

SPHAEROMATIDS (ISOPODA, SPHAEROMATIDAE)
FROM NEW ZEALAND FRESH AND HYPOGEAN WATERS,
WITH DESCRIPTION OF *BILISTRA* N. GEN.
AND THREE NEW SPECIES

BY

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ABSTRACT

Bilistra gen. nov., *B. millari* n. sp., type species, *B. mollicopulans* n. sp. and *B. cavernicola* n. sp. are described from karst areas in the northwest of South Island, New Zealand. *Bilistra millari* n. sp. occurs mainly in surface waters, while *B. mollicopulans* and *B. cavernicola* are stygobiotic and troglomorphic, occurring in cave waters. The genus is related to *Benthosphaeroma* Bruce, 1994, *Neosphaeroma* Baker, 1926, and *Thermosphaeroma* Cole & Bane, 1978, but each of these genera exhibits its own apomorphies, mainly in brood-pouch structure and morphology of pleopods IV-V.

ZUSAMMENFASSUNG

Bilistra gen. nov., *B. millari* n. sp. als Typusart, *B. mollicopulans* n. sp. und *B. cavernicola* n. sp. aus Karstgebieten im Nordwesten der Südinsel von Neuseeland werden beschrieben. *Bilistra millari* n. sp., kommt vor allem in oberirdischen Gewässern vor, während *B. mollicopulans* und *B. cavernicola* Stygobionten sind, die in Höhlengewässern vorkommen und Troglomorphien aufweisen. Die Gattung ist mit *Benthosphaeroma* Bruce, 1994, *Neosphaeroma* Baker, 1926 und *Thermosphaeroma* Cole & Bane, 1978, verwandt. Jede dieser Gattungen weist jedoch ihre eigenen Apomorphien auf, hauptsächlich in der Struktur des Marsupium und Morphologie der Pleopoden IV-V.

INTRODUCTION

The family Sphaeromatidae Latreille, 1825, is species-rich (more than 655 species) and morphologically diverse. It is predominantly marine, inhabiting

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mostly intertidal and shallow waters, including estuaries. Ninety-three genera are recognized (a figure that is constantly increasing), of which many are monotypic but several have more than 20 species (Kussakin, 1979; Harrison & Ellis, 1991; Bruce, 1994a, 1997; Kensley et al., 2002). Several of the larger and long-established genera are considered to be of doubtful monophyly (e.g., Harrison & Holdich, 1984; Harrison & Ellis, 1991; Bruce, 1995, 1997).

The Sphaeromatidae, in contrast to the also species-rich Cirolanidae (442 species, 73 species from freshwater and caves), is poorly represented in freshwater habitats. Continental Europe is home to the richest freshwater sphaeromatid cave fauna in the world (Racovitza, 1910; Sket, 1964, 1986), with three species of *Caecosphaeroma* and the richly diverse genus *Monolistra* with more than 35 species and subspecies (Sket, 1986, new data). In the northern Pacific, the mainly littoral genus *Gnorimosphaeroma* occurs in mixohaline waters with some endemic freshwater species along the American and Asiatic coasts (Kussakin, 1979; Nunomura, 1998). In the region of southern California and western Mexico there is the purely freshwater genus *Thermosphaeroma*, with all but one of the eight species with single-locality distributions (Schotte, 2000).

No purely freshwater sphaeromatids have been described from the Southern Hemisphere [Chapman & Lewis (1976) noted the presence of one or two sphaeromatids in New Zealand, but their book is little known beyond New Zealand and as the isopods were identified as anthurideans the record remained overlooked] and the discovery of three new species in New Zealand represents a considerable shift in knowledge of freshwater and cave-dwelling sphaeromatids. Notwithstanding the lack of published accounts, it is apparent that these sphaeromatids, as revealed by Ian Millar (unpubl.), were known to New Zealand biologists and cavers.

Type material is deposited in the National Museum of New Zealand, Te Papa Tongarewa, Wellington.

Terminology and abbreviations. — Several genera of Sphaeromatidae have the inferior margin of the pereopods provided with a dense mass of “fur”. This seta-like covering is formed from elongate cuticular scales (microtrichs) (see Bruce, 1994a, fig. 8D), not setae or setules, but as they are seta-like in appearance, Bruce (1994a) coined the term setulose fringe for this character, and that term is, besides “setulose mat”, also applied here. Abbreviations: NMNZ – National Museum of New Zealand, Te Papa Tongarewa, Wellington, New Zealand; PMS – plumose marginal setae; ULS ZIsp – University Ljubljani, Slovenia, Zoology Collection, Isopoda.

TAXONOMY

SPHAEROMATIDAE Latreille, 1825

Genus **Bilistra** n. gen.

Male. — Body vaulted, volvate; dorsally smooth or weakly ornamented. Head anteriorly rounded, without median rostral point; eyes small (or reduced), placed laterally; ommatidia weakly to well developed.

Pereonite I longest, anterolateral margins not encompassing head; pereonites II-VII about equal in length; coxae epimera-like, without distinct suture, ventrally with complex interlocking ridge-and-groove system. Pleon extending to lateral body margin; pleonite I entire, in dorsal view largely concealed by pereonite VII; pleonites II-IV indicated by 2 distinct sutures running to the posterior margin (*Sphaeroma*-type of pleon). Pleonal sternite absent. Pleotelson posterior margin arcuate, without ventral exit channel or foramen.

Epistome anterior margin weakly projecting, narrowly rounded; labrum unornamented. Antenna I with peduncular articles collinear; articles 1 and 2 robust, article 3 slender, elongate; article 2 short, about 0.3 as long as article 1. Antenna II peduncle not reflexed or dilated, articles 4 and 5 subequal in length and the longest.

Mandible incisor 4-cuspidate, left mandible with large 3-cuspidate lacinia mobilis; left mandible with row of 10 or more spines parallel to incisor blade, while such a row is oriented towards molar on right mandible; left molar process cylindrical, surface ridged, margin with triangular to lacinate teeth; right molar similar, but obliquely cut; each with anterior basal row of c. 8 long plumose setae. Palp 3-segmented, article 1 longest. Maxilla I lateral lobe with about 10 curved spines, some spatulate, some pectinate; medial lobe with 4 plumose setae. Maxilla II with all articles well developed; lateral and middle lobes each with approximately 10 long, curved and pectinate spines; medial lobe with approximately 15 short and plumose setae. Maxilliped palp articles 2-4 with medial lobes; endite distally rounded, distal margin with densely set plumose spines subterminally and terminally, medial margin with single coupling hook, distally setulose and bent, with 3 plumose spines.

Pereopods all ambulatory, inferior surfaces of ischium or merus to propodus with dense setulose lining; pereopod I propodus distinctly more robust (2 times as long as wide) than pereopods II-III (propodus 3 times as long as wide); pereopods II-VII sub-similar; pereopods I-VII dactylus inferior margin with prominent flattened scales, accessory unguis small and simple.

Penes basally set widely apart, converging at tips, slightly curved medially inwards, elongated conical.

Pleopods I-III with and pleopods IV-V without PMS; pleopods III exopodites with entire transverse suture, exopodites IV-V with incomplete transverse suture.

Pleopod I rami collinear, distally rounded. Male pleopod II with appendix masculina basal in position, simple, distal quarter weakly turned to medial. Both rami of pleopods IV-V with 1 or 2 oblique fleshy folds, without setae. Pleopod V exopodite with 3 scale patches. Uropods anterolateral, rami flat, exopodite about half as long as endopodite.

Female. — Ovigerous female with mouthparts not metamorphosed. Brood pouch formed from 3 pairs of well-developed oostegites arising from pereopods II-IV; with internal pouches, pockets absent.

Type species. — *Bilistra millari* n. sp., here designated.

Other species. — *Bilistra mollicopulans* sp. n. and *Bilistra cavernicola* sp. n.

