

A New Species of the Caridean Genus *Bresilia* Calman (Decapoda: Bresiliidae) Discovered from a Shallow-water Submarine Cave in Okinawa Islands, Japan

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Abstract During SCUBA diving collections of shallow water aphotic submarine caves in Okinawa Islands, Ryukyu Islands, two specimens representing the caridean genus *Bresilia* Calman, 1896 were collected. A new species, *B. rufioculus*, is described on the basis of these two specimens, increasing the number of species in the genus to eight. It is referred to the *B. antipodarum* Bruce, 1990 species group, and is morphologically similar to *B. gibbosa* Komai and Yamada, 2010 and *B. saldanhai* Calado, Chevaldonné and dos Santos, 2004, both collected from submarine caves. Differentiating characters among the six species of the species group are discussed. This new species has a somewhat reduced and reflective cornea and eyestalk with rather limited movability, which may represent an adaptation to the aphotic environments.

Key words: Crustacea, Decapoda, Caridea, Bresiliidae, *Bresilia*, new species, marine cave, Japan.

Although species of the rarely collected caridean genus *Bresilia* Calman, 1896 were considered to be primarily deep-water inhabitants, recent studies have shown that members of the genus also occur in shallow waters, including submarine caves (Calado *et al.*, 2004; Bruce, 2005; Komai and Yamada, 2010). Seven species are known from worldwide (Komai and Yamada, 2010), viz. *B. antipodarum* Bruce, 1990, *B. atlantica* Calman, 1896, *B. briankensleyi* Bruce, 2005, *B. corsicana* Forest and Cals, 1977, *B. gibbosa* Komai and Yamada, 2010, *B. plumifera* Bruce, 1990, *B. saldanhai* Calado, Chevaldonné and dos Santos, 2004, and these species are arranged in two informal species groups (cf. Komai and Yamada, 2010), *B. antipodarum* species group (including *B. antipodarum*, *B. briankensleyi*, *B. gibbosa*, *B. plumifera* and *B. saldanhai*) and *B. atlantica* species group (including *B. atlantica* and *B. corsicana*). From the North Pacific Ocean, only *B. gibbosa*, described on the basis of material from a submarine cave in Okinawa Island, Ryukyu Islands, is known.

In this paper, we describe a new species of *Bresilia*, *B. rufioculus*, on the basis of two ovigerous female specimens collected from the interior of a submarine cave in Ie Island, Okinawa Islands, Japan, during SCUBA diving collections of the cave fauna by the junior author. It is referred to the *B. antipodarum* species group, representing the second species of the family from the North Pacific, as well as Japan. Relationship to other species of the group is discussed.

The type specimens are deposited in the Natural History Museum and Institute, Chiba (CBM) and the National Museum and Nature and Science, Tokyo (NSMT). For detailed observation of the surface structure, the specimens were stained with methylene blue solution. The postorbital carapace length (cl) is used as an indication of the size of specimens.

Taxonomy

Family *Bresiliidae*

Genus *Bresilia* Calman, 1896

Bresilia rufiocus sp. nov.

[New Japanese name: Mehikari-sekiyou-ebi]

(Figs. 1–6)

Material examined. Holotype: ovigerous female (cl 2.1 mm), CBM-ZC 10063, Ohoba Cave, Ie Island, Okinawa Islands, 17 m, 26 June 2010, SCUBA diving, coll. Y. Yamada.

Paratype: ovigerous female (cl 2.3 mm), NSMT-Cr 21341, same cave, 14 m, 14 July 2010, SCUBA diving, coll. Y. Yamada.

Diagnosis. Body integument covered with tegumental scales (pockets of these scales showing as short transverse or oblique striae). Rostrum about 0.6 times as long as carapace, slightly curved dorsally, not reaching distal margin of antennular peduncle; dorsal margin armed with 10 slender teeth, including 2 on carapace, none with basal suture, posteriormost tooth located at about 0.1 of carapace length; ventral margin with 2 minute teeth on distal 0.2. Carapace with pterygostomial margin rounded. Third abdominal tergite not markedly produced or carinate. Fourth abdominal pleuron with small posteroventral tooth, fifth pleuron with 2 posterolateral teeth. Telson with 2 or 3 dorsolateral spines on either side (excluding 1 pair at posterolateral angles); posterior margin produced into blunt process flanked by 2 pairs of greatly unequal spines. Epistome with elongate, acute median process. Eye tapering distally, cornea narrower than eye-stalk, faceted, with reflective pigment. Third segment of antennal peduncle without elongate seta. First maxilliped with well-developed exopodal flagellum. First pereopod with ischium bearing blunt distoventral margin; carpus unarmed; palm without spines on ventral margin, but proximally with 3 minute setae possibly representing reduced grooming apparatus. Second pereopod with ischium bearing 5 spines; tips of fingers bearing tuft of minute setae. Third to fifth pereopods relatively long and slender.

Description. Holotype. Body (Fig. 1) moderately slender, generally subcylindrical; integument not firm, covered with subovate tegumental scales (many scales detached, but numerous transverse or oblique striae representing pockets of scales evident).

