

ON SOME OVIPAROUS FILARIAL NEMATODES MAINLY FROM AUSTRALIAN BIRDS⁽¹⁾

by

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ABSTRACT

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Three groups of filarial nematodes are represented in this collection.

1. Aproctinae.

Four species are described: *Pseudaprocta copemani* n.sp. from *Petroica multicolor*; *Aprocta boulengeri* n.sp. from *Strepera graculina*; *Aprocta bakeri* n.sp. from *Corvus orru*; *Lissonema* sp. from *Ninox novaeseelandiae*.

Pseudaprocta is regarded as being closely linked with the Seuratoidea.

The species assigned to *Aprocta* are heterogeneous, falling into two distinct morphological groups, one of which corresponds with the genus *Lissonema*, which is therefore reinstated. *Aprocta* spp. have a short ovejector, small caudal papillae in males, spicules generally subequal with fine distal extremities, no deirids, small eggs (less than 55 µm long), short larvae (around 200 µm long) with short tail bearing terminal spines. *Lissonema* spp. have a long ovejector, at least one large caudal papilla in male, spicules usually equal, with large blunt distal extremities, deirids, large eggs (more than 65 µm long), long larvae (more than 400 µm long) with long unarmed tail. The genus *Squamofilaria* is regarded as a synonym of *Lissonema* and its species are shown to belong either to *Lissonema* or *Aprocta*. *Lissonema* contains 20 spp. (19 n. comb.) and *Aprocta* 17 spp. (2 n. comb). The host ranges of these two genera are completely different.

2. Dicheilonematinae.

Serratospiculum guttatum (Schneider, 1866) from *Falco longipennis* and *F. peregrinus*, and *S. tendo* (Nitzsch, 1819) from *F. peregrinus* are redescribed. *S. seurati* n.sp. is described.

Serratospiculum, parasites of Falconidae, contains a total of seven species. These species fall within two groups depending on the spicule length. (1) Those

with short spicules are separated further, in that *S. turkestanicum* Skrjabin, 1916, *S. guttatum*, *S. kwangsiensis* Hsü, 1963, possess specific cuticular ornamentations in the female; while *S. chungii* Hoeppli et Hsü, 1929, *S. seurati* n.sp. (= *F. attenuata* Rud., 1819 *sensu* Seurat, 1915), *S. congolensis* Vuylstecke 1957, are distinguished by the morphology of the epaulettes and the right spicule; (2) those with long spicules: *S. tendo* (= ? *S. thoracis* Tubanguai, 1934; = ? *S. lii* Ezzat et Tadros, 1958).

3. Diplotrieninae.

Three species are described: *D. spratti* n.sp. from *Oreoica gutturalis*, *D. beveridgei* n.sp. from *Corvus orru*, and *D. smithi* n.sp. from *Acanthogenys rufogularis*. Additional morphology is given for *D. delta* Johnston and Mawson, 1940 and *D. falconis* (Connal, 1912).

DEPOSITION OF TYPE MATERIAL

Holotypes and allotypes have been deposited in the South Australian Museum, Adelaide; (SAM in text); other material has been deposited as noted, in the Muséum National d'Histoire Naturelle, Paris (MNHN) and in the Australian Helminthological Collection (AHC) at present housed in the South Australian Museum.

In the species described here, the female has been designated as holotype, and the male as allotype. This is because the family, genera and species of filarial worms are more often identified by the female than by the male.

DESCRIPTION OF MATERIAL

I. Aproctoidea—Aproctinae

Genus *Pseudaprocta* Schikhobalova

The morphological characters of the genus *Pseudaprocta* are closer to those of Seuratoidea Ascaridida than of Spirurida (Chabaud, 1974): mouth large and triangular, six external labial papillae, situated on the same circle as the cephalic papillae, oesophagus short and very thick, without

⁽¹⁾ This study was carried out while working under a grant (to O.B.) from the World Health Organisation.

differentiation into two parts, spicules equal and simple, and one pair of caudal papillae situated laterally (8th pair).

It seems that *Pseudaprocta*, and possibly the Aproctinae, evolved from the Seuratoidea.

***Pseudaprocta copemani* n.sp.**

(Figs. 1, 2.)

Material examined

From *Petroica multicolor* Gmelin (Muscicapidae) from Maggs Mt, Tasmania. Holotype ♀, allotype ♂ (SAM V2096, V2097), 1 ♀ and 1 ♂ (MNHN, Paris, No. 201 HD); 2 ♀ and 3 ♂ (AHC 6277).

From *Pachycephala pectoralis* Latham (Muscicapidae), from Heatherleigh, S. Aust.: 3 pieces of ♀ (2 anterior, 1 posterior), 1 ♂, 1 posterior end ♂. (AHC 6282).

Description

Morphology is shown in Figures 1 and 2. The specimens, except in one case, are surrounded with a

thin membrane detached from the rest of the cuticle and forming a vesicle around the body, beginning at the level of the oesophagus and ending at the level of the tail.

In the female, the tail ends in a small rounded knob (Fig. 1, I). In the male, the precloacal unpaired papilla is particularly big (Fig. 2, B and C). The spicule sheaths are thickened near the cloaca; these thickenings apparently assume the role of a gubernaculum (Fig. 2, E).

Measurements

Holotype ♀: body length 16.5 mm, width 500 µm; nerve ring, deirids and vulva at 160 µm, 320 µm and 370 µm from head; length of buccal capsule 25 µm; length of oesophagus 585 µm; length of tail 320 µm.

Allotype ♂: length of body 8.9 mm; width 310 µm; nerve ring 160 µm from head; length of oesophagus 520 µm; length of left spicule, right spicule and tail respectively 640 µm, 600 µm, 190 µm.

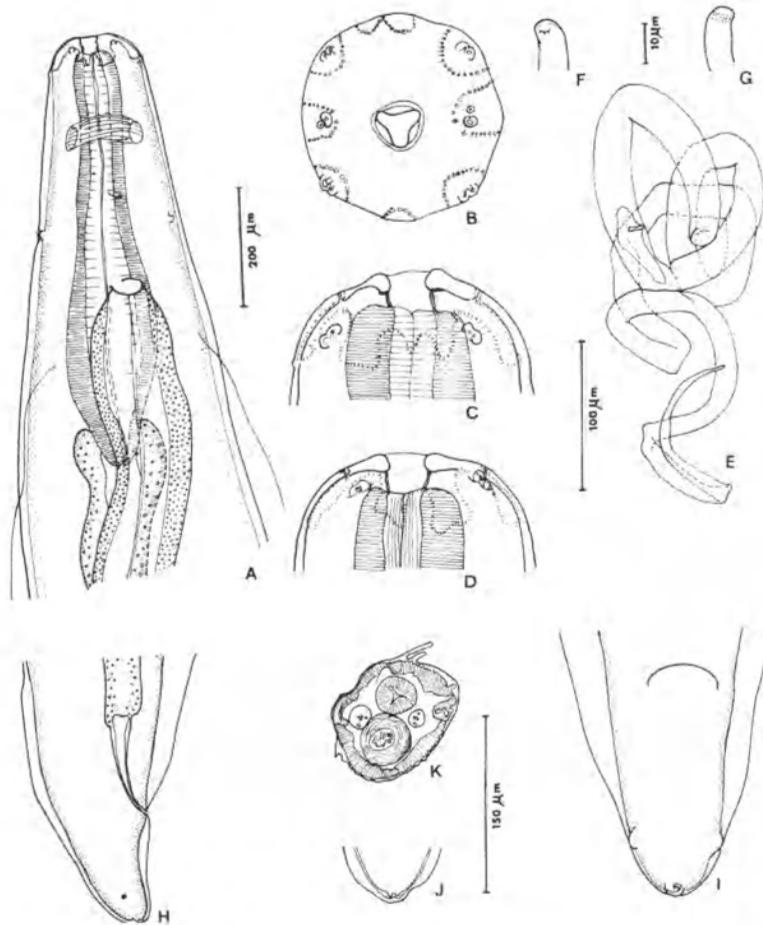


Figure 1. *Pseudaprocta copemani* n.sp., female. A, anterior end, ventral view; B, C, & D, head in apical, dorsal and ventral views; E, larva; F & G, head of larva, from hook side and opposite side; H & I, tail in lateral and ventral views; J, tip of tail; K, transverse section of body. A, H, I, J, K, to scale 200 µm; B, C, D, to scale 100 µm; E, F, G, to scale 10 µm.

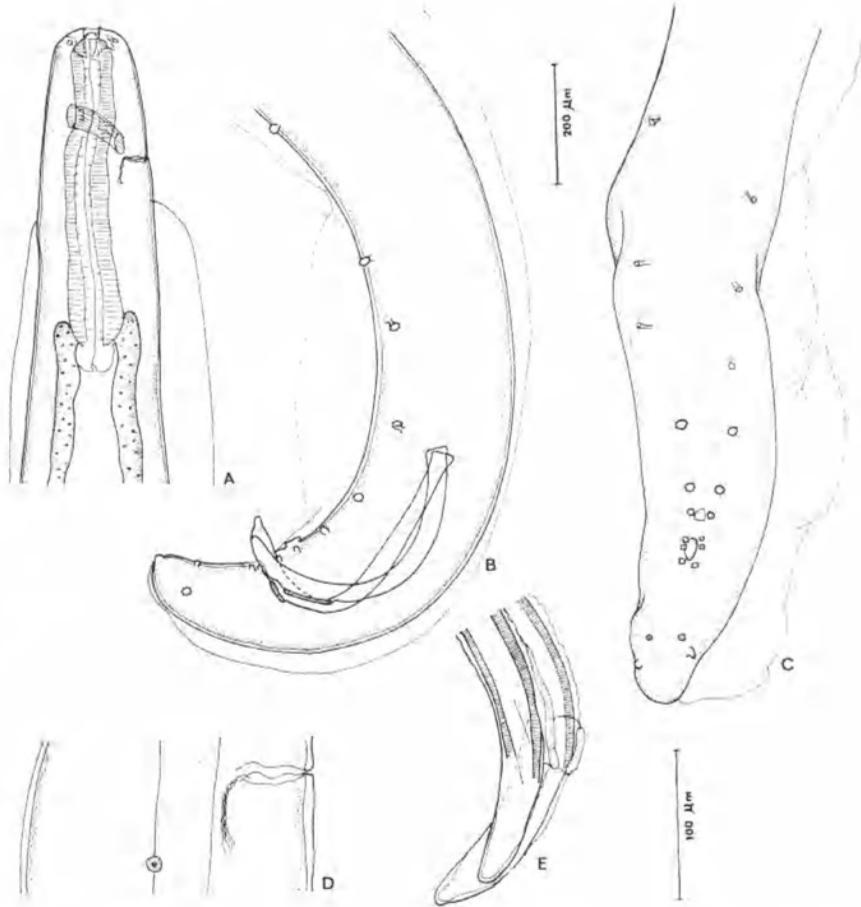


Figure 2. *Pseudaprocta copemani* n.sp., male. A, anterior end, lateral view; B & C, caudal region, lateral and ventral views; D, region of deirid and excretory pore, lateral view; E, distal extremities of spicules and gubernaculum, lateral view. A, B, C, to scale 200 μm ; D, E, to scale 100 μm .

Paratype ♀: body length 18 mm; width 520 μm ; nerve ring, deirids, excretory pore and vulva at 152 μm , 320 μm , 270 μm and 435 μm from head; buccal capsule 25 μm long; egg 52 $\mu\text{m} \times 42 \mu\text{m}$; larva 480 $\mu\text{m} \times 8 \mu\text{m}$.

