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A NEW SPECIES OF PARASITIC COPEPOD, *SPHAERONELLA KEPPELENSIS* N.SP. (SIPHONOSTOMATOIDA: NICOTHOIDAE), FROM THE AMPHIPOD *ORCHOMENE NANUS* (KROYER, 1846) IN THE FIRTH OF CLYDE, SCOTLAND.

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INTRODUCTION

The copepod genus *Sphaeronella* Salensky, 1868 contains over 70 species which live as parasites mainly within the marsupium of marine peracarid crustaceans. Over 40 species are recorded from amphipods (Costello & Myers,1989) with around a dozen of these from amphipods in British Waters (Gotto, 1993, O'Reilly & Geddes, 2000, O'Reilly *et al.*,2001).

In 1993-94 during a study of the amphipod *Orchomene nanus* (Fam. Lysianassidae) undertaken at the University Marine Biological Station, Millport, a small number of the amphipods were found to be infested with copepods which were tentatively identified as *S.callisomae* Scott, 1904 - a species inadequately described almost 100 years ago by Thomas Scott. Of 990 amphipods examined only 8 were found to be parasitised (Moore & Wong, 1996). As the copepod has never been recorded since its original description, the opportunity was taken to undertake a full description of the female, the first description of the male, and also the first description of the copepodite stage. On completion of the descriptive work some new *S.callisomae* material was recovered from the amphipod *Scopelocheiros hopei* (Fam. Lysianassidae) collected in Loch Riddon, in the Firth of Clyde. This amphipod was the original host species of *S.callisomae* and examination of the new material, a mature female and 3 copepodites, revealed an excellent match to Scott's original description. However, it also indicated that the copepod from *Orchomene nanus* actually exhibited significant differences from *S.callisomae*, and indeed from all other known *Sphaeronella* and thus it was considered necessary to establish a new species. The new species is described here. Its congener, *S.callisomae*, will be re-described in a subsequent work.

METHODS

The hosts and parasites were fixed in 10% formalin before transfer to methylated spirit for storage. The copepods were examined as temporary whole mounts in lactic acid or permanent mounts in polyvinyl lactophenol. Drawings were executed at magnifications up to x1,000 with the aid of phase contrast and a camera lucida drawing tube. Host nomenclature follows Costello & Myers (1989).

Sphaeronella keppelensis n.sp.

Material examined

All collected at Keppel Bight, Millport, Isle of Cumbrae, Firth of Clyde (55° 45.75'N, 04°54.48'W), depth 5-6m. (Each sample represents a single host amphipod)

Material deposited in the National Museum of Scotland, Edinburgh:

Sample T33 C9 - 19/4/94 - **Holotype** - 1 female, mature + 1 ovisac (NMSZ 2002.111.1)

Sample T24 B8 - 9/12/93 - **Allotype** - 1 male, mature, mounted on slide (NMSZ 2002.111.2)

Sample T7 A3 - 20/5/93 - **Paratype** - 1 female mature, cephalon dissected and mounted on slide (NMSZ 2002.111.3)

Sample T19 B1 - 22/9/93 - **Paratype** - 1 female immature (NMSZ 2002.111.4), 9 copepodites mounted on slide (NMSZ 2002.111.5), 2 unmounted copepodites (NMSZ 2002.111.6-7), and host amphipod *(Orchomene nanus)*

Sample T26 B3 - 22/2/94 - **Paratype** - 1 female mature + 4 ovisacs (NMSZ 2002.111.8).

Additional material retained in author's collection:

Sample T21 B1 - 26/10/93 - 4 ovisacs (copepod missing!).

Sample T22 B3 - 9/11/93 - 1 female, mature (mounted on slide, poor condition), 1 copepodite dissected and mounted on slide.

Sample T24 B8 - 9/12/93 - 1 female mature (poor condition) + 3 ovisacs, 1 female, immature, mounted on slide.

Etymology:

Named after the type locality - Keppel Bight.