Rostrum (Fig. 2A, B) relatively slender, about 0.6 times as long as carapace, directed forward, slightly curved dorsally, slightly falling short of distal end of antennular peduncle; dorsal margin with 10 slender teeth including 2 teeth on carapace, none with basal suture, posteriormost tooth located at about 0.1 of carapace length; ventral margin with 2 minute teeth on distal 0.2; lateral carina sharp, merging into orbital margin. Carapace (Fig. 1) with dorsal surface rounded, no postrostral ridge, nearly straight in lateral view; orbital margin evenly concave; antennal tooth relatively strong, acuminate (Fig. 2A); pterygostomial margin slightly produced, rounded (Fig. 2A).

Fifth thoracic sternite (Fig. 2C) wide, anteriorly with submedian processes, these processes relatively long, closely approximated, reaching level of mesiodistal margin of coxa of second pereopod, sharply pointed; lateral parts somewhat thickened. Sixth and seventh sternites very narrow, each with pair of long, slender, acuminate processes. Eighth with terminally blunt median process.

Abdominal somites (Fig. 1) all rounded dorsally, third tergite convex but not markedly produced or carinate; no setae on third tergite. Pleura of anterior three somites broadly rounded, fourth pleuron with small, sharp posteroventral tooth, fifth pleuron with 2 small teeth posterolaterally. Sixth somite tapering posteriorly in lateral view, about 0.7 times as long as carapace, 1.8 times longer than fifth somite, and 2.0 times longer than proximal height; posterolateral process terminating in acute tooth; posteroventral tooth very small. Telson (Fig. 2D) subequal in length to sixth somite, tapering distally to blunt posteromedian process; dorsal surface nearly flat, with 3 or 4 lateral spines including 1 pair at posterolateral angle; posterior margin with 1 pair of



Fig. 1. *Bresilia ruficulus* sp. nov., holotype, ovigerous female (cl 2.1 mm), CBM-ZC 10063, habitus, lateral view (preserved tegumental scales are only partially shown). Scale bar=1 mm.

long spines and 1 pair of setae flanking postero-medial process and submedian pair of spiniform setae.

Epistome (Fig. 2E) with long, slender median process.

Eye (Fig. 2B) stout, directed anteriorly, slight-

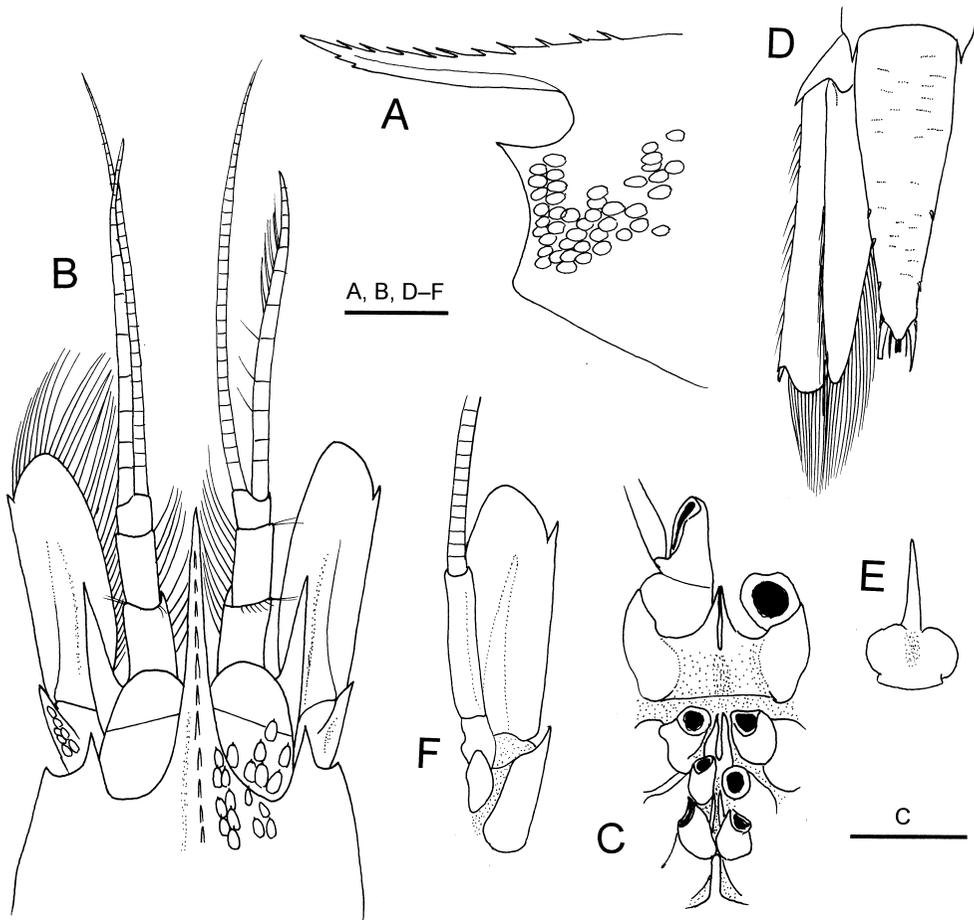


Fig. 2. *Bresilia ruficulus* sp. nov., holotype, ovigerous female (cl 2.1 mm), CBM-ZC 10063. A, rostrum and anterior part of carapace, lateral view; B, rostrum, anterior part of carapace and cephalic appendages, dorsal view (tegumental scales are partially illustrated); C, fifth to eighth thoracic sternites, ventral view (appendages were removed); D, telson and left uropod, dorsal view; E, epistome, ventral view; F, left antenna, ventral view. Scale bars: 0.5 mm.

ly tapering to cornea; cornea small, faceted, reflective; eyestalk with tegumental scales.

