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New copepods from madreporarian corals

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In 1957—58 the Xarifa Expedition, under the leadership of Dr. HANS HASS, visited the Red Sea and the Maldive Islands, where Dr. SEBASTIAN A. GERLACH made several collections of copepods from madreporarian corals. I wish to express my thanks to Dr. GERLACH for the opportunity to study these copepods.

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Xarifiidae fam. n.

With the characters of the genus *Xarifia*.

Xarifia gen. n.

Female. — Body elongated, slender, with the segmentation rather weakly defined. Segment bearing leg 1 not fused with the head. Segments bearing legs 4 and 5 fused dorsally. Region dorsal to the fifth legs bearing long, posteriorly directed processes. Abdomen 3-segmented. Rostrum small, broadly rounded. Caudal ramus with a few short setae.

First antenna with 5 segments (either with all 5 distinct or with the distal 4 incompletely separated) and armed with numerous naked setae and several long aesthetes. Second antenna consisting of 3 segments and a claw (possibly representing a fourth segment). Labrum hemispherical, its posterior transverse margin nearly straight with a small median notch. Mandible a small lobe bearing distally a slender blade provided with a row of spinules. Paragnath absent. First maxilla a small lobe bearing 2 setae. Second maxilla a somewhat larger lobe attenuated distally and bearing 2 minute setae. Maxilliped having 2 segments, the distal one rather tumid and lying parallel to the long axis of the body.

Legs 1—4 similar, with the exopod having 3 segments, the last bearing a terminal recurved claw, and the first either a similar outer claw or a seta. Last 2 segments arising at an angle from the first. Endopod consisting of a single rounded segment bearing a few marginal setae and a distal fringe of either fine hairs or slender setae. Leg 5 with 2 setae arising either from a separate segment or from the body directly, and an adjacent dorsal seta. Leg 6 absent.

Two small egg sacs attached dorsally.

Male. — Body similar to the female, but without the long processes on the region dorsal to the fifth legs. Abdomen 3-segmented. Maxilliped large, with 4 segments, the second swollen, the fourth in the form of a long, recurved claw. Other head appendages, legs 1—4, rostrum, and the caudal ramus as in the female. Leg 5 with 3 setae as in the female, but without a distinct segment. Leg 6 consisting of 2 small setae.

Living on or in various madreporarians.

Type species. — *Xarifia maldivensis* sp. n.

(The genus is named in honor of the „Xarifa", the ship of the expedition.)

Xarifia maldivensis sp. n.

Pl. I, figs. 1—9, Pl. II, figs. 10—17, Pl. III, figs. 18—21.

Type material. — 59 females and 18 males (X170) from a seriatoporid coral, *Pocillopora* sp., from the outer reef at a depth of 1 meter at Welingandu, Rasdu Atoll, Maldive Islands, collected March 11, 1958, by Dr. Sebastian A. Gerlach. Holotype female, allotype, and 12 paratypes deposited in the United States National Museum, Washington, D. C., 12 paratypes in the Zoologisch Museum, Amsterdam, Netherlands, and the remaining paratypes in the author's collection.

Other specimens. — 2 females and 3 males (X204) from *Pocillopora* sp. on the inner reef in 2 meters at Wadewaru, Fadiffolu Atoll, April 4, 1958; 8 females and 10 males (X161) from *Pocillopora* sp. on the inner reef in 1 meter at Welingandu, Rasdu Atoll, March 7, 1958; 2 females and 2 males (without a collection number) from *Pocillopora* sp. on the outer reef at Welingandu, Rasdu Atoll, February 26, 1958; 1 female and 2 males (X55) from *Pocillopora* sp. at the wreck in 15 meters at Addu Atoll, January 6, 1958; and 1 male (X103) from *Pocillopora* sp. at the same locality, January 30, 1958. All these localities in the Maldive Islands.

Female. — Body elongated (fig. 1), a little more than 5 times longer than wide, 1.356 mm (1.260—1.464 mm) x 0.258 mm (0.250—0.264 mm), based on 6 specimens. In alcoholic specimens the abdomen sometimes contracted (fig. 2). In side view (fig. 3) the pedigerous segments somewhat tumid ventrally. Segment of leg 1 not fused with the head and having a short transverse dorsal furrow. Segments of legs 4 and 5 not clearly separated dorsally. Region dorsal to the fifth legs bearing 3 long, posteriorly directed processes, one median and 2 laterodorsal, each about 150μ long (figs. 1 and 4), with 2 small knobs between them. Minute hairs on the dorsal surface of the head and thorax as shown in fig. 1. Genital segment (figs. 1 and 3) short, with the 2 oviducal openings on its dorsal surface. Abdomen 3-segmented (figs. 1 and 3), the segments decreasing slightly in length posteriorly. Caudal ramus (fig. 5) 38 x 30μ, with its inner margin expanded, with 2 unequal setae, the inner 29μ, the outer 9μ, on its slightly insected distal end, and with a subterminal outer seta about 10μ in length. Surface of the ramus with a few minute bosses having delicately bifurcated tips. Egg sac (fig. 2) 160 x 137μ, containing a single egg.