DESCRIPTION

Female (Fig. 1. a, b): Body subspherical comprising a large spherical trunk and a small protruding head. Maximum length 0.85 mm, maximum width 0.72 mm. Ovisacs, irregularly ovoid, detached from female, diameters 0.4-0.5 mm. Cephalon (Fig. 2.a) with naked frontal margin, lateral border margins with fine hairs. First antennae, A.1 (Fig. 2.a,c) relatively short, 3-segmented; proximal segment with 3 setae distally; second segment much shorter without setae, third segment with 9 setae and an aesthetasc (chemosensory appendage). Second antennae, A.2 (Fig. 2.a,b) reduced, comprising a single segment surmounted by a long seta. Oral disc (Fig. 2.a) encircled with fine hairs, with central aperture

through which the tips of the mandibles, Md, are visible. First maxillae, Mx.1 (Fig. 2.a) with 2 long filamentous processes directed anteriorly and a shorter filament on the inner edge. Second maxillae, Mx.2 (Fig. 2.a,d) 2-segmented; proximal segment (syncoxa) robust with stout median process on posterior surface and a row of spinules adjacent to articulation with distal segment; distal segment (basis) forms a curved claw, surmounted with fine curved spine-like process. Maxillipeds, Mxpd (Fig. 2.a) 3-segmented, first segment stout, elongate, with transverse row of fine setules proximally and another row medially on anterior face, second segment considerably smaller with short spine distally on inner edge, third segment curved with minutely tridentate tip. Ratio of maxilliped segments approximately 5:2:1.5. Maxillipeds in paratype (Fig. 2.e) apparently with shorter first segment and 2 spines distally on second segment. The sub-median skeleton (Fig. 2.a) is just visible (dotted) extending back from the base of the first maxillae. Two distinct parallel chitinous ridges are visible between the second maxillae and extend between the base of the maxillipeds to form acute triangular processes. A weak transverse chitinous bar occurs posterior to the maxillipeds.

Trunk (Fig. 1.b) with small spinules scattered throughout. Legs minute (Fig. 3.a,b), consisting of a single short segment with 1-2 setae apically. In the first legs, L.1, the setae are approximately equal in length but the inner seta is much stouter than the outer. Second leg, L.2, a little smaller, the setae are of similar thickness but the outer one is about twice the length of the inner, although 1 seta is sometimes missing. First legs occasionally with an extra seta (Fig. 3.c). The genital area (Fig. 3.d), is mostly covered with spinules through which a pair of oval seminal receptacles and semi-circular genital apertures are visible. The spinules extend posteriorly between the genital apertures towards the caudal rami. The caudal rami (Fig. 3.d,e,f) are short with pronounced conical process on the distal inner edge, and each ramus is ornamented with 2 naked setae, which are about 2-3 times the length of the ramus.

Male: (Fig. 1.c, 2,g) Body small, rhomboidal, maximum length 0.28 mm, maximum width 0.23 mm, head and trunk region each comprising around half of the body. Anteriorly the head is produced medially into a bilobed pseudorostrum. It has pronounced lateral lobes between the pseudorostrum and the first antennae. Lateral lobes, naked ventrally but covered in fine spinules dorsally. The spinule patch is observable even when viewed ventrally through the lateral lobes giving the lobes a dotted appearance. A tuft of these spinules extends around ventrally on either side at the base of the pseudorostrum.

The cephalic shield forms a cape, which partly conceals the base of the second maxillae. The shield margins are ornamented with fine spinules. The exterior border ("shoulder") area is covered with numerous conspicuous nodules.

First and second antennae, oral disc, and first and second maxillae, apparently similar to female, although some details difficult to observe. Maxillipeds similar to female but first segment stouter and with row of fine setules distally at articulation with second segment, and third segment claw is strongly bidentate. The chitinous processes between the base of the maxillipeds are produced posteriorly into two strong spines.

The trunk region is densely covered with long spinules, except for its anterior part. The legs are reduced and very difficult to see. The first legs are mostly concealed by the base of the maxillipeds. The interpretation shown (Fig. 3.h) was gained by focusing through the maxilliped and may not be entirely accurate. Apparently comprising an inner an outer branch with a short rounded lobe between them. The branches have 2 and 3 short apical setae respectively with a longer seta at the base of the inner branch and also on the medial lobe. The second legs (Fig. 3.i) are party obscured by the dense abdominal spinulation. They comprise 2 short simple branches, the inner a little shorter, and each branch with a stout apical seta.

The large oval paired spermathecae are visible through the body wall between the legs. The caudal rami are placed close together at the posterior end of the body. Their structure is similar to the female with the distinctive conical process, though the seta are a little longer.

