Bestiolina arabica sp. nov. (Copepoda, Calanoida, Paracalanidae), a new species from the northwestern Arabian Gulf

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BESTIOLINA ARABICA SP. NOV. (COPEPODA, CALANOIDA, PARACALANIDAE), A NEW SPECIES FROM THE NORTHWESTERN ARABIAN GULF

BY

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ABSTRACT

A new species, *Bestiolina arabica* sp. nov. is described from the northwestern Arabian Gulf. The species can be distinguished from its congeners by the lack of large spinules on the anterior face of the exopods of swimming legs 2-4 in both sexes, and the lack of marginal spinules on the endopods of those same legs.

ZUSAMMENFASSUNG

Bestiolina arabica sp. nov., eine neue Art aus dem nordwestlichen Arabischen Golf, wird beschrieben. Sie unterscheidet sich von anderen Vertretern der Gattung durch das Fehlen von großen Stacheln auf der Vorderseite der Exopodite der Schwimmbeine 2-4 beider Geschlechter und durch das Fehlen randständiger Stacheln an den Endopoditen derselben Beine.

INTRODUCTION

Members of the genus *Bestiolina* Andronov, 1991 (Copepoda, Calanoida, Paracalanidae) are relatively small, they barely exceed 1.00 mm in length, and are common in estuarine habitats (Sewell, 1912, 1914; Shen & Lee, 1966; Andronov, 1972b; Li & Xuang, 1984; McKinnon et al., 2003). There are currently six species in this genus, including the one described here. In the northwestern Arabian Gulf (= Persian Gulf), around the Kuwaiti island of Bubiyan (an area where the Shatt Al-Arab River flows into from Iraq), specimens of a new species of *Bestiolina* were collected. This represents the first record of the genus in the Arabian Gulf.

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The most obvious characters that distinguish *B. arabica* sp. nov. from the five previously described species of the genus are: the lack of large spinules on the anterior face of the exopods of swimming legs 2-4 in both sexes (in *B. arabica*), while the anterior surface of the second endopodal segments of legs 2 and 3 in females bear three spinules, and the same segments in the male bear four spinules. Also, the endopods of legs 2-4 in both sexes are without marginal spinules, which serves to discriminate the new species from *B. sinica* Shen & Lee, 1966, in which there are marginal spinules on the second endopodal segments of legs 2-4.

DESCRIPTION

Bestiolina arabica sp. nov. (figs. 1-4)

Material examined. — Station BUB-4 (29°898N 48°040E), 31 August 2004 (~4 m depth) during oceanographic cruises near Bubiyan Island. At BUB-4, surface salinity and surface temperature were 37.065‰ and 28.6°C, respectively. — All types are ethanol-preserved and deposited at The Natural History Museum, London. Female holotype, BMNH 2005.2093; 8 female paratypes, BMNH 2005.2095-2113; and 8 males: allotype, BMNH 2005.2094; 7 paratypes, BMNH 2005.2114-2120.

Diagnosis. — A species of *Bestiolina* by the structure of leg 5 in both sexes: in the female, leg 5 is present as a strongly reduced pair of rounded lobes that lack any vestige of segmentation or armature; in the male, strongly asymmetrical: right leg rudimentary and reduced to an unarmed, rounded lobe, left leg uniramous and slender, 5-segmented, and longer than urosome. Legs 2-4 in both male and female without large spinules on anterior face of exopodal segments; only in female 3 spinules on endopodal segment 2 of legs 2-3, and in male 4 spinules on those same segments. Endopods of legs 2-4 are without marginal spinules.

Description of female. — Total body length 0.79-0.92 mm, based on 6 specimens. Cephalosome and first pedigerous somite fused and slightly gibbous dorsally (fig. 1a, b). Somites 4 and 5 completely separate, with posterolateral corners rounded and symmetrical in dorsal aspect. Rostrum well developed, bifid, and solid (fig. 1c). Body widest at level of first pedigerous somite; ratio of prosome to urosome length 3.4 : 1. Urosome of 4 free somites with genital double-somite longer than each of free abdominal somites; genital double-somite symmetrical. Anal somite with weakly developed anal operculum. Caudal rami (fig. 1d, e) symmetrical, about 2 times as long as wide, with 4 distal setae and 1 reduced seta distally on medial margin.

