SECTION 1

PARASITES

OF

FREE-LIVING MAMMALS

CHAPTER 1

Descriptions and re-descriptions

of

parasites of free-living mammals

Introduction

This chapter includes descriptions of new parasites of mammals as well as descriptions of larval stages in the life cycle of *Kirkioestrus* and a description of a *Lipoptena* species. Much of it is my work, and only those publications that have not been previously incorporated in one of my theses, are included here. Contributors were J.R. Palmieri (warthog filaria, for whom I collected material (Palmieri, Pletcher, De Vos & Boomker, 1985)), I.G. Horak (*Kirkioestrus*, for which I did the drawings and description (Horak, Boomker & De Vos, 1980)), E. Visagie (to whom I supplied material and edited the manuscript (Visagie, Horak & Boomker, 1992), R. Watermeyer (the *Setaria* species redescription, for which I supplied much of the material and funding, and edited the manuscript (Watermeyer, Boomker & Putterill, 2000, 2003, 2004) and J.R. Lichtenfels (description of *Haemonchus horaki*, material that I supplied after having previously published on the *Haemonchus* with the exceptionally long spicules (Boomker, Horak, Gibbons & De Vos, 1983; Lichtenfels, Pilitt, Gibbons & Boomker, 2001)). The paper on the *Molineus* of feral cats (Durette-Desset, Boomker & Malan, 2000) has been included here, because feral cats can be accepted as wild mammals!

This chapter has been arranged to group likes together, e.g. the descriptions of the trichostrongylids together, the *Setaria* species together and the miscellaneous ones together, and within the various groups, the articles are arranged chronologically.

ARTHROPODS (P 23)

HORAK, I.G., BOOMKER, J. & DE VOS, V., 1980. A description of the immature stages of *Kirkioestrus minutus* (Rodhain & Bequaert, 1915) (Diptera: Oestridae), and the life cycle and seasonal prevalence of this fly in blue wildebeest. *Onderstepoort Journal of Veterinary Research*, 47, 23 - 30.

VISAGIE, ELIZE J., HORAK, I.G. & BOOMKER, J., 1992. The louse fly *Lipoptena paradoxa* Newstead, 1907 (Diptera: Hippoboscidae): Description of its adult and puparium and biology in South Africa. *Onderstepoort Journal of Veterinary Research*, 59, 303 - 314.

TRICHOSTRONGYLID NEMATODES (P 45)

BOOMKER, J., 1977. A revision of the genus *Impalaia* Mönnig, 1924. *Onderstepoort Journal of Veterinary Research*, 44, 131 - 138.

BOOMKER, J., HORAK. I.G. & ALVES, REGINA, 1979. *Cooperia connochaeti* sp. nov. (Nematoda: Trichostrongylidae) from the blue wildebeest, *Connochaetes taurinus* (Burchell, 1823). *Onderstepoort Journal of Veterinary Research*, 46, 83 - 86.

BOOMKER, J., 1986. *Trichostrongylus auriculatus* n. sp. (Nematoda: Trichostrongylidae) from the steenbok *Raphicerus campestris* (Thunberg, 1811). *Onderstepoort Journal of Veterinary Research*, 53, 213 - 215.

BOOMKER, J. & DURETTE-DESSET, M.-C., 1997. Supplement to the description of *Longistrongylus thalae* (Troncy & Graber, 1973) Gibbons, 1981 (Nematoda: Ostertagiinae). *Systematic Parasitology*, 36, 69 - 73.

LICHTENFELS, J. RALPH, PILITT, PATRICIA L., GIBBONS, LYNDA M. & BOOMKER, JOOP D.F., 2001. *Haemonchus horaki* n. sp. (Nematoda: Trichostrongyloidea) from the grey rhebuck *Pelea capreolus* in South Africa. *Journal of Parasitology*, 87, 1095-1103.

BOOMKER, J. & DURETTE-DESSET, M.-C., 2003. Parasites of South African wildlife. XVII. *Ostertagia triquetra* n. sp. (Nematoda: Trichostrongylina) from the grey rhebuck, *Pelea capreolus* (Forster, 1790). *Onderstepoort Journal of Veterinary Research*, 70, 37 - 41.

BOOMKER, J. & TAYLOR, A., 2004. Parasites of South African wildlife. XVIII. *Cooperia pigachei* n. sp. (Nematoda: Cooperiidae) from the mountain reedbuck, *Redunca fulvofufula* (Afzelius, 1815). *Onderstepoort Journal of Veterinary Research*, 71, 171 – 174.

SETARIA SPECIES (P 85)

WATERMEYER, R., BOOMKER, J. & PUTTERILL, J.F., 2000. Studies on the genus *Setaria* Viborg, 1795 in South Africa. I. *Setaria africana* (Yeh, 1959). *Onderstepoort Journal of Veterinary Research*, 67, 229-234.

WATERMEYER, R., BOOMKER, J. & PUTTERILL, J.F., 2003. Studies on the genus *Setaria* Viborg, 1795 in South Africa. II. *Setaria scalprum* (Von Linstow, 1908) and *Setaria saegeri* (Le Van Hoa, 1961). *Onderstepoort Journal of Veterinary Research*, 70, 7-13.

WATERMEYER, R., BOOMKER, J. & PUTTERILL, J.F., 2004. Studies on the genus *Setaria* Viborg, 1795 in South Africa. III. *Setaria thwaitei* Mönnig, 1933. *Onderstepoort Journal of Veterinary Research*, 71, 107-111.

MISCELLANEOUS HELMINTHS (P 103)

PALMIERI, J.R., PLETCHER, J.M., DE VOS, V. & BOOMKER, J., 1985. A new filarial nematode (Onchocercidae) from warthogs (*Phacochoerus aethiopicus*) of the Kruger National Park. *Journal of Helminthology*, 59, 241 - 245.

BOOMKER, J., 1990. Parasites of South African wildlife. V. Description of the males of *Oesophagostomum mocambiquei* Ortlepp, 1964 from warthogs, *Phacochoerus aethiopicus* (Pallas, 1766). *Onderstepoort Journal of Veterinary Research*, 57, 169 - 173.

BOOMKER, J., BAIN, O., CHABAUD, A.G. & KRIEK, N.P.J., 1995. *Stephanofilaria thelazioides* n. sp. (Nematoda: Filariidae) from a hippopotamus and its affinities with the species parasitic in the African black rhinoceros. *Systematic Parasitology*, 32, 205 - 210.

DURETTE-DESSET, MARIE-CLAUDE, BOOMKER, J. & MALAN, F.S., 2000. *Molineus cati* n. sp. (Nematoda, Trichostrongylina, Molineoidea), a parasite of feral cats, *Felis catus* linnaeus, 1758 in South Africa. *Onderstepoort Journal of Veterinary Research*, 67, 173-177.

ARTHROPODS

Onderstepoort J. vet. Res., 47, 23–30 (1980)

A DESCRIPTION OF THE IMMATURE STAGES OF *KIRKIOESTRUS MINUTUS* (RODHAIN & BEQUAERT, 1915) (DIPTERA: OESTRIDAE), AND THE LIFE CYCLE AND SEASONAL PREVALENCE OF THIS FLY IN BLUE WILDEBEEST

I. G. HORAK(1), J. BOOMKER(1) and V. DE VOS(2)

ABSTRACT

HORAK, I. G., BOOMKER, J. & DE VOS, V., 1980. A description of the immature stages of *Kirkioestrus minutus* (Rodhain & Bequaert, 1915) (Diptera: Oestridae), and the life cycle and seasonal prevalence of this fly in blue wildebeest. *Onderstepoort Journal of Veterinary Research*, 47, 23–30 (1980)

Descriptions of the 1st, 2nd and 3rd instar larvae and the puparium of *Kirkioestrus minutus* are given. First instar larvae, which have not previously been described, can be distinguished from other oestrid larvae by the ventral spinulation of segments IV–XII and the spinulation of the anal protuberance.

Of 55 blue wildebeest examined in the Kruger National Park all but two 1-month-old and one 2-month-old animals were infested. First stage larvae are probably deposited in or on the nostrils and may develop within 30 days, initially in the nasal passages and then in the frontal sinuses to mature 3rd stage larvae. Development within the host appears to take longer during the cooler months of the year. Pupal periods vary from approximately 32 days in early or late summer to more than 50 days in winter.

Three of 6 blesbok examined at Badplaas in the eastern Transvaal were infested with 1st instar larvae only of *K. minutus* and it is suggested that blesbok may not be suitable hosts of this fly. Four black wildebeest in the Golden Gate National Park in the eastern Orange Free State were not infested.

Résumé

UNE DESCRIPTION DES STADES D'IMMATURITÉ DU KIRKIOESTRUS MINUTUS *(RODHAIN & BEQUAERT,* 1915) *(DIPTERA: OESTRIDAE), ET DU CYCLE DE VIE AVEC PRÉVALENCE SAISONNIÈRE DE CETTE MOUCHE CHEZ LE GNOU*

Des descriptions des 1er, 2d et 3me stades des larves et chrysalides du Kirkioestrus minutus (Rodhain & Bequaert, 1915) *sont données. Les larves de premier stade qui n'avaient pas été décrites antérieurement peuvent se distinguer des autres larves d'oestrides par la spinulation ventrale des segments IV–XII et par la spinulation de la protuberance anale. A la suite de l'examen de 55 gnous observés au Park National Kruger, tous les animaux, à l'exception de deux d'entr'eux, l'un agé de 1 mois et l'autre de 2 mois, se trouvaient infestés. Les larves du premier stade sont probablement déposées à l'intérieur ou sur les narines et peuvent se développer en 30 jours, initialement dans les passages nasaux et alors dans les sinus frontaux pour y mûrir en larves du 3me stade. Le développement à l'intérieur de l'hôte paraît prendre plus longtemps pendant les mois frais de l'années. Les périodes de chrysalide varient d'approximativement 32 jours au début ou à la fin de l'été jusqu'à 50 jours en hiver.*

Trois des blesboks examinés à Badplaas dans l'est du Transvaal étaient infestés avec des larves de K. minutus *du premier stade et il en est suggéré que le blesbok pourrait ne pas être un hôte adéquat pour cette mouche. Quatre gnous du Parc National Golden Gate dans l'est de l'Etat Libre d'Orange n'étaient pas infestés.*

INTRODUCTION

The larvae of *Kirkioestrus minutus* (Rodhain & Bequaert, 1915) are parasites of the nasal passages and para-nasal sinuses of the blue wildebeest (*Connochaetes taurinus*), korrigum (*Damaliscus korrigum*), common hartebeest (*Alcelaphus buselaphus*) and Lichtenstein's hartebeest (*Alcelaphus lichtensteini*) (Zumpt, 1965) and are also found in the tsessebe (*Damaliscus lunatus*) (Wetzel, 1970).

The 2nd and 3rd stage larvae and a female fly were described by Zumpt (1965), who stated that the 1st stage larva and life cycle were unknown and that few flies hatched from larvae that had been allowed to pupate. Wetzel (1970) mentioned that mature 3rd instar larvae are dark brown in colour, a feature not recorded by Zumpt (1965), and that the life cycle is probably similar to that of other Oestrinae in that the 1st stage larvae are laid around the nasal openings and in the eyes and migrate from there to the nasal and sinus cavities where they develop to 2nd and 3rd stage larvae. He also stated, without giving exact figures, that the pupal period lasted a month and that the life cycle is not seasonally influenced since 3rd stage larvae are present in February, March, July, October and December.

In Zambia, Howard (1977) found that 8 out of 9 Lichtenstein's hartebeest harboured 24–34 3rd stage larvae of a *Kirkioestrus* species, and these he considered to be near *K. minutus*. As he was unable to identify the 1st and 2nd stage larvae specifically, he included these with the *Oestrus* spp. larvae, which were also present.

A survey conducted to determine the seasonal prevalence of the internal and external parasites of blue wildebeest in the Kruger National Park afforded an opportunity to study the oestrid flies parasitizing these animals. Nearly all the wildebeest examined were infested with *K. minutus*, and once the 1st stage larvae had been differentiated from those of other flies and the mature 3rd instar larvae had been allowed to pupate and flies to hatch, it became possible to describe the various developmental stages, the life history of the fly and its seasonal occurrence.

MATERIALS AND METHODS

Each month from November 1977 to November 1978 at least 4 wildebeest were shot in the southern half of the Kruger National Park. The majority of wildebeest in the Park are born during December and an attempt was made each month to shoot 2 animals from the latest calf crop plus 2 from the previous year's crop. This culling procedure meant that animals ranging in age from 1–24 months were ultimately examined. Sometimes older animals were also shot.

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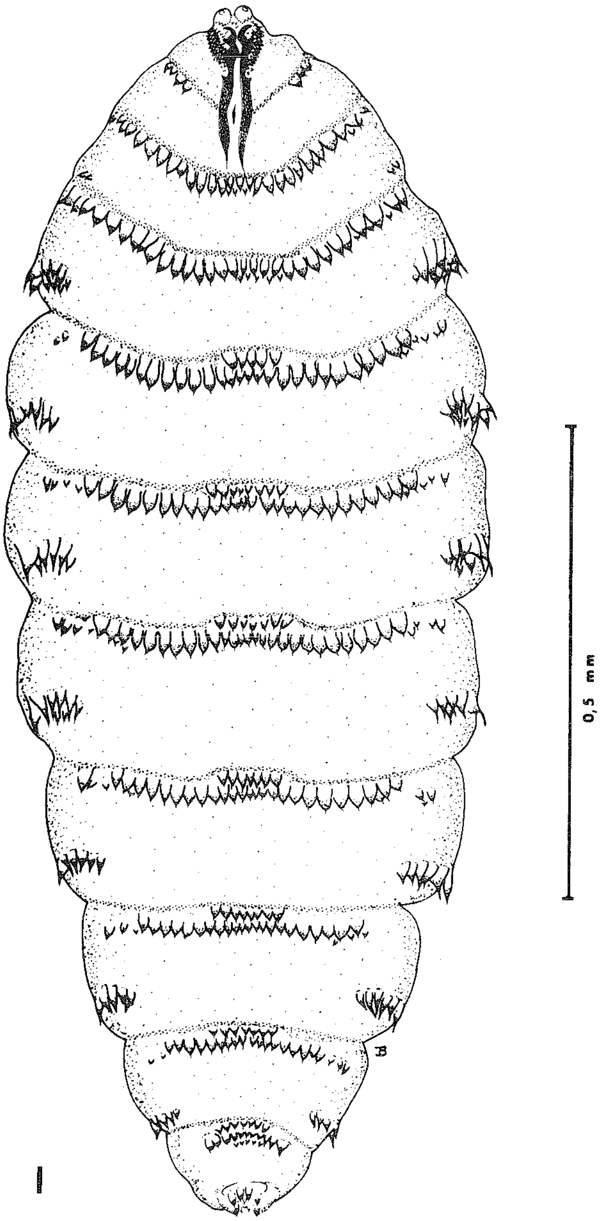
As soon after death as possible the eyes of the animals were examined for oestrid larvae and the heads, severed from the carcasses, placed in plastic bags. The carcasses were eviscerated and the viscera placed in plastic bags and transported with the carcasses and heads to the laboratory at Skukuza.

The skin and ears were removed from each head, which was then divided sagittally by means of a bowsaw. All larvae present on the mucosa of the nasal septum, nasal passages and conchae were removed with fine-tipped forceps and placed in 70% ethyl alcohol. Thereafter the septum, conchae and half of the brain were removed for closer examination. The dura on the side from which the brain had been removed was stripped from the cranial cavity and placed in 70% alcohol. The sinus cavities were opened and all immature larvae removed and preserved in alcohol. The tracheae and the bronchial trees of the right lungs, the hearts and major blood vessels were opened and thoroughly washed. The washings were poured through sieves with 38μm apertures and the contents of the sieves were collected and preserved by adding 10% formaldehyde solution.

Whenever mature 3rd instar larvae were present in the sinus cavities, they were specifically identified under a stereoscopic microscope. The larvae of each species were placed separately in approximately 60 mm of vermiculite in glass bottles with nylon gauze tops and allowed to pupate. The flies hatched in these bottles, which were kept on a shelf in the necropsy room. This room had a single solid wall and three sides constructed of fine wire gauze on wooden supports. The bottles were examined daily and the dates of larval collection and fly emergence noted. Newly-emerged flies were left for approximately 2 h to expand and dry their wings and were then placed in 70% alcohol.

Six blesbok (*Damaliscus dorcas phillipsi*), shot at Badplaas in the eastern Transvaal, and 4 black wildebeest (*Connochaetes gnou*), shot in the Golden Gate National Park in the eastern Orange Free State, were examined in the same way.



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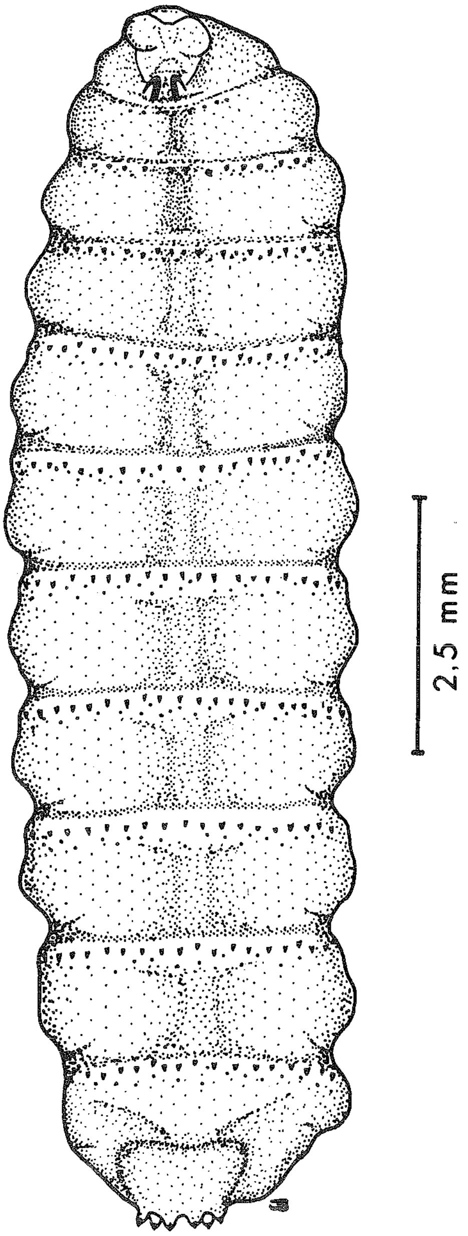

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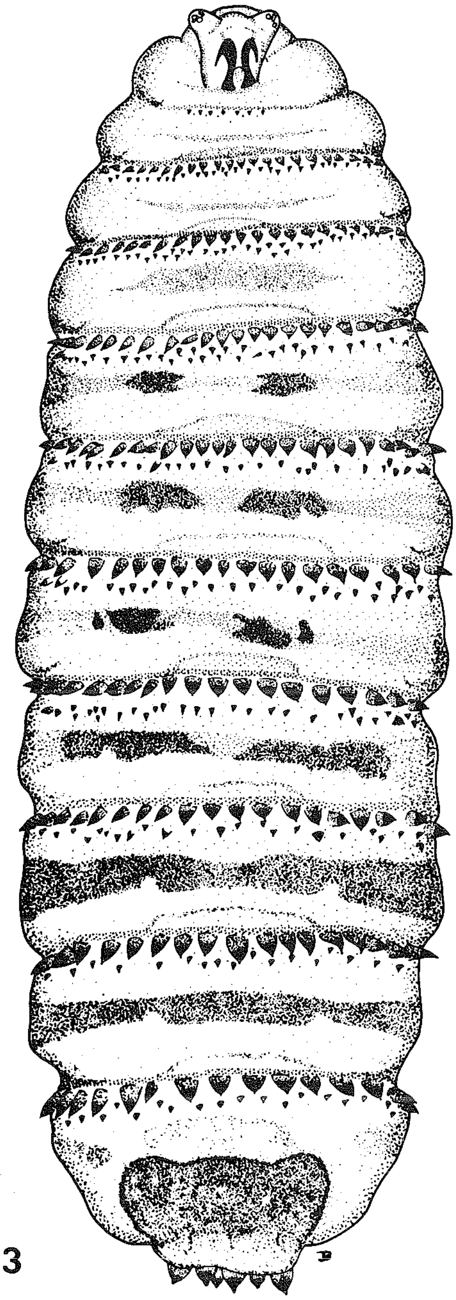
FIG. 1 First instar larva of *K. minutus*, ventral view
FIG. 2 Second instar larva of *K. minutus*, ventral view



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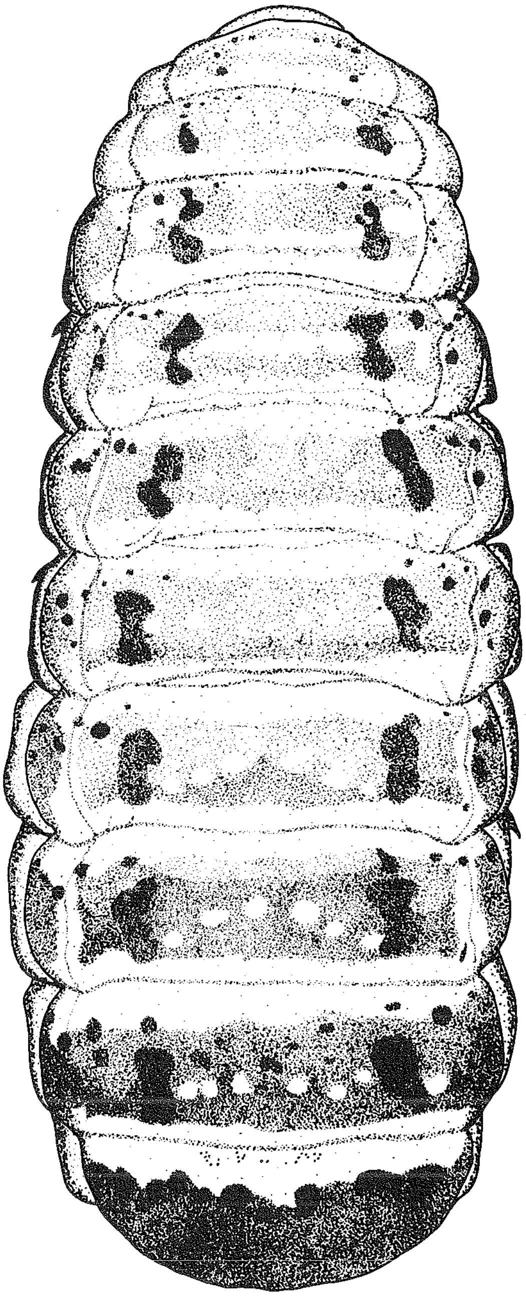

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FIG. 3 Third instar larva of *K. minutus*, ventral view
FIG. 4 Third instar larva of *K. minutus* dorsal view; scale as for Fig. 3

All the material collected was examined under a stereoscopic microscope for oestrid larvae which were identified according to species and stage of development. The body lengths of the larval stages of *K. minutus* were measured and these larvae and the pupal stage are illustrated and described below.

KIRKIOESTRUS MINUTUS (RODHAIN & BEQUAERT, 1915)

DESCRIPTION

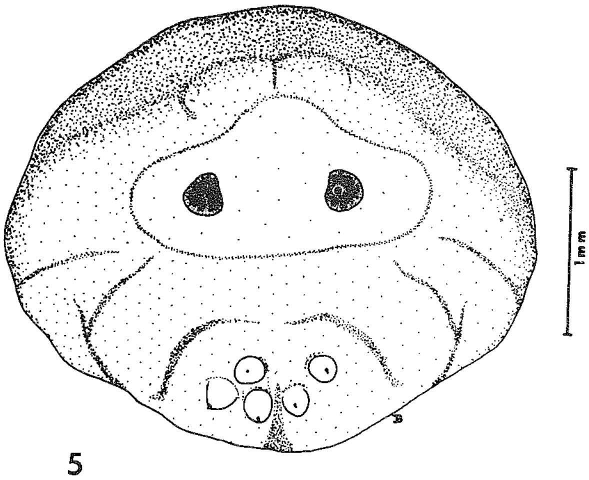
The body lengths of the various larval stages are summarized in Table 1.

First instar larva (Fig. 1)

The semi-transparent, white 1st instar larva, which is broadly-rounded anteriorly widens progressively to the level of the 6th segment, then tapers gradually to a blunt point posteriorly. The antennal lobes each have one small pseudocellus. Ventrally, each of the segments IV–XII bears a band of large pointed spines, arranged in a short anterior row and a longer posterior row on its anterior border. Occasionally a short 3rd row of spines is present. The

TABLE 1 The ranges in length of the various larval stages of *K. minutus* recovered from blue wildebeest

Stage of development	Range in length (mm)	No. of larvae measured
1st stage larvae...	1,1– 4,8	111
2nd stage larvae..	3,1–13,4	106
2nd moult......	10,5–13,9	22
3rd stage larvae..	10,1–28,0	142



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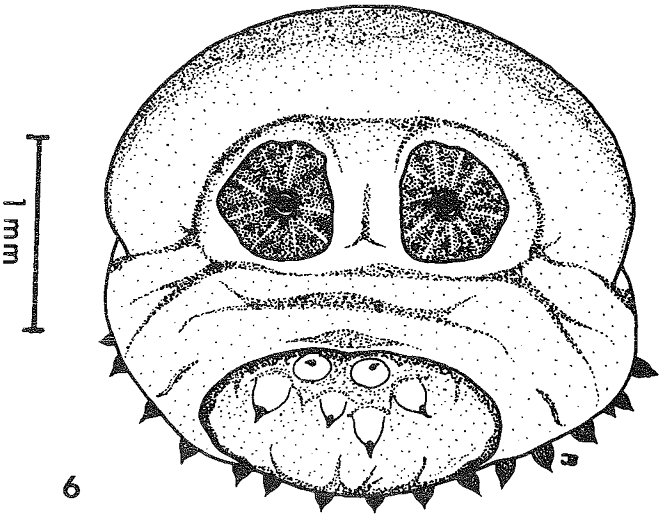

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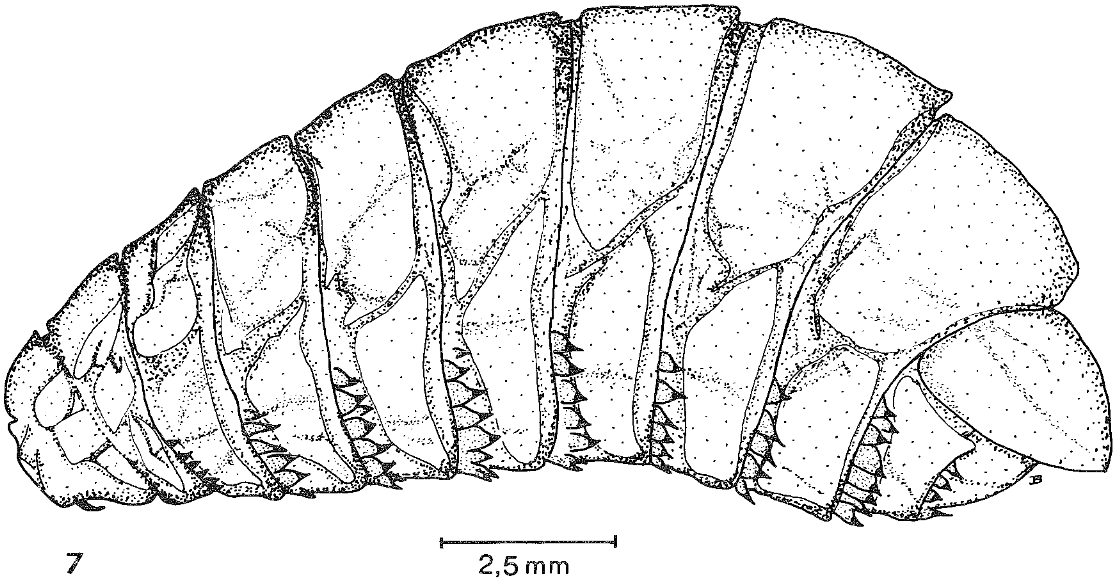

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FIG. 5 Posterior end of 2nd instar of *K. minutus* larva, showing peritremes and spinulation
FIG. 6 Posterior end of 3rd instar larva of *K. minutus*, showing peritremes and spinulation
FIG. 7 Puparium of *K. minutus*, lateral view

posterior part of the 4th segment bears a few small spines lateroventrally, whereas segments V–XI bear a cluster of large spines in this position. The posterior spiracles lie in a shallow depression and are difficult to see. The anal protuberance bears about 7 small ventral and 2 large lateral pointed spines.

Second instar larva (Fig. 2, 5)

Larvae in the second instar (Fig. 2) are creamy-white in colour. The cephalic end is approximately as wide as the posterior end. The spinulation is the same as that of the 3rd instar larva and the latero-ventral spines present posteriorly on segments IV–XI of the 1st instar larva are absent. The peritremes are small, and the anal protuberance is armed with about 5–6 large spines (Fig. 5).

Third instar larva (Fig. 3, 4, 6)

The mature 3rd instar larva is yellow-brown in colour and slightly wider posteriorly than anteriorly (Fig. 3, 4). The antennal lobes each have 3 pseudocelli. Segments III–XII have dark brown patches laterally and segments IV–XI are each encircled by a dark brown band. The bands on the anterior segments are lighter in colour and narrower than those on the posterior segments. Ventrally, segment III bears only a short row of small spines, whereas segments IV–XII bear bands of spines anteriorly, each band consisting of an anterior row of large spines plus a posterior row of short spines. The posterior peritremes are fairly large and lie in a shallow depression. The dorsal margin of this depression is spineless, whereas the well-developed anal protuberance, which forms the ventral margin of the depression, bears approximately 6 large pointed spines (Fig. 6).

Pupa (Fig. 7)

The puparium is about 17 mm long, dark brown or black in colour, flat ventrally and markedly convex dorsally, and bears the spines of the unshed integument of the 3rd instar larva.

LIFE CYCLE AND SEASONAL PREVALENCE IN BLUE WILDEBEEST

The burdens of *K. minutus* larvae recovered from 1–12-month-old wildebeest are summarized in Table 2.

TABLE 2 The numbers of *K. minutus* larvae recovered from 1- to 12-month-old blue wildebeest in the Kruger National Park

Date slaughtered	Age in months	Number and stage of development of *K. minutus* larvae recovered			
		1st	2nd	3rd	Total
1978					
16 January	1	0	0	0	0
16 January	1	0	0	0	0
14 February	2	0	0	0	0
14 February	2	0	1	0	1
13 March	3	0	0	1	1
13 March	3	0	1	1	2
3 April	4	0	1	11	12
3 April	4	0	5	8	13
17 April	4	20	1	13	34
17 April	4	0	11	6	17
8 May	5	0	14	11	25
8 May	5	0	8	5	13
5 June	6	4	21	53	78
5 June	6	68	1	0	69
3 July	7	0	8	29	37
3 July	7	0	11	47	58
7 August	8	0	6	15	21
7 August	8	0	6	25	31
11 September	9	0	6	89	95
11 September	9	0	3	6	9
16 October	10	0	22	51	73
16 October	10	0	17	88	105
15 November	11	0	17	86	103
15 November	11	0	7	138	145
1977					
15 November	11	0	2	30	32
16 November	11	0	0	33	33
13 December	12	7	1	31	39
14 December	12	0	0	8	8

TABLE 3 The mean numbers of *K. minutus* larvae recovered from blue wildebeest older than 3 months in the Kruger National Park

Month killed	No. of wildebeest examined	Mean number of *K. minutus* larvae recovered				
		1st	2nd	3rd	Total	1st and 2nd stage larvae as a % of the total
1977						
November	4	3,25	1,5	24,5	29,25	16,2
December	4	2,5	0,8	22,5	25,8	12,8
1978						
January	2	44,5	2,5	33,0	80,0	58,8
February	2	0,0	0,5	25,0	25,5	2,0
March	2	35,5	0,0	11,5	47,0	75,5
April	6	4,7	6,1	10,0	20,8	51,9
May	4	2,0	10,5	14,5	27,0	46,3
June	4	18,25	6,0	26,25	50,5	48,0
July	5	10,4	4,2	30,8	45,4	32,2
August	4	4,5	3,5	17,5	25,5	31,4
September	4	0,0	6,75	29,75	36,5	18,5
October	4	0,0	11,5	56,0	67,5	17,0
November	4	0,5	6,25	89,25	96,0	7,0

Except for the two 1-month-old animals and 1 of the 2-month-old animals, all the other wildebeest examined were infested. The 2-month-old and 3-month-old wildebeest shot during February and March 1978 harboured only 1 or 2 larvae. Thereafter larval burdens increased in number, reached a peak in the 6-month-old animals shot during June 1978, decreased slightly and then rose again to reach a major peak in the 11-month-old animals slaughtered during November 1978. The latter animals harboured considerably more larvae than the wildebeest of equal age killed the previous November.

Excluding the larval burdens of the animals 1–3 months of age, the mean monthly burdens of *K. minutus* larvae recovered from all the wildebeest examined are summarized in Table 3.

No 1st stage larvae were recovered during February, September or October 1978, while 2nd and 3rd stage larvae were present throughout the survey period. Except in November and December 1977 and February 1978, mature 3rd instar larvae were recovered in every month.

TABLE 4 The length of the pupal period of *K. minutus* in the Kruger National Park

Date larvae collected	No. collected	Date flies hatched	No. of flies hatched	Pupal period in days
1978				
16 Jan.	3	Failed to hatch	0	—
13 March	5	13 April (1), 14 April (3)	4	31–32
17 April	2	Failed to hatch	0	—
8 May	1	Failed to hatch	0	—
5 June	6	Failed to hatch	0	—
3 July	3	*25–30 August (1)	1	*53–58
7 August	7	20 September (2), 22 September (1)	3	44–46
11 Sept.	4	18 October (1)	1	37
16 Oct.	4	18 November (1), 19 November (1), 23 November (1)	3	33–38
15 Nov.	1	Failed to hatch	0	—

* The exact day on which the fly hatched was not recorded.
( ) =Brackets indicate number of flies hatched on a particular date.

TABLE 5 Oestrid larvae recovered from blesbok at Badplaas

Date blesbok killed	Number and stage of development of larvae recovered						
	K. minutus	*Gedoelstia* sp.			*O. macdonaldi*		
	1st	1st	2nd	3rd	1st	2nd	3rd
1978							
17 May	2	138	5	45	0	18	43
17 May	67	128	6	29	0	0	0
19 June	0	7	13	21	0	0	0
19 June	2	67	4	29	0	0	0
19 July	0	6	32	27	0	1	0
19 July	0	1	2	14	0	0	0

Although larval burdens varied considerably, larger proportions of the total burdens were in the 1st and 2nd stage of development from April–August than during September–December. The findings for January–March are difficult to assess as only 2 older animals were examined in each of these months. Large numbers of 1st stage larvae were present, however, during January and March.

First stage larvae were recovered from the nasal septa, ventral conchae and ventral and median nasal passages, 2nd and 3rd stage larvae from the frontal sinuses, and the nasal passages and conchae surrounding the sinus entrances. No *K. minutus* larvae were recovered from the eyes, brain surfaces, dura, hearts and major blood vessels, or lungs and tracheae.

A constant, although subjective observation, was that the mature 3rd instar larvae of *K. minutus* appeared sluggish when compared with similar larvae of the other oestrid species, namely, *Gedoelstia cristata, Gedoelstia hässleri, Oestrus aureoargentatus* and *Oestrus variolosus*, recovered from the wildebeest.

The dates of larval collection and fly emergence and the duration of the pupal periods are summarized in Table 4.

Few flies hatched in comparison with the total number of mature larvae collected. Pupal periods increased from 31–32 days for larvae collected during March 1978 to 53–58 days for the larva collected during July and subsequently decreased to 33–38 days for larvae collected during October.

The larval burdens of the blesbok shot at Badplaas are summarized in Table 5.

Three of the 6 blesbok were infested with 1st stage larvae of *K. minutus*, but harboured no 2nd or 3rd stage larvae of this species. Larvae of *Gedoelstia* sp. near *G. hässleri* in all 3 stages of larval development were present, however. Two animals were infested with *Oestrus macdonaldi*, 1 harbouring a 2nd stage larva and the other 2nd and 3rd stage larvae.

The 4 black wildebeest shot in the Golden Gate National Park harboured only larvae of *G. hässleri.*

DISCUSSION

Larval identification

The 1st instar larva of *K. minutus* has to be differentiated from those of *Oestrus* spp. (*O. aureoargentatus* and *O. variolosus*) and *Gedoelstia* spp. (*G. cristata* and *G. hässleri*), which may also be found in the nasal passages of blue wildebeest (Zumpt, 1965). In *K. minutus* segments IV–XII each bear 2 rows of spines on their antero-ventral borders and the anal protuberance is armed with approximately 7 small ventral and 2 large lateral pointed spines. In *Oestrus* spp. the anterior borders of segments III–XII each bear 3–5 rows of ventral spines and the ventral aspect of the last segment has about 18–54 terminal hooklets arranged in 2 scallops (Basson, 1962; Zumpt, 1965; Nevill & Basson, 1966). In *Gedoelstia* spp. the antero-ventral borders of segments IV–XII each carry 3–4 rows of spines and the anal protuberance of segment XII is nude (Basson, 1962).

Life cycle

The recovery of 1st stage larvae from the nasal septa and passages of the wildebeest and not from the eyes, brain surfaces or dura implies that the life cycle is similar to that of *Oestrus ovis* in sheep, with the flies depositing larvae on or in the nostrils (Bedford, 1925; Capelle, 1966), and not like that of *Gedoelstia* spp., in which the larvae are deposited in the eyes and make their way to the brain and dura (Basson, 1966; Horak & Butt, 1977). The larvae may be deposited singly or in either small or large batches as indicated by the single larva recovered from the 2 and 3-month-old animals and the large numbers of 1st instar larvae recovered from older individuals.

Development of the 1st stage larvae takes place on the mucosa of the nasal passages and conchae and they grow from approximately 1,1 mm–4,8 mm during this process. The first moult probably occurs soon after this length has been reached but, since no larvae in the 1st ecdysis were recovered, this cannot be verified. This moult probably takes place on the median conchae as is the case with *O. ovis* (Cobbett & Mitchell, 1941; Horak, 1977). The newly emerged 2nd instar larvae, which may initially be shorter than larvae of the preceding stage, migrate to the frontal sinuses, where they grow to approximately 13,4 mm before commencing the 2nd ecdysis. During this moult the larvae also shrink slightly, as larvae at the commencement of the ecdysis usually exceeded 13,0 mm in length, while those at the point of emergence measured little more than 10,0 mm. Third stage larvae may grow to approximately 28,0 mm in length, but mature larvae considerably shorter than this were recovered. As the larvae mature their integument darkens to form bands around segments III–XII.

The total time taken for development in the host animal may be as short as 30 days. This period can be deduced from the fact that young wildebeest, shot during a particular month, often harboured considerably more 3rd stage larvae than the total larval burdens of animals shot during the previous month.

Mature 3rd instar larvae leave the host and pupate in the soil, pupal periods varying from approximately 32 days for larvae collected during October (early summer) and March (late summer) to more than 50 days for larvae collected during July (mid-winter). The pupal periods of the mature larvae collected during mid-summer would probably have been shorter than 30 days had they given rise to flies. The freed mature larvae or the pupae apparently required particular conditions for subsequent maximum eclosion of the flies. Only 12 flies hatched from a total of 36 mature larvae collected, while 29 of 37 *G. hässleri* larvae and 22 of 31 *O. aureoargentatus* larvae collected during the same period hatched. Zumpt (1965) commented on the small number of flies resulting from *K. minutus* larvae he had allowed to pupate. It is not clear from his description of the 3rd instar larvae whether he realized that these larvae are only mature once they exhibit dark circular bands, and he may have used immature 3rd stage larvae in his experiments.

Seasonal fluctuation

No clear seasonal fluctuations in the composition of the larval burdens were apparent, probably because the comparatively warm winter temperatures in the Kruger Park made development throughout the year possible. The increase in the proportion of 1st and 2nd stage larvae during the cooler months does indicate, however, a slower rate of development then, than in spring and summer. Similar observations have been made on the development of *O. ovis* in sheep (Cobbett & Mitchell, 1941; Rogers & Knapp, 1973; Horak, 1977).

A marked increase in infestation compared with the level of infestation during 1977 appeared imminent during the summer of 1978/79. Three out of the 4 animals shot during November 1978 harboured more than 100 larvae compared with the 25–33 larvae harboured by the 4 animals shot during the previous November. The reason for this increase cannot be deduced from the available data.

The pupal periods of *K. minutus* were generally similar to those of *G. cristata* and *O. aureoargentatus* larvae collected at the same time. However, *K. minutus* larvae collected during April–June failed to develop into flies, while the other 2 flies had pupal periods of approximately 70 days for larvae collected during May and June. The inability of *K. minutus* to develop to adulthood from mature larvae collected during this period is a finding apparently only applicable to the laboratory. The burdens of 1st instar larvae in wildebeest shot during July and August implied that mature larvae had successfully pupated in the field and flies hatched and deposited larvae during this time.

The seasonal fluctuations noted in the lengths of the pupal periods indicate that atmospheric temperature played an important role. Pupal periods were short during the warm months and considerably longer during the cooler months. Similar observations have been made for the pupal periods of *O. ovis* on the Transvaal Highveld (Horak, 1977). The shortest pupal period recorded for *K. minutus* in this study being 31 days compares favourably with the period of 1 month mentioned by Zumpt (1965) and Wetzel (1970), although they gave no exact figures nor the month in which the larvae had been collected.

Host specificity

Although a number of alcelaphine antelope have been listed as hosts of *K. minutus* (Zumpt, 1965; Wetzel, 1970), *K. minutus* had not previously been recovered from blesbok. The presence of 1st instar larvae only in blesbok at Badplaas suggests that these animals are not suitable hosts. Infestation in this area may have been maintained in tsessebe or in black wildebeest running in the same camp as the blesbok, although black wildebeest have not been described as hosts of this fly, nor did those in the Golden Gate National Park harbour its larvae.

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We wish to thank Messrs P. C. Pieterse and B. de Klerk for their assistance with the necropsies of the wildebeest.

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THE LOUSE FLY *LIPOPTENA PARADOXA* NEWSTEAD, 1907 (DIPTERA: HIPPOBOSCIDAE): DESCRIPTION OF ITS ADULT AND PUPARIUM AND BIOLOGY IN SOUTH AFRICA

ELIZE J. VISAGIE (1), I. G. HORAK (2) and J. BOOMKER (3)

ABSTRACT

VISAGIE, ELIZE J., HORAK, I. G. & BOOMKER, J., 1992. The louse fly *Lipoptena paradoxa* Newstead, 1907 (Diptera: Hippoboscidae): description of its adult and puparium and biology in South Africa. *Onderstepoort Journal of Veterinary Research,* 59, 303–314 (1992)

Lipoptena paradoxa Newstead, 1907 is re-described using scanning electron microscopy and its puparium is described for the first time. The distribution of the fly is restricted to the eastern half of South Africa, generally at altitudes below 600 m. Its preferred hosts are all browsing antelope namely, bushbuck, nyalas, kudus and common duikers. The largest numbers of flies were present on kudus in the Kruger National Park from July or August to January and large numbers were recovered from these animals' tails from November to January. Considerably more female than male flies were collected.

INTRODUCTION

Conventional descriptions of the adults of the louse fly, *Lipoptena paradoxa* Newstead, 1907 (Diptera: Hippoboscidae) have been published in Newstead, Dutton & Todd (1907), and by Ferris (1930), Bequaert (1940; 1942), Tendeiro (1951) and Maa (1963; 1965; 1969). No descriptions based on scanning electron microscopic examination of the fly have been published nor has the puparium been described. There are a number of rather incomplete descriptions of the exterior of the puparia of various other hippoboscid flies (Ferris & Cole, 1922; Ferris, 1923; Schuurmans-Stekhoven, 1926; Bequaert, 1953; Maa, 1969; Theodor, 1975), while Baker (1990) has given a detailed description of the external features of the puparium of *Lipoptena mazamae* Rondani, 1878.

The distribution of *L. paradox* is confined to sub-Sharan Africa where it has been recorded from Ethiopia, Ghana, Kenya, Burundi, Uganda, Congo, Zaïre, Tanzania, Angola, Malawi, Zambia, Mozambique, Zimbabwe, Botswana and South Africa (Bequaert, 1942; Haeselbarth, Segerman & Zumpt, 1966; Maa, 1968; 1969; Hutson & Oldroyd, 1980). Within the Republic of South Africa it has been recorded in Transvaal, Natal and the Cape Province (Bedford, 1926; Maa, 1969; Boomker, Du Plessis & Boomker, 1983; Horak, Keep, Spickett & Boomker, 1989; Horak, Boomker, Spickett & De Vos, 1992).

The fly has been recovered from roan antelope (*Hippotragus equinus*), oribi (*Ourebia oribi*), grysbok (*Rhaphicerus melanotis*), common duiker (*Sylvicapra grimmia*), impala (*Aepyceros melampus*), bushbuck (*Tragelaphus scriptus*), lesser kudu (*Tragelaphus imberbis*), nyala (*Tragelaphus angasii*), kudu (*Tragelaphus strepsiceros*), eland (*Taurotragus oryx*), common reedbuck (*Redunca arundinum*) and waterbuck (*Kobus ellipsiprymnus*) (Bedford, 1926; Bequaert, 1940, 1942; Haeselbarth *et al.*, 1966; Maa, 1968; 1969; Boomker *et al.*, 1983; Horak *et al.*, 1989; 1992).

L. paradoxa has an interesting life cycle in that the 3 larval instars develop *in utero* and the ensuing prepupa is deposited on the host animal. The prepupa falls to the ground and pupates. The imago that hatches is winged, but the wings break off once a host is found, the fly thus becoming confined to the host.

In this paper important taxonomic features of *L. paradoxa* are illustrated by means of scanning electron photomicrographs and the morphology of the puparium is described for the first time. The fly's geographic distribution and host-preference within the Republic of South Africa, which had hitherto been based on collections from individual animals, are now more clearly defined by surveys conducted in various regions on numerous hosts. The seasonal abundance of *L. paradoxa* on kudus in the Kruger National Park, eastern Transvaal Lowveld is discussed, as well as the ratio of male to female flies on these and other antelopes.

TAXONOMY

MATERIALS AND METHODS

Scanning electron microscopy (SEM)

Adult flies

Both fresh material and material stored in alcohol were used for SEM purposes. Dirt on specimens was removed with KOH or NaHpCl in an ultrasonic cleaner, or carefully brushed off with acetone before drying. Fresh specimens were frozen for 24 h or more, whereafter relevant structures were dissected out under a stereoscopic microscope and freeze-dried for 24 h. Specimens stored in alcohol were dehydrated in graded ethyl alcohol and completely desiccated in an oven at 35 °C. All specimens were stored in a desiccator until mounted on stubs using a chloroform-based adhesive. Small specimens were mounted with colourless nail varnish. Specimens were sputter-coated with gold and examined with an ISI 100 scanning electron microscope.

Puparia

Pupae were obtained from flies collected from immobilised bushbuck and kept in an incubator at 25 °C and 30 % RH until eclosion. The empty puparia were cut in half, mounted and sputter-coated as described for the adult flies.

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Lipoptena paradoxa Newstead, 1907

Lipoptena paradoxa Newstead, 1907: 91;

Echestypus paradoxus Bruce, Hammerton & Bruce, 1911: 228;

Eschetypus paradoxus Curson, 1928: 182, laps cal.;

Echestypus parvipalpis Speiser, 1907: 3, 5; Falcoz, 1929: 52.

The institutions from which dry, or alcohol preserved, or slide-mounted specimens were obtained for study and comparison are listed below:

BMNH — British Museum (Natural History)
KGP — Kalahari Gemsbok National Park
KNP — Kruger National Park
NMSA — Natal Museum, South Africa
SAMC — South African Museum, Cape Town
SANC — South African National Collection of Insects
VRIO — Veterinary Research Institute, Onderstepoort
ZMHB — Museum für Naturkunde der Humboldt Universität zu Berlin

There are 2 syntype females. One of these is preserved in 70 % ethyl alchohol and the other is mounted under a coverslip on a glass slide. Information concerning these flies is given verbatim from the labels. Lines on the labels are separated by a slash (/), and different labels, from the top of the pin to the bottom, by a double slash (//).