Copepodite: (Fig. 4.a) Length 0.19 mm (excluding caudal setae), width 0.15 mm, cephalothorax oval, dorsally shield like, covering almost the entire body, only the last 2 segments of the urosome and the caudal rami protruding. The dorsal surface is finely granular with a transverse suture around the midpoint. The dorsal margin has 4 pairs of long setules positioned symmetrically, on anterior margin, and laterally level with the oral cone, mid-dorsal suture, and legs. Frontal border with narrow rostral brim, and a pair of shorter setules ventrally. Lateral margins slightly in-rolled ventrally.

First antennae(Fig. 4.b) similar to adult but setae and aesthetasc on third segment much longer. Second antennae (Fig. 4.c) 4-segmented with 2 terminal setae on distal segment. Oral disc and first maxillae apparently similar to adult. Second maxillae (Fig. 4.d) 3-segmented. First segment stout with row of fine setules, second segment narrow elongate, third segment forming a curved claw. Maxillipeds (Fig. 4.e) 4-segmented, first segment naked, greatly enlarged, second and third segment considerably smaller, third segment with a long seta distally which lies parallel to (and is around 75% the length of) the fourth segment which forms a long slender claw. Ratio of maxilliped segments approximately 9:1:1:6.

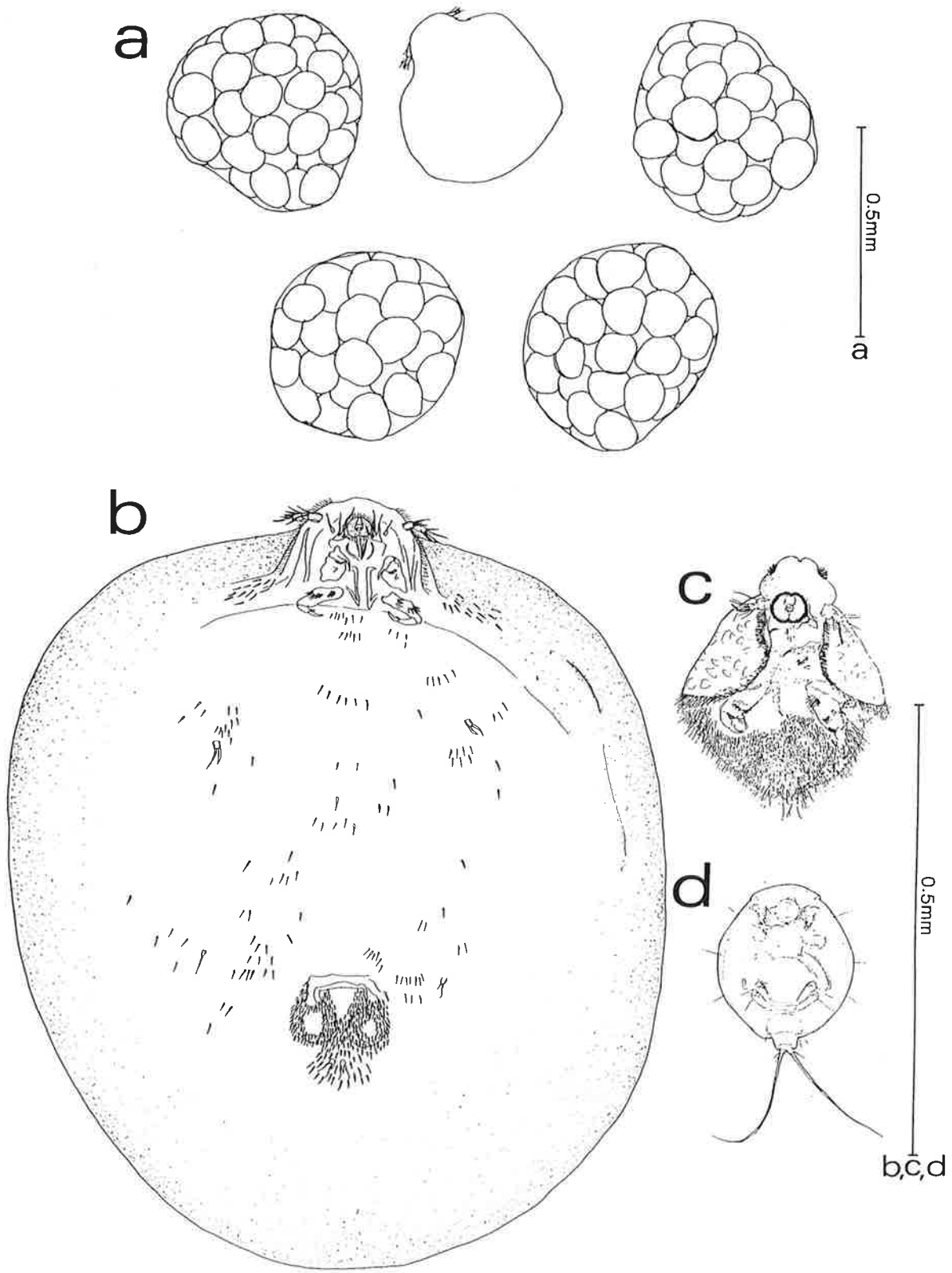

Figure 1: *Sphaeronella keppelensis* n.sp. - **a) Paratype** - Female gravid (T.26 B3) dorsal, with ovisacs, **b) Holotype** - Female gravid (T.33 C9), habitus ventral **c) Allotype** - Male (T.24 B8), habitus, ventral, to scale, **d)** Copepodite (T.19 B1) - habitus, ventral, to scale.