Another ♂ from AHC6277: body length 9 mm long, width 400 μm ; nerve ring, deirids and excretory pore 160 μm , 290 μm and 230 μm from head; buccal capsule 22 μm long; oesophagus 440 μm long; length of left spicule, right spicule and tail respectively 550, 575 and 200 μm .

Discussion

This material is distinguished by its longer spicules from *P. gubernaculum* Schikhobalova, 1930 (Caucasia); *P. decorata* Li, 1933 (China); *P. buckleyi* (Singh, 1949) and *P. leiperi* (Rasheed, 1960) (India), and *P. ungriai* Chabaud *et al.*, 1964 (Madagascar), in which the spicules are about 400 μm long. It differs from *P. sichotealinensis* Oshmarin & Belouss, 1951 from Eastern USSR (Sonin, 1966) and *P. skrjabini* (Ali, 1956) from India, by the rather greater spacing, longitudinally, of the papillae near the cloaca. *P. myzanthae* Johnston & Mawson, 1940, from

Myzantha flavigula (Meliphagidae) from South Australia, is known only by the female, the measurements of which are very similar to those of the present specimens with the exception of the body length which is greater. It seems better to keep the two species separate, in view of the difference in hosts, and of the fact that Johnston & Mawson show a slightly different arrangement of the cephalic spines (Johnston & Mawson, 1940, fig. 14). We therefore propose it as a new species, *P. copemani*, in honour of our Australian colleague Bruce Copeman.

The Genera *Aprocta* Linstow, *Lissonema* Linstow, and *Squamifilaria* Schmerling

The genus *Aprocta* according to Anderson and Bain (1976), is large and heterogenous. Some authors (Boulenger, 1928; Sandground, 1933 etc . . .) had previously proposed to recognize two genera, *Aprocta* Linstow, 1883 and *Lissonema* Linstow, 1903, separated on the form of the head (flat or with two lateral elevations), the oesophagus (divided or not), the caudal papillae of the male (few and small or large and numerous). As pointed out by

Anderson and Chabaud (1958) the two first of these characters are of doubtful use, because there are many species in which the division is not clear. However, since their work, further descriptions and redescriptions have been made (Ezzat and Tadros, 1958; Rasheed, 1960; Diaz-Ungria, 1963; Chabaud *et al.*, 1964; Schmidt and Kuntz, 1970; Yoyotte, 1972; Quentin *et al.*, 1976), so the morphology of the group is better understood.

It appears that the structure of the ovejector is of importance, as this can be either of two distinct types: it may be long (1500-5000 μm) often with the middle part dilated to form a chamber (e.g. *A. travassosi* Caballero, 1938) or very short (200-600 μm) and simple (e.g. *A. turgida* Stossich, 1902, in Chabaud and Choquet, 1955). Examination of well described species shows that the character "ovejector long" is found in species with large caudal papillae, and the character "ovejector short" is found in species with small papillae.

This division is borne out by other characters: spicules equal or unequal, with tips wide or fine, presence or absence of deirids, large or small eggs, larvae with long smooth tails (Chabaud *et al.*, 1959) or short spiny tails (Quentin *et al.*, 1976).

The two groups represent Linstow's two genera, *Aprocta* and *Lissonema*, and *Lissonema* is now reinstated. *Aprocta* Linstow, 1883: ovejector short; caudal papillae small; spicules generally subequal with distal extremity finely pointed; deirids absent; eggs small (less than 55 μm long); larvae short (about 200 μm), with short tail with terminal spines. Type species; *A. cylindrica* Linstow, 1883 (redescribed by Quentin *et al.*, 1976) from Passeriformes.

Other species sufficiently known to be allotted to the genus, with the bird groups in which they occur, are:

- A. angolica* (Vuylsteke, 1953); Passeriformes
- A. caballeroi* Ybarra, 1948; Falconiformes and Passeriformes
- A. cercomelae* Sonin, 1966; Passeriformes
- A. colapidis* Schuurmans-Stekhoven, 1952; Passeriformes
- A. crassa* Railliet et Henry, 1910; Ralliformes
- A. laevicutis* (Sandground, 1933); Passeriformes
- A. matronensis* Railliet et Henry, 1910; Passeriformes
- A. narium* Linstow, 1901; Falconiformes
- A. ophthalmophaga* Stossich, 1902; Falconiformes
- A. orbitalis* Linstow, 1901; Falconiformes
- A. piloscelidis* Schuurmans-Stekhoven, 1952; Charadriiformes

A. sudarikowi Sobolev, 1947*; Charadriiformes et Ralliformes

A. textori Vuylsteke, 1953, Passeriformes

A. turgida Stossich, 1902 (redescribed by Chabaud et Choquet, 1955); Lariformes.

The species *A. caudata* Mendonca, 1961, of which only the male is known, seems to belong to the Splendidofilariinae.

Lissonema Linstow, 1903: ovejector long; at least one large caudal papilla (a single precloacal papilla, 0-4 pairs cloacal papillae); spicules generally equal, with distal extremity wide and blunt; deirids present; eggs large (over 65 μm long), larvae large (over 400 μm long), tail long unarmed. Type species: *L. rotundata* Linstow, 1903 (redescribed by Rasheed, 1960) parasitic in Cuculiformes.

Other species which are sufficiently known to be allotted to the genus, listed with the bird groups in which they occur, are:

- L. brevicaudata* (Chow, 1939) n.comb. (Strigiformes).
- L. calliderma* (Schmidt et Kuntz, 1970) n.comb. (Cuculiformes).
- L. caprimulgi* (Kazubski, 1958) n.comb. (Caprimulgiformes)
- L. cosmetocephala* (Yoyotte, 1972) n.comb. (Cuculiformes)
- L. ghesquieri* (Ezzat et Tadros, 1958) n.comb. (Caprimulgiformes).
- L. golvani* (Diaz-Ungria, 1963) n.comb. (Piciformes)
- L. lepidogrammi* (Tubangui et Masilungan, 1937) n.comb. (Cuculiformes.)
- L. noctuae* (Spaul, 1927) n.comb., redescribed by Chabaud (1951) (Strigiformes).
- L. nyctidromi* (Caballero et Peregrina, 1938) n.comb (Caprimulgiformes).
- L. obtusa* (Dujardin, 1845) n.comb. (= *Eucampytus obtusus* D., 1845, *Eucampytus* Chevr., 1833 preoccupied, Coleoptera) (Caprimulgiformes).
- L. papillosa* (Chabaud, Anderson et Brygoo, 1959) n.comb. (Cuculiformes).
- L. proctata* (Lent et Freitas, 1948) n.comb. (Strigiformes).
- L. semenovi* (Skrjabin, 1934) n.comb. (Caprimulgiformes).

**A. sudarikowi* Sobolev, 1947 (in Sonin, 1966) is hard to classify: according to this author, the spicules are pointed and the eggs small as in *Aprocta* spp., but the caudal papillae are large as in *Lissonema* spp. The ovejector cannot be analysed. However, Sandground (1933) describing analogous material, emphasised the absence of caudal papillae. It seems to us that this species belongs to *Aprocta*.

L. spasskyi (Sonin, 1966) n.comb. (Cuculiformes).

L. travassosi (Caballero, 1938) n.comb. (Trogoniformes).

The genus *Squamofilaria* Schmerling, 1925, which was reinstated by Anderson and Chabaud (1958) for Aprocinae with a short well sclerotized buccal capsule, is itself heterogenous. In these species, the buccal capsule appears to be a secondary cuticularisation of the wall of the buccal cavity, as in *Lissonema* sp., described below from *Ninox novaeseelandiae*. It is poorly limited externally, as compared with the true buccal capsule seen in *Dipetalonema* spp., *Litomosa* spp., etc. which are descended from forms with a buccal capsule formed from rhabdions.

The species attributed to *Squamofilaria* fall into the same two morphological groups found in *Aprocta* and *Lissonema*, and can be allotted to one or other of these genera as follows:

(a) *Aprocta*

A. vestibulata (Johnston et Mawson, 1950) n.comb. (Passeriformes).

A. pillersi (Yorke et Maplestone, 1926) n.comb. (Passeriformes).

(b) *Lissonema*

L. coraciae (Gmelin, 1790) n.comb. syn. *Squamofilaria coraciae* (Gmelin, 1870). This is the type species of *Squamofilaria* which now falls as a synonym of *Lissonema* (Coraciadiformes).

L. sicki (Strachan, 1957) n.comb. (Strigiformes).

L. nepalensis (Soota et Chaturverdi, 1970) n.comb. (Coraciadiformes).

L. ungriai (Guerrero, 1971)* n.comb. (Trogoniformes).

It appears that the host ranges for *Lissonema* and *Aprocta* are mutually exclusive.

Lissonema spp. are known from the Strigiformes, the Cuculiformes†, the Piciformes (Bucconidae), the Trogoniformes, the Caprimulgiformes and the Coraciadiformes. It is of interest to note that Berlioz, in his Classification of Birds, treated these six groups consecutively (pages 930 to 974, in Grassé, 1950).

Aprocta spp. are known from the Lariformes, the Charadriiformes, the Ralliformes (Burhinidae and

Otididae), the Falconiformes (similarly grouped by Berlioz, p. 884-929), and the vast group of Passeriformes.

The Australian species which have been studied herein are assigned to the two genera *Aprocta* and *Lissonema*.

***Aprocta boulengeri* n.sp.**

(Figs. 3, 4)

Material

Strepera graculina Shaw (Cracticidae) from Warwick, Qd., from head and nasal cavities, holotype ♀, allotype ♂ (SAM V2098 and V2099) and 1 entire ♀ and 2 broken ♂ (AHC 5839).

Morphology

The morphology is shown in Figures 3 and 4. Unpaired portion of ovejector short and simple.

Dimensions

Holotype ♀: length 50 µm; width 920 µm; cephalic papillae form area 110 µm (laterally) by 70 µm (dorsoventrally); nerve ring and vulva respectively 175 µm and 940 µm from head; oesophagus 1060 µm long, with muscular part 215 µm long; tail length 385 µm, egg 58 µm by 32 µm.

Allotype ♂: length 25.6 mm, diameter 600 µm; cephalic papillae area 110 µm x 55 µm; buccal capsule 20 µm long; nerve ring and excretory pore 205 µm and 305 µm from head; oesophagus 800 µm long with muscular part 190 µm; tail length 320 µm; right and left spicules 400 µm and 440 µm long, 22 µm wide.

Other entire female: body length 37 mm, diameter 910 µm; cephalic papillae on area 88 µm x 57 µm; buccal capsule 38 µm long; nerve ring, excretory pore and vulva respectively 220 µm, 310 µm and 680 µm from head; oesophagus 965 µm long, with muscular part 200 µm; unpaired part of ovejector 600 µm long; tail length 240 µm; larvae 190 and 205 µm long, 11 µm wide.

Discussion

This species is easily differentiated by the following characters: presence of a median subterminal papilla on the male tail, spicules 400-440 µm in length, with tricuspid distal extremities, vulva slightly in front of the oesophago-intestinal junction, anus of the female not terminal. This is proposed as a new species *A. boulengeri*.

***Aprocta bakeri* n.sp.**

(Fig. 5)

Material

Corvus orru Bonaparte (Corvidae) from Emu Vale, near Warwick, Qd., from nasal cavity: holotype ♂ (SAM V21000).

* The eggs measure only 45 µm x 25 µm, but their concave form indicates that they are not embryonated.