Etymology. — From “bilistra” (Greek), meaning two-spaded, for its bi-lobed uropods and as an allusion to the sphaeromatid genus *Monolistra* from Dinaric freshwater caves. Gender feminine.

Remarks. — *Bilistra* belongs to a group of genera that are all similar to each other with regard to their general morphology, and in particular the plesiomorphic nature of the pleotelson, which is generally broadly rounded, without an exit channel or foramen. Bruce (1994b) discussed the marine genera of this group: *Sphaeroma* Bosc, 1802, *Lekanesphaera* Verhoeff, 1943, *Exosphaeroma* Stebbing, 1900, *Exosphaeroides* Holdich & Harrison, 1983, *Neosphaeroma* Baker, 1926, and *Benthosphaera* Bruce, 1994a. To this list of rather similar genera can also be added the tropical estuarine *Apemosphaeroma* Bruce, 1994 (see Bruce, 1994a), and also the North American thermophilic freshwater *Thermosphaeroma* Cole & Bane, 1978 (see Bowman, 1981, 1985).

The characters that best define and identify *Bilistra* are: the simple arcuate pleotelson, pleonal sutures running to the posterior margin of the pleon, pereopods inferior margins with a dense setulose lining, very weakly-ridged pleopods IV and V and the uropods with the exopodite only about half as long as the endopodite. For those speciose genera of the Sphaeromatidae that can be perceived to be monophyletic (e.g., *Oxinasphaera* Bruce, 1997 or *Paracassidina* Baker, 1911; see Bruce, 1994a) uropod morphology is remarkably constant. It is our opinion that uropod characteristics are generally of generic value in the family and we therefore attach a certain weight to these differences in making the decision to establish the new genus *Bilistra*.

Sphaeroma can easily be distinguished from *Bilistra* by the serrate lateral margin of the uropodal exopodite, the conspicuous row of setae along the dorsal side of the pereopods and a maxillipedal palp that lacks clearly expressed lobes. The similarly looking *Lekanesphaera* can also be distinguished by these characters although in some species the uropod exopodite margin is not serrate, and the maxillipedal palp articles are more or less strongly lobate. However, the type species of *Lekanesphaera* (*L. monodi* (Arcangeli, 1934) = *Europosphaera* (*L.*) *excavatum*

Verhoeff, 1943) has very clearly serrated uropodal exopodites. *Gnorimosphaeroma* is superficially similar, but the pleonal sutures run to the pleon lateral margin (much as in *Cymodoce* Leach), and furthermore the pereopods lack the conspicuous setulose mat (fringe).

Exosphaeroma is readily differentiated from *Bilistra* by the shape of the posterior margin of pleonite I, the medial portion of which is in the shape of two varyingly expressed sub-median lobes, and also by the lack of a setulose mat (fringe) on the inferior margin of the pereopods, amongst other characters. Some folds on pleopods IV-V can be homologous between both genera (fig. 11). Two other genera are exceedingly similar to *Exosphaeroma* – *Exosphaeroides*, which is characterized by pleopods IV-V being thickened but without ridges and the female with only two pairs of oostegites, and *Ptyosphaera* Holdich & Harrison, 1983, which is primarily characterized by huge uropodal rami and a posteriorly extended pleotelson. The relationship of these two monotypic genera to *Exosphaeroma* is unclear and the distinguishing characters may be species-level autapomorphies.

The genera, then, that *Bilistra* is most similar to, are *Apemosphaeroma*, *Benthosphaera*, *Neosphaeroma*, and *Thermosphaeroma*. All of these genera have a conspicuous setulose mat on the pereopod inferior margins, similar pleopod morphology, and all but *Apemosphaeroma* have a simple arcuate pleotelson without any form of exit channel. *Neosphaeroma* is immediately distinguished by the excised uropodal exopodite, by distally setose rami of pleopods IV, and also by having well-developed pleopod ridges that also occur on pleopod III. *Benthosphaera* has subequal uropodal rami, the exopodite of which has a falcate apex, the dorsum is moderately to heavily setose; both rami of pleopods III are distally setose and while the pleopodal ridges vary from weak to absent, there are very weak ridges on pleopod III of two of the species. *Apemosphaeroma*, regarded as *incertae sedis* by Bruce (1994a) is readily separated from *Bilistra* by the dorso-ventrally flattened body, posteriorly narrow and sub-truncate pleotelson, anteriorly wide and truncate epistome, and the relatively longer antenna I peduncle article 2.

Thermosphaeroma is perhaps the most similar genus, and also occupies a habitat similar to that of *Bilistra* in that it occurs in freshwater springs. There are a number of significant characters that separate these two genera, including, in *Thermosphaeroma*, narrower basal articles of antenna I, distally more distinctly narrowed pleopod I endopodites, differently shaped ridges on pleopods IV-V, subequal uropodal rami (in *T. mendozai* Schotte, 2000, *T. macrura* Bowman, 1985, and *T. thermophilum* (Richardson, 1897), the exopodite is between 25% and 43% shorter than the endopodite).

At this point we hesitate to make unsubstantiated assertions as to the relationships of *Bilistra* to other genera, and indeed about the other genera discussed here to each other. *Bilistra* seems to lack any unique characters, as do some of the other

genera here mentioned. Implicit in this is that the genus could be a paraphyletic taxon. The alternative to establishing the new genus is to attempt to fit these three species into an existing genus. That is an unacceptable, and to us, in the absence of a clear phylogenetic assessment of the genera of the family, a counterproductive course of action as the uniformity of the species does suggest a common ancestor for the species of *Bilistra*, and certain character states in each of the other genera precludes the inclusion of the species here placed in *Bilistra*.

***Bilistra millari* n. sp.** (figs. 1-3, 4A-D, F-H, 9A, 10A, 11A-B, 12A)

Material examined. — Holotype, female with oostegites, 7.8 mm. New Zealand, South Island, Nelson Region, Pohara, spring c. 100 m SE of campsite, 40°50.1'S 172°53.2'E; coll. B. Sket and I. Millar, 27 March 1998 (NMNZ Cr.9961). Paratypes: 2 subadult males, 45 females and juveniles; locality as for holotype (NMNZ Cr.9962, ULS ZIsp).

Other material. Pohara Water Supply Cave, 40°50.1'S 172°53.6'E (6 juveniles, coll. B. Sket and I. Millar, 27 March 1998) (NMNZ Cr.9826, ULS ZIsp). Creek below Pohara Water Supply Cave; 3 juveniles (coll. B. Sket and I. Millar, 27 March 1998) (ULS ZIsp). Cave Stream Resurgence, lower Pohara Valley, 40°50.0'S 172°53.5'E (2 juveniles, coll. I. Millar, 25 July 1997) (NMNZ Cr.9827).

Etymology. — Named for Ian Millar, biologist and conservation officer, whose company and guidance enabled the senior author to collect these animals. The species name is a noun in the genitive singular.

Description. — Females (incl. holotype; for some meristic and metric characters, consult table I). Body 6.8-7.8 mm long, parallel-sided, less than twice as long as wide; width 52-56% (to 60% in juveniles) of length (1 : 1.8-1.9), coxal plates close to vertical. Dorsum brownish-green and pale grey maculated in different patterns. Eyes small but well developed, with c. 30 ommatidia each. Dorsal surface of head with scattered minute tubercles, densely setulose on top; a row of approximately a dozen such tubercles parallel with the posterior margin of each tergite, scattered tubercles on pleotelson and on some epimera.

Epistome much broader than long, nearly triangular in shape, embracing half of labrum. Labrum with broadly rounded outer lobes, inner lobes not discernible.

Coxa I posterior edge grooved, lateral disto-posterior margin acute, only slightly rounded; medial margin caudally extended into a nearly angulate, narrowly rounded lobe. Coxae II-IV and VII narrow, apically rounded, V-VI broader; no sutures can be traced between tergites and coxae. Posterior pleonal tergite with posterior margin reaching 2 curved parallel sutures either side of mid-line (*Sphaeroma*-type pleon).