Rostrum (fig. 6) broadly rounded, 19 x 25μ, projecting slightly in dorsal view. First antenna (fig. 7) short, having apparently 5 segments, but the last 4 incompletely separated from each other. With 4 long, subterminal aesthetes and numerous naked

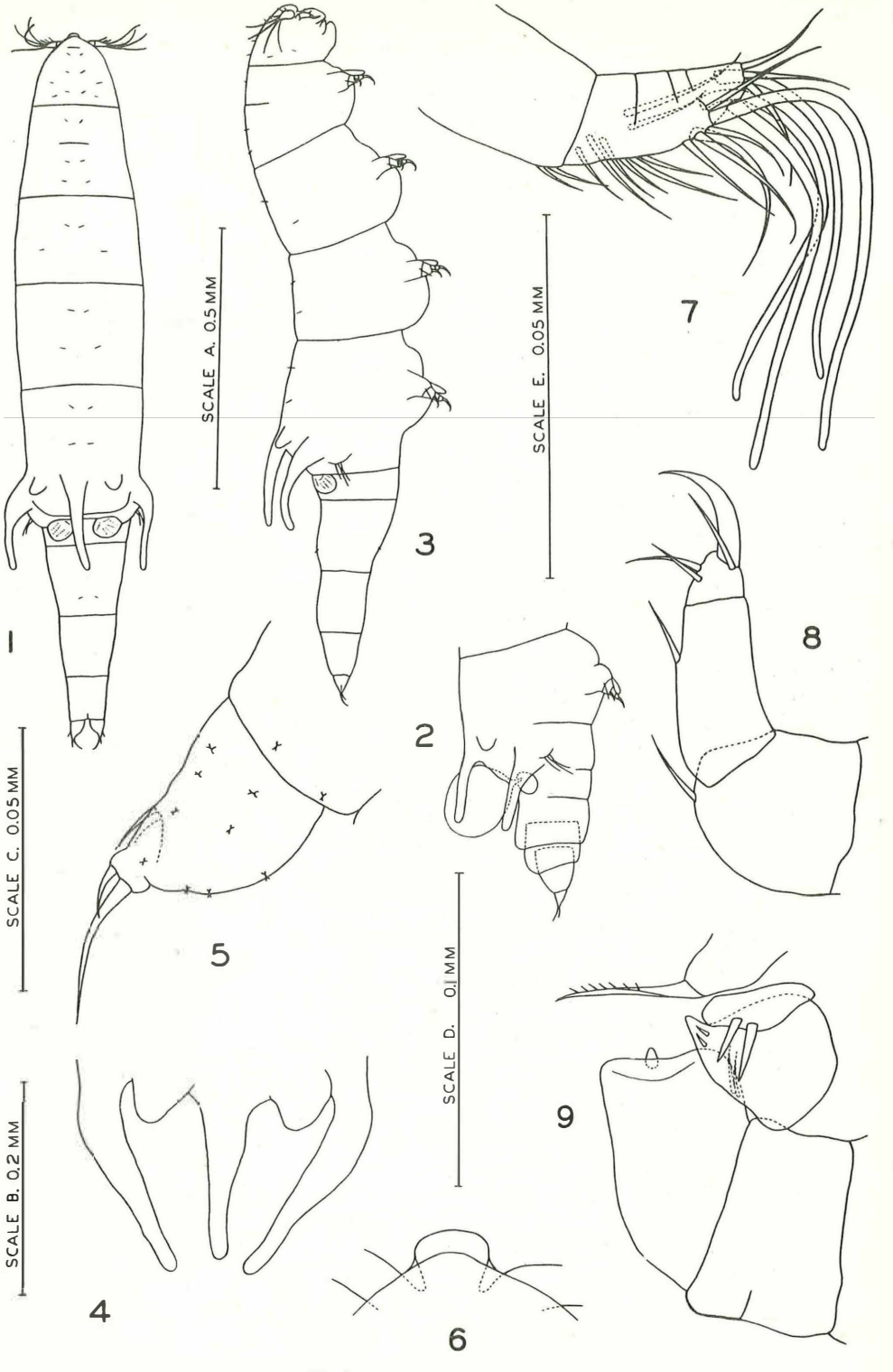
Plate 1.