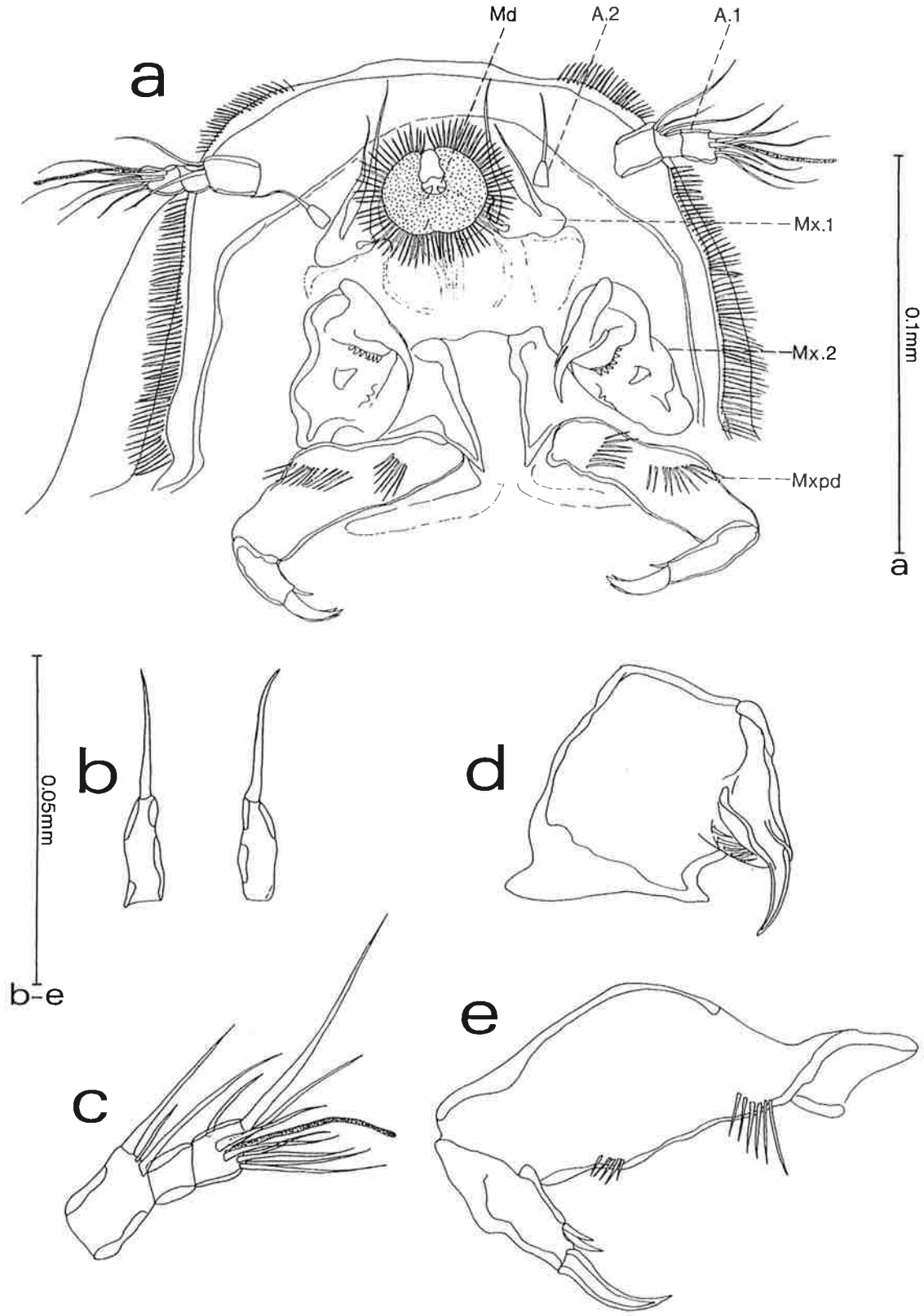

Figure 2: *Sphaeronella keppelensis* n.sp. - **a) Holotype** - Female, mature (T.33 C9) - cephalon, ventral, Md.- mandible, A.2 - second antenna, A.1 - first antenna, Mx.1 - first maxilla, Mx.2 second maxilla, Mxpd.- maxilleped, **b) Paratype** - Female (T.7 A3) - right & left second antennae (A.2), **c)** Female (T.24 B8) - first antenna (A.1), left, **d) Paratype** - Female (T.7 A3) - second maxilla (Mx.2), left, anterior view, **e) Paratype** - Female (T.7 A3) - maxilliped (Mxpd.).