Antennules (fig. 1f) long and symmetrical, extending about as far as posterior margin of anal somite; 23-segmented with failure to express articulations between ancestral segments I-IV, X-XI (although vestige of articulation between segments expressed antero-dorsally), and XXVII-XXVIII. Armature formula of segments as follows: segment 1 (corresponding to compound ancestral segments I-IV), 7 setae

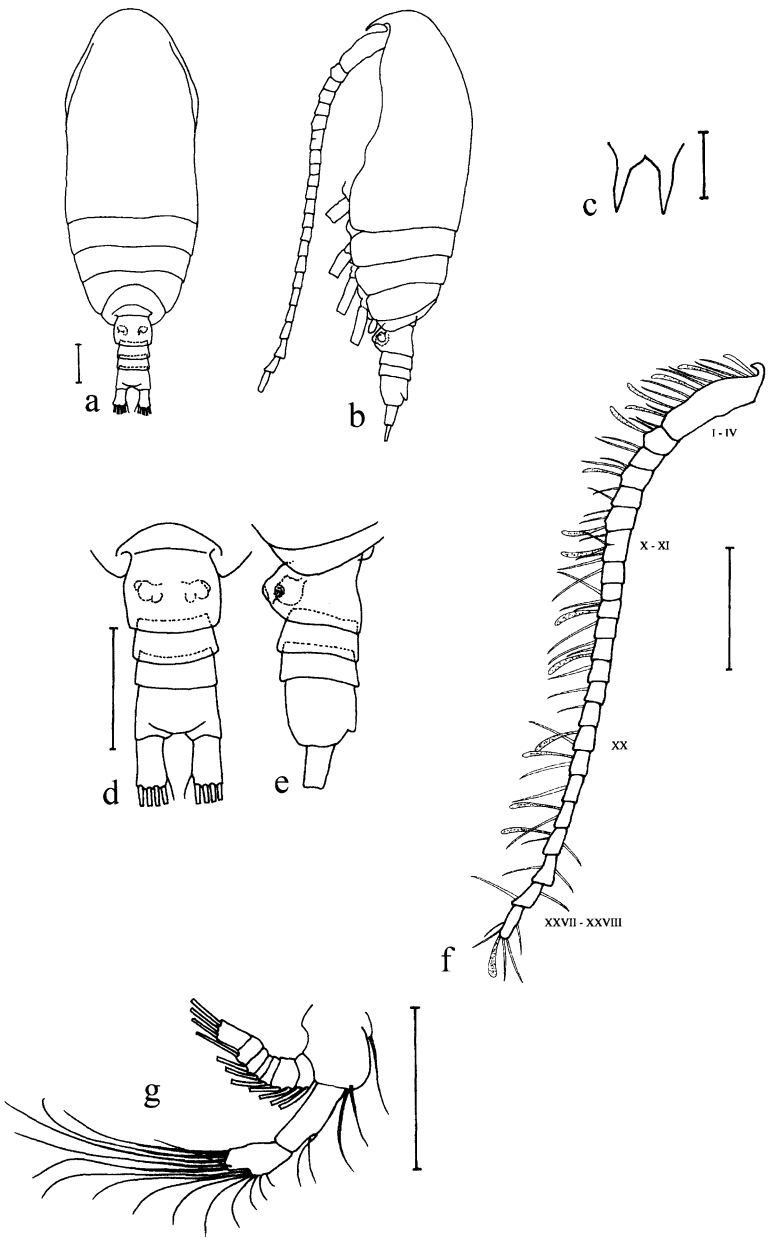

Fig. 1. *Bestiolina arabica* sp. nov., female. a, dorsal view; b, lateral view; c, rostrum; d, urosome, dorsal view; e, urosome, lateral view; f, antennule; g, antenna. Scale bars: a, b, d-g, 0.01 mm; c, 0.05 mm.