Xarifia maldivensis gen. n., sp. n., female

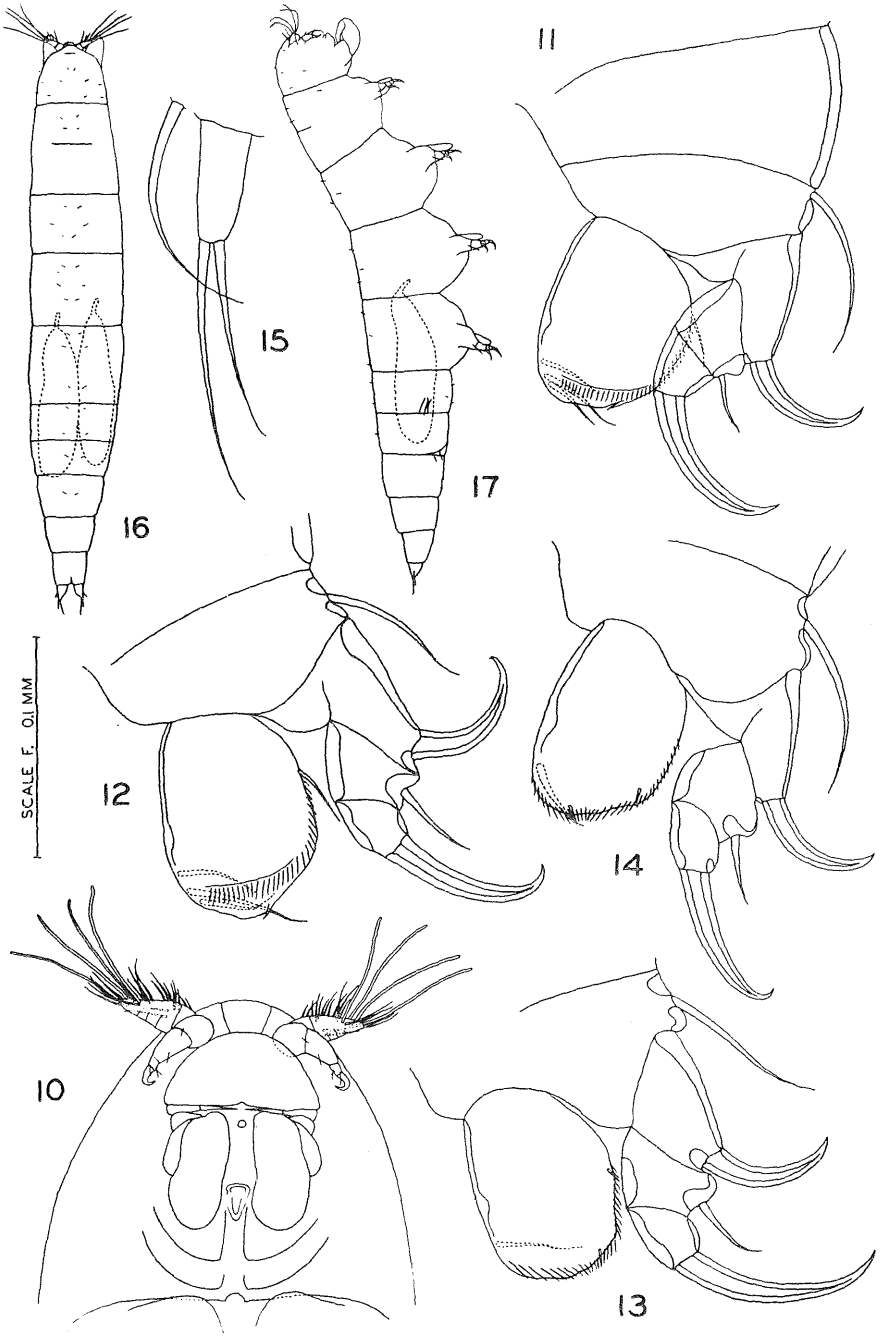
Fig. 1. Dorsal (A).
Fig. 2. Posterior part of thorax and abdomen, lateral (A).
Fig. 3. Lateral (A).
Fig. 4. Posterior processes on region above fifth legs, dorsal (B).
Fig. 5. Caudal ramus, dorsal (C).
Fig. 6. Rostrum, dorsal (D).
Fig. 7. First antenna (E).
Fig. 8. Second antenna (E).
Fig. 9. Mandible, first maxilla, second maxilla, and maxilliped (E).

Explanation of figures.

(All figures were drawn with the aid of a camera lucida. The letter after each figure refers to the scale at which it was drawn.)