Cotype: female; *Lipoptena paradoxa* / Newst. Type lot / On antelope / Kasongo / 28–1–05 Dutton & Todd // Kasongo / Congo Free State / 28–1–1905 / Drs Dutton & Todd / Recd. fr. R. Newstead // On antelope // *Lipoptena* / Co / type / paradoxa / Newstead // BMNH.

We hereby designate the alcohol preserved specimen as the lectotype and the other fly becomes a paralectotype.

Material examined

The material listed below was collected in South Africa by the authors and is deposited at the National Museum, Bloemfontein, Republic of South Africa.

115 specimens, Pafuri (23° 27′ S, 31° 19′ E), KNP, Transvaal (Tvl), ex kudu, 1981; 5 ♂, 5 ♀, Pafuri, KNP, ex bushbuck, 6 Oct. 1981; 5 ♂, 5 ♀, Pafuri, KNP, ex nyala, 6 Oct. 1981; 198 specimens, Satara (24° 23′ S, 31° 47′ E), KNP, ex kudu 8 Oct. 1982; 5 ♂, 5 ♀, Riekerts Laager (24° 30′ S, 28° 29′ E), Tvl, ex common duiker, 5 Nov. 1980; 1 ♂, 1 ♀, Skukuza (24° 58′ S, 31° 36′ E), KNP, ex kudu, 8 Jan. 1990; 1 ♂, 1 ♀, Skukuza (24° 58′ S, 31° 36′ E), KNP, ex kudu, 8 Jan. 1990; 1 ♂, 1 ♀, Skukuza, KNP, ex impala, 23 Apr. 1980; 1 ♀, Skukuza, KNP, ex lion, 14 Oct. 1986; 69 ♂, 94 ♀, Skukuza, KNP, ex bushbuck, 10 Jan. 1990; 13 ♂, 40 ♀, Skukuza, KNP, ex bushbuck, 6 Mar. 1990; 147 ♂, 282 ♀, Skukuza, KNP, ex bushbuck, 8 Mar. 1990; 166 ♂, 401 ♀, Skukuza, KNP, ex bushbuck, 4 Apr. 1990; 2 ♀, Kruger Gate (24° 59′ S, 31° 29′ E), KNP, ex cheetah, 3 July 1988; 2225 specimens, southern KNP (between 25° 06′–25° 21′ S and 31° 27′–31° 36′ E), ex kudu, 1981–1983; 1 ♂, 2 ♀, Mbyamiti (25° 15′ S, 31° 36′ E), KNP, ex impala, 21 Jan. 1981; 5 ♂, 5 ♀, Malelane (25° 28′ S, 31° 31′ E), KNP, ex kudu, 7 Dec. 1981; 5 ♂, 5 ♀, Umfolozi (between 28° 12′–28° 21′ S and 31° 42′–31° 59′ E), Natal, ex nyala, 18 Mar. 1983; 1 ♂, Charters Creek (28° 14′ S, 32° 25′ E), Natal, ex red duiker, 21 Mar. 1983; 5 ♂, 5 ♀, Charters Creek, Natal, ex bushbuck, 22 Mar. 1983; 5 ♂, 5 ♀, Weza State Forest (30° 35′ S, 29° 45′ E), Natal, ex bushbuck, April 1984; 5 ♂, 5 ♀, Andries Vosloo Kudu Reserve (33° 07′ S, 26° 40′ E), Cape Province, ex kudu, 21 Oct. 1985; 3 ♂, Southwell (33° 32′ S, 26° 41′ E), Cape Province, ex caracal, January 1986.

Material borrowed from other institutions:

1 ♀, Monze (16° 16′ S, 27° 29′ E), Northern Rhodesia (Zambia), ex bushbuck, 1959 (SAMC); 1 ♀, Chipangali (locality uncertain), Zambia, ex common duiker, 13 May 1963 (NMSA); 1 ♂, 4 ♀, Beira (19° 50′ S, 34° 52′ E), Mozambique, ex oribi, 15 Nov. 1941 (SAMC); 1 ♀, Pafuri, KNP, Tvl, ex nyala, date not given (VRIO); 1 ♂, 5 ♀, Nylsvley (24° 29′ S, 28° 42′ E), Tvl, ex kudu, 11 Sept. 1980 (VRIO); 11 ♂, 17 ♀, Skukuza, KNP, ex bushbuck, 15 Nov. 1982 (KNP); 10 ♂, 5 ♀, Skukuza, KNP, ex bushbuck, 18 Nov. 1982 (KNP); 1 ♂, Skukuza, KNP, ex impala, 2 June 1984 (KNP); 3 ♂, 5 ♀, Mbyamiti, KNP, ex kudu, 13 Aug. 1984 (KNP); 1 ♂, 4 ♀, Berg en Dal (25° 26′ S, 31° 26′ E), KNP, ex kudu, 31 Oct. 1986 (KNP); 2 ♂, 2 ♀, Barberton (25° 48′ S, 31° 03′ E), Tvl, host not given, 20 Aug. 1924 (SANC); 2 ♂, 1 ♀, Barberton, Tvl, ex bushbuck, 9 Oct. 1919 (SANC); 2 ♂, Ndumu (between 26° 50′–26° 56′ S and 32° 09′–32° 21′ E), Natal, host not given, 8 Oct. 1970 (VRIO); 7 specimens, Zululand (locality not supplied), host not given, 1922 (SANC); 1 ♂, Umfolozi, Natal, ex common duiker, 26 Oct. 1965 (NMSA); 1 ♀, Umfolozi, Natal, ex nyala, 26 Oct. 1965 (NMSA); 4 ♀, Bucklands* (locality uncertain), Cape Province, ex kudu, 21 Aug. 1976 (SAMC); 1 ♀, Bucklands (locality uncertain), Cape Province, ex kudu, 10 Oct. 1976 (SAMC); 2 ♀, Bucklands (locality uncertain), Cape Province, ex kudu, 29 Mar. 1977 (SAMC); 1 ♂, Bucklands (locality uncertain), Cape Province, ex kudu, 16 June 1977 (SAM); 6 ♀, Harvest Vale (locality uncertain), Cape Province, host not given, 3 May 1910 (SANC).

DESCRIPTION OF IMAGO

Female

Length (head and thorax): 1,87–2,1 mm.

Head: width 1,0–1,1 mm, extended behind eyes; mediovertex 0,18–0,30 mm × 0,15–0,22 mm, nearly as long as or slightly longer than wide, about as long as frontoclypeus and slightly longer than postvertex (0,12–0,20 mm). Clypeus fused with frons, median longitudinal furrow rather short, ending in a circular pit; preptilinal area distinct but short; inner orbit

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* This farm probably adjoins the Andries Vosloo Kudu Reserve from which some of our own material was collected

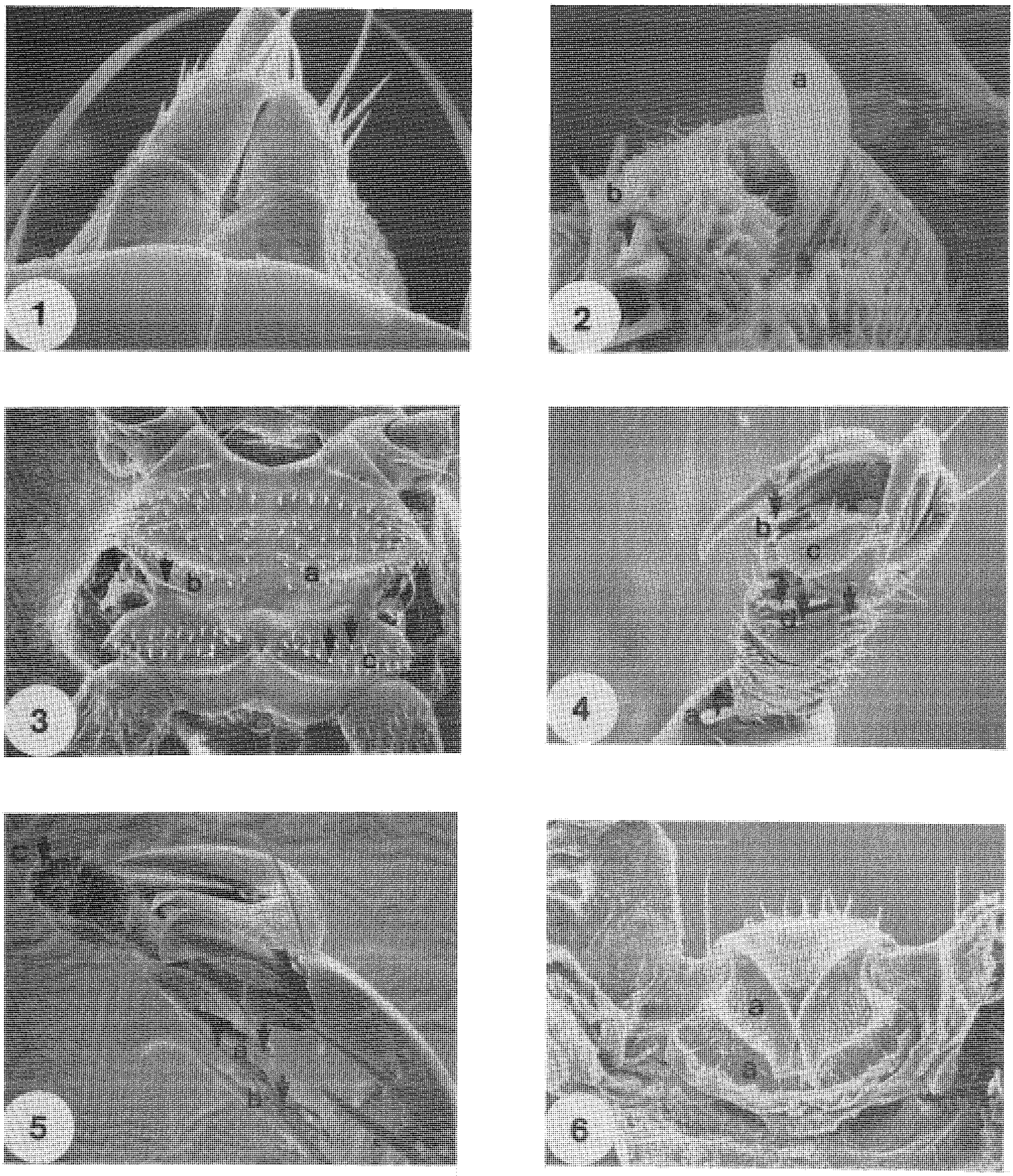


FIG. 1–6 *Lipoptena paradoxa* (female fly)

(1) Extended palpi with setae at the apex
(2) Tip of antenna with arista (a) and setae (b)
(3) Ventral view of the thorax showing the mesosternum with 4 or 5 rows of short spines (a) and 1 pair of posterolateral bristles (b). The metabasisternum has spines in 2 regular rows (c)
(4) First tibia with an apical spur (a), vestigial anterior pulvillus (b), well-developed posterior pulvillus (c), and the 4th and 5th tarsal segments with 1 large and 2 small spines (d)
(5) Third tarsus with 2 large plantar spines (a), a small ventral spine (b), and the long and well developed posterior pulvillus (c)
(6) Postgenital plate (a) after removal of the pregenital plate

(Scale: — — — ——— 100 μm; — — ——— 10 μm; — ——— 0,1 μm)

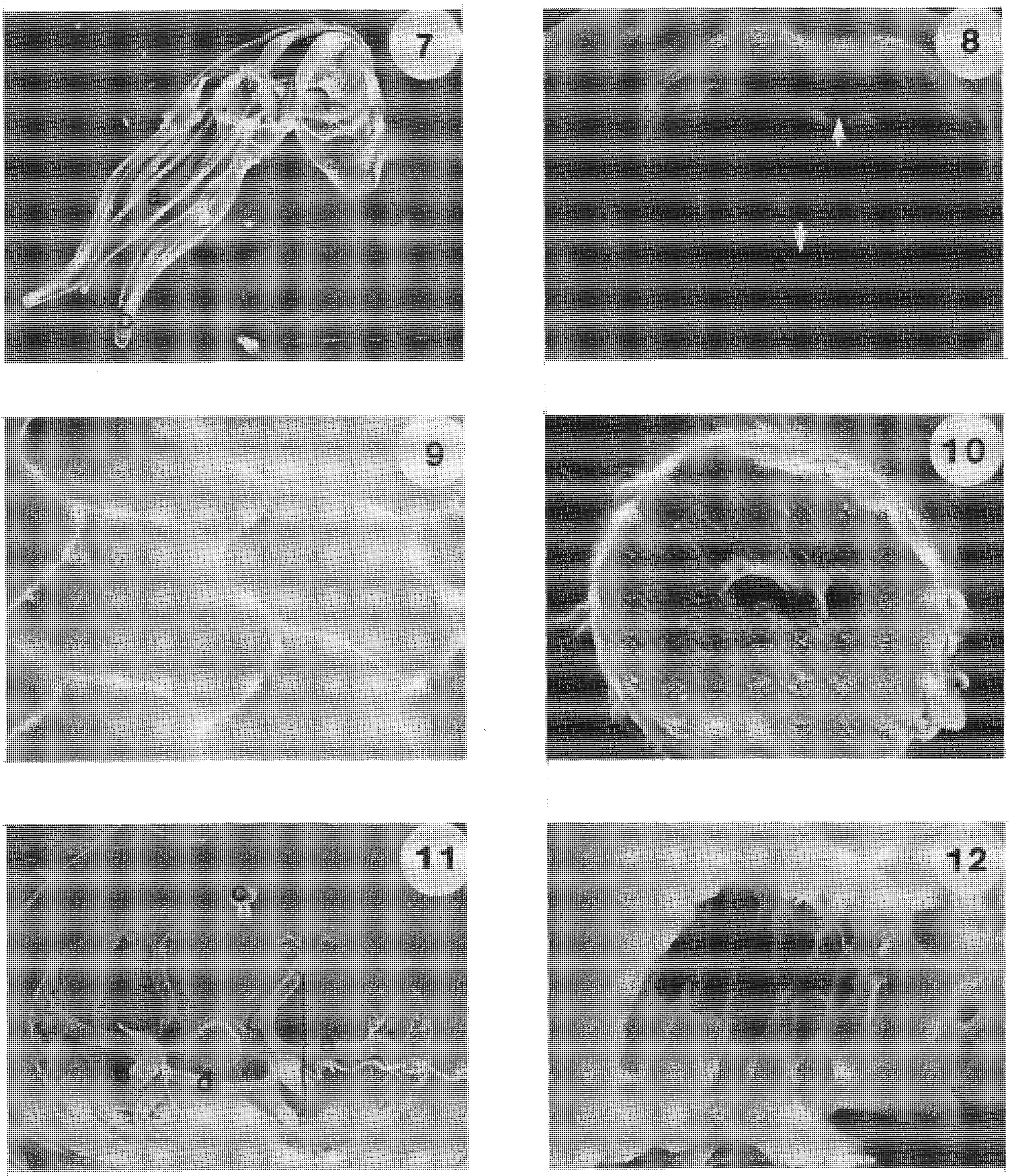


FIG. 7–12 *Lipoptena paradoxa*

(7) Male genitalia showing the aedeagus (a) and the parameres (b)
(8) Posterior end of the puparium with central depression and tracheal openings (a), spiracles (b) and the anal opening (c)
(9) Cuticular pattern between the spiracles on the puparium
(10) Spiracular pore on puparium with small central opening surrounded by a circular plate
(11) Interior of the posterior part of the puparium with 3 large tracheal branches on either side (a), each with smaller radiating branches. A large branch (b) with a smaller side branch (d) extends into the body. The apical pit is visible at (c)
(12) Supporting cuticular meshwork in a tracheal branch of the puparium

(Scale: — — — ——— 100 μm; — — ——— 10 μm; — ——— 0,1 μm)

0,15–0,20 mm, narrower than eye (0,28–0,32 mm), with 1 long vertical bristle; 2 short orbital bristles and 5 fine, very short orbital setae in an inner curved row. Anterior margin of frontoclypeus, between longitudinal furrow and apex of antennal pit, bearing 6 small setae; 5 short setae and 1 long bristle ventrally, next to palpi; 2 long bristles and 4 short setae below eye. Outer margin of eye bears a series of fine spines and a few scattered short fine setae are present on the postgena. A few setae on the gula at the concave margin of prosternal lobes. Postvertex short and very wide, flattened semi-elliptically. Rudimentary or vestigial palpi, only barely or not at all visible beyond anterior margin of frontoclypeus from above. However, SEM of a newly hatched fly shows extended palpi each with 7 setae on the apex (Fig. 1). Antennae short, sub-globular and recessed in antennal pits, which are surrounded by a continuous rim. Fig. 2 provides a more detailed picture of the antennal setae and arista.

Thorax: Prothorax: Pronotum transverse, anterior margin concave and posterior margin angularly convex. Promesonotal suture clearly visible.

Mesothrorax: median notal suture very faint, no intrascutal grooves; transverse mesonotal suture broadly interrupted medially; posthumeral suture well-demarcated. Large mesothoracic spiracle at posterolateral edge of humeral callosity. According to Bequaert (1942) mesonotal chaetotaxy of type specimen consists of 6 acrostichals in a curved row, some distance from the middle line. However, they are asymmetrically placed and may vary from 4 to 7 on either side. Three humerals and 2 laterocentrals close to notopleuron, and 2 rows each of 4 or 5 notopleurals, those of posterior row very long; usually 4 (rarely 3 or 5) scutellars in 2 pairs, inner pair very long; 3 or 4 postalar bristles, inner pair very long; 1 pair of very long posterior dorsocentral bristles; prosternal lobes with 2–3 ventral spines and 1 bristle on anterior inner margin. Mesosternum with a pair of long posterolateral bristles, and numerous relatively short spines, arranged more or less in 4–5 regular transverse rows, of which those of the 1st row are the largest.

Metathorax: Metabasisternum with 2 regular rows of spines, length and robustness similar to those of the last 3 rows on the mesosternum (Fig. 3).

Legs: Anterior coxa enlarged bearing oblique marginal row of setae dorsally, 1 of these very long; ventroposteriorly a row of 4 long setae; femora 1–3 with 3, 3 and 5 major dorsal bristles respectively; 1 anterior bristle on femora 1 and 3; tibiae 1–3 with 1, 2 and 3 apical spurs respectively (Fig. 4); tibia 3 with 3 major ventral bristles (plus a few minor ones), which are slightly longer but less robust than longest apical spur; tarsi 1–2 without ventral spines on segments 1–3, but with 1 major and 2 very small ventral spines on each of segments 4 and 5; tarsus 3 with 2, 1 and 1 small anterior spines on under-sides of segments 1–3 respectively, 2 major plantar spines and 1 minor ventral spine on each under-side of segments 4 and 5 (Fig. 5); anterior pulvilli of all legs vestigial, posterior pulvilli well-developed (Fig. 4); claws slightly asymmetrical.

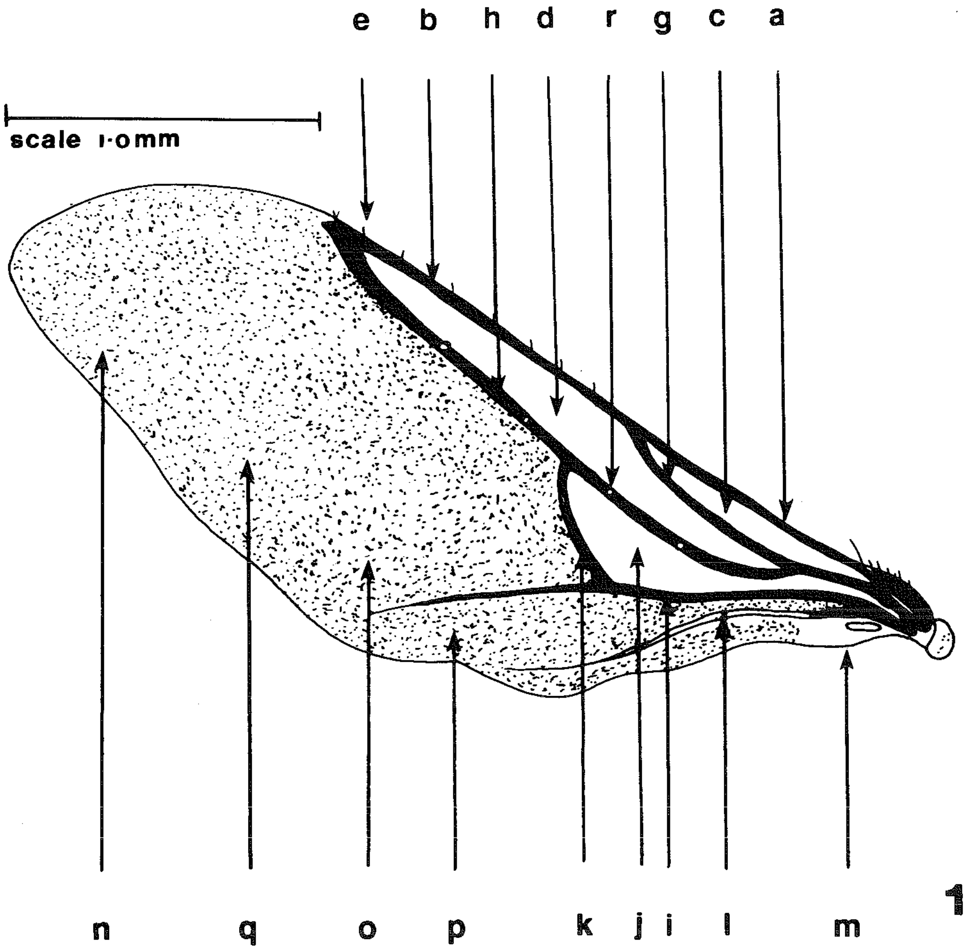
Wings: Length: 2,96 mm. Wing venation (Fig. 13) similar to that of *Lipoptena cervi* Linnaeus 1758 (Bequaert, 1940). Only 3 well-developed longitudinal veins are present, apparently the 1st (R1), 3rd (R4 & 5) and 5th (M_3 & C_2); the 6th (2nd An) is incomplete; other veins indicated by concave lines; only 1 cross-vein, between assumed 3rd and 5th longitudinals, and therefore, according to Bequaert (1940), probably a fusion of the anterior basal cross-vein (M_3), anterior cross-vein (r–m) and portion of 4th longitudinal vein (M_1 & M_2); the 3rd longitudinal ends in the tip of the costa at an acute angle without a knob-like swelling; costa thickened only at extreme base and between tips of 1st and 3rd longitudinals. Four sensoria on 3rd (R4+5) longitudinal vein. The thickened basal costa (CO1) has 1 long and a few short setae. Apical costa (CO2) has 8 setulae. Dorsal surface of basal cell and 2nd marginal cell free of microtrichia (Fig. 13). Microtrichia ventrally on basal cell and apical angle of 2nd marginal cell (between CO2 and R4+5) (Fig. 14); dorsal and ventral cells 3r, 1m and 2m as well as the axillary cell bear microtrichia. Alula rudimentary; no closed anal cell; haltere well-developed.

Abdomen: basal dorsal sclerotized pleurite I large, transverse, with a marginal row of long bristles and angular row of shorter setae on disc; pleurites II to V well demarcated and lightly sclerotized with a few uniformly spaced setae; 5 median tergal plates, all short and transverse, gradually increasing in size from 1st to 3rd, 4th smaller; 1st and 2nd bear a medially interupted transverse row of 4 to 6 setae; 3rd and 4th with 1 or 2 setae in each corner; 5th divided into 2 sclerites, each bearing 2 setae; remainder of dorsum usually extensively sclerotized, with traces of segmentation, and a few setae towards edges. Basal ventral sclerite broadly emarginate at apex, somewhat more shallowly than in other species, with broader lobes to the crescent; many sturdy setae along hind margin and a few on disc, 2 of the very long setae are placed near tip of each lobe; ventral portion of pleurites well-demarcated; abdominal spiracles small, more or less sclerotized, with fairly uniformly spaced setae arising from thickened bases, spiracles VI and VII almost enclosed in 4th and 5th tergal plates.

Genitalia: Median pregenital plate elongate, weakly sclerotized, with 3–5 setae in a transverse series on posterior margin, outer pair usually longer and more robust; lateral pre-genital plate entirely wanting; supra-anal plate with very fine and rather robust small setae. Fig. 6 illustrates post-genital plate after removal of pre-genital plate. Infra-anal plate with rather dense posterior setae, about as long as those on supra-anal plate and as stout as those on disc of abdominal venter.

Male

Length (head and thorax): 1,65–1,80 mm. Similar to ♀ in structure and chaetotaxy. Only 4 median tergal plates, corresponding to T1–4 of female, somewhat larger than in that sex, particularly the 1st and 2nd. Post-genital plate narrow with slightly broader anterior end (Maa, 1965). Parameres (Fig. 7) long, slender, straight, sharply pointed and punc-



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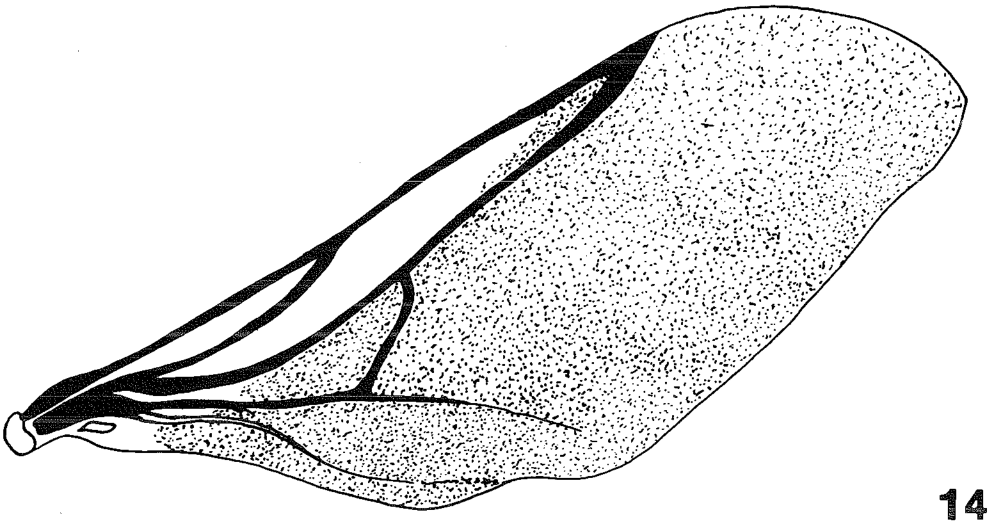

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FIG. 13 and 14 *Lipoptena paradoxa*

(13) Wing (dorsal) venaton and distribution of microtrichia
(a) basicosta CO1; (b) apical costa CO2; (c) 1st marginal cell; (d) 2nd marginal cell; (e) setulae; (g) R1; (h) R4+5; (i) M3+C1; (j) 1 + 2nd basal cell; (k) M3 + r–m cross-vein; (l) 2nd An; (m) alula—rudimentary; (n) 3r cell; (o) 1m cell; (p) 2m cell;(q) microtrichia; (r) sensoria

(14) Distribution of microtrichia on ventral aspect of wing

tate; aedeagus narrow, sharply pointed cone of which the dorsolateral surfaces are covered with small setae.

DESCRIPTION OF PUPARIUM

The small, black, oval puparium of *L. paradoxa* is *ca* 2,2 mm long and *ca* 1,6 mm wide. Small anterior buccal opening with a slit-like extension. Circular seam of anterior cap, through which adult escapes, runs across and around surface of puparium, while the semicircular seam passes over the top to the sides and ends in circular seam.

The surface of the puparium is smooth and shiny with an indistinct polygonal pattern. The protruding posterior end of the puparium bears the tracheo-spiracular system. The spiracular pores radiate laterally from a central depression at the posterior end of the puparium, which contains 2 tracheal openings, and form 3 areas with a distinct pentagonal pattern on either side (Fig. 8 and 9). Each spiracular pore consists of a circular plate with a granular appearance and a small central opening (Fig. 10). Ventrally, just anterior to the posterior plate, there is a circular opening (the anus) with a raised cuticular rim described by Maa (1963, 1969) and Baker (1990) as the ventro-apical pit (Fig. 8). Three internal tracheal branches are attached to tracheal openings in the pupal wall on either side of the central depression (Fig. 11). These have shorter secondary branches extending to spiracular openings (Fig. 11) A larger tracheal branch with a smaller side branch extends into body of the pupa on either side (Fig. 11). Internal surface of trachea honeycombed with cuticular thickenings (Fig. 12).

DISCUSSION

Imago

Newstead in his original description of the fly, published in Newstead *et al.* (1907), noted the almost entire absence of external mouthparts, with the only indication of these organs being a minute truncated cone. Ferris (1930), however, stated that the palpi, while extremely small and in some individuals retracted into the head, are clearly recognisable and apparently constitute the cone mentioned above. In our studies, SEM of a newly hatched fly shows extended palpi attached to the head by a membranous structure giving the impression that the palpi are 2-segmented (Fig. 1).

No mention is made of the spines and bristles on the ventral aspect of the thorax by Newstead (Newstead *et al.*, 1907), but Ferris (1930) remarks that the thorax is ventrally beset with rows of tubercle-like setae. Maa (1965) describes the chaetotaxy of the ventral abdomen in greater detail and our findings add to his description.

Although Newstead did not describe the tarsus and claw of *L. paradoxa,* he has illustrated these structures, indicating a single pulvillus (Newstead *et al.*, 1907). Ferris (1930) has, however, illustrated the last tarsal segment as bearing 2 equal-sized pulvilli without commenting upon this in the text. Maa (1956) states that the anterior pulvilli are all vestigial, a finding with which we concur (Fig. 4).

No previous description of the wings of this fly has been published. We obtained newly hatched, winged specimens for this purpose from pupae incubated in the laboratory and based our nomenclature of the wing venation on that supplied by Bequaert (1940; 1942) and Maa (1963).

Puparium

The size and shape of the puparium of *L. paradoxa* is similar to that of *L. mazamae*. Baker (1990) gives a detailed description of the hexagonal pattern, with spherical cuticular extensions, which encircles the posterior end of the puparium of *L. mazamae*, but this is not mentioned in the case of the closely related *Lipoptena depressa* Say, 1823. This pattern does not occur in *L. paradoxa* (Fig. 9).

Baker (1990) also observed that the remainder of the puparial surface of *L. mazamae* has a polygonal pattern with distinct pits. The surface of the puparium of *L. paradoxa* is covered with a mesh of microscopic lines without pits. More research is needed to determine whether the differences in surface pattern and sculpturing are taxonomically important.

Anteriorly the ventral slit-like extension of the buccal opening of *L. paradoxa* is much larger and folded more deeply than that of *L. mazamae.* Posteriorly the number and arrangement of the spiracles also differ. We consider the large opening below the posterior end of the puparium (Fig. 11), which is referred to as the ventro-apical pit (Maa, 1963, 1969; Baker, 1990), to be the anal opening and it seems to be similar to that of *L. mazamae.* Details of the anal opening, and internal and external structure of the puparium of *L. paradoxa* are given in Fig. 8 and 11.

Previous descriptions of the tracheal branches of *Lipoptena* do not mention the 2 larger tracheal branches with 2 smaller side branches which extend forward into the body of the pupa (Fig. 11). The internal and external structure of the spiracular pores on the posterior end of the puparium also requires further investigation.

BIOLOGY

METHODS, RESULTS AND DISCUSSION

Geographic distribution

This was ascertained from the collection localities of specimens lent to us for taxonomic study and those we collected ourselves during surveys of ectoparasites of various hosts (Boomker *et al.*, 1983; Horak *et al.*,1989; 1992).

The geographic distribution of *L. paradoxa* within the Republic of South Africa is depicted in Fig. 15.

The fly is present in the eastern half of the country and then particularly in those regions where there are woodland, thickets or scrub of sufficient height to provide shelter for the hosts. It occurs at altitudes from a few metres to 2 000 m above sea level. Most collections, however, were made at altitudes below 600 m. The eastern regions of South Africa lie within the summer rainfall region of this country. With the possible exception of the south-western Cape

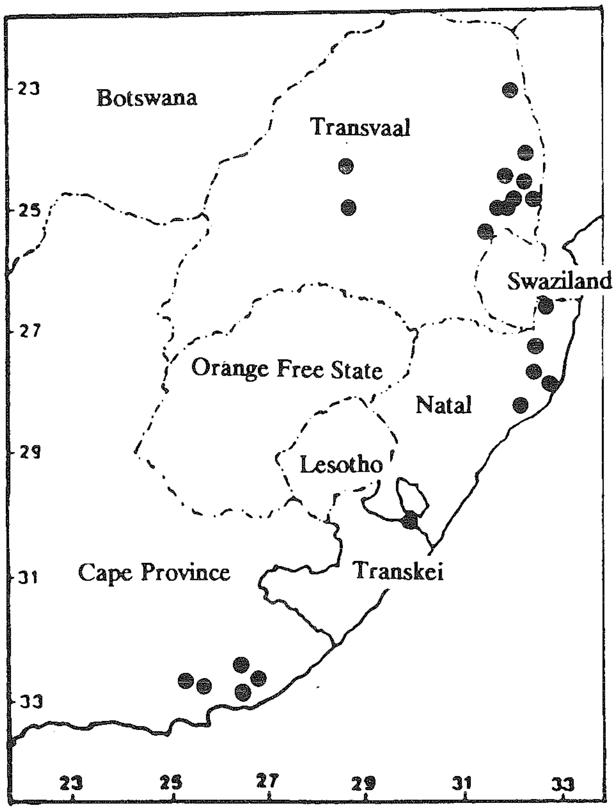

FIG. 15 The geographic distribution of *Lipoptena paradoxa* within the Republic of South Africa

TABLE 1 Birds and mammals examined for ectoparasites, including *Lipoptena paradoxa,* at various localities in South Africa within the distribution range of the fly. The preferred hosts of *L. paradoxa* are indicated in bold type

Species	Common name	Total No. examined
Birds		
Numida meleagris	Helmeted guineafowl	194
Mammals		
Lepus saxatilis	Scrub hare	312
Crocuta crocuta	Spotted hyaena	2
Acinonyx jubatus	Cheetah	2
Panthera pardus	Leopard	3
Panthera leo	Lion	5
Felis caracal	Caracal	22
Lycaon pictus	Wild dog	1
Canis adustus	Side-striped jackal	1
Equus burchelli	Burchell's zebra	33
Potamochoerus porcus	Bushpig	8
Phacochoerus aethiopicus	Warthog	68
Giraffa camelopardalis	Giraffe	2
Connochaetes taurinus	Blue wildebeest	47
Cephalophus natalensis	Red duiker	23
Sylvicapra grimmia	**Common duiker**	29
Aepyceros melampus	Impala	140
Capra hircus	Domestic goat (Angora)	48
Ovis aries	Domestic sheep (Dorper)	48
Bos sp.	Domestic cattle	46
Syncerus caffer	Buffalo	4
Tragelaphus strepsiceros	**Kudu**	133
Tragelaphus angasii	**Nyala**	9
Tragelaphus scriptus	**Bushbuck**	26
Taurotragus oryx	Eland	3
Redunca arundinum	Reedbuck	27

Province, which has a mediterranean climate, the eastern half of the country is moister than the west.

The preferred hosts of the fly all prefer savanna woodland or thickets and generally avoid open country (Smithers, 1983). Thus within its distribution range *L. paradoxa* is restricted to localities in which its preferred hosts occur and hence in which woodland or thickets predominate.

Hosts

Host preference was determined from animals we have examined within the distribution range of the fly during various surveys of ectoparasites, some of which have been published (Boomker *et al.,* 1983; Horak, Keep, Flamand & Boomker, 1988; Horak *et al.,* 1989; 1992). The species and numbers of animals examined are listed in Table 1.

Of all the species examined only those from which *L. paradoxa* was recovered are listed in Table 2. The regions in which these hosts were examined and the total numbers of flies collected are also given in this table.

Bushbuck, nyala, kudus and possibly common duikers are the preferred hosts. Twelve of the 16 common duikers examined in the central Transvaal were infested, but not 1 of the 13 seen in south-eastern Natal.

The preferred hosts are all browsers and consequently are found in or near woodland or thickets where browse is plentiful (Smithers, 1983). Although common duikers may be considered preferred hosts, where they and bushbuck were shot in the same habitat in the Weza State Forest, south-eastern Natal, not 1 of the 13 duikers was infested, while 6 of the 13 bushbuck were (Horak *et al.,* 1989; Table 2). All the bushbuck examined at other localities were infested and harboured considerably larger individual burdens than any of the animals shot in the Weza Forest.

All other animal species we found to be infested harboured very low individual burdens. Where fairly large numbers had been examined, as in the case of impala, red duikers and caracals only a small percentage of hosts was infested. We cannot comment on the host status of roan antelope, grysbok, oribi and waterbuck listed as hosts by Haeselbarth *et al.* (1966) and Maa (1969). We have either not examined these animals or have not examined them within the distribution range of the fly. Although Haeselbarth *et al.* (1966) list common reedbuck as a host not 1 of the 27 animals we examined was infested.

Study area for biology on kudus

This has been described by Boomker, Horak & De Vos (1989). In summary the site is situated in the southern part of the Kruger National Park between latitudes 25° 06′–25° 21′ S and longitudes 31° 27′–31° 36′ E and an altitudinal range from 200–350 m. The vegetation is classified as Lowveld (Acocks, 1988). The days are warm to very hot in summer and mild in winter and frost occurs occasionally. Rainfall varies form 600–700 mm per annum and usually falls in summer.

TABLE 2 Hosts in various regions of South Africa from which the authors have collected *Lipoptena paradoxa*

Host species	No. examined	No. infested	Total number of flies recovered
North-eastern Transvaal Lowveld			
Impala	4	0	0
Kudu	2	2	501
Nyala	2	2	314
Bushbuck	3	3	559
Eastern Transvaal Lowveld			
Cheetah	2	1	2
Lion	5	1	1
Impala	134	3	6
Kudu	97	96	5 082
Bushbuck	8	8	2 768
Eland	2	1	8
Central Transvaal			
Common duiker	16	12	277
North-eastern Natal			
Red duiker	23	1	2
Impala	2	0	0
Nyala	9	9	635
Bushbuck	2	2	564
South-eastern Natal			
Common duiker	13	0	0
Bushbuck	13	6	156
South-eastern Cape Province			
Caracal	22	1	3
Kudu	34	29	514
Eland	1	0	0

Survey animals

Each month from April 1981 to March 1983, 4 kudus were shot in the study area. At each occasion an attempt was made to obtain 1 adult male, 1 adult female, 1 young adult male and 1 juvenile or calf of either sex. The animals were aged according to the criteria described by Simpson (1971). Collections were made not less than 3 weeks or more than 5 weeks apart. A total of 96 kudus were shot but only 95 were examined as the material collected from 1 had been inadequately preserved. For statistical reasons, the animals were grouped, according to age, into calves, 0–12 months old (age group 1), juveniles, 13–24 months old (age group 2), young adults, 25–48 months old (age group 3) and prime or old adults, 49 months and older (age group 4) (Boomker *et al.,* 1989).

Four bushbuck were chemically immobilised in the Skukuza region of the KNP and live flies for pupal studies were collected from them.

Parasite recovery

The carcasses of the kudus were transported to the laboratory at Skukuza where they were processed for parasite recovery. The carcass of each animal was skinned and half the skin of the head and half the skin of the neck, body and upper legs, the whole skin of the tail, and 1 lower front leg and lower back leg with skin attached were placed separately in plastic bags. A tick-detaching agent [Triatix; Coopers SA (Pty) Ltd] was added to the skins in the bags and these were stored overnight. The following morning the skins were thoroughly scrubbed with brushes with 40 mm long steel bristles and washed. The tick-detaching agent remaining in the plastic bags and the material obtained from scrubbing and washing the skins were sieved over sieves with 0,15 mm apertures. The residues in the sieves were collected and preserved separately in 10 % formalin.

Representative samples of the material collected were examined under a stereoscopic microscope for the presence of lice, ticks and louse flies. The remainder of the material was examined macroscopically for adult ticks and louse flies. Only the data pertaining to the louse flies are reported here, those obtained for the lice and ticks have been published by Horak *et al.* (1992). The kudus were also examined for internal parasites and the findings published (Boomker *et al.*, 1989).

Observations on flies

The seasonal abundance of the flies on the kudus during the 2 years of the survey is illustrated in Fig. 16. The largest numbers of flies were present on the kudus from August 1981 to January 1982 and from July 1982 to January 1983. Large numbers of flies were recovered from the tails of the kudus from November to January during both years of the survey.

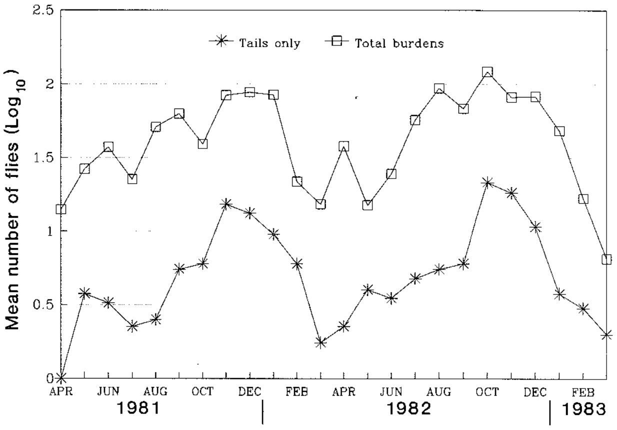

FIG. 16 The seasonal abundance of *Lipoptena paradoxa* on kudus in the southern region of the Kruger National Park

The pattern of abundance on the kudus could be due to the seasonal preference of the flies or the behaviour of the kudus. If it is due to the former, it would indicate that large numbers of flies hatched in mid-winter and early spring after prolonged pupal periods and infested the kudus. Since hippoboscid flies produce only a single mature 3rd instar larva at a time, with perhaps several days between successive larvae, it implies that each female fly would have to survive for several weeks or months to produce sufficient larvae to ensure the survival of the species. These flies and their offspring, which emerged after shorter pupal periods during summer, would then be responsible for the 5 to 6 month period of peak abundance on the kudus.

If the pattern of abundance was caused by the behaviour of the kudus this would presuppose that kudus frequent habitat that is favourable for the survival of pupae from July or August to January. Such habitat would be dense riverine scrub and bush, the preferred habitat of bushbuck, or wooded slopes of hills and in valleys, where kudus tend to shelter during midday. The bushbuck immobilised during March and April 1990 and a bushbuck killed in a car accident in the Park during June 1982 (months of low *L. paradoxa* abundance on kudus), harboured considerably more flies than kudus, even during the periods of peak abundance on the latter animals. In addition 2 kudus shot during July 1980 in the Skukuza area, where the vegetation is much denser than in the study area, also harboured large numbers of louse flies (184 and 282). This seems to indicate that the pattern of abundance on kudus in the study area could be due to the antelopes' seasonal habitat choice within that region rather than the seasonal preference of the flies.

The large numbers of flies found on the tails of the kudus from November to January could be an attempt to escape grooming activities of the host during a period of peak abundance. Evans (1950) has described seasonal differences in the distribution of keds (*Melophagus ovinus*) in the fleece of various body regions of sheep. Amongst the preferred hosts of the louse flies, kudus have the shortest and sparsest hair cover. Especially during the warm summer months the bushy tails of kudus would afford protection for the flies against heat, firstly as cover against the sun and secondly, because of the long hair, an ideal means of moving away from the host's skin where the temperature would be fairly high.

The number of flies recovered from adult male and adult female kudus shot in the same months and from adult and juvenile animals also shot in the same months are compared in Table 3. Thus only data from animals that could be paired as to the months in which they were shot were used for comparison employing the paired Wilcoxon T-test.

TABLE 3 Differences in *Lipoptena paradoxa* burdens on paired age and sex groups of kudus shot in the Kruger National Park from April 1981 to March 1983

Kudu age	Kudu sex	Number of animals*	Mean number of flies	Significance	Wilcoxon value	
					Calculated	Table
Juveniles	Both sexes	14	78			
Adults	Males	14	62	P=0,10	19	22
Juveniles	Both sexes	13	86			
Adults	Females	13	31	P=0,04	17	18
Juveniles	Both sexes	15	78			
Adults	Both sexes	15	45	P=0,10	28	31
Adults	Males	15	63			
Adults	Females	15	26	P=0,01	11	16

* These animals could be paired with animals of different ages or sexes as both animals of each pair were shot during the same month

Adult male and juvenile kudus harboured significantly more flies than adult female kudus.

The smaller number of flies recovered from the adult female animals when compared with the adult males and the juveniles could be due to more efficient grooming by the females or to hormonal differences between the females and the other 2 groups of kudus. It could also be due to transference of flies from female animals to their calves, or as a result of differences in the resistance status of the various groups. If it was due to size one could expect males to harbour most flies, followed by females and then juveniles. There can, however, be many other reasons for these differences. In the case of ixodid tick infestation on domestic cattle, cows carry significantly fewer maturing females of *Boophilus microplus* than do male animals (Seifert, 1971). The 15 adult female kudus used for comparative purposes in the present study also carried significantly fewer nymphs and adults of the ixodid tick *Amblyomma hebraeum* and adults of *Boophilus decoloratus* than did the 15 adult male animals shot at the same time (Horak *et al.*, 1992). Similar differences were, however, not evident for the other tick species on the kudus.

The sex ratios of newly hatched flies, those collected from immobilised bushbuck, those collected from dead kudus, and those collected from common duikers by Boomker *et al.* (1983), are summarized in Table 4.

TABLE 4 The sex ratio of *Lipoptena paradoxa* hatching from pupae and recovered from bushbuck, kudus and common duikers in South Africa

Origin of flies	Number of animals examined	Number of male flies	Number of female flies	Sex ratio
Pupae	—	25	31	1:1,24
Immobilised bushbuck	4	395	817	1:2,07
Kudus	90*	853	1 253	1:1,47
Common duikers	16	103	173	1:1,68

* 96 kudu shot in total, flies for sex ratio determination only available from 90

The sex ratio of newly hatched flies was 1 male:1,24 females, on immobilised bushbuck it was 1:2,07 and on kudus and common duikers 1:1,47 and 1:1,68, respectively.

More females than males emerged from the pupae. A similar phenomenon has also been observed for *Hippobosca equina* (Hafez, Hilali & Fouda, 1977) and *Hippobosca longipennis* (Hafez & Hilali, 1978). In addition, the female flies probably also survive for longer on their hosts than do males if the findings for *H. equina* and *H. longipennis* are applicable (Hafez *et al.*, 1977; Hafez & Hilali, 1978). This would further accentuate the difference in the sex ratio. A single mating is apparently sufficient for the female to produce all her prepupae (Hafez *et al.*, 1977).

TABLE 5 The pupal period of *Lipoptena paradoxa* pupae incubated at various temperatures and relative humidities. The pupae were deposited by flies collected from bushbuck in the Kruger National Park

Pupal deposition date	Number of pupae incubated	Temperature (°C)	Relative humidity (%)	Number of adults emerged	Pupal period (days)
8 March 1990	11	25	30	1	32
8 March 1990	11	30	55	6	24
6 April 1990	47	25	30	23	23–28
6 April 1990	47	30	55	33	23–26

Observations on pupae

Flies captured on immobilised bushbuck were kept alive for as long as possible (1 or 2 days) without a blood-meal to allow them to produce fully developed larvae which became pupae. The pupae were placed in small glass tubes with gauze stoppers. These were suspended in plastic nets in long plastic jars which were half-filled with saturated solutions of $MgCl_2$ or glucose to produce humidities of 30 % and 55 % respectively.

To determine the effect of temperature on pupal duration, pupae were incubated at constant temperatures of 25° (30 % relative humidity) and of 30 °C (55 % relative humidity). The tubes were examined daily for adult emergence.

A total of 22 pupae were obtained within 24 h from 282 female flies collected from an immobilised bushbuck during March 1990. A total of 401 female flies collected from an immobilised bushbuck during April 1990 produced 94 pupae within 24 h. Approximately 1/4 of the latter flies thus produced prepupae within 24 h. This indicates that the period between the deposition of successive prepupa by individual flies may be as short as 4 days. Evans (1950) reports this period to be 7–8 days for *M. ovinus* and Hafez & Hilali (1978) found that for *H. longipennis* it could be 3–5 (mean 3,6) days during the warmer months and 3–8 (mean 6,4) days during the cooler months.