† Among species from Cuculiformes, those from *Centropus* are unusual in having a long oesophagus (5-7 mm), clearly divided.

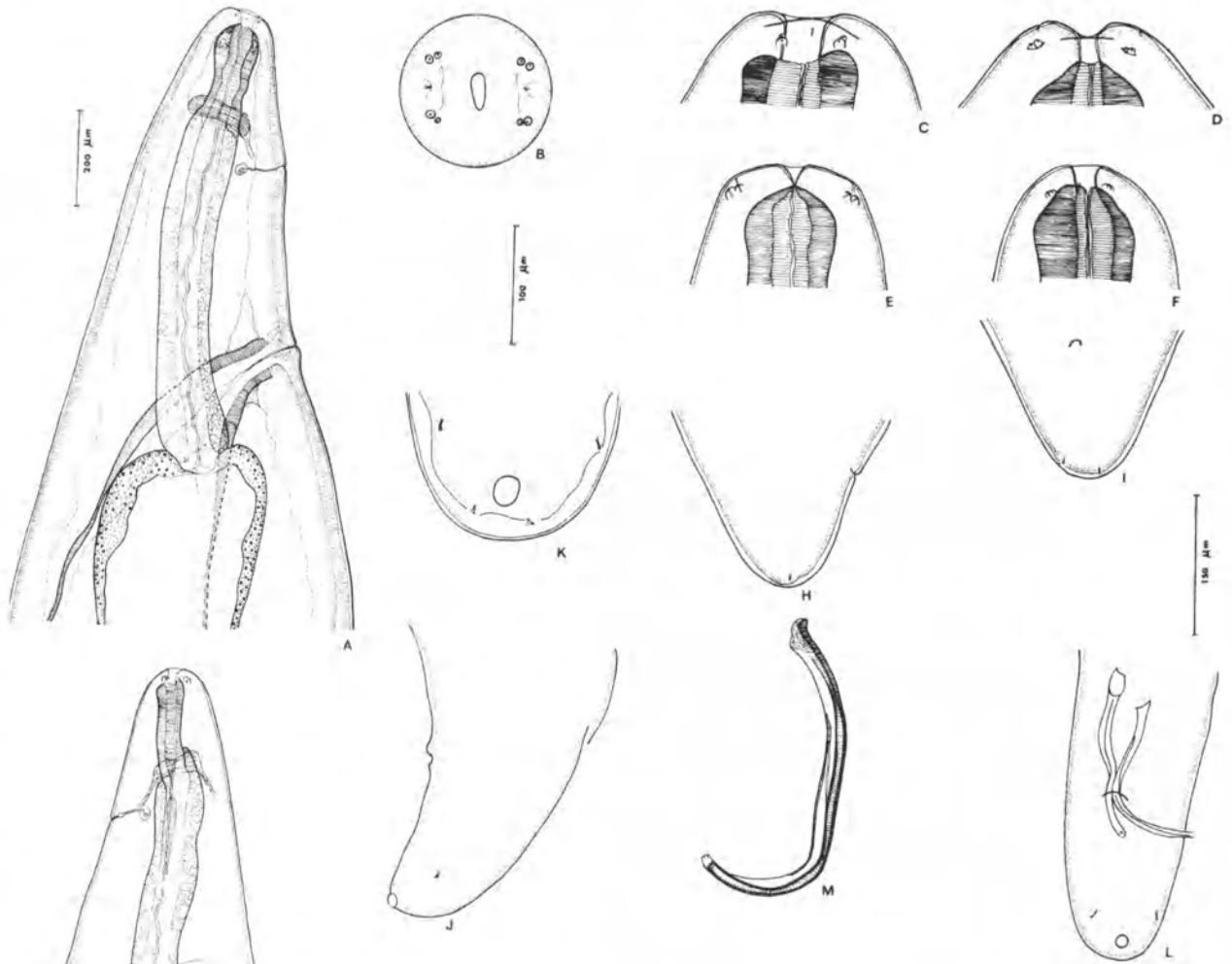


Figure 3. *Aprocta boulegeri* n.sp., female, and male allotype. A, anterior end of female, lateral view; B, C, & D, head of female, in apical, lateral and dorsal views; E, F, head of male, ventral and lateral views; G, anterior end of male, lateral view; H, I, tail of female, lateral and ventral views; J, K, L, tail of male, lateral and ventral views; M, left spicule. A, G, H, I, J, L, to scale 200 μ m; B, C, D, E, F, K, to scale 100 μ m; M, to scale 150 μ m.

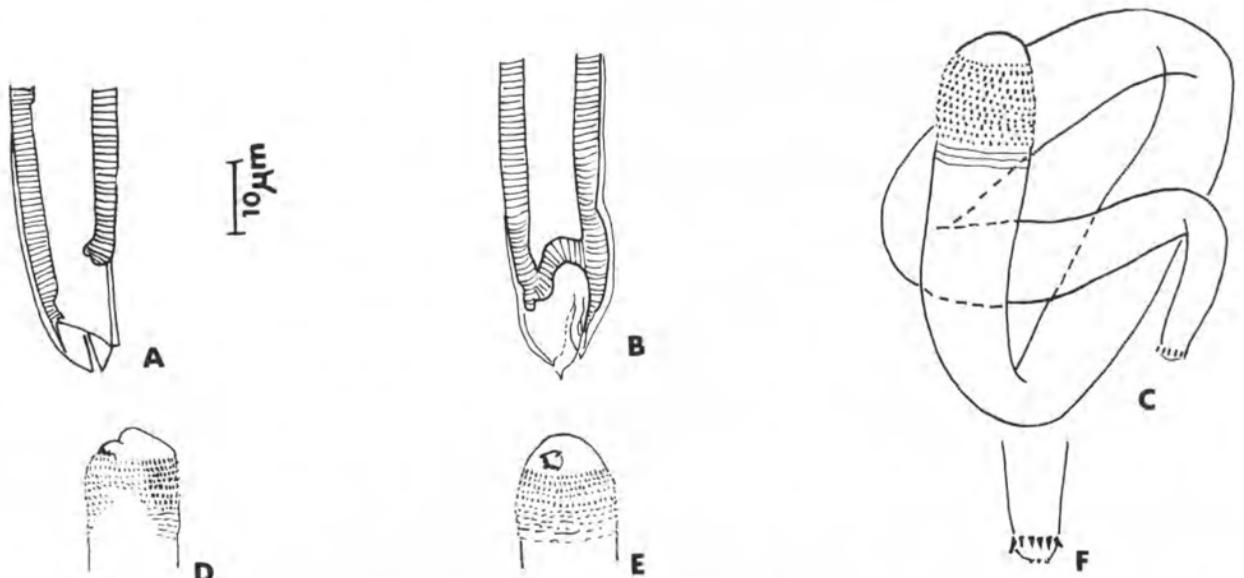


Figure 4. *Aprocta boulegeri* n.sp. (cont.) A, and B, tips of left and right spicules, ventral views; C, larva; D, E, head of larvae, with hooks seen in profile and full face; F, tip of tail of larva. A-E, to scale 10 μ m; F, free-hand.

Description

Morphology is shown in Figure 5. Triangular buccal cavity. Cloaca opening on conspicuous protuberance.

Dimensions

Body length 29 mm, diameter 550 μm ; buccal capsule 40 μm long; nerve ring 140 μm from head; left and right spicules respectively 390 μm and 330 μm long; tail length 260 μm .

Discussion

The bifid extremity of the testis in these specimens resembles that of *Aprocta laevicutis* from *Cyornis banyumas whitei* but is distinguished from this species by the larger body size and by the spicule length (390 and 330 μm instead of 210-170 μm). It is also distinguished from all other *Aprocta* spp. by a

voluminous protuberance bearing the cloacal opening. It is proposed as a new species, *A. bakeri*, dedicated to our Canadian colleague, Michael Baker.

Lissonema sp.

(Fig. 6)

Material

From *Ninox novaeseelandiae* Gmelin (Strigidae) from Berrimah, N.T., 1 ♀ (AHC 6261).

Description

The morphology is shown in Fig. 6. Mouth and buccal capsule narrower dorso-ventrally than laterally; buccal capsule stoutly built, of two parts—anteriorly, a thickening of the cephalic cuticle,

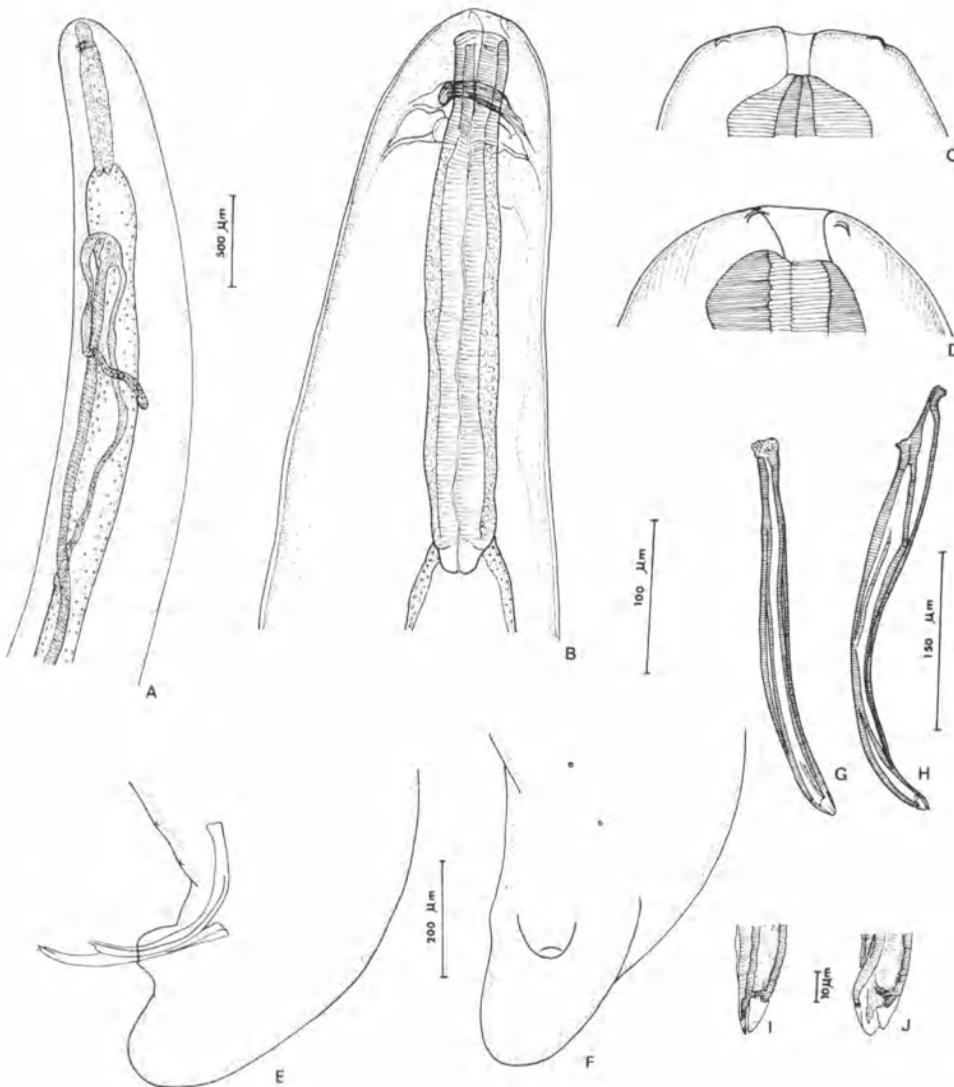


Figure 5. *Aprocta bakeri* n.sp., holotype male. A, anterior end; B, oesophageal region, lateral view; C, D, head in dorso-ventral and lateral views; E, F, tail, in lateral and subventral views; G, H, right and left spicules, ventral views; I, J, distal extremities of same spicules; A, to scale 500 μm ; B, E, F, to scale 200 μm ; C, D, to scale 100 μm ; G, H, to scale 150 μm ; I, J, to scale 10 μm . v, vulva.

posteriorly, a pre-oesophageal thickening, poorly defined externally, and thicker laterally. Base of buccal cavity formed by the three prominent and sclerotised oesophageal lobes. The cuticular 'scales' are irregularly distributed over the body length, but the lateral fields are smooth. Unpaired portion of ovejector long and complex (Fig. 6 J).