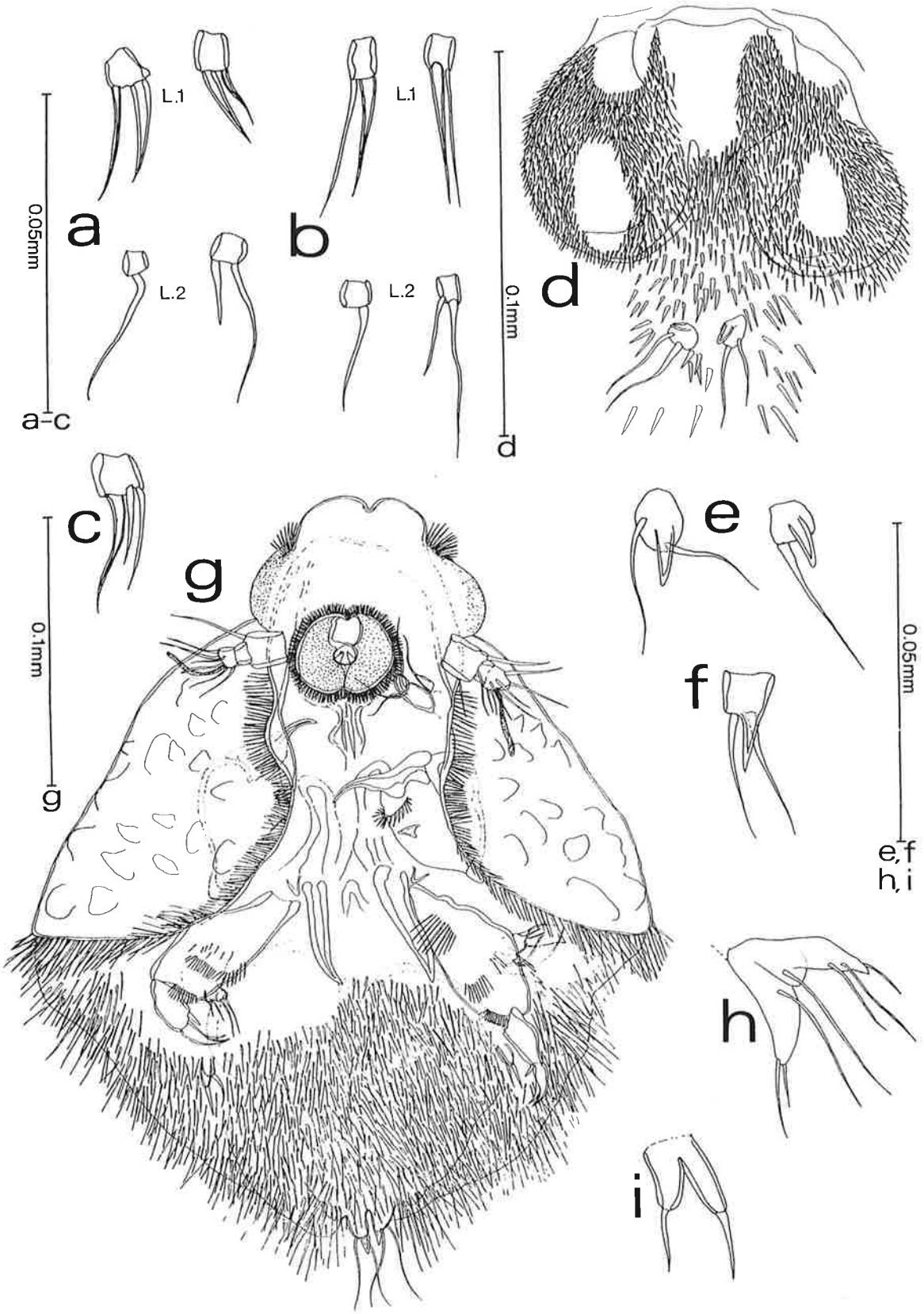

Figure 3: *Sphaeronella keppelensis* n.sp. - **a) Holotype** - Female (T.33 C9) -1st and 2nd leg pairs, **b) Paratype** - Female (T.26 B3) -1st and 2nd leg pairs, **c)** Female (T.24 B8) -1st leg right, **d) Holotype** - Female (T.33 C9) - genital area and caudal rami, **e) Paratype** - Female (T.26 B3) - caudal rami, **f)** Female (T.24 B8) - caudal ramus, right, **g) Allotype** - Male (T.24 B8), habitus, ventral, right A.2 and Mx.1 omitted, **h)** Male (T.24 B8), first leg, left, interpretation, **i)** Male (T.24 B8), second leg, left, interpretation.