Tafel 1 (zu A. G. Humes)



Tafel 2 (zu A. G. Humes)

setae as indicated in the figure. Second antenna (fig. 8) having 3 segments and a terminal recurved claw. First and second segments each with a marginal seta. Third segment with 2 marginal setae and a third seta near the base of the claw. Mandible (fig. 9) consisting of a basal lobe bearing an inwardly directed, attenuated, slender blade with a row of spinules. Paragnath absent. First maxilla (fig. 9) a small lobe bearing 2 broad setae. Second maxilla (fig. 9) a somewhat larger, inwardly attenuated lobe bearing 2 minute subterminal setae. Maxilliped (fig. 9) having 2 segments, the first largely obscured by the second in ventral view. Second segment large and bearing a small terminal knob and 2 slender marginal setae. Arrangement of the head appendages as in fig. 10. Labrum (fig. 10) hemispherical with its transverse posterior edge having a small median notch.

Legs 1—4 similar in general form, the exopods with 3 segments, the endopods with one segment. Spine and setal formula as follows:

	leg 1		leg 2		leg 3		leg 4	
	exp	end	exp	end	exp	end	exp	end
1st segment . . .	1 : 0	2 : 3	1 : 0	2 : 3	1 : 0	2 : 1	1 : 0	2 : 1
2nd segment . . .	1 : 0		1 : 0		1 : 0		1 : 0	
3rd segment . . .	1		1		1		1	

All 4 legs with an outer basipod seta, but without an inner basipod seta.

Leg 1 (fig. 11) with the first exopod segment bearing a large recurved claw on its outer distal angle, the second bearing an outer slender naked seta, and the third bearing terminally a large recurved claw. Inner margin of the first segment short, with the axis of the second and third segments at a pronounced angle to the axis of the first segment. Endopod segment a broad, rounded lamella with 2 minute setae on the outer margin and 3 long slender setae near the inner distal corner. With a row of fine hairs around the outer and distal edge. Leg 2 (fig. 12) similar to leg 1. Leg 3 (fig. 13) similar to leg 1, but with only one slender seta near the inner distal corner instead of 3. Leg 4 (fig. 14) like leg 3.

Leg 5 (fig. 15) consisting of an elongated segment 16 x 6μ, bearing 2 subequal terminal setae. A single seta arising separately close to the base of the segment. Leg 6 absent.

Male. — Body (figs. 16 and 17) of the same general form as the female, but a little shorter and slenderer, 1.203 mm (1.110—1.284 mm) x 0.190 mm (0.185—0.192 mm), based on 6 specimens. Posterior dorsal area of the segment bearing leg 5 smooth, without long processes as in the female. Segments bearing the fifth and sixth legs and the abdominal segments of about the same length. Abdomen 3-segmented. Caudal ramus as in the female. Spermatophore (fig. 18) elongated, 263 x 80μ, including the neck.

Plate 2.

Xarifia maldivensis gen. n., sp. n., female (continued)

Fig. 10. Head, ventral (F).
Fig. 11. Leg 1 (C).
Fig. 12. Leg 2 (C).
Fig. 13. Leg 3 (C).
Fig. 14. Leg 4 (C).
Fig. 15. Leg 5 (E).

Same, male

Fig. 16. Dorsal (A).
Fig. 17. Lateral(A).

Rostrum, first antenna, second antenna, labrum, mandible, first maxilla, and second maxilla like those of the female. Maxilliped (fig. 19) large, with 4 segments, the first unarmed and short, the second large and swollen with a small seta and a slightly recurved, spiniform process on its inner surface, the third very small and unarmed, and the fourth segment in the form of a long recurved claw 53μ in length, with 2 small setae near its base and a row of spinules along its concave distal half. Arrangement of the head appendages as in the female, with the enlarged maxillipeds projecting conspicuously (figs. 16 and 17).

Legs 1—4 as in the female, with the same spine and setal formula. Leg 5 (fig. 20) located on the side of the segment, without a distinct segment, consisting of 2 subequal setae, 28μ long, arising from a protuberance, and an adjacent more dorsal seta. Leg 6 (fig. 21) consisting of 2 equal setae 23 μ long arising from the lateroventral posterior area of the sixth thoracic segment (fig. 17).

(The specific name *maldivensis* refers to the group of islands where the type locality is located.)

Xarifia fimbriata sp. n.

Pl. III, figs. 22—29, Pl. IV, figs. 30—35.

Type material. — 4 females and 1 male (X170) from *Pocillopora* sp. on the outer reef in 1 meter at Welingandu, Rasdu Atoll, Maldive Islands, collected March 11, 1958, by Dr. SEBASTIAN A. GERLACH. Holotype female, allotype, and 1 paratype deposited in the United States National Museum.

Other specimens. — 1 male (X116) from *Pocillopora* sp. in 10 meters in Gan Channel, Addu Atoll, Maldive Islands, February 4, 1958.