The numbers of flies that hatched from pupae after they had been incubated at various temperatures and relative humidities are summarized in Table 5.

There was considerable overlap in the pupal periods of the flies that hatched from those pupae kept at higher temperatures and humidities and of those kept at lower temperatures and humidities.

The greatest numbers of flies hatched during the daylight hours between 07:00 and 15:00. The newly emerged flies were very active and their wings expanded within a few minutes. However, some of the flies died just after emergence, while the wings of others failed to expand.

The pupal period of approximately 23–26 days recorded at 30 °C and 55 % RH corresponds fairly closely to the 20–26 days at 30 °C and 65 % RH recorded for *H. equina* by Hafez *et al.* (1977) and 19–23 days at 30 °C and 75 % RH for *H. longipennis* (Hafez & Hilali, 1978). The rate of emergence of adult *H. longipennis* from pupae was highest between 07:00 and 09:00, with few emerging at midday and none at night (Hafez & Hilali, 1978). Most of the *L. paradoxa* adults emerged in the early morning, but emergence continued till 15:00.

An attempt was made to ascertain the life-span and rate of reproduction of *L. paradoxa* by feeding newly emerged flies on a penned Cameroon goat. The flies were contained in a plastic tube with a gauze-covered lid at the 1 end and with the other end fixed tightly by means of glue and Elastoplast to the shaved neck of the goat.

The flies did not feed on the goat and all died.

Both *H. equina* and *H. longipennis* will feed successfully on guinea pigs and reproduce (Hafez *et al.*, 1977; Hafez & Hilali, 1978). As we were unable to get *L. paradoxa* to feed on the goat we consequently had to rely on pupae produced by flies collected from immobilised bushbuck for our studies on the life cycle.

The density of the vegetation frequented by the preferred host is probably essential for the survival of the pupae. The prepupae produced by the flies are not motile and rapidly darken and harden. In the field these prepupae would fall to the ground and the pupae would form on the soil surface, where they would be exposed to the elements. Hence, the dense type of vegetation preferred by the tragelaphine antelope is also the most suitable for the survival of the pupae.

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A REVISION OF THE GENUS *IMPALAIA* MÖNNIG, 1924

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ABSTRACT

BOOMKER, J., 1977. A revision of the genus *Impalaia* Mönnig, 1924. *Onderstepoort Journal of Veterinary Research*. 44 (3), 131–138 (1977).

A revision of the genus *Impalaia* Mönnig, 1924 forms the subject of this report. Besides the type species, *Impalaia tuberculata* Mönnig, 1924, there are 2 valid species, viz., *I. nudicollis* Mönnig, 1931 and *I. okapiae* (Van den Berghe, 1937). *I. tuberculata longispiculata* (Wetzel & Fortmeyer, 1960), *I. somaliensis* (Crovieri, 1929) and *I. aegyptiaca* Soliman, 1956 are synonymous with *I. tuberculata*. *I. taurotragi* (Le Roux, 1936) appears to be an aberrant form of *I. nudicollis*. A parasite/host check-list is included.

Résumé

LA RÉVISION DU GENRE IMPALAIA *MÖNNIG,* 1924

Ce rapport a pour objet une révision du genre Impalaia *Mönnig,* 1924. *Outre l'espèce-type,* Impalaia tuberculata *Mönnig,* 1924, *il y a* 2 *espèces valides, soit* I. nudicollis *Mönnig,* 1931, *et* I. okapiae (*Van den Berghe,* 1937). I. tuberculata longispiculata (*Wetzel & Fortmeyer,* 1960), I. somaliensis (*Crovieri,* 1929) *et* I. aegyptiaca *Soliman,* 1956 *sont synonymes de* I. tuberculata. I. taurotragi (*Le Roux,* 1936) *semble être une forme irrégulière d'*I. nudicollis. *Une liste de contrôle des parasites et de leurs hôtes est jointe à cette révision.*

INTRODUCTION

In July 1970, a giraffe (*Giraffa camelopardalis* Linn., 1758) died in the National Zoological Gardens, Pretoria, Republic of South Africa. At autopsy the animal was found to be infested with *Cooperia punctata* (von Linstow, 1907), *Nematodirus spathiger* (Railliet, 1896), *Trichuris globulosa* (von Linstow, 1901) as well as with a number of specimens belonging to the genus *Impalaia*. In an attempt to identify these nematodes, type specimens of *Impalaia tuberculata* Mönnig, 1924, *I. nudicollis* Mönnig, 1931, *I. aegyptiaca* Soliman, 1956 and *I. taurotragi* (Le Roux, 1936), as well as specimens of *I. tuberculata* and *I. nudicollis* from different species of herbivores were examined. The range of variation of the different characters was determined and used to assess the validity of the various species.

DIAGNOSIS OF THE GENUS

Trichostrongylidae, Heligmosominae: The body is filiform and not spirally coiled. The cuticle bears about 14 longitudinal ridges which are supported by sclerotized rods. The cephalic region is inflated and bears 18–20 fine cross striations. The mouth is terminal and is surrounded by 3 small lips. The bursa is hoodshaped with an indistinct dorsal lobe. The arrangement of the bursal rays is typical for the genus. The vulva is located near the anus in the terminal tenth of the body. The female tail is knob-like and bears 3 subterminal papillae.

Redescription of **Impalaia tuberculata** *Mönnig,* 1924

Type host

Aepyceros melampus (Lichtenstein, 1812)—impala.

Other recorded hosts

Capra hircus Linn., 1758—domestic goat
Damaliscus dorcas dorcas (Pallas, 1766)—bontebok
Damaliscus dorcas phillipsi (Harper, 1939)—blesbok
Damaliscus lunatus (Burchell, 1823)—tsessebe
Giraffa camelopardalis (Linn., 1758)—giraffe
Hippotragus niger (Harris, 1838)—sable antelope
Raphicerus campestris (Thunberg, 1811)—steenbok
Raphicerus melanotis (Thunberg, 1811)—Cape grysbok
Redunca fulvorufula (Afzelius, 1815)—mountain reedbuck

Material examined

A. melampus—Type specimens (Onderstepoort Helminthological Collection, No. T 2010), 3 males, 6 females. Additional material: 15 males, 12 females, from 6 impala.
D. d. phillipsi—1 male and 2 females
D. lunatus—3 females
G. camelopardalis—5 males and 6 females
H. niger—5 males and 6 females
R. campestris—1 male and 1 female, both damaged anteriorly
R. fulvorufula—9 males and 9 females

Description

The principal measurements are listed in Table 1.

Male: The copulatory bursa has 2 large lateral lobes and an indistinct dorsal lobe (Fig. 1). The latero-ventral and ventro-ventral rays originate separately and both curve ventrally and anteriorly. The antero-lateral and medio-lateral rays run parallel for about one-half of their length. When they diverge, the antero-lateral ray curves anteriorly and the medio-lateral ray ventrally. The postero-lateral ray diverges from the medio-lateral ray at about one-fourth of its length and runs caudally and ventrally. The postero-lateral ray is the longest and the antero-lateral ray the shortest of the lateral rays. The length of the dorsal ray could not be determined in the type specimens. In the additional specimens from the type host, the 2 externo-dorsal rays arise at different levels from the dorsal ray, about one-fourth of its length from its origin. The right externo-dorsal ray is longer than the left one and shows a characteristic curvature near its end. Distally, the dorsal ray divides and each of the divisions redivides into laterally and caudally directed branches which give it a wide and squat appearance. The caudally directed branches each bear a small median protuberance. The lateral branches are longer than the caudally directed ones and end in small hooks that usually point anteriorly (Fig. 3).

The spicules are equal, slender, and end in fine points. Their proximal ends are clavate and do not show the hooks illustrated by Mönnig (1924) (Fig. 5a). The gubernaculum is boat-shaped and poorly sclerotized.

Female: The vulva is simple and slightly protruding and is situated in the caudal tenth of the body. The single ovijector consists of a muscular *pars ejaculatrix* which is separated from the *pars haustrix* by a well-

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developed sphincter. There is a single uterus and one ovary. The tail is blunt and bears 3 subterminal papillae (Fig. 6a). Eggs are slightly elongated, thin-walled and contain a morula. Occassional eggs contain a larva.

Description of **Impalaia tuberculata longispiculata** (*Wetzel & Fortmeyer,* 1960)

Type host

Litocranius walleri (Brooke, 1878)—gerenuk

Other recorded hosts

Capra hircus (experimental)—domestic goat

Description

The principal measurements as recorded by Wetzel & Fortmeyer (1960) are listed in Table 1.

The following is an abridged version of the description given by Wetzel & Fortmeyer (1960):

Males: The copulatory bursa has the same structure and ray pattern as that of *I. tuberculata.* The almost symmetrical, long, thin externo-dorsal rays emerge from the dorsal ray about one-sixth of its length from its origin. Distally, the dorsal ray divides and redivides as in *I. tuberculata.* The spicules show greater variation in their lengths than those of *I. tuberculata* from the impala and are enclosed in a sheath for most of their length.

Females: The females conform to the description of *I. tuberculata* from the impala.

Redescription of **I. aegyptiaca** *Soliman,* 1956

Type host

Camelus dromedarius Linn., 1758—camel.

Material examined

Six paratype males and 10 paratype females.

Description

The principal measurements are listed in Table 1.

Males: The copulatory bursa has the same structure and ray pattern as that of *I. tuberculata.* The externo-dorsal rays arise from the dorsal ray at about one-seventh of its length from the base. The right externo-dorsal ray is longer than or equals the length of the left externo-dorsal ray. Distally, the dorsal ray divides and redivides as in *I. tuberculata.* A small protuberance on the caudally directed branch is present. The spicules are equal and slender. The gubernaculum is boat-shaped.

Females: The tail is blunt and bears 3 subterminal papillae. The vulva is a transverse slit. The single ovijector resembles that of *I. tuberculata.* Eggs are subspherical to elongate. The larger eggs contain larvae.

Description of **Impalaia somaliensis** (*Crovieri,* 1929) *Travassos,* 1937

Syn. **Anthostrongylus somaliensis** *Crovieri,* 1929

Host

Camelus dromedarius Linn., 1758—camel.

Description

The principal measurements recorded by Crovieri (1929) and cited by Travassos (1937) are listed in Table 1. The following is an abridged version of the description given by Travassos (1937).

Males: They are about 9 mm in length. Spicules are of uniform width in the middle and are dilated at the proximal end and acute and curving inwards at the distal end. The gubernaculum is 0,090 mm long.

Females: They are larger than the males. The posterior extremity is conical and ends in a very sharp point. The anus is at the base of the tail and the vulva is slightly in front of the anus. A prominent muscular vagina which divides into 2 uteri is present.

Description of **Impalaia okapiae** (*Van den Berghe,* 1937)

Syn. **Anthostrongylus okapiae** *Van den Berghe,* 1937

Type host

Okapia johnstoni (Sclater, 1901)—okapi.

Description

The principal measurements as recorded by Van den Berghe (1937) are listed in Table 4. The description is that given by Van den Berghe (1937).

Males: The dorsal lobe is separated from the 2 lateral lobes by a small ridge. The lateral lobes are asymmetrical, the left lobe and rays being larger than those on the right. The structure and disposition of the bursal rays are similar to those of *I. tuberculata.*

Females: According to Van den Berghe (1937), "the posterior extremity is enlarged at the height of the vulva and rings and terminates in a fine point. The vulva and the rings are closely approximated".

Redescription of **Impalaia nudicollis** *Mönnig,* 1931

Type host

Damaliscus dorcas phillipsi (Harper, 1939)—blesbok.

Other recorded hosts:

A. melampus—impala
Bos spp.—domestic cattle
C. dromedarius—camel
D. lunatus—tsessebe
Gazella thomsoni (Günther, 1884)—Thomson's gazelle
Kobus ellipsiprymnus (Ogilby, 1833)—waterbuck
O. aries—domestic sheep
R. campestris—steenbok
Sylvicapra grimmea (Linn., 1758)—grey duiker

Material examined

D. d. phillipsi—Type specimens (Onderstepoort Helminthological Collection, No. T 2030), males and females. Additional material: 4 males and 6 females from 3 blesbok.

O. aries—8 males and 6 females from experimental infestations, 14 and 30 days after infestation.

Taurotragus oryx (Pallas, 1776)—3 males and 3 females.

Description

The principal measurements are listed in Table 2.

Males: The bursa is fairly large, but markedly smaller than that of *I. tuberculata,* having 2 distinct lateral lobes and an indistinct dorsal lobe (Fig. 2). The origin and disposition of the lateral and ventral rays are identical with those of *I. tuberculata.* The dorsal ray does not have the characteristic bend of *I. tuberculata* but may be slightly curved and though the externo-dorsal rays are usually equal in number, they may differ slightly in length. They originate about one-fifth of the length of the dorsal ray from its base, at the same or slightly different levels. Distally, the

TABLE 4 Principal measurements of *I. okapiae* as given by Van den Berghe, 1937*

	♂	♀
Length (mm)	11,0	13,0
Width	247	330
Cephalic inflation length	53	—
Head width	—	—
Oesophagus length	478	462
Excretory pore	644	—
Spicule length	2,062	—
Gubernaculum length	170	—
Tail to anus	—	83
Anus to vulva	—	107
Vulva to tail	—	190
Ovijector	—	—
Eggs	—	82×65

* All measurements given in μm unless stated otherwise

dorsal ray divides and redivides immediately. The lateral branches are shorter than or equal to the median branches, which usually bear a protuberance (Fig. 4). In some specimens there is an additional small papilla immediately in front of the primary bifurcation. The spicules are slender, clavate, equal, and terminate in fine points. Proximally, they bear a small median process (Fig. 5b). The gubernaculum is boat-shaped.

Females: The tail is blunt and knob-like and bears 3 subterminal papillae (Fig. 6b). The vulva is a slightly protruding transverse slit situated in the caudal tenth of the body. The single ovijector consists of a muscular *pars ejaculatrix,* a well developed sphincter and a *pars haustrix.* The vagina is simple and muscular. There is a single uterus and one ovary. Eggs are slightly elongate.

Redescription of **Impalaia taurotragi** (*Le Roux,* 1936) *Travassos,* 1937.

Syn. **Minutostrongylus taurotragi** *Le Roux,* 1936

Type host

Taurotragus oryx (Pallas, 1776)—Cape eland

Material examined

The slightly damaged holotype male and the allotype female.

Description

These worms are the smallest in the genus.

The principal measurements are listed in Table 3.

The nerve ring is situated 136,8 μm from the anterior extremity in the female. The excretory pore could not be located in either specimen.

Male: The bursal rays resemble those of the genus. The dorsal ray is straight and very short. The externo-dorsal rays arise at the same height and the left externo-dorsal ray is a little shorter than the right. Distally, the dorsal ray divides and immediately redivides. The median branches each bear a small protuberance and are shorter than the lateral branches. The spicules are lightly sclerotized, equal, and terminate in fine points. The gubernaculum is boat-shaped.

Females: The tail is blunt and no papillae are present. The vulva is a slightly protruding transverse slit situated in the caudal tenth of the body. The single ovijector consists of a muscular *pars ejaculatrix,* a well-developed sphincter and a *pars haustrix.* The eggs are slightly elongate.

DISCUSSION

The species in the genus *Impalaia* may be divided into (a) the *I. tuberculata* group, which includes *I. tuberculata, I. t. longispiculata, I. aegyptiaca, I. somaliensis* and *I. okapiae* and (b) the *I. nudicollis* group, which includes *I. nudicollis* and *I. taurotragi.*

The I. tuberculata *group*

All the species belonging to this group have a large copulatory bursa and a characteristic bend in the distal third of the dorsal ray. The tip of the dorsal ray spreads so that it is wider than long.

According to Mönnig (1924), the cervical region of *I. tuberculata* bears numerous irregularly arranged tubercles. Mönnig (1932), however, points out that these tubercles were artifacts and could not be used for specific identification. Daubney (1933) collected an *Impalaia* sp. from sheep in Kenya. The nematodes of this species did not have tubercles and were erroneously assigned to *I. nudicollis* instead of *I. tuberculata.* The measurements and illustrations given by Daubney (1933) are undoubtedly those of *I. tuberculata.* Wetzel & Fortmeyer (1960) described tubercles in the cervical region of *I. t. longispiculata.* The latter subspecies was based on specimens obtained from a goat which was infested with infective larvae derived from faecal cultures of gerenuk (Wetzel & Fortmeyer, 1960). Pande, Rai & Bhatia (1962) recovered an *Impalaia* sp. from a camel which they identified as *I. nudicollis.* They also provide a key for the genus *Impalaia* in which they erroneously use the presence of tubercles to differentiate between *I. tuberculata* and *I. nudicollis.*

It must be stressed that no tubercles were found in any of the specimens examined and their presence or absence cannot be used as a valid criterion for the separation of *I. tuberculata* and *I. nudicollis.*

Yeh (1956) identified nematodes from Thomson's gazelle as *I. nudicollis.* From the measurements he provides (Table 1), it is clear that these parasites are *I. tuberculata* and that they closely resemble *I. t. longispiculata* which differs from the type specimens only in the length of the spicules. The validity of *I. t. longispiculata* as a distinct subspecies is doubtful.

Pande *et al.,* (1962) compared *I. nudicollis* from the camel with those from Thomson's gazelle described by Yeh (1956). The parasites from the camel, however, cannot be assigned to any species as the measurements quoted in the text do not agree with those calculated from the illustrations.

I. aegyptiaca is the largest member of the genus. The excretory pore is situated 426–618 μm from the anterior extremity in the paratype males and 562–602 μm in the paratype females and not 3 800–4 200 μm as erroneously recorded by Soliman (1956). The shape and disposition of the bursal rays are identical with those of *I. tuberculata* type specimens. The length of the spicules is within the range of *I. tuberculata* as recorded by Yeh (1956) and Wetzel & Fortmeyer (1960).

Travassos (1937) stated that *I. somaliensis* differed from *I. tuberculata* in that it had a double uterus and larger spicules and eggs. The reference to the double uterus was evidently the result of an incorrect observation. The larger size of the spicules of *I. somaliensis* was not confirmed by a comparison with the figures of *I. tuberculata* as illustrated in Yorke & Mapleston (1926) (Travassos, 1937). Moreover, the size of the eggs is too variable to be considered a valid criterion for separating species.

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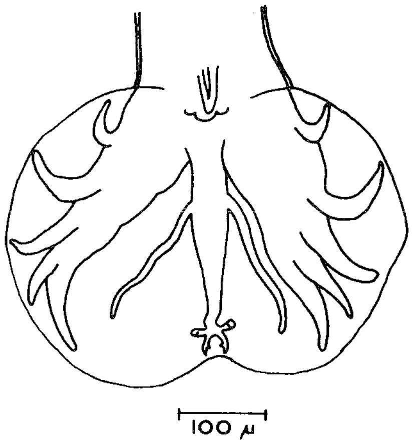

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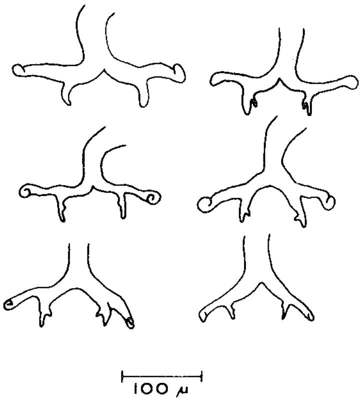

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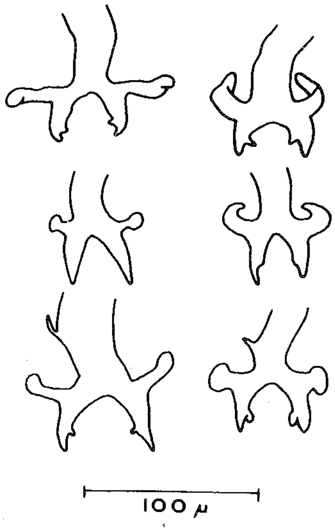

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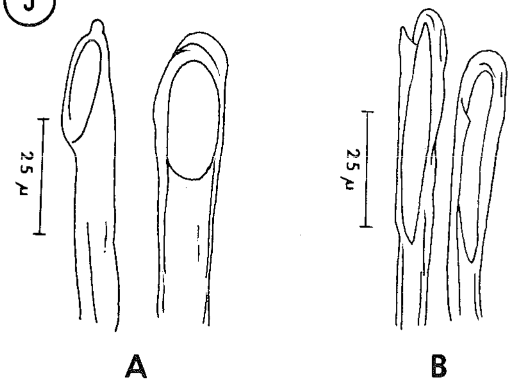

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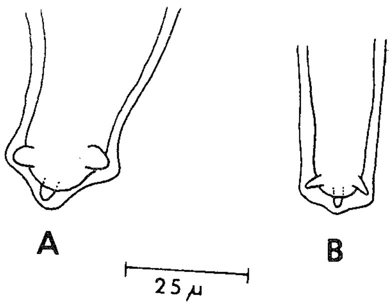

FIG. 1 Bursa of *I. tuberculata* from the type host, *A. melampus*. Ventral view
FIG. 2 Bursa of *I. nudicollis* from *T. oryx*. Dorsal view
FIG. 3 Variation in the tip of the dorsal ray of *I. tuberculata*. Top figures: from *C. dromedarius*; centre: from *R. fulvorufula*; bottom: from *A. melampus*
FIG. 4 Variation in the tip of the dorsal ray of *I. nudicollis*. Top figures: from *D. d. phillipsi*; centre and bottom: from *O. aries*
FIG. 5 Proximal end of spicules; (a) *I. tuberculata* from *A. melampus* (b) *I. nudicollis* from *D. d. phillipsi*
FIG. 6 Tail of female of (a) *I. tuberculata* from *A. melampus* (b) *I. nudicollis* from *D. d. phillipsi*

Both *I. aegyptiaca* and *I. somaliensis* are known only from the camel and have not been reported since their original description. *I. aegyptiaca* and *I. somaliensis* are considered synonyms of *I. tuberculata.*

Baer (1950) is of the opinion that *I. okapiae* and *I. somaliensis* should be retained as separate species as they differ from one another and from *I. tuberculata* in the length of the spicules and the size of the eggs. As no material of *I. okapiae* was available, the relationship of *I. okapiae* to the other members of the genus could not be determined.

I. tuberculata has been recorded from many species of antelope in Africa and the length of the spicules varies greatly in the different host animals. The spicules of *I. tuberculata* from the type host, the impala, are the shortest, while those from the reedbuck, giraffe, gerenuk, Thomson's gazelle, sable antelope and camel are longer. The specimens from the goat (Wetzel & Fortmeyer, 1960) showed a great variation in spicule length, viz., 838–1 202 μm. Such variation was also found in specimens from the Thomson's gazelle (Yeh, 1956) and may be due to the immune status of the host. This conclusion is supported by the findings of Keith (1967), who found that spicules of *Cooperia pectinata* (Ransom, 1907) were shorter in animals which had previously been exposed to the nematode. According to Keith (1967), the reduction in spicule length was due to a host reaction, stimulated by prior infestation and was not directly attributable to the presence of survivors of a previous infestation.

The I. nudicollis *group*

Mönnig (1931) experimentally infested sheep with infective larvae of *I. nudicollis* obtained from faecal cultures of a blesbok. The principal measurements of the parasites, recovered 14 and 30 days after infestation, are listed in Table 2.

Parasites from an eland, identified as *I. tuberculata* by Mönnig (1933), proved to be *I. nudicollis* upon re-examination and they are compared with *I. nudicollis* from blesbok in Table 2.

I. nudicollis may be differentiated from *I. tuberculata* by the smaller and shorter copulatory bursa, the straight dorsal ray and the narrow tip of the dorsal ray. The lateral branches of the tip of the dorsal ray of *I. nudicollis* are equal to or shorter than the median branches, whereas in *I. tuberculata* they are longer than the median branches and terminate in small hooks. The proximal ends of the spicules of *I. nudicollis* bear small median protuberances. Variations of the tip of the dorsal ray are illustrated in Fig. 4.

I. taurotragi males show characteristics of both *I. nudicollis* and *I. tuberculata.* The small size of the parasite, the copulatory bursa and the straight dorsal ray resemble those of *I. tuberculata* in that the lateral branches are longer than the median branches. Except for the smaller size, the females resemble those of *I. nudicollis.* Since *I. taurotragi* has not been recorded since its original finding and *I. nudicollis* has been recovered from the eland (Mönnig, 1933), *I. taurotragi* may possibly represent an aberrant form of *I. nudicollis.*

CONCLUSION

Specimens of *I. tuberculata* from different host species show great variation in the length of the spicules while the dorsal ray pattern remains constant. Those from the type host, the impala, have the shortest spicules (804–851 μm) and those from the sable antelope the longest (1 016–1 068 μm). The spicules of nematodes from the gerenuk (838–1 075 μm), the sheep (900–1 000 μm) and Thomson's gazelle (835–1 160 μm) fall between the two extremes. Since *I. t. longispiculata, I. aegyptiaca* and *I. somaliensis* have spicule lengths within the range of *I. tuberculata* from different hosts and have a similar dorsal ray pattern, they are considered synonymous with *I. tuberculata.*

I. nudicollis shows little variation in different host animals and *I. taurotragi* is possibly an aberrant form of *I. nudicollis.*

I. okapiae must be retained until further material becomes available, so that its status may be determined.

The parasites from the camel, described by Pande *et al.* (1962) need further study to verify their identity.

Revised host-parasite list for the genus Impalaia

1. *Impalaia tuberculata*
   Syn.:
   - *I. tuberculata longispiculata*
   - *I. aegyptiaca*
   - *I. somaliensis*
   - *I. nudicollis* from sheep (Daubney, 1933)
   - *I. nudicollis* from *G. thomsoni* (Yeh, 1956)

   Host:
   - *Aepyceros melampus*—Mönnig, 1924
   - *Capra hircus*—Wetzel & Fortmeyer, 1960
   - *Camelus dromedarius*—Crovieri, 1929; Soliman, 1956
   - *Damaliscus dorcas dorcas*—Ortlepp, 1961
   - *D. dorcas phillipsi*—Ortlepp, 1961
   - *D. lunatus*—Ortlepp, 1961
   - *Gazella thomsoni*—Yeh, 1956
   - **Giraffa camelopardalis*—this paper
   - **Hippotragus niger*—Verster, 1976 (personal communication)
   - *Litocranius walleri*—Wetzel & Fortmeyer, 1960
   - *Ovis aries*—Daubney, 1933
   - *Raphicerus campestris*—Mönnig, 1931
   - *R. melanotus*—Mönnig, 1931
   - *Redunca fulvorufula*—Baker & Boomker, 1973

2. *Impalaia nudicollis*
   Syn.:
   - *I. tuberculata,* from eland—Mönnig, 1933

   Host:
   - *Aepyceros melampus*—Mönnig, 1933
   - **Alcelaphus buselaphus*—this paper
   - *Camelus dromedarius*—Round, 1962
   - *Damaliscus dorcas phillipsi*—Mönnig, 1931
   - *D. lunatus*—Mönnig, 1932
   - *Kobus ellipsiprymnus*—Round, 1962
   - *Raphicerus campestris*—Mönnig, 1933
   - *Taurotragus oryx*—Mönnig, 1933

3. *Impalaia okapiae*
   - *Okapia johnstoni*—Van den Berghe, 1937

4. *Impalaia taurotragi*
   - *Taurotragus oryx*—Le Roux, 1936

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* New host records

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TABLE 1 Comparison of primary measurements of *I. tuberculata* from different hosts*

Host	Synonym	Author		Length (mm)	Width	Cephalic inflation, length	Head width	Oesophagus length	Nerve ring from anterior extremity	Excretory pore from anterior extremity	Spicule length	Gubernaculum length	Bursa length	Externo-dorsal length		Dorsal length	Anus to tail	Anus to vulva	Vulva to tail	Ovijector	Eggs
														Right	Left						
A. melampus		Mönnig (2924)	♂	7,2–7,5	120	86–100	40–45	440	Just behind middle of oesophagus	—	600	—	—	—	—	—	—	—	—	—	—
			♀	18,5	120	86–100	40–45	440		—	—	—	—	—	—	—	40	60	100	—	60×32
		Types, this paper	♂	7,0–8,0	103–129	81,4–92	25,9	440–445	240–307	—	850–858	74	—	—	—	—	—	—	—	—	—
			♀	16,0–18,7	148	79,9–96	29,5	555–603	277	—	—	—	—	—	—	—	51,8–59,2	185–188,7	240,5–244	—	—
		Additional material	♂	7,5	122,1–148	96–114,7	25,9–29,6	425–477	266,4–300	499–569,5	804–851	81,4–92,5	562–737	384–684	284,9–351	415–576	—	—	—	—	—
			♀	15,5–16,9	137,9–192,4	103–129,5	29,6–37	451–499,5	285–314	495–529,1	—	—	—	—	—	—	44,4–66,6	136,9–203,5	181,3–270,1	407	55–66×26–44
D. d. phillipsi			♂	4,2–6,3	140,6	85,1	33,3	362,6	—	403,3	950,9	92,5	737	473,3	351	603	—	—	—	—	—
			♀	10,7–12,6	166–185	122,1–125,8	33,3	410–444	240–278	481	—	—	—	—	—	—	51,8–59,2	143–159	194,8–218,2	358,4–362,6	62,9×37
G. camelopardalis			♂	8,8–9,2	136–160	95–107	26	333–338	240–277	420–490	871–898	88,8–93,8	743–777	407–585	340–384	627–670	—	—	—	—	—
			♀	12,5–13,6	166–185	118–125	37	429–455	311–318	490–560	—	—	—	—	—	—	63	137–177	200–240	314–415	63–65×35–45
H. niger			♂	7,1–9,5	142–172,8	98,4–156	31,2–36	417–494	211–261,8	537–600	1 016–1 168	84–112,8	684–807	420–484	330–367,2	607,5–704,5	—	—	—	—	—
			♀	13,1–15,6	161,5–192	108–121,8	33,6–38,4	454–532	228–319,2	603–607	—	—	—	—	—	—	52–72	136–172	188–224	408–589	60–76×28–55
R. fulvorufula			♂	7,2–8,0	103–147,4	85,1–129,5	25,9–33,6	388,5–425	259–277,5	—	780–832	74–92,5	469–603	351–432,9	259–330	402–495	—	—	—	—	—
			♀	12,5–14,7	166,5–177	107,3–118,4	33,3–37	462,5–499,5	259–314,5	507,6–525,4	—	—	—	—	—	—	55,5–59,2	118,4–162,8	173,9–222	351–370	55,5–59,2×37–44,4
C. dromedarius	*I. somaliensis*	Travassos (1937)	♂	9,0	163	—	—	—	—	—	1 080	90	—	—	—	—	—	—	—	—	—
			♀	14,0–17,0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	80–90×50–54
	I. aegyptiaca	Soliman (1956)	♂	8,5–11,5	130–160	—	32–38	380–520	320–330	3 800–4 200	1 300–1 600	82–100	—	—	—	600–700	—	—	—	—	—
			♀	15,0–21,0	140–170	—	34–36	460–620	320–370	3 800–4 200	—	—	—	—	—	—	52–68	114–192	182–260	400–600	65–73×37–41
		Paratypes, this paper	♂	7,4–9,6	129,5–177,6	111–136,9	29,6–33,3	418–499,5	227–344	426,5–617,9	1 246–1 380	89–103,6	573,5–740	370–469,9	318,2–388	522–643	—	—	—	—	—
			♀	14,8–19,6	187,6–214,6	114,7–140,6	33,3–40,7	480–585	300–343	535–660	—	—	—	—	—	—	51,8–77,7	148–203,5	199,8–281,2	462–629	55,5–70,3×33,3–40,7
L. walleri	*I. t. longispiculata*	Wetzel & Fortmeyer (1960)	♂	6,7–7,9	50–63 at oesophagus	—	—	300–365	207–246	391–437	838,1–1 202	79–104	—	—	—	—	—	—	—	—	—
			♀	12,5–16,1	52–69	—	—	316–382	206–246	418–478	—	—	—	—	—	—	38–49	—	139–224	—	63–79×41–46
G. thomsoni	*I. nudicollis*	Yeh (1956)	♂	6,2–8,2	120–130	60–100	40–50	380–430	—	330–440	835–1 160	90–100	—	—	—	440	—	—	—	—	—
			♀	14,6–15,3	130–150	60–100	40–50	400–490	—	330–440	—	—	—	—	—	—	54–63	—	170–220	500–600	67–73×38–44
O. aries	*I. nudicollis*	Daubney (1933)	♂	7,5–9,0	100	100–130	30	350–450	—	—	900–1 000	85	—	—	—	400–500	—	—	—	—	—
			♀	11,0–13,0	200	100–130	45	350–450	—	—	—	—	—	—	—	—	55–60	—	200	500–700	78×40

* All measurements given in μm unless stated otherwise

TABLE 2 The principal measurements of *I. nudicollis* from different hosts*

Host	Author		Length (mm)	Width	Cephalic inflation, length	Head width	Oesophagus length	Nerve ring from anterior extremity	Excretory pore from anterior extremity	Spicule length	Gubernaculum length	Bursa length	Externo-dorsal length		Dorsal length	Anus to tail	Anus to vulva	Vulva to tail	Ovijector length	Eggs
													Right	Left						
D. d. phillipsi	Mönnig (1931)	♂	7,5–8,2	110–120	130–140	51	440–480	370–410	—	910–980	94–100	—	—	—	—	—	—	—	—	—
		♀	14,8–16,7	140–160	140–150	46–59	440–520	330–390	—	—	—	—	—	—	—	67–75	173–186	240–260	—	63–75×39–46
	Types, this paper	♂	6,5–7,5	98–105	107–114	22,2–25,9	322–370	222–226	422	740–795	92,5	333–351	137–159	116–148	203–222	—	—	—	—	—
		♀	14,0–16,0	107–114	118–125	29,6	396–414	270–274	440	—	—	—	—	—	—	55,5–66,6	147,5–170,4	203–237	277–317	68×39
	Additional material	♂	7,0–8,0	114,7–155,4	107–122	25,9	344,1–384	222–296	491	788–910	81,4–92,5	351–407	185–222	185–210	263,4–277	—	—	—	—	—
		♀	14,0–16,5	159,1–203,5	118–129	29,6–33,3	370–407	240–296	524	—	—	—	—	—	—	62,9–74	155–222	217–296	222–340	59,2–66,6×37–44,4
O. aries																				
14 days in sheep		♂	6,3–7,0	111–136,9	99,1–107,3	22,2–25,9	351–403	185–240	370–440	871–951	81,4–96,2	333–370	166–210,9	185–222	222–296	—	—	—	—	—
		♀	12,5–13,7	148	111	33–37	407–410	259	462–484	—	—	—	—	—	—	74	185–222	259–296	296–370	59,2–62,9×33,3–37
30 days in sheep		♂	6,0–6,7	100–133,6	100–114,7	25,9	314–340	240–259	388–462	777–832,5	85,1–92,5	296–333	166–185	166–177,6	240–259	—	—	—	—	—
		♀	10,8–12,9	125–137	111–118,4	29,6–33,3	370–384,5	240–259	425–458	—	—	—	—	—	—	111–122,5	129–148	240,5–259	222–259	55,5–59,2×37–40,7
T. oryx		♂	6,3–7,0	118,4–140,6	48,1–62,9	25,9–29,6	333–370	215,7–227,8	388,5	743–802	81,4	296–333	170–185	155–166,5	222–258	—	—	—	—	—
		♀	12,5–14,0	122,1–136,9	92,5–99,9	25,9–29,6	395–447	203–258	402,8–528,4	—	—	—	—	—	—	62,9–66,6	159–177,1	222,4–243,7	259–296	55,5–59,2×40,7–48,7

* All measurements are given in μm unless stated otherwise

TABLE 3 The principal measurements of *I. taurotragi**

Host	Author		Length (mm)	Width	Cephalic inflation, length	Head width	Oesophagus length	Nerve ring from anterior extremity	Excretory pore from anterior extremity	Spicule length	Gubernaculum length	Bursa length	Externo-dorsal length		Dorsal length	Anus to tail	Anus to vulva	Vulva to tail	Ovijector length	Eggs
													Right	Left						
T. oryx	Le Roux (1936)	♂	4,8	56	—	—	—	—	—	580	±60	—	—	—	40	—	—	—	—	—
		♀	6,1	88	—	18	645	—	165	—	—	—	—	—	—	52	126	178	—	78×35
	Holotype this paper	♂	3,1	46,8	—	—	—	—	—	554,4	57,6	92,2	64,8	57,6	39,6	—	—	—	—	—
	Allotype this paper	♀	4,85	93,6	32,4	14,4	637	136,8	—	—	—	—	—	—	—	54	111,6	165,6	342	61–68×36–39

* All measurements are given in μm unless stated otherwise

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COOPERIA CONNOCHAETI SP. NOV. (NEMATODA, TRICHOSTRONGYLIDAE) FROM THE BLUE WILDEBEEST, *CONNOCHAETES TAURINUS* (BURCHELL, 1823)

J. BOOMKER(¹), I. G. HORAK(¹) and REGINA ALVES(²)

ABSTRACT

BOOMKER, J., HORAK, I. G. & ALVES, REGINA, 1979. *Cooperia connochaeti* sp. nov. (Nematoda, Trichostrongylidae) from the blue wildebeest, *Connochaetes taurinus* (Burchell, 1823). *Onderstepoort Journal of Veterinary Research*, 46, 83–86 (1979).

A new species of nematode, *Cooperia connochaeti*, was collected from cross-bred blue and black wildebeest at Krugersdorp (Transvaal), blue wildebeest *Connochaetes taurinus* (Burchell, 1823) from the Kruger National Park (Transvaal) and Lake Xhau (Botswana), as well as from impala *Aepyceros melampus* (Lichtenstein, 1812) at Malelane (Transvaal) and Pafuri (Kruger National Park).

These nematodes are smaller than *Cooperia pectinata* Ransom, 1907, and their spicules, which are bifid in the distal third, are shorter (145–166 μm) than those of *C. pectinata* (240–280 μm). In addition, the lateral branches of the dorsal ray of *C. connochaeti* are directed ventrally and slightly anteriorly, while those of *C. pectinata* are directed posteriorly.

Résumé

COOPERIA CONNOCHAETI *SP.NOV.* (*NEMATODA, TRICHOSTRONGYLIDAE*), *PARASITE DU GNOU BLEU* CONNOCHAETES TAURINUS (*BURCHELL*, 1823)

On a récolté une nouvelle espèce de nématode, Cooperia connochaeti, *chez des hybrides de gnous bleus et noirs à Krugersdorp* (*Transvaal*), *chez le gnou bleu* Connochaetes taurinus (*Burchell*, 1823) *au Parc National Kruger* (*Transvaal*) *et au lac Xhau* (*Botswana*), *ainsi que chez l'impala* Aepyceros melampus (*Lichtenstein*, 1812) *à Malelane* (*Transvaal*) *et à Pafuri* (*Parc National Kruger*).

Ces nématodes sont plus petits que Cooperia pectinata *Ransom*, 1907, *et leurs spicules, bifides au tiers distal, sont plus courts* (145–166 *μm*) *que ceux de* C. pectinata (240–280 *μm*). *En plus, les branches latérales de la raie dorsale de* C. connochaeti *sont dirigées ventralement et légèrement vers l'avant, tandis que celles de* C. pectinata *sont dirigées vers l'arrière.*

INTRODUCTION

During an anthelmintic test conducted in a private game park near Krugersdorp, Transvaal, nematodes of the genus *Cooperia* Ransom, 1907 were found in the small intestine of 17 of 18 cross-bred blue and black wildebeest (*Connochaetes taurinus* × *Connochaetes gnou*). Identical nematodes were found in 7 of 8 blue wildebeest, *Connochaetes taurinus* (Burchell, 1823), in the Kruger National Park and 1 of 7 from Lake Xhau, Botswana, as well as in impala, *Aepyceros melampus* (Lichtenstein, 1812), from Malelane, Transvaal and Pafuri, Kruger National Park.

The parasites were never present in vast numbers, 1 771 worms from a single animal at Krugersdorp and 1 256 from an animal in the Kruger National Park being the maximum numbers collected. With few exceptions they were the only nematodes present in the small intestine (Horak, unpublished data).

As these nematodes could not be assigned to any of the known species of *Cooperia,* they are described as *Cooperia connochaeti* sp. nov. The type host selected was *C. taurinus* from the Kruger National Park, since the wildebeest at Krugersdorp were hybrids.

DIAGNOSIS OF THE SPECIES

Trichostrongylidae, Trichostrongylinae: Anterior end with a cuticular dilatation, buccal capsule vestigeal; cervical papillae absent; 12–16 longitudinal ridges on body. Male with a symmetrical bursa; dorsal lobe distinct; spicules relatively short, thick and complex; gubernaculum absent. Female didelphic; vulva in posterior half of body; tail tapering to a more or less acute point.

Description of Cooperia connochaeti *sp. nov.*

Type host

Connochaetes taurinus (Burchell, 1823) from the Kruger National Park.

Material examined

C. taurinus, Kruger National Park, type specimens (Onderstepoort Helminthological Collection, No. 2153), 12 males and 12 females.

C. taurinus, Lake Xhau, Botswana, 5 males, 5 females.

Connochaetes hybrids, Krugersdorp, Transvaal, 6 males, 6 females.

A. melampus, Malelane, Transvaal, 3 males, 4 females.

A. melampus, Pafuri, Transvaal, 6 males, 6 females.

Paratypes, 12 males and 12 females from blue wildebeest from the type locality, have been deposited in the Onderstepoort Helminthological Collection (No. 2154).

Description

The principal measurements are listed in Table 1.

Small worms of which the anterior end of the body is spirally coiled. The cuticle bears 12–14 longitudinal striations which begin approximately 100–135 μm from the anterior end and are supported by sclerotized rods. The supporting rods are larger and more strongly developed dorsally. There is a cephalic inflation which extends further dorsally than ventrally (Fig. 1). The measurements of the length of the cephalic inflation, as given in Table 1, are those of the longer dorsal portion.

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TABLE 1 The principal measurements of *Cooperia connochaeti* sp. nov.*

Host locality	*C. taurinus* Kruger National Park (Type specimens)		*Connochaetes* hybrids Krugersdorp		*C. taurinus* Botswana	
	♂	♀	♂	♀	♂	♀
Length (mm)	4,4–5,1	5,9–7,1	5,0–5,8	6,2–7,9	4,4–5,1	5,1–7,2
Width	96,2–114,4	80,6–106,6	113–118	114,4–127,4	96,2–111,8	88,4–101,9
Head width	26–31,2	26–33,8	26–33,8	28,6–33,8	26–28,6	28,6–31,2
Cephalic inflation:						
Length	91–130	96,2–132,6	119,6–130	106–143	98,8–106,6	98,8–122,2
Width	28,6–46,8	44,1–57,2	39–49,4	44,2–49,4	36,4–39	36,4–39
Oesophagus	275,6–338	322,4–378,8	317–348,2	351–364	286–314	304–379
Nerve ring	208–260	221–293	205,4–273	241,8–273	208–221	218–241
Excretory pore	260–350	345–410	348,4–361,4	369–405,6	286–325	365–404,2
Bursa:						
Length closed	130–176,8	—	144,2–176	—	143–172,4	—
Width	117–169	—	175–185,4	—	143–166,4	—
Dorsal ray	91–109,2	—	91–104	—	104–130	—
Spicules	145–166,4	—	153–166,4	—	156–163,8	—
Tail to vulva	—	1 359,6–1 658,3	—	1 503,8–1 792,2	—	1 336–1 648
Tail to anus	—	123,6–169	—	144,4–164,8	—	130–176,8
Anus to vulva	—	1 190,6–1 534,7	—	1 339–1 647,8	—	1 159,2–1 518
Ovijector	—	309–473,8	—	364–416	—	391–432,6
Eggs:						
Length	—	56–72,8	—	65–72,8	—	54,6–70,8
Width	—	31,2–39	—	36,4–49,4	—	28,8–31,2

* All measurements given in μm unless stated otherwise

The mouth is surrounded by 3 small lips, each of which bears a small papilla. A pair of phasmids is also present (Fig. 1). The oesophagus has the usual cylindrical shape and is slightly thickened distally. The nerve ring is fairly distinct. The excretory pore may be situated either anterior to, at the end of, or posterior to the end of the oesophagus.

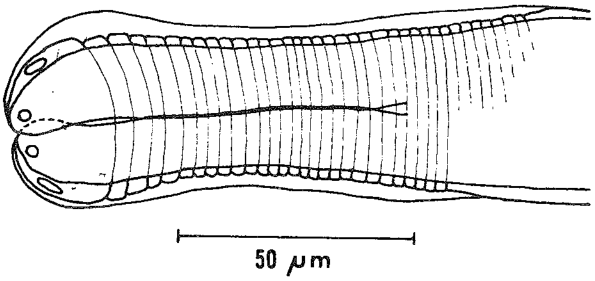

FIG. 1 Head, lateral view

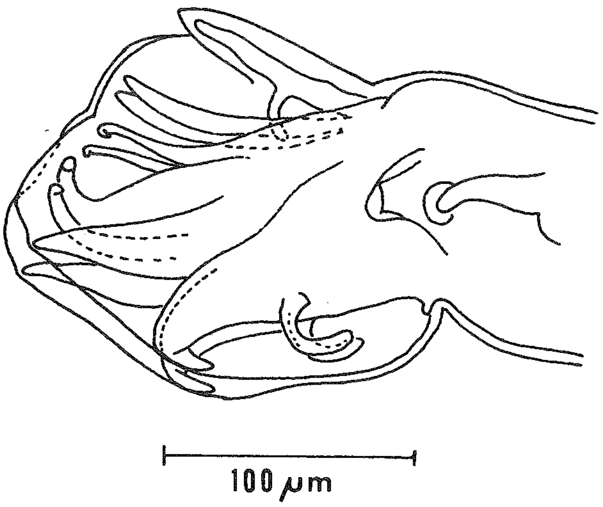

FIG. 2 Male bursa, lateral view

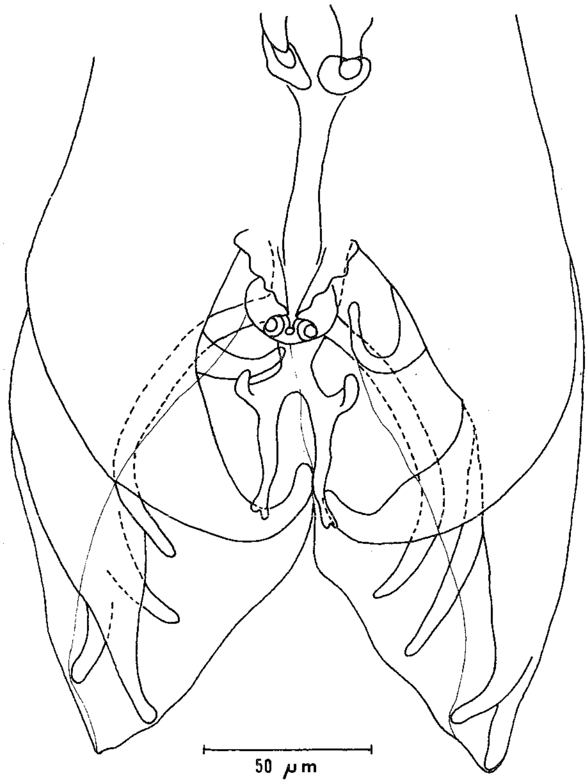

FIG. 3 Male bursa, ventral view

The males are 4,4–5,8 mm long. The bursa has the compact appearance of the genus, with 2 small lateral lobes from which the dorsal lobe is distinctly demarcated (Fig. 2). The ventro-ventral and latero-ventral rays are well separated, the latter being considerably larger than the former. Both rays curve anteriorly. Of the lateral rays, the antero-laterals are the largest, curve slightly inward and reach the margin of the bursa. The medio-lateral rays diverge from the antero-laterals and curve slightly inward and dorsally. The postero-lateral rays are slender and curve dorsally

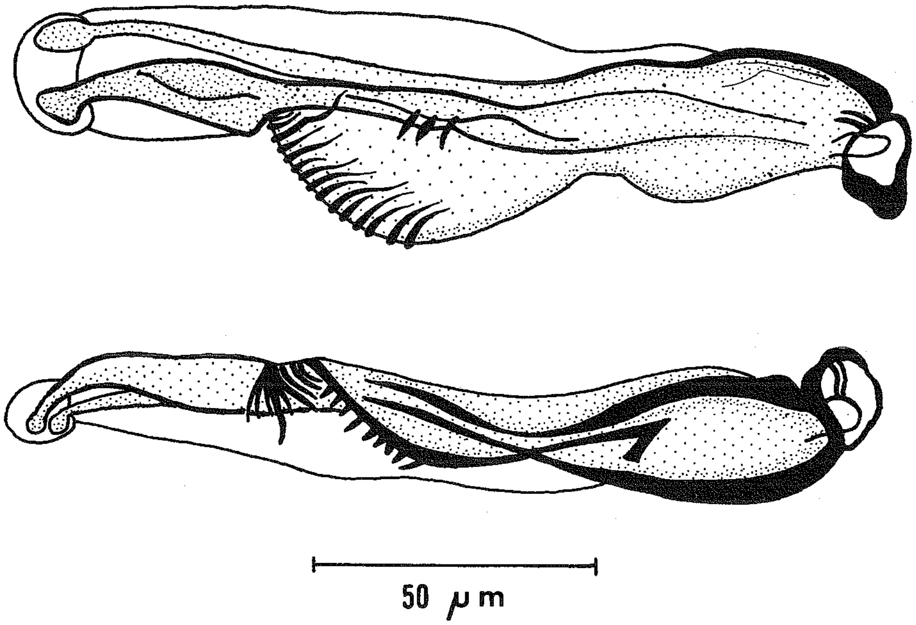

FIG. 4 Spicules; top lateral view, bottom ventral view

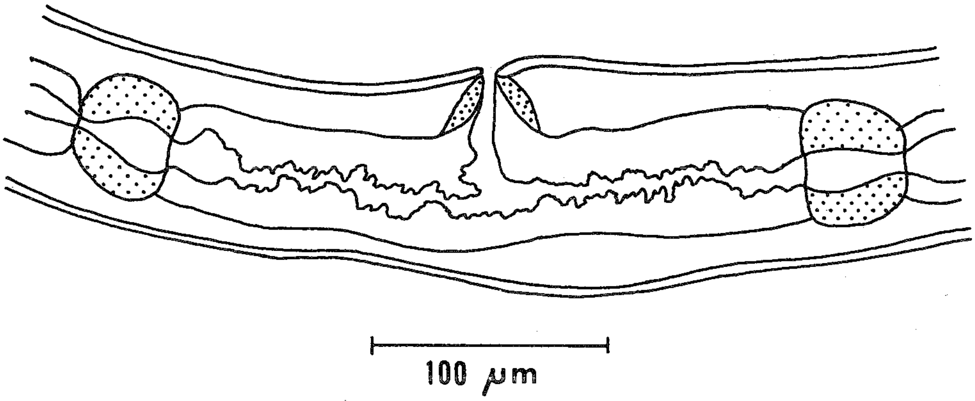

FIG. 5 Ovijector, lateral view

(Fig. 2). The dorsal ray is stout and the posterior third is divided into 2 branches. Ventrally directed branches arise posteriorly to the bifurcation of the main branch. The main branches, which together assume the typical lyre-shape of the genus, end in bifid tips, which are of equal thickness, but which may differ in length. The externo-dorsal rays arise from the middle of the main trunk of the dorsal ray. They are slender and have the characteristic shape of the genus (Fig. 3).