Antennular peduncle (Fig. 2B) reaching distal 0.2 of antennal scale. First segment longer than distal two segments combined; ventral surface slightly thickened mesially, unarmed; stylocerite gradually tapering distally to sharp tip, slightly overreaching distal margin of first peduncular segment. Distal two segments cylindrical; third segment about half-length of second segment. Outer flagellum uniramous, longer than peduncle, aesthetasc-bearing portion consisting of about 8 articles; inner flagellum longer than and

more slender than outer flagellum.

Antennal peduncle (Fig. 2B, F) with stout basicerite bearing small ventrolateral and ventrodorsal teeth, dorsolateral distal angle also terminating in sharp tooth. Third segment without prominent plumose seta. Carpoperite (fifth segment) cylindrical, distinctly overreaching midlength of antennal scale. Antennal scale elongate oval, about 0.6 times as long as carapace, about 3.0 times longer than wide; dorsal surface nearly smooth; lateral margin straight, terminating in small, acute distolateral tooth; distal lamella strongly produced, far overreaching distolateral

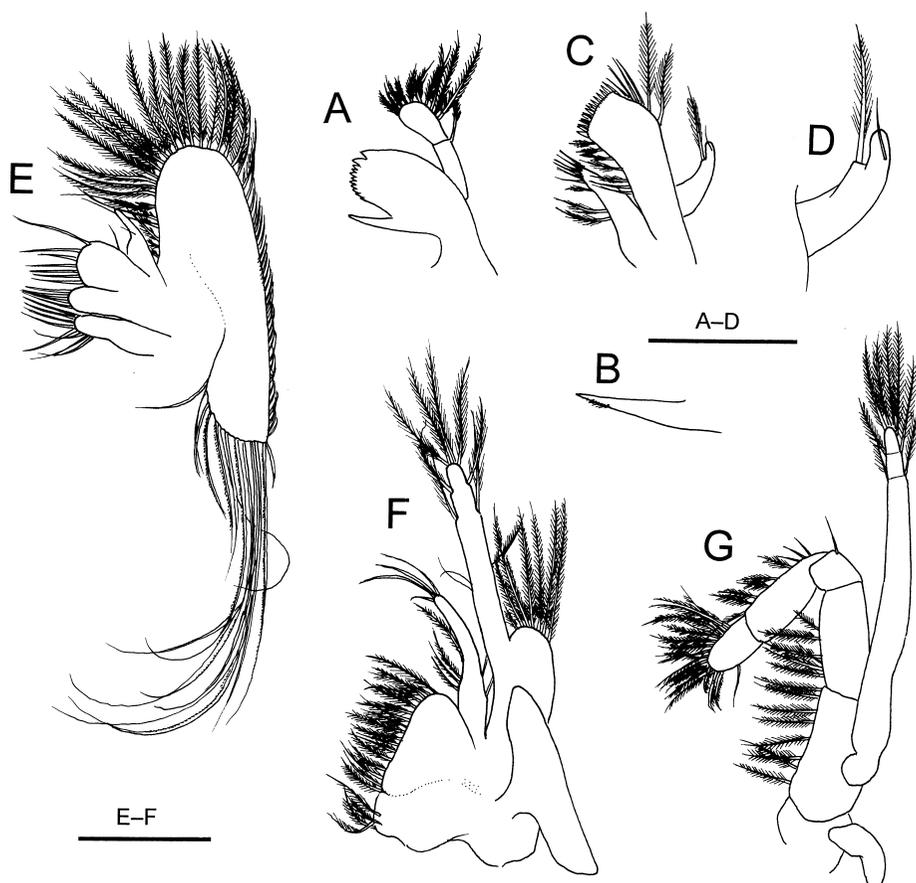


Fig. 3. *Bresilia rufioculus* sp. nov., holotype, ovigerous female (cl 2.1 mm), CBM-ZC 10063, left mouthparts. A, mandible, external view; B, same, detail of molar process; C, maxillule, external view; D, same, detail of endopod; E, maxilla, external view; F, first maxilliped, external view; G, second maxilliped, external view. Scale bars: 0.5 mm for A, C, E-F; 0.25 mm for B, D.

tooth. Flagellum shorter than body (missing at time of examination).