Female. — Body elongated (fig. 22), somewhat slenderer than in the preceding species, 1.398 mm (1.260—1.452 mm) x 0.208 mm (0.192—0.228 mm), based on 4 specimens. Intersegmental furrows of the pedigerous segments not continued dorsally (fig. 23). Region dorsal to the fifth legs bearing 2 rather widely separated, posteriorly directed processes, each about 170μ long (figs. 22 and 24). Genital segment short with the 2 oviducal openings on its dorsal surface. Abdomen 3-segmented (figs. 22 and 23), the segments nearly equal in length. Caudal ramus (fig. 25) more elongated and slenderer than in the preceding species, 61 x 30μ, with 3 short terminal setae, with a minute recurved rather hyaline seta on its outer edge, and with minute scattered hairs on its surface. Egg sac (fig. 26) oval, 170 x 109μ, containing a single egg.

Rostrum as in the preceding species. First antenna (fig. 27) short, with 5 segments, the last bearing 2 aesthetes, the penultimate one aesthete, and with numerous naked setae

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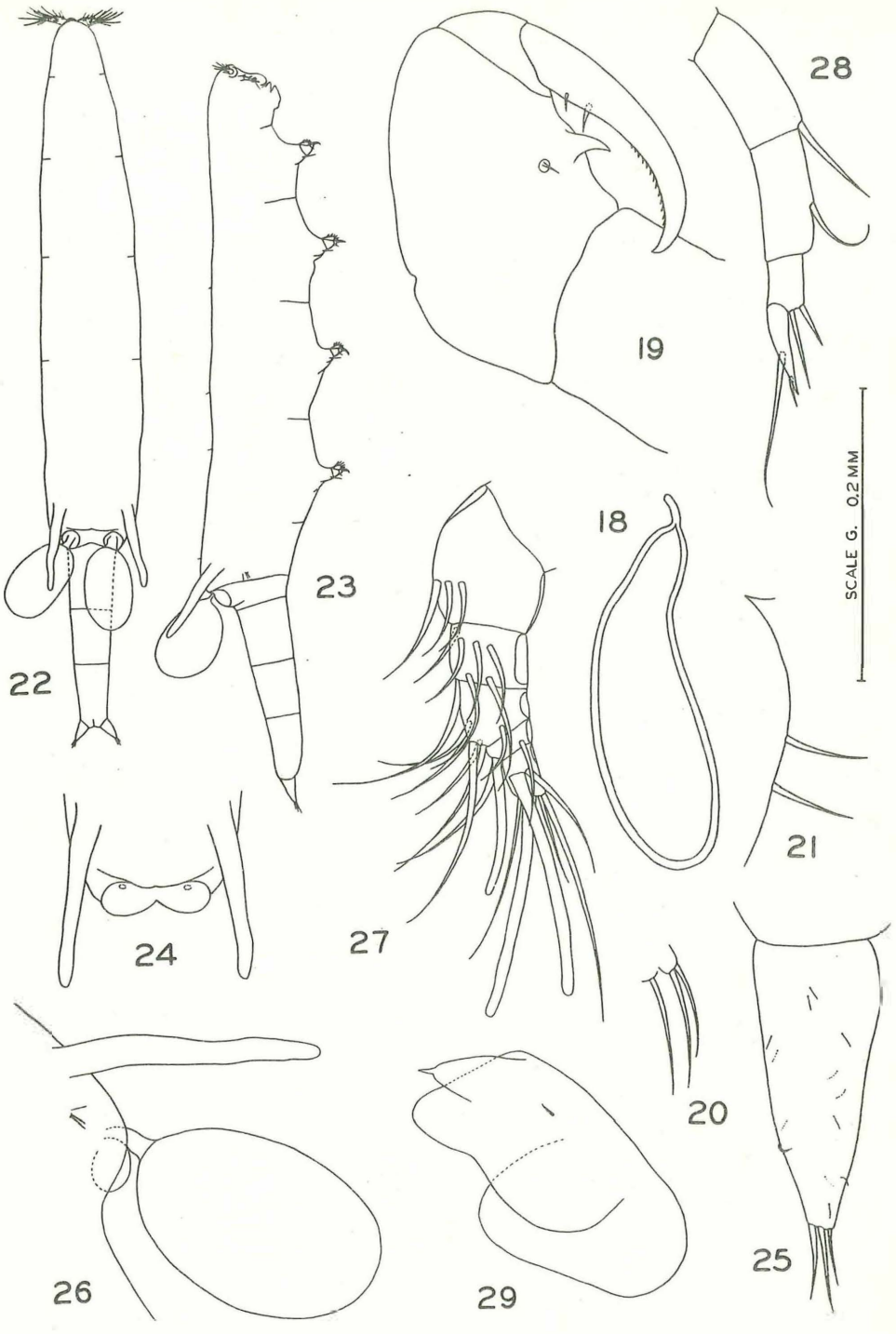
Plate 3.