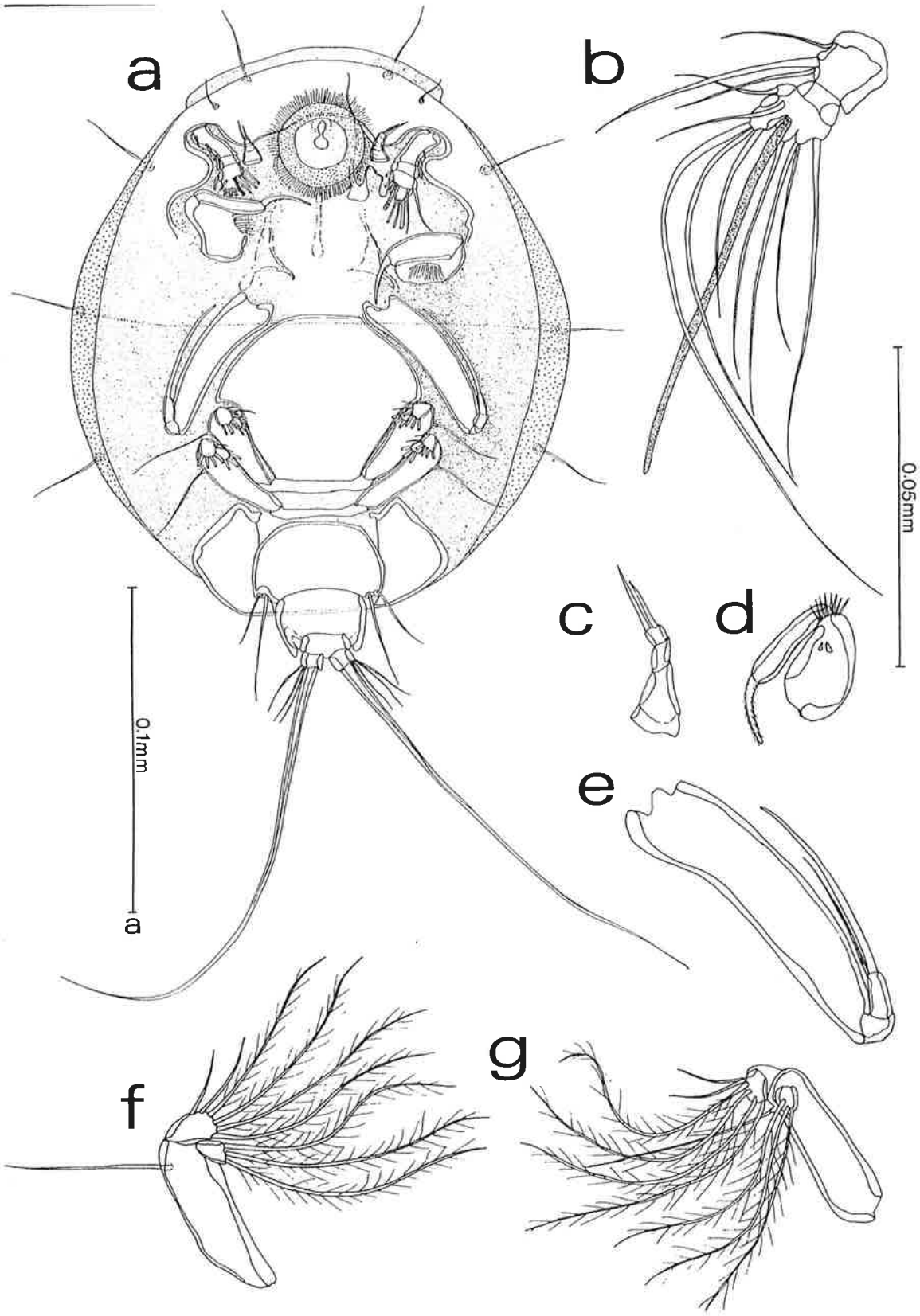

Figure 4: *Sphaeronella keppelensis* n.sp - Copepodite (T.19 B1) **a)** habitus, ventral, (A1 & leg setae truncated), **b)** first antenna (A.1), right, **c)** second antenna (A.2), right, **d)** second maxilla (Mx.2), left, **e)** Maxilliped (Mxpd.), left, **f)** left leg, rami & setae folded inwards, **g)** left leg, rami & setae folded outwards.

A medial prosomal swelling forms an approximate hexagonal shape between the maxillipeds and the legs. It has a smooth surface and is without furrows exhibited by copepodites in many other species of *Sphaeronella.*

There are 2 pairs of biramous legs (Fig. 4.f,g) which are similar in structure, each pair joined ventrally by a narrow intercoxal plate. They have a long basal segment with a single long seta distally on the outer edge. The inner ramus (endopod) is very small with 3 long plumose setae. The outer ramus (exopodite) is a little larger with 4 long plumose setae and 2 shorter naked setae on outer edge. The first legs are incorporated into the cephalosome. The somite of the second legs expands laterally and posteriorly where it form the rear edge of the cephalothorarax.

The urosome comprises 3 segments of decreasing size, and a pair of caudal rami. The first segment has 2 pairs of setae distally on the outer edges. The second and third urosomal segments are un-ornamented. The caudal rami each have 3 relatively short lateral setae and an extremely long inner seta, which is around 75% the length of the cephalothorax.

DISCUSSION

The *S.keppelensis* material was initially attributed to *S.callisomae* on the basis of the unusual combination of a 3-segmented maxilliped with 3-segmented first antennae and 1-segmented second antennae. Its utilisation of a lysianassid host, and its occurrence in the same Sea area added weight to this assertion.