Mandible (Fig. 3A) with broad, rounded incisor process bearing 11 closely set, acute teeth on mesial margin (2 teeth at distolateral angle much stronger than others); molar process very slender, tapering to acute tip, extending as far as incisor process, bearing few microscopically minute setae subdistally (Fig. 3B); palp moderately broad, 2-articulated, proximal article with 1 seta at outer angle; distal article subequal in length to proximal article, slightly expanded, with several stiff plumose setae. Maxillule (Fig. 3C) with proximal endite tapering distally and bearing stiff setae terminally; distal endite

widened distally, with double row of small spines on truncate mesial margin; endopod divided in two unequal lobes terminally, mesial lobe very short, bearing stout plumose setae apically, lateral lobe elongate, bearing 1 simple subterminal seta (Fig. 3D). Maxilla (Fig. 3E) with broad endites; proximal endite rather slender; distal endite divided in two unequal lobes, distal lobe rounded; endopod broad basally, but abruptly tapering distally at midlength, curved mesially; scaphognathite moderately broad, anterior lobe broadly rounded, posterior lobe rounded, not particularly elongate, bearing some greatly elongate setae posteriorly. First maxilliped (Fig. 3F) with endites incompletely fused; endopod moderately

slender, rather abruptly narrowing at about midlength, far overreaching base of exopod; exopod with moderately broad caridean lobe and well-developed flagellum; epipod large, faintly bilobed. Second maxilliped (Fig. 3G) with endopod sub-pediform; coxa with small epipod lacking podobranch; basis and ischium incompletely fused (suture still discernible); merus with nearly straight mesial margin; carpus short; propodus with stiff setae on mesial (extensor) margin; articulation between propodus and dactylus transverse, not oblique; dactylus shorter than propodus, rounded terminally, bearing stiff setae on mesial and terminal margins. Third maxilliped (Fig. 4A, B) slender, reaching distal margin of antennal scale, consisting of 4 segments; coxa with small, papilla-like epipod; antepenultimate segment longest, sinuously curved in dorsal view, with 1 minute spine near ventrolateral angle; ultimate segment about 1.4 times longer than penultimate segment, slightly tapering distally to bluntly pointed tip, with some transverse tracts of short stiff setae and 1 prominent subterminal seta on ventral (flexor) margin (Fig. 5A); exopod well-developed, flagellum-like, falling short of distal margin of antepenultimate segment.

First pereopod (Figs. 4C, D) overreaching antennal scale by about 0.3 length of chela; articulation between basis and ischium distinct; ischium slightly widened distally, distoventral angle not markedly produced, angular; merus not widened distally, dorsodistal margin not produced; carpus short, cup-like, unarmed, with few setae on ventromesial distal margin; chela about half length of carapace; palm oval in cross section, not increasing in depth distally, unarmed, but with longitudinal row of few minute setae proximally on ventromesial face; fingers somewhat deflexed, forming deep concavity on outer side, terminating in acute tips; cutting edge of fixed finger bordered by thin chitinous plate; inner side of chitinous plate with fossae to accommodate chitinous spines on cutting edge of dactylus; dactylus curving, subequal in length to palm, cutting edge pectinate with row of small chitinous spines; exopod flagellum-like, falling

short of distal margin of merus. Second pereopod (Fig. 4E) slender, overreaching antennal scale by length of chela; ischium with longitudinal row of 5 slender spines on lateral face ventrally; merus distinctly longer than ischium, with row of 4 spines on lateral surface ventrally; carpus about 0.5 times as long as chela, unarmed; palm sub-cylindrical, longer than carpus; fixed finger very slightly deflexed in extensor view, with sparse microscopically minute spinules on cutting edge, tipped by tuft of minute setae (Fig. 5B); dactylus subequal in length to palm, tapering to acute tip, slightly curving in lateral view, tipped by tuft of minute setae, cutting edge with row of microscopically minute spinules; exopod flagellum-like, overreaching distal margin of ischium, with tuft of setae distally. Third to fifth pereopods slender, lacking exopod, generally similar; propodus-carpus combined shorter than merus-ischium combined in third and fourth pereopods, vice-versa in fifth pereopod. Third pereopod (Fig. 4F) overreaching distal margin of antennal scale by half length of propodus; ischium with row of 4 spines on lateral surface ventrally; merus distinctly longer than ischium, with 2 spines proximally; carpus about 0.6 times as long as propodus; propodus with 1 spinule on flexor distal margin (Fig. 5C); dactylus (Fig. 5C) slightly curving, 0.15 times as long as propodus, terminating in long unguis, bearing 4 long, slender accessory spinules over entire length of flexor margin. Fourth pereopod (Fig. 4G) with ischium bearing 4 spine on lateral face ventrally; merus with 2 spines on lateral face proximally; dactylus (Fig. 5D) with 4 accessory spinules. Fifth pereopod (Fig. 4H) overreaching antennal scale by about half length of propodus; ischium unarmed; propodus with few spinules on flexor margin, terminal spinule setulose (Fig. 5E); dactylus with 4 accessory spinules as in preceding pereopods.

Gill formula summarized in Table 1. Pleurobranch on seventh thoracic somite much larger than others.