Pleotelson cupulate, with flattened or scarcely concave caudal surface; with wide, but shallow and inconspicuous ventral channel, ventral margin nearly even; with narrow vertically set and grooved border around ventral margin.

Antenna I sparsely setose, about 75% as long as antenna II; peduncular article 1 and flagellum subequal in length, articles 2 and 3 together nearly as long as

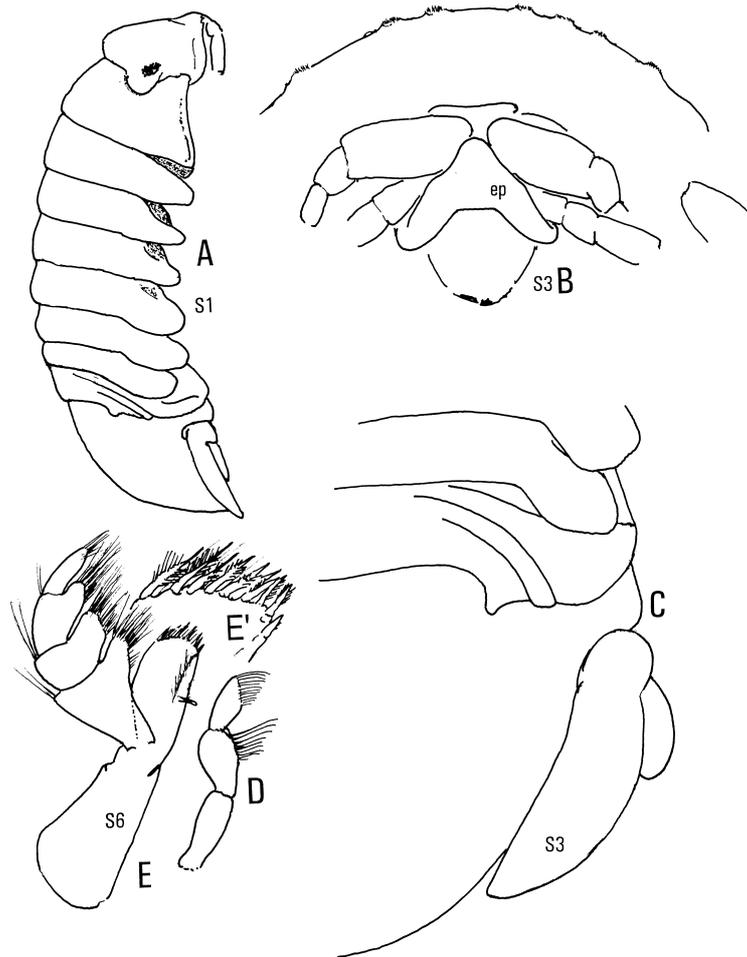


Fig. 1. *Bilistra millari* n. sp., spring at Pohara. A-C, female 7.8 mm; D-E, female 6.8 mm. A, body, lateral; B, head frontal, to show epistome (ep) and dorsal tubercles; C, dorsal right side of pereonite VII, pleon, uropod; D, mandibular palp, flattened; E-E', maxilliped, top of its endite; for scales (S), see fig. 8.

article 1; articles 1-2 widened, article 3 rod-shaped; flagellum with 7-8 articles, article 3 and both apical articles with single aesthetascs, those between with paired ones, aesthetascs joined with few short setae.

Antenna II robust, about 35-38% as long as body; when in natural position not reaching posterior margin of pereonite I; peduncular articles 4-5 less than twice as long as wide and twice as long as articles 2-3, all articles with scattered setae and weak spines; flagellum of 14-16 articles, proximal articles nearly twice as wide as long, with dense tufts of strong setae distally, which are twice as long as corresponding articles.

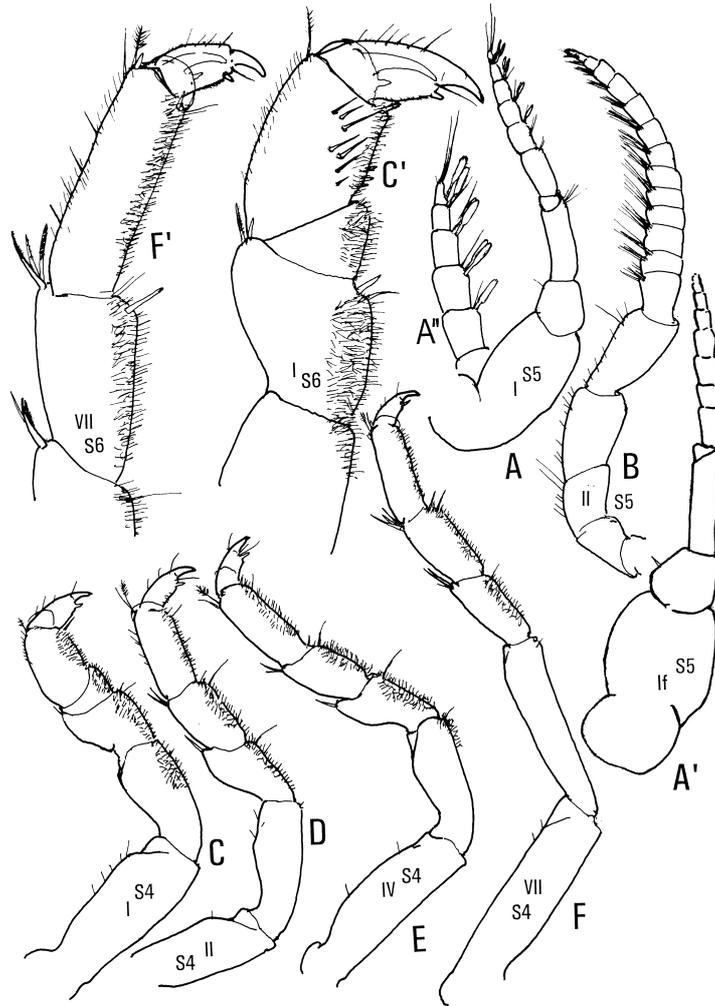


Fig. 2. *Bilistra millari* n. sp., spring at Pohara. A-F, C', F', male 6.4 mm; A', female 6.8 mm. A-B, antennae I-II (A', basal articles from broader side; A'', apical articles). C-F, pereopods I, II, IV, VII, respectively; for scales (S), see fig. 8.

Mandible incisor process only weakly to deeply 4-dentate, lacinia mobilis tridentate; two lateral spines on right mandible spatulate, the following two spines lacinate; c. 8 long plumose setae originate at the molar base and reach beyond the apical margin of the molar; other details as in the genus diagnosis. Palp with article lengths 100 : 85 : 70, distal article nearly half as wide as long (width is 40% of length), widest in middle; proximal article finely pubescent, article 2 pear-shaped with 9 setae, distal article with 13 setae.