Xarifia maldivensis gen. n., sp. n., male (continued)

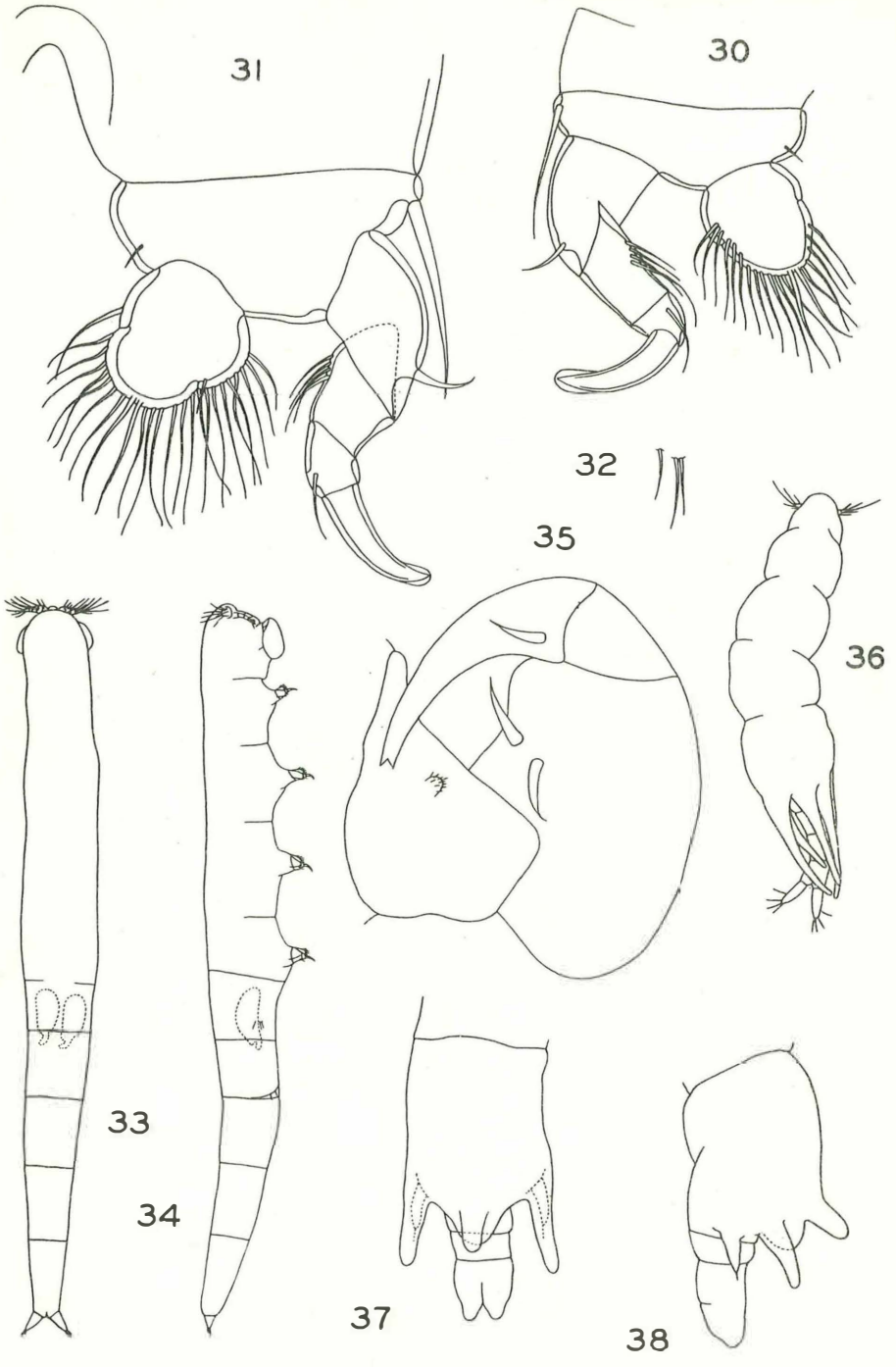
Fig. 18. Spermatophore (G).
Fig. 19. Maxilliped (C).
Fig. 20. Leg 5 (D).
Fig. 21. Leg 6 (D).

Xarifia fimbriata gen. n., sp. n. female

Fig. 22. Dorsal (A).
Fig. 23. Lateral (A).
Fig. 24. Posterior processes on region above fifth legs (B).
Fig. 25. Caudal ramus, dorsal (C).
Fig. 26. Egg sac and region of attachment, lateral (G).
Fig. 27. First antenna (E).
Fig. 28. Second antenna (E).
Fig. 29. Maxilliped (E).