The spicules (Fig. 4) are equal and well sclerotized. The middle third of each has a pectinate expansion, followed by a depression into which the corrugations extend. The distal third of the spicule consists of 2 slender, slightly curved spurs, each terminating in a small, ovoid, non-sclerotized knob. Membranous alae are present. They extend from the pectinate expansion medially to enclose the 2 spurs of the spicules, and laterally to enclose the distal five sixths of the spicule. There is no gubernaculum.

The females are 5,0–7,9 mm long, and 80,6–127,4 µm wide across the vulva. The vulva is a slightly protruding transverse slit on the ventral aspect of the body, and is usually flanked by a pair of small lateral alae. The longitudinal striations are interrupted in the vulvar region, but are continuous dorsally. The ovijectors are well developed (Fig. 5). The tail is moderately long and ends acutely (Fig. 6). Eggs are ovoid to elongated.

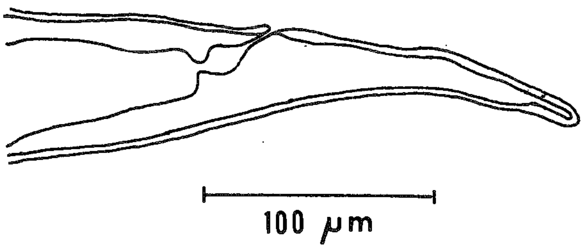

FIG. 6 Tail of female, lateral view

DISCUSSION

The various *Cooperia* species may be divided into 2 groups. The first group, in which the lateral branches of the distal part of the dorsal ray arise anteriorly to, or at the bifurcation, includes *C. africana* Mönnig, 1933, *C. curticei* (Giles, 1892) Ransom, 1907, *C. minor*

Gutteres, 1947, *C. neitzi* Mönnig, 1933, *C. punctata* (von Linstow, 1907) Ransom, 1907, and *C. spatulata* Baylis, 1938.

In the second group the lateral branches of the distal part of the dorsal ray arise posteriorly to the bifurcation. The species included in this group are *C. borgesi* Gutteres, 1947, *C. fuelleborni* Hung, 1926, *C. hippotragusi* Gutteres, 1947, *C. hungi* Mönnig, 1931, *C. mcmasteri* Gordon, 1932, *C. oncophora* (Railliet, 1898) Ransom, 1907, *C. pectinata* Ransom, 1907, *C. reduncai* Gutteres, 1947, *C. verrucosa* Mönnig, 1933, *C. yoshidai* Mönnig, 1939, as well as *C. connochaeti*. The spicules of *C. connochaeti* resemble those of *C. pectinata* in shape but are smaller, (viz., 145–166 μm in *C. connochaeti* and 240–250 μm in *C. pectinata*) and are bifid in their distal third. The lateral branches of the dorsal ray of *C. connochaeti* are directed ventrally and slightly anteriorly, while those of *C. pectinata* are directed posteriorly.

Additional material from impala was examined and it was found that the measurements of these worms fall within the range given for the type specimens from the type host.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the Board of Curators, National Parks Board, and the Krugersdorp Game Reserve and Pleasure Resort for placing the wildebeest and impala at their disposal, to Dr V. de Vos, National Parks Board, for assisting with the necropsies in the Kruger National Park, and to Dr I. Carmichael, Department of Helminthology, Veterinary Research Institute, for the loan of his material from Botswana.

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TRICHOSTRONGYLUS AURICULATUS N. SP. (NEMATODA: TRICHOSTRONGYLIDAE) FROM THE STEENBOK, *RAPHICERUS CAMPESTRIS* (THUNBERG, 1811)

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ABSTRACT

BOOMKER, J., 1986. *Trichostrongylus auriculatus* n. sp. (Nematoda: Trichostrongylidae) from the steenbok *Raphicerus campestris* (Thunberg, 1811). *Onderstepoort Journal of Veterinary Research*, 53, 213–215 (1986).

During a pilot survey of the parasites of some artiodactylids in the Kalahari Gemsbok National Park a new species of *Trichostrongylus* Looss, 1905 was recovered from the small intestine of a steenbok, *Raphicerus campestris* (Thunberg, 1811), a gemsbok, *Oryx gazella* (Linnaeus, 1758), and a red hartebeest, *Alcelaphus buselaphus* (Pallas, 1766). The male spicules were 0,120–0,148 mm long and an ear-shaped protuberance was present on the shaft of the left spicule. The presence of only a single protuberance is characteristic of the species.

INTRODUCTION

During a pilot survey of the parasites of some of the artiodactylids in the Kalahari Gemsbok National Park (KGNP), Cape Province, a new species of *Trichostrongylus* Looss, 1905 was recovered from the small intestine of a steenbok, *Raphicerus campestris* (Thunberg, 1811), a gemsbok, *Oryx gazella* (Linnaeus, 1758) and a red hartebeest, *Alcelaphus buselaphus* (Pallas, 1766). These worms were referred to as a *Trichostrongylus* species by Boomker, Horak & De Vos (1986) and are described here as *Trichostrongylus auriculatus* n. sp.

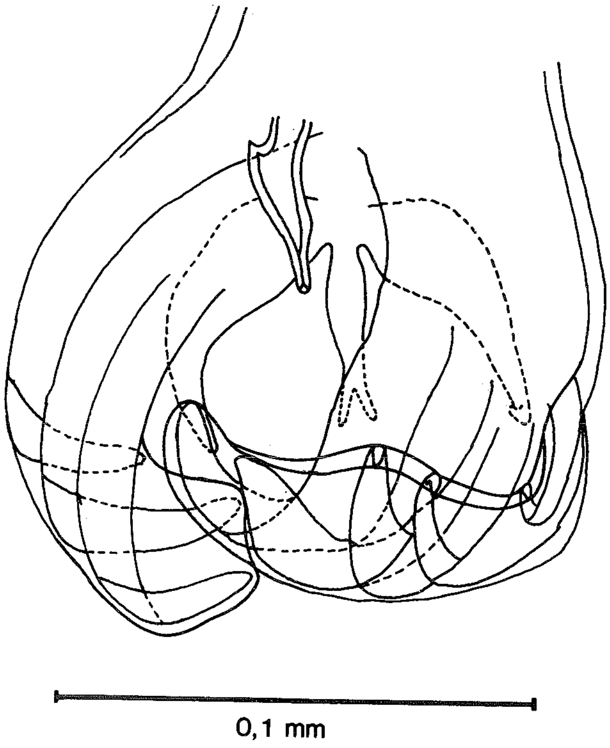

FIG. 1 Ventral view of the bursa of *Trichostrongylus auriculatus*

Only a few worms were recovered from each of the animals, the steenbok harbouring 60, the gemsbok 356 and the red hartebeest 50 male and female worms (Boomker *et al.*, 1986). The syntype specimens were selected from the steenbok, but paratypes were not selected because the worms from the other antelope were poorly preserved.

Received 30 June 1986—Editor

DIAGNOSIS OF THE GENUS

Trichostrongylidae: Trichostrongylinae: Small, slender worms with a small head and without a buccal capsule or cervical papillae; the excretory pore opens in a ventral notch slightly behind the nerve ring. The male bursa has large lateral lobes and a more or less distinct, symmetrical dorsal lobe; an accessory bursal membrane is absent and small prebursal papillae are present; the spicules are short and stout, ridged and variably sclerotized. A gubernaculum is present. Females are slightly larger than the males; the uteri are amphidelphic and the ovijector is situated in the posterior 1/3rd to 1/5th of the body; eggs are segmented when laid.

Description of *Trichostrongylus auriculatus* n. sp.

Type host

Raphicerus campestris (Thunberg, 1811) from the Kalahari Gemsbok National Park, Cape Province, Republic of South Africa.

Material examined

R. campestris from the type locality, syntype specimens (Onderstepoort Helminthological Collection, No. T2173), 5 male and 8 female worms.

O. gazella from the type locality, 5 males and 5 females.

A. buselaphus from the type locality, 2 male worms.

Paratype specimens were not selected because of the poor state of preservation of the worms from the gemsbok and the red hartebeest.

TABLE 1 The principal measurements (mm) of *Trichostrongylus auriculatus*

	Males	Females
Length	4,01 –4,99	4,20 –6,07
Width	0,084–0,104	0,084–0,100
Length of oesophagus	0,742–0,912	0,560–0,840
Distance of excretory pore form anterior end	0,140–0,156	0,140–0,156
Distance of prebursal papillae from posterior end	0,038–0,052	—
Length of left spicule	0,136–0,148	—
Length of right spicule	0,120–0,134	—
Length of gubernaculum	0,062–0,076	—
Combined length of ovijectors and sphincters	—	0,400–0,468
Distance of vulva from anus	—	0,844–1,208
Distance of anus from tip of tail	—	0,056–0,080
Distance of vulva from tip of tail	—	0,900–1,272
Eggs *(in utero)*, length	—	0,072–0,076
width	—	0,038–0,048

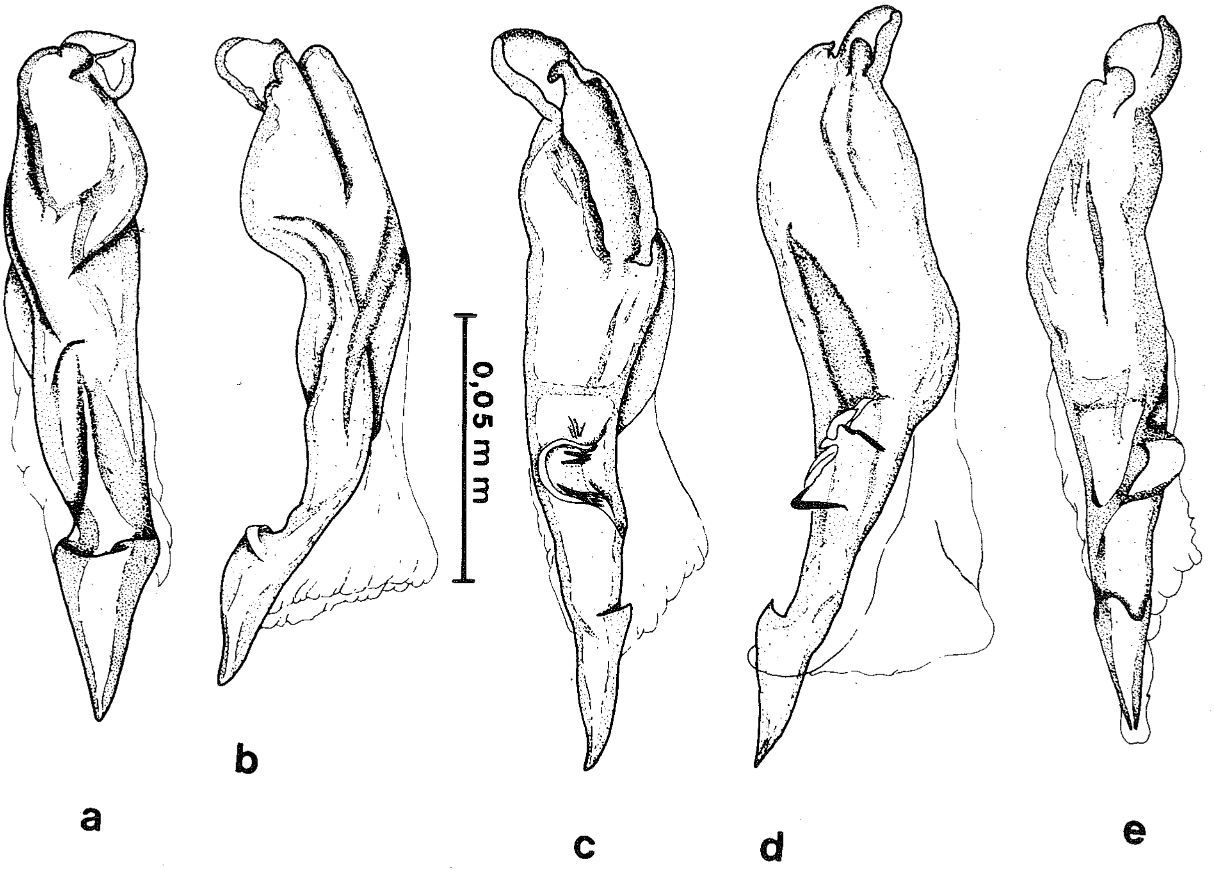

FIG. 2 Ventral (a) and lateral (b) views of the left spicule and dorsolateral (c), lateral (d) and ventrolateral (e) views of the right spicule of *Trichostrongylus auriculatus*

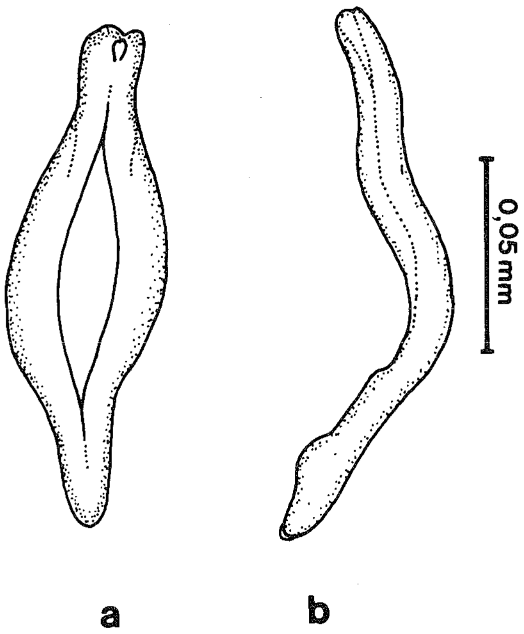

FIG. 3 The gubernaculum of *Trichostrongylus auriculatus* in (a) dorsal view and (b) ventral view

Description

The principal measurements are listed in Table 1.

Small worms that are often coiled; buccal capsule and cervical papillae absent; excretory pore opens in a ventrally situated notch slightly distal to the nerve ring; oesophagus cylindrical and only slightly distended distally.

The male bursa has the typical shape of those of other members of the genus (Fig. 1). There are 2 large lateral lobes and a more or less distinct dorsal lobe. The anteroventral rays are slender and curve anteriorly. The posteroventral rays are considerably thicker and curve laterally or only slightly anteriorly. The lateral rays diminish in size; the anterolateral curves anteriorly, the mediolateral curves laterally or slightly posteriorly and the posterolateral curves posteriorly. The externodorsal rays arise from the base of the dorsal ray and do not reach the bursal margin. The dorsal ray is short and slender and bifurcates at its distal end, each branch dividing in turn to form small digitate branches. Small prebursal papillae are present.

The spicules are subequal and complex; they appear to be longitudinally twisted and bear prominent ridges. The right spicule resembles that of *Trichostrongylus colubriformis* (Giles, 1892) Ransom, 1911 and has a fairly large body, a thinner shaft and a well-developed convex shoe (Fig. 2 a, b). The left spicule is longer and has a protuberance on the shaft which appears ear-shaped in dorsolateral or ventrolateral views, but angular in lateral view (Fig. 2 c–e). The protuberance consists of a sclerotized rim with 2 or 3 well-sclerotized rods that support the weakly sclerotized body. The shoe of this spicule is straight or only slightly concave. Well-developed membranous alae enclose the distal half of each spicule (Fig. 2). A weakly sclerotized, asymmetrically boat-shaped gubernaculum is present (Fig. 3 a). In lateral view, the gubernaculum is irregularly crescent-shaped and is slightly thickened distally (Fig. 3 b).

The females are slightly larger than the males and have the typical appearance of the genus. The vulva is situated approximately at the division of the anterior 2/3rds and the posterior 1/3rd of the body and vulvar lips are inconspicuous. The uteri are amphidelphic, and eggs are segmented when laid.

DISCUSSION

Although the spicules of *T. auriculatus* somewhat resemble those of *T. colubriformis,* the former nematodes are unique in that there is a protuberance on only 1 of the spicules. Another species that has prominent protuberances on the shafts of the spicules is *Trichostrongylus pietersi* Le Roux, 1932, where the protuberances have a different shape and occur on both spicules.

T. auriculatus seems to be limited to the arid areas of the country and has not been recovered from steenbok from the summer rainfall area (Boomker *et al.*, 1986).

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Systematic Parasitology **36:** 69–73, 1997.

Supplement to the description of *Longistrongylus thalae* (Troncy & Graber, 1973) Gibbons, 1981 (Nematoda: Ostertagiinae)

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Abstract

Longistrongylus thalae (Troncy & Graber, 1973) Gibbons, 1981 is briefly re-described. The synlophe, the spicules and the apical cephalic structures, previously either inadequately or not figured, are illustrated. The authors concur with Gibbons (1981) that this nematode belongs to the genus *Longistrongylus* Le Roux, 1931, but consider the degree of asymmetry of the ovejector, as depicted by Troncy & Graber (1973), as not being representative of the species.

Introduction

Troncy & Graber (1973) originally described *Ostertagia thalae* from the abomasa of roan antelope *Hippotragus equinus* (Desmarest) and red hartebeest or kongoni *Alcelaphus buselaphus* (Pallas). Subsequently, Graber & Delavenay (1978) elevated the subgenus *Pseudomarshallagia*, created by Roetti (1941) for *Ostertagia (Pseudomarshallagia) elongata* Roetti, 1941, to full generic status and transferred *O. thalae* to *Pseudomarshallagia* in a new combination. Gibbons (1981) transferred *Pseudomarshallagia thalae* to the genus *Longistrongylus* Le Roux, 1931, because these genera had several characteristics in common. Durette-Desset (1989), however, retained the name *O. thalae*, and suggested that the species should be excluded from the Ostertagiinae and placed in the Graphidiinae, mainly because of the apparently asymmetrical uterus in the female.

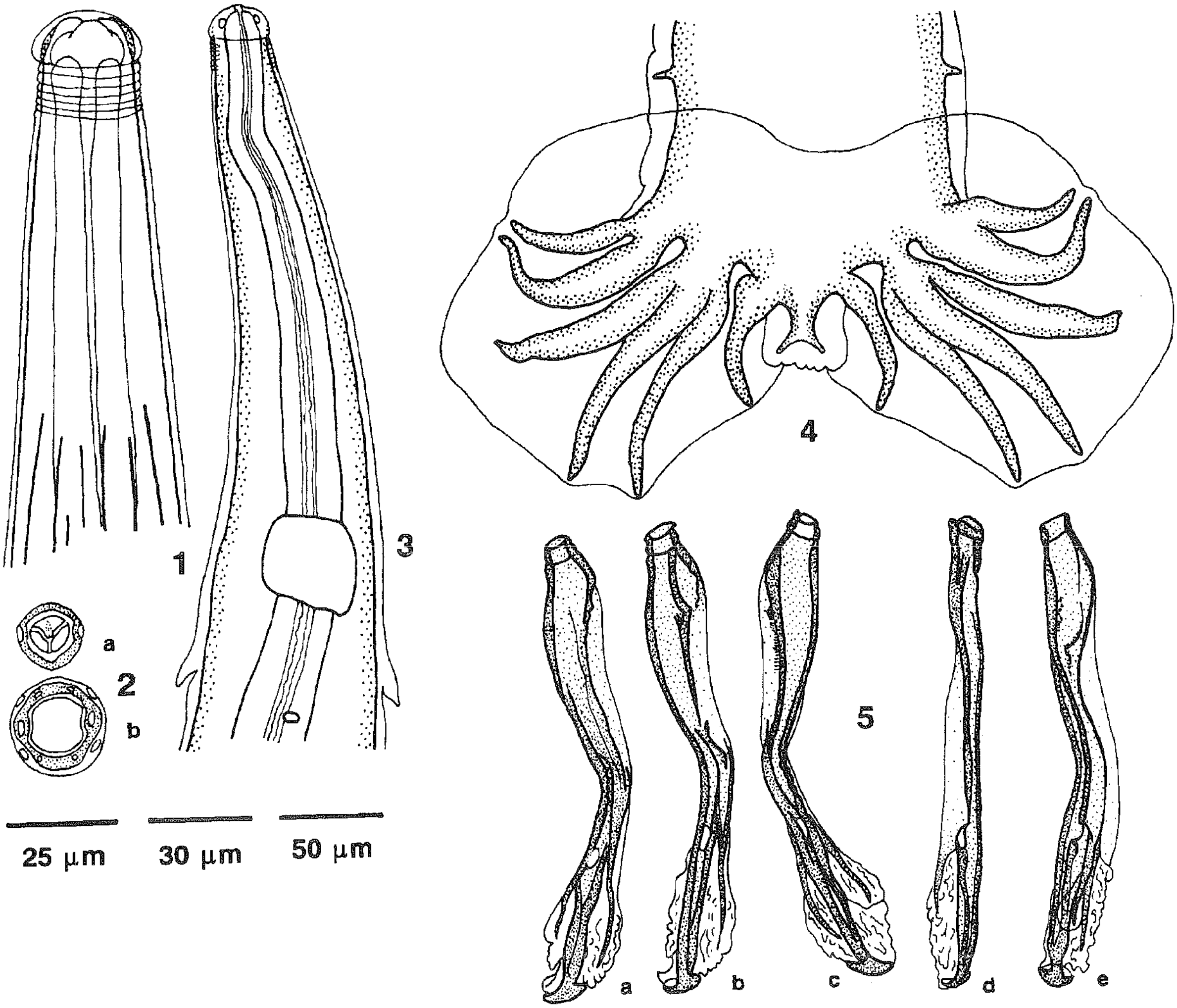
The purpose of this paper is to provide additional information on the species, as some of the illustrations provided by Troncy & Graber (1973) could be misleading.

Materials and methods

The specimens on which Troncy & Graber (1973) based their original description are in the collection of the Muséum National d'Histoire Naturelle (MNHN) and the following specimens were examined: 2 males, 2 females from *Alcelaphus buselaphus*, labelled *Bigalkenema thalae*, No. MNHN 43 MA; 1 male, 3 females from *Hippotragus equinus*, labelled *Ostertagia thalae*, No. MNHN 44 MA; holotype male, allotype female from *A. buselaphus*, labelled *Ostertagia thalae*, No. MNHN 45 MA; 6 males, 6 females from *A. buselaphus*, labelled *Ostertagia thalae*, No. MNHN 46 MA.

The nematodes were initially examined in water and, when deemed necessary, cleared in lactophenol. An *en face* preparation and cross-sections of the mid-body of male and female worms were made and studied in water and glycerine jelly, respectively. The cephalic synlophe was studied on nematodes mounted in phenol-alcohol. The spicules were dissected out of a male and examined in lactophenol. Measurements were made from drawings of the material, and all drawings were made with the aid of a Wild compound microscope and a drawing tube.

Measurements are given as those of the holotype or allotype, followed by those of the other specimens



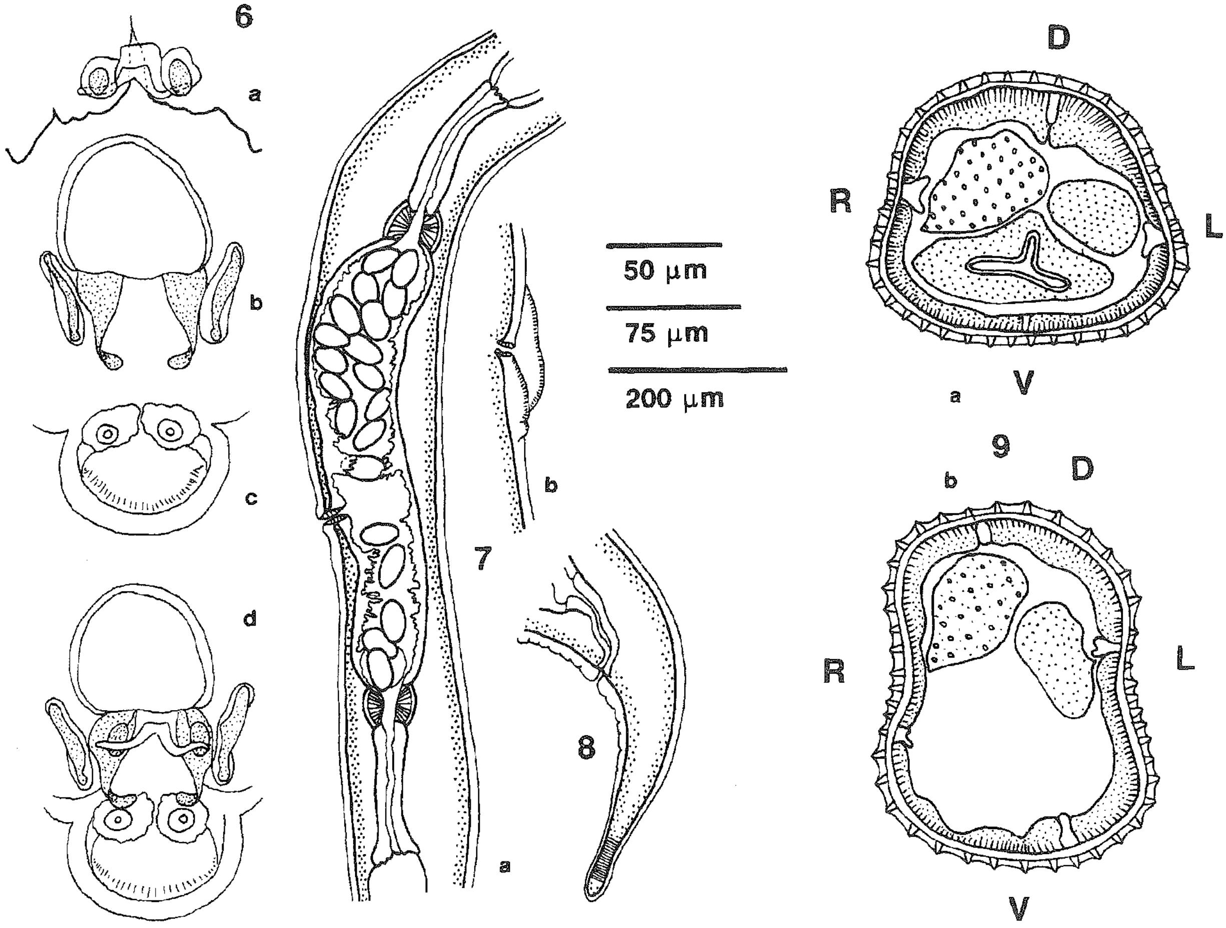
Figures 1–5. Longistrongylus thalae. 1. Dorsal view of the anterior end of a female showing the cross-striation in the cervical region and the beginning of the cuticular ridges. 2. A slightly deeper than *en face* view of a male, showing the proximal tip and opening of the dorsal oesophageal gland (a) and the apical structures on the head of a female (b). 3. Ventral view of the anterior end of a male. 4. Dorsal view of the bursa. 5. Interno-lateral, ventral and externo-lateral views (a–c) of the right, and ventral and dorsal views (d,e) of the left spicules. *Scale-bars*: 1,2,5, 25 μm; 3,4, 50 μm.

examined (in parentheses), and all measurements are given in micrometres (μm).

Longistrongylus thalae (Troncy & Graber, 1973) Gibbons, 1981

Description

Slender worms, with small cephalic vesicle. Fine cross-striations present on cuticle of the anterior region posterior to cephalic vesicle (Figures 1,3). Mouth round, without lips. Amphids comparatively large, 4 external labial and 4 cephalic papillae are visible (Figure 2b). Dorsal lobe of oesophagus immediately posterior to mouth exhibits proximal tip and opening of dorsal oesophageal gland (Figure 2a). Oesophagus clavate, indistinctly divided into muscular and glandular regions. Deirids prominent and situated laterally (Figure 3). Cervical synlophe consisting 3 parallel lateral ridges with adjacent parallel synlophe (Figure 10).



Figures 6–9. Longistrongylus thalae. 6. Genital cone; (a) ventral raylets and associated structures, dorsal view; (b) median, somewhat tubular, telamon, ventral view; (c) dorsal accessory bursal membrane with two papillae, representing rudimentary dorsal raylets, ventral view; (d) entire genital cone, ventral view. 7. Vulvar region of a female, showing the ovejector (a) and cuticular expansions at the vulva (b). 8. Lateral view of the female tail. 9. Transverse section through the mid-body of (a) a male and (b) a female. *Abbreviations*: D, dorsal; V, ventral; L, left; R, right; *Scale-bars*: 9, 25 µm; 6, 50 µm; 8, 75 µm; 7, 200 µm.

Males

Holotype male extensively damaged, so few anterior and posterior structures could be seen and measured. Body 7,905 (7,813–9,105) long, 157 (129–153) wide. Cephalic vesicle not measured in holotype; 10–15 long, 23–24 wide in other males. Cervical cross-striations could not be seen in holotype, but extend for 11–14 posterior to cephalic vesicle in other specimens. Muscular oesophagus 348 (278–376); glandular oesophagus 546 (557–613); total oesophageal length 894 (835–972); all measured from anterior extremity. Nerve-ring, deirids and excretory pore not seen in holotype, but 230–299, 286–355 and 261–327, respectively, in other specimens.

In hand-cut sections of mid-bodies of 4 males 44–51 (50, 51, 44, 50) cuticular ridges are present, the three in the lateral fields being slightly smaller than the rest. All ridges are perpendicular to body surface (Figure 9a).

Bursa with 2 well-developed lateral lobes and one small dorsal lobe which is crenulate posteriorly. Bursa of 2-1-2 type (Figure 4) and rays follow the description of Durette-Desset & Chabaud (1981).

Spicules equal or almost equal in length, well-sclerotised, curved in lateral view. Proximal part wider than distal part; latter consisting of stout main branch with rounded tip and 2 slender, pointed additional branches. Tip of each branch is enclosed in convoluted, transparent membranes (Figure 5a–e). Left spicule

209 (198–226); right spicule 205 (209–219). Gubernaculum absent.

Genital cone comparatively large and complex, contains lightly sclerotised elements; not seen in the holotype, 74–83 long and 40–43 wide in other males. The ventral raylets (papillae 0) paired and united at base (Figure 6a,d). Telamon present (Figure 6b,d); consists of lightly sclerotised structures which extend dorsally and caudally; latter forming incomplete loop through which spicules pass during extrusion. Accessory bursal membrane consists of membranous disc, on anterior end of which 2 ventrally directed papillae (papillae 7) occur (Figure 7c,d). Proconus not evident.

Females

Body 10,236 (9,532–10,963) long, 165 (150–181) wide. Cephalic vesicle 10 (11–14) long, 26 (24–27) wide. Cross-striations extend for 10 (12–16) posterior to cephalic vesicle. Muscular part of oesophagus 366 (342–367) long; glandular part 515 (512–553) long; combined length 881 (877–937). Nerve-ring not seen in allotype, situated 205–271 from anterior end in other females. Excretory pore and deirids 251 (238–317) and 289 (245–344) from anterior extremity, respectively.

Forty-two to 45 cuticular ridges present in mid-body (Figure 4b), arranged as described for males.

Vulva in posterior third of body, 1,414 (1,407–1,560) from anus and 1,616 (1,546–1,708) from caudal extremity. Small cuticular expansion may or may not occur in vulvar region (Figure 8a,b). Ovejector 898 (725–949) long, consisting of anterior infundibulum (167 (146–159)), anterior sphincter (38 (35–49)), anterior part of vestibule (289 (187–396)), posterior infundibulum (164 (104–167)), posterior sphincter (42 (35–49)) and posterior part of vestibule (198 (160–264)) (Figure 8a). There are 25 eggs in anterior branch of uterus of allotype, none in anterior infundibulum, 15 in anterior part of vestibule and 19 eggs in posterior branch of uterus, none in infundibulum and 19 in posterior part of vestibule. Eggs containing morula measure 52 × 28 (52–65 × 33–40). Tail bluntly pointed, 202 (125–156) long (Figure 9).

Discussion

Except for the male spicules and the female ovejector, the original description and illustrations of *L. thalae* are precise. Troncy & Graber (1973) illustrated the ovejector as asymmetrical, with the posterior part bearing no eggs. While it is entirely possible that such a situation could occur, the majority of specimens we examined had eggs in both the anterior and posterior parts of the vestibule, although the posterior part tended to contain fewer eggs and was shorter than the anterior. The ovejector illustrated by Troncy & Graber (1973) should not be considered as representative, since only the anterior vestibulum contains eggs.

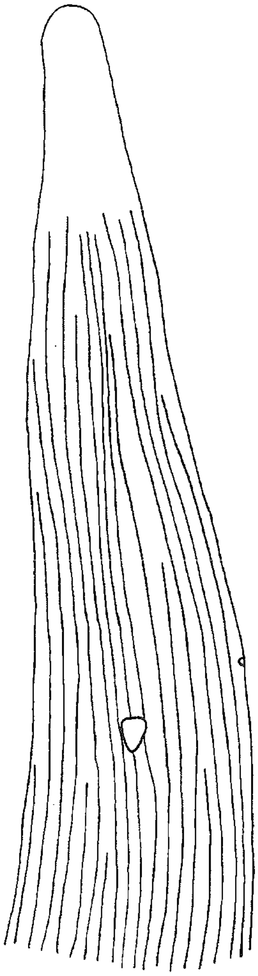


Figure 10. Longistrongylus thalae. Schematic representation in right lateral view of the anterior synlophe showing three parallel lateral ridges and adjacent parallel ridges.

Troncy & Graber (1973) stated that there are between 30 and 50 longitudial ridges, and Gibbons (1981) that these are numerous, but neither author illustrated the synlophe. We found four males to have between 44 and 51 ridges, and two females 42 and 45 ridges, in the mid-body. This is unusual, as male trichostrongylid nematodes generally tend to have fewer cuticular ridges than females. Although the females are longer than the males, there is little difference in their widths, and often the females are thinner than the males. The length of the oesophagus and the position of the deirids, nerve-rings and excretory pores in relation to the anterior ends also differ little between the sexes, and this may explain the similarity in the numbers of cuticular ridges. The anterior synlophe is closest to that of *Ostertagia mossi* Skrjabin, 1929, as illustrated by Hoberg, Lichtenfels & Pilitt (1993) and Lichtenfels & Hoberg (1993), and consists of three parallel lateral ridges with adjacent parallel synlophe.

We concur with Gibbons (1981) that *O. thalae (sensu stricto)* belongs to the genus *Longistrongylus*, and that it closely resembles *Longistrongylus banagiense* (Gibbons, 1972) Gibbons 1977. *L. thalae* may be distinguished from *L. banagiense* by its longer oesophagus and spicules, the presence of a telamon and by having more cuticular ridges in the synlophe of the mid-body.

Acknowledgements

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HAEMONCHUS HORAKI N. SP. (NEMATODA: TRICHOSTRONGYLOIDEA) FROM THE GREY RHEBUCK *PELEA CAPREOLUS* IN SOUTH AFRICA

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ABSTRACT: In the course of a revision of species of *Haemonchus* Cobb, 1898 (Nematoda), commonly referred to as large stomach worms and significant pathogens of ruminants, a new species was discovered in the grey rhebuck *Pelea capreolus,* and the bontebok *Damaliscus pygarthus,* in South Africa. The new species, *Haemonchus horaki,* was previously reported as a long-spicule form of *H. contortus* (Rudolphi, 1803) Ransom, 1911. The new species, compared with *H. contortus,* can be distinguished by significantly longer spicules (555–615 μm vs. 383–475 μm); a synlophe with fewer ridges (26 vs. 30 in the region of the posterior part of the esophagus) that extend more posteriorly (within 1 mm of the copulatory bursa in males and postvulvar in females, vs. 2/3 to 3/4 of prebursal and prevulvar lengths); and an asymmetrical dorsal lobe with a long dorsal ray divided for more than half of its length, forming 2 branches of unequal length (vs. a dorsal ray divided for less than half of its length and forming 2 equal branches in *H. contortus*).

Nematodes in *Haemonchus* Cobb, 1898, commonly referred to as large stomach worms, are significant pathogens of ruminants. They are among the most economically important parasites of cattle, sheep, and goats, causing significant production losses due to morbidity, mortality, cost of treatment, and suboptimal use of contaminated pastures (Gibbs and Herd, 1986). State-of-the-art descriptions, using the most sensitive characters for identification of species (the pattern of surface cuticular ridges, the synlophe), are available only for 3 species of *Haemonchus* that occur in North America. A phylogenetic classification of the 10 species of the genus is lacking. Modern descriptions of the remaining species and a predictive classification of the species of *Haemonchus* would greatly improve the diagnosis and prospects for controlling these nematode pathogens worldwide.

The synlophe (Desset, 1964) is the system of cuticular ridges distributed longitudinally on the surface of most nematodes in the Trichostrongyloidea. The synlophe has been used by Durette-Desset (1983) to classify genera and higher taxa of the Trichostrongyloidea. The number and pattern of ridges on the anterior half of the nematode also has been found to be the most sensitive and useful character for identifying species of many genera of Trichostrongyloidea (Lichtenfels, 1977, 1983; Measures and Anderson, 1983; Lichtenfels and Hoberg, 1993; Lichtenfels et al., 1994, 1997). In a revision of *Haemonchus,* Gibbons (1979) included midbody cross-sections of most species showing the number of ridges in that region of the body. Lichtenfels et al. (1986) have shown that the pattern of distribution of the ridges could be used to identify species of *Haemonchus.* Lichtenfels et al. (1994) found that *Haemonchus contortus* (Rudolphi, 1803) Ransom, 1911 has a synlophe of 30 ridges in the region of the posterior esophagus compared with 34 ridges in that region in both *H. placei* (Place, 1893) Ransom, 1911 and *H. similis* Travassos, 1914. Subsequently, Lichtenfels and Pilitt (2000) reported that a common synlophe pattern was found within several genera of the Haemonchinae, including *Ashworthius* Le Roux, 1930, *Mecistocirrus* Railliet & Henry, 1912, and *Haemonchus.* In addition, they identified specific areas of the pattern where variations among taxa were found. They suggested that differences among synlophe patterns would provide sensitive characters for evaluating or reevaluating the specific status of populations of large stomach worms, and that similarities among patterns would provide information for recognizing relationships among species and developing predictive classifications for these economically important nematode pathogens of ruminants.

A study of all available species of *Haemonchus* was undertaken to provide a further assessment of the synlophe and its usefulness for distinguishing among species and determining relationships within the genus. In the course of this study we discovered a new species of *Haemonchus.* The objective of the present paper is to present a description of the new species, previously reported (Horak et al., 1982; Boomker et al., 1983; Boomker and Horak, 1992) as a long-spicule form of *H. contortus.*

MATERIALS AND METHODS

Specimens measured included 2 lots each including 5 males and 5 females from 2 individual grey rhebuck *Pelea capreolus* (Forster, 1790) collected in the Bontebok National Park, Swellendam, Western Cape Province, South Africa, during December 1979 and the summer of 1990.

Nematodes were cleared in phenol–alcohol (80 parts melted phenol crystals and 20 parts absolute ethanol) for study in temporary wet mounts on glass microscope slides. Interference-contrast light microscopy was used to study the synlophe and other characters at a magnification of ×200–400. Some specimens were examined as temporary mounts in lactoglycerol to study the genital cone and bursa. A few specimens were dissected in Berlese's fluid, forming permanent mounts to study the spicules and gubernaculum. Cross-sections were studied as freehand cuts made with a cataract knife and mounted in glycerine jelly. Drawings of the synlophe patterns were prepared freehand. Drawings of characteristics of males were prepared with the aid of a camera lucida. Photomicrographs were obtained either with 35-mm cameras using Kodak T-max 100 black and white film or Kodak Ektachrome 100 or with a Jenoptik ProgRes 3012 digital camera. Selected images on film were digitized with a Nikon Cool Scan III. Photomicrographs were prepared for presentation in Microsoft Powerpoint. Measurements were made with a calibrated ocular micrometer. Nematode taxa above genus level follow the system of the *CIH Keys to Nematode Parasites of Vertebrates, No. 10* (Durette-Desset, 1983).

Terminology for the ridges of the synlophe follows Lichtenfels et al. (1994) and Lichtenfels and Pilitt (2000). Terminology for ovejectors follows Veglia (1915) in recognizing 3 parts of the ovejectors of

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Haemonchus. Veglia used the name pars haustrix for the long, slightly funnel-shaped part that communicates at its broad end with the uterus. The modern term for the pars haustrix is the universally adopted infundibulum (Chitwood and Chitwood, 1950). Veglia used the name pars ejectrix for the 2-part (sphincter and cylindrical or barrel-shaped part) second section of the ovejector of *H. contortus.* The proximal end (pars ejectrix 1), or sphincter, surrounds the distal end of the infundibulum. Both the sphincter and the cylindrical part (pars ejectrix 2) are covered with a thick layer of muscle with spiraling continuous fibers (Veglia, 1915) that clearly define it as a single structure demarcated at both ends (Fig. 26). Unfortunately, the only modern term used for the entire pars ejectrix is sphincter (Chitwood and Chitwood, 1950), and in some trichostrongyloid nematodes the cylindrical part (pars ejectrix 2) is reduced and the demarcation between the pars ejectrix and the vestibule is not distinct. This has led many workers to restrict the term sphincter to pars ejectrix 1, and to include pars ejectrix 2 with the vestibule, even in nematodes such as *Haemonchus* spp. in which the unity of pars ejectrix 1 and 2 and its separation from the vestibule is obvious. The muscular unpaired part of the ovejector that joins the anterior and posterior parts with the vagina was identified as a vestibule by Veglia (1915) and this term is universally accepted. The vestibule is clearly delimited from the cylindrical portion (= pars ejectrix 2) of the sphincter (sensu lato) in species of *Haemonchus,* but it is not in some other trichostrongyloids. We use the term infundibulum for pars haustrix, sphincter for both parts of pars ejectrix, and vestibule for the unpaired part as described by Veglia (1915).

DESCRIPTION

Haemonchus horaki n. sp.

(Figs. 1–26)

With characters of *Haemonchus.* Synlophe extends posteriorly over almost the entire body. Synlophe consists of 26 ridges through most of the length of the esophagus (Figs. 1–8). Ridges divided, for the purpose of discussion and comparison, into lateral fields of 4 on each side and dorsal and ventral fields of 9 roughly parallel ridges each. Ridges of the synlophe distinctly larger laterally than dorsally or ventrally (Figs. 7, 8). Ridges in the lateral field consist of 2 lateral ridges adjacent and parallel to the lateral line and 2 sublateral ridges, 1 dorsal and 1 ventral and parallel to the lateral ridges. One ventral ridge in line with excretory pore. Ridges of dorsal field arranged in similar pattern as those in ventral field. About 0.5 to 1.5 mm posterior to junction of esophagus and intestine, sublateral ridges on each side end, usually irregularly (Figs. 1–6) reducing number of ridges to 22 (Figs 2, 4, 5, and 8). About 10 to 16 mm posterior to ends of sublateral ridges (shorter distances in smaller males) lateral-most ridges of ventral and dorsal fields on each side end irregularly next to lateral ridges, reducing number of ridges to 18 (Fig. 6).

Male (on the basis of 10 specimens, 5 from each of 2 hosts): Body length 18.0–20.5 (19.2) mm. Esophagus length 1.51–1.71 (1.62) mm; 7.8–8.8 (8.5) % of body length. Anterior end to: nerve ring 315–380 (354); excretory pore 350–430 (388) (Fig. 11); cervical papillae 430–545 (484) (Fig. 10); subventral esophageal gland duct orifices (SVGO) 510–615 (564) (Fig. 11). Spicule length 555–615 (587); each with single lateral barb near distal tip (Figs. 13, 15, 20), right barb 45–60 (52) from tip, left barb 25–35 (32) from tip. Gubernaculum 300–335 (322) long (Figs. 17, 21), spindle-shaped in dorsal view, but with dorsal curve when viewed laterally (Fig. 17). Dorsal ray relatively long 235–260 (245), divided for more than half its length (Figs. 14, 18); slightly asymmetrical, right branch 140–200 (160) long, left branch 110–170 (135) long. Genital cone with single ventral "0" papilla (Figs 16, 19), paired lateral, rounded genital appendages (Figs. 13, 16, 19), and paired dorsal "7" papillae (Figs. 13, 16, 19). Synlophe ends distally within 1.0 mm of copulatory bursa.

Female (on the basis of 10 specimens, 5 from each of 2 hosts): Body length 21.2–31.1 (26.6) mm. Esophagus length 1.59–1.88 (1.75) mm, 5.9–7.5 (6.6) % of body length. Anterior end to: nerve ring 220–335 (290); excretory pore 240–385 (321); cervical papillae 300–480 (392); SVGO 475–600 (541). Vulva with protruding lips (Fig. 26), with or without knobs or vulval flap or lobe (Fig. 26); located posteriorly 82–87 (85) % of body length. Vagina length 140–235 (200). Ovejector (Figs. 25, 26) well-developed posteriorly and anteriorly, consisting of distinct parts (lengths): vestibule 215–265 (234); anterior sphincter 215–335 (252); anterior infundibulum 335–505 (438); posterior sphincter 198–410 (263); posterior infundibulum 215–515 (394). Eggs in uterus 75–85 (80) by 45–52 (48) (Fig. 23). Perivulval pore on surface of cuticle, dorsolaterally on each side in region of posterior infundibulum. Tail tapers gradually 450–670 (578) long (Fig. 24); phasmids dorsolaterally 127–235 (200) from tip. Synlophe ends posteriorly within 1.0 mm of anus.