Maxilla I lateral lobe narrow, with c. 6 curved spatulate and 5 pectinate spines, medial lobe with 4 large plumose setae nearly equally long. Maxilla II with outer

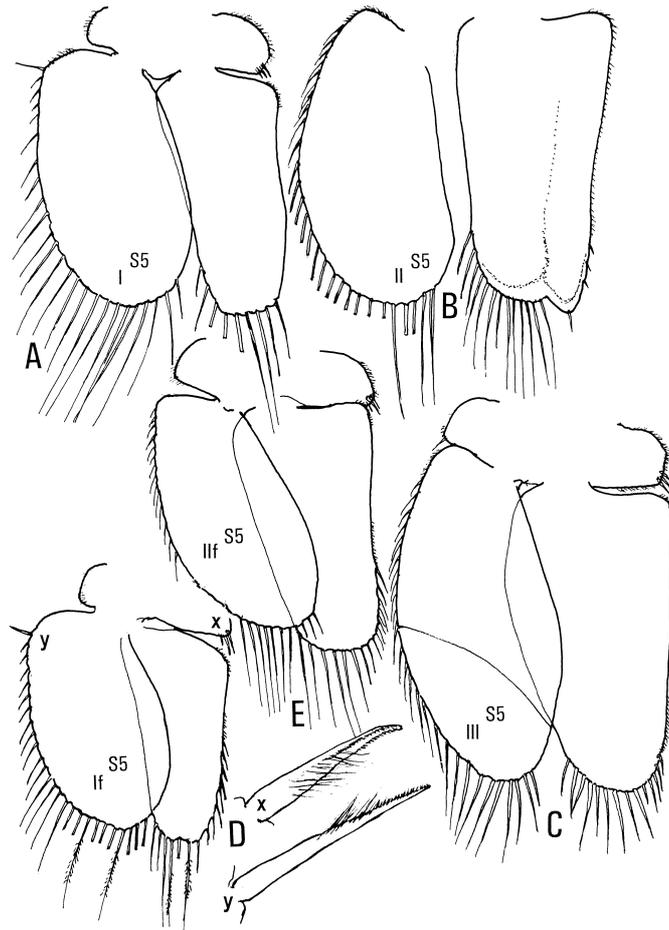


Fig. 3. *Bilistra millari* n. sp., spring at Pohara. A-C, male 6.4 mm; D-E, female 6.8 mm. A-C, pleopods I-III; D-E, Pleopods I-II (x, y, spines of protopodite and endopodite, respectively). Remark: all marginal setae of the pleopod I-III rami in figs. 3-8 are plumose; for scales (S), see fig. 8.

lobes each bearing approximately 10 long, curved, and pectinate spines; inner lobe with 16 short, plumose spines.

Maxilliped palp articles 2-4 bearing pairs of setae distolaterally; medial lobes longer than wide, with dense rows of setae distally.

Lengths of pereopods I-VII evenly increasing to 140% in the last. Pereopod VII is good half the body length, its articles 2-7 (article 1 is the transformed coxa) lengths in relation 100 : 76 : 32 : 37 : 42 : 22. Dactyli very stout, distal unguis curved, approximately 3 times as long as conical ventral spine; 2-3 long setae between unguis and spine. Pereopod articles with long serrate spines only distally, with few strong setae along their surfaces. All pereopods with inferior surface of

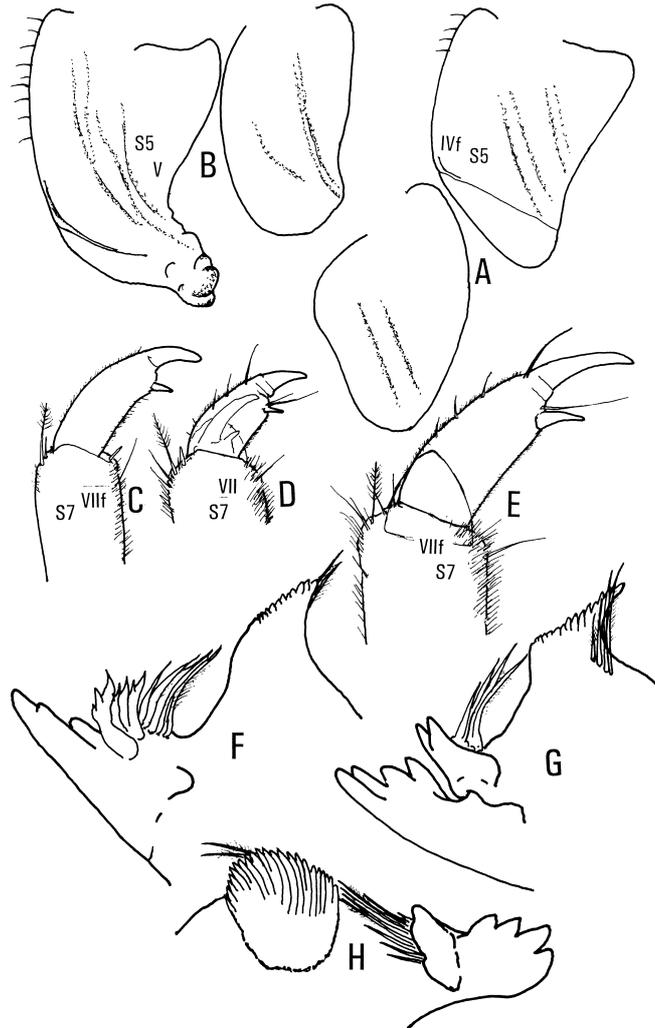


Fig. 4. A-D, F-H, *Bilistra millari* n. sp., spring at Pohara. A, C, F-H, female 6.8 mm; B, D, male 6.4 mm; E, *B. cavernicola* sp. n., Riwaka, female 10.6 mm. A-B, pleopod IV-V; C-E, pereopod VII, distal parts; F, right mandible, posterior side; G-H, left mandible, posterior and distal aspect; for scales (S), see fig. 8.

articles 4-6 (merus, carpus, and propodus) covered by a coat of densely setulose mat (fringe); sparser setulose fringe covering all other pereopod surfaces.

Pereopod I with subequally thick articles, articles 2 and 4 (basis and merus) slightly thicker. Propodus less than twice as long as wide, nearly cylindrical (outer margin indistinctly convex); with 7 slender spines, mainly in the distal half of its anterior face and with c. 5 small and blunt spines hardly visible between the setules of the inner face. Dactylus very stout, with a short inner spine.

TABLE I

Some characteristic numbers and relative measures in species of *Bilistira* n. gen. Abbreviations: A, antenna; f, female; fl, flagellum; m, male; Pp, pereopod; Plp, pleopod; rl, relative length (roman numerals, somites or appendages; arabic numerals, articles). Columns: 2, relative length of AI (% of AII) / number of articles in fl; 3, AII rl (% of body length) / number of articles in flagellum; 4, lengths of articles and flagellum in AI 1 : 2 : 3 : fl / aII 2 : 3 : 4 : 5 : fl; 5, pereopods I-II, VII length ratios; 6, length ratios of articles in Pp VII 2 : 3 : 4 : 5 : 6 : 7; 7-8, relative lengths of pereopods II and VII in % of body length; 9-11, number of marginal setae on pleopods I-III, endopodite + exopodite

	1	2	3	4	5	6	7	8	9	10	11
	Body length in mm	AI rl (% aII) / fl art	AII rl (% body) / fl art	Lengths of articles and flagellum in ai / aII	Pp I : II : VII	Pp VII 2 : 3 : 4 : 5 : 6 : 7	rl	Pp VII	Setae plp I	Setae plp II	Setae plp III
Pohara f 2	6.80	75 / 8	38 / 15	100 : 33 : 58 : 101 / xxxxxxxx	100 : 115 : 131	100 : 76 : 32 : 37 : 42 : 22	47	53	16 + 30	18 + 33	17 + 36
Pohara f 1	7.82	71 / 7	35 / 16	100 : 33 : 54 : 85 / 100 : 81 : 148 : 163 : 555	100 : 115 : 142	100 : 79 : 31 : 36 : 39 : 23	44	55			
Pohara m 3	6.40	72 / 6	35 / 13	100 : 35 : 55 : 105 / xxxxxxxx	100 : 110 : 134	100 : 82 : 35 : 36 : 42 : 20	43	55	15 + 26	14 + 29	14 + 26
Riwaka f	10.65	72 / 8	38 / 18	100 : 36 : 78 : 95 / 100 : 117 : 115 : 163 : 478	100 : 119 : 161	100 : 91 : 36 : 39 : 45 : 23	45	61	20 + 33	23 + 39	17 + 46
Megamania f	10.50	71 / 9	37 / 15	100 : 31 : 56 : 97 / 100 : 93 : 174 : 181 : 700	100 : 109 : 134	100 : 86 : 37 : 40 : 46 : 26	47	58	21 + 37	29 + xx	26 + 50
Megamania m	10.30	69 / 8	37 / 17	100 : 34 : 59 : 98 / 100 : 100 : 185 : 233 : 778	100 : 119 : 141	100 : 91 : 41 : 42 : 49 : 25	53	63	17 + 31	25 + 40	27 + 45

Oostegites at pereopods II-IV well developed, overlapping medially. In a large female there were 21 embryos in internal pouches, reaching deep into the pleotelson; number of pouches could not be established.