+ 5 aesthetascs (ae); segment 2 (V), 2 + ae; segment 3 (VI), 2 setae; segment 4 (VII), 2 + ae; segment 5 (VIII), 2 setae; segment 6 (IX), 2 + ae; segment 7 (composed X-XI), 4 + ae; segments 8 (XII) and 9 (XIII), 1 seta each; segment 10

(XIV), 2 + ae; segment 11 (XV), 1 seta; segment 12 (XVI), 2 + ae; segments 13 (XVII) to 15 (XIX), 1 seta each; segments 16 (XX) and 17 (XXI), 1 + ae each; segment 18 (XXII), 1 seta; segment 19 (XXIII), 1 + ae; segment 20 (XXIV), 1 + 1 + ae; segments 21 (XXV) and 22 (XXVI), 1 + 1 setae each; segment 23 (composed XXVII-XXVIII), 5 + ae.

Antenna (fig. 1g) biramous. Coxa and basis with 1 and 2 setae on distomedial angle, respectively. Exopod 7-segmented, setal formula as follows: segment 1 (corresponding to compound ancestral segments I and II), 2 setae; segment 2 (III-IV), 2 setae; segments 3 (V) to 6 (VIII) 1 seta each; compound segment 7 (IX-X), 3 setae. No seta found at midlength. Endopod 2-segmented, proximal segment with 2 setae, distal segment expanded subdistally into medial lobe bearing 9 setae, and with distal portion crowned with 6 setae.

Mandibular gnathobase (fig. 2a) cutting edge comprising 4 teeth plus dorsal spinulose seta; ventralmost tooth largest, smooth and monocuspidate; 3 adjacent teeth with row of 3 small denticles, monocuspidate; 4 dorsal teeth reduced, tricuspidate, with transverse comb of long spinules basally. Palp biramous, basis with 4 setae on inner margin. Exopod indistinctly 5-segmented, setal formula 1, 1, 1, 1, 2. Proximal endopodal segment with 4 setae on distomedial angle; distal segment with 10 setae.

Maxillule (fig. 2b) with the first praecoxal arthrite carrying 9 stout terminal spines and 4 posterior and 1 anterior setae. Praecoxal arthrites 2-4 with 3, 4, 4 setae, respectively; endopod not articulated with basis, with 13 setae; exopod with 11 marginal setae; coxal endite 2 is indistinct, coxal endite 1 with 7 stout and 3 fine setae.

Maxilla (fig. 2c) indistinctly 6-segmented, comprising partially coalesced praecoxa and coxa, allobasis, and 3-segmented endopod. Armature of praecoxal and coxal endites 5, 3, 3, 3, respectively. Basal endite with 4 setae, one stouter than the rest; endopodal endite with 1 distal seta. Free endopod with 7 setae.

Maxilliped (fig. 2d) 7-segmented, with syncoxa, basis plus partially incorporated first endopodal segment, and free 5-segmented endopod. Syncoxa with 1, 2, 3, 4 setae on medial margin. Basoendopod slightly shorter than preceding segment, with 3 + 2 setae; medial row of fine spinules on proximal surface of segment. Free endopod setal formula: 3, 4, 3, 3 + 1, 3 + 1. Syncoxa ornamented with row of fine spinules on inner distal surface.

Swimming legs 1-4 (fig. 3a-d) progressively larger towards the posterior, each comprising coxa, basis, and 3-segmented exopod; endopod of first leg (fig. 3a) 2-segmented; endopods of second, third, and fourth legs (fig. 3b-d) 3-segmented. Seta on distomedial angle of basis of leg 1 slender, longer than ramus (fig. 3a); outer spines on exopod of leg 1 slender, needle-like (fig. 3a); outer spines on

