Copepods from Microhabitats in Fiji, Western Samoa, and Tonga

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Abstract—Samples of copepod Crustacea were taken from taro leaf axils, tree holes, crab holes, tin cans, and car tires in conjunction with experiments by collectors on the susceptibility of these species to infection with *Coelomomyces* fungus, which alternates from copepod to mosquito hosts. To aid collectors and experimenters in identifying copepods from the South Pacific Islands, descriptions and figures are given for each species and subspecies. Included are eleven kinds of cyclopoids: *Halicyclops thermophilus*, *Halicyclops thermophilus spinifer*, *Halicyclops septentrionalis*, *Bryocyclops fidjiensis*, *Bryocyclops bogoriensis*, *Mesocyclops leuckarti*, *Cryptocyclops bicolor linjanticus*, *Microcyclops microsetus* (new species), *Tropocyclops confinis*, *Ectocyclops phaleratus*, and *Paracyclops fimbriatus*. Nine harpacticoids are described, including *Phyllognathopus viguieri*, *Darcythompsonia inopinata*, *Tigriopus angulatus*, *Tisbella pulchella*, *Schizopera tobae*, *Nitocra lacustris pacificus* (new subspecies), *Nitocra pseudospinipes* (new species), *Elaphoidella taroi*, and *Elaphoidella grandidieri*. Some of these species are widely distributed over the world. Some are transported in plants and water containers carried by humans.

Introduction

Certain species of copepod Crustacea are obligate alternate hosts for *Coelomomyces* fungus, which parasitizes and destroys mosquito larvae (Whisler, et al. 1974, 1975). By determining which species of copepod can be infected with the various species of *Coelomomyces*, biological control of mosquitoes may be enhanced by the introduction of copepods containing *Coelomomyces* into mosquito habitats (Toohey, et al. 1981). For several years, the author identified copepods for the *Coelomomyces* research of John Couch, Kenan Professor of Botany, Emeritus, University of North Carolina, Chapel Hill. When Marshall Laird, Director of the Research Unit on Vector Pathology, Memorial University of Newfoundland, was seeking someone to identify copepods for *Coelomomyces* research on several South Pacific islands, Couch suggested the author, who was pleased to undertake the work. Here was an opportunity to identify and record the distribution of the copepods from plant leaf axils, tree holes, tin cans, car tires, crab holes, etc. of Fiji, Western Samoa, and Tonga.

The purpose of this report is to report the species of copepods collected from microhabitats on these islands, to add to the knowledge of distribution of these copepods, to describe new species encountered, and to aid *Coelomomyces* researchers and collectors in identification of these copepods.

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Materials and Methods

When taking the copepods, collectors recorded the types, exact locations and chemical analyses for each microhabitat. Some copepods from the collections were retained alive for research on infectability with *Coelomomyces* and some were fixed and preserved in McGregor's fluid (10 cc commercial formalin, 10 cc 5% Borax, 2 cc glycerol, and 80 cc distilled water) and placed in small vials to be sent for identification. The author dissected copepods in dilute glycerol (40 cc glycerol and 60 cc water) and mounted representative specimens in Masters nonresinous mounting medium (CMCP-10, CMCP-9AF, CMCP-9 and CMCP-9AB) and some in glycerine jelly.

All drawings, except the tracing of the electron microscope picture, were done with the aid of a camera lucida.

Body length measurements were made with a micrometer eyepiece, and caudal setae are not included in this length measurement.

For identification of these copepods, the cyclopoid body is egg-shaped anteriorly and tubular posteriorly, and the first antennae of the female consist of six (*Halicyclops*) to seventeen segments (usually eleven to seventeen). The harpacticoid body is generally tubular, tapering posteriorly, and the first antennae of the female consist of seven to nine segments (eight segments in most species in this area). Both first antennae of males of both orders are geniculate (modified for grasping females).

Of great importance for identifying the species of cyclopoids are: number of segments of first antennae, proportions and ornamentation of the caudal rami, and shape and ornamentation of the fifth legs. Females are preferable to males (geniculate first antennae)for identification. The shape of the seminal receptacle is useful, if visible.

For identifying female harpacticoid species use: number of body segments, number of segments of first antennae, number of segments of palp of second antenna, proportions and ornamentation of the caudal rami, first legs (perhaps most important), and fifth legs. The shape of the geniculate first antennae and first legs of the male is important.

Species Collected

The following species of copepods were collected and partially or completely described for identification purposes. In addition one damaged male copepod of the genus *Apocyclops* was found in a tree hole at Viti Levu, Fiji on 2 May 1979. It is not in condition to be described, but may be *Apocyclops borneoensis* Lindberg (1954).

Order CYCLOPOIDA
Family CYCLOPIDAE Dana
Subfamily HALICYCLOPINAE Kiefer

Halicyclops thermophilus thermophilus Kiefer

Fig. 1a–m

MATERIAL EXAMINED: Thirty females and thirty males-ten of each sex from Tonga (1976), Western Samoa (1975–1976), and Fiji (1978, 1979, and 1980). These were taken from crab holes and rarely from tires, ponds, and tree holes.

FEMALE: Body length 0.60–0.72 mm for Fiji and 0.53–0.66 mm for Tonga and Western Samoa. Prosome egg-shaped, 5-segmented, opisthosome tubular and 4-segmented. Genital segment generally as broad as long, but slightly longer than broad in some individuals. It bears bluntly-pointed lateral protuberances (Fig. 1a–c). Next to last abdominal segment posterior border bears spinules, medial spinules distinctly longer than lateral. These long spinules specific for all varieties of *H. thermophilus*. First antenna 6-segmented and second antenna 3-segmented (Fig. la and e). Swimming legs biramous and each ramus 3-segmented. Spine formula of terminal segments of exopods of swimming legs is 3, 4, 4, 3 and setal formula is 5, 5, 5, 5 (Fig. 1g–j). Fifth leg consists of basal segment bearing an outer seta and fused to last thoracic segment and one distinct segment bearing 3 spines and 1 seta (Fig. 1k–l).

MALE: Body length 0.40–0.54 mm. First anternnae prehensile. Swimming legs like those of female. Fifth leg like that of female, but distinct segment bears 3 spines and 2 setae. Sixth leg consists of 1 spine and 2 setae (Fig. 1m).

DISTRIBUTION: *H. thermophilus thermophilus* has been reported from Java and Madagascar; however, Lindberg's (1952) figure of the species from Madagascar resembles more closely *H. thermophilus spinifer*.

Halicyclops thermophilus spinifer Kiefer

Fig. 2a–f

MATERIAL EXAMINED: Two females from crab holes, Tonga, 27 August 1976.

FEMALE: Body length 0.58–0.60 mm. This subspecies resembles *H. thermophilus thermophilus* except lateral spines of genital segment more pronounced, sharper-pointed, and extend further posteriorly (Fig. 2a–c). Lindberg's (1952) figures closely resemble the Tonga specimens in these structures.

DISTRIBUTION: India, Iran, Tonga (present record) and probably Madagascar.

REMARKS: Although Lindberg (1957) considered this copepod a distinct species in his key, this form should be retained as a subspecies of *H. thermophilus*, because there are only minor differences in structures. More specimens and breeding experiments are indicated.

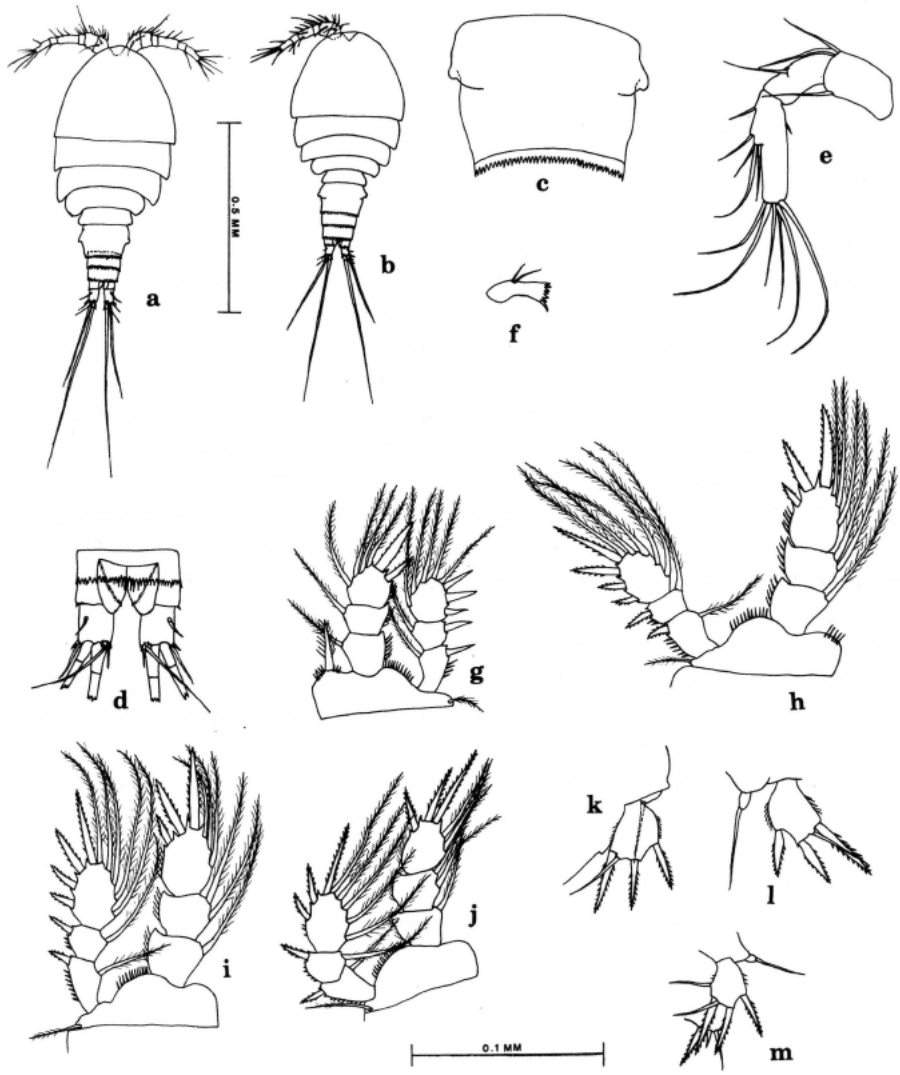

Fig. 1. *Halicyclops thermophilus*: *a*, female from Fiji; *b*, female from Western Samoa; *c*, female genital segment; *d*, last abdominal segment and caudal rami, dorsal; *e*, second antenna; *f*, mandible; *g*, first leg; *h*, second leg; *i*, third leg; *j*, fourth leg; *k*, *l*, fifth leg of female; *m*, fifth and sixth legs of male.

Halicyclops septentrionalis Kiefer
Fig. 2g–j

MATERIAL EXAMINED: Eight females and six males from crab holes at Yanuca Village, Serua, Yanuca Island, Fiji, 15 March 1979. One female was taken

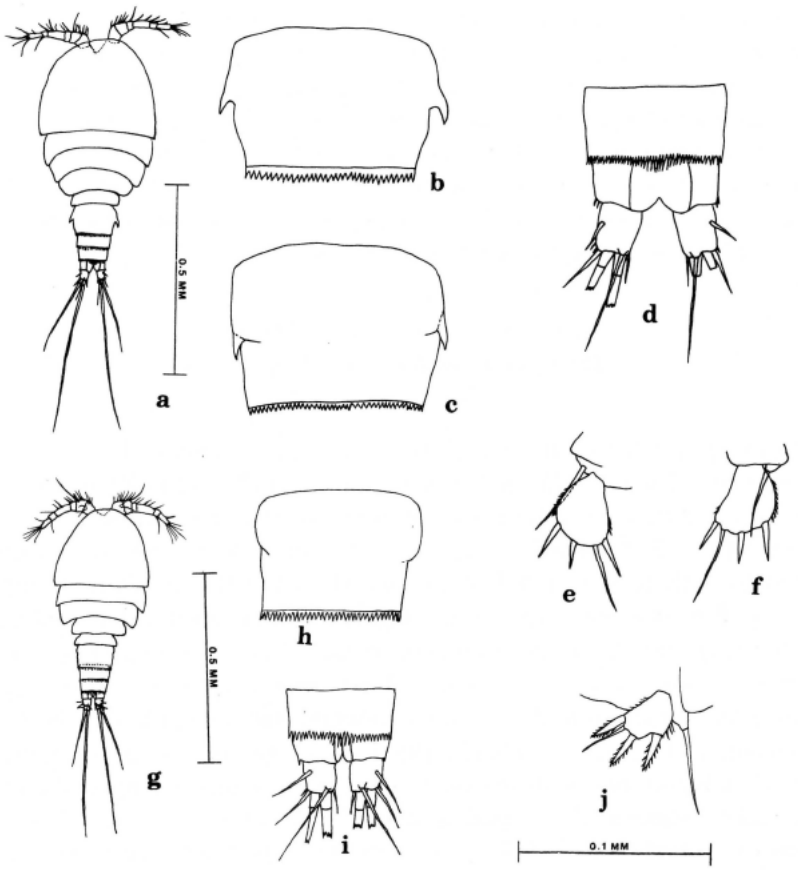

Fig. 2. *Halicyclops thermophilus spinifer*: *a*, female from Tonga; *b*, female genital segment; *c*, variation in female genital segment; *d*, last abdominal segment and caudal rami, dorsal; *e* & *f*, fifth leg of female. *Halicyclops sententrionalis*: *g*, female from Fiji; *h*, female genital segment; *i*, last abdominal segment and caudal rami, dorsal; *j*, fifth leg of female.

from crab hole at Nadi, Ba, Viti Levu, Fiji on 2 May 1979 and one female from a sea shell at Beqa Island, Fiji on 21 November 1978.