Pleopods I-III similar to each other, rami progressively increasing in size from I to III, with marginal setosity also progressively increasing. Pleopod III exopodite with distal third separated by an oblique and slightly curved articulation. Protopodites more than 3 times as wide as long, intero-distally each with 3 spines, protopodite III also with stout distolateral seta; the spines plumose in the middle, narrowly spatulate and marginally serrate towards the end. Endopodites with nearly straight longitudinal margins, tapering to rounded distal margin; exopodites ovate. Rami with plumose marginal setae, endopodites with long setae only distally and along half length of medial margins, very finely setulose around medio-proximal angle and close to plumose setae; exopodites with plumose setae distally and along entire outer margins; only distal setae are long, lateral setae decreasing in length proximally, but exopodite I with prominent seta proximally. Endopodites with approximately 15-20 setae, exopodites with close to twice that number.

Pleopods IV-V, both rami transversally bent along proximal-mediodistal line along which a pleat is present. Endopodites smaller (shorter and narrower) than exopodites, ovoid, without setae, fleshy, but without transverse folds. Exopodite IV with moderately oblique and V with exceedingly oblique transverse sclerotized articulation line; with only 5 short setae along proximal part of lateral margin; medio-proximally with large triangular lobe with free angle hardly rounded. Exopodite V with lobate scale patch and with 2 smaller scale patches at median end of articulation suture.

Uropodal protopodite approximately one third of uropod, exopodite 40-50% length of endopodite. Each ramus nearly half as wide as long, endopodite distally evenly narrowed, exopodite more narrowly ovate; exopodite rounded, endopodite apically rounded or pointed. All parts densely pubescent.

Male (paratype; sub-adult, pre-ecdysial). Body 6.4 mm long. The entire body, tergites, coxae and most appendages similar to, and with similar spination as that of the female. Exceptions are primary sexual characters.

Pleotelson only slightly flatter than in female, its caudal surface less steep.

Penes little longer than wide, conical, bases separated by width of one penial process, apices touching each other.

Antenna I, flagellum 6-segmented, 5 articles with individual or paired aesthetascs of articles' length. Antenna II stout, 35% of body length, flagellum of 13 articles.

Pereopod VII only 35% longer than pereopod I, attaining at this stage the same relative length as in females.

Pleopods I and III similar to those of the female but endopodites without setae along most of the longitudinal margins. Pleopod II with an ovate exopodite with 29 plumose setae that are long at distal and short along exterior margins. Endopodite with 14 distolateral setae; interior part differentiated, slightly elongated, with only 5 short setae, appendix masculina visible inside.

Juveniles. Body similar to that of adults, but pleotelson in the smallest specimens, at c. 2 mm body length, lack the grooved border along the ventro-caudal edge; this only starts to form at more than 5 mm body length.

***Bilistra mollicopulans* n. sp.** (figs. 5-6, 9C, 10C)

Material examined. — Holotype: female with undeveloped oostegites, New Zealand, South Island, Karamea Region, Megamania Cave (in main stream), 40°58.20'S 172°09'E; coll. C. Wood and R. Bromley, 23 November 1999 (NMNZ Cr.9963). Paratypes: mature male (NMNZ Cr.9964) and juvenile (NMNZ Cr.9825), same data as for holotype.

Etymology. — From the Latin “softly copulating” for the soft lining of the male pereopods, probably used when copulating. The species name hence is a present participle used as an adjective.

Description. — Female (holotype; for some meristic and metric characters, consult table I). Very similar to *B. millari*, only differences will be given here.

Body whitish translucent, 10.5 mm long, width 57% of length. Eyes with black pigmentation visible deep below feebly-faceted ocular region; dorsally with very scarce and widely set melanophores. Dorsal tubercles on pereon absent, they are scarce and very small on pleotelson.

Coxa I similarly sculptured to that of *B. millari* but outer angle broadly rounded and inner extension truncated. Pleotelson more highly vaulted than in *B. millari*, caudal profile steeper and slightly concave; ventral border more pronounced and grooved.

Antenna I similar to *B. millari*, peduncle article 1 only slightly narrower (but wider than in *B. cavernicola*); 5 of 9 flagellar articles with paired and 2 apical ones with single aesthetascs. Flagellum II with 15 articles.

Mouthparts mostly as in *B. millari*. Right mandible with only 7 large setae and similar group of smaller ones at lacinia mobilis (right mandible as in *B. millari*), setae at molar base only reach molar's top. Palp article lengths 100 : 92 : 78; articles 2 and 3 with approximately 13 and 25 setae, respectively. Maxilliped palp articles with rounded medial lobes and groups of 3-5 setae laterodistally.

All pereopods similar, setose and spinose as in *B. millari*, hardly any longer. Unguis more slender and sharper, resembling *B. cavernicola*. The fine setulosity of the medial sides of articles 4-6 somewhat denser, felt-like. Pereopod VII shorter than in *B. cavernicola*.

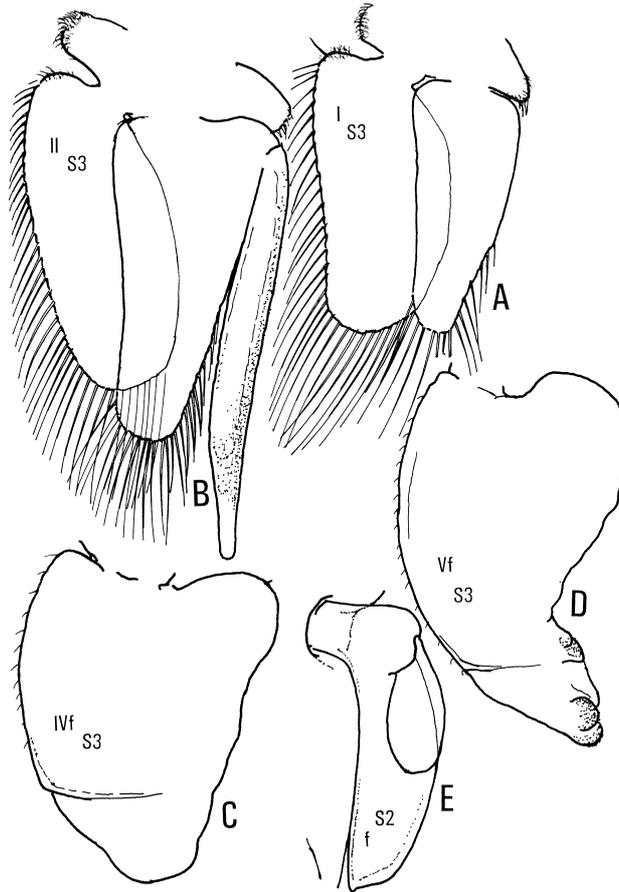


Fig. 5. *Bilistra mollicopulans* sp. n., Megamania Cave. A-B, male 10.3 mm; C-E, holotype female 10.5 mm. A-B, pleopods I-II; C-D, pleopods IV-V exopodites; E, uropod; for scales (S), see fig. 8.

Pleopods similar to *B. millari*. Pleopods I-III with plumose setae on medial margins limited to distal quarter, remaining margin densely setulose, setules stronger than in *B. millari*. Marginal setae numbers increasing progressively in pleopods I-III from 21 to 26 in endopodites, 37 to 50 in exopodites.

Pleopods IV-V poorly preserved but similar to those of *B. millari* with exception of exopodite articulations that are nearly perpendicular in IV and moderately oblique in pleopod V. Exopodite IV with medio-proximal lobe broadly rounded-triangular, similar to that of *B. cavernicola*; exopodite V broadly rounded, less prominent than in *B. cavernicola* or *B. millari*.