Pleopods without distinctive features. Uropod (Fig. 2D) overreaching tip of telson; endopod slender, tapering distally; exopod slightly shorter

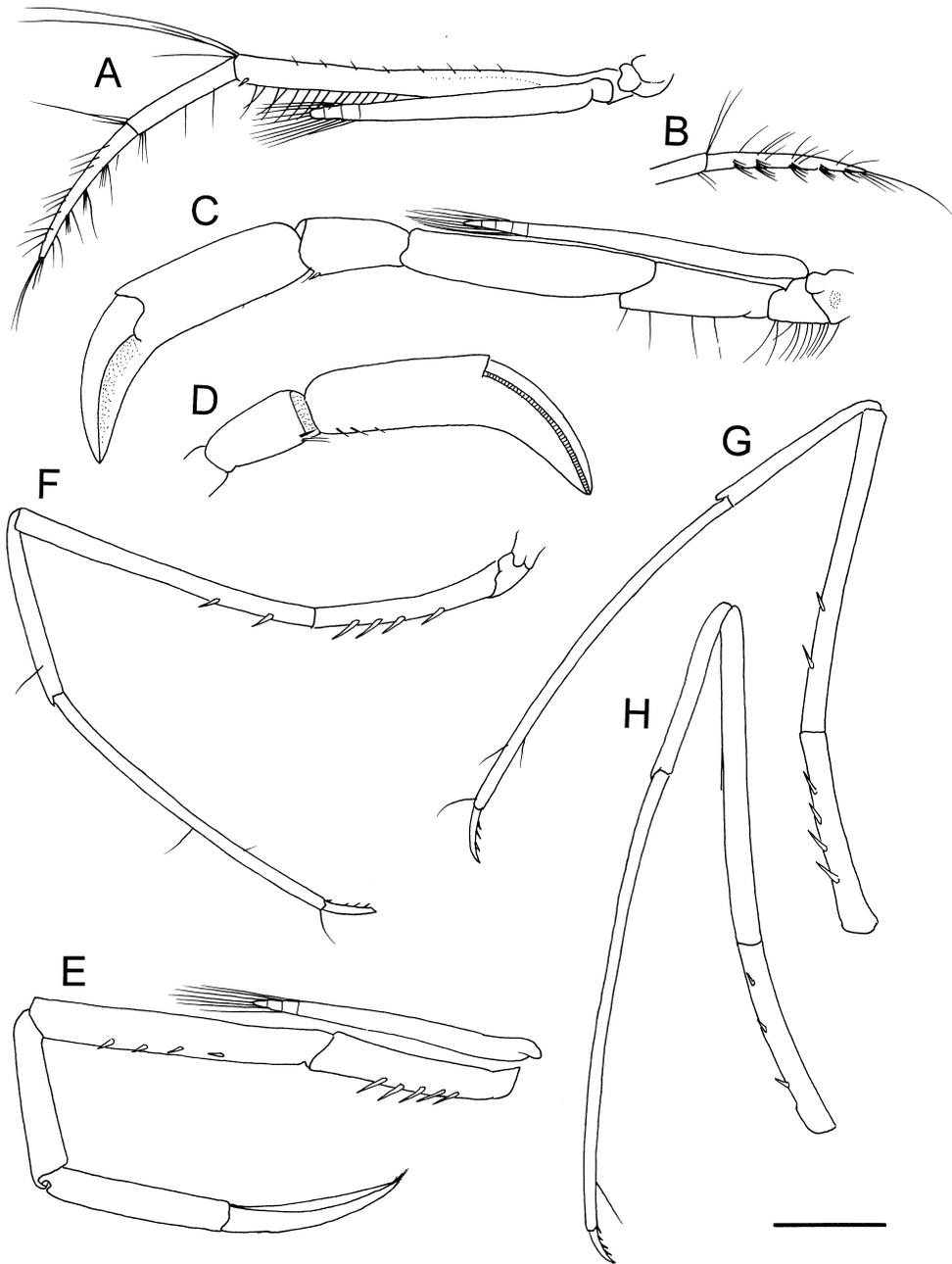


Fig. 4. *Bresilia rufioculus* sp. nov., holotype, ovigerous female (cl 2.1 mm), CBM-ZC 10063, left thoracic appendages. A, third maxilliped, lateral view; B, same, ultimate segment, mesial view; C, first pereopod, lateral view; D, same, chela and carpus, mesial view; E, second pereopod, lateral view; F, third pereopod, lateral view (tip of dactylus is broken off); G, fourth pereopod, lateral view; H, fifth pereopod, lateral view. Scale bar: 0.5 mm.