Taxonomic summary

Type host: Grey rhebuck, *Pelea capreolus* (Forster, 1790) (Artiodactyla: Bovidae).

Site of infection: Abomasum.

Type locality: Bontebok National Park, Swellendam, Western Cape Province, Republic of South Africa (20°30′E, 34°03′S) (collected December 1979).

Prevalence and intensity: 11 of 25 *Pelea capreolus* infected; average 194 nematodes per host.

Specimens deposited: From type host and type locality: The National Collection of Animal Helminths, South Africa (holotype, no. T2182; allotype, no. T2183; paratypes, no. T2157, 14 males and 14 females and T2158, 5 males and 5 females; U.S. National Parasite Collection, Beltsville, Maryland 20705-2350, USA (paratypes, no. 70277); specimens from *Damaliscus pygarthus* from the type locality described by Boomker et al. (1983) have been lost.

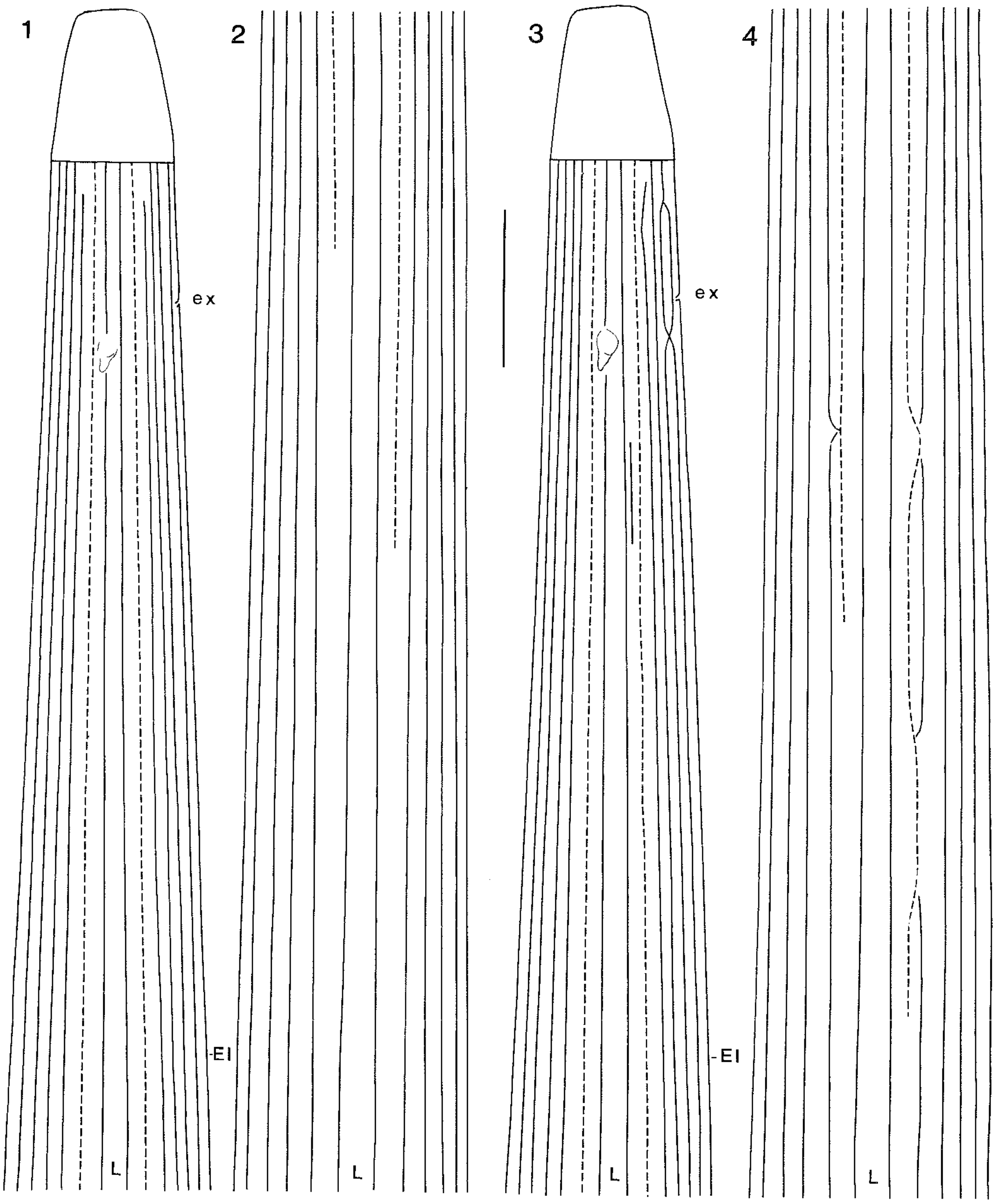
Etymology: The species is named in honor of Professor Ivan G. Horak, University of Pretoria, who first collected the nematode and recognized it as different from *H. contortus* because of its long spicules.

Diagnosis

The new species, *H. horaki,* is one of 5 species that have a synlophe of 30 or fewer ridges in the region of the posterior half of the esophagus that extends posteriorly over most of the body (J. R. Lichtenfels, pers. obs.). Included with *H. horaki* n. sp. in this group are *H. contortus, H. lawrenci* Sandground, 1933, *H. krugeri* Ortlepp, 1964, *H. dinniki* Sachs, Gibbons and Lweno, 1973. In only 3 species, *H. horaki, H. krugeri,* and *H. dinniki,* does the synlophe extend within 1 mm of the bursa in the males and postvulvarly to within 1 mm of the anus in the females. Among these 5 species, only *H. horaki* and *H. contortus* are significantly longer than 10 mm in length and have spicules significantly longer than 400 μm. The 3 remaining species, *H. lawrenci, H. krugeri,* and *H. dinniki,* are small, about 10 mm in length, with spicules under 400 μm in length or shorter. The new species can be distinguished further from *H. lawrenci, H. krugeri,* and *H. dinniki* by the symmetrical arrangement of the distal barbs on the spicules of those species. The new species can be separated further from *H. contortus* by its significantly longer spicules (555–615 in *H. horaki* and 383–475 in *H. contortus*) and its synlophe with fewer ridges (26 in the region of the posterior part of the esophagus in *H. horaki* and 30 in *H. contortus*) that extend more posteriorly (within 1 mm of the copulatory bursa in males and postvulvar in females of *H. horaki* compared with 2/3 to 3/4 of prebursal and prevulvar lengths in *H. contortus*). All the remaining species of *Haemonchus* have synlophes consisting of 34 or more ridges (Lichtenfels et al., 1994; J. R. Lichtenfels, pers. obs.). The ridges present in *H. contortus* but absent in *H. horaki* are the shorter of the paired sublateral ridges that begin near the level of the cervical papillae in *H. contortus* (dashed lines, Fig. 4 in Lichtenfels et al., 1994). The ridges present in *H. placei* (and all species with 34 or more ridges) but absent in both *H. horaki* and *H. contortus* are the subventral and subdorsal ridges that begin near the level of the middle of the esophagus in *H. placei* (dot-dash lines, Fig. 5 in Lichtenfels et al., 1994).

DISCUSSION

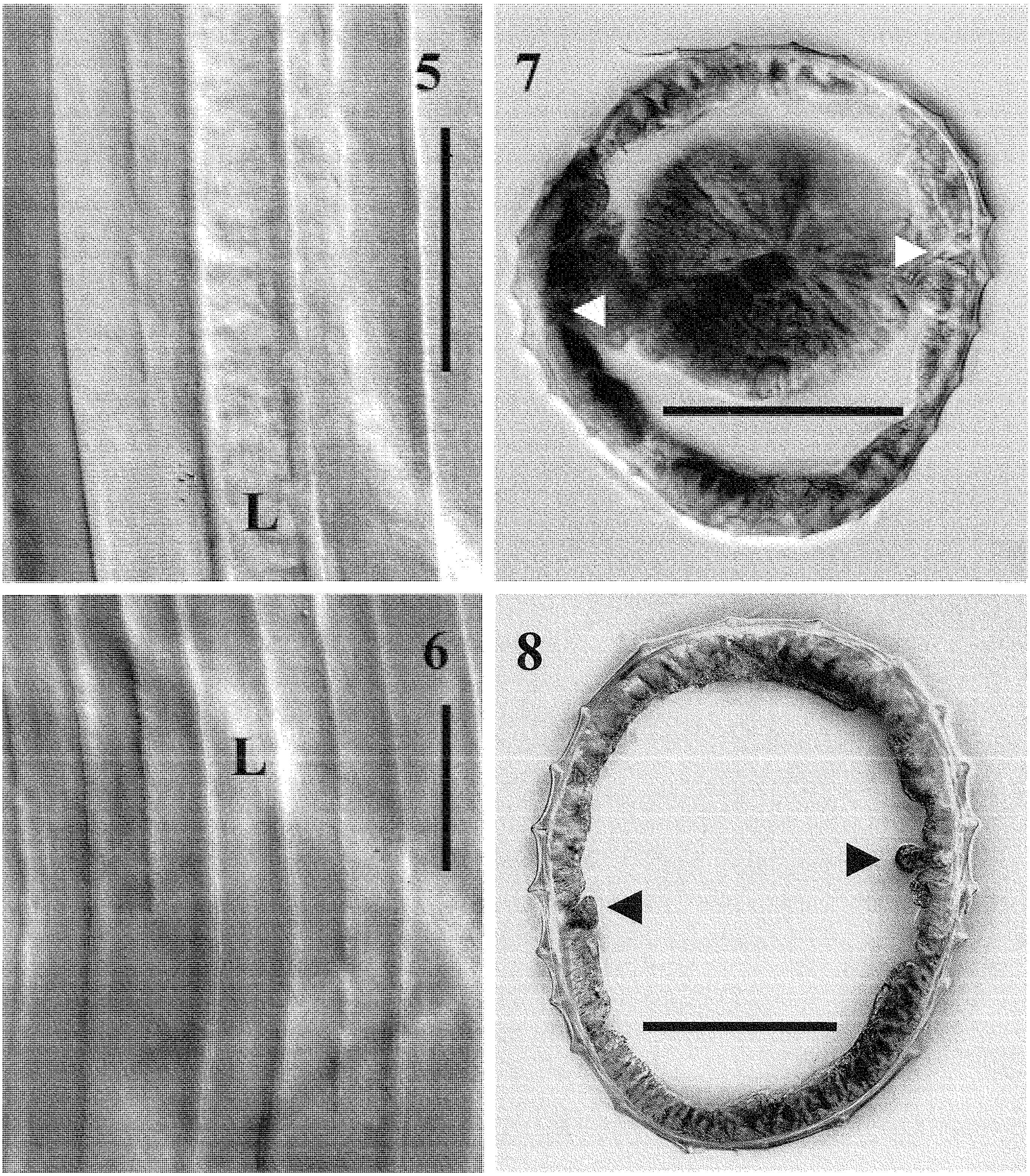
The long-spicule form of *H. contortus* described by Boomker et al. (1983) was recognized as unique initially because of its long spicules. However, because *H. placei* was considered by many (Gibbons, 1979) to be a synonym of *H. contortus,* there was a continuous range of spicule lengths for *H. contortus* of Gibbons (1979). After the discovery of synlophe differences (Lichtenfels et al., 1986; Lichtenfels et al., 1994) between *H.*



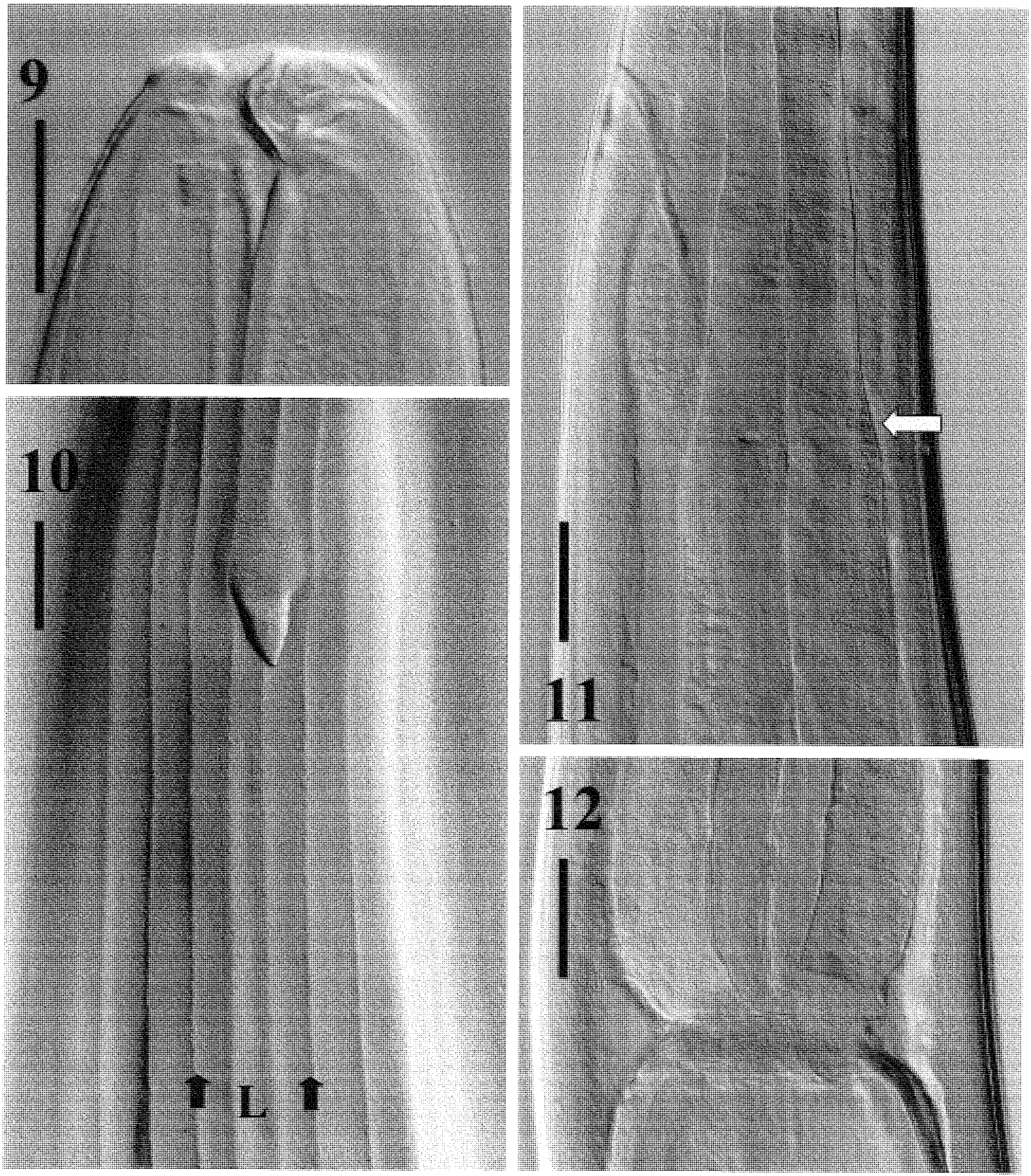
FIGURES 1–4. *Haemonchus horaki* n. sp., diagrammatic drawings of the synlophe, right lateral views (dashed lines = sublateral ridges; ex =excretory pore; EI = esophageal–intestinal junction; L = lateral). Scale bar 250 μm. **1.** Anterior end through region of the esophagus showing a typical pattern of 26 ridges. **2.** Postesophageal region (continuous with Figure 1) showing posterior ends of sublateral ridges of right side. Two additional sublateral ridges end on the left side. **3.** Anterior end through region of esophagus showing examples of variations in the synlophe that occur in this and related species. Note crossover and anastomosing of ridges near excretory pore and short extra ridge between lateral and sublateral ridges. **4.** Postesophageal region (continuous with previous figure) showing crossovers, anastomoses, and gaps in sublateral and adjacent ridges that occur in some specimens.

contortus and *H. placei,* the portion of the range of spicule lengths attributable to *H. placei* could be recognized (Lichtenfels et al., 1988). It then became increasingly apparent (Boomker and Horak, 1992) that the long-spicule form of *Haemonchus* reported by Boomker et al. (1983) was probably not *H. contortus*. The information on the synlophe provided by Lichtenfels et al. (1994) was sufficient to distinguish *H. horaki* from *H. placei,* which has 8 more ridges than the 26 of *H. horaki*, and those of *H. placei* are confined to the anterior half of the body in both sexes. Two additional species, *H. mitchelli* Le Roux, 1929 and *H. longistipes* Railliet and Henry, 1909, have long spicules that overlap the range of those of *H. horaki* sp. n. However, both *H. longistipes* and *H. mitchelli* have 34 or more ridges in synlophes confined to the anterior half of the body (J. R. Lichtenfels, pers. obs.).

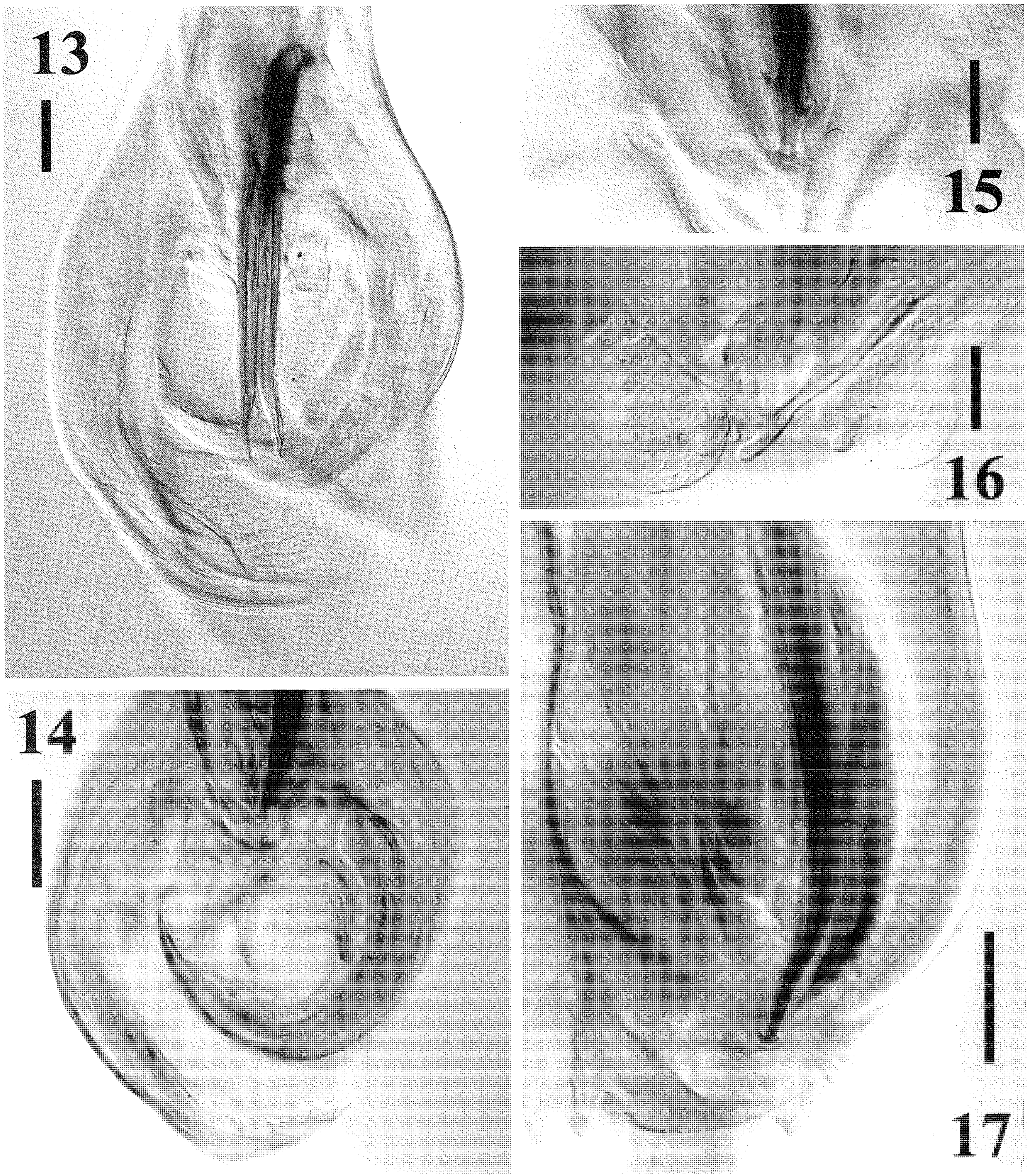
The discovery that in some species of *Haemonchus* the synlophe extends for most of the length of the body, whereas in others it is confined to the anterior half, is paralleled by a similar discovery (E. P. Hoberg, pers. obs.) in an undescribed species of *Ashworthius*. Lichtenfels et al. (2000) have shown that the synlophe patterns among these genera and *Mecistocirrus* of the Haemonchinae are highly conserved, but variable regions



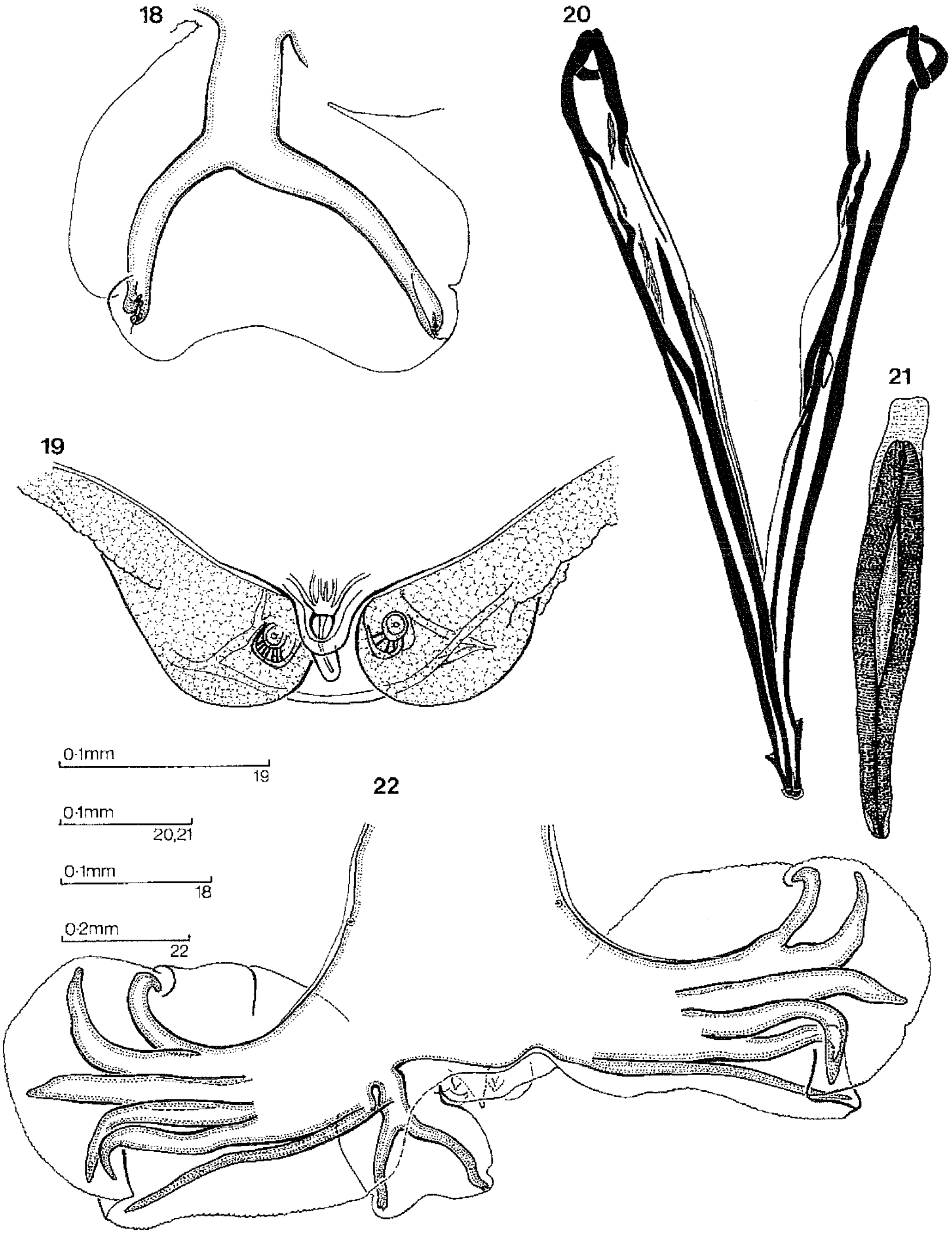
FIGURES 5–8. *Haemonchus horaki* n. sp., photomicrographs of characteristics of the synlophe. Scale bars 100 μm. **5.** Lateral synlophe, 3 mm from anterior end, showing posterior ends of sublateral ridges adjacent to lateral ridges (L = lateral). **6.** Posterior lateral synlophe, about 15 mm from anterior end, showing posterior ends of a pair of ridges adjacent to the lateral ridges (L = lateral). **7.** Cross-section through posterior portion of the esophagus of a male showing 26 cuticular ridges (arrowheads mark lateral). **8.** Cross-section at about midbody of a male showing 22 cuticular ridges (arrowheads mark lateral).



FIGURES 9–12. *Haemonchus horaki* n. sp., photomicrographs of head and esophageal region. **9.** Head, left lateral view showing large dorsal tooth. Scale bar 25 μm. **10.** Surface view of left lateral cervical papilla and synlophe (L = lateral; arrows mark sublateral ridges). Scale bar 50 μm. **11.** Excretory pore and esophagus, left lateral view, arrow at level at which ducts of subventral esophageal glands empty into lumen of esophagus and esophagus narrows anteriorly. Scale bar 50 μm. **12.** Esophageal–intestinal junction, right lateral view. Scale bar 50 μm.



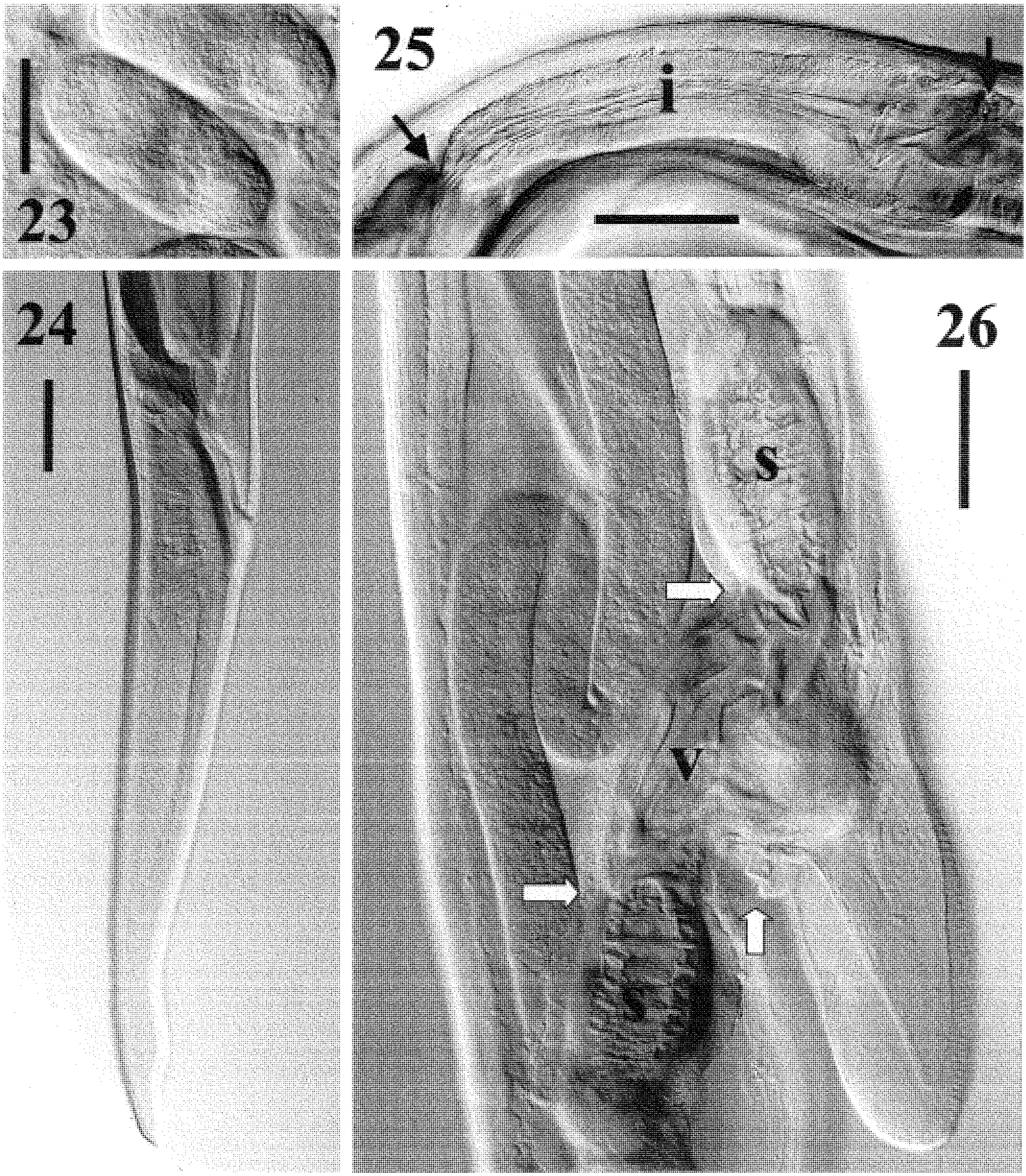
FIGURES 13–17. *Haemonchus horaki* n. sp., photomicrographs of male characteristics. **13.** Copulatory bursa and spicules, ventral view. Scale bar 100 μm. **14.** Dorsal ray of copulatory bursa, ventral view. Scale bar 100 μm. **15.** Distal tips of spicules, ventral view, showing barbs. Scale bar 50 μm. **16.** Genital cone, ventral view, showing single ventral "0" papilla, pair of dorsal "7" papillae, and lateral rounded genital appendages. Scale bar 50 μm. **17.** Genital cone, left lateral view, showing distal ends of spicules, gubernaculum, and papillae of genital cone. Scale bar 100 μm.



FIGURES 18–22. *Haemonchus horaki* n. sp., line drawings of male characteristics. **18.** Dorsal lobe and ray of copulatory bursa, ventral view. **19.** Genital cone, ventral view showing the ventral "0" papilla, lateral genital appendages, and the dorsal "7" papillae. **20.** Spicules dissected out of tissues, dorsal view. **21.** Gubernaculum dissected out of tissues, dorsoventral view. **22.** Copulatory bursa, dorsal view.

of the patterns were identified (Lichtenfels et al., 1994) among 3 species of *Haemonchus* and more recently among groups of species (J. R. Lichtenfels, pers. obs.) within *Haemonchus.* Thus, the preliminary data suggest that the synlophe has great potential also for understanding phylogenetic relationships within the Haemonchinae, although such studies and a key to the species of *Haemonchus* are beyond the scope of the present paper.

This nematode has been reported in 3 previous publications. Horak et al. (1982) reported *H. contortus* with exceptionally long spicules from *P. capreolus* and *D. pygarthus,* and Boomker et al. (1983) described this nematode from these hosts as *H. contortus.* In a later survey, Boomker and Horak (1992) found 11 of 25 *P. capreolus* to be infected with the long-spicule form of *H. contortus* and failed to find it in 16 *D. pygarthus,* the only other host from which this nematode had been reported (from a single animal). On the basis of these observations, Boomker and Horak (1992) suggested that the primary host of this nematode is *P. capreolus* and that *D. pygarthus* is not a normal host. Typical *H. contortus* occurs in other hosts such as *Redunca redunca* (Pallas, 1767)



FIGURES 23–26. *Haemonchus horaki* n. sp., photomicrographs of female characteristics. **23.** Uterine eggs. Scale bar 50 μm. **24.** Tail, right lateral view. Scale bar 100 μm. **25.** Anterior infundibulum (i) of ovejector. Arrows mark junctions, to the left with the anterior sphincter of the ovejector and to the right with the uterus. Scale bar 100 μm. **26.** Vulva (vertical arrow), vestibule (V), and sphincters of ovejector, right lateral view. (Horizontal arrows mark junctions of vestibule with sphincters.) Scale bar 100 μm.

in the same grazing area and must be considered to be sympatric with the new species.

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Onderstepoort Journal of Veterinary Research, 70:37–41 (2003)

Parasites of South African wildlife. XVII. *Ostertagia triquetra* n. sp. (Nematoda: Trichostrongylina) from the grey rhebuck, *Pelea capreolus* (Forster, 1790)

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ABSTRACT

BOOMKER, J. & DURETTE-DESSET, M-C. 2003. Parasites of South African wildlife. XVII. *Ostertagia triquetra* n. sp. (Nematoda: Trichostrongylina) from the grey rhebuck, *Pelea capreolus* (Forster, 1790). *Onderstepoort Journal of Veterinary Research*, 70:37–41

Re-examination of *Teladorsagia hamata* (Mönnig, 1932) Durette-Desset, 1989 reported from grey rhebuck, *Pelea capreolus* (Forster, 1790) proved it to be a new species of *Ostertagia* Ransom, 1907. The new species, for which the name *Ostertagia triquetra* n. sp. is proposed, differs from *Teladorsagia hamata* in the configuration of the bursal rays (2-1-2 in the former, 2-2-1 in the latter), and in that the interno-dorsal branch of the spicules bears a process that is triangular and convex in the new species, but concave and shaped like an ice-cream scoop in *Teladorsagia hamata*.

Ostertagia triquetra has so far been found only in grey rhebuck in the Eastern Cape Province while *Teladorsagia hamata* was recorded from springbok, *Antidorcas marsupialis* (Zimmerman, 1780) and gemsbok, *Oryx gazella* (Linnaeus, 1758) in the western part of the country.

Keywords: Nematoda, *Ostertagia triquetra*, *Pelea capreolus*

INTRODUCTION

Horak, De Vos & De Klerk (1982), Boomker (1990) and Boomker & Horak (1992) recorded *Teladorsagia hamata* (Mönnig, 1932) Durette-Desset, 1989 from grey rhebuck, *Pelea capreolus* (Forster, 1790) in the Bontebok National Park, Eastern Cape Province. Subsequent re-examination of the material, however, proved it to be a new species of *Ostertagia* Ransom, 1907. The new species, for which the name *Ostertagia triquetra* n. sp. is proposed, is described here and compared to *Teladorsagia hamata*, which it closely resembles as regards the principal measurements and the configuration of the spicules.

MATERIALS AND METHODS

Specimens were initially examined in water and, when necessary, cleared in lactophenol or phenol-alcohol. Temporary *en face* preparations and cross-sections of the mid-body of male and female specimens were made and mounted in lactophenol. The spicules were dissected out of several males and also examined in lactophenol. All drawings were made with a compound microscope and a drawing tube, and measurements were derived from these drawings. The nomenclature of the bursal rays used here is that of Durette-Desset & Chabaud (1981).

No specimens of *Teladorsagia hamata* were available for study and the measurements provided in Table 1 are those of Mönnig (1932).

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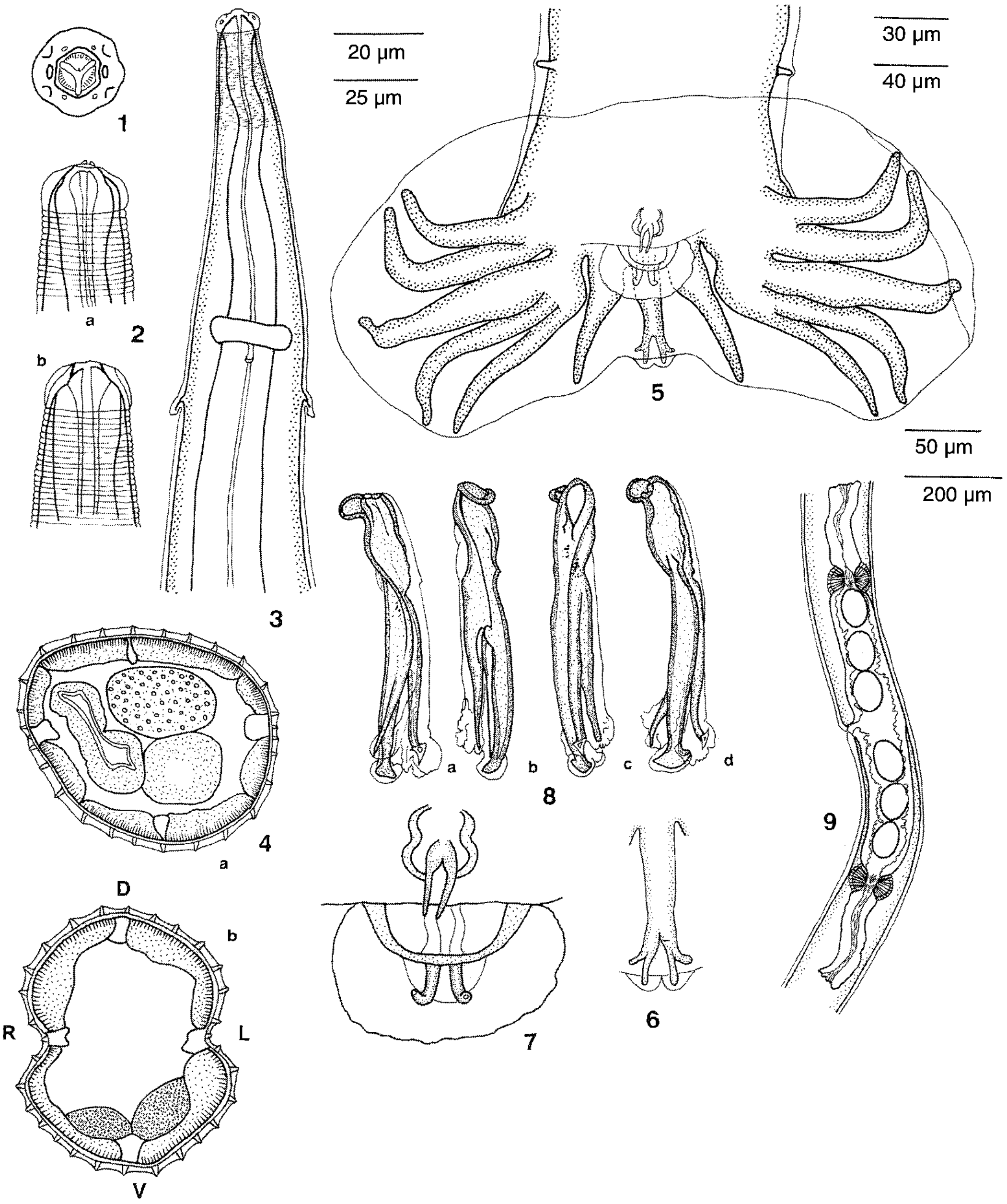

FIG. 1–9 ***Ostertagia triquetra*** **n. sp.**

FIG. 1 En face view of the head. Scale bar: 25 µm

FIG. 2 Ventral (a) and lateral (b) views of the head. Scale bar: 25 µm

FIG. 3 Dorsal view of the anterior part of a female. Scale bar: 50 µm

FIG. 4 Cross-section at mid-body of (a) a female and (b) a male; L—left, R—right, D—dorsal and V—ventral aspect of the body. Orientation of (a) is the same as that of (b). Scale bar: 30 µm

FIG. 5 Male bursa, ventral view. Scale bar: 40 µm

FIG. 6 Dorsal ray, showing the membranous extensions of the dorsal lobe. Scale bar: 25 µm

FIG. 7 Composite drawing of the genital cone and accessory bursal membrane, ventral view. Scale bar: 20 µm

FIG. 8 The right spicule in (a) ventromedian and (d) median views, showing the internoventral branch to the left and the internodorsal branch to the right in the latter figure. The ventral and dorsal aspect of the left spicule are illustrated in (b) and (c), respectively. Scale bar: 50 µm

FIG. 9 Left lateral view of the vulvar region and ovejector. Scale bar: 200 µm

DESCRIPTION OF *OSTERTAGIA TRIQUETRA* n. sp.

Synonymy

Ostertagia hamata sensu Horak, De Vos & De Klerk (1982), Boomker (1990) and Boomker & Horak (1992) *nec* Mönnig, 1932.

Type host

Pelea capreolus (Forster, 1790), from the Bontebok National Park, Swellendam, South Africa.

Material examined

Holotype male, allotype female, eight male and four female paratypes, all housed in the collection of the Muséum National d'Histoire Naturelle (MNHN), Paris, France, No. MNHN 431 MD; additional material from several grey rhebuck, 20 males and 20 females.

Etymology

The species name is derived from the Latin meaning 'triangular' *a propos* the triangular tip of the interno-dorsal branch of the spicules.

Description

The principal measurements are listed in Table 1.

Small nematodes with a small cephalic vesicle. The mouth is hexagonal and without lips. The dorsal lobe of the oesophagus immediately below the buccal ring appears tooth-like and has a small canal. Four external labial and four cephalic papillae are present, and the amphids are comparatively large (Fig. 1). The cephalic vesicle is followed by an area of fine transverse striations (Fig. 2). The oesophagus is indistinctly divided into an anterior muscular and a posterior glandular part, the division being slightly behind the nerve ring (Fig. 3). The excretory pore is near the laterally situated deirids. On cross-section at the mid-body, the males have 25–30 longitudinal cuticular ridges and the females 28–34, the lateral three or four of which appear smaller than the rest. In some male specimens the dorsolateral and ventrolateral ridges are slightly curved towards the dorsal and ventral aspects of the body, respectively, while the dorsal and ventral ridges are perpendicular to the body surface (Fig. 4A). The lateral synlophe is illustrated in Fig. 10.

MALES: The bursa has two large lateral lobes and a smaller dorsal lobe, which is indistinctly demarcated (Fig. 5). In some specimens the bursa is somewhat asymmetrical, the left lobe being slightly larger than the right one. The bursal rays have the 2-1-2 pattern. The pre-bursal papillae are large and easily visible; the tips of rays 2 and 3 are close to each other and both reach the bursal margin. Rays 4–6 have a common origin; ray 4 is thick, and its tip is some distance from rays 5 and 6 and also from the bursal margin; it curves toward rays two and three. Rays 5 and 6 become progressively thinner; they are close together with converging tips, the latter being near the bursal margin; both curve towards ray 8, which is relatively thick. The dorsal ray is short and bifurcates in the distal quarter, each branch in turn dividing into ray 9, which is small and papilla-like, and ray 10, which is undivided. The tip of ray 10 is enclosed in what appears to be membranous extensions of the dorsal lobe (Fig. 5 and 6). The genital cone is conspicuous and membranous, with fairly long ventral raylets. A large semicircular accessory bursal membrane with two slender dorsal raylets is present (Fig. 7).

The spicules are equal and well sclerotized. Each consists of a stout main "handle" and three branches. The externo-lateral branch bears ends in a shoe-like process and bears two branches of almost the same length. The shorter (interno-ventral) branch ends acutely, while the longer (interno-dorsal) branch is curved and bears a convex, triangular shoe. The tips of the two internal branches are covered by transparent membranes that extend cranially along the medial aspect of the spicules (Fig. 8). The 'ostertagiid' window is situated in the middle of the spicules. A lightly sclerotized gubernaculum, spoon-shaped in ventral view (Fig. 9), is present and it appears as if its rounded distal tip is fixed in or close to the cloacal opening.

FEMALES: The uterus is didelphic and situated in the posterior part of the body. The ovejector is slightly asymmetric in that the anterior part is often longer than the posterior part. The vulva is a slightly raised transverse slit and vulvar flaps are absent (Fig. 9). The tail is finely cross-striated and ends in an ovoid knob. The eggs are segmented when laid.

DISCUSSION

We consider the new species as belonging to the genus *Ostertagia* because the bursa is of the 2-1-2 type, the dorsal lobe and rays are reduced in length when compared to that of the genus *Marshallagia* Orloff, 1933, the tip of ray 4 curves towards rays 2 and 3, while rays 5 and 6 curve towards ray 8 and

TABLE 1 The principal measurements, in micrometres (µm), of *Ostertagia triquetra* n. sp. and *Teladorsagia hamata* (Mönnig, 1932)

Measurement	*Ostertagia triquetra* Males		*Ostertagia triquetra* Females		*Teladorsagia hamata* (After Mönnig 1932)	
	Holotype	Paratypes (*n* = 8)	Allotype	Paratypes (*n* = 4)	Males	Females
Length	8 159	7 847–9 197	10 490	10 420–11 275	6 600–7 850	8 090–11 020
Width	104	97–139	139	120–160	90–110	116
Length of cephalic vesicle	17	12–17	14	12–14	N	N
Width of cephalic vesicle	29	27–29	28	21–29	22–28	22–29
Extent of transverse striations behind head	70	64–80	65	52–64	N	N
Distance of deirids from anterior end	312	293–352	314	243–282	330–420	330–420
Distance of nerve ring from anterior end	249	216–279	233	191–213	240–290	240–290
Distance of excretory pore from anterior end	289	261–321	284	227–253	At deirids	At deirids
Length of muscular oesophagus	230	216–251	223	219–237	N	N
Length of glandular oesophagus	334	334–397	334	355–404	N	N
Total length of oesophagus	564	560–648	557	574–641	710–800	710–860
Ratio of oesoohagus length to body length	1:14.5	1:12.1–1:16.4	1:18.8	1:16.3–1:19.7	1:8.3–1:11.1	1:9.4–1:15.5
Length of left spicule	184	178–200	–	–	161–191	–
Length of right spicule	184	171–197	–	–	161–191	–
Length of gubernaculum	91	77–100	–	–	112	–
Length of tail	–	–	132	150–167	–	176–190
Distance of anus from vulva	–	–	1 680	1 686–1 928	–	1 130–1 584
Length of ovejector	–	–	1 069	951–1 055	–	150–230
Length of anterior infundibulum	–	–	219	180–215	–	N
Length of anterior sphincter	–	–	52	42–56	–	N
Length of anterior vestibulum	–	–	282	271–288	–	N
Length of posterior vestibulum	–	–	237	215–250	–	N
Length of posterior sphincter	–	–	42	42–49	–	N
Length of posterior infundibulum	–	–	237	194–229	–	N
Number of eggs, anterior part of uterus and ovejector	–	–	19	18	–	N
Number of eggs, posterior part of uterus and ovejector	–	–	18	13	–	N
Length of eggs	–	–	76	76–77	–	71
Width of eggs	–	–	44	44–46	–	39

– Not applicable
N Not given

the synlophe is of the *Ostertagia* type (Durette-Desset & Cabaret 1994). Furthermore, the spicules are ornamented and a gubernaculum is present. These characteristics conform to those given for the genus by Gibbons & Khalil (1982) and Durette-Desset (1989).

The males of *Ostertagia triquetra* can be differentiated from those of *Teladorsagia hamata* in the pattern of the bursal rays (2-1-2 in the former and 2-2-1 in the latter) and the tip of the interno-dorsal branch of the spicules, which is bent and has a convex, triangular process in the former species, while it is straight and concave, like a shallow ice-cream scoop, in the latter. Furthermore, the externodorsal rays of *Teladorsagia hamata* are longer than those of *Ostertagia triquetra*. The females of the two species closely resemble each other but can be separated on the synlophe and the larger size of *Ostertagia triquetra*. The oesophagus of *Teladorsagia hamata* is also longer than that of *Ostertagia triquetra* as indicated by the smaller ratio of the length of the oesophagus and the total body length.

In view of the morphological and host differences, we consider *Teladorsagia hamata sensu* Horak *et al.* (1982), Boomker (1990) and Boomker & Horak (1992) to be a distinct species for which the name *Ostertagia triquetra* n. sp. is proposed.

Horak (1981) and Boomker (1990) categorize the helminths of antelope into definitive, occasional, accidental and host-specific parasites. *Ostertagia triquetra* should be considered as a host-specific parasite, since it has been recorded only from *P. capreolus* and from this host only in the Bontebok National Park.