Uropod similar to that of *B. millari* but endopodite less apically narrowed, distally truncate with extended inner tip.

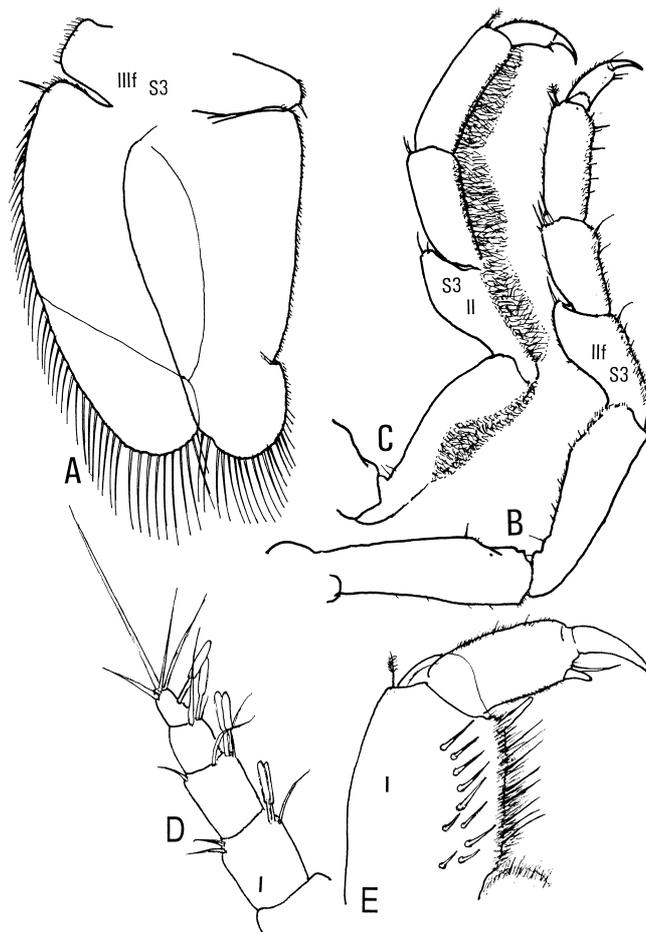


Fig. 6. *Bilistra mollicopulans* sp. n., Megamania Cave. A-B, holotype female 10.5 mm; C-E, male 10.3 mm. A, pleopod III; B-C, pereopod II; D, apical articles of antenna I; E, apical articles of pereopod I; for scales (S), see fig. 8.

Male (adult; paratype). Body length 10.3 mm, width 59% of length. Pleotelson as for female but caudal flank scarcely concave. Penes similarly set as in *B. millari* male but shorter and twice as long as basal width, in contact apically.

Antenna I with 8-segmented flagellum but with same number of aesthetascs as in female. Flagellum II with 17 articles.

Pereopods as in female but setulose lining of medial sides of articles 4-6 massive, thickness may nearly match article diameter. Pereopod VII slightly longer than in the other two species.

Pleopods similar to those of female but with only 30-45 plumose setae on exopodites I-III. Pleopod II endopodite with nearly straight and finely rugose

appendix masculina originating close to medio-proximal angle, approximately 1.50 times as long as endopodite.

Juvenile. A juvenile of 7 mm with already developed ventro-caudal pleotelson border. Dorsal tuberculation stronger than in adults but less developed than in *B. millari*. Pigmentation denser than in adults but melanophores in pleotelson still far apart and very scarce on pereon.

***Bilistra cavernicola* n. sp.** (figs. 4E, 7-8, 9B, 10B, 12B)

Material examined. — Holotype. Female with developed oostegites, New Zealand, South Island, Motueka Region, Riwaka River, South Branch resurgences, 41°04.8'S 172°52.3'E; coll. I. Millar and B. Sket, 26 March 1998 (NMNZ Cr.9965).

Other material (not reliably identifiable). Riwaka North Resurgence Cave, 41°01.9'S 172°53.9'E (1 juvenile, coll. T. Stanbridge, 26 September 1998); Spittal Spring, 40°57.1'S 172°49.7'E (1 juvenile, coll. B. Sket and I. Millar, 27 March 1998) (all ULS ZIsp). Unnamed cave on Takaka Hill, 41°01.9'S 172°53.9'E (I. Millar, pers. comm., specimens not seen by the authors).

Etymology. — Named for its evidently cavernicolous habitat. The species name is a Latin noun, meaning “cave dweller”, in apposition to the generic name.

Description. — Female (with oostegites; holotype). Very similar to *B. millari*, only differences will be given here (for some meristic and metric characters, consult table I).

Body whitish translucent, 10.6 mm long, width 50% of length. Ocular region indistinctly faceted, some black pigment visible below ocular cuticle. Dorsal tubercles similar to those of *B. millari* but developed only on pleotelson, lower and inconspicuous.

Posterior groove of coxal plate I shallower than in *B. millari*, both posterior angles somewhat more widely rounded; apical (ventral) surface narrowed. Coxae II-VII wider. Pleotelson profile less even than in *B. millari*, caudal surface slightly wavy, border above ventral margin not developed.

Antenna I similar as in *B. millari*, but peduncle articles less wide, 7 articles with aesthetascs, the proximal and two distal with single, others with paired. All articles of antenna II more slender; flagellum with 18 articles.

Mouthparts mostly as in *B. millari*. Mandibular palp articles 2 and 3 with about 13 and 23 setae, respectively; row of 15 setae at lacinia mobilis while such a row is preceded by vestigial lacinia-like scale on right mandible; setae at base of molar much longer than molar. Maxilla II with approximately 12 spines on lateral lobes, medial lobe with dense brush of approximately 30 stout, plumose setae, one distinctly longest. Maxillipedal palp articles with groups of 3 setae laterodistally.

All pereopod articles somewhat more slender than in *B. millari*; dactylar ungues less curved, very slender and comparatively longer. Only pereopod VII slightly longer than in *B. millari*, 60% of body length.

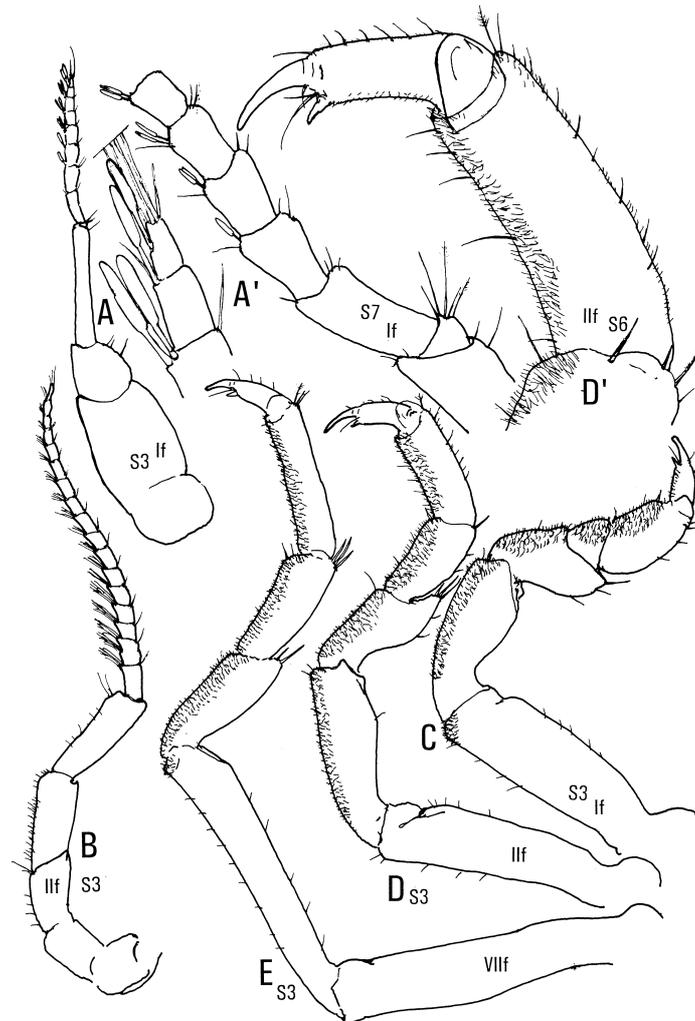


Fig. 7. *Bilistra cavernicola* sp. n., Riwaka, holotype female 10.6 mm. A-B, antennae I-II (A', apical and median part of antenna I); C-E, pereopods I, II, VII; for scales (S), see fig. 8.