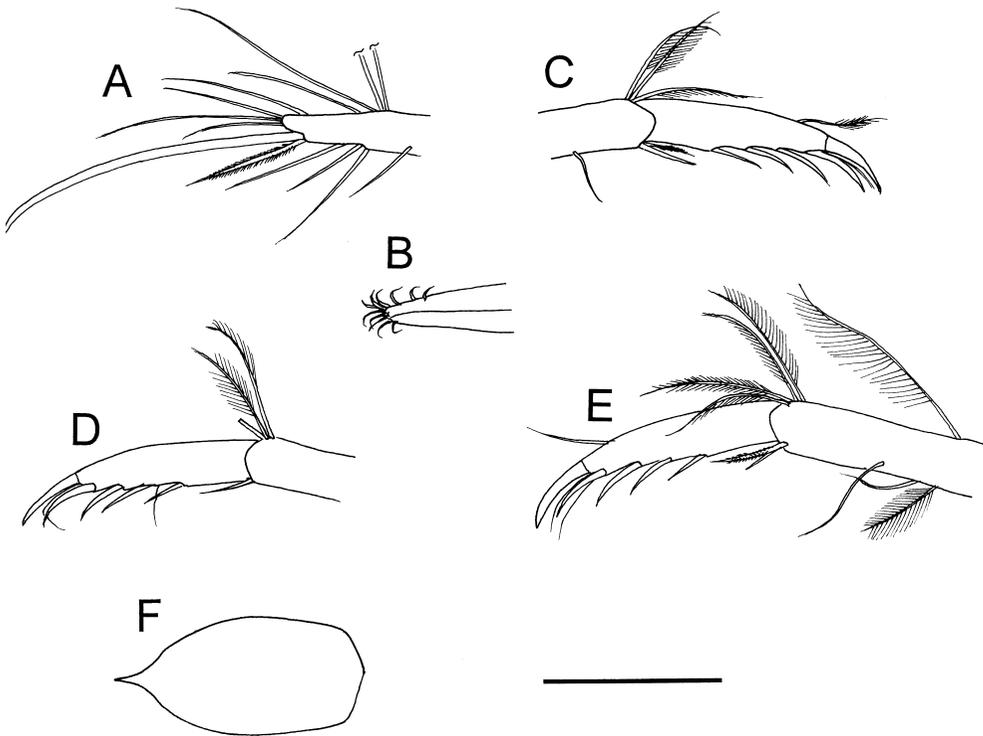


Fig. 5. *Bresilia rufiocus* sp. nov., holotype, ovigerous female (cl 2.1 mm), CBM-ZC 10063. A, detail of tip of ultimate segment of left third maxilliped, lateral view; B, detail of tip of fingers of left second pereopod; C, dactylus and distal part of propodus of right third pereopod, lateral view; D, dactylus and distal part of propodus of left fourth pereopod, lateral view; E, dactylus and distal part of propodus of left fifth pereopod, lateral view; F, tegumental scale removed from lateral face of carapace. Scale bar: 0.2 mm for A–E; 0.1 mm for F.

Table 1. *Bresilia rufiocus* sp. nov. Gill formula. r: rudimentary.

Thoracic somites	1	2	3	4	5	6	7	8
	Maxillipeds			Pereopods				
Appendages	1	2	3	1	2	3	4	5
Pleurobranchs	0	0	0	1	1	1	1	0
Arthrobranchs	0	0	0	0	0	0	0	0
Podobbranchs	0	0	0	0	0	0	0	0
Epipods	1	1	r	0	0	0	0	0
Exopods	1	1	1	1	1	0	0	0

than endopod, not tapering distally, bearing tiny posterolateral tooth and 1 slender spine just mesial to posterolateral tooth, distal lamella rounded; protopod sharply pointed posterolaterally.

Tegumental scale (Fig. 5F) minute, strongly flattened, distal portion abruptly tapering to sharp

tooth; proximal margin slightly convex.

Eggs about 0.5 mm measured along longer axis (about 0.25 of carapace length); number not precisely counted, but about 10.

Paratype. Generally similar to holotype. Rostrum with 10 dorsal teeth, including 3 on carapace, and 2 minute ventral teeth. Telson and