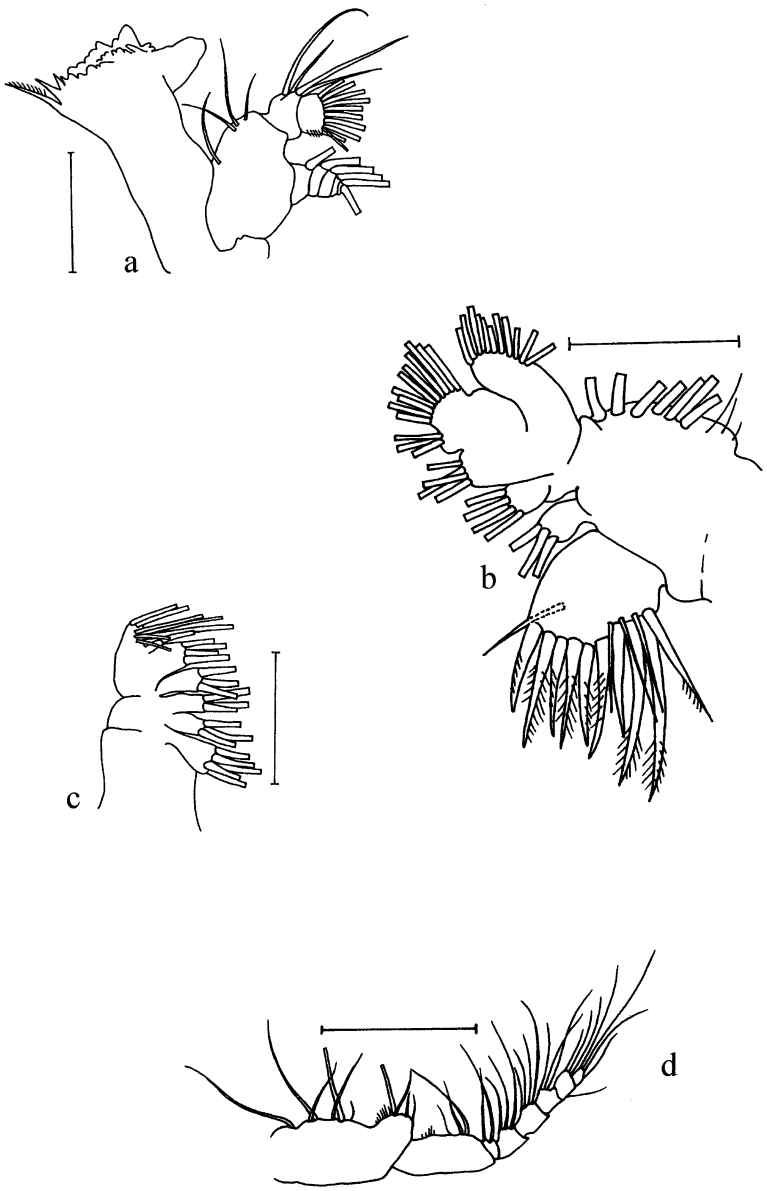

Fig. 2. *Bestiolina arabica* sp. nov., female. a, mandible; b, maxillule; c, maxilla; d; maxilliped. Scale bars: a-c, 0.05 mm; d, 0.01 mm.

exopods of legs 2-4 short, sigmoid in shape (fig. 3b-d). Terminal spine on exopods of leg 1 longer than entire ramus. Armature of the legs as stated in table I.

Swimming legs 1-4 (fig. 3a-d) ornamentation as follows: leg 1 coxa with patches of fine spinules on inner and outer margins as figured (fig. 3a), first exopodal segment with tiny outer margin spinule, second exopodal segment with row of

TABLE I
Armature of the swimming legs of *Bestiolina arabica* sp. nov. female

	Coxa	Basis	Exopodal segments			Endopodal segments		
			1	2	3	1	2	3
Leg 1	0-0	0-1	0-1	0-1	II, I, 4	0-1	1, 2, 2	
Leg 2	0-1	0-0	I-1	I-1	III, I, 5	0-1	0-2	1, 2, 3
Legs 3, 4	0-1	0-0	I-1	I-1	III, I, 5	0-1	0-2	1, 2, 3

Arabic numerals represent setae; Roman numerals indicate spines.

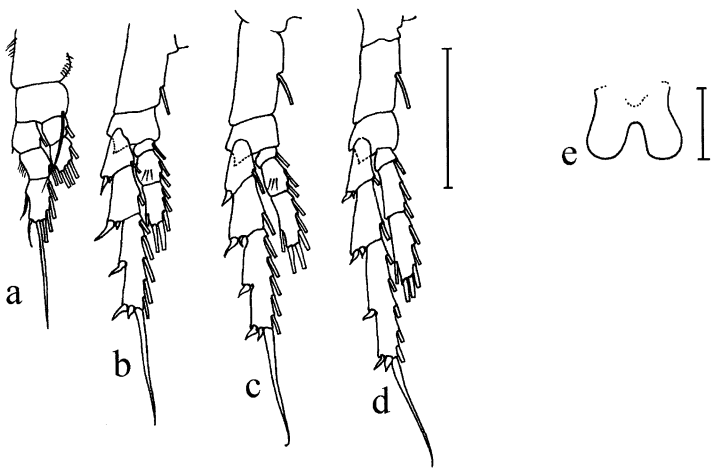

Fig. 3. *Bestiolina arabica* sp. nov., female. a, leg 1; b, leg 2; c, leg 3; d, leg 4; e, leg 5. Scale bars: a-d, 0.01 mm; e, 0.05 mm.