Measurements

Body length 34 mm, diameter 590 μm ; buccal cavity 22 μm long; nerve ring, excretory pore and deirids at 155 μm , 242 μm and 270 μm from head; oesophagus 1200 μm long, with muscular part 230 μm long; vulva 700 μm from head; unpaired part of ovejector 4660 μm long; tail length 95 μm ; cuticular

scales on body 22 μm long, 13 μm wide, commencing at 1150 μm from head and ending 550 μm from posterior end of body. Eggs 66 μm x 38 μm ; larva 415 μm long, 13.5 μm in diameter.

Discussion

Among the species of this genus in which there is a buccal capsule, *L. sicki*, *L. nepalensis*, *L. ungriai* and *L. coraciae*—only the last named agrees with the Australian specimens in having 'scales' on the body, but the shape and arrangement of these was not exactly described. The dimensions of the female are very close, except the length, which is only half that of the Australian specimens. In view of this, and of the different geographical range, no specific identification is made.

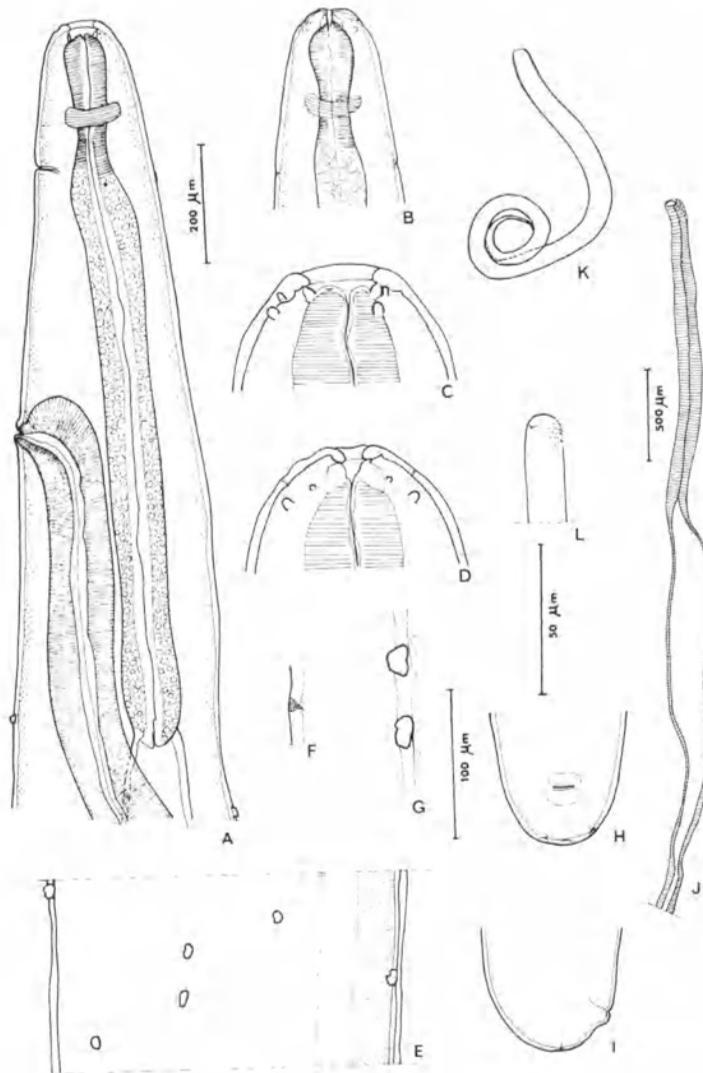


Figure 6. *Lissonema* sp., female. A, oesophageal region, lateral view; B, anterior end, median view; C, D, head, lateral and median views; E, cuticular ornamentation in region of mid-body, in submedian view; F, deirid, lateral view; G, cuticular scale in lateral view; H, I, tail, ventral and lateral views; J, ovejector, distal part; K, larva; L, head of larva; A, B, E, H, I, to scale 200 μm ; C, D, F, G, K, to scale 100 μm ; J, to scale, 500 μm ; L, to scale 50 μm .

II. Diplotriaenoidea—Dicheilonematinae

Genus *Serratospiculum* Skrjabin

The genus *Serratospiculum* contains (a) species with small spicules (left spicules 600-700 μm , right spicule 300-350 μm), which may be considered as grouped about *S. guttatum* and (b) species with large spicules (left spicule 1100-1300 μm , right spicule 350-500 μm) grouped about *S. tendo*.

(a) Species with small spicules

S. guttatum (Schneider, 1866): the most characteristic feature of this species is the cuticular ornamentation of the female body, in the form of large bosses, well described by Schneider. The species is recorded in Australia from *Falco berigora* by Schneider, 1866, from *F. longipennis* and *F. peregrinus* (Syn. *F. melanogenys*) by Johnston & Mawson, 1941, and in the present paper.

Species grouped with *S. guttatum* may have (i) smooth or (ii) ornamented cuticle.

(i) With smooth cuticle:

S. chungii Hoeppli & Hsu, 1929, from *Falco* sp., China.

S. congolensis Vuylsteke, 1957, from *Butastur rufipennis* (Sund.) from equatorial Africa*. This species is distinguished from *S. chungii* by the structure of the right spicule: the oblique crests are present on the distal third of the spicule, not on the distal half.

S. seurati n.sp. (syn. *Filaria attenuata* Rud., 1819 sensu Seurat, 1915) from various Falconidae, from North Africa, is close to *S. chungii* but can be distinguished by the cephalic structure—the epaulettes concave with regard to the dorso-ventral axis, and not rectilinear (Fig. 18 of Hoeppli & Hsu, 1929), relatively narrower—(30 μm wide by 100 μm long in *S. seurati*, 50 μm wide by 120 μm long in *S. chungii*).

(ii) With cuticular ornamentation:

S. turkestanicum Skrjabin, 1916 (type species of the genus), from *F. tinnunculus* L. from Central Asia, is well distinguished by the type of cuticular ornamentation, consisting of points curved backwards.

S. kwangsiensis Hsu, 1963, from *F. columbarius insignis* (Clark) from China, is close to *S. guttatum* in the structure of the head and the presence of rounded bosses on the cuticle of the female, but these bosses continue to the level of the anus in this

species but only to 1 mm from the posterior extremity in *S. guttatum*; also, the distal half of the spicule is particularly delicate.

The filarial worms described by Li (1933) from *F. columbarius* (syn. *Hypotriorchis aesolon*), from China, as *S. turkestanicum* seems from the character of the female cuticle, to be *S. kwangsiensis*.

(b) Species with large spicules

This group contains three species, all without cuticular ornamentation in the female:

S. tendo Nitzsch, 1819†, the species is parasitic in *F. peregrinus* in Europe (Nitzsch in Rudolphi, 1819; Dujardin, 1845; Yorke & Maplestone, 1926) and in Australia (material described here and, as pointed out by Sonin (1968), some parts of the material seen by Johnston & Mawson, 1941, and noted as *S. guttatum*). The species is also found in other falcons, and in other parts of the Old World.

S. thoracis Tubangui, 1934, from *Falco ernesti* in the Philippines; the dimensions of this species are similar to those of *S. tendo*.

S. lii Ezzat & Tadros, 1958, from *F. peregrinus callidus* from Belgian Congo. In this species the measurements resemble those of the two preceding species. The *area rugosa* and the detailed structure of the spicules have not been described, and as pointed out by Sonin (1968), it is possible that these three species are synonymous.

It appears that there are more species of *Serratospiculum* than allowed by Sonin (1968). It also appears that *S. guttatum* is found only in Australia, and that references to its presence in other parts of the world are erroneous.

The Australian material from falcons (Falconidae) permits the redescription of two species, *Serratospiculum guttatum* (Schneider, 1866) and *S. tendo* (Nitzsch, 1819). Comparison of the Australian material with specimens in MNHN has led to the identification of a new species, *S. seurati*.

Serratospiculum guttatum (Schneider, 1866)

(Fig. 7)

Material

From *Falco longipennis* Swainson, from Fleurieu Peninsula and Yorke Peninsula, South Australia. 9♂, 5 anterior and 2 posterior ends of ♂, 7♀, 4 anterior and 5 posterior ends ♀ (AHC 6279); 2♂ and 2♀ (MNHN, 193 HD).

From *Falco peregrinus* Tunstall, from Mallala, S.A. 3♂, 1 posterior end ♂, (AHC 6280).

Description

The morphology is shown in Fig. 7. The shape of the head is the same in all specimens, . . . broader on lateral axis, epaulettes twice as long as wide (80 μm

* The apical view shown in Fig. 36 appears to be in error; the piece of the head shown is probably seen upside down, from the posterior aspect.

† Railliet & Henry (1916) have resolved clearly the question of the nomenclature of this species.