FEMALE: Body length 0.49–0.53 mm. This species resembles *H. thermophilus thermophilus* except lateral spines of genital segment absent, and it is distinctly smaller in size (Fig. 2g–j).

MALE: Differs from male of *H. thermophilus thermophilus* in same respects as female. Body length is 0.39–0.40 mm.

DISTRIBUTION: Baltic Sea, North Sea, Norway, Germany, and Fiji (present record).

REMARKS: Having the elongated dorsal spinules of the posterior margin of the next to last abdominal segment (Fig. 2i) leads this copepod directly to *H.*

thermophilus septentrionalis in Kiefer's (1936) key, thus differing from our specimens of *H. neglectus*. In Lindberg's (1957) key, using different characters, it goes to *H. neglectus septentrionalis*. Although showing morphological similarities to both *H. thermophilus* and *H. neglectus*, it can be distinguished from these species and should be raised to the rank of distinct species. The presence of this northern copepod on a tropical South Pacific island is unusual, but several species of copepods described from northern, cold waters have later been found in warm southern waters. This is especially true of some harpacticoid copepod species.

Subfamily CYCLOPINAE Dana

Bryocyclops fidjiensis Lindberg, 1954

Fig. 3a–g

MATERIAL EXAMINED: Thirty females and twenty males from Fiji (1978, 1979, and 1980), Tonga (1976), and Western Samoa (1975 and 1976) in tree holes, leaf axils of taro and Pandanus, tin cans, bamboo, bottles, and ditches.

FEMALE: Body length is 0.47 to 0.55 mm. Body small and stubby and described by collectors, Karen Toohey and Mark Goettel, as shiny in appearance when alive. Prosome egg-shaped and 5-segmented and opisthosome tubular and 4-segmented (Fig. 3a). Anal operculum conspicuous and triangular (Fig. 3c). Caudal rami short, twice as long as broad. First antennae short, eleven-segmented. Swimming legs biramous and each ramus 2-segmented, except last exopod, which is one-segmented (Fig. 3f). Lindberg (1954) drew the female fourth foot with 1-segmented endopod, but in all specimens from type locality, endopod shows definite joint to make 2-segmented endopod, as in male fourth leg. Spine formula of terminal segments of exopods is 3, 3, 3, 4 (4 spines in the single fourth leg exopod) and setal formula is 5, 5, 5, 4 (Fig. 3d–f). Second and third legs alike in armature. Fifth leg not distinct from fifth body segment and bears 3 setae (Fig. 3g).

MALE: Body length 0.39 to 0.47 mm. First antennae geniculate (Fig. 3b). Fourth leg endopod 2-segmented, as in female endopod (Fig. 3f).

DISTRIBUTION: This species is abundant on Fiji, Tonga, and Western Samoa.

REMARKS: *B. fidjiensis* differs from the closely related *B. anninae* (Menzel) in the 1-segmented exopod of the fourth leg. *B. anninae* has a 2-segmented exopod of this leg. The author has a *B. anninae* female from the leaf axil of Pandanus, The Pali, Oahu, Hawaiian Islands, collected August 1963 by Bassett Maguire, Jr.

Bryocyclops bogoriensis (Menzel)

Fig. 4a–j

MATERIAL EXAMINED: Eight females and five males from Ivi tree holes (*Inocarpus edulis*), Navua Dump, Viti Levu, Fiji, 2 May 1979.

FEMALE: Body length 0.40 to 0.50 mm. Like *B. fidjiensis*, small and stubby,

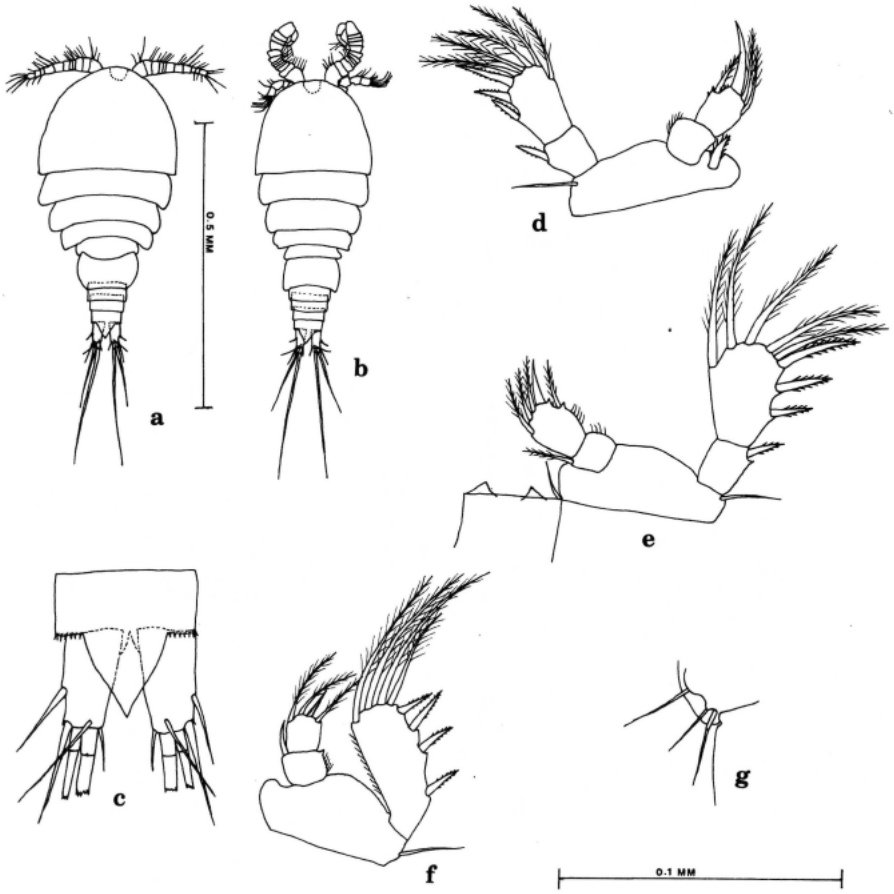

Fig. 3. *Bryocyclops fidjiensis*: *a*, female from Fiji; *b*, male from Fiji; *c*, last abdominal segment and caudal rami, dorsal; *d*, first leg; *e*, third leg of female; *f*, fourth leg; *g*, fifth leg of female.

but even smaller than that species. Prosome egg-shaped and 5-segmented, opisthosome tubular and 4-segmented (Fig. 4a). Anal operculum rounded (not pointed) and bears a row of tiny spinules on its border (fig. 4c). Caudal rami 1.8 to 2 times as long as broad. First antennae short and 11-segmented. Swimming legs biramous and each ramus 2-segmented except last endopod, which 1-segmented. Spine formula of terminal segments of exopods is 3, 3, 3, 3 and the setal formula is 5, 5, 5, 4 (Fig. d, e, g). Difference in spine formula from that of *B. fidjiensis* not due to fewer spines, but to separation of exopod into 2 segments, and elimination of spine from formula count (Fig. 4g). Second and third legs alike in armature. Two inner terminal setae of fourth leg endopod much longer than outer terminal spine and seta of that segment (Fig. 4g–i). Fifth leg not distinct from fifth body segment and bears 3 setae (Fig. 4j).

MALE: Body length 0.35 to 0.40 mm. Prosome 5-segmented and opisthosome

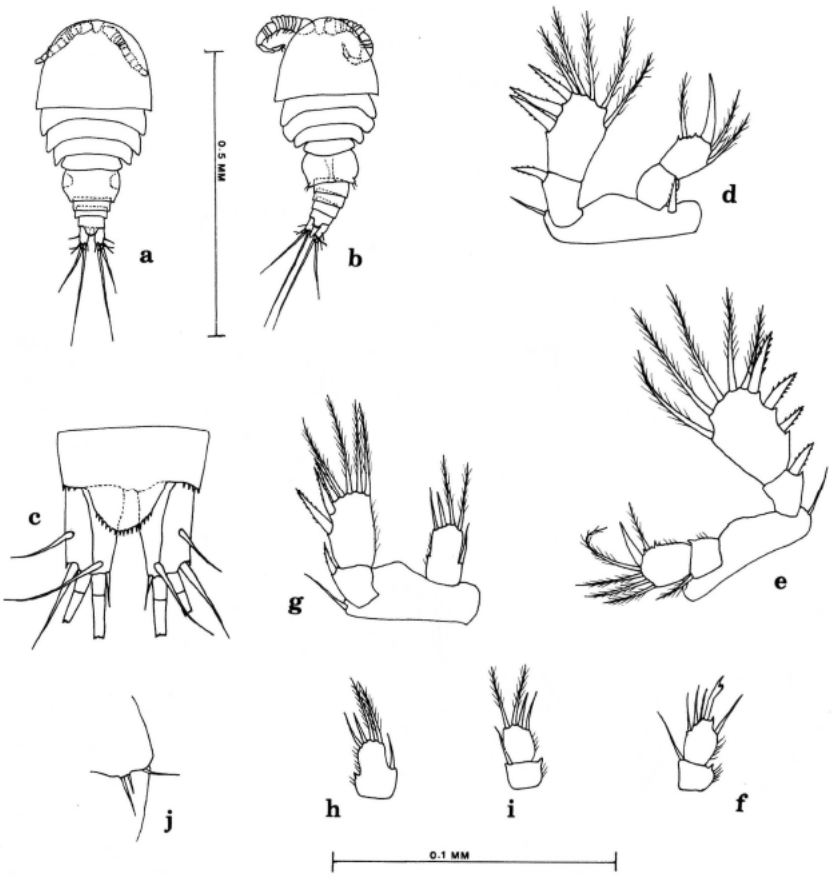

Fig. 4. *Bryocyclops bogoriensis*: *a*, female from Fiji; *b*, male from Fiji; *c*, last abdominal segment and caudal rami, dorsal; *d*, first leg; *e*, third leg of female; *f*, endopod of third leg of male, terminal spine modified; *g*, fourth leg of female; *h*, endopod of fourth leg of female; *i*, endopod of fourth leg of male, 2 segmented; *j*, fifth leg of female.

5-segmented, as typical for male cyclopoids. First antennae geniculate. Terminal spine of third leg endopod modified into a bulge near its end (Fig. 4f). Endopod of fourth leg 2-segmented (Fig. 4i).

DISTRIBUTION: R. Menzel (1925) described the species from mosses and bromeliads in Java, and F. Kiefer (1928b) redescribed it from bromeliads in Java. Its presence on Fiji was unexpected because collectors Karen Toohey and Mark Goettel had sampled Ivi tree holes quite extensively prior to its discovery. They recognized that the anal operculum was rounded and differed from the triangular anal operculum of the abundant *B. fidjiensis* and sent the specimens to the author for identification. They wrote that the habitat surrounding the Ivi trees in Navua was different from other Ivi areas by having grass cover instead of mud and that these

particular trees were along the side of a sandy beach instead of a mangrove swamp.

Mesocyclops leuckarti (Claus)

Figs. 5a–g, 6a–f

MATERIAL EXAMINED: Five females from crab holes on Tonga, 27 and 30 August 1976. Ten females from crab holes, ground pools and blocked drains on Viti Levu, Fiji, 1 and 21 November 1978, 15 March 1979, 6 June 1979.