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Parasites of South African wildlife. XVIII. *Cooperia pigachei* n. sp. (Nematoda: Cooperiidae) from the mountain reedbuck, *Redunca fulvorufula* (Afzelius, 1815)

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ABSTRACT

BOOMKER, J. & TAYLOR, W.A. 2004. Parasites of South Africa wildlife. XVIII. *Cooperia pigachei* n. sp. (Nematoda: Cooperiidae) from the mountain reedbuck, *Redunca fulvorufula* (Afzelius, 1815). *Onderstepoort Journal of Veterinary Research*, 71:171–174

A new species of *Cooperia*, for which the name *Cooperia pigachei* n. sp. is proposed, was recovered from a mountain reedbuck, *Redunca fulvorufula*, from the Sterkfontein Dam Nature Reserve, Free State Province, and is described and illustrated. It is close to *Cooperia neitzi* Mönnig, 1932 and the South African race of *Cooperia rotundispiculum* in having more than 14 longitudinal cuticular ridges and in that the lateral cervical synlophe is of the closed type. The new species differs from all the other species of the genus in that the lateral branches of the dorsal ray are large and T-shaped. The spicules are robust, over 0.3 mm long and have large, curved shoes on their tips.

Keywords: *Cooperia pigachei*, mountain reedbuck, Nematoda, *Redunca fulvorufula*

INTRODUCTION

During a study on the ecology of antelope in the Sterkfontein Dam Nature Reserve, Free State Province, the helminth parasites of a number of mountain reedbuck, *Redunca fulvorufula*, and grey rhebuck, *Pelea capreolus*, were collected. The area falls within the Grassland Biome, specifically the Moist Cool Highveld Grassland type (Bredenkamp & Van Rooyen 1996). Rainfall varies from 600 to 900 mm per year and occurs in summer. Temperatures vary from –11 °C to 38 °C, with an average of 17 °C. This is mountain grassland, with the typical cool, wet Drakensberg montane climate and severe frost. Occasional snow and frequent burning have major influences on the vegetation.

The mountain reedbuck from which the worms were recovered was a large adult female that was lactating but not pregnant, and, as determined from the kidney fat index, she was in reasonable condition. She was culled on the eastern side of the dam in the Park and was the only mountain reedbuck out of the 41 examined from which the new *Cooperia* species was recovered.

MATERIALS AND METHODS

Specimens were initially examined in water and when deemed necessary, cleared in lactophenol or phenol alcohol. Temporary cross-sections of the mid-body of a female specimen were made and mounted in lactophenol. All drawings (Fig. 1) were made with a compound microscope and a drawing tube, and measurements made from the drawings. Measurements are given as holotype/allotype fol-

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lowed by the range of measurements of the paratypes (in parentheses). All are given in millimetres unless otherwise indicated.

The new species is placed in the family Cooperiidae, subfamily Cooperiinae according to the classification of Durette-Desset, Hugot, Darlu & Chabaud (1999).

RESULTS

Description

Males are 8.30 (8.23–8.93) long, and 0.202 (0.202–0.276) wide. The cephalic inflation is 0.143 (0.120–0.150) long and 0.051 (0.043–0.051) wide. The nerve ring was not seen in the holotype and was 0.253–0.332 from the anterior end in the paratype males. The excretory pore is 0.345 (0.366–0.406) and the minute deirids 0.363 (0.380–0.413) from the anterior end. The oesophagus is 0.552 (0.453–0.589) long.

The bursa has the typical appearance of the genus in that the short ray 2 is widely separated from the considerably longer ray 3. Rays 4 and 5 run parallel next to each other and have diverging tips, and the dorsal ray has a lyre-shaped appearance (Fig. 1A). The lateral branches of the dorsal ray arise at or just after the bifurcation of the main stem. These branches are unique within the genus in that they are quite robust and T-shaped (Fig. 1B). The spicules are virtually equal, the left one being 0.373 (0.340–0.396) long and the right one 0.368 (0.331–0.396). The tips of the spicules are large and enclosed in semi-transparent “shoes” (Fig. 1C). A gubernaculum is absent.

Females are 10.249 (8.353–11.249) long and 0.147 (0.120–0.207) wide. The cephalic inflation is 0.154 (0.076–0.161) long and 0.048 (0.041–0.083) wide. The nerve ring was not seen in the allotype but is situated 0.145–0.276 from the anterior end in the paratype females. The excretory pore and minute deirids are close together, 0.343 and 0.352 (0.251–0.465 and 0.265–0.478) from the anterior end, respectively. The oesophagus is 0.456 (0.336–0.465) long.

The vulva lies in the posterior third of the body, 7.698 (6.526–8.066) from the anterior end. Vulvar flaps are limited to the immediate vicinity of the vulva and are only slight expansions of the surrounding cuticular ridges of all individuals (Fig. 1D), except one, who has definitive flaps and several expanded cuticular ridges. The combined length of the opposed ovejectors, including the infundibula, sphincters and vestibule, is 1.370 (0.966–1.906). The tail is 0.159 (0.138–0.202) long. Eggs *in utero* measure 0.069–0.078 (0.074–0.097) long and 0.035–0.039 (0.037–0.055) wide.

On cross-section at the midbody, both the male and the female have seven dorsal and seven ventral ridges in addition to three lateral ridges on each side (Fig. 1D). The three lateral ridges are quite small. Ridges D1, D7, V1 and V7 are of similar size and slightly bigger than the lateral ones. The remaining dorsal and ventral ridges are large and more or less of equal size. All the ridges are perpendicular to the body surface.

In lateral view, the male cervical synlophe has 11 cuticular ridges (Fig. 1E) that are widely separated. The dorso- and ventro-lateral ridges (those bordering the minute lateral ridge) emerge close to each other a short distance behind the deirid. These then diverge slightly and run parallel over the length of the body. The lateral ridge starts a short distance behind the emergence of the dorso- and ventro-lateral ridges. Initially this field is hardly visible but soon becomes a distinct, solid band that runs for almost the entire length of the body. The lateral fields differ from the other fields in having a hyaline appearance and no ornamentation, whereas all the others have a tuberculated appearance brought about by underlying struts. As in many other species of the genus, the ridges extend from the base of the cervical inflation to the anterior part of the bursa in males and beyond the anus in females.

Type host

Mountain reedbuck, *Redunca fulvorufula* (Afzelius, 1815), from the Sterkfontein Dam Nature Reserve, (28°24'30 S; 28°58'25 E), eastern Free State Province, South Africa.

Material examined

Holotype male, allotype female, and four male and 13 female paratypes. The specimens have been deposited in the National Collection of Animal Helminths (formerly the Onderstepoort Helminthological Collection), Onderstepoort, access number T2185.

Etymology

The specific name is derived from the French for the long-toed, turned-up shoes, “pigaches”, worn during the Middle Ages.

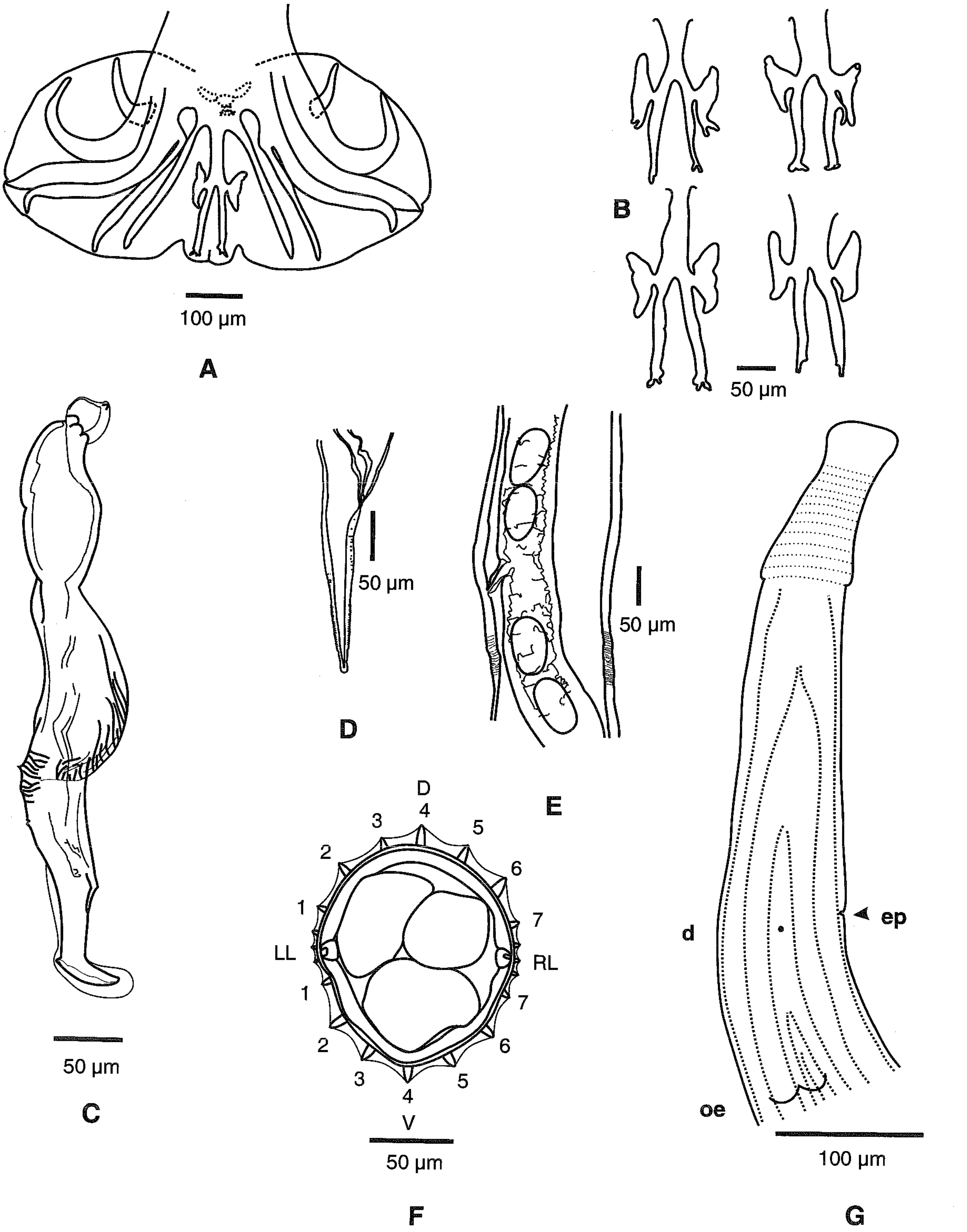

FIG. 1 *Cooperia pigachei.* A, dorsal view of the bursa; B, variations in the configuration of the dorsal ray; C, externo-lateral view of the right spicule; D, female tail, right lateral view; E, left lateral view of the vulval region of a female without flaps; F, schematic representation of a cross-section at mid-body of a female (D = dorsal, V = ventral, LL = left lateral and RL = right lateral); G, schematic representation of the lateral synlophe of a male (d = deirid, ep = excretory pore and oe = end of the oesophagus)

DISCUSSION

A large number of species of the genus *Cooperia* Ransom, 1907 occur in ruminants in Africa and these have been revised by Gibbons (1981). The majority of these species have 14 longitudinal cuticular ridges, five dorsal, five ventral, and two in each lateral field. Those with fewer ridges are *Cooperia chabaudi* Diaouré, 1964 that has 10 ridges and *Cooperia connochaeti* Boomker, Horak & Alves, 1979, that has 12 ridges of which the dorsal three are considerably smaller than the others. According to Gibbons (1981), *Cooperia neitzi* Mönnig, 1932 and *Cooperia verrucosa* Mönnig, 1932 have 19–20 ridges, 13 or 14 in the dorsal and ventral fields, and three in each lateral field. Hoberg, Lichtenfels & Pilitt (1993) state that at the midbody there are 20 ridges in male *C. neitzi* and 20–25 in females, and Boomker (1991) found *Cooperia rotundispiculum* to have 18–20 ridges. The male and female specimens examined in this study have 20 ridges, the arrangement of which is similar to that described for *C. neitzi*.

The cuticular inflations around the vulval area of the one specimen in which they were present are similar to that described by Hoberg *et al.* (1993) for *C. neitzi*. It is a prominent bilateral inflation, formed by hypertrophied ridges and reverts back to the pattern at midbody immediately following the posterior ovejector.

The cervical synlophe of *C. pigachei* is similar to that described for *C. neitzi*, *Cooperia punctata* and *Cooperia pectinata* (Lichtenfels 1977; Hoberg *et al.* 1993) in that it is of the converging or closed type. As is the case with *C. neitzi*, the minute lateral-most ridge of *C. pigachei* does not appear to be supported by struts, hence its hyaline appearance, while the remaining ridges are supported by struts giving them a striated or beaded appearance (Hoberg *et al.* 1993). From the illustrations provided by Hoberg *et al.* (1993) the lateral-most ridge of *C. neitzi* arises immediately posterior to the deirids, close to or at the junction of the oesophagus with the intestine, while the adjoining two (dorso- and ventro-lateral ridges) arise some distance in front of the deirid. In *C. pigachei* these three ridges arise quite a distance behind the deirids.

The configuration of the spicules of *C. pigachei* is near that of *Cooperia curticei* (Giles, 1892) Ransom, 1907, *Cooperia fuelleborni* Hung, 1926, *Cooperia hungi* (Mönnig, 1931) Mönnig, 1932, *Cooperia neitzi* Mönnig, 1932, *Cooperia pectinata* Ransom, 1907, *Cooperia rotundispiculum* Gibbons & Khalil, 1980 and the *Cooperia rotundispiculum* race described by Boomker (1991) in having large pectinate expansions more or less in the middle of each spicule. However, the new species differs from all of these by the presence of large curving "shoes" on the distal parts of the spicules. In addition, the dorsal ray is also unique among the *Cooperia* spp. in that it is the only species where the lateral branches of the dorsal ray are T-shaped.

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SETARIA SPECIES

Onderstepoort Journal of Veterinary Research, 67:229–234 (2000)

Studies on the genus *Setaria* Viborg, 1795 in South Africa. I. *Setaria africana* (Yeh, 1959)

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ABSTRACT

WATERMEYER, R., BOOMKER, J. & PUTTERILL, J.F. 2000. Studies on the genus *Setaria* Viborg, 1795 in South Africa. I. *Setaria africana* (Yeh, 1959). *Onderstepoort Journal of Veterinary Research*, 67:229–234

Setaria africana (Yeh, 1959) is represented by two subspecies, *Setaria africana africana* Troncy, Graber & Thal, 1976 from giant eland (*Taurotragus derbianus*) from the Central African Republic and Cameroon and *Setaria africana farchai* Troncy, Graber & Thal, 1976 from bushbuck (*Tragelaphus scriptus*), also from the Central African Republic. Material collected from nyala (*Tragelaphus angasii*), bushbuck and kudu (*Tragelaphus strepsiceros*) from several localities in the eastern region of South Africa was re-examined. Measurements of adult worms confirmed the differences between the two subspecies and scanning electron microscopy showed that the deirids of *S. africana africana* are single whereas those of *S. africana farchai* are double. *Setaria africana farchai* is recorded for the first time in South Africa.

Keywords: Helminth parasites, *Setaria africana, Setaria africana farchai,* South African wildlife

INTRODUCTION

The genus *Setaria* Viborg, 1795 is wide-spread and in Africa it occurs in equids, suids, hyracoids and ruminants (Round 1968). Yeh (1959) divided the genus *Setaria* into the genera *Setaria*, *Hyraconema* and *Artionema*, and described *Artionema africana* from, amongst others, nyala (*Tragelaphus angasii*) from KwaZulu-Natal. However, Nelson (1962) and Round (1968) did not accept this division. Ortlepp (1964) also rejected the genus *Artionema* and placed *Artionema hartwichi* Yeh, 1959 and *Artionema africana* Yeh, 1959 in the genus *Setaria.* Chabaud (1965) and Desset (1966) treated Yeh's (1959) divisions as subgenera while Anderson & Bain (1976) consider *Hyraconema* and *Artionema* as synonyms of *Setaria.*

During several surveys of the helminth parasites of South African wildlife, many specimens of the genus *Setaria* were collected from a variety of hosts, including kudu (*Tragelaphus strepsiceros*), nyala and bushbuck (*Tragelaphus scriptus*) (Boomker, Keep, Flamand & Horak 1984; Boomker, Horak & De Vos 1989; Boomker, Horak & Flamand 1991). *Setaria africana* was recovered from bushbuck, but the specimens from kudu and nyala were identified to the genus level only (Boomker *et al.* 1984, 1989, 1991). Ortlepp (1961) recorded the presence of *S. africana* in kudu and bushbuck and Troncy, Graber & Thal (1976) described *Setaria africana africana* and *Setaria africana farchai* from the abdominal cavities of the giant eland (*Taurotragus derbianus*) and bushbuck, respectively. The material from the South African hosts was re-examined, and the scanning electron microscopic appearance together with the measurements of the two subspecies of *S. africana* are presented here and compared with the findings of Yeh (1959) and Troncy *et al.* (1976).

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MATERIALS AND METHODS

The specimens originated from the helminthological collection of one of us (JB), currently housed in the Department of Veterinary Tropical Diseases, University of Pretoria, and the following specimens were examined: one female from kudu, Pafuri, Kruger National Park (KNP); four males and 11 females from nyala in the Mkuzi Game Reserve, KwaZulu-Natal (KZN); two females from nyala in the Umfolozi Game Reserve, KZN; 22 males and 81 females from nyala in the Ndumu Game Reserve, KZN; one female from bushbuck from Pretoriuskop, KNP; three females from bushbuck in the Weza Forest Nature Reserve, KZN and one female from bushbuck at Charters Creek, KZN.

The nematodes were cleared in lactophenol and examined under a compound microscope with Nomarski's interference contrast lighting. Drawings were made with the aid of a drawing tube. Measurements were derived from the drawings and all are given in millimetres (mm). With the exception of the extensive collection from nyala, from which ten males and ten females were selected and measured, all the material was measured.

Specimens for scanning microscopy were dehydrated through graded ethyl alcohol and critically point dried from 100 % ethanol to liquid carbon dioxide. They were mounted on stubs and sputter-coated with gold. The examinations and photography were done with a Hitachi S-2500 scanning electron microscope operated at 8 kV.

RESULTS AND DISCUSSION

Of the 126 helminths examined, 121 proved to be *S. africana africana*. One female was recovered from kudu at Pafuri, four males and 11 females from nyala in the Mkuzi Game Reserve, two females from the same host in the Umfolozi Game Reserve and 22 males and 81 females from nyala in the Ndumu Game Reserve. These localities represent the northern part of the KNP and the northern game reserves of KZN. A total of five nematodes, one female from bushbuck at Pretoriuskop, KNP, three females from the same host in the Weza Forest and one female from bushbuck at Charters Creek, in the central part of KZN, proved to be *S. africana farchai*.

In Tables 1 and 2 the measurements of *S. africana africana* and *S. africana farchai* are compared with those made by Yeh (1959) and Troncy *et al.* (1976), respectively.

Desset (1966) found little difference between her *S. africana* material and that of Yeh (1959), and the measurements of the South African material also correspond well with those of Yeh (1959).

The majority of measurements of the South African *S. africana farchai* were similar to those recorded by Troncy *et al.* (1976). However, the cephalic elevations are larger and approach the measurements of those of *S. africana africana*. The oesophagus is also longer, the shortest measurements being well in excess of those given by Troncy *et al.* (1976). The caudal appendages are bigger and nearer the tail tip.

TABLE 1 Comparative measurements (in mm) of *Setaria africana africana*

Criterion	Males		Females		
	This paper	Yeh (1959)	This paper	This paper	Yeh (1959)
	Nyala (*n* = 10)		Kudu (*n* = 1)	Nyala (*n* = 10)	
Length	32,00–46,00	31,00–46,00	72,00	61,00–90,00	44,00–94,00
Width	0,320–0,380	0,270–0,350	0,690	0,490–0,650	0,500–0,700
Muscular oesophagus length	0,340–0,650	0,400–0,700	0,680	0,460–0,870	0,400–0,700
Glandular oesophagus length	4,790–6,450	3,500–6,200	7,620	5,920–8,470	4,500–8,400
Total oesophagus length	5,300–7,100	4,000–7,000	8,300	6,500– 9,100	5,000–9,000
Nerve ring from anterior end	0,170–0,250	0,200–0,270	0,240	0,200–0,280	0,200–0,300
Deirids from anterior end	0,270–0,490	0,320–0,650	0,440	0,420–0,630	0,400–0,500
Vulva distance from anterior end	–	–	0,540	0,450–0,620	0,400–0,600
Tail, length	0,160–0,240	0,160–0,180	0,358	0,350–0,610	0,400–0,600
Caudal appendages from tail tip	–	–	0,046	0,063–0,104	0,060–0,080
Caudal appendages length	–	–	0,015	0,011–0,017	0, 011
Right spicule, length	0,070–0,100	0,110–0,130	–	–	–
Left spicule shaft, length	0,170–0,200	0,170–0,190	–	–	–
Left spicule blade, length	0,070–0,090	0,080–0,110	–	–	–
Distance between cephalic elevations, lateral view	0,070–0,110	0,080–0,100	0,130	0,110–0,160	0,130–0,170
Distance between cephalic elevations, ventral view	0,020–0,030	#	0,050	0,030–0,040	0,050

– Not applicable
Measurements not given by author

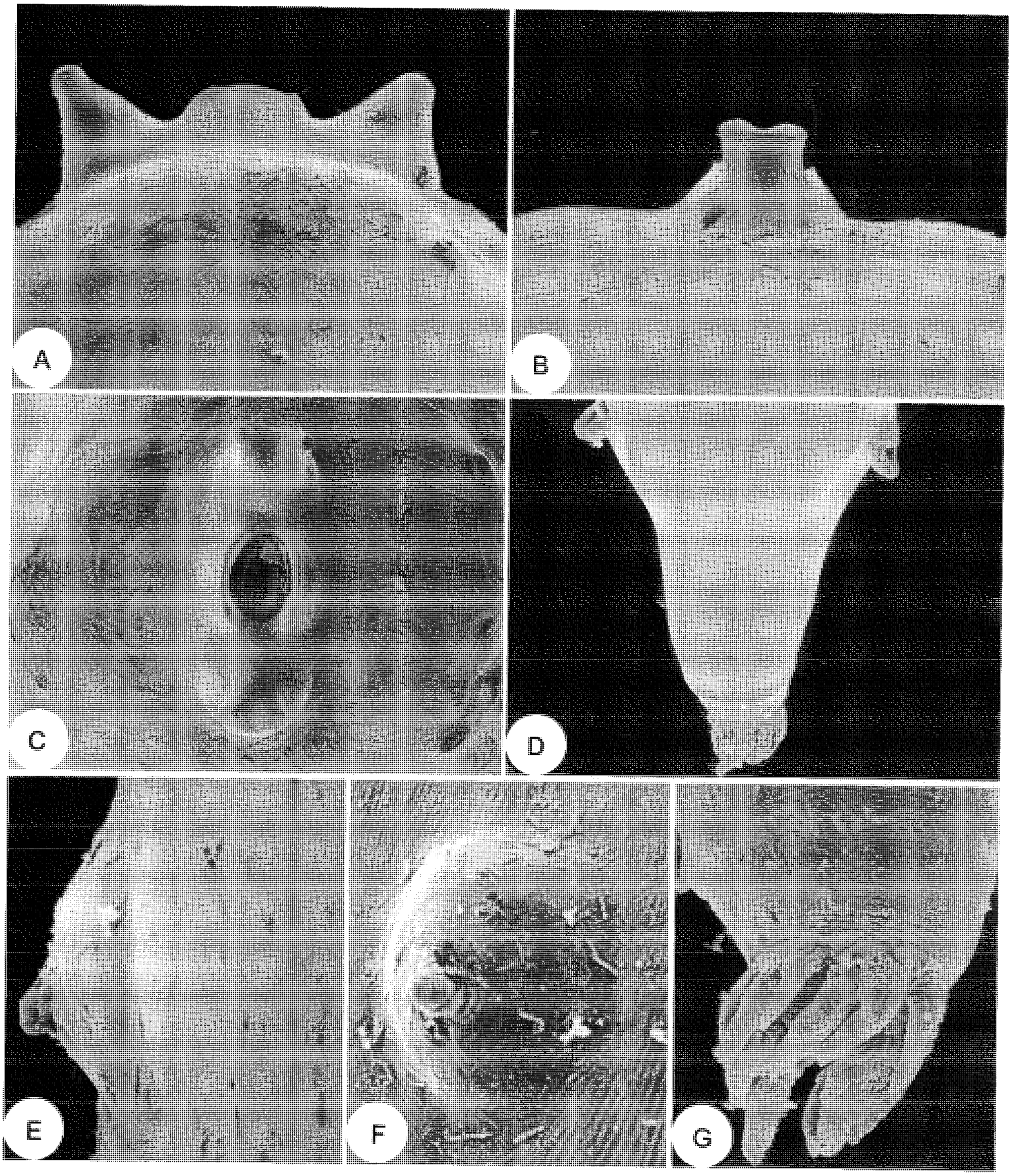

FIG. 1 *Setaria africana africana*

- A Lateral view of cephalic elevations, x 600
- B Ventral view of elevations, x 600
- C *En face* view of elevations, x 500
- D Ventral view of female tail, x 1000
- E Lateral view of deirid, x 3000
- F *En face* view of deirid, x 3000
- G Terminal part of female tail, x 3000

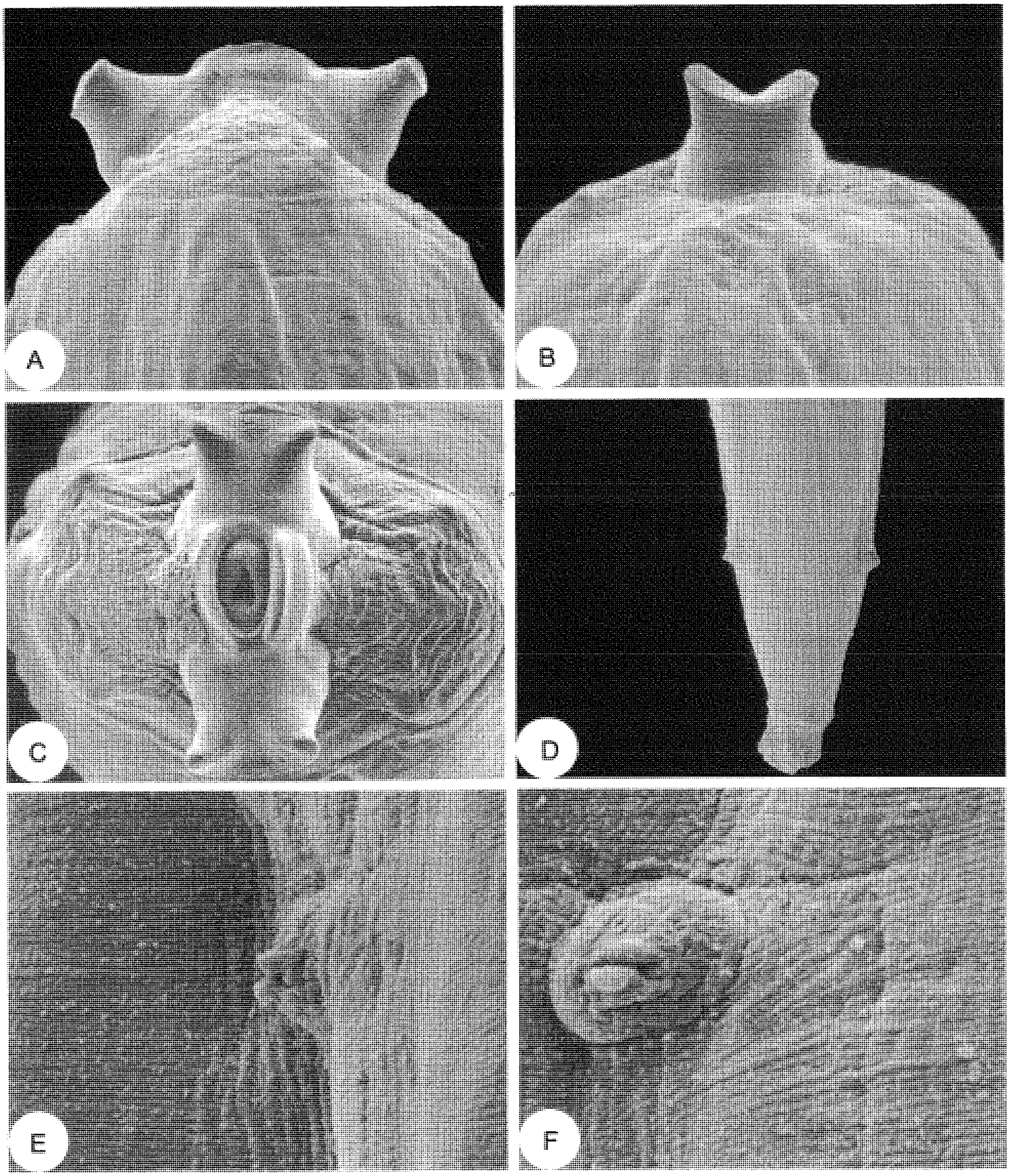

FIG. 2 *Setaria africana farchai*

A Lateral view of cephalic elevations, x 600
B Ventral view of elevations, x 600
C *En face* view of elevations, x 600
D Ventral view of female tail, x 1000
E Lateral view of deirid, x 3000
F *En face* view of deirid, x 3000

TABLE 2 Comparative measurements (in mm) of *Setaria africana farchai* females from bushbuck (*Tragelaphus scriptus*)

Criterion	Females		
	This paper		Troncy *et al.* (1976)
	Range	Mean	Range
Length	63,00–83,00	77,50	80,00
Width	0,350–0,630	0,510	0,600
Muscular oesophagus, length	0,400–0,970	0,750	0,660
Glandular oesophagus, length	5,330–7,420	6,130	4,440
Total oesophagus, length	6,300–7,820	6,880	5,100
Nerve ring from anterior end	0,220–0,290	0,270	0,260
Deirids from anterior end	0,400–0,550	0,490	0,560
Vulva from anterior end	0,460–0,580	0,530	0,570
Tail, length	0,320–0,670	0,510	0,630
Caudal appendages from tail tip	0,058–0,081	0,069	0,110
Length of right caudal appendage in ventral view	0,019	0,019	0,015*
Length of left caudal appendage in ventral view	0,017	0,017	0,008*
Distance between cephalic elevations, lateral view	0,097–0,173	0,134	0,104
Distance between cephalic elevations, ventral view	0,039–0,046	0,043	0,017

* Orientation of specimens not indicated

In addition, they are almost equal in length in the South African material whereas Troncy *et al.* (1976) found them to be unequal.

The scanning electron microscopical appearance of the two *S. africana* subspecies are presented in Fig. 1 and 2.

It is evident from the scanning electron micrographs that the description of Troncy *et al.* (1976) is accurate. However, they do not mention the deirids which in all specimens of *S. africana africana* examined are single and situated on a large promontory (Fig. 1E and 1F), whereas those of *S. africana farchai* are double and occur on a much smaller promontory (Fig. 2E and 2F). In addition, the peri-buccal crown of *S. africana africana* is more rectangular in shape than that of *S. africana farchai* which is spindle-shaped. The caudal extremities of female *S. africana africana* bear numerous rounded tubercles whereas those of *S. africana farchai* carry six to eight pointed tubercles.

Setaria africana was described from nyala but has also been recorded from bushbuck (Yeh 1959; Ortlepp 1961; Desset 1966; Roth & Dalchow 1967), kudu (Ortlepp 1961; Roth & Dalchow 1967) and giant eland (Sachs & Sachs 1968). Desset (1966) describes the deirids of *S. africana africana* from bushbuck as being single, but since the division is very difficult to see under a light microscope she might have examined *S. africana farchai*. The records of Ortlepp (1961) and of Roth & Dalchow (1967) from bushbuck could also be *S. africana farchai* but their records from kudu were in all probability *S. africana africana*. However, definitive conclusions cannot be made since the material of Desset (1966), Ortlepp (1961) and Roth & Dalchow (1967) was unavailable.

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Onderstepoort Journal of Veterinary Research, 70:7–13 (2003)

Studies on the genus *Setaria* Viborg, 1795 in South Africa. II. *Setaria scalprum* (Von Linstow, 1908) and *Setaria saegeri* (Le Van Hoa, 1961)

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ABSTRACT

WATERMEYER, R., BOOMKER, J. & PUTTERILL, J.F. 2003. Studies on the genus *Setaria* Viborg, 1795 in South Africa. II. *Setaria scalprum* (Von Linstow, 1908) and *Setaria saegeri* (Le Van Hoa, 1961). *Onderstepoort Journal of Veterinary Research*, 70:7–13

Setaria scalprum (Von Linstow, 1908) and *Setaria saegeri* (Le Van Hoa, 1961) are closely related filarid species that occur in the smaller antelope of Africa. Material previously collected from common duiker, *Sylvicapra grimmia,* steenbok, *Raphicerus campestris* and grysbok, *Raphicerus melanotis,* from several localities in the northern and eastern regions of South Africa was re-examined and measurements of adult worms were compared with those given in the original descriptions of the species. Scanning electron microscopy of the anterior and posterior regions of the female worms confirmed the validity of the two species. Differences in the postdeirid, ventral transverse bands and bosses on the cuticle of the male specimens were also observed. *Setaria saegeri* in common duiker and grysbok is a new parasite record for these hosts.

Keywords: Filarids, *Setaria saegeri*, *Setaria scalprum*, South African wildlife

INTRODUCTION

Various *Setaria* species have been recorded from wildlife in Africa, amongst which are *Setaria scalprum* (Von Linstow, 1908), described from steenbok, *Raphicerus campestris* and *Setaria saegeri* (Le Van Hoa, 1961) from common duiker, *Sylvicapra grimmia.* These two filarids are very similar and the possibility of misidentification of either species is possible, as stated by Le Van Hoa (1961) and Desset (1966). The description by Yeh (1959) of *S. scalprum* was, amongst others, from steenbok from Grahamstown, Eastern Cape Province, South Africa. *Setaria saegeri* has been recorded from common duiker in other parts of Africa, but no records of this species in South Africa could be found in the literature. Detailed scanning electron microscopic (SEM) studies on the morphological characteristics of *Setaria* species have been conducted by various workers, but mainly on species that occur in domesticated animals. There appears to be a paucity of information regarding SEM studies of *Setaria* spp. of wild animals of Africa.

During surveys of the helminth parasites of South African wildlife, specimens of the genus *Setaria* were collected from various artiodactylids, including common duiker (Boomker, Du Plessis & Boomker 1983; Boomker, Horak & De Vos 1986; Boomker, Keep & Horak 1987; Boomker, Horak & MacIvor 1989) and grysbok, *Raphicerus melanotis*, (Boomker *et al.* 1989). Ortlepp (1961) and Boomker *et al.* (1987, 1989) recorded *Setaria caelum* and *S. scalprum* from common duiker. Subsequent records of *Setaria* spp. from common duiker (Boomker *et al.*

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1983, 1986) and grysbok (Boomker *et al.* 1989) were identified only to the genus level. The SEM appearance, together with the measurements of *S. scalprum* and *S. saegeri,* are presented here and compared with the findings of Yeh (1959), Le Van Hoa (1961), and Desset (1966).

MATERIALS AND METHODS

The specimens originated from the helminthological collection of one of us (J.B.), currently housed in the Department of Veterinary Tropical Diseases, University of Pretoria, as well as the National Collection of Animal Helminths (NCAH). The following specimens were examined: 25 females from common duiker from the Weza Forest Nature Reserve, KwaZulu-Natal (WFNR); three males from the same host from Uitenhage, Eastern Cape Province; one female from grysbok, from the latter locality; five males and 19 females from common duiker from the farm Riekerts Laager, Limpopo Province; ten females from common duiker from Malelane, Kruger National Park (KNP); one female from steenbok from Nwashitsumbe, KNP; five males and 28 females from steenbok from Stellenbosch, Western Cape Province; two males and ten females from common duiker from Ondangua, Namibia, NCAH No. S2246 and three females from common duiker from Ndumu Nature Reserve, KwaZulu-Natal, NCAH No. S2336.

The nematodes were cleared in lactophenol and examined under a compound microscope using differential interference illumination. Measurements were obtained from *camera lucida* drawings of the material, and are given in millimetres in Tables 1 and 2. Specimens for scanning electron microscopy, which had been preserved in 70 % ethanol, had a segment of the head and tail removed prior to further processing. Samples were re-hydrated to distilled water after which they were post-fixed in 4% glutaraldehyde and 1% osmium tetroxide. Specimens were dehydrated through graded ethanol and critical point dried from 100% ethanol to carbon dioxide. Each dried head and tail segment was individually mounted onto a conical brass SEM viewing stub and sputter coated with gold. Samples were viewed and micrographed using a Hitachi S-2500 scanning electron microscope operated at 8 kV.

RESULTS AND DISCUSSION

Of the 112 helminths examined, 65 out of 77 from common duiker from the different localities as well as the one nematode from grysbok from Uitenhage proved to be *S. saegeri.* The 12 specimens from common duiker from Ondangua, Namibia were not suitable for identification. The 34 helminths from steenbok from the KNP and Stellenbosch were identified as *S. scalprum.*

In Tables 1 and 2 the measurements of *S. scalprum* and *S. saegeri* are compared with those of Yeh (1959) and Le Van Hoa (1961), respectively.

Setaria scalprum from steenbok examined in this study generally corresponded closely to the description of Yeh (1959), except for being slightly smaller. The majority of measurements of the South African *S. saegeri* were similar to those recorded by Le Van Hoa (1961). However, the following differences were apparent: female specimens had a shorter oesophagus, the deirids were closer to the anterior end, and the tail was longer than that recorded by Le Van Hoa (1961). The scanning electron microscopical appearance of *S. scalprum* and *S. saegeri* are presented in Fig. 1 and 2.

It was evident that the two species are morphologically distinct, as recorded by Le Van Hoa (1961) and Desset (1966). In lateral view, the cephalic elevations of *S. scalprum* are short, stub-like projections whereas those of *S. saegeri* are prominent, long, tooth-like structures (Fig. 1A and 2A). In ventral view the elevations of *S. scalprum* have a wide base with the sides tapering down gradually towards the peribuccal crown whereas those of *S. saegeri* have a rounded base with the sides almost parallel (Fig. 1B and 2B). In apical view, the mouth opening of *S. scalprum* is round and is surrounded by a slightly raised peribuccal crown. The elevations are elongated in a dorsoventral plane. The mouth of *S. saegeri* is oval in shape and the elevations are smaller and rounded with diverging tips (Fig. 1C and 2C). Furthermore, the deirids of *S. scalprum* are single whereas those of *S. saegeri* are double (Fig. 1D, E and 2D, E) and the caudal appendages of *S. scalprum* are larger than those of *S. saegeri* (Fig. 1F and 2F). Yeh (1959) described the terminal button on the posterior extremity of *S. scalprum* females as a small knob, often ill-defined and Le Van Hoa (1961) only mentions the tail length of *S. saegeri.* Desset (1966) describes the terminal buttons of the two species as more or less tuberculated in *S. saegeri* and smooth in *S. scalprum* and her illustrations are the same as those of Le Van Hoa (1961). This is contradictory to our findings in that the terminal button of *S. scalprum* is bluntly rounded and bifid whereas that of *S. saegeri*

TABLE 1 The comparative measurements (in mm) of *Setaria scalprum* from steenbok, *Raphicerus campestris*

Criterion	Males			Females		
	This paper (*n* = 5)	Mean	Yeh (1959)	This paper (*n* = 6)	Mean	Yeh (1959)
Length	27.00–38.00	34.40	37.00	60.00–86.00	75.25	95.00
Width	0.299–0.345	0.328	0.270	0.377–0.519	0.471	0.670
Muscular oesophagus, length	0.230–0.446	0.369	0.380	0.391–0.480	0.421	0.420
Glandular oesophagus, length	2.880–4.400	3.415	3.540	3.980–4.809	4.386	4.700
Total oesophagus length	3.280–4.630	3.784	3.920	4.460–5.200	4.811	5.120
Nerve ring from anterior end	0.154–0.230	0.196	0.210	0.179–0.270	0.211	0.170
Deirids from anterior end	0.213–0.472	0.370	*	0.267–0.368	0.326	*
Vulva, distance from anterior end	–	–	–	0.184–0.370	0.283	0.290
Tail, length	0.110–0.143	0.130	0.120	0.276–0.368	0.328	0.420
Caudal appendages from tail tip	–	–	–	0.017–0.025	0.022	0.020
Caudal appendages, length	–	–	–	0.004–0.005	0.004	*
Right spicule, length	0.101–0.126	0.109	0.130	–	–	–
Left spicule shaft, length	0.133–0.179	0.159	0.140	–	–	–
Left spicule blade, length	0.055–0.103	0.077	0.100	–	–	–
Left spicule, total length	0.234–0.236	0.235	0.240	–	–	–
Distance between cephalic elevations, lateral view	0.033–0.040	0.037	*	0.031–0.050	0.041	*
Distance between cephalic elevations, ventral view	0.010–0.020	0.013	*	0.020	0.020	*

– Not applicable
* Measurements not given by author

TABLE 2 The comparative measurements (in mm) of *Setaria saegeri* from common duiker, *Sylvicapra grimmia*

Criterion	Males			Females			
	This paper		Le Van Hoa (1961)	This paper			Le Van Hoa (1961)
	Grey duiker (*n* = 5)		Grey duiker	Grysbok (*n* = 1)	Grey duiker (*n* = 19)		Grey duiker
	Range	Mean			Range	Mean	
Length	26.00–33.00	29.00	30.00	37.00	44.00–76.00	66.28	70.00
Width	0.300–0.370	0.330	0.230	0.390	0.360–0.560	0.470	0.470
Muscular oesophagus, length	0.280–0.500	0.410	0.370	0.510	0.280–0.590	0.470	0.480
Glandular oesophagus, length	2.600–5.180	4.210	4.700	5.150	4.570–5.660	5.230	6.120
Total oesophagus length	3.050–5.680	4.670	5.070	5.660	5.160–6.140	5.710	6.600
Nerve ring from anterior end	0.180–0.250	0.200	0.180	0.170	0.180–0.200	0.180	0.200
Deirids from anterior end	0.450–0.530	0.500	0.475	0.340	0.310–0.450	0.340	0.800
Vulva, distance from anterior end	–	–	–	0.250	0.230–0.350	0.280	0,300
Tail, length	0.120–0.140	0.120	0.140	0.320	0.300–0.480	0.380	0.230
Caudal appendages from tail tip	–	–	–	0.020	0.020–0.030	0.020	*
Caudal appendages, length	–	–	–	0.002	0.002–0.003	0.002	*
Right spicule, length	0.100–0.130	0.110	0.120	–	–	–	–
Left spicule shaft, length	0.188–0.207	0.197	*	–	–	–	–
Left spicule blade, length	0.062–0.064	0.063	*	–	–	–	–
Left spicule, total length	0.252–0.269	0.260	0.230	–	–	–	–
Distance between cephalic elevations, lateral view	0.030–0.040	0.030	*	0.040	0.040–0.050	0.040	*
Distance between cephalic elevations, ventral view	0.020	0.020	*	0.020	0.020	0.020	*

– Not applicable

* Measurements not given by author

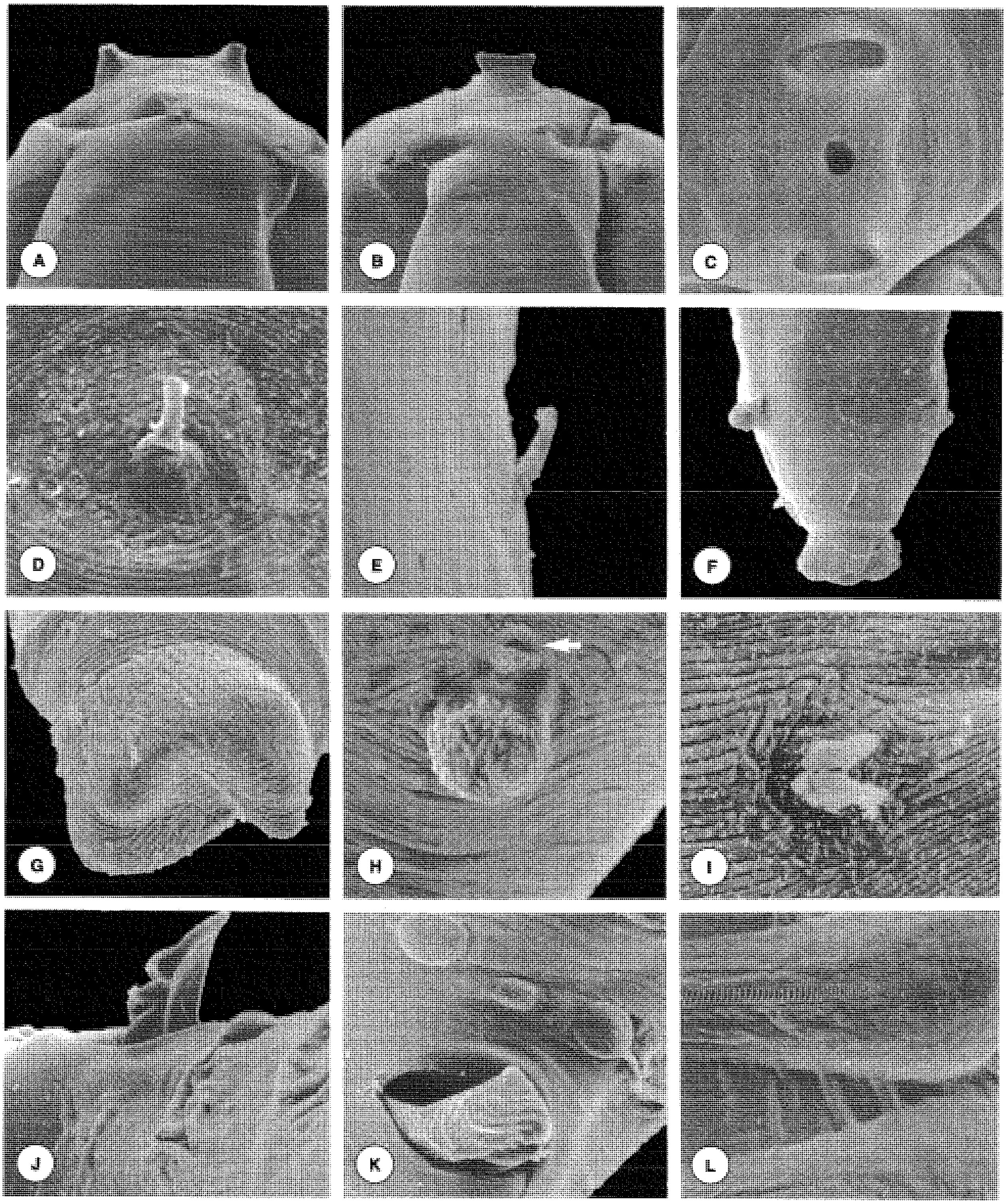

FIG. 1 *Setaria scalprum*

A. Lateral view of cephalic elevations, x 600. B. Ventral view of elevations, x 600. C. Apical view of elevations, x 600. D. Apical view of deirid, x 3 000. E. Lateral view of deirid, x 3 000 F. Ventral view of female tail, x 1 000. G. Terminal knob of female, x 4 000. H. Phasmidial pore of female (arrow), x 5 000 I. Postdeirid of male, x 5 000. J. Bosses on the cuticle, x 2 000. K. Male posterior end, x 2 000. L. Ventral transverse bands of male, x 1 500

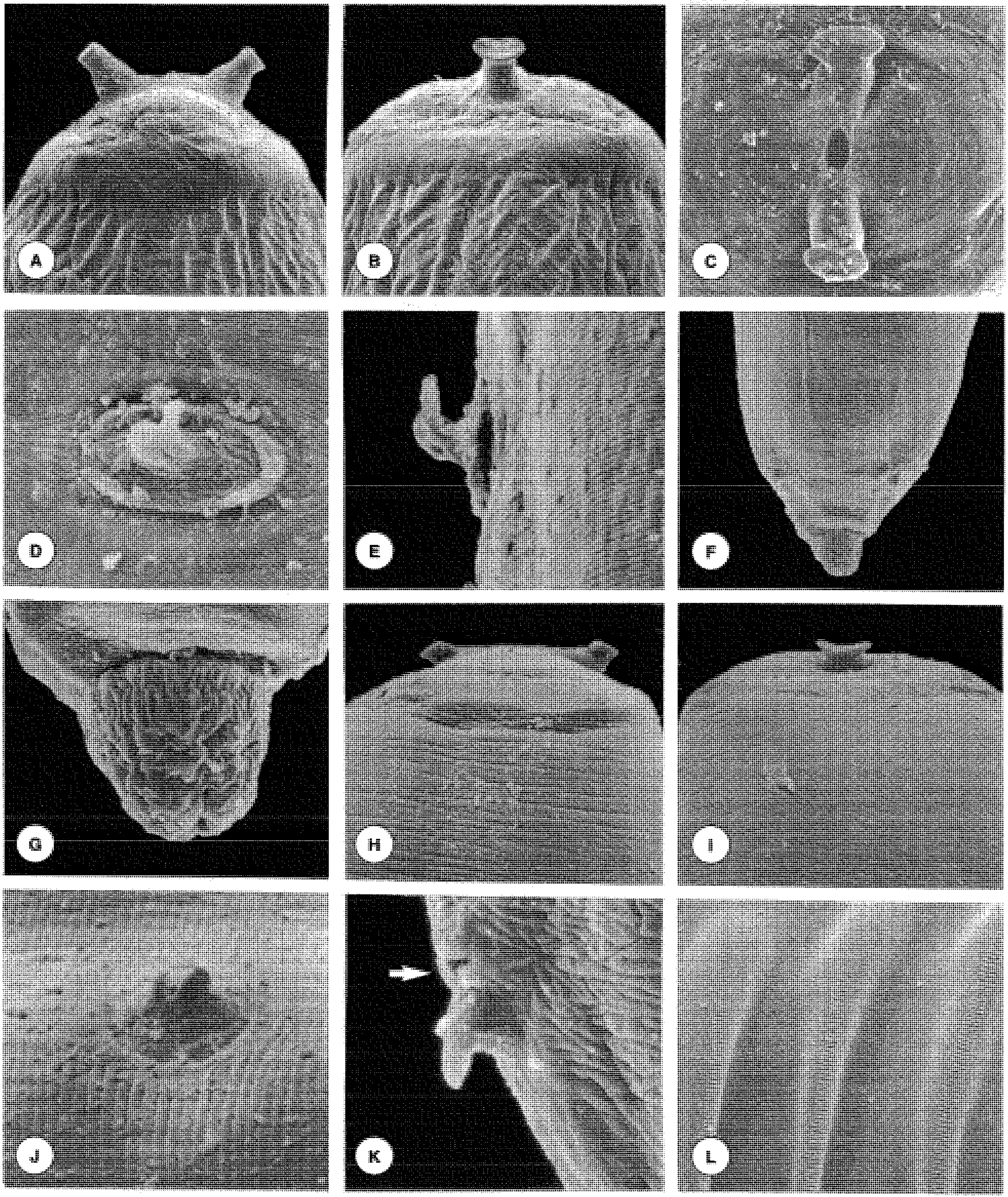

FIG. 2 *Setaria saegeri*

A. Lateral view of cephalic elevations, x 600. B. Ventral view of elevations, x 600. C. Apical view of elevations, x 600. D. Apical view of deirid, x 3 000. E. Lateral view of deirid, x 3 000. F. Ventral view of female tail, x 1 000. G. Terminal knob of female tail, x 4 000. H. Lateral view of cephalic elevations, x 600. Elevations are shortened due to shrinkage during SEM preparation. I. Ventral view of elevations, J. Postdeird of male, x 5 000. K. Caudal appendage of male with phasmidial pore (arrow), x 2 000. L. Ventral transverse bands of male, x 1 500 is thimble-shaped and rugose (Fig. 1G and 2G). The phasmidial pore, first visualized with the aid of scanning electron microscope by Shoho & Uni (1977), is situated on the upper side of the caudal appendages in both sexes and clearly visible in the female of *S. scalprum* and that of the male of *S. saegeri* (Fig. 1H and 2K). The postdeirid of the male *S. scalprum* is double and spine-like, the spines being of equal length, whereas that of *S. saegeri* is also double but shorter than that of *S. scalprum,* with spines of unequal length. (Fig. 1I and 2J). Small uniform bosses are present on the cuticle of *S. scalprum* males (Fig. 1J). The posterior end of a *S. scalprum* male with its protruding right spicule and a small sessile papilla just anterior to the cloaca and a pair of pre-cloacal papilla are illustrated in Fig. 1K. The ventral transverse bands on the cuticle of *S. scalprum* males appear larger with interconnecting ridges whereas in *S. saegeri* the bands are smaller and the ridges absent (Fig. 1L and 2L).