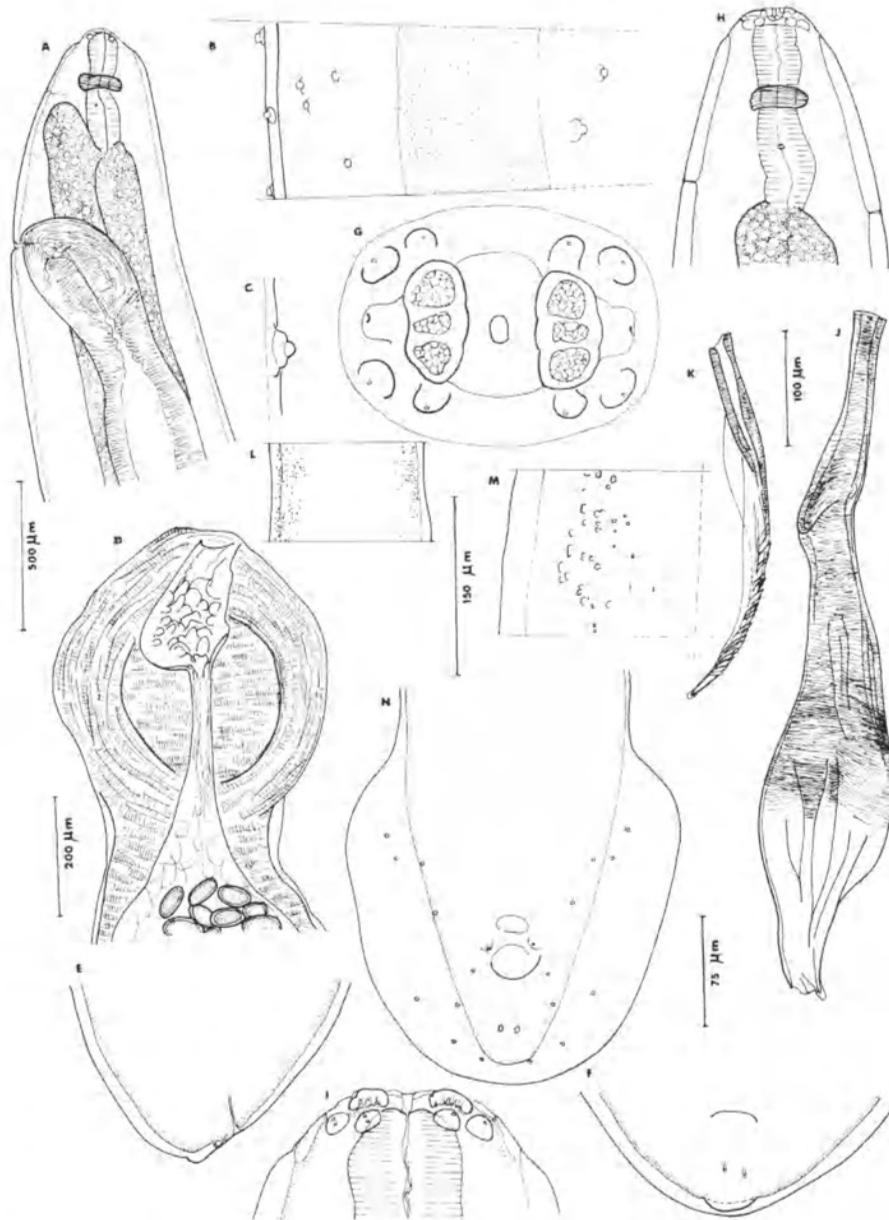


Figure 7. *Serratospiculum guttatum* A-G, female H-N male, A, anterior end, lateral view; B, cuticular ornamentation in mid-body, lateral view; C, the same, detail of one boss; D, distal end of ovejector; E, F, tail, in lateral and ventral view; G, head, apical view; H, anterior end, ventral view; I, head, median view; J, K, left and right spicules; L, *area rugosa*, ventral view; M, the same, in detail; N, tail, ventral view; A, scale 500 μm ; B, D, H, to scale 200 μm ; C, E, F, to scale 150 μm ; G, I, L, M, N, to scale 75 μm .

by 40 μm) and in apical view, convex with regard to the dorso-ventral axis. Cuticular ornamentation present only in the female. *Area rugosa* forms two latero-ventral bands of low cuticular protuberances.

Dimensions

Three females: length 127, 150 and 140 μm , width 700, 790, and 600 μm ; nerve ring at 175, 180, and 240 μm from head; excretory pore at 205, ?, and 240 μm from head; deirids at 250, 220, and 510 μm from head; muscular oesophagus 420 μm long, and with glandular part 13 mm long (measured on one of the

females dissected); vulva at 740, 600, and 1050 μm from head; length of unpaired part of ovejector 2150 μm (in female dissected); tail 90-110 μm long; embryonated eggs 52 by 30 μm ; cuticular ornamentation starts at 3 mm from the head and ends at 1 mm from the posterior end.

Two males: length 72 and 93 mm, width 480, 560 μm ; nerve ring and excretory pore 150, 230 μm from head (measured on one male); deirids at 280 and 340 μm , 212 and 275 μm from head; muscular oesophagus 320, 365 μm long, length of glandular

oesophagus not determined; tail length 80, 82 μm ; length of left spicules 650, 670 μm , of right spicules 350, 360 μm ; *area rugosa* lying from 5.4 mm to 450 μm from the posterior end (measured on one male).

This material has been compared with MNHN 510 JJ collected in France from the same host species; this consists of one anterior end and two posterior ends of δ and the anterior and posterior ends of 1 \varnothing .

Serratospiculum tendo (Nitzsch, 1819)
(Fig. 8)

Material

From *Falco peregrinus* Tunstall, from Port Augusta, S.A. 1 \varnothing , 1 δ (AHC 6273).

Description

The morphology of the two lots of material is similar, and is shown in Figure 8. The cephalic structure is constant: rounded head, epaulette 3-4 times as long as wide (110 μm by 30 μm), concave

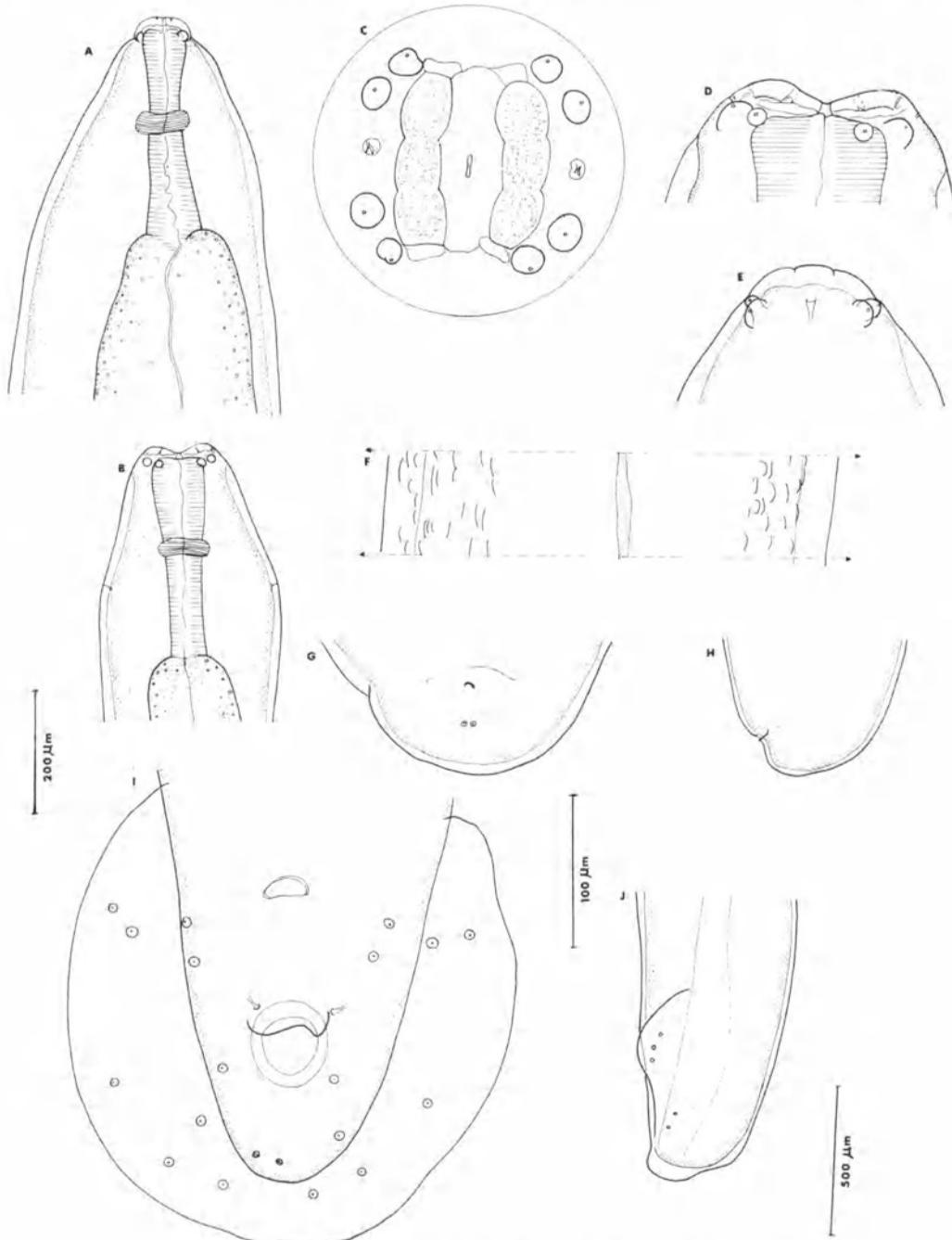


Figure 8. *Serratospiculum tendo*. A, anterior end of female, lateral view; B, anterior end of male, median view; C, head of female, apical view; D, E, head of male, median and lateral views; F, male, *area rugosa*, ventral view; G, H, female, tail, ventral and lateral views; I, J, tail of male, ventral and lateral views; F and J, Australian material, other figures French material. A, B, G, J, to scale 200 μm ; C, D, E, F, I, to scale 100 μm ; H, to scale 500 μm .

with regard to the dorso-ventral axis, and prolonged by 4 small additional swellings. *Area rugosa* in form of two ventro-lateral bands of small longitudinal cuticular wrinkles. Spicules not drawn, as studied by Bain & Vassiliades (1969).

Measurements of Australian specimens

Female: length of body 190 μm , width 825 μm ; nerve ring and deirids 300 μm and 210-220 μm from head; length of oesophagus 19.7 mm, of muscular part 600 μm ; vulva 1650 μm from head; tail 100 μm long.

Male: length of body 148 mm, width 410 μm ; nerve ring and deirids 200 μm and 305-310 μm from head; length of oesophagus 11 mm, of muscular part 600 μm ; length of left spicule 1120 μm , of right 505 μm ; tail 130 μm long; *area rugosa* extends from 4650 μm -600 μm from the caudal extremity.

Measurements of specimens from France

In female, vulva 1 mm from the head, tail 140 μm long. In male nerve ring and deirids 165 μm and 230 μm from head; length of left spicule 1150 μm , and 1120 μm , of right spicules 510 μm and 500 μm ; tail 145 and 110 μm .

Serratospiculum seurati n.sp.

(Fig. 9)

Syn. *Filaria attenuatum* Rudolphi, 1819 *sensu* Seurat, 1915.

Material

Specimens studied by Seurat, 1915, and determined as '*Filaria attenuata* Rud., 1819 (= *F. guttatum* Schneider, 1866)'. This material, now in the MNHN, Paris, was taken from *Falco biarmicus erlangeri* Kleinschm at Biskra, North Africa; it comprises 2♂ of which one is in two pieces, 1