Tafel 3 (zu A. G. Humes)



Tafel 4 (zu A. G. Humes)

as indicated in the figure. Second antenna (fig. 28) having 3 segments and a nearly straight and rather weakly sclerotized claw (perhaps representing a fourth segment, since it bears 2 very unequal setae). Labrum, mandible, first maxilla, and second maxilla as in the preceding species. Maxilliped (fig. 29) of about the same relative size and apparently consisting of 2 segments as in the preceding species, but bearing a minute lateral surficial seta and having a terminal conical mucronate process.

Legs 1—4 similar in general form, the exopods having 3 segments, the endopods a single segment. Spine and setal formula as follows, the + signs indicating minor surficial setae which may in some cases be variable in number and probably should not be regarded as comparable to the major marginal setae:

	leg 1		leg 2		leg 3		leg 4	
	exp	end	exp	end	exp	end	exp	end
1st segment	1 : 0	2+	1 : 0	1 : 2+	1 : 0	1 : 2+	1 : 0	1 : 2+
2nd segment	0 : 0+		0 : 0+		0 : 0+		0 : 0+	
3rd segment	1+		1+		1+		1+	

All 4 legs with a minute inner basipod seta and a long outer basipod seta.

Leg 1 (fig. 30) with the first exopod segment bearing a small slender seta on its outer distal area, the second bearing a group of long slender setae on its inner surface, and the third bearing a subterminal slender seta and a terminal recurved claw with a hyaline membrane around its tip. Last 2 segments set at an angle to the first as in the preceding species. Endopod segment a broad rounded lamella, its sclerification suggesting a subdivision of the segment. With 2 long slender terminal setae, whose bases extend through the sclerified edge of the segment, and a fringe of long slender setae around the distal half of the segment. Legs 2, 3, and 4 alike (see fig. 31), with the exopod like that of leg 1 but with a slender recurved outer spine instead of a seta on the first segment. Endopod also similar to leg 1, but with a minute seta on the outer margin in addition to the 2 distal setae and the fringe of setae.

Leg 5 (fig. 32) lacking a distinct segment, and consisting of 2 subequal setae 20μ in length arising side by side, and an adjacent dorsal seta. Leg 6 absent.

Male. — Body (figs. 33 and 34) of the same general form as in the female, 1.416 x 0.156 mm in the single specimen. Posterior dorsal area of the segment bearing leg 5 smooth, without long processes as in the female. Segments bearing the fifth and sixth legs and the abdominal segments of nearly equal length. Abdomen 3-segmented. Caudal

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Plate 4.

Xarifia fimbriata gen. n., sp. n., female (continued)

Fig. 30. Leg 1 (E).
Fig. 31. Leg 3 (E).
Fig. 32. Leg 5 (D).

Same, male

Fig. 33. Dorsal (A).
Fig. 34. Lateral (A).
Fig. 35. Maxilliped (C).

Xarifia sp. undetermined, female

Fig. 36. Dorsal (A).

Xarifia sp. undetermined, female

Fig. 37. Posterior part of thorax and abdomen, dorsal (A).
Fig. 38. Posterior part of thorax and abdomen, lateral (A).

ramus as in the female. Spermatophores (seen only within the body of the male) as in fig. 33, shorter than in the preceding species.

Rostrum, first antenna, second antenna, labrum, mandible, first maxilla, and second maxilla like those of the female. Maxilliped (fig. 35) large, with 4 segments, the first with a minute hairy inner knob, the second swollen with 2 broad hyaline inner setae, the third small and unarmed, and the fourth in the form of a recurved claw 51μ in length bifurcate at its tip and bearing a seta near its base. Maxillipeds projecting conspicuously as in the preceding species.

Legs 1—5 as in the female. Leg 6 as in the preceding species.

(The specific name *fimbriata*, fringed, alludes to the fringe of setae on the endopods of legs 1—4.)

Xarifia sp. undetermined

Pl. IV, fig. 36.

A single female (X19) was found in *Stylophora* sp. at a depth of 1 meter at Sarso, in the southern part of the Red Sea, on November 20, 1957. The region dorsal to the fifth legs has four very long, posteriorly directed processes (fig. 36). This specimen undoubtedly represents a third species of *Xarifia*, but is left undescribed because of the lack of specimens.

Xarifia sp. undetermined

Pl. IV, figs. 37—38.

A single female (X37) was found in *Acropora* sp. in 2 meters at Hitadu Island, Addu Atoll, Maldive Islands, on December 28, 1957. Although unfortunately the head of this specimen is missing, the copepod seems to belong also to the genus *Xarifia*. There are three posteriorly directed processes on the region dorsal to the fifth legs, the middle one shorter and situated over a rounded projection (figs. 37 and 38). The apparent fifth legs are relatively large and tipped with a seta.