However, Scott's description of his single female of *S.callisomae* does show some significant differences from *S.keppelensis*. The most notable of these is the presence of a "conspicuous tubercle" projecting from the frontal border of the cephalon of *S.callisomae*. In addition its first antennae has only a single setae on the first segment, and a longer third segment with 7 setae (and no aesthetasc). The size and shape of the first and second maxillae also appear to be slightly different and the maxilliped has a shorter basal segment with some spinulation at the articulation with the second segment. Preliminary examination of the new *S.callisomae* female from Loch Riddon substantiates these differences.

Bradford (1975) tabulated the then known species of *Sphaeronella* described from amphipods (41 spp.), isopods (7 spp.), cumaceans (7 spp.), and ostracods (17 spp.) and arranged them into groups based on key features of their morphology. Among these she recognised one group of eight amphipod-infesting species, where the females have a 3-segmented maxilliped (and 3-segmented first antennae), as shown in Table 1.

This group which can informally be called the "*S.giardii* Group" is also characterised by males in which the legs are relatively small with short setae (although males are only known for *S.giardii, S.bonnieri, S.aeginae,* and *S.longipes*). The inclusion of *S.valida* in the group is based on the re-description by Green (1958) who figures a 3-segmented maxilliped, although the original figure of Scott (1905) is clearly 4-segmented. Among five species considered by Bradford as "not well described" and not placed in any group were *S.callisomae* and *S.cluthae* both described from the Firth of Clyde by Scott (1904). They are depicted by Scott with 3-segmented maxillipeds suggesting they ought to belong to the "*S.giardii* Group". The description and figure of the maxilliped of a third species, *S.pilosa* Blake, 1929, is unclear although it shares the same host species (and geographical location) as *S.photidas.*