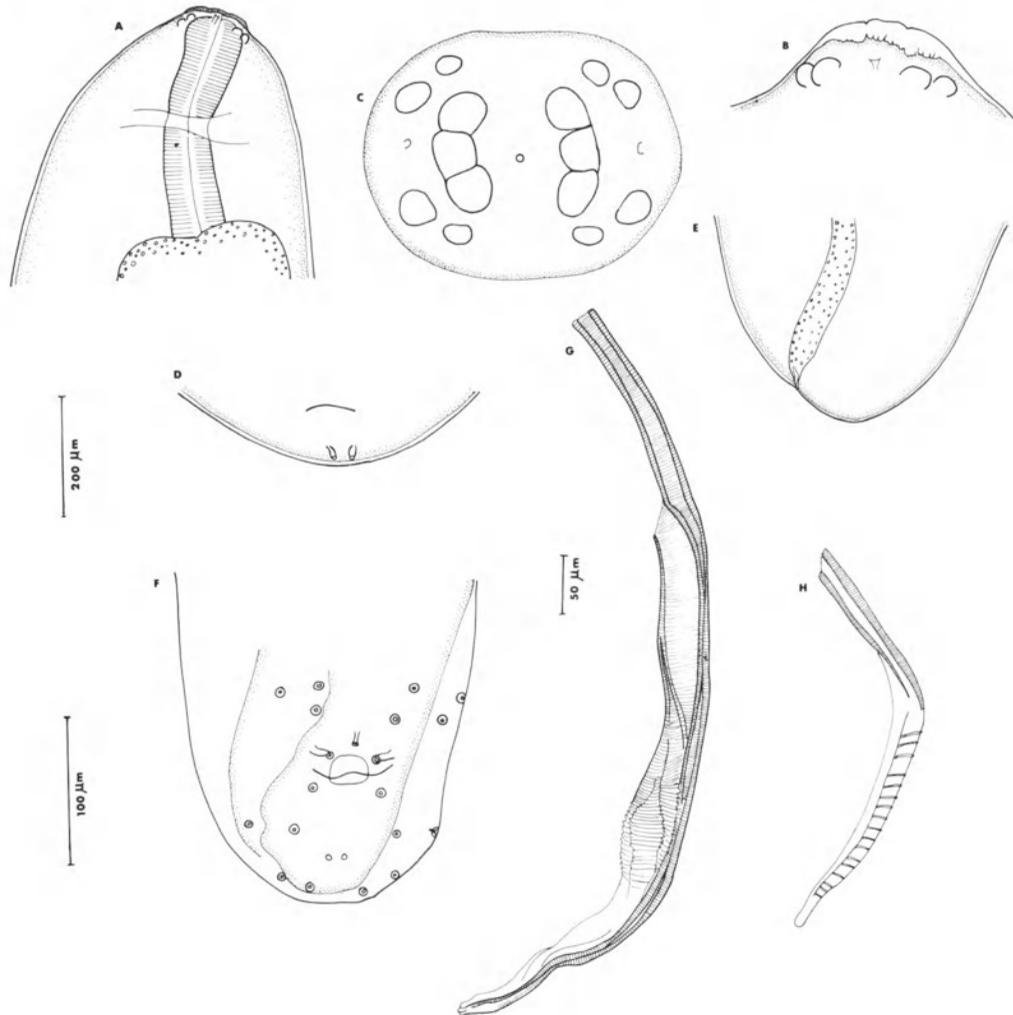


Figure 9. *Serratospiculum seurati* n.sp. A, anterior end of female, lateral view; B, head of holotype female, lateral view; C, head of female, apical view; D, E, tail of holotype female, ventral and lateral views; F, tail of male, subventral view; G, H, left and right spicules, lateral view. A, E, to scale 200 μm ; B, C, D, F, H, to scale 100 μm ; G, to scale 50 μm .

anterior end ♂, 2 ♀ and 2 posterior ends ♀, 1 entire ♀ and 1 entire ♂ were chosen as holotype and allotype respectively (MNHN 110 EJ).

(2) specimens collected by Dollfus (MNHN 114 A) in 1914 from *Falco* sp., from Rabat, Morocco, labelled *S. guttatum* (Schneider, 1866); consisting of numerous pieces including 2 anterior and 4 posterior ends of ♀, 3 anterior and 1 posterior ends ♂.

Morphology

The general morphology, well described by Seurat, is complemented by Figure 8. The structure of the head, in both lots of material, is similar. The position of the vulva is somewhat variable (450-1000 µm from head). An *area rugosa* appears to be absent. The right spicule bears low crests, obliquely placed.

Measurements

Holotype ♀: length of body 135 mm, width 770 µm; vulva 470 µm from head; tail length 40 µm. Specimen not sufficiently clear for other measurements.

Allotype ♂: length of body 42 mm, width 480 µm; nerve ring and deirids 130 µm and 230 µm from head; length of oesophagus 10 mm, of its muscular part 270 µm; left spicule and right spicules respectively 775 µm and 300 µm; tail length 110 µm.

From MNHN 114 A (2 pieces): length unknown; width 500 µm; nerve ring 170 µm from head; muscular oesophagus 310 µm; left and right spicules respectively 650 µm and 350 µm, tail length 110 µm.

Diplotriaenoidea: Diplotriaenidae

Diplotriaena spratti n.sp.

(Fig. 10)

Material

From *Oreoica gutturalis* Vigors & Horsfield (Muscicapidae) from the Petermann Ranges, N.T. Holotype ♀ and allotype ♂ (SAM, V2101 and V2102 respectively); 6 ♀, 9 ♂, and numerous pieces of ends of ♀ and 1 posterior end ♂ (AHC 6272); 1 ♀ and 2 ♂ paratypes (MNHN, Paris, 204 HD).

Description

Morphological features are shown in Figure 10.

Measurements

Holotype ♀: length of body 68 mm, width 700 µm; nerve ring 240 µm from head; tridents 150 µm

and 172 µm long; length of oesophagus 3720 µm, of muscular part 370 µm; vulva 500 µm from head, unpaired portion of ovejector 3300 µm long; tail length 110 µm; eggs, non-fertilized, 32 µm by 18 µm.

Paratype ♀s: body length 66-71 mm; in ♀ length 66 mm, width 500 µm; nerve ring and vulva 290 µm and 425 µm from head; trident 135 µm; oesophagus 4500 µm; eggs 45 µm by 35 µm.

Allotype ♂: body length 32 mm, width 400 µm; nerve ring 200 µm from head; muscular oesophagus 3850 µm long; tail 50 µm; left and right spicules respectively 4500 and 600 µm long.

Paratype ♂s: length of body 32-34 mm; of oesophagus 2600-3275 µm; left spicule 4200-6300 µm, right spicule 510-600 µm; in one male 32 mm long; body width 455 µm, nerve ring 230 µm from head; tridents 125 µm; length of oesophagus 3400 µm, of tail 55 µm; left spicule 4200 µm long, with calamus 650 µm, right spicule 550 µm.

Discussion

This species can be compared with the others of the genus in which the left spicule is longer than 2000 µm. These are: *D. bhamaensis* (Parona, 1889)* redescribed by Anderson (1959) from Sturnidae and Turdidae in Asia, has the trident not pointed but concave at the apex, a much longer oesophagus (8-12 mm instead of 2.6-6.3 mm), left spicule not exceeding 2600 µm, and the right spicule spiralled about a strongly curved axis, whereas in the Australian specimens the axis is almost straight.

In *D. ecaudata* (Oerley, 1882), from Sturnidae in Africa the trident is concave at the tip, the left spicule is not longer than 2800 µm, and the axis of the right spicule has three strong bends.

D. tricuspis (Fedtschenko, 1874) sensu Singh, 1949, is, as pointed out by Anderson (1959), a mistaken determination. It is clear from Singh's paper that though the female is a *Diplotriaena* sp., the male (Fig. 27) is a *Hamatospiculum* sp. The Australian species is proposed as *D. spratti* n.sp., named after our colleague David Spratt. The species is characterised by the pointed apex of the trident, the long left spicule (over 4000 µm) and the right spicule spiralled around an almost straight axis.

* *B. buckleyi* Fotedar & Kaw, 1965, and *D. mirzapurensis* Soota & Chaturvedi, 1967, both parasites of *Acridotheres tristis*, have no morphological difference from *D. bhamaensis*, and are regarded as synonyms of this species.

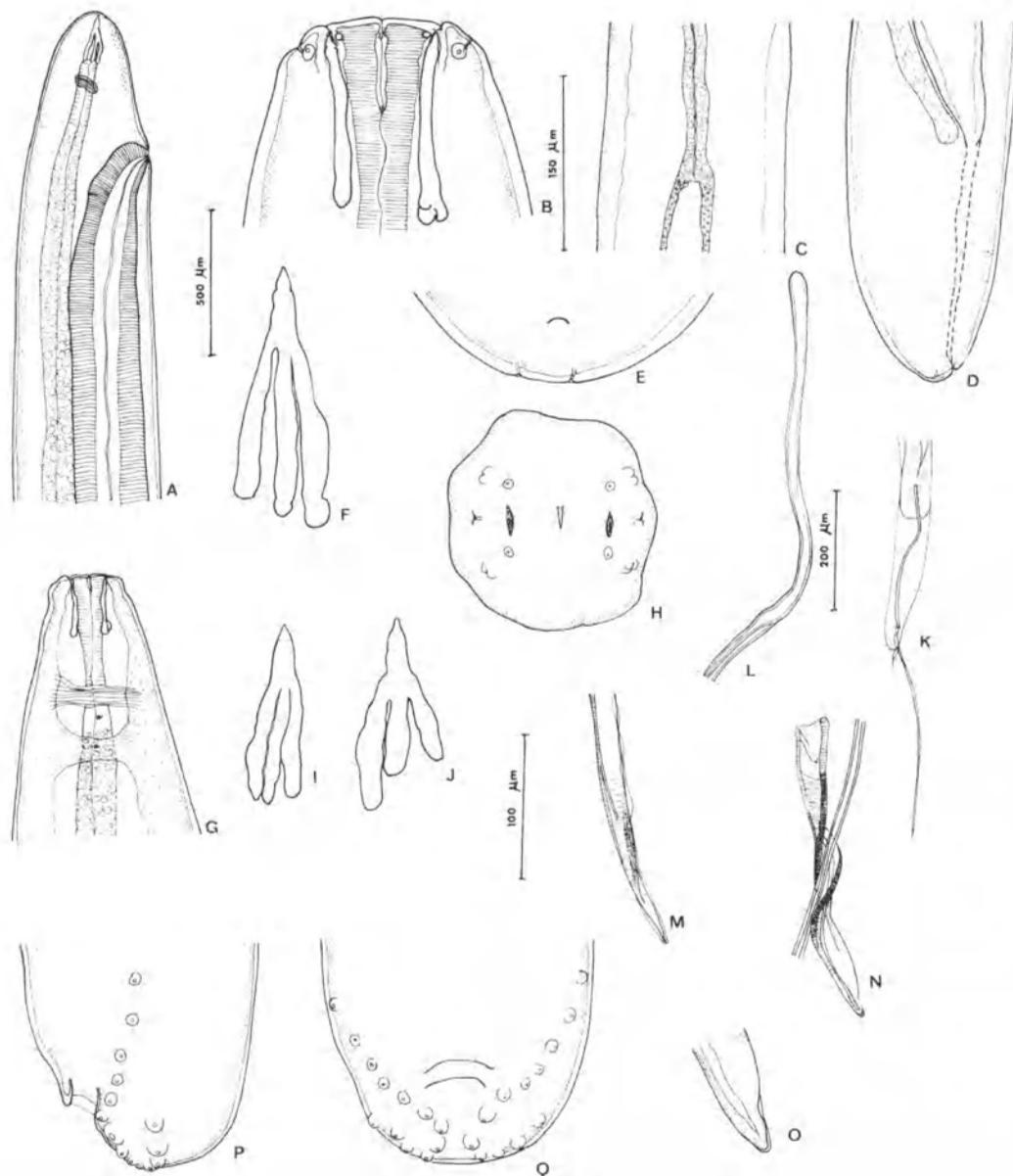


Figure 10. *Diplotriaena spratti* n.sp. A, anterior end of holotype female, lateral view; B, head of holotype female, median view; C, junction of oesophagus and intestine, paratype female; D, E, tail of paratype female, lateral and ventral views; F, trident of holotype female; G, anterior end, ventral view; H, head, apical view; I, J, tridents of two specimens; K, posterior end, lateral view; L, M, the two extremities of the left spicule; N, right spicule and part of the left spicule; O, distal end of right spicule, ventral view; P, Q, tail in lateral and ventral views. A, D, to scale 500 μm ; B, to scale 150 μm ; C, E, G, L, N, to scale 200 μm ; F, I, J, M, O, P, Q, to scale 100 μm .

Diplotriaena beveridgei n.sp.

(Fig. 11)

Material

From *Corvus orru* Bonaparte (Corvidae) from Emu Vale, near Warwick Qd: Holotype ♀ (SAM V 2103) and posterior end (10 mm) of allotype ♂ (SAM V 2104); 2 ♀, 2 anterior and 3 posterior ends ♀ (AHC 6276).