Oostegites as in *B. millari*.

All pleopods with slightly narrower rami than in *B. millari*. Pleopods I-III with slightly more extensive marginal setation: 20-27 in endopodites, 33-46 in exopodites; plumose setae on endopodites limited to distal part. Pleopods IV-V flat, but nevertheless with 1-2 distinct folds along diagonal line; distal articles of exopodites slightly larger than in *B. millari* but with similarly oblique articulations. Exopodite IV with medio-proximal lobe broadly rounded-triangular, this lobe in pleopod V trapezoidal.

Uropod similar as in *P. millari* but narrower, endopodite nearly banana-shaped.

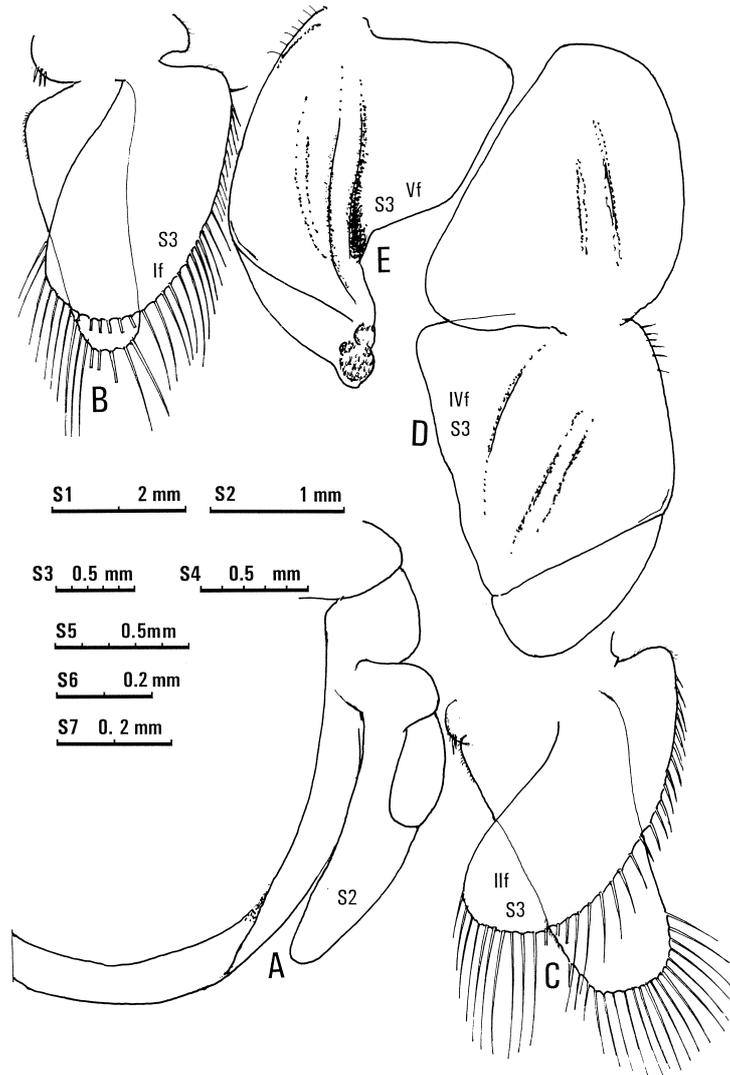


Fig. 8. *Bilistra cavernicola* sp. n., Riwaka, holotype female 10.6 mm. A, ventral left side of pleotelson with uropod; B-E, pleopods I-II, IV-V. S1-S7, scale bars for figs. 1-8.

KEY TO THE SPECIES OF *BILISTRA*

1. Pleotelson posteroventral margin with a narrow, posteriorly open groove (figs. 10A, C); uropod apices with acute medial point (figs. 1C, 5E) 2
- Pleotelson posteroventral margin without groove (fig. 10 B); uropod apices narrowly rounded (fig. 8A) *B. cavernicola* n. sp.
2. Eyes well developed, black; dorsum usually well pigmented; uropodal exopod one-third as long as endopod (fig. 1C) *B. millari* n. sp.
- Eyes reduced, feebly pigmented; dorsum not pigmented; uropodal exopod half as long as endopod (fig. 5E) *B. mollicopulans* n. sp.

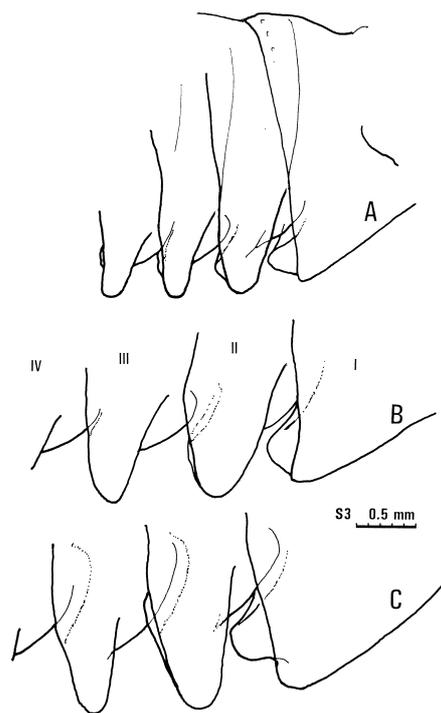


Fig. 9. Right epimera I-III and adjacent structures of *Bilistra* gen. n. A, *B. millari* sp. n.; B, *B. cavernicola* sp. n.; C, *B. mollicopulans* sp. n.

DISTRIBUTION AND HABITATS OF *BILISTRA*

All *Bilistra* species were found in karst limestone areas of Nelson area, in the extreme north-west of the South Island (fig. 12). Adult specimens were obtained only from the type localities, and therefore the following distribution lists are only tentative ones.

Bilistra millari inhabits surface and cave brooks, and was found at a few localities, all within a kilometre of each other in a small patch of Tertiary limestone in the immediate vicinity of Pohara. Only samples from the type locality contained adult specimens that were reliably identifiable. Specimens from the Pohara Water Supply Cave and from the brook below it are, with the exception of normally pigmented eyes, mostly either partly or completely without pigment. If pigmentation is partly developed it is pale and irregularly (asymmetrically) distributed.

The spring at Pohara Campsite is a rheocrene flowing from rocks and rubble, with moss. Numerous *Bilistra* were accompanied by snails (*Potamopyrgus* sp.) and few Ephemeroptera larvae, Oligochaeta, Tricladida, and pigmented and troglomorphic Amphipoda. Juvenile *Bilistra* present in the creek below cave were pig-

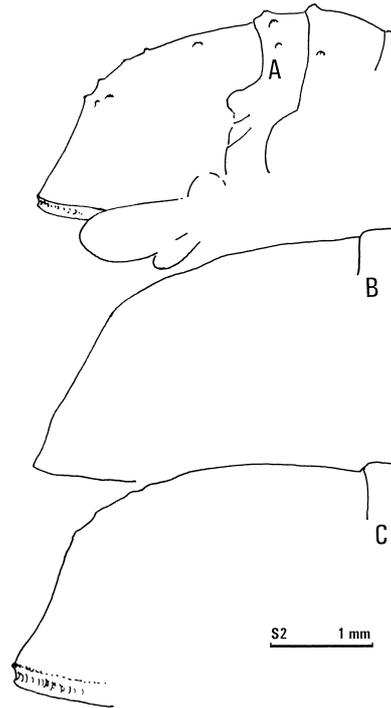


Fig. 10. Pleotelson profiles of *Bilistra* gen. n. A, *B. millari* sp. n.; B, *B. cavernicola* sp. n.; C, *B. mollicopulans* sp. n.

mented; Amphipoda were very numerous and some shrimps (Atyidae) were also present there. In the Pohara Water Supply Cave the fauna was cavernicolous: numerous troglomorphic Amphipoda, numerous tiny Oligochaeta, some troglomorphic Gastropoda, very few insect larvae; few juvenile *Bilistra*.