outer hair-like spinules. Leg 2 and leg 3 each with 3 large spinules on the anterior surface of the second endopodal segment. Fifth legs (fig. 3e) strongly reduced, represented by a pair of rounded lobes lacking any vestige of segmentation or armature.

Description of male. — Total body length 0.79-0.90 mm, based on 8 specimens. Cephalosome and first pedigerous somite fused as in female (fig. 4a, b). Dorsal cephalic hump visible in lateral view (fig. 4b), located at level just posterior to bases of antennules. Somites 4 and 5 completely separate, with posterolateral corners rounded and symmetrical. Rostrum bifid and solid, more slender than in female (fig. 4c). Body widest at incorporated first pedigerous somite; ratio of prosome to urosome length ca. 2.4 : 1. Urosome of 5 somites, with short genital somite carrying single genital aperture on left side (fig. 4d). First abdominal somite longer than second and third; anal somite with weakly developed anal operculum. Caudal rami (fig. 4d) symmetrical, about 2 times as long as wide, with 4 distal setae and 1 reduced seta distally on medial margin.

Antennules (fig. 4b) non-geniculate; long and symmetrical, extending about as far as mid-urosome; 19-segmented with the presence of vestige of articulation in segment 1 (ancestral segments I-IV), XI-XII (although vestige of articulation between segments expressed antero-dorsally) and XXVII-XXVIII. Armature formula of segments similar to that in female with respect to ancestral segments, since generally the setation in males and females of the Paracalanidae is similar.

Antenna (fig. 4e) biramous but with modified exopod. Basis with 1 seta on distomedial angle. Exopod indistinctly segmented: elongate proximal segment carrying 1 seta; middle part of ramus with incompletely expressed segmentation and armed with total of 4 setae; distal segment small, knob-like, unarmed. Endopod 2-segmented; proximal segment with single distal seta, bilobed compound distal segment bearing 5 setae on inner lobe and 6 setae on distal lobe.

Maxilliped (fig. 4f) 4-segmented: proximal segments robust, longer than wide, unarmed; second segment ornamented with patch of fine spinules distally, third segment slender, armed with 2 short inner setae and single long, reflexed outer seta; apical segment with 3 setae, outer longer and more robust than other two. Mandible, maxillule, and maxilla highly reduced.

Swimming legs' ornamentation (fig. 4g-j) as in female, except: leg 1 coxa lacking patches of fine spinules on inner and outer margins, outer margins of first and second exopodal segments unornamented. Legs 2 and 3 each with 4 large spinules on anterior surface of second endopodal segment.

Fifth legs strongly asymmetrical; right leg rudimentary, left leg uniramous and slender, longer than urosome (fig. 4k). Right leg reduced to unarmed, rounded lobe. Left leg 5-segmented: relative lengths of segments 1.4 : 2 : 2.4 : 2.1 : 1. Segments 1 (coxa) and 2 (basis) more robust than exopodal segments; first exopodal segment unarmed; second exopodal segment drawn out into pointed process at outer distal angle; apical segment terminating in 2 spines, inner 5 times as long as outer and 0.8 times as long as the segment.

Etymology. — The new species is named with respect to the land "Arabia" that lies on the western side of the Arabian Gulf.