FEMALE: Body length 0.93 to 1.20 mm. Compared to other microhabitat species, large and robust (Fig. 5a). Prosome egg-shaped, 5-segmented. Caudal rami 3 to 3.5 times as long as wide, lateral seta at about two thirds of distance from base of ramus. Inner margins of these rami without hairs except in *M. leuckarti pilosa* Kiefer, which occurs in South Africa, Madagascar, Iran, Tahiti, Philippines. Author has

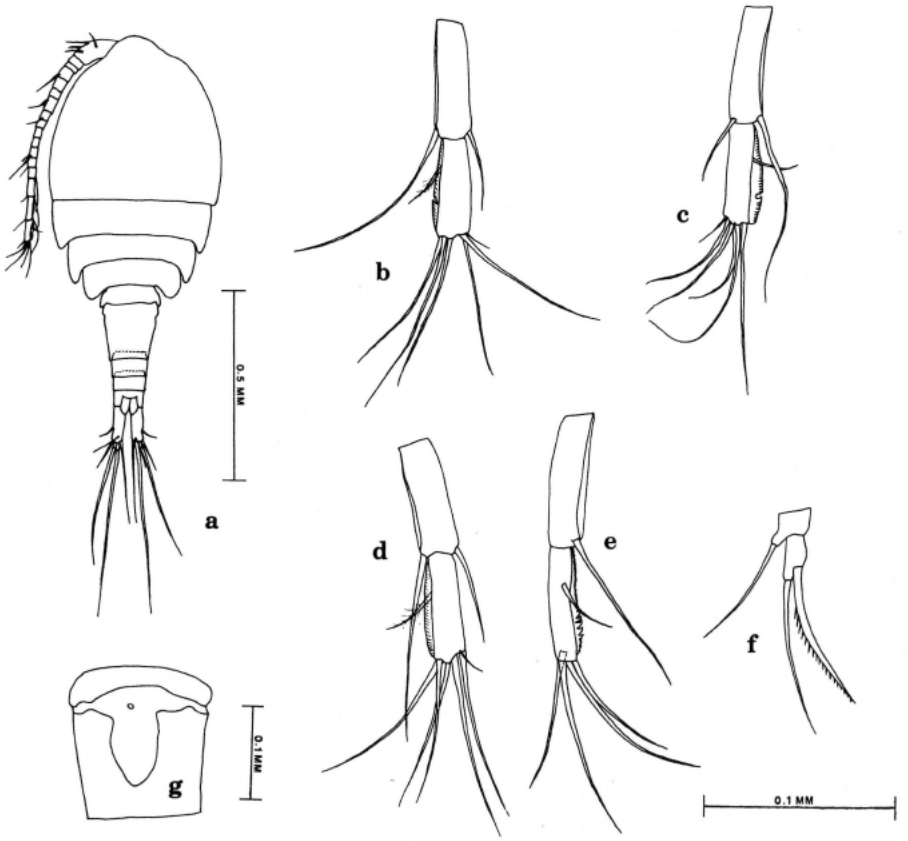

Fig. 5. *Mesocyclops leuckarti*: *a*, female from Fiji; *b*, *c*, *d*, variations in hyaline membrane of terminal segments of first antenna of females from Fiji; *e*, terminal segments of first antenna of female from Tonga; *f*, fifth leg of female from Fiji; *g*, seminal receptacle of female from Fiji.

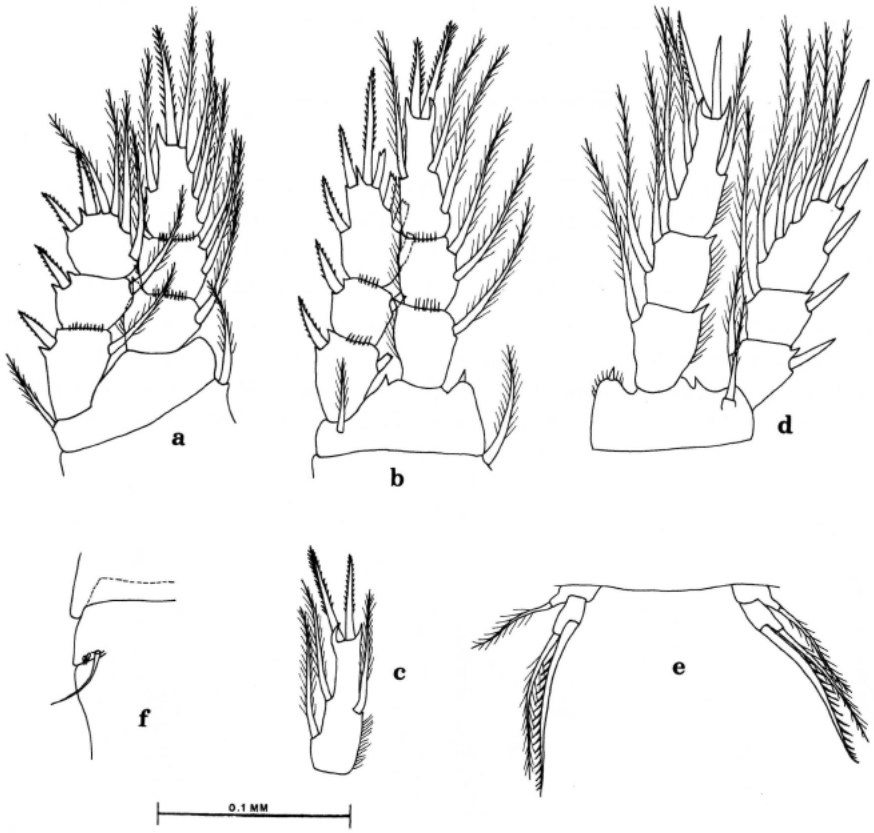

Fig. 6. *Mesocyclops leuckarti*: *a*, first leg of female from Tonga; *b*, fourth leg of female from Tonga; *c*, terminal endopod segment of fourth lag of female from Tonga; *d*, fourth leg of female from Fiji; *e*, fifth legs of female from Tonga; *f*, sixth leg of female from Tonga.

specimens from last localities. First antenna 17-segmented with hyaline plate on segments 16 and 17. Gurney (1933) described and figured much variation in dentations on plate of last segment—from large serrations and a notch, large serrations without notch, to small serrations without notch. Specimens from Fiji show all these variations, but those from Tonga are notchless (Fig. 5e). Swimming legs biramous and each ramus 3-segmented. Spine formula of terminal segments of exopods of these legs is 2, 3, 3, 3 and setal formula is 4, 4, 4, 4 (Fig. 6a–d). First leg without spine or seta at inner distal angle of basipod. Absence of this structure characteristic of all varieties of this species. Relative lengths of terminal spines of fourth leg endopod vary. Here inner spine is the longer, but in some populations they are of equal length; in Europe and America outer spine slightly longer. Gurney (1933) described this variance. Fifth foot 2-segmented, basal segment with an outer seta and distal segment with a terminal seta and an inner spine, attached slightly beyond

middle of segment. Inner spine may be shorter than terminal seta or longer (Figs. 5f & 6e). Sixth leg reduced to 2 outer spinules and 1 inner seta (Fig. 6f). Seminal receptacle T-shaped, with posterior portion bag-like (Fig. 5g).

DISTRIBUTION: Cosmopolitan—Europe, Asia, Africa, North America, Australia, New Zealand, and islands in the Pacific. This species can tolerate brackish water as shown by its living in brackish crab holes. Wilson (1942) collected several specimens from a lagoon on Penrhyn Island (Solomon Islands) in the tropical Pacific along with nine other species, all typically marine. Lindberg (1954) reported it from Sikaiana Island (Solomon Islands) and Toutouba and Viti Levu (Fiji Islands). Watkins and Belk (1975) reported it from a spring pond, an ephemeral pond, and a lake on Guam.

REMARKS: This species has been successfully infected with a species of *Coelomomyces* fungus in Africa. It is interesting that this copepod could directly control mosquito larvae by predation and also indirectly by acting as intermediate host for this fungus that destroys mosquito larvae.

Cryptocyclops bicolor linjanticus (Kiefer, 1928a)
Fig. 7a–g

MATERIAL EXAMINED: Ten females from tree holes, blocked drains, ponds, rice paddies, and metal drums from Viti Levu, Fiji on 30 November 1978 and 4 and 5 April 1979.

FEMALE: Body length 0.60 to 0.70 mm. Prosome egg-shaped, 5-segmented, opisthosome tubular and 4-segmented. Caudal rami 3.2 to 3.5 times longer than broad. Inner long terminal seta of caudal ramus 3.5 to 4 times longer than the ramus (Fig. 7b). This seta less than 3 times longer than ramus in *Cryptocyclops bicolor bicolor* (Sars). This is the principle difference between these two subspecies. First antenna 11-segmented. Swimming legs biramous, each ramus 2-segmented. Spine formula of terminal segments of leg exopods is 3, 4, 4, 3 and setal formula is 5, 5, 5, 5 (Fig. 7c–f). Fifth leg consists of basal segment bearing an outer seta and not separated by a joint from the fifth body segment and a narrow tubular, distinct segment with a terminal seta (Fig. 7g).

DISTRIBUTION: East Africa, West Africa, Madagascar, Sumatra, Java, India, Iran, Afghanistan, Burma, Cambodia, Philippines, Taiwan, Manchuria, New Hebrides, Fiji. Lindberg (1954) was the first to report it from Viti Levu, Fiji. Recently, the author identified this copepod in material sent by B. F. Gabriel of the University of the Philippines at Los Baños.

REMARKS: Recently, *Microcyclops varicans* (Sars) has been sent to me in collections made by B. F. Gabriel in the Philippines. This species differs from *C. B. linjanticus* by having the longest caudal seta longer than the abdomen (shorter in *C. B. linjanticus*) and a bag-shaped posterior portion of the female seminal receptacle (short and oval in *C. B. linjanticus*).

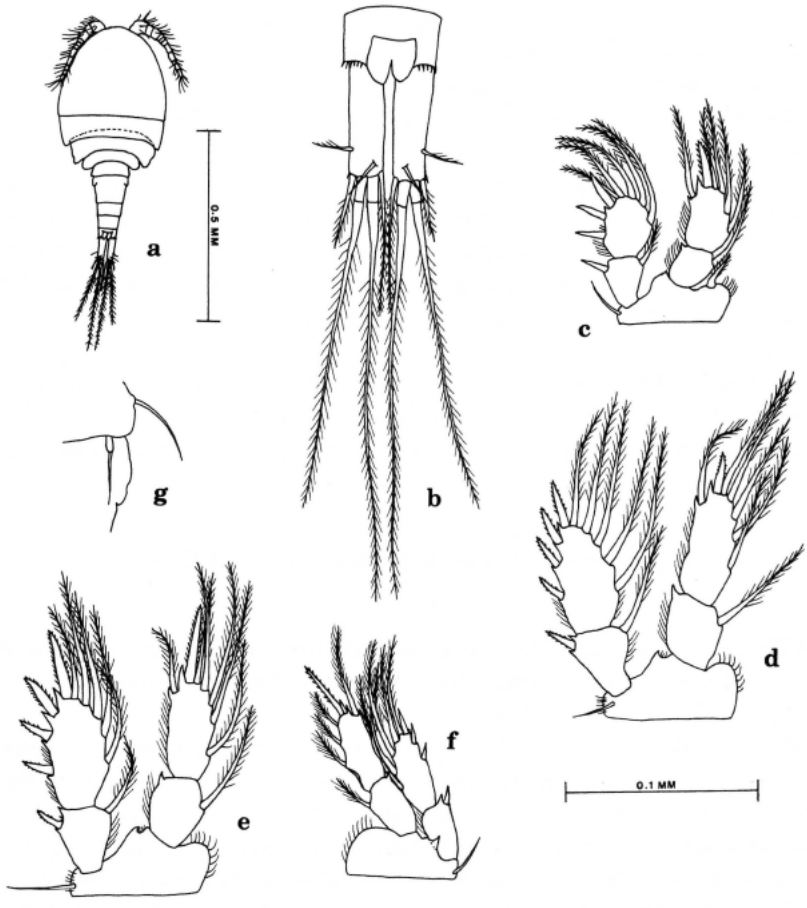

Fig. 7. *Cryptocyclops bicolor linjanticus*: *a*, female from Fiji; *b*, last abdominal segment and caudal rami, dorsal; *c*, first leg; *d*, second leg; *e*, third leg; *f*, fourth leg; *g*, fifth leg.

Microcyclops microsetus new species
Figs. 8a–m, 9a–i

MATERIAL EXAMINED: Twenty-eight females and six males taken from crab holes on Fiji (1978, 1979, 1980). Salinity of water in these crab holes varied from 12 to 31 0/00, but most specimens occurred at salinities 12, 16, and 21 0/00. U. S. National Museum No. 204463 (holotype), No. 204464 (allotype) and No. 204465–204469 (paratypes).