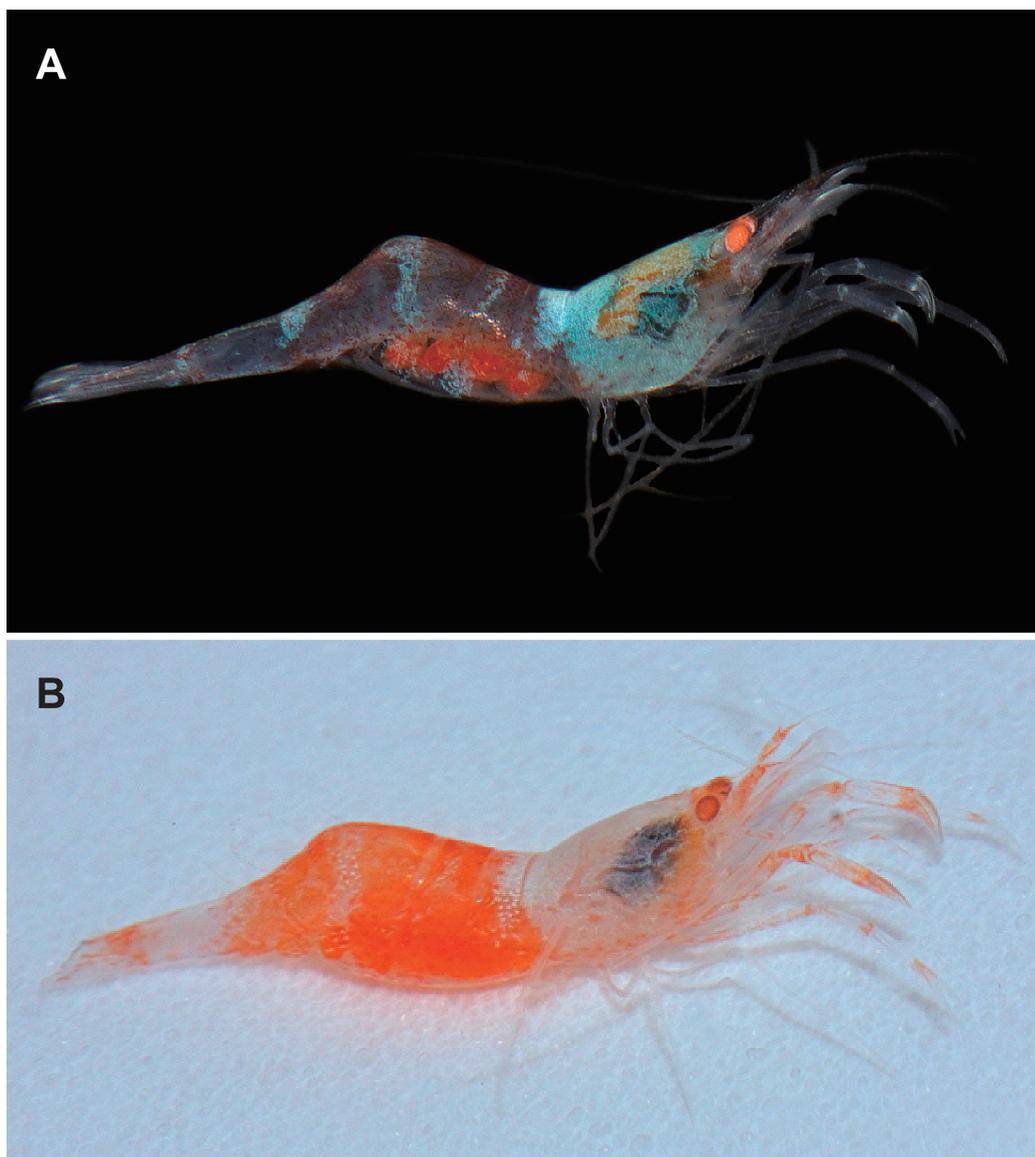


Fig. 6. *Bresilia rufulioculus* sp. nov., photographs showing color in life. A, holotype, ovigerous female (cl 2.1 mm), CBM-ZC 10063; B, paratype, ovigerous female (cl 2.3 mm), NSMT-Cr 21341.

uropods abnormal, probably in process of regeneration. Second pereopod with ischium bearing 5 spines; merus also with 5 spines. Third pereopod with 5 spines on ischium; merus with 1 spine proximally. Fourth pereopod with 3 or 5 spines on ischium; merus with 1 spine proximally. Fifth pereopod with 1 spine on ischium; merus with 2 spines proximally.

Coloration in life. Rostrum translucent. Cara-

pace whitish, anterolateral part translucent. Abdomen generally reddish or translucent with scattered reddish spots, whitish transverse band on each first, second, third and fifth somites. Cornea of eye reddish, reflective. Antennular and antennal peduncles translucent, with tinge of brown; antennular flagella whitish. Pereopods generally translucent. Eggs reddish orange. See Fig. 6.

Distribution and habitat. So far known only

Table 2. Comparison among six species of the *Bresilia antipodarum* group.