Table 1. *Sphaeronella* species of the "*S. giardii* Group"

***S. giardii* Hansen, 1897**
Host *Protomedeia fasciata*
Locality Denmark

***S. bonnieri* Hansen, 1897**
Host *Protomedeia fasciata*
Locality West Greenland

***S. longipes* Hansen, 1897**
Host *Ampelisca tenuicornis*
Locality Denmark, British Isles

***S. amphilochi* Hansen, 1897**
Host *Paramphilochoides odontonyx*
Locality Denmark, British Isles

***S. dulichiae* Hansen, 1897**
Host *Dyopedos monacanthus*
Locality Denmark

***S. valida* Scott, 1905**
Host *Megamphopus cornutus*
Locality British Isles

***S. aeginae* Hansen, 1923**
Host *Aeginina longicornis*
Locality Iceland / Faroes

***S. photidis* Blake, 1929**
Host *Photis reinhardi*
Locality New England, USA

It is clear that *S.keppelensis* should also be included in the "*S.giardii* Group" based on the female maxillipeds and reduced male legs. In addition to the 3-segmented maxilliped *S.keppelensis* possesses two features which are unusual within the group; the 1-segmented second antennae and the conical process on the caudal rami. These characters are exhibited by both sexes. The 1-segmented second antennae appears to be shared only with *S.callisomae* whilst the conical process appears to be unique within the group. It is impossible to compare adequately the new *S.keppelensis* material with *S.cluthae*, known by a single female from the amphipod *Harpinia pectinata* (Fam. Phoxocephalidae). Only the habitus (lateral and dorsal) and maxilliped of *S.cluthae* were figured, although the latter is not inconsistent with *S.keppelensis* there is insufficient information overall to draw any inference regarding the affinity of *S.cluthae.*

The male *S.keppelensis* has additional features which also appear to be unique within the "*S.giardii* Group", notably the pronounced bilobed pseudorostrum and lateral lobes of the cephalon and also the conspicuous nodules on the exterior border area. The male has 3-segmented maxillipeds in common with the female but this does not appear to be the case in all males of the "*S.giardii* Group" as *S.giardii* and *S.aeginae* males are figured with 4-segmented maxillipeds. The legs of the male *S.keppelensis* appear to be generally similar to *S.bonnieri.*

The larval or copepodite stage has only been described for around a third of *Sphaeronella* species: 10 from amphipods, 3 from isopods, 5 from cumaceans, and 9 from ostracods (including 2 among the latter for which only the copepodite stage is known).

In almost all *Sphaeronella* copepodites the entire urosome protrudes beyond the cephalothorax, the only exception being *S.bradfordae* Boxshall & Lincoln, 1983 (an isopod parasite) where only the setae of the caudal rami protrude. *S.keppelensis* falls between these two extremes with just the tip of the urosome visible in dorsal view. The legs of the *S.keppelensis* copepodite are also unique with their reduced rami bearing only plumose or shorter simple setae. All other described *Sphaeronella* copepodites have legs with elongate rami (as long as or longer than the basal segment) and possess both plumose setae on the inner edge and spines or simple setae on the outer edge. Similar reduced rami are present in the copepodite of *Sphaeronelliodes vargulae* Bradford, 1975, sole representative of an allied genus from an Antarctic ostracod, but the basal segments of its legs are much shorter and its urosome is only 2-segmented with the caudal rami fused to the last segment. These, along with other unusual features of the mature female *Sphaeronelliodes,* warranted its separation as a distinct genus. It is apparent then that *S.keppelensis* is clearly different from any other described *Sphaeronella* species with both the female and male, as well as the copepodite stage, exhibiting distinctive morphologies.

Most *Sphaeronella* appear to be relatively host-specific occurring in only one or two allied host species. *Orchomene nanus* and *Scopelocheirus hopei* occupy a similar niche as scavengers and were recently found to be the dominant amphipods in carrion-baited traps in the Firth of Clyde (Bergmann *et al.,* 2002). In view of their close association, both phylogenetically and ecologically, it is not surprising that their copepod parasites may also be closely related. Only two other *Sphaeronella* species have been described from lysianassoid amphipods: *S.norvegica* Hansen, 1905 from *Tmetonyx similis* collected in Norway and *S.australis* Boxshall & Harrison, 1988 from the genus *Amaryllis* collected in Tasmania. However, both of these have 4-segmented maxillipeds excluding them from the "*S.giardii* Group".

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