Shrinkage is one of the disadvantages of using SEM techniques and could lead to incorrect identification if not taken into consideration (Fig. 2H and 2I). Thus, light microscopy and scanning electron microscopy, used in conjunction are a useful combination for descriptions of nematodes.

Setaria saegeri was described from common duiker from the Congo but has also been recorded from the same host from Zimbabwe (Roth & Dalchow 1967), the Central African Republic and Cameroon (Troncy, Graber & Thal 1976). *Setaria scalprum* was described from steenbok but has also been found in impala, *Aepyceros melampus,* (Yeh 1959; Ortlepp 1961), common duiker (Desset 1966); Grants gazelle, *Gazella granti* (Yeh 1959), oribi, *Ourebia ourebi*, (Chabaud & Rousselot 1956; Yeh 1959; Ortlepp 1961; Desset 1966), red duiker, *Cephalophus natalensis,* (Boomker, Keep, Flamand & Horak 1984; Boomker, Horak & Flamand 1991). Boomker *et al.* (1989) recorded *S. scalprum* from common duiker that was, after re-examination, found to be *S. saegeri.* In 1961, Ortlepp recorded the presence of *S. caelum* in common duiker. The material was re-examined but due to severe shrinkage, the critical characteristics, such as cephalic elevations, deirids and posterior ends could not be clearly distinguished. Material collected from common duiker during 1963, by the same author and identified as *S. caelum* could be established as *S. saegeri* and the record of Boomker *et al.* (1987) of *S. caelum* from the same host was confirmed as *S. saegeri.*

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Onderstepoort Journal of Veterinary Research, 71:107–111 (2004)

Studies on the genus *Setaria* Viborg, 1795 in South Africa. III. *Setaria thwaitei* Mönnig, 1933

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ABSTRACT

WATERMEYER, R., BOOMKER, J. & PUTTERILL, J.F. 2004. Studies on the genus *Setaria* Viborg, 1795 in South Africa. III. *Setaria thwaitei* Mönnig, 1933. *Onderstepoort Journal of Veterinary Research*, 71:107–111

Mönnig (1933) described *Setaria thwaitei* from a sable antelope, *Hippotragus niger,* the type host, as well as from roan antelope, *Hippotragus equinus,* and waterbuck, *Kobus ellipsiprymnus.* Yeh (1959) considered *Setaria thwaitei* to be synonym of *Setaria hornbyi.* Material collected from roan antelopes, sable antelopes and gemsbuck, *Oryx gazella,* from several localities in the north and south of South Africa, together with Mönnig's (1933) material, were re-examined. Measurements of the adult worms obtained in this study were compared with those in the original description of the species. Scanning electron microscopy of the anterior and posterior regions of the female worms confirmed *S. thwaitei* as a valid species.

Keywords: Nematodes, *Setaria thwaitei*, wildlife

INTRODUCTION

Mönnig (1933) created the species *Setaria thwaitei* for worms that were collected from the peritoneal cavity of a sable antelope, *Hippotragus niger,* from Limpopo Province, South Africa, but Yeh (1959) considered *S. thwaitei* conspecific with *Setaria hornbyi.* Since Mönnig's (1933) description of *S. thwaitei* only two records of this species are mentioned in the literature, namely those of Van den Berghe & Vuylsteke (1936) and Vuylsteke (1956) from roan antelopes, *Hippotragus equinus*, from the Congo and Angola respectively.

Material recovered from roan antelopes, sable antelopes and gemsbuck, *Oryx gazella,* from two nature reserves and three game farms as well as Mönnig's (1933) type specimens from a sable antelope, roan antelope and waterbuck, *Kobus ellipsiprymnus*, were re-examined. Specimens of *S. hornbyi* from gemsbuck, previously recovered by Ortlepp (1961) and Basson, Kruger, McCully & Van Niekerk (1966), was also re-examined. The scanning electron microscopic appearance, together with the measurements of *S. thwaitei* and *S. hornbyi* are presented here and compared with the Mönnig's (1933) findings.

MATERIAL AND METHODS

The specimens originated from the helminthological collection of the National Collection of Animal Helminths (NCAH) as well as those collected by one of us (JB), and are currently housed in the Department of Veterinary Tropical Diseases, Uni-

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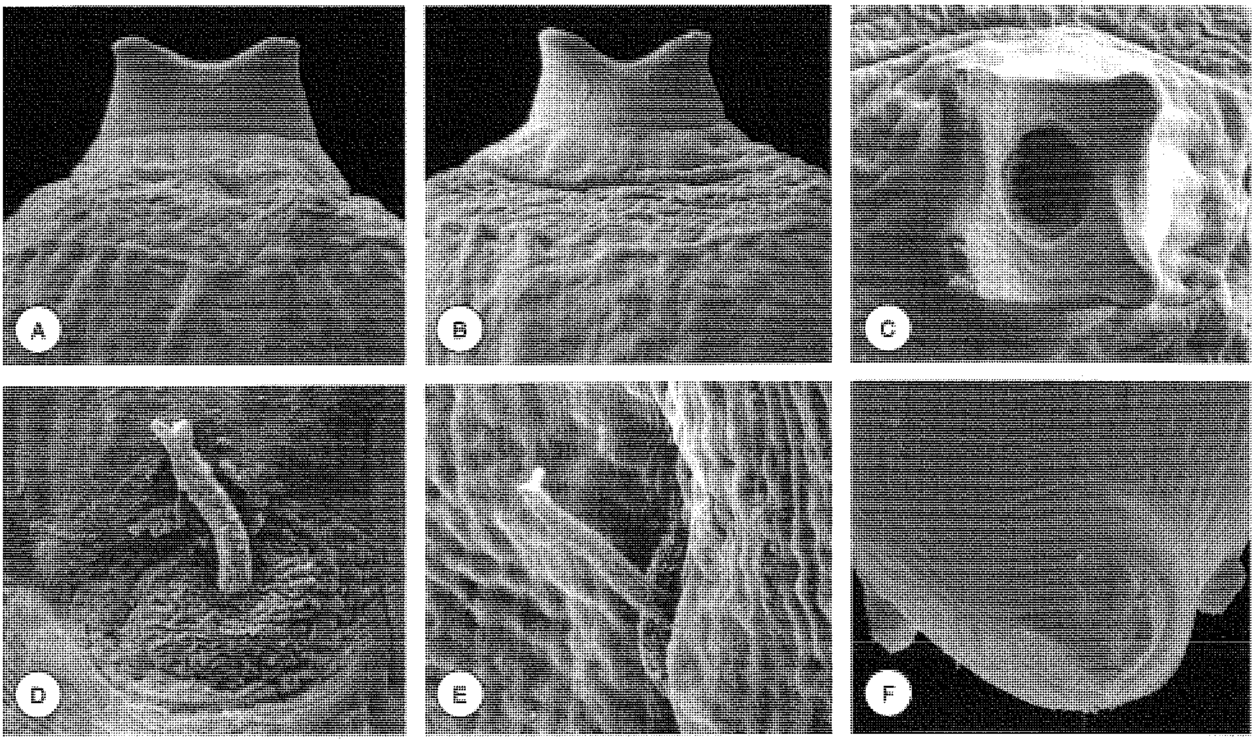

FIG. 1 *Setaria thwaitei*

(A) Lateral view of cephalic elevations, x 600; (B) ventral view of elevations, x 600; (C) apical view of elevations, x 600; (D) apical view of deirid, x 3 000; (E) lateral view of deirid, x 3 000; (F) terminal knob of female tail, x 1 500

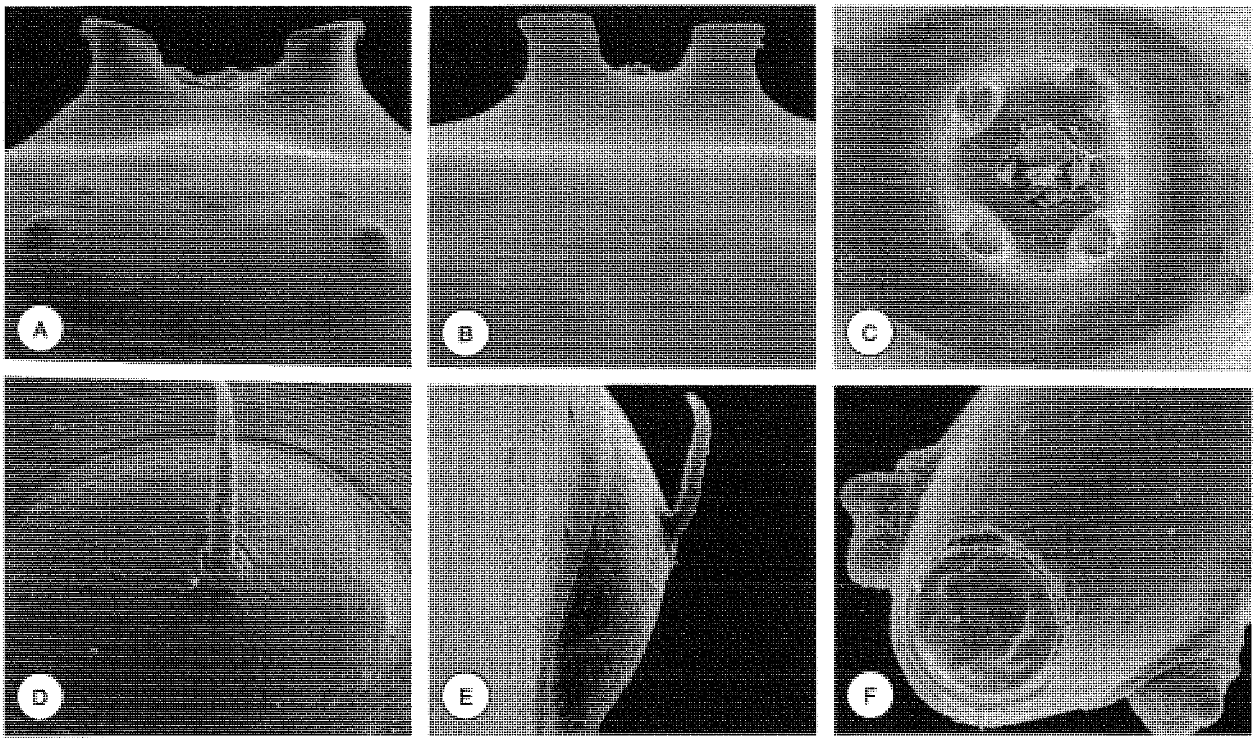

FIG. 2 *Setaria hornbyi*

(A) Lateral view of cephalic elevations, x 600; (B) ventral view of elevations, x 600; (C) apical view of elevations, x 600; (D) apical view of deirid, x 3 000; (E) lateral view of deirid, x 3 000; (F) terminal knob of female tail, x 1 500

TABLE 2 Comparative measurements (in mm) of the South African Setaria hornbyi and of *Setaria thwaitei*

Criterion	Males		Females	
	S. hornbyi	*S. thwaitei*	*S. hornbyi*	*S. thwaitei*
Length	83.00–87.00	63.00–82.00	157.00–212.00	115.00–321.00
Width	0.55–0.74	0.48–0.61	0.72–1.26	0.86–1.41
Muscular oesophagus, length	0.47–0.63	0.39–0.48	0.60–0.95	0.51–0.75
Glandular oesophagus, length	14.12–17.49	6.15–6.32	14.28–17.25	6.23–9.31
Total oesophagus length	14.59–18.12	5.30–6.80	15.00–18.12	6.77–10.06
Nerve ring from anterior end	0.25–0.31	0.28–0.29	0.30–0.37	0.26–0.51
Deirids from anterior end	0.55–0.73	0.62–0.71	0.63–0.92	0.54–0.77
Vulva, distance from anterior end	–	–	0.47–0.64	0.43–0.68
Tail, length	0.21–0.22	0.24–0.28	0.56–0.73	0.55–0.87
Caudal appendages from tail tip	–	–	0.05–0.08	0.04–0.09
Caudal appendages, length	–	–	0.017–0.019	0.016–0.034
Right spicule, length	0.18–0.20	0.17–0.21	–	–
Left spicule shaft, length	0.24–0.29	0.27–0.29	–	–
Left spicule blade, length	0.19–0.20	0.12–0.16	–	–
Left spicule sclerotized membrane	0.44–0.48	0.39–0.45	–	–
Distance between cephalic elevation, lateral view	0.11–0.13	0.06–0.07	0.11–0.13	0.07–0.09
Distance between cephalic elevation, ventral view	0.06	0.06–0.07	0.08–0.09	0.07–0.09

– Not applicable

Thwaite (1927) examined a large number of *Setaria* spp. from a variety of hosts. He concluded that there was considerable variation in the length of the specimens as well as in the "depth of the buccal ring and its protrusion in front of the head... even in worms from the same host". This could be because of the presence of more than one species of *Setaria*, in all probability both *S. hornbyi* and *S. thwaitei*. Yeh (1959) states: "Mönnig (1933), when he found the true *Artionema hornbyi* which Boulenger described, took the trouble to name it *Setaria thwaitei* new species with his only cited reference being Thwaite (1927)". This statement should be treated with reserve, since it appears that Boulenger (1921) described the "true" *S. hornbyi*, while Mönnig (1933) was quite correct in describing *S. thwaitei* as a separate new species.

Setaria thwaitei can be distinguished from *S. hornbyi* using several characteristic features. The cephalic elevations are distinct and the constriction at the level of the nerve ring, as described by Mönnig (1933), is much more prominent in *S. thwaitei*. Furthermore, *S. thwaitei* has a shorter oesophagus: body length ratio and the deirids have bifid tips. In view of these differences, we conclude that *S. thwaitei* is a separate and distinct species and it is herewith reinstated as such.

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A new filarial nematode (Onchocercidae) from warthogs (*Phacochoerus aethiopicus*) of the Kruger National Park

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ABSTRACT

Fifty-five warthogs [*Phacochoerus aethiopicus* (Suidae: Artiodactyla)] from the Kruger National Park, Republic of South Africa, were examined for parasites. Adult filarial nematodes were found in lymphatic vessels adjacent to peripheral and visceral lymph nodes, and microfilariae were found in lymph nodes and circulating blood. Both the adult parasite and the microfilaria are described. Specific identification is pending confirmation and recovery of intact adult specimens and microfilariae identical to those described herein.

MATERIALS AND METHODS

Fifty-five warthogs [*Phacochoerus aethiopicus* (Suidae: Artiodactyla)] were collected from the Kruger National Park, Republic of South Africa, and tissues from them examined at both the Onderstepoort Veterinary Research Institute and the Armed Forces Institute of Pathology. Nearly all warthogs over four months of age had some degree of eosinophilic lymphadenitis involving peripheral or visceral lymph nodes or both. 11 (30%) had microfilariae (mff) within affected nodes and two (4%) had mff as well as adult filariids located in lymphatic vessels adjacent to the nodes. Tissues containing worms were fixed in 10% buffered formalin, sectioned at 6 μm, and stained with haematoxylin and eosin and Movat's pentachrome stains. Microfilariae (mff) were preserved in 2·0% formalin (Knott's concentration technique) and stained with Mayer's haematoxylin and fast green. All measurements are in μm unless otherwise stated.

DESCRIPTION

(Filarioidea, Onchocercidae: Setariinae)

Material: Based upon 23 sections of lymph node with three adult male worms and four gravid female worms within dilated lymph vessels, 50 complete mff (Knott's concentration technique), and many partial mff found in tissue sections and in lymphatic and blood vessels. Voucher specimens (microfilariae and sectioned adults *in situ*) are deposited in the collections of the U.S.N.M. (77588 Helm. Coll. No.) National Parasite Collection, Beltsville, MD 20705, and the Armed Forces Institute of Pathology, Washington, D.C.

The investigators adhered to the principles described in "Guide for the Care and Use of Laboratory Animals" prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Animal Resources, National Research Council, DHEW Publication No. (NIH) 78-23, Revised 1978.
The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army, the Department of the Air Force, or the Department of Defense.

Host: *Phacochoerus aethiopicus*, Pallos 1766.

Habitat: Adults in efferent lymphatic vessels, microfilariae in circulating blood and lymph nodes.

Locality: Kruger National Park, Eastern Transvaal, Republic of South Africa.

Periodicity: Unknown.

Diagnosis: Onchocercidae (Leiper, 1911) (=Dipetalonematidae Wehr, 1935; =Setariidae Yorke and Maplestone, 1926).

Microfilaria: (N=20) (Fig. 1). Body slender and sheathed, with nuclei distinct when stained with Mayer's haematoxylin; 129 (118–136) by 3·8 (3·0–4·0) at level of first anterior nucleus, 3·8 (3·0–4·0) at nerve ring, 3·7 (3·0–4·0) at anal pore. Distance from anterior end to first nucleus, 2·9 (2·0–3·5); to nerve ring, 33·2 (32·5–35·0); to posterior *Innenkörper*, 56·1 (54·0–59·0); to anal pore, 87·4 (84·0–91·0); and to last nucleus in tail, 126·2 (114·0–130·5). Cephalic space short, slightly bulbous, and 2·8 (2·0–3·5) long by 3·9 (3·0–4·5) wide; ratio of cephalic L/W, 0·72 (0·67–0·88)/1. *Innenkörper*, 9·8 (8·0–11·0) long. Anal pore distinct, between *Innenkörper* and terminal body nuclei. R1 and R2-4 cells

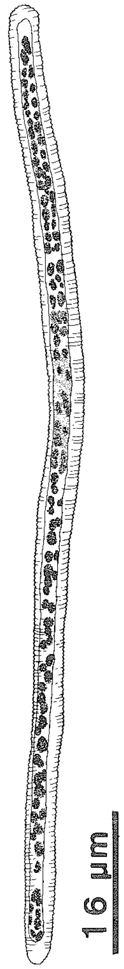

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FIG. 1. Microfilaria of onchocercid nematode from the blood of the warthog *Phacochoerus aethiopicus*. (AFIP 83-7788).

not distinct when stained with Mayer's haematoxylin or Giemsa. First cephalic nucleus single (30%) or overlapping second (70%). Last nucleus, almost to tip of tail, 2·9 (1·5–3·5). Tail nuclei overlapping.

Adult worm (*male*): Body 65 (35–103) wide, 43–52 at level of oesophagus, 35–55 at level of spicules. Two dorso-lateral cuticularized curved areas in cephalic extremity. Lateral chords broad (approx. 20–25% of circumference), 3–6 on entering body-cavity. Somatic muscles well developed, 7–11 from cuticle to body-cavity. Oesophagus muscular, 22–25 wide with a triangular lumen. Cuticle thin (2·5–3·0) with fine, shallow longitudinal striations, approximately two per μm, and with pronounced bosses or papillae. Testis single, 20–29 wide; vas deferens 42–53 wide. Right and left spicules unequal in length; left, larger with a thin-walled tubular proximal portion (12 long × 7 wide), thick hyaline midsection (40 × 6) and a narrow, curved rod-like distal portion (12 × 4).

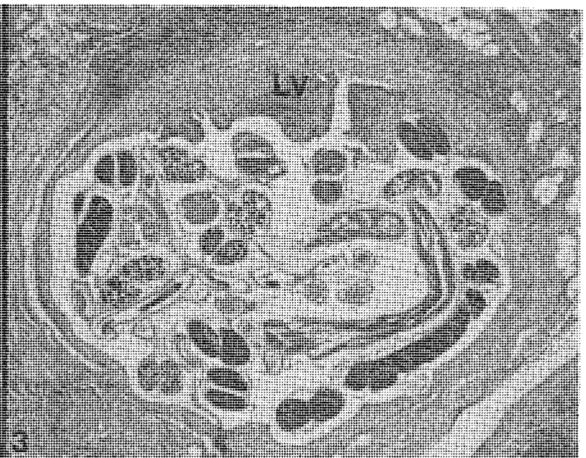
Adult worm (*female*): Anterior half of body 130–260 wide, posterior half 106–150 with two cuticularized curved areas in cephalic extremity. Lateral chords poorly developed. Somatic muscles poorly developed, protruding 1·0–2·5 into body-cavity. Cuticle (3·0–3·5) with fine, shallow longitudinal striations approximately two per μm, with pronounced bosses or papillae. Oesophagus as in male. Both uteri fill the body-cavity. Uteri with embryos, 46–52 by 60–72 wide; uteri with well developed mff, 62–72 × 82–103 wide. Mff *in utero* have a parallel or crystalline pattern (similar to cross section of rope).

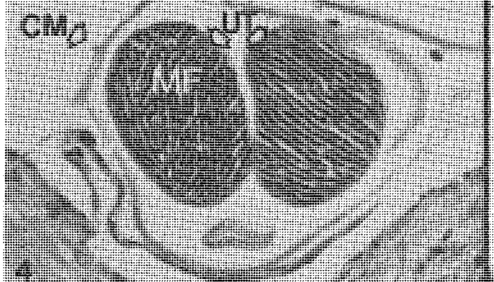
Pathology: Affected lymph nodes were enlarged and multilobulated; accessory nodes were usually present and perinodal tissue was oedematous. Most nodes were mottled creamy-white and red-brown. On incision, clear to sanguinous fluid exuded and numerous cystic spaces measuring up to 2 mm in diameter were observed in the nodal parenchyma. Microscopically, changes in affected nodes included mild to marked infiltrations of eosinophils, plasmacytosis, lymphoid and reticular macrophage hyperplasia, the presence of multinucleated giant cells, haemorrhage and cystic dilatation of sinuses; these changes were most severe when mff were present. A segmental eosinophilic and proliferative inflammation was associated with the presence of intraluminal adult filariids in thin-walled vessels adjacent to affected nodes. The vessels were presumed to be lymphatics. A detailed description of the pathological changes in both lymph nodes and lymphatics is the subject of an additional report.

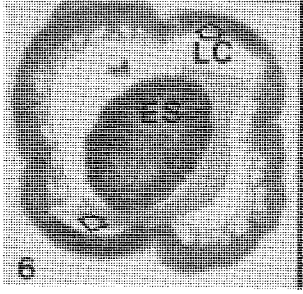
DISCUSSION

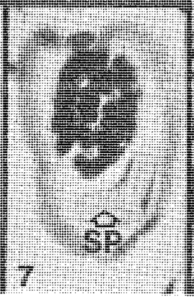
Reports of filariid nematodes infecting hosts of the family Suidae include the following: in Africa *Setaria congolensis* (=*S. bernardi*, *S. rodhaini*) has been reported from *Potomochoerus porcus*, *P. koiropotamus* and *Sus scrofa* in the Congo, Zimbabwe and Mozambique, *S. castroi* (=*S. shohoi*) from *Phacochoerus aethiopicus* and *Potomochoerus porcus* in Mozambique and Madagascar and *Suifilaria suis* in *Sus scrofa* in South Africa; in Asia a species of *Onchocerca*, namely, *O. dewittei* has been reported from *Sus scrofa jubatus*.

Reports of filariids in warthogs are rare. Neitz (1931, 1933) in a study of blood parasites of game in Zululand (South Africa) reported, without morphological description, 110-μm-long microfilariae in blood, spleen and gland (lymph?) smears from 5 of 56 warthogs. This number was later expanded to include another 7 of warthogs from the Umfolozi district. In 1963, Dr. H. H. Roth of the Department of Veterinary Services, Salisbury, Rhodesia, gave his collection of 20,000 nematodes from warthogs (*Phacochoerus aethiopicus*) to Dr. H. A. Kreis (Kreis, 1970), who reported two new filarial nematodes from the warthog. Kreis' description of the *Setaria* sp. is based upon one adult female, and that of *Papillosetaria phacochoeri* from one male worm.









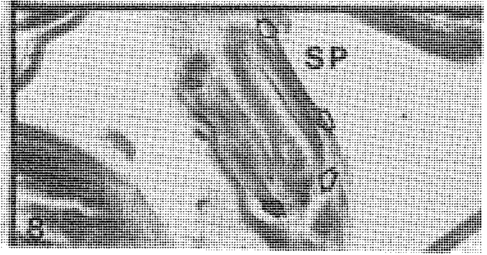


FIG. 2. Histological section of a lymph node (LN) with a dilated lymphatic vessel (LV) containing adult male and female onchocercid nematodes. (40 ×, AFIP 83-77900).

FIG. 3. Dilated lymphatic vessel (LV) in thickened and inflamed lymph node capsule. Note the sections of adult male and female onchocercid nematodes within. (160 ×, AFIP 83-7791).

FIGS. 4–5. Cross section of paired uteri (UT) of adult female onchocercid nematode. Uteri contain microfilariae (MF) in crystalline pattern. Note cuticular modification (CM) on outer body wall. (Fig. 4, 400 ×, AFIP 83–7795; Fig. 5, 630 ×, AFIP 83-7789).

FIG. 6. Cross section through the anterior portion of adult male onchocercid nematode demonstrating lateral chords (LC) and muscular oesophagus (ES). (630 ×, AFIP 83-7794).

FIG. 7. Cross section through the posterior portion of an adult male onchocercid nematode showing right and left spicules (SP) (630 ×, AFIP 83-7796).

FIG. 8. Longitudinal section through the right and left spicules (SP). Hollow arrows indicate the longer, curved right spicule, while arrow points out the shorter left spicule. (60 ×, AFIP 83-7792).

ORTLEPP (1964) examined nematodes from 30 warthogs and several bushpigs (*Potamochoerus porcus*) from Portuguese East Africa and Northern Rhodesia and recovered 21 female and 8 male worms (*Setaria congolensis* Railliet & Henry, 1911) from bushpigs, and a new species, *Setaria castroi*, from three warthogs and a single bushpig. No description is made of microfilariae of *Setaria* sp. in any of the above reports.

The microfilariae reported by NEITZ (1931) measured 110 μm; ours ranged from 118 to 136 μm. Adult filarial worms in the warthogs we examined had vulva in the anterior body, two lateral cuticularized expansions on the cephalic extremity, at least two cephalic tubercles, and markedly dissimilar spicules. We are confident that they represent a species within the Setariinae. ANDERSON & BAIN (1976) assign only two genera to this subfamily, *Setaria* and *Papillosetaria*. Our specimens lacked large cuticularized tubercles throughout the midbody, separating this parasite from the genus *Papillosetaria*. Our worms are probably the same or a closely related species to the *Setaria* sp. reported by KREIS (1970) or to *S. castroi* reported by ORTLEPP (1964). *Setaria* is not the only genus of filariid occurring in the family Suidae although the presence of sheathed mff would suggest the possible identity of the adults as *Setaria*.

There is no doubt that this nematode species belongs to the Filarioidea; however, we lacked intact adult specimens necessary for specific identification of this lymph-dwelling filarial nematode. Characteristics such as the precise location of the vulva, buccal structure and ornamentation, arrangement of caudal papillae, oesophageal structure, and body length were not available to us. There is a possibility that this is an accidental infection by a parasite not normally found in warthogs particularly in view of the site from which it was recovered. Although recorded in the cavity of some organs *Setaria* spp. are primarily parasites of the peritoneal cavity of their hosts. The parasites described in this paper are recovered from lymph vessels which is an atypical site for *Setaria*. At present we feel that it is advisable to leave the identification open to confirmation.

ACKNOWLEDGEMENTS

We thank Drs. Daniel H. Connor and Dean Gibson for the initial consultation report, the WHO Collaborating Center for Filarial Infection of Man, and the Armed Forces Institute of Pathology, Departments of Infectious and Parasitic Disease Pathology, and Veterinary Pathology, for support. We also thank Dr. Mark Eberhard of the Delta Regional Primate Center for taxonomic suggestions and direction. We thank the National Parks Board of Trustees, Republic of South Africa, for sanctioning the study of warthogs in the Kruger Park.

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PARASITES OF SOUTH AFRICAN WILDLIFE. V. A DESCRIPTION OF THE MALES OF *OESOPHAGOSTOMUM MOCAMBIQUEI* ORTLEPP, 1964 FROM WARTHOGS, *PHACOCHOERUS AETHIOPICUS* (PALLAS, 1766)

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ABSTRACT

BOOMKER, J., 1990. Parasites of South African wildlife. V. A description of the males of *Oesophagostomum mocambiquei* Ortlepp, 1964 from warthogs, *Phacochoerus aethiopicus* (Pallas, 1766). *Onderstepoort Journal of Veterinary Research*, 57, 169–173 (1990).

Oesophagostomum mocambiquei Ortlepp, 1964 was described from 9 females recovered from a warthog, *Phacochoerus aethiopicus* (Pallas, 1766), from northern Mozambique. Large numbers of *O. mocambiquei* were recovered during subsequent surveys of the parasites of warthogs from the Kruger National Park and the Hoedspruit Nature Reserve. The males, which have not yet been described, resemble those of *Oesophagostomum santosdiasi* Ortlepp, 1964 in the principal measurements. They can, however, be differentiated by the shape of the mouth capsule, which is round in *O. mocambiquei* and oval in *O. santosdiasi.*

A simplified key for the identification of the *Oesophagostomum* species that occur in warthogs in South Africa and Namibia is provided and the differences between them tabulated.

The names *Oesophagostomum moçambiquei* and *Oesophagostomum santos-diasi* are corrected to *O. mocambiquei* and *O. santosdiasi* respectively, since diacritic marks are not allowed under the Code of International Zoological Nomenclature.

INTRODUCTION

The species *Oesophagostomum mocambiquei* Ortlepp, 1964 was created for female worms recovered from the large intestines of warthogs, *Phacochoerus aethiopicus* (Pallas, 1766), from the northern parts of Mozambique and near Pilgrim's Rest in the eastern Transvaal (Ortlepp, 1964). The males of this species, however, have not yet been described.

Surveys of the parasites of warthogs have since been conducted in the Kruger National Park (KNP) (Horak, Boomker, De Vos & Potgieter, 1988) and the Hoedspruit Nature Reserve (HNR) (Boomker, Horak, Booyse & Meyer, unpublished data, 1989). Large numbers of male and female *O. mocambiquei* were recovered from the KNP and the HNR, and many of the worms were fixed *in copula*. As only *O. mocambiquei* and *Oesophagostomum mwanzae* Daubney, 1924 were present in the warthogs from the HNR, and in view of the distinct differences between the 2 species, the males found in association with female *O. mocambiquei* were considered to be the males of that species. They are described here and a simplified key for the identification of the *Oesophagostomum* spp. of warthogs in South Africa and Namibia is provided, and the differences between them tabulated.

MATERIALS AND METHODS

Large numbers of *O. mocambiquei* were recovered from the caecum and colon of warthogs shot in the HNR in the eastern Transvaal Lowveld. They were killed in hot saline and fixed in cold 10 % formalin. To clear them, worms were individually mounted in lactophenol and Berlese's medium, and they were measured with the aid of a calibrated ocular micrometer. Drawings were made with a camera lucida.

The specimens were prepared for scanning electron microscopy by rinsing in buffer and dehydrating in graded concentrations of ethyl alcohol. They were then critical point dried with carbon dioxide and mounted on stubs, followed by coating with a thin layer of carbon and sputter coating with gold. The examinations and photography were done with a Jeol 35C scanning electron microscope.

DESCRIPTION

Material examined

Six female worms from *Phacochoerus aethiopicus*, from the type locality (Onderstepoort Helminthological Collection, No. T 2141).

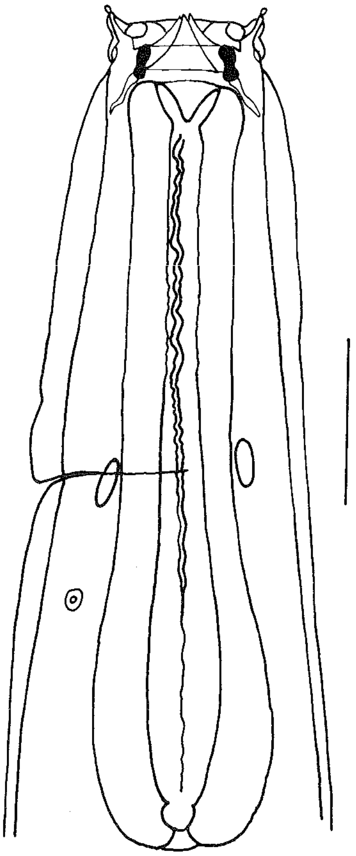

FIG. 1 Lateral view of the anterior end of a male *Oesophagostomum mocambiquei* (Bar length = 0,1 mm)

Received 10 May 1990—Editor

TABLE 1 The principal measurements (in mm) of *Oesophagostomum mocambiquei*

	Type specimens		This study	
	Ortlepp (1964)	This study	Males	Females
Length	17 – 20	13,18 – 17,92	12,30 – 15,82	16,26 – 19,88
Maximum width	0,350 – 0,420	0,580 – 0,800	0,408 – 0,552	0,560 – 0,760
Width of mouth collar	0,090 – 0,100	Damaged	0,080 – 0,092	0,088 – 0,104
Depth of buccal capsule	0,014 – 0,016	0,016 – 0,032	0,028 – 0,034	0,024 – 0,048
Width of buccal capsule	0,044 – 0,048	0,040 – 0,056	0,036 – 0,048	0,032 – 0,052
Thickness of buccal capsule wall	0,008	0,006 – 0,008	0,006 – 0,008	0,006 – 0,008
Distance of cervical groove from anterior end	0,220 – 0,227	0,220 – 0,280	0,180 – 0,252	0,160 – 0,296
Distance of cervical papillae from anterior end	0,300 – 0,330	0,384 – 0,402	0,260 – 0,424	0,280 – 0,412
Distance of nerve ring from anterior end	Just behind cervical groove	0,220 – 0,268	0,208 – 0,280	0,208 – 0,288
Length of oesophagus	0,420 – 0,500	0,464 – 0,536	0,424 – 0,556	0,484 – 0,564
Length of spicules	Not applicable		2,180 – 2,950	–
Length of gubernaculum	Not applicable		0,084 – 0,160	–
Length of vagina	0,650 – 0,750	0,664 – 0,720	–	0,728 – 0,952
Distance from tip of tail to anus	0,100 – 0,130	0,088 – 0,116	–	0,088 – 0,132
Distance from tip of tail to vulva	Not given	0,208 – 0,268	–	0,236 – 0,340
Distance between anus and vulva	0,130 – 0,150	0,120 – 0,160	–	0,140 – 0,212
Eggs *(in utero)*, length	0,080 – 0,090	0,080 – 0,092	–	0,080 – 0,100
width	0,047 – 0,048	0,048 – 0,068	–	0,040 – 0,056

TABLE 2 A summary of the differences between the species of *Oesophagostomum* that occur in warthogs in South Africa and Namibia

Species	Length (mm)	Shape of mouth capsule	Shape of oesophagus	Tail	Vagina (mm)	Spicules (mm)	Source
O. mocambiquei	12 – 20	Cylindrical	Club	Bent	0,73 – 0,95	2,18 – 2,95	This study
O. mpwapwae	13 – 15	Cylindrical	Club	Straight	2,1	3,10 – 3,80	Duthy, 1947; Ortlepp, 1964
O. mwanzae	13 – 20	Oval	Club, with 3 valves	Bent	0,35 – 0,50	1,87 – 2,20	Daubney, 1924; Ortlepp, 1964
O. roubaudi	17 – 23	Oval	Club	Bent	0,17 – 0,26	1,27 – 1,32	Daubney, 1926
O. santosdiasi	12 – 15	Oval	Club	Bent	0,70 – 1,0	2,40 – 2,70	Ortlepp, 1964
O. simpsoni	15 – 21	Oval	Short, thick sides almost parallel	Straight	0,10 – 0,15	1,20 – 1,30	Goodey, 1924 Ortlepp, 1964

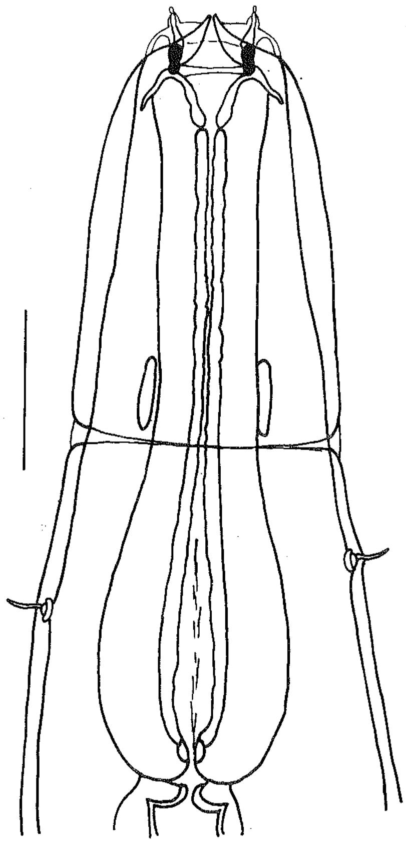

FIG. 2 Ventral view of the anterior end of a male *Oesophagostomum mocambiquei* (Bar length = 0,1 mm)

Sixteen male and 8 female worms from *P. aethiopicus* from the Hoedspruit Nature Reserve, eastern Transvaal (Onderstepoort Helminthological Collection, No. T 2180).

Twenty-four male and 16 female worms from 2 warthogs from the Hoedspruit Nature Reserve.

Additional material, consisting of numerous male and female worms from warthogs from the HNR, have been deposited with the Onderstepoort Helminthological Collection and the collection of the CAB International Institute of Parasitology, St. Albans, Herts, United Kingdom.

Description

As part of this study the type specimens were re-examined and their measurements, together with those of the male and female worms collected from the warthogs from HNR, are listed in Table 1.

Like the females, the males have a flattened mouth collar which is only slightly set off from the rest of the body. The circum-oral papillae are prominent (Fig. 1, 2 & 7a, b) and the amphids are raised slightly above the surface (Fig. 7a, b). The cervical swelling is small and is demarcated posteriorly by the cervical groove into which the excretory pore opens. The nerve ring is situated either just in front or just behind the cervical groove (Fig. 1 & 2). The cervical papillae are long and spike-like (Fig. 2, 7a) and lateral alae are absent. The buccal capsule is cylindrical (Fig. 7a & b). There are 6 triangular external leaf crown elements that extend obliquely forwards (Fig. 1, 2, 7a & b); an internal leaf crown is absent. An

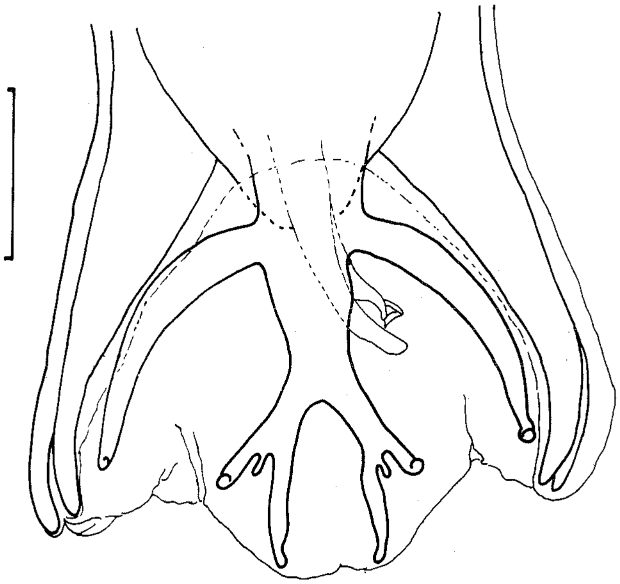

FIG. 3 Dorsal view of the partly opened bursa of *Oesophagostomum mocambiquei* (Bar length = 0,1 mm)

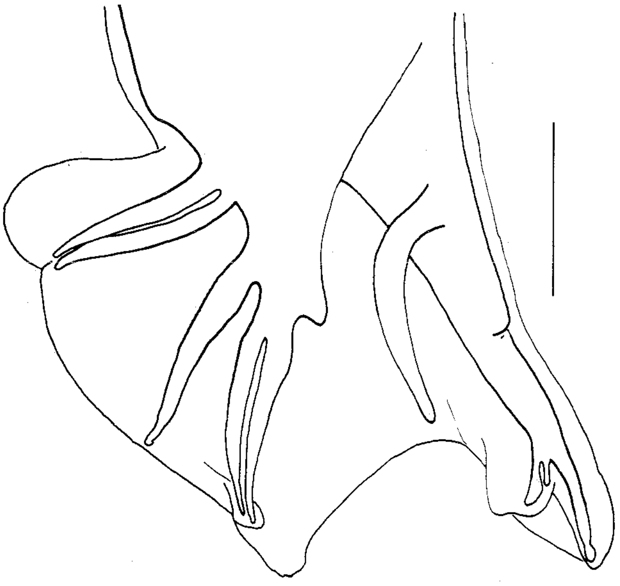

FIG. 4 Lateral view of one half of the bursa of *Oesophagostomum mocambiquei* (Bar length = 0,1 mm)

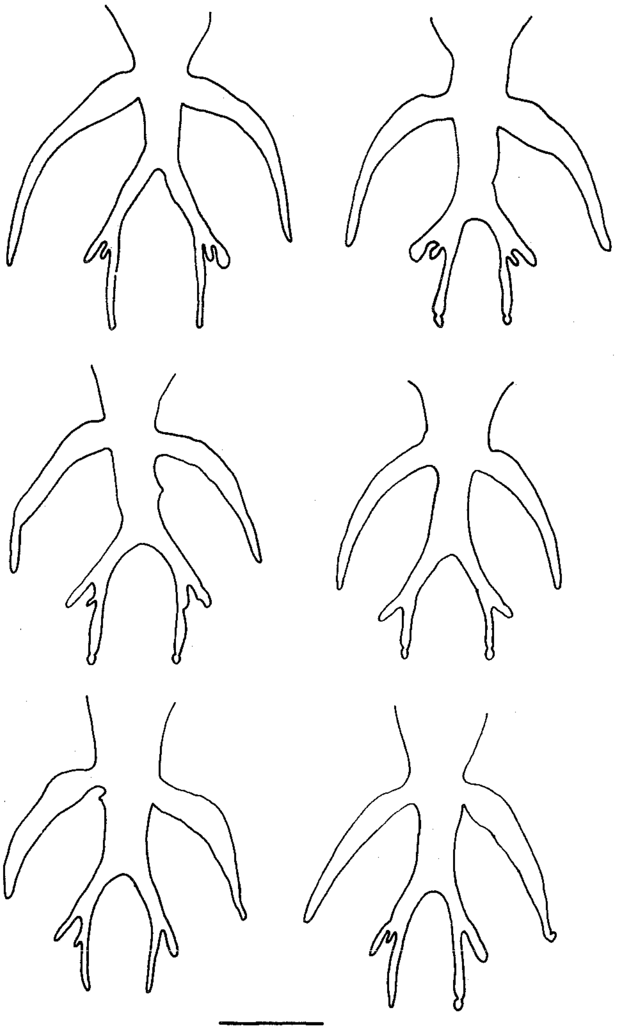

FIG. 5 Variations in the configuration of the dorsal ray of *Oesophagostomum mocambiquei* (Bar length = 0,1 mm)

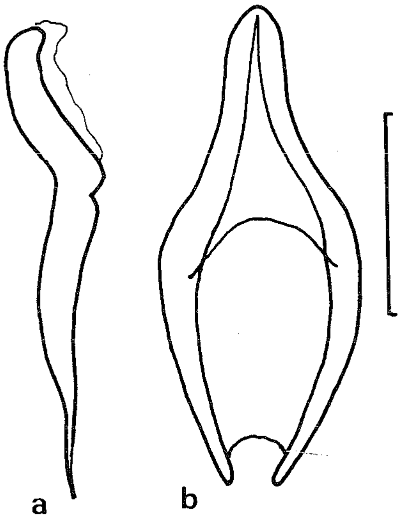

FIG. 6 The gubernaculum of *Oesophagostomum mocambiquei* in (a) lateral and (b) ventral views (Bar length = 0,05 mm)

oesophageal funnel is present and the oesophagus is club-shaped (Fig. 1 & 2).