Characters/species	<i>B. rufioculatus</i> sp. nov.	<i>B. antipodarum</i>	<i>B. briankenselyi</i>	<i>B. gibbossa</i>	<i>B. plumifera</i>	<i>B. saldanhai</i>
Rostrum						
Extension						
Third tergite	overreaching distal margin of second segment of antennular peduncle	reaching nearly to distal margin of first segment of antennular peduncle	reaching nearly to distal end of antennular peduncle	reaching distal margin of antennular peduncle	not reaching distal margin of first segment of antennular peduncle	reaching to distal margin of second segment of antennular peduncle
Armature on dorsal margin	with 10 slender teeth, all fixed, 2–3 on carapace	with 9 small teeth, all fixed, none on carapace	8 small teeth, all fixed, none on carapace	with 6 or 7 teeth, posterior 3 or 4 basally articulated, 2 on carapace	4 small teeth, all fixed, 1 on carapace	10–13 small teeth, all fixed, 1 on carapace
Pterygostromial angle of carapace	rounded	with sharp tooth	with sharp tooth	angular	with sharp tooth	with sharp tooth
Abdomen						
Third tergite	non-carinate, non-produced	carinate, produced	carinate, produced	non-carinate, produced	carinate, produced	non-carinate, produced
Fourth pleuron	with posteroventral tooth	with posteroventral tooth	with posteroventral tooth	with posteroventral tooth	rounded	with posteroventral tooth
Fifth pleuron	with 2 teeth posteriorly	with posteroventral tooth	with posteroventral tooth	with 2 teeth posteriorly	with posteroventral tooth	with 2 teeth posteriorly
Telson						
Number of dorsolateral spines	2–3	4	ND	5	at least 3	5–7
Shape of posterior margin	produced in small triangular projection	angulate	ND	narrowly convex	ND	truncate
Eyestalk	directed anteriorly	freely movable	freely movable	freely movable	freely movable	freely movable
Antennal peduncle	third segment without plumose seta	third segment without plumose seta	third segment without elongate plumose seta	third segment with elongate plumose seta	third segment with elongate plumose seta	third segment without elongate plumose seta
Third maxilliped	without elongate seta at dorsodistal margin of antepenultimate segment	ND	ND	without elongate seta at dorsodistal margin of antepenultimate segment	with elongate plumose seta at dorsodistal margin of antepenultimate segment	without elongate seta at dorsodistal margin of antepenultimate segment
First pereopod						
Ischium ventrodistal margin	at most angular, non-produced	non-produced, rounded	ND	terminating in acute tooth	terminating in acute tooth	rounded, non-produced
Merus dorsodistal margin	unarmed	unarmed	ND	produced in strong tooth	unarmed	unarmed
Carpus dorsodistal margin	unarmed	produced in strong tooth	ND	produced in strong tooth, bearing 1 submarginal spine	slightly produced, with 1 minute spine	not produced, with 1 small spine
Ventral surface of palm	with 3 minute setae arranged in longitudinal row proximally	with 3 transverse rows of grooming setae proximally	ND	with only 1 long movable spine located at midlength setae and	with 3 transverse rows of grooming setae and 1 spine at midlength	with 2 transverse rows of grooming setae and 1 spine located distal to midlength
Distribution	Okinawa Islands	Tasman Sea, Australia and NewCaledonia	Egyptian Red Sea	Okinawa Island, Ryukyus	Tasman Sea, Australia	Madeira, northeast Atlantic
Depth range	17 m	770–830 m	750–753 m	30 m	133 m	15 m
Source	this study	Bruce (1990a; 2004)	Bruce (2005)	Komai and Yamada (2010)	Bruce (1990b)	Calado <i>et al.</i> (2004)

from shallow-water cave near Ie Island, Okinawa Islands. The shrimps were found in a totally dark chamber of the cave at depths of 14–17 m, located at about 50 m from the entrance at a depth of 20 m. The floor of the chamber was made of fine silty sediment, on which there were several burrows, indicating the presence of infauna. Associated fauna includes *Palaemonella* sp. (Decapoda: Caridea: Palaemonidae), *Parhippolyte misticia* (Clark, 1989) (Decapoda: Caridea: Hippolytidae), *Carupa ohashii* Takeda, 1993 (Decapoda: Brachyura: Portunidae), *Apogon coccineus* Rüppel, 1838, and *A. evermanni* Jordan and Snyder, 1904 (Pisces: Perciformes: Apogonidae).

Remarks. *Bresilia rufioculus* sp. nov. is referred to the *B. antipodarum* group because of the presence of a prominent epistomal process and the possession of an exopodal flagellum on the first maxilliped (cf. Komai and Yamada, 2010). Differentiating characters between the new species and five known species are summarized in Table 2. The new species is similar to *B. gibbosa* and *B. saldanhai* in the non-carinate tergum of the third abdominal somite and the possession of two posterolateral teeth on the fourth abdominal pleuron, but it appears unique within the species group in the non-produced tergum of the third abdominal somite. Furthermore, the anteriorly directed eyestalk and the fewer dorso-lateral spines on the telson (two or three versus more than three) are characteristic to the new species. In the other known species, the eyestalk is freely mobile, and is normally directed anterolaterally. Other differentiating characters between the new species and the other two allied species include the rostral armature and the structure of the first pereopod (see Table 2).

In the new species, the movability of the eyestalk is rather limited, and thus the eyestalk is normally directed anteriorly. The cornea is somewhat reduced and reflective. Such presumably derived structures of the eye might represent an adaptation to aphotic cave environments. The other two species originally discovered from underwater caves, i.e. *B. gibbosa* and *B. saldanhai*, have normally developed eyes (see Calado *et al.*,

2004; Komai and Yamada, 2010), suggesting that these two species may be opportunistic inhabitants in caves.

It has been confirmed that there are tegumental scales on the carapace and abdomen in this species; the striae on the tegumental surface represents pockets of these scales. Such scales are considered to have a sensory function, and are seen seen widespread in various groups of carideans (e.g. Mauchline *et al.*, 1977; Chace, 1985; Komai, 2001). The present new species, however, is the first example of Bresiliidae having tegumental scales. Komai and Yamada (2010) reported the presence of short striae on the carapace and abdomen in *B. gibbosa*, and now it can be assumed that *B. gibbosa* also has tegumental scales. It needs to be verified that such scales are present in other species of *Bresilia*.

Etymology. From the combination of the Latin *rufulus* (red) and *oculus* (eye), referring to the reddish, reflective cornea of this new species. Considered as a noun in apposition.

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