FEMALE: Body length 0.56–0.61 mm. Prosome egg-shaped and 5-segmented, opisthosome slender, tubular and 4-segmented (Fig. 8a). Caudal rami about 3-times longer than broad and lateral seta attached slightly beyond half the distance from base to distal end of each ramus (Fig. 8b). Dorsal seta and outer, thick terminal seta

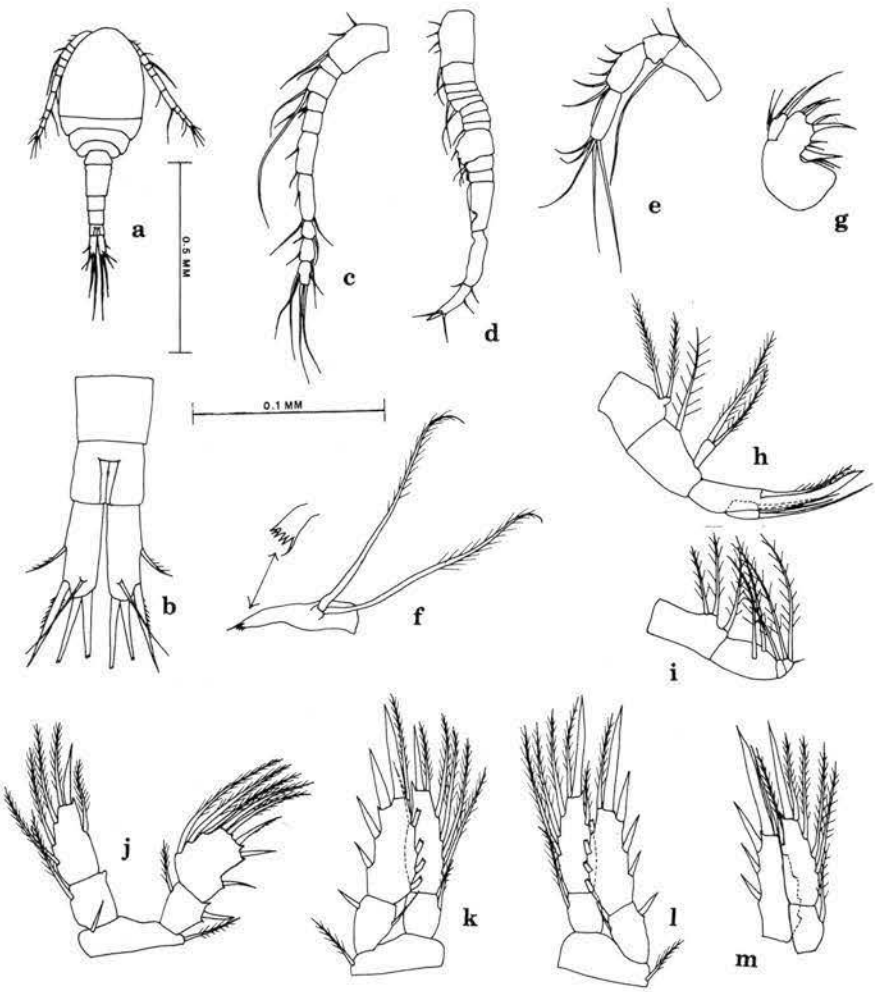

Fig. 8. *Microcyclops microsetus*: *a*, female from Fiji; *b*, last abdominal segment and caudal rami, dorsal; *c*, first antenna of female; *d*, first antenna of male; *e*, second antenna; *f*, mandible, turned; *g*, first maxilla; *h*, second maxilla; *i*, maxilliped; *j*, first leg; *k*, second leg; *l*, third leg; *m*, endopod and terminal exopod segment of third leg.

about same length as caudal ramus. Innermost terminal seta so slender and tiny that it is not visible under magnification of 600 diameters, light microscopy and was believed to be absent. Using scanning electron microscopy (magnification of 2,000 diameters), Harry Blanton Miller photographed the caudal rami and showed these setae to be present. They are quite hair-like and frequently lie on or close to the base of the longest terminal seta (Fig. 9i). Small size of this seta indicated in specific name of this copepod. First antennae 10-segmented and reach posterior border of third body segment. Second antennae 4-segmented (Fig. 8e). Mandible typical for freshwater cyclopoids, being the biting and chewing form. Two setae very long and quite

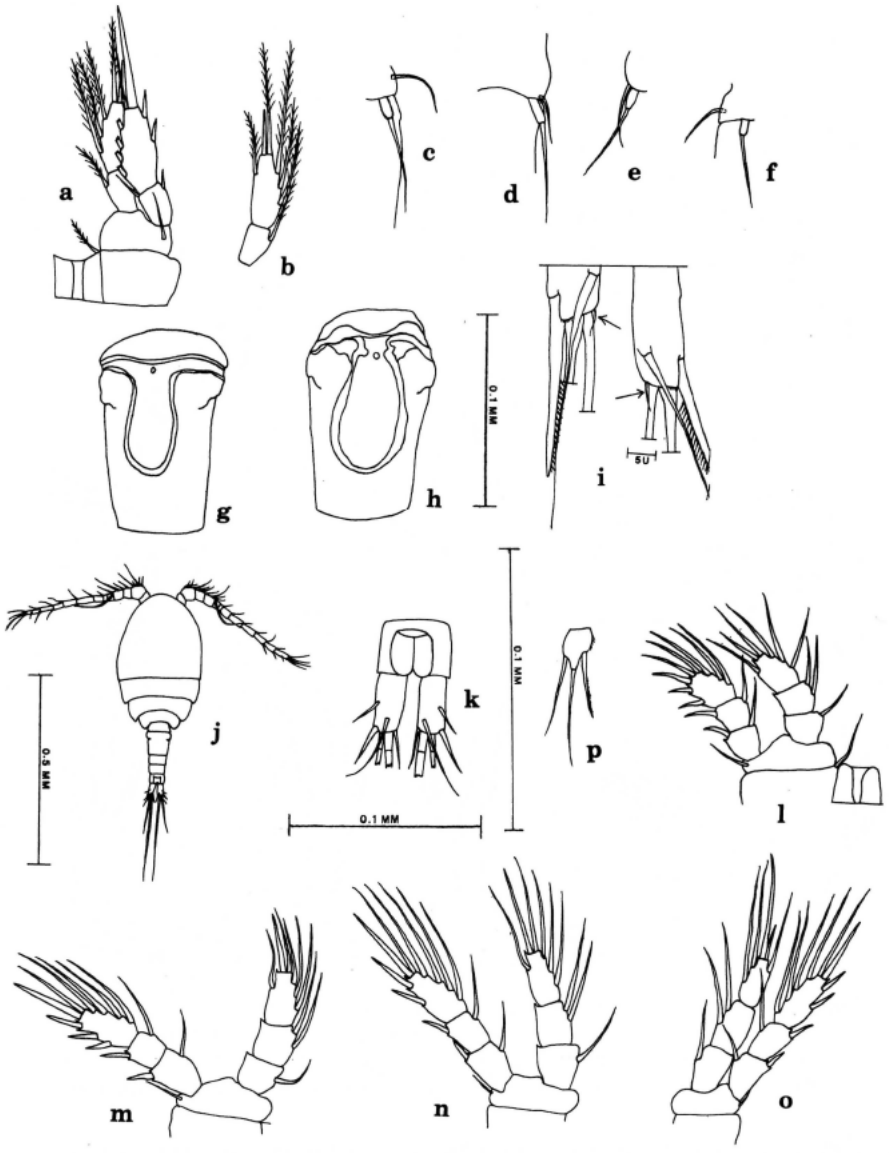

Fig. 9. *Microcyclops microsetus*: *a*, fourth leg; *b*, endopod of fourth leg; *c*, *d*, *e*, fifth legs of females; *f*, fifth leg of male; *g*, seminal receptacle of female; *h*, variation of seminal receptacle; *i*, tracing of scanning elecrton microscope photo to show microsetae of caudal rami. *Tropocyclops confinis*: *j*, female from Western Samoa; *k*, last abdominal segment and caudal rami; *l*, first leg; *m*, second leg; *n*, third leg; *o*, fourth leg; *p*, fifth leg.

visible in a whole mount of copepod (Fig. 8f). First and second maxillae and maxillipeds shown in Fig. 8g–i. Swimming legs biramous and each ramus 2-segmented (Figs. 8j–m, 9a, b). Spine formula of terminal segments of the exopods is 3, 4, 4, 3 and setal formula is 5, 5, 5, 5. Setal formula of inner side of the endopods (not counting terminal seta) is 3, 4, 3, 3 (in one individual-3, 4, 4, 3). Basal segment of fifth leg not separated from fifth body segment and bears an outer seta and a narrow tubular segment with a terminal seta (Fig. 9c–f). Seminal receptacle T-shaped, with posterior portion baglike, similar to that structure in *Mesocyclops leuckarti* (Fig. 9g, h).

MALE: Body length 0.50 to 0.60 mm, usually 0.52 mm. Prosome 5-segmented, opisthosome 5-segmented. Both first antennae geniculate (Fig. 8d).

REMARKS: This new species keys to the Genus *Microcyclops*. Its distinct segment of the fifth leg is narrow and tubular like that of *Microcyclops* and *Cryptocyclops* and not broad as in *Apocyclops*. The length of the shorter terminal spine of the endopod of the fourth leg exceeds that of *Cryptocyclops*, and the bag-like posterior portion of the seminal receptacle is more like that of *Microcyclops* than the very short, posterior portion of seminal receptacle of *Cryptocyclops* (Dussart, 1969). The tiny innermost terminal caudal seta should not eliminate consideration of this copepod in Genus *Microcyclops*. Within Genus *Diacyclops* are species in which this seta is very short (*D. crassicaudis*) and some long (*D. bicuspidatus*). In spite of being an inhabitant of brackish water and having a slight difference in setal armature in the third leg endopod (three instead of four inner setae of the terminal segment), the species is considered by the author to be within Genus *Microcyclops*.

Tropocyclops confinis Kiefer
Fig. 9j–k

MATERIAL EXAMINED: One female from a stream in mountain highlands, Western Samoa, 13 October 1976.

FEMALE: Body length 0.52 mm. Prosome egg-shaped and 5-segmented, opisthosome tubular and 4-segmented. Caudal rami 2.3 times longer than broad. *Tropocyclops prasinus prasinus* (Fischer) generally has slightly longer caudal rami (2.5 to 3 times longer than broad). First antenna 12-segmented and reaches beyond second segment of body, with fine hyaline membrane on last three segments. Swimming legs biramous, and each ramus 3-segmented. Spine formula of terminal segments of exopods of swimming legs is 3, 4, 3, 3 (3, 4, 4, 3 for *T. prasinus prasinus*) and setal formula is 5, 5, 5, 5 (Fig. 9l–o). Fifth leg consists of single segment armed with a slender inner spine, an outer seta, and a terminal seta (Fig. 9p).

DISTRIBUTION: Africa, Madagascar, Java, Flores, Sumatra, India, Iran, Burma, Syria, United States (rare), New Hebrides, Czechoslovakia, Russia.

REMARKS: Although this single individual was taken from a stream and the genus is usually limnetic, the species is available on Western Samoa for distribution to microhabitats. The author has many specimens of the nearly related *T. prasinus*

mexicanus collected from bromeliads in Jamaica by Laessle (1961). It is therefore a potential microhabitat species and included here.

Ectocyclops phaleratus (Koch)
Fig. 10a–d

MATERIAL EXAMINED: Two females from Itatoko, Ba, Viti Levu, Fiji, in a blocked drain and a crab hole, 6 June 1979.

FEMALE: Body length 0.80 and 0.75 mm. A stubby species (Fig. 10a). First antenna very short and 10-segmented. Caudal rami very short, about 1.3 to 2 times as long as broad and ornamented with oblique rows of spinules on inner surfaces (Fig. 10b). Swimming legs biramous and each ramus 3-segmented. Spine formula of terminal segments of exopods is 3, 4, 4, 3 and setal formula is 5, 5, 5, 5. Terminal segment of endopod of fourth leg about 1.5 times longer than broad and inner terminal spine twice as long as outer terminal spine (Fig. 10c). Fifth leg not distinct from fifth body segment and armed with two strong spines and an outer seta (Fig. 10d).

DISTRIBUTION: Europe, Africa, Asia, America, Australia, and Fiji (present record).

REMARKS: Although several subspecies of *E. phaleratus* and several additional species for the genus have been described, the Fiji specimens are not different from the North American specimens or those available from Europe.

Paracyclops fimbriatus (Fischer)
Fig. 10e–i

MATERIAL EXAMINED: Five females from Beqa Island and Viti Levu, Fiji in tree holes and a rubber tire, 21 November 1978 and 15 February 1979.

FEMALE: Body length 0.70 to 0.80 mm. A small species, but more slender in body than *Ectocyclops phaleratus* (Fig. 10e). Caudal rami are 3.2 to 4 times as large as broad and bear a short transverse row of spinules just above dorsolateral seta (Fig. 10f). North American specimens show more variation in proportions of caudal rami than do those from Fiji. *P. fimbriatus poppei* (Rehberg), which is common in North America and bears longitudinal dorsal row of spinules on caudal rami, not been found on Fiji, but recorded by Sars (1904) from Hawaii. First antennae very short and 8-segmented (Fig. 10e), not 11-segmented as in *Paracyclops affinis* (Sars). Swimming legs biramous and 3-segmented. Spine formula of terminal segments of exopods is 3, 4, 4, 3 and setal formula is 5, 5, 5, 5. Terminal segment of endopod of fourth leg about 1.6 to 1.8 times longer than broad and inner terminal spine about twice as long as outer terminal spine (Fig. 10g, h). Fifth leg consists of one broad segment, armed with an inner spine and two outer seta, terminal seta much longer than inner spine (Fig. 10i).