Description

Morphological features are shown in Figure 11.

Measurements

Holotype ♀: body length 102 mm, width 1400 μm , nerve ring 450 μm from head; trident 285 μm long; oesophagus 9500 μm long, its muscular part 575 μm ; vulva 630 μm from head; eggs 50 x 35 μm ; tail 200 μm long.

Allotype ♂: the piece is 1.11 mm wide; tail 10 μm long; left spicule 1355 μm long (calamus 250 μm); right 1075 μm .

Paratypes: one anterior end of ♀, 1400 μm wide, with nerve ring 390 μm from head, tridents 250 μm

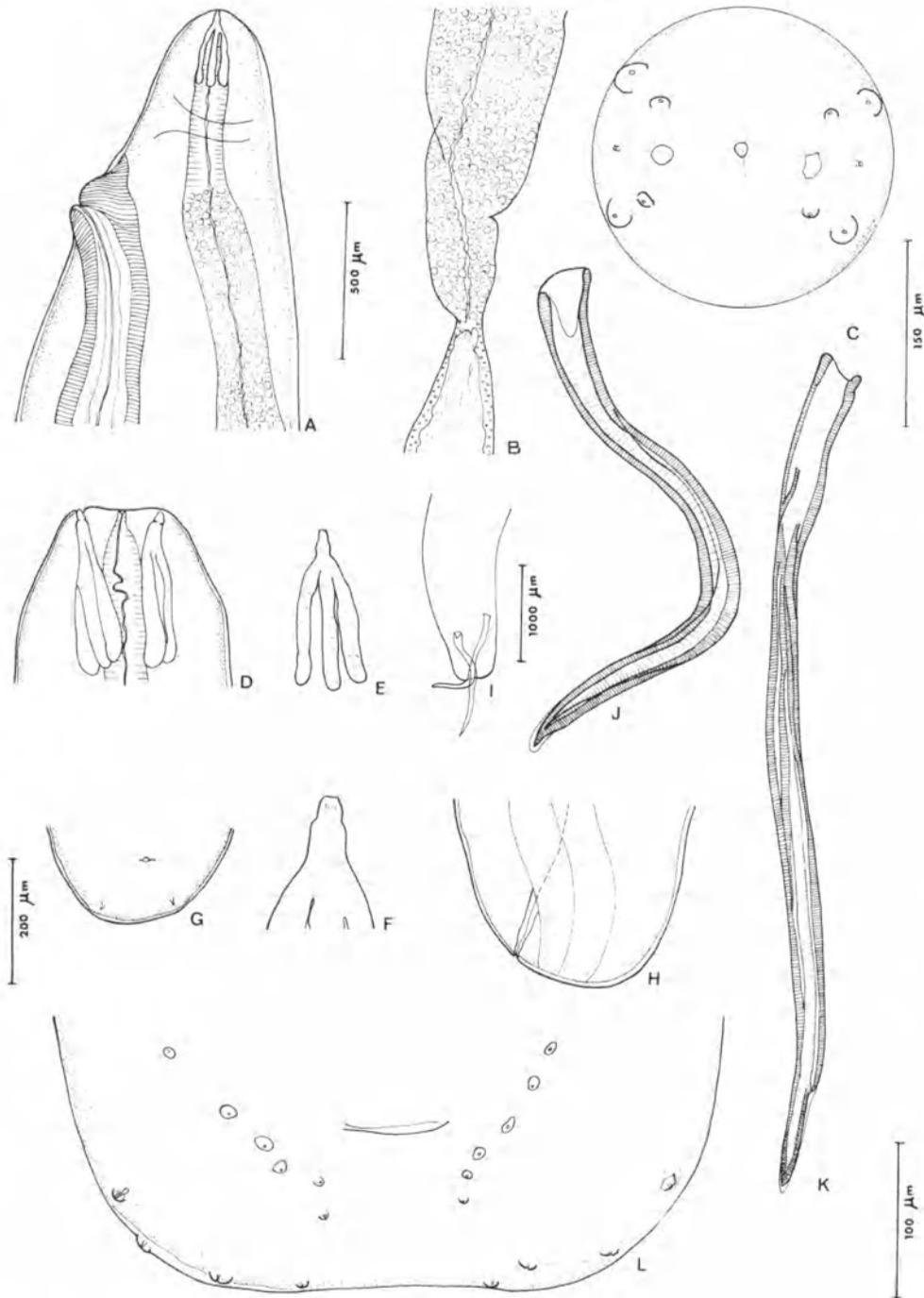


Figure 11. *Diplotrriaena beveridgei* n.sp. A-H, female; I-L, male. A, anterior end, lateral view; B, oesophago-intestinal junction; C, head, apical view; D, head, lateral view; E, F, trident and its apex; G, H, tail, ventral and lateral views; I, posterior end, ventral view; J, K, right and left spicules; L, tail, ventral view. A, B, G, H, to scale 500 μm ; C, to scale 150 μm ; D, E, J, K, to scale 200 μm ; F, L, to scale 100 μm ; I, to scale 1000 μm .

and 270 μm ; oesophagus 8950 μm with muscular part 580 μm ; vulva 650 μm from head, unpaired ovejector 2900 μm . One posterior end with tail 200 μm . Length of entire female 81 mm.

Discussion

The specimens differ from the other two *Diplotrriaena* spp. from Australian Corvidae as follows:

In *D. alpha* Johnston & Mawson, 1940, the trident is smaller (120 μm instead of 250-285 μm) and oesophagus twice as long.

In *D. beta* Johnston & Mawson, 1940, considered by Anderson (1959) as a synonym of *D. flabellata* (Linstow, 1888) the oesophagus is very long, but the tridents shorter (190-200 μm), more massive, and with rounded apex, and the right spicule is a different shape.

The right spicule is bent in an 'L' similar to that of *D. delirae* Pinto & Noronha, 1970, from Tyrannidae in Brazil, however our material is distinguished from this species by the longer oesophagus, and the longer right spicule (1075 μm instead of 610 μm).

This material is therefore proposed as *D. beveridgei* n.sp., named after the collector, Dr Ian Beveridge. It is characterised by the large tridents, the long oesophagus (about 9 mm) and the 'L' shape of the right spicule.

Diplotriaena smithi n.sp.

(Fig. 12)

Material

5 collections from *Acanthogenys rufogularis* Gould: From The Bunkers, S. Aust.: 4 birds, as follows:

1. holotype ♀ (SAM V2105), allotype ♂ (SAM V2106)
2 ♀, 1 ♂, pieces of ♀ and ♂ (AHC 6278)
1 ♀, 1 ♂, posterior end 1 ♂ (MNHN, Paris 208 HD)
2. 1 ♀, 1 ♂ pieces of ♀ (AHC 6270)
3. 1 ♀, pieces of ♀ and ♂ (AHC 6268)
4. 4 ♀, 3 ♂, pieces of ♀ (AHC 6267)

From Wubin, W. Aust.: 6 ♀, 3 ♂ (AHC 6264); 3 ♀, 2 ♂ (MNHN, 208 HD).

Description

Morphological details are shown in Figure 12.

Dimensions

Holotype ♀: body length 50 mm, width 680 μm ; trident length 220 μm ; nerve ring and vulva 350 μm and 660 μm from head; length of oesophagus 4000 μm , of tail 45 μm , of unpaired part of ovejector 2100 μm .

Allotype ♂: length of body 22 mm, width 530 μm ; trident length 190 μm ; nerve ring and excretory pore 310 μm and 350 μm from head; length of oesophagus 2850 μm , of tail 68 μm , of left spicule 800 μm , of right spicule 650 μm .

Paratype 3 ♀: Length of body 35, 22, 39 mm; width 650, 610, 520 μm ; tridents 205, 195, 190 μm ; nerve ring 300, 290, 330 μm from head; length of oesophagus 2400, 2100 μm , damaged in 3rd; vulva 650, 730, 500 μm from head; tail length 40, 55, 55 μm .

Paratype ♂: body length 22 mm, width 520 μm , trident length 165 μm ; nerve ring 280 μm from head; oesophagus 3400 μm long (muscular part 340 μm); length of tail 80 μm ; of left spicule 785 μm , of right spicule 500 μm .

Variations observed among all the specimens: tridents 165-190 μm in males, 190-220 μm in females; vulva 480-730 μm from head; oesophagus 2000-3600 μm long in ♀; left spicule 730-850 μm , right spicule 500-680 μm . One male from AHC 6278 is teratological, with left and right spicules respectively 260 μm and 310 μm .

Discussion

D. zeta Johnston & Mawson, 1940, redescribed by Anderson (1959) was also taken from *Acanthogenys rufogularis*; the only female known is of similar dimensions to the present specimens, except that the trident is smaller (150 μm instead of 190-205 μm). Moreover, there are two grooves on the head of tridents in *D. zeta* not seen on any of the new specimens. These two differences, and the absence of a male of *D. zeta*, prevent the identification of the new material as *D. zeta*.

Five other species must be considered:

Two species have similar dimensions and spicule shape: *D. clelandi* (Johnston, 1912) from Cracticidae in Australia (male only known) and *D. kennedyi* Grewal, 1965, from Pycnonotidae from India. These two species are of doubtful status, as their morphology is imperfectly known, and it is impossible to compare our specimens with them.

The three other species in which the trident and spicules are similar to our specimens are distinguished as follows: in *D. pungens* (Schneider, 1866) from Turdidae in Asia, the oesophagus is very long (14500 μm in the ♀) and three pairs of papillae lie distinctly in front of the cloaca. In *D. flabellata* (Linstow, 1888), from Paradiseidae in the Aru Islands, the trident is more stoutly built, the body is particularly wide, the glandular oesophagus very long (6500-7500 μm in the female)—the left spicule strongly curved and the male tail rounded.

In *D. urocisoides* Anderson, 1959, from Corvidae in India, the head structure is characteristic ('buccal cavity surrounded by a clearly defined cuticular thickening often forming a plug,' Anderson, 1959) and the number of papillae is small.

It seems that the material described here is new, and the name *D. smithi* is proposed for it, in honour of our colleague I. Humphrey Smith. It is characterised by the large trident with blunt tip and without grooves, the oesophagus not very thick and not particularly long or short (2000-4000 μm), the spicules of medium length (730-850 μm and 500-600 μm) the tail of male rectangular in ventral view, with precloacal papillae few in number and situated close to the cloaca.