DISCUSSION

The species described is referred to the genus *Bestiolina* Andronov, 1991 because of the shape and construction of the fifth legs in both sexes. In the female, these are always present as two reduced rounded lobes only, while in the male the right fifth leg is a reduced rounded lobe and the left leg is 5-segmented, of which the last segment has 2 spines, the inner one longer than the outer. Another

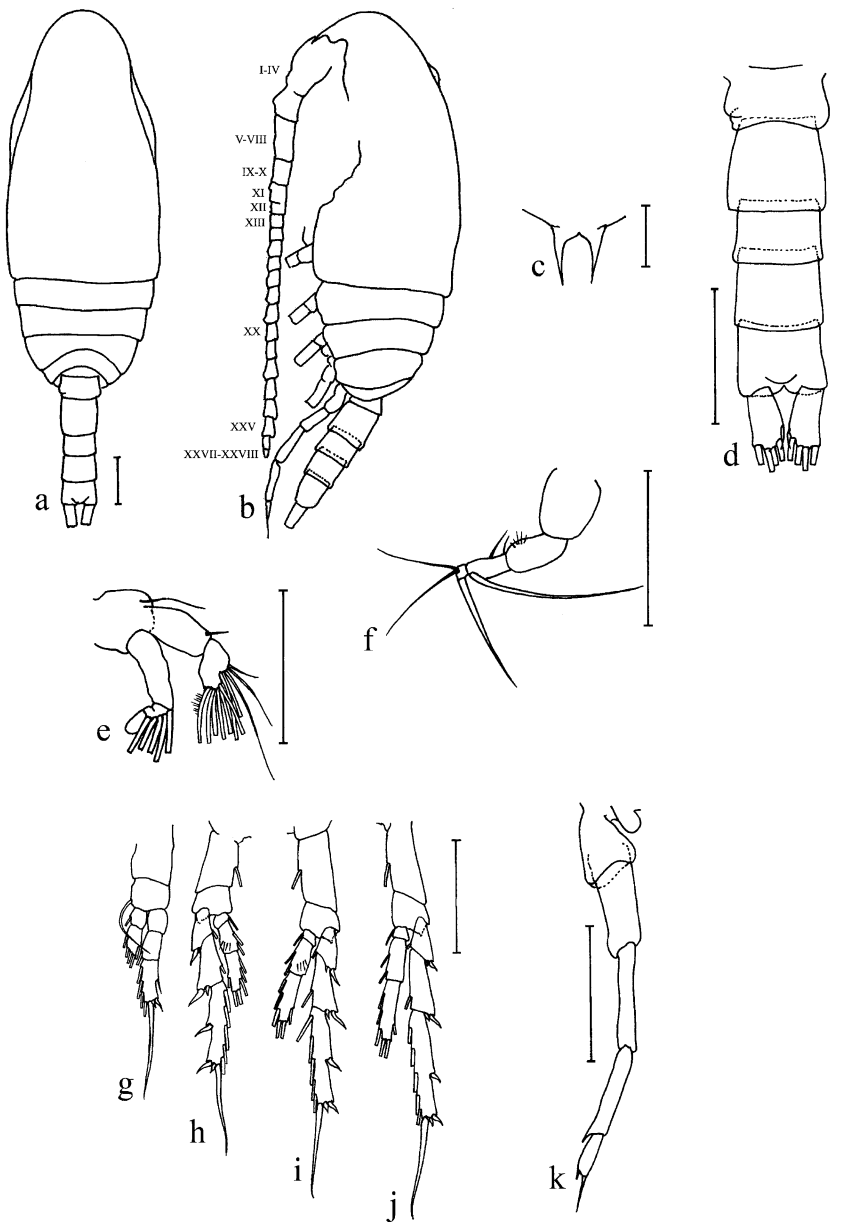

Fig. 4. *Bestiolina arabica* sp. nov., male. a, dorsal view; b, lateral view; c, rostrum; d, urosome dorsal view; e, antenna; f, maxilliped; g, leg 1; h, leg 2; i, leg 3; j, leg 4; k, leg 5. Scale bars: a, b, d-k, 0.01 mm; c, 0.05 mm.

characteristic feature of the genus *Bestiolina* is the absence of serration on the exopods of legs 1-4. These differences separate it from other Paracalanidae such as *Acrocalanus* Giesbrecht, 1888, *Paracalanus* Boeck, 1865, and *Parvocalanus*

TABLE II

Presence and number of spinules on the anterior surface of the exopods and endopods of legs 2-4 of the six described *Bestiolina* females