DISTRIBUTION: Europe, Asia, Africa, New Zealand, New Guinea, North

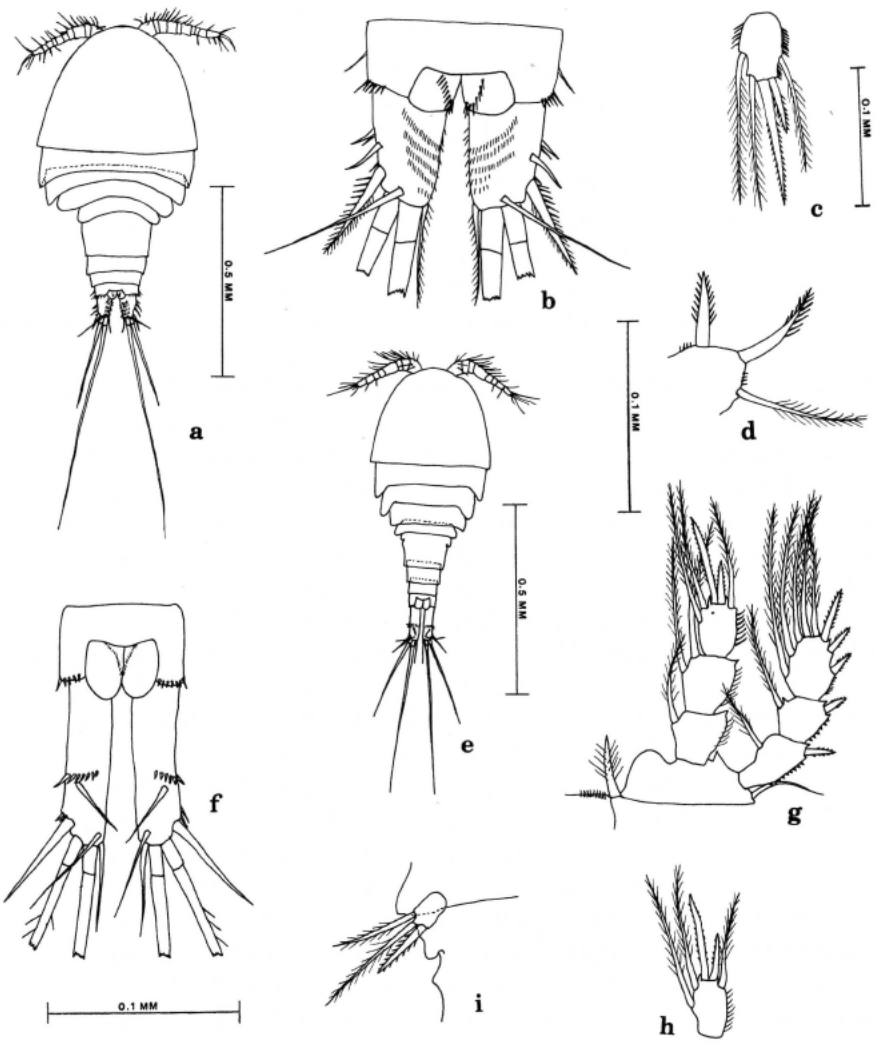

Fig. 10. *Ectocyclops phaleratus*: *a*, female from Fiji; *b*, last abdominal segment and caudal rami; *c*, terminal segment of endopod of fourth leg; *d*, fifth leg; *Paracyclops fimbriatus*: *e*, female from Fiji; *f*, last abdominal segment and caudal rami; *g*, fourth leg; *h*, terminal segment of endopod of fourth leg; *i*, fifth leg.

America, South America, Sumatra, Java, Taiwan, Fiji, China, Japan. *P. fimbriatus poppei*, which some authors consider a distinct species, has frequently been confused with the typical species, therefore some distribution records are questionable.

REMARKS: Several subspecies of *P. fimbriatus* have been described, based on proportions of the caudal rami and other structures, but the variability of these proportions within a population in North American makes such designations (except for *P. f. poppei*) questionable.

Order HARPACTICOIDA
Family PHYLLOGNATHOPODIDAE Gurney
Phyllognathopus viguieri (Maupus)
Fig. 11a–l

MATERIAL EXAMINED: Thirty females and fifteen males-ten females and five males from each of the localities-Tonga (1976), Western Samoa (1975, 1976), and Fiji (1978, 1979, 1980). These were taken from tree holes, taro leaf axils, old auto tires, tin cups, plastic containers, bamboo, old boats, and ground pools.

FEMALES: Body length 0.40 to 0.55 mm. A tiny, tubular-bodied copepod with 10 body segments and conspicuous rostrum (Fig. 11a). Caudal rami stubby-either slightly longer than broad or just as long as broad. Considerable variation of shape and armature of these rami, even in the same population in a microhabitat (Fig. 11c–e). Long terminal caudal rami may be represented by spike-like projections (Fig. 11e). First antennae very short and 8-segmented. Swimming legs biramous and each ramus except endopod of fourth leg (2-segmented) is 3-segmented. Armature of swimming legs of this well-described species is shown in Figure 11 f–i. Fifth leg a projection from sixth body segment and has median indention. Outer portion bears seta and spines, and the inner has 2 large spines (Fig. 11j, k).

MALE: Body length 0.35 to 0.55 mm. Body consists of 11 segments (Fig. 11b). First antennae geniculate and very short. Although variable, fifth leg of these specimens consists of basal segment with an outer seta and inner, strong spine and usually distinct exopod with total of six setae and spines (Fig. 11l).

DISTRUBUTION: Cosmopolitan-Europe, Asia, Africa, America, Pacific tropical islands, Caribbean islands, etc. It is easily transported with plants, food, water containers, etc. Lowndes (1931) stated that it could be "found at any time by taking some of the liquid enclosed by the leaves of the Bromeliaceous plants (pineapples) from the Botanic Gardens" (Birmingham, England). He also said he had obtained them from pineapples bought from any food store by adding water to the leaf axils and examining this water after a few weeks. The author has specimens from *Guzmania* bromeliad leaf axils on Jamaica and Puerto Rico and from *Pandanus* leaf axils on Oahu, Hawaiian Islands. Watkins and Belk (1975) reported *P. veguieri menzeli* (Chappuis) from Guam. This subspecies is mainly based on the details of structure of the male fifth legs. The author prefers to avoid subspecific designation for such a variable species.

Family DARCYTHOMPSONIIDAE Lang
Darcythompsonia inopinata Smirnov
Fig. 12a–k

MATERIAL EXAMINED: Two females and two males from crab holes on Western Samoa (15 April 1976 and 29 January 1976), and twelve females and five males from crab holes at Culanuku, Viti Levu, Fiji (15 September 1978).

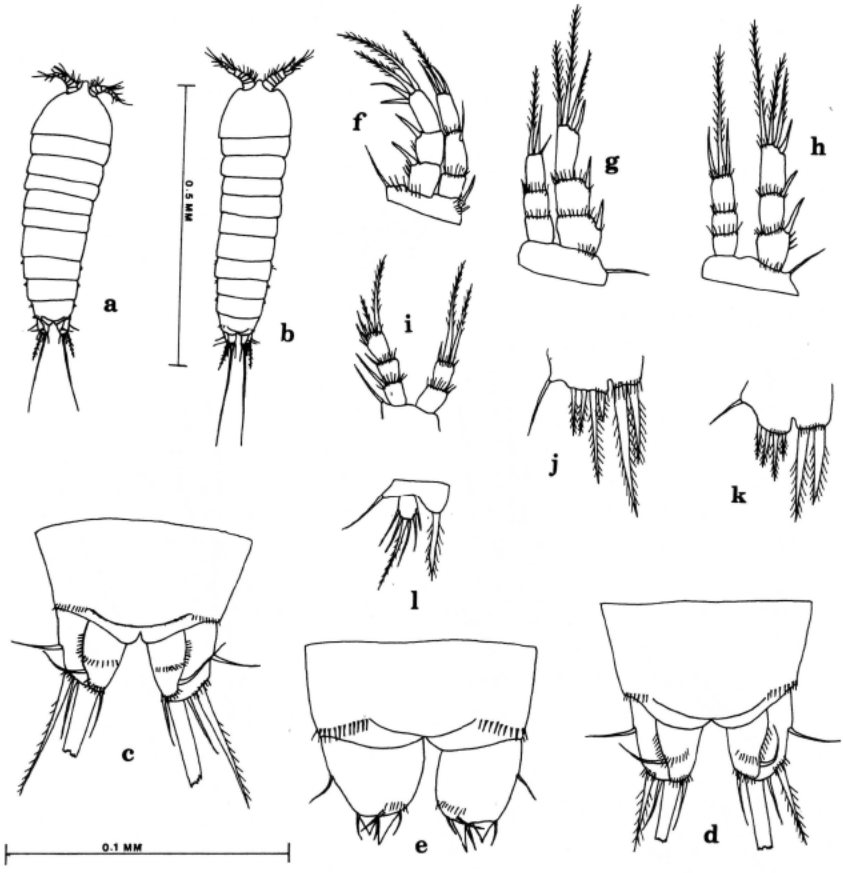

Fig. 11. *Phyllognathopus viguieri*: *a*, female from Western Samoa; *b*, male from Western Samoa; *c*, *d*, *e*, variations in caudal rami and setae; *f*, first leg; *g*, second leg; *h*, third leg; *i*, fourth leg; *j*, *k*, fifth legs of females; *l*, fifth leg of male.

FEMALE: Body length 1.20 to 1.35 mm. Large tubular-shaped harpacticoid copepod with 10 body segments (Fig. 12a). Caudal rami small and taper posteriorly-almost 3 times longer than width at middle (Fig. 12b). They are armed with several small setae and a single, large terminal seta. First antennae short and 7-segmented (Fig. 12c). Swimming leg biramous. Exopods 3-segmented and endopods 2-segmented. Armature shown in Fig. 12d–g. Fifth leg consists of small projection bearing outer seta and strong terminal spine (Fig. 12h).

MALE: Body length 1.18 to 1.35 mm. Body is 11-segmented. First antennae geniculate. Inner basal segment of first leg bears bent spine (straight spine in female), as shown in Fig. 12i (2 distal segments of exopods not drawn). Fifth leg is small projection bearing an outer seta and a tiny segment with a strong terminal spine (Fig. 12j). Sixth leg consists of a single, slender spine (Fig. 12k).

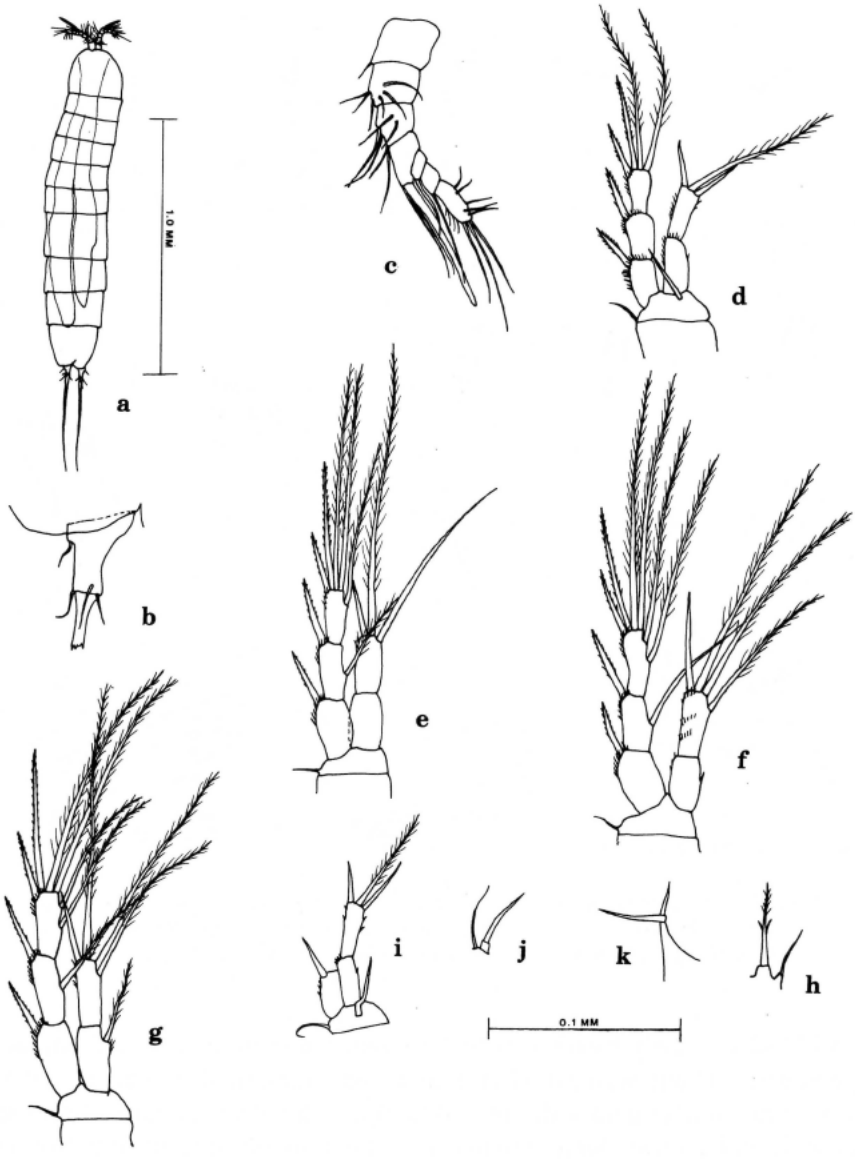

Fig. 12. *Darcythompsonia inopinata*: *a*, female from Fiji; *b*, caudal ramus; *c*, first antenna of female; *d*, first leg of female; *e*, second leg of female; *f*, third leg of female; *g*, fourth leg of female; *h*, fifth leg of female; *i*, first leg of male, terminal segments of exopod not shown; *j*, fifth leg of male; *k*, sixth leg of male.

DISTRIBUTION: Japanese Sea (Smirnov), Fiji, and Western Samoa (present records). Apparently, it has rarely been collected.

REMARKS: Kunz (1961) separated this species from *Darcythompsonia fair-*

liensis (T. Scott) (also with 7-segmented first antennae) from Ireland, by the absence of angular caudal ramus projections on *Darcythompsonia inopinata*.