Observations on the color and behavior of living *Xarifia* in the Maldives have been made by Dr. GERLACH. With his permission his diary notes are included here: „Lebende Stücke von *Pocillopora* unter dem Binokular beobachtet. Copepodenweibchen läuft zunächst ein Stück über die Oberfläche der Koralle und schaut dabei in verschiedene Korallenkelche kurz hinein. Schließlich bleibt es in einem Kelch etwas länger und bei näherem Zusehen kann ich erkennen, daß der gesamte Vorderkörper des Krebses in dem Korallenkelch verschwunden ist, so daß schließlich nur die Eipakete herausragen. Nach ein paar Minuten kommt der Krebs wieder heraus und kriecht weiter, das Gewebe in dem besuchten Korallenkelch scheint etwas zerfetzt zu sein.

„Die Farbe der Tiere ist gewöhnlich hell, im Auflicht grünlich schillernd, der Darm war dagegen leuchtend rot gefärbt."

„Ich erbeutete die Tiere mit Hilfe folgender Methode: Die Korallenstöcke wurden gründlich unter Wasser mit einem Pinsel abgebürstet und anschließend mit einem Hammer in kleine Trümmer zerschlagen. Daraufhin wurde kräftig umgerührt und das Wasser mit den leichteren Partikeln dekantiert und durch ein Planktonnetz filtriert."

„Gelegentlich kamen die Tiere auch in den Proben vor, bei denen die Korallen nur abgewaschen wurden, und ich möchte deshalb für die Lebensweise folgendes annehmen: Die Tiere kriechen mit raupenartigen Bewegungen auf der Oberfläche der Korallen herum, sind aber andererseits imstande, mit den scharfen Klauen das Polypengewebe zu zerfetzen und sich so auch Zugang zu den Kelchen zu verschaffen und vielleicht auch längere Zeit so eingebohrt in das Korallengewebe zu leben."

Several genera of copepods are known to live in coelenterates. References to these may be found in the works of ZULUETA (1911), GRAVIER (1914), and BOULIGAND and DELAMARE-DEBOUTTEVILLE (1959). None of these, however, is associated with madreporarian corals. *Linaresia* ZULUETA, 1908, *Lamippe* BRUZELIUS, 1858, *Isidicola* GRAVIER, 1914, and *Lamippella* BOULIGAND and DELAMARE-DEBOUTTEVILLE, 1959, live in alcyonarians. *Mesoglicola* QUIDOR, 1906 and *Staurosoma* WILL, 1844, inhabit actiniarians. The discovery of *Xarifia* in *Pocillopora*, *Stylophora*, and *Acropora* now extends the list of coelenterate hosts of copepods to include certain of the true corals.

In highly modified endoparasitic copepods evolutionary convergence may have brought about similarities in body form. The general form of *Xarifia*, a genus which appears to be endoparasitic, may be due in part, at least, to such convergence. In some respects its general body form reminds one of certain elongated copepods parasitic on polychaete annelids, but important details of the appendages make it impossible to reconcile it with these or other cyclopoid genera.

One might naturally look for affinities of *Xarifia* with the other coelenterate inhabiting copepods such as *Lamippe*. The first and second antennae of *Lamippe* resemble in general those of *Xarifia*. The two pairs of legs of *Lamippe* also suggest the first two legs of *Xarifia* in having prehensile exopods and much reduced endopods. The mouth parts of *Lamippe* are so reduced and obscure that there seems to be little resemblance to *Xarifia*. The discovery of the developmental stages of *Xarifia* would undoubtedly help to clarify the position of the genus. The new family Xarifiidae, in which the genus *Xarifia* has been placed, is apparently closely related to the well-known family Lamippidae, but differs from it principally in showing segmentation of the body, in having the mouth parts fairly well formed, with sexual dimorphism in the maxillipeds, and in possessing five pairs of legs, the first four pairs with distinct endopods.

Zusammenfassung

Es werden zwei Vertreter der neuen Familie Xarifiidae (Crust. Copepoda) beschrieben, *Xarifia maldivensis* und *X. fimbriata* n.g.n.sp. Sie leben als Schmarotzer auf Riffkorallen (*Poccillopora*) und wurden von der Xarifa-Expedition 1957/58 im Gebiet der Malediven (Indischer Ozean) gesammelt. Die neue Familie ist in die Nähe der Lamippidae zu stellen, unterscheidet sich aber durch die Segmentierung des Körpers, durch gut entwickelte Mundteile, ausgeprägten Sexualdimorphismus bei den Maxillipeden und durch fünf Beinpaare, von denen die vorderen vier deutliche Endopoditen tragen.

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