Character	Swimming leg (P)	*B. amoyensis* (Li & Xuang, 1984), ♀	*B. arabica* sp. nov., ♀	*B. inermis* (Sewell, 1912), ♀	*B. similis* (Sewell, 1914), ♀	*B. sinica* (Shen & Lee, 1966), ♀	*B. zeylonica* (Andronov, 1972), ♀
Number of spinules on the anterior surface of exopodal segments 1-3 of legs 2-4	P2	2, 1, 1	None	0, 3, 0	0, 0, 3	None	3, 3, 2
	P3	1, 1, 2	None	?	0, 0, 3	None	0, 3, 2
	P4	1, 2, 1	None	?	None	None	None
Number of spinules on the anterior surface of the second endopodal segment of legs 2-4	P2	5	3	4	5 with marginal serration	4 + 4 marginal spinules	4
	P3	4	3	?	5 with marginal serration	5 + 4 marginal spinules	4 + 3 marginal spinules
	P4	None; with small marginal serration	None	?	None	4 marginal spinules	None; with small marginal serration

Andronov, 1970 (cf. Giesbrecht, 1893; Sewell, 1912, 1914; Shen & Lee, 1966; Andronov, 1972a, b; Li & Xuang, 1984; Bradford-Grieve et al., 1999).

However, *Bestiolina arabica* has its own distinguishing features when compared to the other members of its genus. The most obvious difference from all other species is the presence and number of anterior spinules on endopodal segment 2 of legs 2-3, and the absence of marginal spinules from the specified locations plus the absence of anterior spinules from exopodal segments 1-3 of legs 2-4. These differences are shown in table II. The comparison in that table relates only to females of the various species, because most of the literature concentrates on detailed description of the females rather than of the males.

In the *B. arabica* female, the first exopod segment of leg 1 has a small outer spine, as in all other *Bestiolina* spp. except *B. sinica* (Shen & Lee, 1966). In the *B. sinica* female, endopod segment 2 of leg 4 has 4 marginal spinules and is devoid of anterior spinules (Shen & Lee, 1966), while the marginal spinules are absent in *B. arabica* females. If compared with the female of *B. zeylonica* Andronov, 1972, the

basis of leg 3 has 3 spinules and the lower inner margin of endopodal segment 2 of leg 4 is serrated (Andronov, 1972b); in *B. arabica*, these characteristics are not found.

In *B. zeylonica* females, 3 spinules are present on pedigerous somite 5, in lateral view, and this character does not apply to *B. arabica*. In the *B. arabica* female, the widest region of the genital somite in dorsal view is in its middle part, while in *B. sinica* it is in the posterior part.

In *B. arabica* males, the location of the "hump" in lateral view is in the middle of the distance between the anterior end of the head and the border of pedigerous somite 2, as in *B. similis* (Sewell, 1914) (cf. Sewell, 1914), whereas in *B. sinica* and *B. zeylonica* the most prominent part of the "hump" is located more anteriorly (Shen & Lee, 1966; Andronov, 1972b), and in *B. inermis* (Sewell, 1912), more posteriorly (Sewell, 1912). *B. amoyensis* Li & Xuang, 1984 is not gibbous dorsally (Li & Xuang, 1984).

In *B. arabica* males, the second endopodal segments of legs 2 and 3 have 4 anterior spinules, while the exopods of legs 1-4 are devoid of anterior spinules. Endopodal segment 2 of leg 4 is also devoid of anterior spinules and the endopodal segments 2 of legs 2-4 lack marginal spinules. These characters are not found in any other described male of *Bestiolina*.

This is the first report of the genus from the Arabian Gulf, although it is known that members of *Bestiolina* are found in estuarine habitats also in this region of the world (Sewell, 1912, 1914; Shen & Lee, 1966; Andronov, 1972b; Li & Xuang, 1984; McKinnon et al., 2003). It seems that, until now, nobody has been interested to conduct such precise studies regarding the Paracalanidae in the Arabian Gulf in general, and especially not around Bubiyan Island, since this is the first time that the copepod community around Bubiyan Island has been studied. As a result, *Bestiolina* may have been identified before under the name of *Acrocalanus*, whence the literature described *Bestiolina* species as *Acrocalanus* until Andronov (1972b) established this taxon as a new paracalanid genus under the name *Bestiola*, which has subsequently been changed to *Bestiolina* (cf. Andronov, 1991).

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