Family HARPACTICIDAE Sars, 1904
Tigriopus angulatus Lang
and
Tigriopus californicus (Baker)
Fig. 13a–i, j–n

MATERIAL EXAMINED: Five females and three males of *T. angulatus* from Otago, New Zealand (February 1976). One female *T. angulatus* (1976, in vial with *Elaphoidella taroi* and *Bryocyclops fidjiensis*) from Fiji. Six females and three males of *T. californicus* from Che Ju Island and Pusan, South Korea (6 January and 4 January 1979). Collected from brackish supralittoral pools and a freshwater pool.

DESCRIPTIONS: Because these two species have been so frequently confused in identification and in literature on copepod distribution, the following descriptions are given in the form of comparisons. Where the species agree, no distinctions are made in the descriptions.

FEMALES: Body length for *T. angulatus* 0.75 to 0.81 mm, for *T. californicus* 1.04 to 1.16 mm (Fig. 13a, j). Prosome narrowly egg-shaped tapering posteriorly to a tube-shaped opisthosome. Caudal rami stubby, about as long as broad. First antennae short and 9-segmented. Second antenna bears 4-segmented exopodite (Fig. 13c). Bradford (1967) stated that there is a difference in the "proportions of their [the two species] limbs, especially the first leg in both sexes", but the author's specimens show no differences in the first legs except the overall size of the legs (Fig. 13d, k). Bradford (1967) stated that the last segment of the fourth leg exopod of *T. angulatus* has a total of eight spines and setae instead of seven as in *T. californicus*. This is true of both sexes of the species and is a notable difference (Fig. 13h, l). As Bradford pointed out, the fifth legs of the females differ in the two species. For *T. angulatus*, the basal expansion extends much longer than the exopod segment, and for *T. californicus*, this expansion is much shorter than the exopod (Fig. 13f, m).

MALES: Body length for *T. angulatus* 0.71 to 0.73 mm, for *T. californicus* 1.03 to 1.05 mm. First antennae geniculate (Fig. 13b). Second leg differs from that of female in both species by presence of long outer terminal projection on second segment of endopod (Fig. 13g). Fourth legs like those of females and differ in two species as described for females. Fifth legs of *T. californicus* show greater separation of 2 basal setae from 3 median setae of exopod than is shown in fifth legs of *T. angulatus* (Fig. 13i, n).

DISTRIBUTION: Because of confusion of these two species, many of the records of *T. californicus* from the southwest Pacific are probably *T. angulatus*. *T. californicus* has definitely been collected at Laguna Beach, California and Vancouver Island, Canada, and South Korea (present record). *T. angulatus* has been collected from New Zealand; Macquarie Island; Santiago, Chile; and possibly East Africa. The

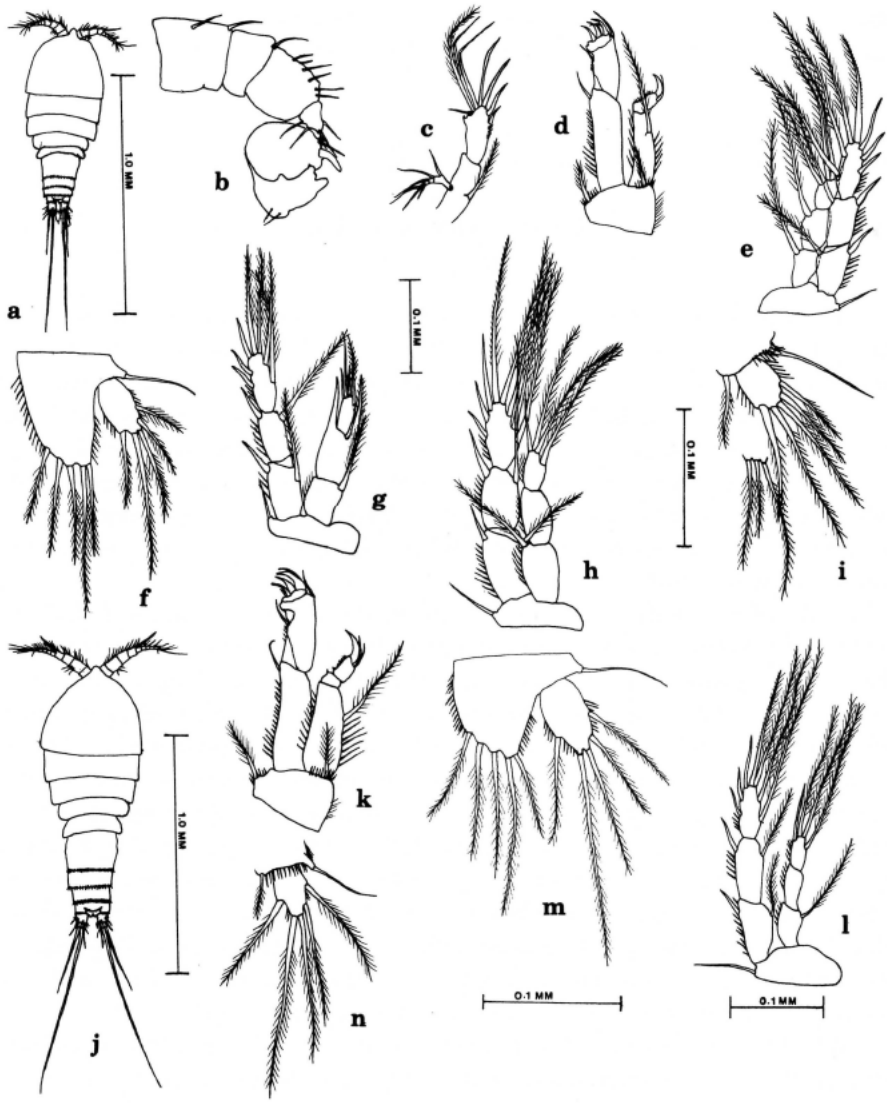

Fig. 13. *Tigriopus angulatus*: *a*, female from Fiji; *b*, first antenna of male; *c*, second antenna of female; *d*, first leg of female; *e*, third leg of female; *f*, fifth leg of female; *g*, second leg of male; *h*, fourth leg of male; *i*, fifth and sixth legs of male. *Tigriopus californicus*: *j*, female from South Korea; *k*, first leg of female; *l*, fourth leg of female; *m*, fifth leg of female; *n*, fifth leg of male.

single specimen from Fiji may represent an error in collecting or labelling according to J. S. Pillai, who sent the collection to the author. It is included here because it possibly occurs in Fiji and may be expected to be found there in future collections. It is a euryhaline species, living in freshwater, brackish water, or even in sea water in

tide pools.

REMARKS: J. S. Pillai, who collected and sent specimens of both species, stated that in life, these species are orange in color. *T. angulatus* has been infected with a *Coelomomyces* fungus that destroys mosquito larvae.

Family TISBIDAE (Stebbing) Lang, 1948
Tisbella pulchella (Wilson)
Fig. 14a–f

MATERIAL EXAMINED: One female from crab hole at Bau Landing, Fiji (2 August 1978) and one female from ground pool on Yanuca Island, Fiji (5 March 1979).

FEMALE: Body length 1.0 to 1.12 mm. Prosome egg-shaped and 5-segmented, opisthosome tubular and 4-segmented. General body appearance like that of copepods of genus *Tisbe*. Caudal rami stubby, about as long as broad (Fig. 14b). First antennae slender and 8-segmented (Fig. 14a). Second antennae and mouthparts described by Yeatman (1963), as have swimming legs. As for most harpacticoid copepods, proportions of segments of first legs and their ornamentation is of importance in identification. This leg biramous, its exopod 3-segmented and endopod 2-segmented. This species readily distinguished from Gurney's (1927) *Tisbella timsae* by length of second endopod segment-as long as first segment in *T. timsae* and much shorter than first segment in *T. pulchella* (Fig. 14c, d). Fifth leg has short basal segment bearing an outer seta and two inner setae and a long (4 to 5 times longer than broad) exopod segment. This segment bears five terminal and subterminal setae (Fig. 14e). Sixth leg present, and consists of a long inner seta and a short outer seta (Fig. 14f).

DISTRIBUTION: Chappaquiddick Island, Massachusetts; Bermuda Islands; drainage ditch to North Sound, Grand Cayman, BWI (many collected by the author on 26 August 1978); Fiji Islands (present record). The species is probably more widespread in marine and brackish littoral water in the tropics than past collecting would indicate.

REMARKS: The occurrence of this copepod in water far from America and the Caribbean Sea raises again the question of whether it is the same as Gurney's (1927) *T. timsae*. If Gurney's figures of the first leg and first antenna (7-segmented) are correct and his single specimen from Ismailia, Egypt is not abnormal, *T. pulchella* is certainly distinct from that species. Collecting specimens from Egypt is necessary to close the case. Nevertheless, the discovery of these specimens of *Tisbella* on Fiji is exciting for copepod distribution studies.

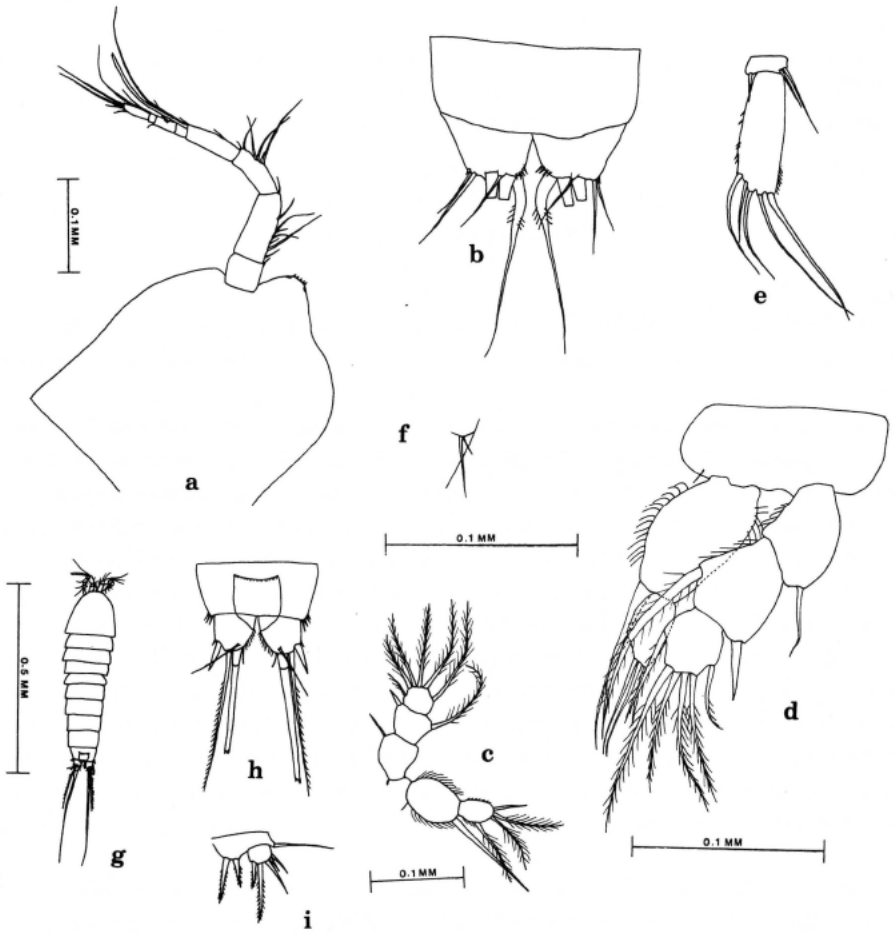

Fig. 14. *Tisbella pulchella*: *a*, first body segment and first antenna of female from Fiji; *b*, last abdominal segment and caudal rami of female; *c*, *d*, first legs; *e*, fifth leg of female; *f*, sexth leg of female. *Schizopera tobae*: *g*, male from Fiji; *h*, last abdominal segment and caudal rami of male; *i*, fifth leg of male.

Family DIOSACCIDAE Sars
Schizopera tobae Chappuis
Fig. 14g–i

MATERIAL EXAMINED: One male from crab hole at Bau Landing, Fiji, 2 August 1978.

DESCRIPTION: This genus distinguished from other genera of Family Diosaccidae (female bears two egg sacs, not one) by location of aesthetasc or sensory club on fourth segment (instead of third) of female first antenna and presence of 2 spines (not three) on outer margin of terminal exopod segment of third leg. Female

well described by Lang (1948) and no females were collected from microhabitats on Fiji. Brief description of male from Fiji given here to show it is representative of species.

MALE: Body length 0.50 mm. Body small, tubular and 10-segmented (Fig. 14g). Posterior border of anal operculum bears tiny spinules. Caudal rami about as long as broad, and outer corner armed with strong spine (Fig. 14h). Innermost terminal seta very tiny. First segment of endopod of first leg slightly longer than exopod of that leg and slightly more than twice as long as two end segments (combined) of this ramus. Fifth leg consists of basal segment armed with outer seta and two strong, inner spines and an almost round exopod segment with a total of five setae and spines (Fig. 14i). Unlike some species of *Schizopera*, there is a seta on the first segment of the fourth leg endopod.

DISTRIBUTION: Sumatra, Java, and Fiji (present record).

REMARKS: This species is probably not a regular inhabitant of crab holes, because this type of microhabitat was extensively investigated on the Fiji Islands.

