsby at the HWN ($< 1/cm^{-2}$), in crevices between the shells of *Isognomon ephippium* (Linne) at MTL, ($> 1/cm^{-2}$), and amongst the tubes of *Pomatoleios kraussi* (Baird) at LWN. In this last habitat the isopod was found at extremely high densities exceeding $20/cm^{-2}$, occupying a volume of 15 cc in a serpulid tube sample of 120 cc. Associated with these *Cirolana* species were several sphaeromid isopoda, *Sphaeroma terebrans* Bate, *Dynoides dentisinus* Shen, and what appear to be new species of *Dynoides*, *Cymodocella*, (Bruce in preparation). Several specimens of *Paranthura laticauda* Nunomura were also present.

The only other cirolanid isopod known to occur in similar high densities is *C. harfordi harfordi* (Johnson 1976), of which *C. harfordi japonica* is a subspecies. However, this author reports that *C. harfordi harfordi* is found under stones towards low tide mark on Californian shores. This species grows to a larger size and females brooding eggs were found throughout the year (Johnson 1976). None of the 2000 specimens of *C. harfordi japonica* collected in July were brooding eggs and a size frequency plot of the population revealed a single peak, suggesting one short breeding season each year.

It would seem likely that the smaller size and more rugose exoskeleton shown by *C. harfordi japonica* are adaptations to the cryptozoic habitat adopted by this species in Japan, as other cirolanids occupying crevices in dead coral exhibit a similar morphology.

Summary

Descriptions are given of *Cirolana coronata* sp. nov., *Eurydice nipponica* sp. nov., and *C. harfordi japonica* from deep water, sand, and rocky shore habitats respectively in Japan. *Excirolana japonica*, *E. kincaidi*, and *E. vancouverensis*, are considered to be only geographical variations of *E. chiltoni* which now has a circum-north Pacific distribution. *C. australiense* is reported for the first time from Japanese waters, and the sub species *C. harfordi japonica* Thielemann is confirmed by comparison with *C. harfordi harfordi* Lockington from California. The ecology of the two latter species is briefly compared.

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