Bilistra mollicopulans was found only in Megamania Cave, north of Karamea, in a small karst area of Gunnar River. It is on the west coast, 50 km away from the *B. millari* and *B. cavernicola* area and separated from these by the high, non-karstic Tasman Mountains. Its collection data reported that it is "from main stream" in an extensive cave system.

Bilistra cavernicola inhabits cave waters between Motueka and East Takaka. The type locality of *B. cavernicola* is south of Takaka Hill and all localities are in the same comparatively extensive massif of Ordovician karst limestones and marbles, 10-20 km south of Pohara. Only the type specimen was assessed taxonomically but other specimens are equally depigmented (in specimens from North Riwaka Resurgence Cave and from Spittal Spring even the eye pigmentation is invisible or absent, which may or may not be an artefact) and most probably taxonomically identical. Their area is hydrographically split, belonging to two systems.

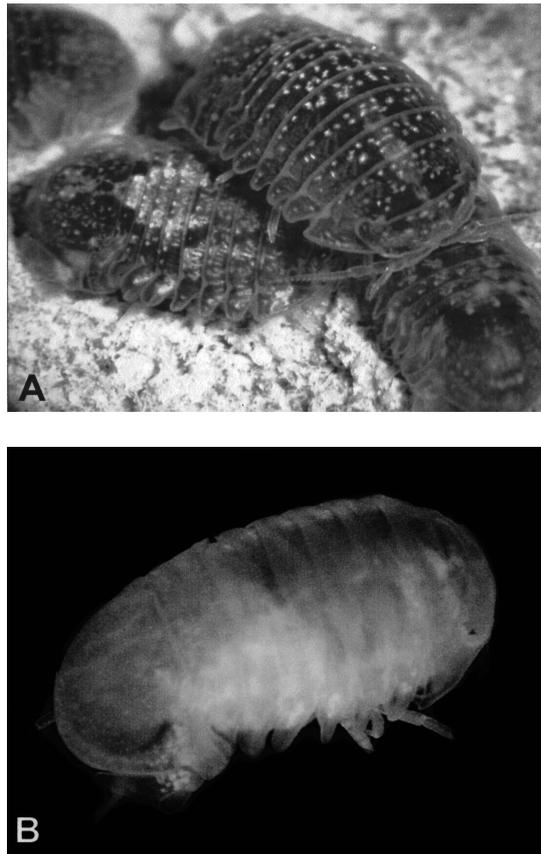


Fig. 11. A, *Bilistra millari* n. sp., spring at Pohara, live specimens. B, *B. cavernicola* sp. n., Riwaka, live female. Photo B. Sket.

The type locality is in the system of the Riwaka River South Branch Resurgences. A small spring in the rubble below large blocks yielded, besides the unpigmented *Bilistra* and a troglomorphic amphipod, only surface fauna, including numerous amphipods. Spittal Spring is a strong karst spring, difficult to sample, where, beside a young *Bilistra*, a few specimens of troglomorphic Amphipoda and Gastropoda were obtained. Neither the Riwaka Resurgence Cave where a young *Bilistra* was found, nor the small cave on Takaka Hill where Ian Millar (pers. comm.) had found numerous specimens in the past, were sampled or visited by any of the authors.

All localities are freshwater. Although the mighty (discharge averaging 5.3-21.0 m³ per second) Waikoropupu Springs (better known as Pupu Springs) nearby, 4 km inland and 14-17 m a.s.l. are known to be slightly saline (Williams, 1992), their chloride ion contents may hardly reach beyond 100 g/m³ which is still far in the limnic range according to the Venice protocol (cit. Reid, 1961). Only very

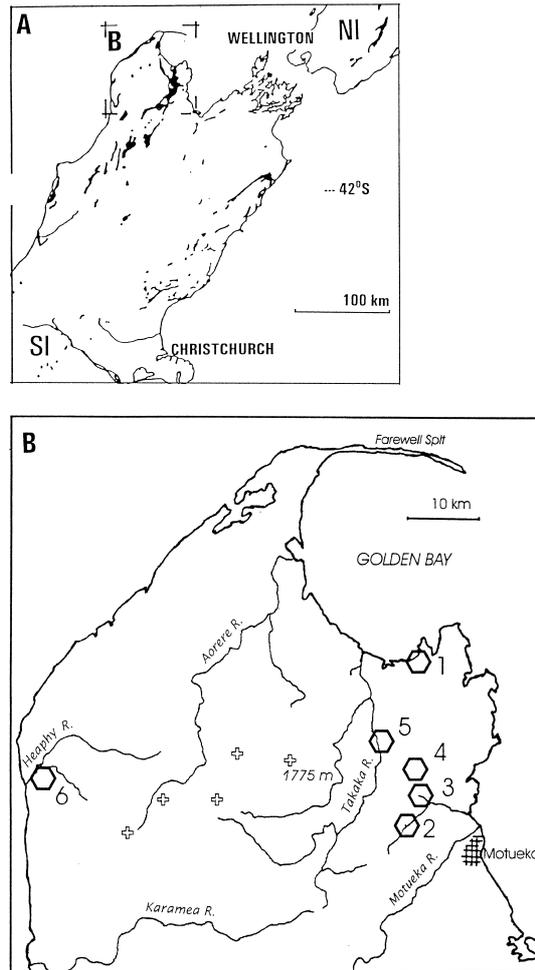


Fig. 12. A, Karst areas in central parts of New Zealand (after New Zealand Geological Survey from Williams, 1992; reshaped); NI SI, North Island and South Island; black areas, carbonate rocks; B, Nelson area of South Island with localities of *Bilistra* spp., only major rivers traced. 1, Pohara area with all localities of *B. millari* sp. n.; 2, Riwaka, South Branch Resurgence, type locality of *B. cavernicola* sp. n.; 3-5, supposed additional localities of *B. cavernicola* sp. n., Riwaka North Branch, cave on Takaka Hill, Spittal Spring; 6, Megamania Cave with *B. mollicopulans* sp. n.; crosses, highest peaks of Tasman Mountains.

numerous troglomorphic Amphipoda but no *Bilistra* were collected in the closer Waikoropupu region, e.g., in a smaller spring of 27 g/m^3 , chloride. The chlorinity of springs in the range of *Bilistra* was lower, with 1.7 in Riwaka River, North Branch Rising and $9.5\text{-}10 \text{ g/m}^3$ in springs in Pohara Valley, close to the sea. The position of Megamania Cave is more than 3 km inland and nearly surrounded by surface rivers, thus only fresh water can be expected there.

Temperatures of spring and cave waters in the known range of *Bilistra* were measured from 9.2°C (Riwaka Resurgence) to 11.5°C (Pohara Water Supply Cave) at the time of collection. Contrary to the situation in extensive karst areas in Europe, these temperatures are less stable since “autogenic” cave waters are here regularly mixed with waters from the surface. In the Riwaka South Branch Rising temperature may vary between 8.0°C in winter and 10.9°C in summer (Dowling, 1976).

Another post-manca stage (and therefore unidentifiable) sphaeromatid, was found in a brook at The Grove near Picton, just a few meters away from its mouth to the sea. It was nevertheless accompanied by a normal freshwater fauna: freshwater Amphipoda, Gastropoda (*Potamopyrgus* sp.), Oligochaeta, Ephemeroptera larvae, a specimen of a probably freshwater Anthuridea (*Cyathura* sp. n., as identified by Poore, pers. comm.).

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