Family AMEIRIDAE (Monard) Lang

Nitocra lacustris pacificus n. subsp.

Fig. 15a–p

MATERIAL EXAMINED: Two females and one male from Western Samoa (18 March 1976). U. S. National Museum, No. 204473 (holotype), No. 204475–204478 (paratypes), and No. 204474 (allotype). Four females and one male from Tonga (27 August 1976), and one female from Fiji (17 July 1978)-all taken from crab holes. One female *N. lacustris* from India.

FEMALE: Body length 0.37 to 0.40 mm. Body tubular, tapering posteriorly. Prosome 5-segmented, opisthosome 4-segmented (Fig. 15a). Rostrum conspicuous. Anal operculum bears small spinules; caudal rami slightly longer than broad. Posterior lappets of last abdominal segment bear long seta and short seta, viewed between caudal rami (Fig. 15b,c). Longer setae exceed caudal rami in length and distinguish this subspecies from typical *N. lacustris*, which have very short setae in this place (Fig. 15d, e). First antennae short and 8-segmented. Exopod of second antenna is one-segmented (Fig. 15f). Segmentation and armature of swimming legs typical for the species (Fig. 15g, i–k). Unlike *Nitocra lacustris sinoi* Marcus et Por, basal segment of first leg endopod is shorter than first two segments of exopod. Third segment of second leg endopod bears three setae. Exopod of fifth leg bears 6 setae and inner expansion of basal segment bears a total of 5 spines and setae (Fig. 15n, o).

MALE: Body length 0.35 to 0.39 mm. Prosome 5-segmented, opisthosome 5-segmented. Lappet setae of last abdominal segment long, as in female. Inner spine of first leg basal segment modified into blunt hook (Fig. 15h), as typical for species and sex; armature of legs typical.

REMARKS: Except for the elongated setae on lappets of the last body segment, these specimens resemble the well-described, typical *N. lacustris*.

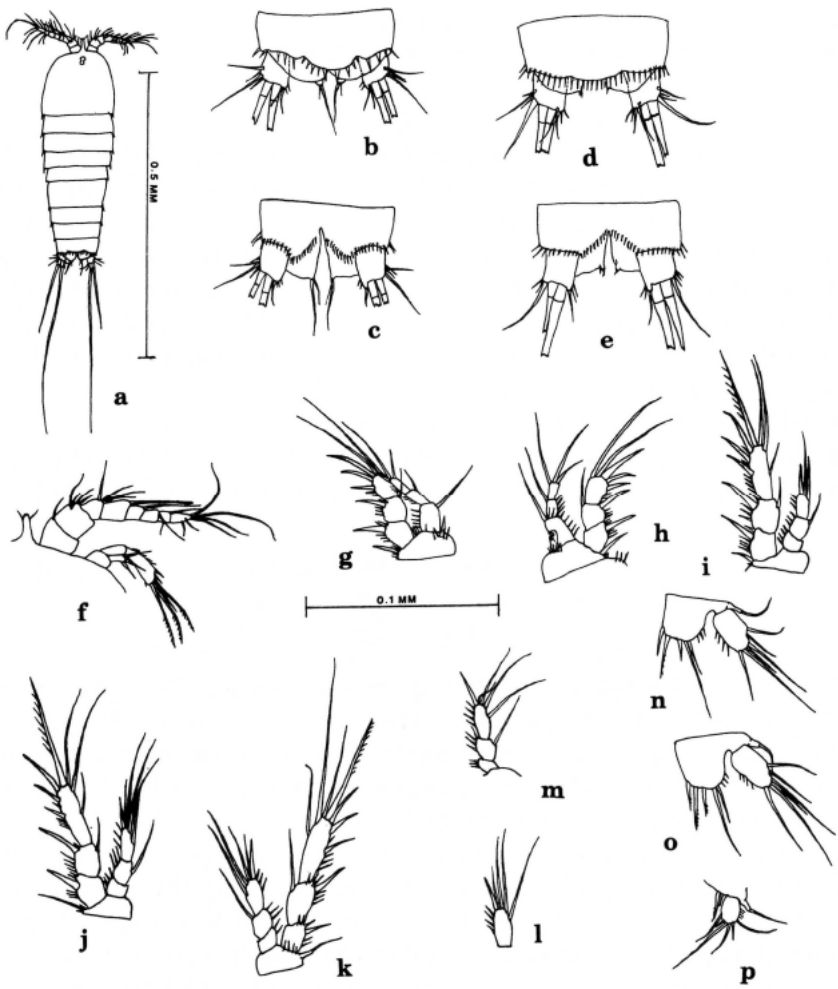

Fig. 15. *Nitocra lacustris pacificus*: *a*, female from Fiji; *b*, last abdominal segment and caudal rami of female from Fiji, dorsal; *c*, last abdominal segment and caudal rami of female from Fiji, ventral; *d*, last abdominal segment and caudal rami of female *N. lacustris* from India, dorsal; *e*, last abdominal segment and caudal rami of *N. lacustris* from *India*, ventral; *f*, first and second antennae of female; *g*, first leg of female; *h*, first leg of male; *i*, second leg of female; *j*, third leg of female; *k*, fourth leg of female; *l*, terminal segment of fourth leg endopod of female; *m*, fourth leg endopod of male; *n*, *o*, fifth leg of females; *p*, fifth leg of male.

Nitocra pseudospinipes new species
Figs. 16a–g, 17a–g

MATERIAL EXAMINED: Two females (30 August 1976) U. S. National Museum, No. 204471 (holotype slide) and two males (27 August 1976) U. S. National

Museum, No. 204472 (allotype slide) from Tonga and two females from Fiji (21 September 1978)-all taken from crab holes.

FEMALE: Body length 0.68 to 0.75 mm. Body tubular, tapering posteriorly. Prosome 5-segmented, opisthosome 4-segmented. Rostrum conspicuous. Caudal rami broader than long. Anal operculum almost straight and bears small spinules (Fig. 16b). First antennae short and 8-segmented, exopod of second antennae 1-segmented. Rami of biramous swimming legs 3-segmented. Unlike Genus *Nitocrella*, these legs bear 3 (not 2) outer spines on outer sides of terminal segment of exopods. Combining spines and setae for terminal segment of endopods gives 3 for first leg, 4 for second leg, 5 for third leg, and 5 for fourth leg. First segment of first leg endopod shorter than first two segments of exopod, as in typical *N. lacustris*. First segment of

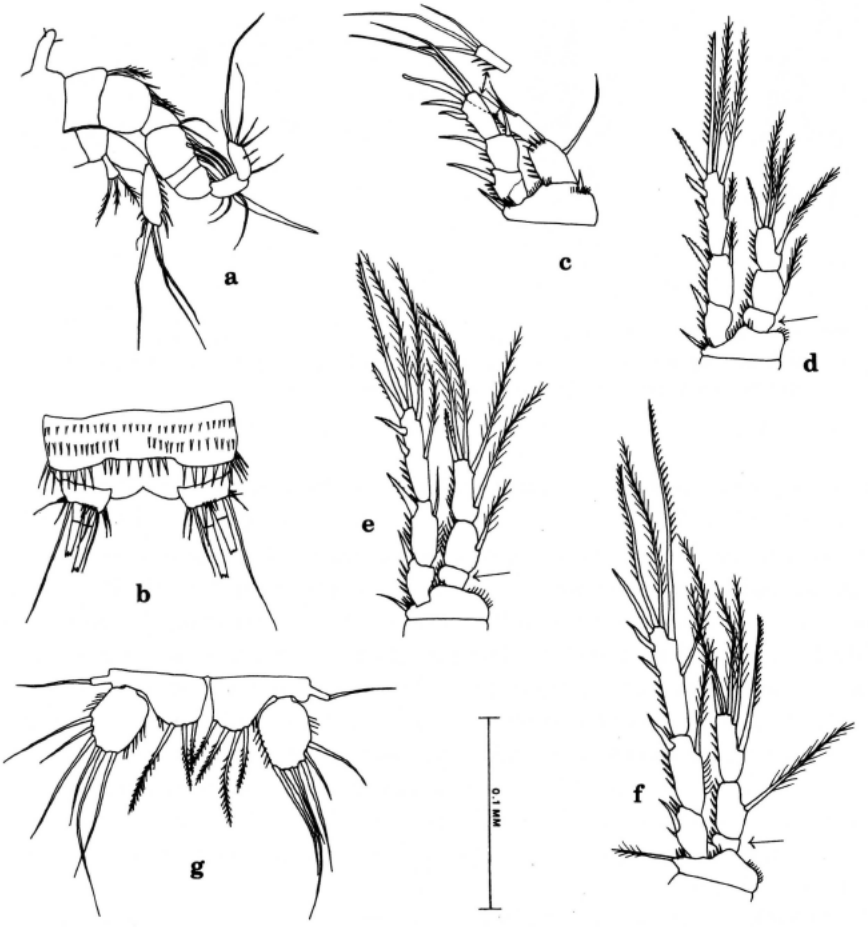

Fig. 16. *Nitocra pseudospinipes*: *a*, first and second antennae of female from Tonga; *b*, last abdominal segment and caudal rami of female, dorsal; *c*, first leg of female; *d*, second leg of female; *e*, third leg of female; *f*, fourth leg of female; *g*, fifth legs of female (right and left differ).

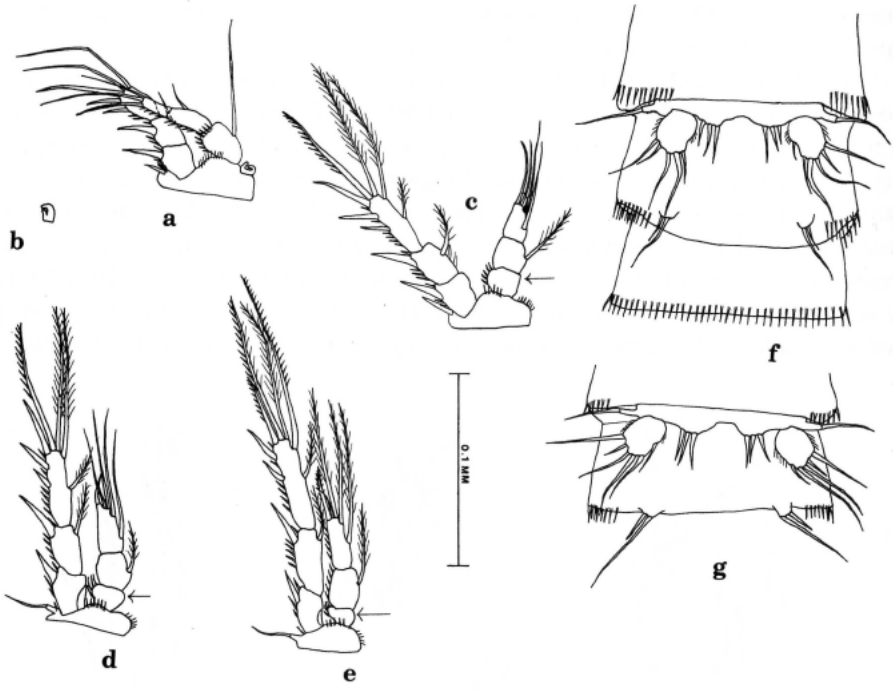

Fig. 17. *Nitocra pseudospinipes*: *a*, first leg of male; *b*, modified inner basal spine of male first leg; *c*, second leg of male; *d*, third leg of male; *e*, fourth leg of male; *f*, *g*, fifth and sixth legs of males (right and left differ.)

endopod of second, third, and fourth legs lack an inner spine (Fig. 16d–f) as in *N. lacustris* and unlike *N. spinipes*, which bears a seta in that position. Exopod of fifth leg bears 6 setae and inner expansion of basipod bears either 3 or 4 setae; sometimes differing on right and left in the same individual (Fig. 16g). Female fifth leg of *N. spinipes* bears 5 setae on exopod and 5 setae on inner basal expansion (Dussart, 1967).

MALE: Body length 0.60 to 0.63 mm. Prosome 5-segmented. First leg bears modified spine on inner side of basal segment (Fig. 17a, b). Exopods armed like those of female. First segments of endopods of second, third and fourth legs unarmed. Terminal endopod segment of second, third, and fourth legs bear totals of 5 spines and setae, one seta of the second and fourth legs very tiny and outer terminal spine of third leg scythe-shaped (Fig. 17c–d). Exopod of fifth leg bears either 5 or 6 setae, sometimes differing on right and left sides (Fig. 17f, g). Inner expansion of basal segment bears 3 spines.

REMARKS: This species resembles *N. spinipes* in many characters and keys out in Lang (1948) to that species, but differs in armature of the fifth legs of both sexes and in lack of a seta on the first segment of the endopods of second, third, and fourth legs.

Family CANTHOCAMPTIDAE (Sars) Monard

Elaphoidella taroi Chappuis

Fig. 18a–p

MATERIAL EXAMINED: Twenty females and twelve males from taro leaf axils, tree holes, coconut shells, and tin cans at Wailoku, Viti Levu, Fiji (29 August 1979 and 30 September 1978). Three females and two males from taro leaf axils on Western Samoa (7 August 1976).