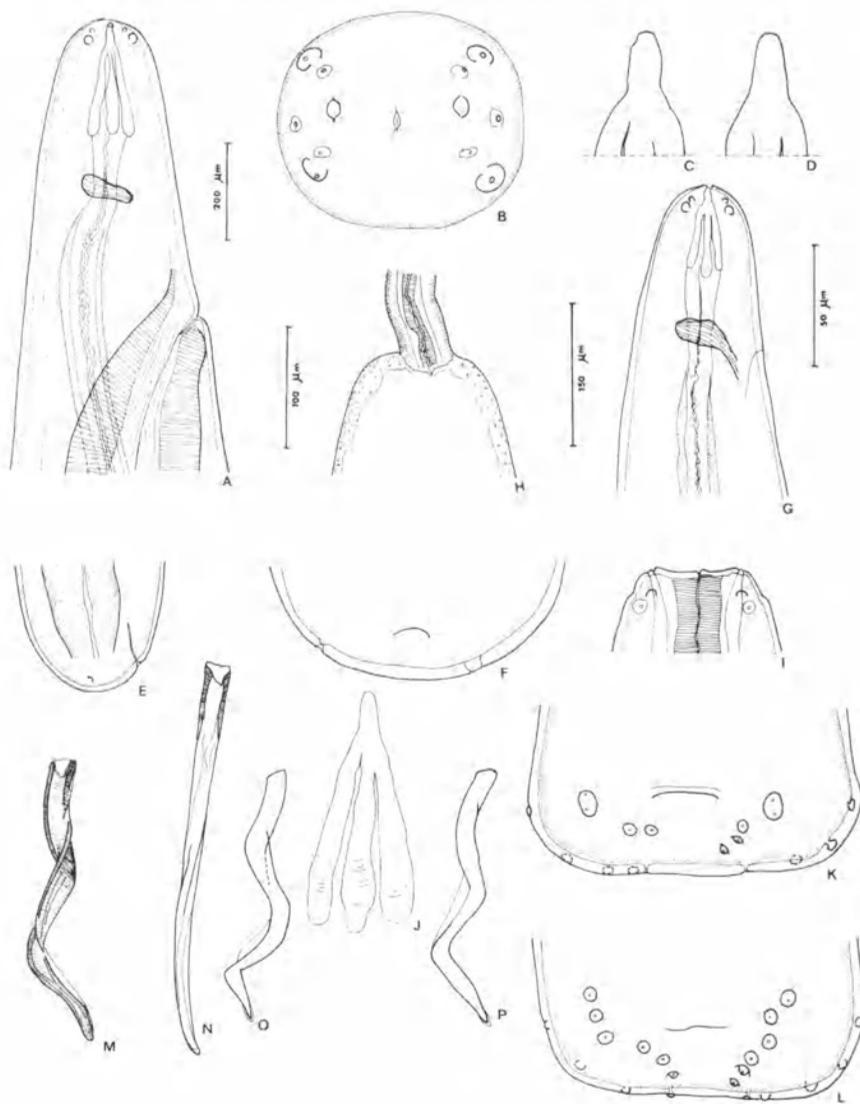


Figure 12. *Diplotrriaena smithi* n.sp. A, anterior end of female holotype, lateral view; B, head of female paratype, apical view; C, D, same female, apex of tridents; E, F, tail of same female in lateral and ventral views; G, anterior end of male allotype, lateral view; H, same male, oesophago-intestinal junction; I, head of same male, lateral view; J, trident of male paratype; K, tail of male allotype, ventral view; M, N, male allotype, right and left spicules, ventral views; O, P, two other views of same right spicule; A, E, G, M, N, O, P, to scale 200 μm; B, H, F, J, K, L, to scale 100 μm; C, D, to scale 50 μm; I, to scale 150 μm.

***Diplotrriaena delta* Johnston & Mawson, 1940**
(Fig. 13 A-O)

Material

From *Amytornis gwyderi* (Gould) (Maluridae), from the Simpson Desert, S. Aust.: 10 ♀, 2 ♂ (AHC 6274); 2 ♀ and 1 ♂ (MNHN 207 HD).

Description

Additional morphological details are given in Figure 13 A-O.

Dimensions

2 ♀: body length 70, 72 mm, width 460, 400 μm;

tridents 115-120 μm and 100 μm; nerve ring 180, 190 μm from head; oesophagus length 1850, 2110 μm, its muscular part 330, 160 μm; vulva 525, 400 μm from head; tail length 70, 32 μm; eggs 46 x 29 μm. The extremes of the oesophagus are 1750 μm and 2400 μm, in females measuring respectively 62 mm and 70 mm.

2 ♂: body length 30, 28 mm, width 400, 380 μm; tridents 110, 120 μm; nerve ring 170, 160 μm from head; left spicule 950 μm long, (calamus 240 μm), and 1050 μm; right spicule 720, 630 μm long; tail 50, 60 μm.

Discussion

These specimens are identified as *D. delta*, described from *Malurus lamberti* (Maluridae) in Australia. This species, placed by Anderson (1959) as a synonym of *D. tridens* (Molin, 1858), was reinstated by Ogden (1965), who had specimens from *M. lamberti* from various parts of Australia.

D. delta is recognisable by the simultaneous presence of the following characters (taken from the

new material and from Ogden): large body size (60-127 mm in female); tridents small (78-122 μm) with three small digitations at the tip; oesophagus of average size (1750-3900 μm in female, 1560-2600 μm in male), with glandular part thin or thick; left spicule 950-1140 μm , right spicule 620-730 μm , with triple twist; tail of male with two lateral swellings.

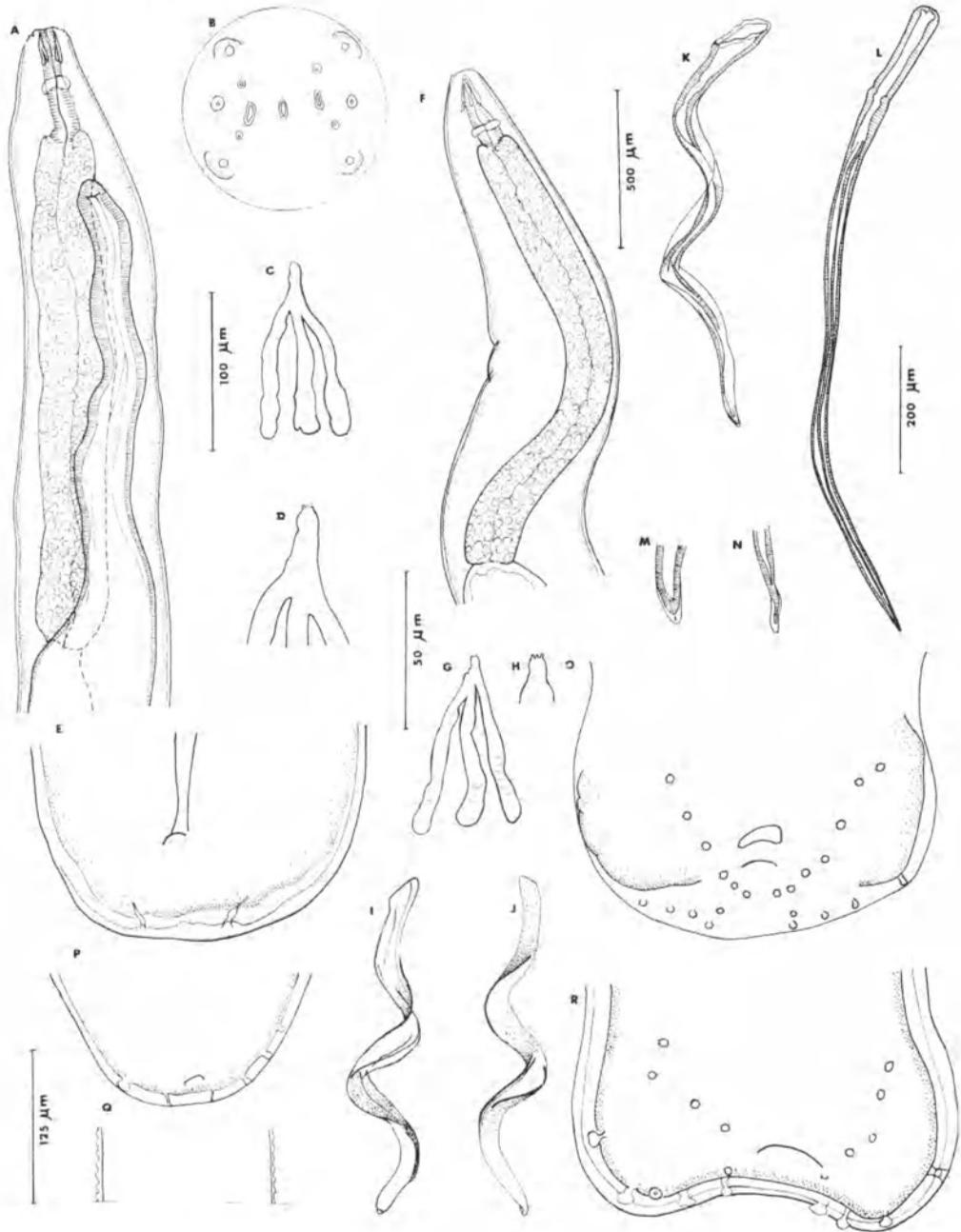


Figure 13. A-O, *Diplotriaeana delta*. A-E, female: A, anterior end, subventral view; B, head, en face; C, D, trident and its apex; E, tail, ventral view; F-O, male: F, anterior end; G, H, trident and its apex; I, J, two views of right spicule; K, L, right and left spicules of another male, lateral view; M, N, tips of right and left spicules, ventral views; O, tail, ventral view.

P-R, *D. falconis*. P, tail of female, ventral view; Q, profile of cuticle at mid-body; R, tail of male, ventral view.

A, F, Q, to scale 500 μm ; I, J, K, L, to scale 200 μm ; P, to scale 125 μm ; B, E, G, M, N, O, R, to scale 100 μm ; H, to scale 50 μm .

Diplotriaeana falconis (Connal, 1912)

(Fig. 13 P-R)

Material

From *Falco berigora* Vigors & Horsfield, from Yorke Peninsula, S. Aust.: 3♀, 1♂ (AHC 6269).

Description

Additional morphological details are given in Figure 13 P-R.

Measurements

2♀: body length 70, 72 mm; width 590, 660 µm; trident length 135, 135 µm; nerve ring 230, 230 µm from head; vulva 430, 660 µm from head; oesophagus in second female 2550 µm long, with muscular part 400 µm; tail 22, 28 µm; eggs 65 × 30 µm.

♂: body length 45 mm, width 550 µm; trident length 135 µm, oesophagus length 2700 µm, with muscular part 450 µm; tail 32 µm long; left spicule broken, 1025 µm long; right 1100 µm long (850 µm if measured in a straight line).

Discussion

The measurements, general morphology, and the characteristic anatomy of the left spicule agree with those of *D. falconis*, redescribed by Anderson (1959), from Falconidae in Africa. In the Australian specimens, there are ten pairs of papillae in the male, the tail of the female bears papillae, and the cuticle of the female is marked with regular and distinct undulations.

ACKNOWLEDGEMENTS

We are grateful to all those who collected the birds hosts or the parasites which enabled this work to be undertaken. These are Dr Ian Beveridge, Mrs Joan Paton, Dr Dom Serventy, Mr Shane Parker, and officials of the South Australian Museum and the Northern Territory Administration (Animal Industry and Agriculture Branch).

APPENDIX

Australian Species Described in this Paper, Arranged under their Hosts

Corvidae

Corvus orru Bonaparte
Aprocta bakeri n.sp.
Diplotriaeana beveridgei n.sp.

Cractiidae

Strepera graculina (Shaw)
Aprocta boulengeri n.sp.

Muscicapidae

Petroica multicolor (Gmelin)
Pseudaprocta copemani n.sp.
Pachycephala pectoralis (Latham)
Pseudaprocta copemani n.sp.
Oreoica gutturalis (Vigors and Horsfield)
Diplotriaeana spratti n.sp.

Maluridae

Amytornis goyderi (Gould)
Diplotriaeana delta Johnston and Mawson

Meliphagidae

Acanthogenys rufogularis Gould
Diplotriaeana smithi n.sp.

Falconidae

Falco berigora (Vigors and Horsfield)
Diplotriaeana falconis (Connal)
Serratospiculum guttatum (Schneider)
Falco peregrinus Tunstall
S. tendo (Nitzsch)
Falco longipennis Swainson
Serratospiculum guttatum (Schneider)

Strigidae

Ninox novaeseelandiae (Gmelin)
Lissonema sp.

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