FEMALE: Body length 0.59 to 0.67 mm. Body tubular and 9-segmented. Small rostrum present at anterior end (Fig. 18a). Anal operculum has row of small spinules at its posterior border. Caudal rami short, taper posteriorly and have dorsal, inner hooklike process (Fig. 18b). First antennae short and 8-segmented. Exopod of second antenna 1-segmented (Fig. 18e). Swimming legs biramous. Exopods and first leg endopod 3-segmented and other leg endopods 2-segmented. Leg segments armed with spines and setae as shown in Figure 18f–i. Fifth leg basal segment bears an outer seta and its long inner expansion bears 4 setae. Exopod short, almost circular and bears 4 setae (Fig. 18n).

MALE: Body length 0.60 to 0.65 mm. Body consists of 10 segments (Fig. 18c). Rostrum and anal operculum like those of female. Caudal rami have dorsal, inner hook smaller than that of female (Fig. 18d). First leg like that of female, but other legs conspicuously different. Second segment of second leg endopod cone-shaped and bears 3 setae instead of 4. Some of spines of third leg exopod enlarged and endopod 3-segmented, middle segment bearing long spine-like projection and end segment with only 2 terminal setae. Outer terminal spine of fourth foot exopod has 2 or 3 long barbs. For comparison of these legs in sexes, Figure 18g–i (female legs) are placed in a row and corresponding male legs (Fig. 18j–l) are placed directly below them. Right and left fifth legs are joined at the inner base and there is an outer seta. Exopod round and bears 3 setae or spines (Fig. 18o, p).

DISTRIBUTION: Fiji and Western Samoa (present record).

REMARKS: This species may readily be distinguished from *Elaphoidella bromeliacola* (Chappuis, 1928), which has a total of 4 setae and spines (instead of 3) on the end segment of the fourth leg endopod (Lang, 1948). Karen Toohey and Mark Goettel, who collected the Fiji material, described *E. taroi* as "mostly a bottom-dweller, always gripping onto the substrate." They were able to infect this species with *Coelomomyces* fungus (Toohey, et al. 1982). It therefore has great potential for use in mosquito control, where it occurs.

Elaphoidella grandidieri (Guerne and Richard)

Fig. 19a–j

MATERIAL EXAMINED: Three females from blocked drain at Itatoko, Ba, Viti Levu, Fiji (6 June 1979) and three females from tires on Western Samoa (22 September 1975).

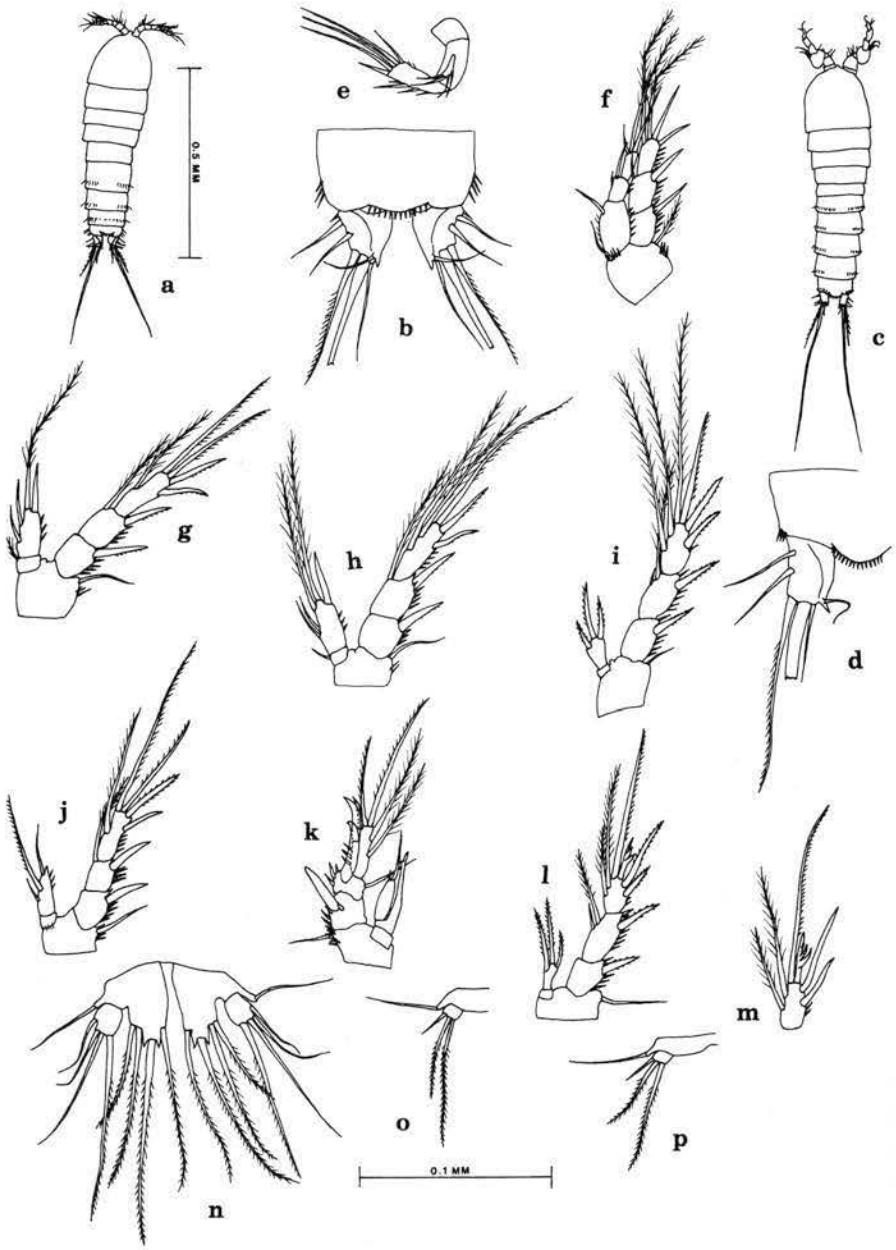

Fig. 18. *Elaphoidella taroi*: *a*, female from Fiji; *b*, last abdominal segment and caudal rami of female, dorsal; *c*, male from Fiji; *d*, left caudal ramus of male, dorsal; *e*, second antenna; *f*, first leg of female; *g*, second leg of female; *h*, third leg of female; *i*, fourth leg of female; *j*, second leg of male; *k*, third leg of male; *l*, fourth leg of male; *m*, terminal exopod segment of fourth leg of male; *n*, fifth legs of female; *o*, *p*, fifth legs of male.

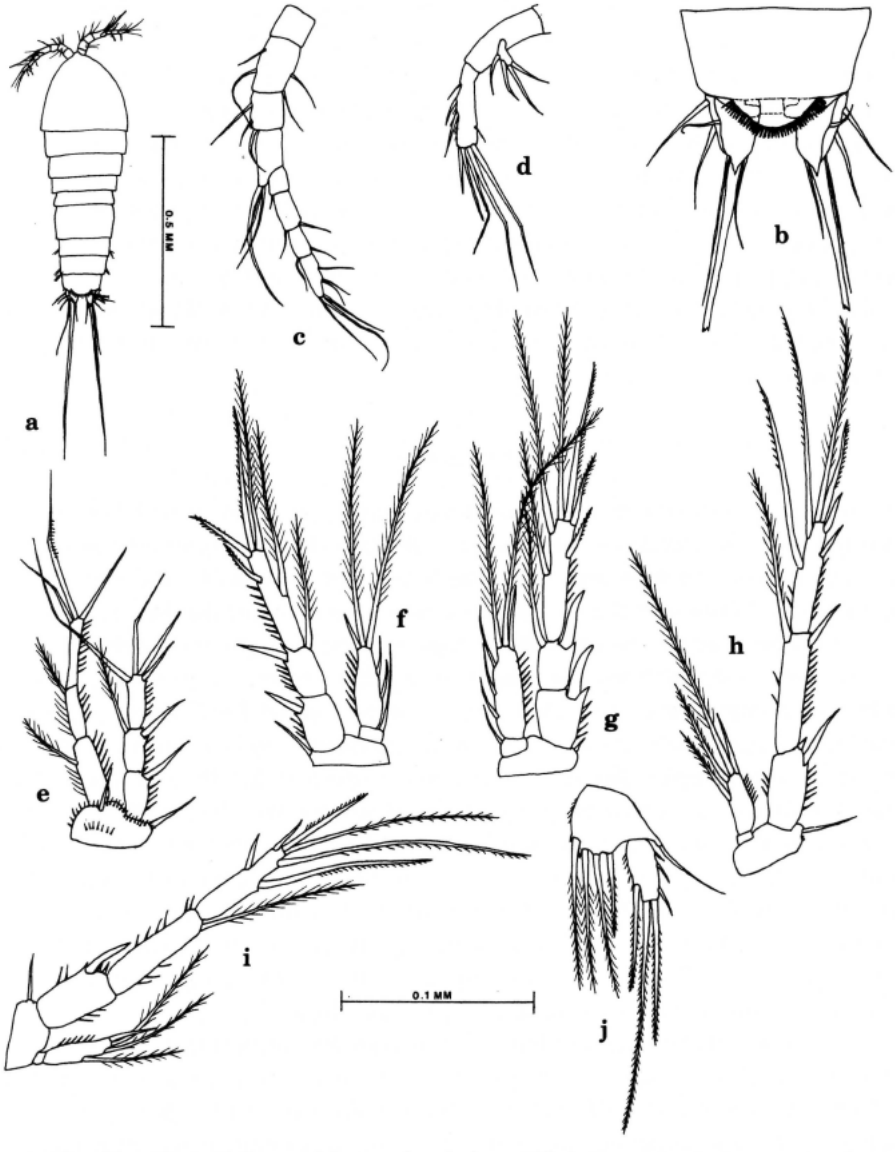

Fig. 19. *Elaphoidella grandidieri*: *a*, female from Fiji; *b*, last abdominal segment and caudal rami of female, dorsal; *c*, first antenna of female; *d*, second antenna of female; *e*, first leg of female; *f*, second leg of female; *g*, third leg of female; *h*, fourth leg of female; *i*, abnormal fourth leg of female (no spine on second segment of exopod); *j*, fifth leg of female.

FEMALE: Body length 0.63 to 0.70 mm. Body tubular and 9-segmented (Fig. 19a). Small rostrum. Anal operculum extends posteriorly to about middle of caudal rami and bears a row of densely-placed spinules. Caudal rami short and have short,

terminal, dorsal, sharp projection (Fig. 19b). This process not as conspicuous as process of caudal rami of *E. taroi*. First antennae short and 8-segmented (Fig. 19c). Exopod of second antenna 1-segmented. Swimming legs biramous. Exopods and first leg endopod 3-segmented. Unlike *E. taroi*, first leg endopod longer than exopod. Leg segments armed with setae and spines as shown in Fig. 19e–h. Fig. 19i shows an abnormal fourth leg with no outer spine on second exopod segment. There is no socket to indicate that this spine was lost by breakage. Fifth leg notably different from that of *E. taroi*. Its basal segment expansion, bearing 4-setae, is short, and the exopod bearing a total of 6 setae and spines, is elongated (Fig. 19j).

DISTRIBUTION: Africa, Madagascar, Ceylon, China, Thailand, Vietnam, Java, Sumatra, Flores, New Guinea, Hawaiian Islands, Fiji, and Western Samoa (last 2 are present record).

Discussion

Some microhabitats such as crab holes may be flooded during high tides or connected with the ocean or with other crab holes by underground tunnels. The freshwater habitats such as leaf axils, tree holes, and some types of containers may have their small flora and fauna shifted by splashing of water during heavy rains or these organisms may be transported by frogs, insects, etc. Of considerable interest is the means of transport from one island to another or even from one continent to another. As pointed out in the "Distribution" section under *Phyllognathopus viguieri*, species have stages that can survive much drying during transportation of plant leaf axils, such as pineapples. Because pineapples evolved in South America and were taken by Indians and later explorers to other areas, one wonders if *Phyllognathopus viguieri* evolved in the Americas. This copepod may have evolved in the Hawaiian Islands or other islands and invaded these transplanted pineapples to eventually be shipped to anywhere in the world. Humans, in transporting their boats, plants, drinking water, etc. have played a great part in extending the distribution of many species of copepods. Botanic gardens, having plants from various continents, can be sources of unusual copepods and other fauna and flora.

The ecology of the microhabitats is of interest and importance. In many of the microhabitats, *Bryocyclops fidjiensis* and *Elaphoidella taroi* are commonly found together in harmony, and both species are numerous. Apparently, *Bryocyclops* is not predacious on adult copepods of its species or other species, although it might eat copepod nauplii. *Elaphoidella taroi* also commonly occurs with *Phyllognathopus viguieri*. The difference in size between these two harpacticoid species may prevent competition by selection of different-sized foods. In many collections *Bryocyclops fidjiensis* accompanies these two harpacticoids. *Mesocyclops leuckarti*, a known predator of other copepods and even mosquito larvae, occurred with *Cryptocyclops bicolor linjanticus* in a few crab holes, but numbers of each species were low. *Halicyclops thermophilus* and *Halicyclops septentrionalis* occurred together in collections from six crab holes. This shows that because these copepods can coexist

without interbreeding, they are very likely different species.

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