The bursa is rather small and compact. The dorsal lobe is longer than the ventral ones (Fig. 3 & 4). The ventral bursal rays are equally long and remain parallel for their entire length (Fig. 4). The anterolateral ray is widely separated from the mediolateral ray; the medio- and posterolateral rays run parallel and remain close to each other for their entire length. There is a distinct swelling on the posterior edge of the main trunk of the lateral rays, slightly cranial to the level of the origin of the posterolateral ray (Fig. 4). The externodorsal rays are of variable thickness, and curve posteriorly and ventrally (Fig. 4). The dorsal ray has a broad origin but tapers considerably before bifurcating, and each bifurcation is divided into lateral and medial branches (Fig. 3 & 5). A small papilla, which is sometimes hardly more than a small protuberance, may be present in a highly variable position between the lateral and medial branches, or it may be present on the dorsal ray (Fig. 5). In some males it is absent. In lateral view, the dorsal ray appears to consist of a thinner distal part that fits into a thicker proximal part; the junction of these parts is marked by a distinct crease (Fig. 4).

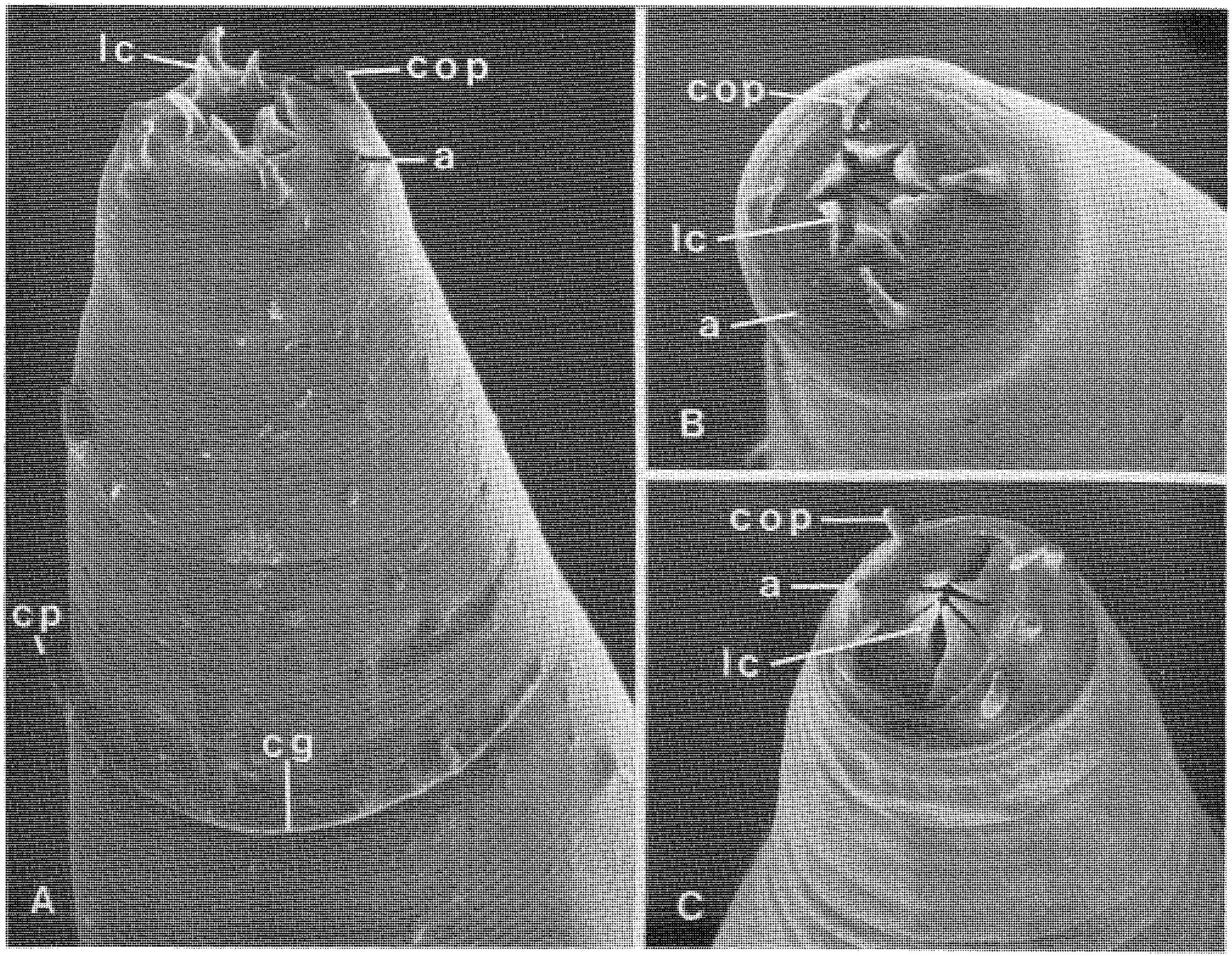

FIG. 7 (a) Ventral view of a male *Oesophagostomum mocambiquei*
(b) *En face* view of the head of a male *Oesophagostomum mocambiquei* showing the round mouth opening
(c) The head of a male *Oesophagostomum mwanzae,* showing the oval mouth opening

a = amphid
cg = cervical groove
lc = leaf crown
cp = cervical papillae
cop = circum-oral papillae

The spicules are long and slender and terminate in curved points that are enclosed in membranous alae. Transversely striated alae are present along their median margins. The gubernaculum is undulated in lateral view, but broadly diamond-shaped in dorsal or ventral views (Fig. 6). The genital cone is simple.

Apart from slight differences in the principal measurements of the type specimens, and thus the females of the species, Ortlepp's (1964) description is accurate.

For comparative purposes, the head of *O. mwanzae,* which has an oval buccal capsule, is illustrated in Fig. 7c.

DISCUSSION

Ortlepp (1964) described 2 new *Oesophagostomum* species from warthogs as *O. moçambiquei* and *O. santos-diasi,* using the c-cedilla and a hyphen respectively. Horak *et al.* (1988) disregarded the c-cedilla in the species name *mocambiquei* but retained the hyphen in the name *santos-diasi*. Under the code of International Zoological Nomenclature, diacritic marks, including hyphens, are not allowed, and the species names are corrected here to *Oesophagostomum mocambiquei* and *Oesophagostomum santosdiasi.*

During this study it was found that the larger the total individual worm burden, the smaller the worms tended to be, and vice versa. This probably explains the differences in some of the measurements of the type specimens and those examined during this study. It also explains the rather wide range of the principal measurements of the worms examined during this study (Table 1).

No characteristic differences in the configuration of the bursa and its associated rays exist between the different *Oesophagostomum* spp. from warthogs. The protuberance on the median branch of the dorsal ray was illustrated and commented on by Daubney (1926) in *Oesophagostomum roubaudi* Daubney, 1926 and *O. mwanzae,* and is also present in *O. mocambiquei.*

O. mocambiquei closely resembles *O. santosdiasi* in the principal measurements. The most outstanding difference between the males of these two species is the shape of the buccal capsule, which is round in *O. mocambiquei* but oval in *O. santosdiasi,* similar to that of *O. mwanzae.*

Twelve *Oesophagostomum* spp. have so far been recovered from the large intestines of warthogs in Africa. They are *Oesophagostomum aethiopicum* Duthy, 1947, *Oesophagostomum eurycephalum*

Goodey, 1924, *Oesophagostomum farchai* Troncy, Graber & Thal, 1972, *Oesophagostomum goodeyi* Daubney, 1926, *O. mocambiquei, Oesophagostomum mpwapwae* Duthy, 1947, *O. mwanzae, Oesophagostomum oldi* Goodey, 1924, *O. roubaudi, O. santosdiasi, Oesophagostomum simpsoni* Goodey, 1924, and *Oesophagostomum yorkei* Thornton, 1924. There is, however, some doubt as to the correctness of the collection data, since Duthy (1947) reported that *O. mpwapwae, O. mwanzae, O. simpsoni* and *O. yorkei* were present in helminth collections from elephant, *Loxodonta africana,* and Goodey (1924) stated that *O. eurycephalum, O. mwanzae, O. oldi* and *O. simpsoni* were found in helminth collections from roan antelope, *Hippotragus equinus.* The fact that the records have been made cannot be ignored (Round, 1968) and they are therefore included in the list.

Of the worms listed above, only *O. mocambiquei, O. mwanzae, O. santosdiasi* and *O. simpsoni* have been found in warthogs in South Africa (Ortlepp, 1964; Horak *et al.,* 1988), while *O. mpwapwae, O. mwanzae* and *O. roubaudi* were recovered from warthogs from Namibia (Horak, Biggs, Hanssen & Hanssen, 1983). The differences between these 6 species are summarized in Table 2 and a simplified key for the identification of the *Oesophagostomum* spp. of warthogs in South Africa and Namibia is given below.

A simplified key to the *Oesophagostomum* spp. of warthogs in South Africa and Namibia.

Females

1. Tail bent dorsalwards 2
   Tail straight 5
2. Mouth capsule cylindrical .... *O. mocambiquei*
   Mouth capsule oval 3
3. Oesophageal valves present .... *O. mwanzae*
   Oesophageal valves absent 4
4. Vagina about 1 mm long .... *O. santosdiasi*
   Vagina not longer than 0,26 mm ..... *O. roubaudi*
5. Mouth capsule cylindrical .... *O. mpwapwae*
   Mouth capsule oval .... *O. simpsoni*

Males

1. Mouth capsule oval 2
   Mouth capsule round 5
2. Oesophageal valves present .... *O. mwanzae*
   Oesophageal valves absent 3
3. Spicules 2,4 to 2,7 mm long .... *O. santosdiasi*
   Spicules less than 1,5 mm long 4
4. Oesophagus short and wide with parallel sides .... *O. simpsoni*
   Oesophagus club-shaped .... *O. roubaudi*
5. Spicules more than 3 mm long .... *O. mpwapwae*
   Spicules less than 3 mm long.... *O. mocambiquei*

ACKNOWLEDGEMENTS

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Stephanofilaria thelazioides n. sp. (Nematoda: Filariidae) from a hippopotamus and its affinities with the species parasitic in the African black rhinoceros

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Abstract

Stephanofilaria thelazioides n. sp. (Filarioidea: Filariidae: Stephanofilariinae) is described from a hippopotamus *Hippopotamus amphibius*. This nematode is close to *S. dinniki* Round, 1964, a parasite of the black rhinoceros *Diceros bicornis* in Africa, but differs from it in the number of cuticular spines surrounding the mouth, the arrangement of the cloacal papillae and the measurements of the spicules, gubernaculum and microfilariae. Species of the genus *Stephanofilaria* possess spines on the head which have been derived by modification of the sensory papillae. *S. thelazioides* is the most primitive species of the genus and has the least modified arrangement of these papillae, with six bifid internal labial spines, four bifid external labial spines and four cephalic papillae. The genus appears to have diversified in various mammals which have in common a thick skin, such as rhinoceroses, elephants, buffaloes and now the hippopotamus. It appears to have become adapted secondarily to domestic bovines, initially in Asia and subsequently in North America.

Introduction

During a recent drought in the Kruger National Park, it became necessary to cull a number of hippopotami in several rivers traversing the park. One of these animals had an ulcerated skin lesion of about 5 cm in diameter on the shoulder region. The lesion was excised, preserved in 10% buffered formalin and submitted to one of us (NPJK) for examination and diagnosis.

Histopathological examination revealed numerous nematodes embedded in a hyperplastic epidermis. Preliminary examination of the remainder of the lesion indicated that the worms belonged to the genus *Stephanofilaria* Ihle & Ihle–Landenberg, 1933, but they could not be assigned to any known species.

Materials and methods

Nematodes were dissected out of the lesion mentioned above using a stereoscopic microscope. Fourteen females, including the holotype, and two males, the allotype and a paratype, were recovered. In addition, the anterior and posterior ends of several females, as well as one anterior and two posterior ends of males, were found. All the specimens are housed in the collection of the Museum National d'Histoire Naturelle, Paris, number MNHN 122HS. Measurements were derived from *camera lucida* drawings.

Stephanofilaria thelazioides n. sp.

Type-host and locality: *Hippopotamus amphibius* Linnaeus, 1758, from the Kruger National Park, Republic of South Africa.

Description (Figs 1–3)

Cuticle without frills but transverse striations well-defined and large at level of mid-body (Fig. 2E). Head with projecting cuticular ring, hexagonal in apical view (Fig 1); external border of ring vertical; internal border gently sloping. Six small bifid cuticular internal labial spines on internal aspect of ring; further posterior are 4 cuticular external labial spines and, at their bases, 4 cephalic papillae. Amphids at level of external labial spines. Deirids bifid (Figs 2D, 3B), posterior to nerve-ring. Oral opening hexagonally-rounded; buccal cavity with thin wall. Oesophagus joining intestine immediately posterior to nerve-ring (Figs 2C, 3A).

Female. Lateral alae absent. Vulva near anterior end; vagina slender anteriorly; ovejector initially slightly dilated, then tubular (Figs 2B, C); opisthodelphic; ovaries and oviducts short. Tail almost straight or slightly curved ventrally, with rounded tip and subterminal phasmids (Fig 2H). Few microfilariae present in females examined; head slightly narrower than body; posterior end conical; sheath with same shape as microfilaria.

Male. Testes at mid-body; vas deferens runs anteriorly and reflexes near posterior extremity of oesophagus. *Area rugosa* with pattern of small beads packed close together, situated latero-ventrally (Figs 3D,E,G); at border of *area rugosa* bead-like pattern replaced by small longitudinal ridges (batonnets). Cuticle expanded in pre- and postcloacal regions, ventrally and laterally, forming caudal vesicle with lateral alae. Fifteen pairs of caudal papillae, arranged in 3 groups: one group of ventral ventro-lateral papillae comprising single precloacal papilla, one adanal pair, 2 strongly pedunculate postcloacal pairs and 2 subterminal pairs (Figs 3D, E); one group of 2 latero-ventral rows of pedunculate papillae, hind-most being at level of cloaca, the anterior-most 300 μm anterior to cloaca; and one group of 2 lateral rows of 3–4 pedunculate pairs in pre- and postcloacal regions (Fig 3F). Left spicule long and thin (Fig 3H) with shaft slightly longer than blade and spirally twisted distal tip (Fig 3I). Right spicule with shaft and blade only slightly differentiated; membranous alae present along blade; tip obtusely conical (Fig 3J). Gubernaculum lightly sclerotised.

Measurements (in micrometres unless otherwise stated)

Females. (Measurements are for holotype, with range in parentheses). Body 6.8 (6.3–6.8) mm long and 135 (135–180) wide; nerve-ring and deirids 110 (90–150) and 210 (140–275) respectively from anterior end; buccal capsule length 10 (10–11); oesophagus 150 (144–171) long; vulva 35 (22–35) from anterior end; vagina 220 (130–220) long; ovejector 280 long; tail 60 (50–60) long. Microfilariae expressed from ovejector 180 (160–195) long and 8 (8–10) wide.

Males. (Measurements are for allotype, with paratype fragments in parentheses). Body 3.2 (3.2) mm long, 80 (90) wide; length of buccal cavity 7 (7); nerve-ring and deirids 100 (80) and 160 (127) respectively, from anterior extremity; tail 30 (25, 25) long; left spicule 945 (880, 925) long with blade 500 (500, 475) long; right spicule 130 (120, 148) and gubernaculum 35 (25, 35) long.

Discussion

Sonin (1977) and Johnson (1987) revised the species of the genus *Stephanofilaria* and no new species have been added subsequently. Like Johnson (1987), we are of the opinion that *Stephanofilaria andamani* Sinha & Das, 1958 from the water buffalo *Bubalus bubali* in the Andaman islands and *Stephanofilaria srivastavi* Bhattacharjee, 1967 from the elephant *Elephas maximus* in India are *species inquirendae*, because "no taxonomic descriptions have been published in support of either name" (Johnson, 1987). Four species are currently recognised: *Stephanofilaria dedoesi* Ihle & Ihle–Landenberg, 1933 is a parasite of cattle, goats and water buffalo in Indonesia. Johnson (1987) considered *S. assamensis* Pandit, 1936 from India, *S. kaeli* Buckley, 1937 from Malaysia and *S. okinawaensis* Ueno & Chibana, 1977 from Japan (erroneously assigned to *S. rono* Kono, 1965 by Ivashkin, Shmytova & Koishibaev, 1971) as probable synonyms of *S. dedoesi*. All these species (or subspecies?, or synonyms?) have several features in common: cuticle with frills; head with a circle of internal labial spines, a circle of external labial spines and four cephalic papillae; female with the vulva at the level of the nerve-ring and a short conical tail; male with the left spicule 150–230 μm long, right spicule 40–50 μm long, gubernaculum present and lateral alae absent; and microfilariae 85–140 μm long with an elongate sheath.

Stephanofilaria zaheeri Singh, 1958 is also a parasite of cattle in Asia. Nevertheless, it may be distinct from *S. dedoesi* in that it has more internal and external

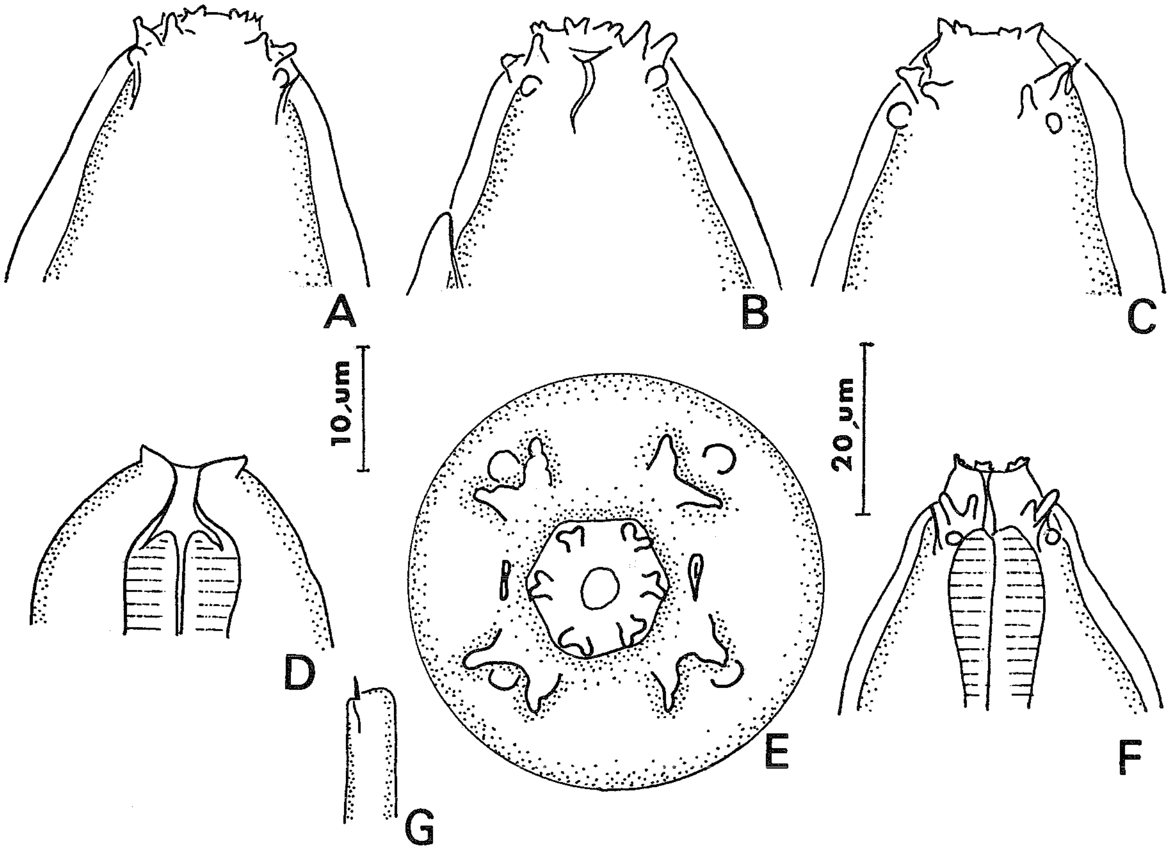

Fig. 1. *Stephanofilaria thelazioides* n. sp. Cephalic extremities of the female (A–E), the male (F) and the microfilaria (G). A, dorsal view; B, left lateral view; C, ventral view (since the head is slightly curved dorsally the internal labial papillae are more visible in A and the external labial papillae in C); D, longitudinal optical section, lateral view; E, apical view; F, lateral view; G, ventral view. *Scale-bars*: A,B,C,D,F, 20 μm; E,G, 10 μm.

labial spines (23–24 *vs* 15–18, and 28–32 *vs* 16–23). Singh (1958) stated that four external labial and four cephalic papillae are present, but these are difficult to see in such a small worm.

Stephanofilaria stilesi Chitwood, 1934 is a parasite of *Bos taurus* in the Nearctic region, but it has also been found in Russia. It differs from the previous species in the configuration of the cephalic structures, i.e. the external labial papillae are not transformed into cuticular spines (Anderson, 1968), there are five submedian cuticular spines (lateroventral according to Hibler, 1966), and frills on the cuticle of the body are absent. The microfilariae are also much smaller (40–60 μm long, 2–4 μm wide) and possess an ovoid sheath (Hibler, 1966).

Stephanofilaria dinniki Round, 1964 is a parasite of the black rhinoceros *Diceros bicornis* (Linnaeus, 1758) in East and South Africa. This species has no frills on the cuticle of the body. Round (1964) stated that the head bears a crown of 11–12 peribuccal spines (but illustrates 16), eight spines grouped in pairs slightly posteriorly and four cephalic papillae. This species also differs from the others in that the vulva is situated more anteriorly, the vagina is longer, the nerve-ring is further posterior, and the tail of the female is longer than wide and its tip is rounded; the spicules are also longer, the caudal alae are present and the cloacal papillae are pedunculate.

The last named species is the only one that bears close resemblance to our specimens. It was not possible to do comparative studies because the material from the rhinoceros had been lost. Nevertheless, the description of Round (1964) is precise and clearly shows the distinctive characteristics of the head, the caudal papillae and the dimensions of the spicules, gubernaculum and microfilariae. *S. dinniki* differs from our speci-

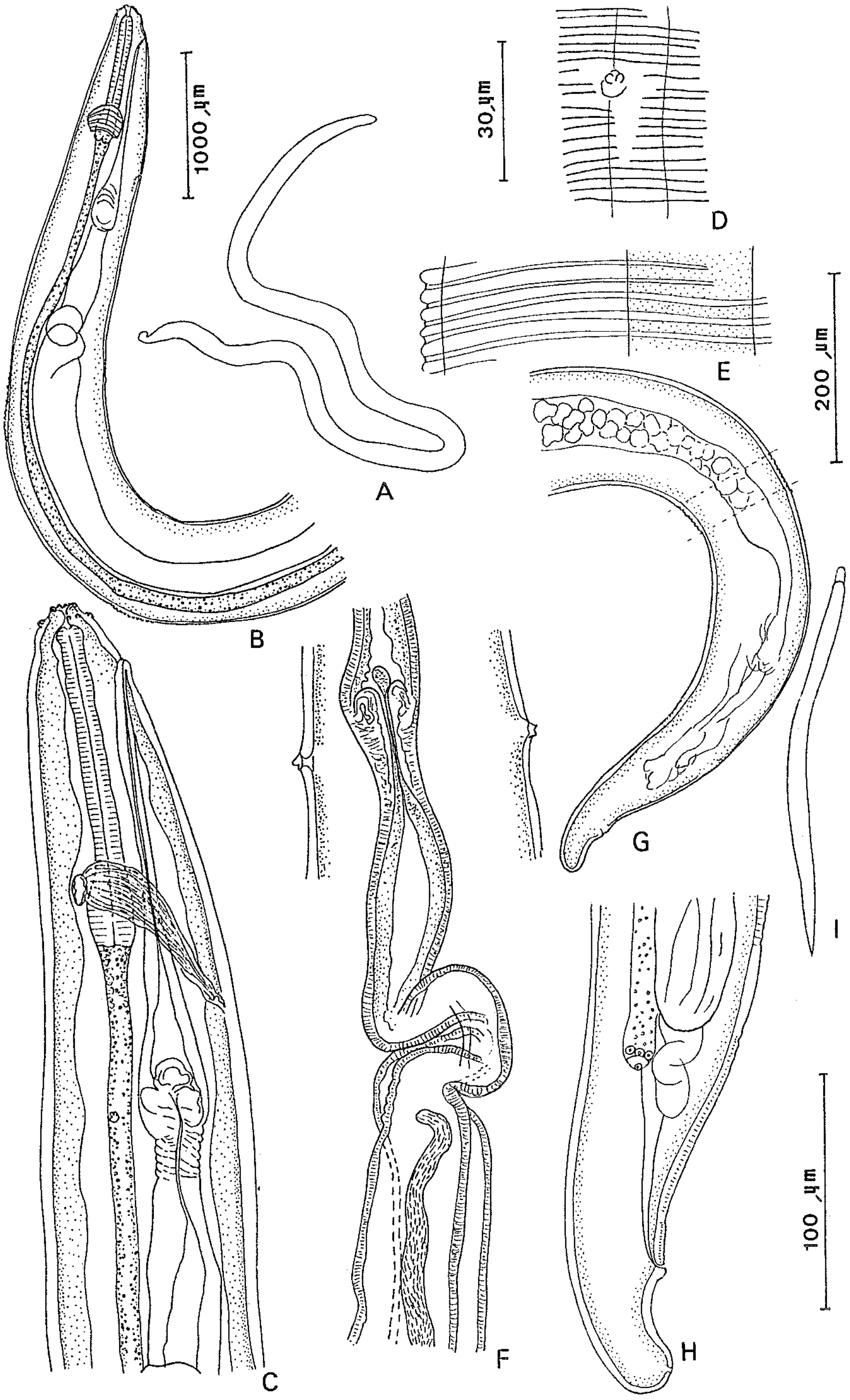

Fig. 2. *Stephanofilaria thelazioides* n. sp. Female. A, entire body; B, anterior region in right lateral view; C, anterior extremity in right lateral view showing the oesophagus and vagina; D, deirid; E, cuticular ornamentation; F, deirids and the division of the ovejector; G, posterior region; H, posterior extremity; I, microfilaria. *Scale-bars*: A, 1,000 µm; B,G, 200 µm; C,F,H, 100 µm; D,E,I, 30 µm.

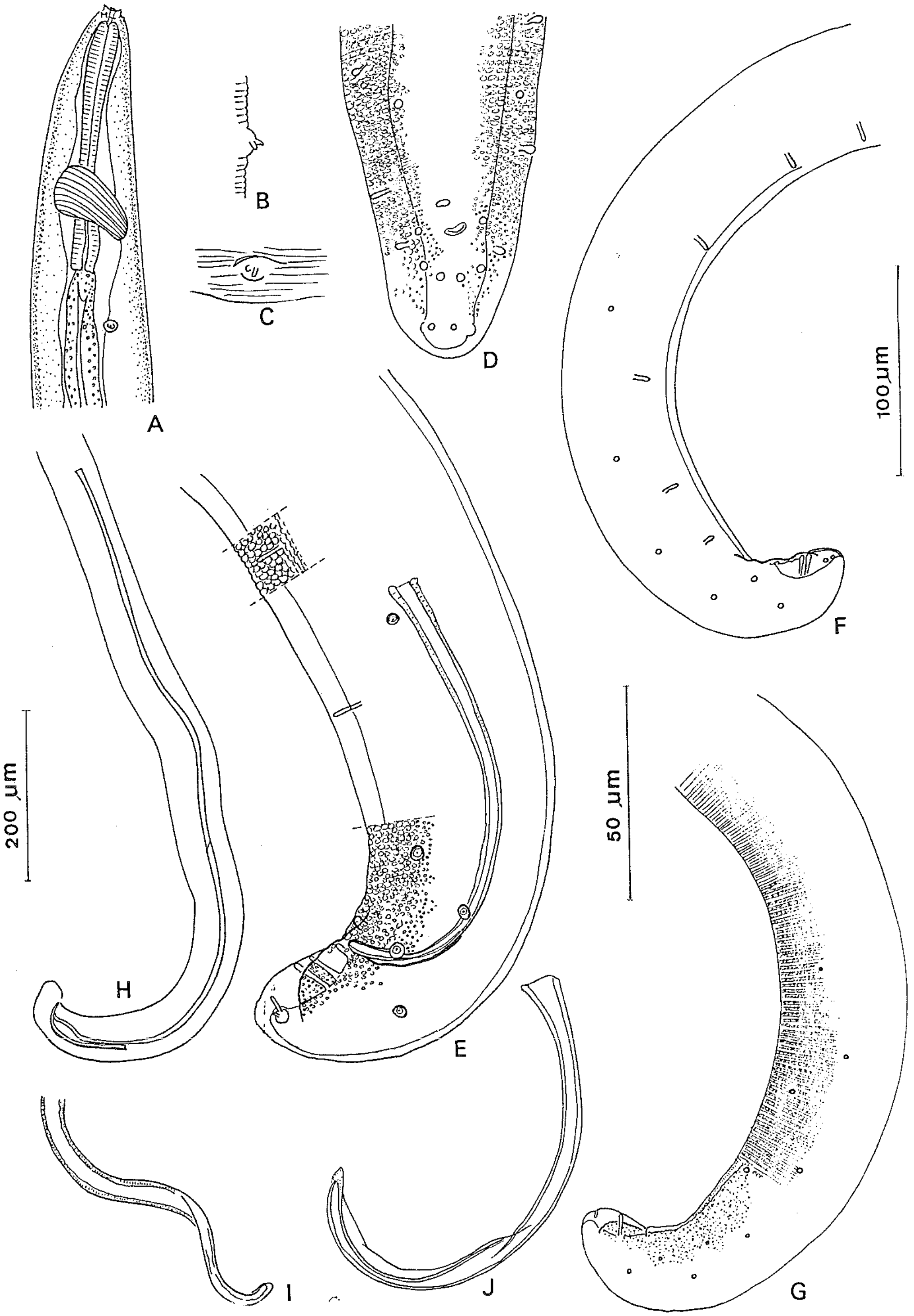

Fig. 3. *Stephanofilaria thelazioides* n. sp. Male. A, anterior extremity, right lateral view; B, deirid, median view; C, deirid, lateral view; D, posterior extremity, ventral view; E, posterior extremity, left lateral view, showing the right spicule and gubernaculum (the cuticular ornamentation is not drawn at mid-body); F, posterior extremity, right lateral view, showing the arrangement of the cloacal papillae; G, posterior extremity, left lateral view, showing the cuticular ornamentation; H, spicules; I, tip of the left spicule; J, right spicule. *Scale-bars*: H, 200 µm; A,D,F,G, 100 µm; B,C,E,I,J, 50 µm.

mens in the following respects: the head bears 12 (or 16?) internal labial spines arranged regularly, while our specimens have six distinct bifid spines; the three pairs of ventral postcloacal papillae are close together, while in our specimens one pair is adanal and two pairs are clearly more posterior; the left and right spicules and the gubernaculum are, respectively, 62–115, 530–750 and 11–14.5 μm long, while in our specimens they are 880–945, 120–148 and 25–35 μm in length; and the microfilariae are 120–150 μm long and have a cuticular cap, while in our specimens they are 180 μm long and without a cap.

In view of these differences, we consider the specimens from the hippopotamus to be a new species for which we propose the name *Stephanofilaria thelazioides* n. sp. The specific name refers to the affinities of *Stephanofilaria* with the genus *Thelazia* Bosc, 1819, previously established by Anderson (1957), Anderson & Bain (1976) and Bain (1981), which are especially apparent in the new species.

The different species of the genus *Stephanofilaria* can be classified phyletically. They have a cephalic ring which is already present in the larval stages (Hibler, 1966). The spines on the head, equally characteristic of the genus, are derived by modification of the sensory papillae, and these spines have become more modified as the species evolve. Several other characteristics give an indication of the degree of specialisation in each species: female and male tails that are shortened to a lesser or greater degree; caudal papillae which may or may not be numerous and have a lesser or greater tendency to accumulate in the cloacal region; and the considerable variation in the length of the spicules.

Based on the above, *S. thelazioides* from the hippopotamus appears to be the most primitive. *S. dinniki* from the rhinoceros is closely related, but the disposition of the spines on the head and the cloacal papillae are slightly more specialised. The species parasitising the domesticated Asiatic mammals (water buffalo, cattle, goats and elephants) are clearly more evolved, as is indicated by the multiplication of the internal labial and external labial spines and the shorter tail, as well as by the development of cuticular frills covering the body. *S. stilesi*, a parasite of cattle in North America, has the most advanced morphology in that the cuticular spines on the head are replaced by a small newly formed group of latero-ventral spines and in that the tail of the male is very short with the papillae arranged around the cloaca (Ivashkin, Timofeeva & Khromova, 1961).

Hippopotami, rhinoceroses, elephants and water buffaloes are mammals without obvious zoological affinities, but they have a thick skin in common. The evolution of the genus *Stephanofilaria* seems to be associated with this favourable biotope rather than with the phylogeny of the hosts. We assume that this genus is of African origin, was introduced into Asia and that its occurrence in cattle is recent.

Acknowledgements

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Onderstepoort Journal of Veterinary Research, 67:173–177 (2000)

Molineus cati n. sp. (Nematoda, Trichostrongylina, Molineoidea), a parasite of feral cats, *Felis catus* Linnaeus, 1758 in South Africa

MARIE-CLAUDE DURETTE-DESSET[1], J. BOOMKER[2] and F.S. MALAN[3]

ABSTRACT

DURETTE-DESSET, MARIE-CLAUDE, BOOMKER, J. & MALAN, F.S. 2000. *Molineus cati* sp. n. (Nematoda, Trichostrongylina, Molineoidea), a parasite of feral cats, *Felis catus* Linnaeus, 1758 in South Africa. *Onderstepoort Journal of Veterinary Research*, 67:173–177

A new species of the genus *Molineus* Cameron, 1923 was recovered from feral cats, *Felis catus* Linnaeus, 1758, in Mpumalanga Province, South Africa. Because of a caudal bursa with rays of the 2-1-2 type, but with the extremities of rays 4 nearer those of rays 3 than those of rays 5, the new species is closely related to seven Neotropical *Molineus* spp., four parasitic in Primates, two parasitic in Mustelidae and one a parasite of Procyonidae. Amongst these species, only *Molineus barbaris* Cameron, 1936, a parasite of *Tayra barbara* (Mustelidae) from Trinidad and *Molineus vexillarius* (Dunn, 1961), a parasite of *Tamarinus nigricollis* (Primates) from Peru have rays 4 longer than two-thirds the length of rays 3, like the new species. However, the new species is differentiated from the other two in that rays 9 arise at the level of the bifurcation of the dorsal ray and not after the division as is the case with *M. barbaris* and *M. vexillarius*.

Keywords: *Molineus cati*, Nematoda, Trichostrongylina, Molineoidea, *Felis catus*, Felidae, South Africa

INTRODUCTION

The genus *Molineus* was created by Cameron (1923) and redefined by Durette-Desset & Chabaud (1981b). It consists of 28 species, parasitic in Carnivora throughout the world (except Australia) and in Neotropical Primates. Three species were described in the Afrotropical region, two from Viverridae (Cameron 1927; Le Roux 1933) and one from Canidae (Troncy 1970). The new species represents the first record of a *Molineus* sp. of Felidae in this region. However, since it is a parasite of a domestic cat, *Felis catus* Linnaeus, 1758, it is not possible to determine whether it is a parasite of the Afrotropical region or was introduced from some other biogeographical region together with its host.

MATERIALS AND METHODS

During a survey of *Taenia* spp. in the vicinity of Middelburg, Mpumalanga Province (25°44'–25°47'S; 29°25'–29°30'E), a total of 22 feral domestic cats were caught and processed for worm recovery. Nematodes of the genus *Molineus* were encountered in the small intestine of four of these cats. The helminths were fixed and stored in 70 % ethanol, studied in temporary wet mounts in water and, when necessary, cleared in lactophenol. Apical views and cross-sections were mounted and studied in lactophenol. Measurements are given in micrometers unless otherwise stated.

The nomenclature of taxa higher than the family-group is that of Durette-Desset & Chabaud (1993).

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The synlophe was studied according to the method of Durette-Desset (1985), and the nomenclature used for the components of the caudal bursa is that of Durette-Desset & Chabaud (1981a).

DESCRIPTION

Type material

Holotype male, allotype female, number 187 MQa; three male and two female paratypes plus three posterior parts of female paratypes, number 187 MQb. All the specimens have been deposited in the Museum National d'Histoire Naturelle, Paris.

Type host

Felis catus Linnaeus, 1758 (Carnivora, Felidae).

Site

Small intestine.

Type locality

Middelburg, Mpumalanga Province (25°44'–25°47'S; 29°25'–29°30'E).

Etymology

The species is named after its host.

Description

Small nematodes, body not coiled. The nerve ring, excretory pore and deirids are situated at the same level, at mid-oesophagus (Fig.1I). A circular excretory groove, not surrounded by cuticular expansions, is present, as is an excretory sinus, 38 long (Fig. 1A and B).

Head

A cephalic vesicle is present. In apical view, the buccal opening is rounded and surrounded by two small amphids, six externo-lateral papillae and four cephalic papillae (Fig. 1D).

Synlophe

(Studied in one male and one female). In both sexes, the cuticle bears a varying number of uninterrupted ridges which appear posterior to the excretory groove (Fig. 1C) and disappear just anterior to the caudal bursa in male and at the caudal extremity in female (Fig. 1H). In the male, the number increases from 14 at the level of the oesophago-intestinal junction to 16 at mid-body (Fig. 1E), then to 28 in front of caudal bursa (Fig. 1F). In the female, the number increases from 21 at the oesophago-intestinal junction to 28 in the anterior third of body, then decreases to 16 at mid-body and increases again to 30 in the posterior third of body. Only the ventral ridges are interrupted in front of the vulva (Fig. 1G). Ridges are regularly spaced except those opposite the lateral fields, which are closer together and slightly smaller than the other. The smaller ridges continue for the entire length of the body of the male (Fig. 1E and F) but are present only at mid-body in female. Ridges are orientated perpendicularly to the body surface (Fig. 1E–H).

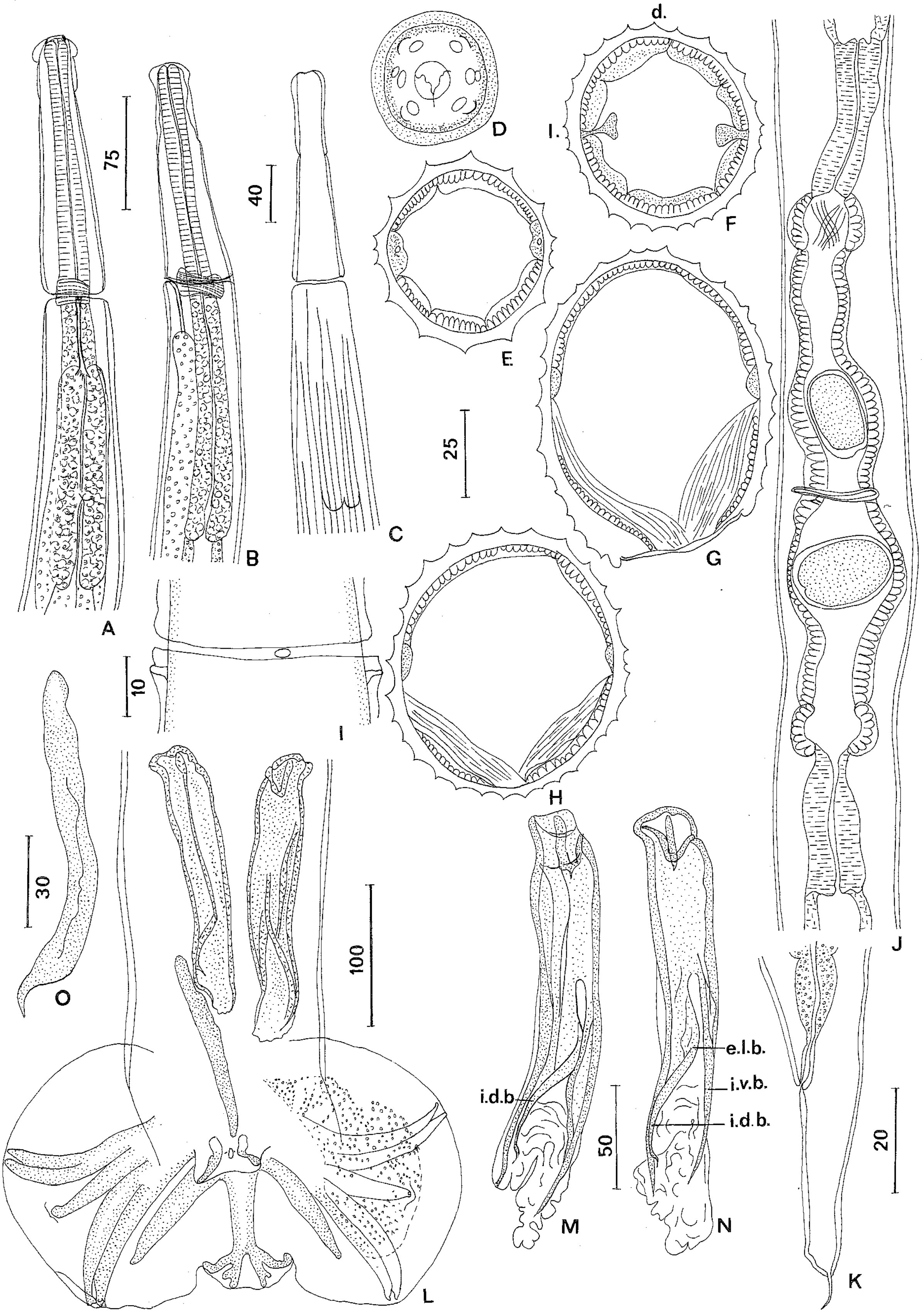
FIG. 1 *Molineus cati* n. sp.

A: Female, anterior extremity, ventral view
B: Holotype male, anterior extremity, left lateral view
C: Male, anterior extremity, ventral view showing the appearance of the cuticular ridges
D: Male, head, apical view
E–H: Transversal sections of the body
E: Male at mid-body
F: Male, 400 µm above caudal bursa
G: Female at vulva level
H: Female, between vulva level and tail
I: Female, detail of the excretory pore, the excretory groove and the deirids, ventral view
J: Female, ovejector, ventral view
K: Female tail, left lateral view
L: Male, caudal bursa, ventral view. The spiny projections are illustrated only on the left lateral lobe
M, N: Left spicule, dorsal and internal views
O: Male gubernaculum, left lateral view

Note: The transversal sections are all orientated as indicated in Fig. 1F

Abbreviations: d, dorsal side; l, left side; e.l.b., externo-lateral branch; i.d.b., interno-dorsal branch; i.v.b., interno-ventral branch

Scale bars: A, B, J: 75 µm; C: 40 µm; D, O: 30 µm; E-H: 20 µm; I: 10 µm; K: 20 µm; L: 100 µm; M, N: 50 µm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i.v.b.
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20
K

Holotype male

The nematode is 5,1 mm long and 65 wide at midbody. The cephalic vesicle is 55 long by 20 wide. The nerve ring, excretory pore and deirids are situated at 150, 150 and 155 from the apex, respectively, and the oesophagus is 335 long (Fig. 1B).

The caudal bursa is symmetrical and the bursal ray pattern is of type 2-1-2. Spiny projections occur on the lateral lobes (Fig. 1L). Rays 4 are short with their extremities nearer those of rays 3 than those of rays 5. Rays 8 are thick and arise from the basis of the dorsal ray, and are slightly shorter than the latter. The dorsal ray is divided into two branches at its distal extremity, each one in turn giving rise to three small branches; firstly, the external branches (rays 9), then the phasmids and rays 10 (internal branches).

The spicules are alate, 95 long, with the handle slightly shorter than blade. The blade is divided into two primary branches, the externo-lateral branch and the interno-ventral branch. The interno-dorsal branch arises from the externo-lateral branch and is smaller. All three the branches have sharp tips and are enveloped by a membrane (Fig. 1M and N). In ventral view the gubernaculum is rectangular in shape while in lateral view it is slightly curved (Fig. 1O).

The two paratype males are 4,6 and 4,8 mm long and 65, 60 wide at mid-body. The cephalic vesicle measures 50, 55 long by 20, 20 wide. The nerve ring, excretory pore and deirids are situated at the same level, 160, 160 and 165 from the apex, respectively. The oesophagus is 360, 355 long. The spicules are 105, 120 long and the gubernaculum is 75, 72 long in ventral view.

Allotype female

This female is 5,7 mm long and 65 wide at mid-body. A cephalic vesicle is present and measures 60 long by 20 wide. The nerve ring, excretory pore and deirids are situated at 165, 170, 175 from the apex, respectively. The oesophagus is 390 long. The uterus is didelphic and the vulva situated 1 100 from the caudal extremity, in the posterior sixth of the body. The *vagina vera* is 25 long and the vestibule 320 long. The anterior sphincter and infundibulum are 35 x 40 and 65 long, respectively, and the posterior sphincter and infundibulum 30 x 40 and 55 long, respectively (Fig. 1J). The anterior uterine branch is 960 long and contains 8 eggs while the posterior uterine branch is 500 long and contains 6 eggs. The eggs, in the morula stage, are 60 long by 45 wide. The tail is 60 long and the caudal spine is broken (seen only in 2 paratypes, 11 long) (Fig. 1K).

The two paratype females are 6,4 and 5,9 mm long and 80, 60 wide at mid-body. The cephalic vesicle is 65, 55 long by 23, 20 wide and the nerve ring is situated 180, 140 from the apex, the excretory pore 180, 140 and the deirids 185, 145, respectively. The oesophagus is 370, 360 long. Vulva is situated 1,1 and 1,2 mm from the caudal extremity. The vestibule is 305, 320 long. The anterior sphincter and infundibulum measure 45 x 48, 35 x 45 and 100, 70 long, respectively and the posterior sphincter and infundibulum 35 x 45, 30 X 40 and 90, 80 long, respectively. The anterior uterine branch is 800, 840 long and contains 12, 9 eggs while the posterior uterine branch 550, 580 long with 10, 4 eggs. Eggs in the morula stage measure 50, 58 long by 35, 40 wide. The tail is 60, 60 long and the caudal spine 11, 11 long.

DISCUSSION

The specimens from *Felis catus* belong to the genus *Molineus* Cameron, 1923 (Molineoidea), because of a synlophe with ridges orientated perpendicularly to the body surface and the pattern of the bursal rays. Rays 2 and 3 (ventral) are close together and run parallel as do rays 5 and 6 (lateral) and a short 4th ray is present. The spicules are short and thick, and the female is didelphic and her tail bears a spine.

Amongst the 28 species described, only seven species (four in Primates, two in Mustelidae and one in Procyonidae), all of Neotropical origin, share two common characters with the parasites of the cat, namely that the pattern of the caudal bursa is of type 2-1-2 (i.e. rays 4 arising from the common trunk at the same level as rays 2 and 3 on one side and rays 5 and 6 on the other) tending towards type 3-2 (i.e. extremities of rays 4 nearer those of rays 3 than those of rays 5) (Durette-Desset & Chabaud, 1981a). The second characteristic lies in the shape of the spicules, which have a blade that is divided into three branches of equal length.

Of these seven Neotropical species, five can be separated from the specimens of the cat by rays 4, which are shorter than two-thirds of the length of rays 3. Three species, *Molineus elegans* (Travassos, 1921), from *Saimiri sciurea* in Brazil, *Molineus midas* Durette-Desset & Corvione, 1998, from *Sanguinus midas* in French Guyana and *Molineus torulosus* (Molin, 1861) from *Cebus capucinus* in Brazil, occur in Primates, *Molineus nasuae* Lent et Freitas, 1938 occurs in *Nasua narica* (Procyonidae) in Brazil and *Molineus major* Cameron, 1936 in *Tayra barbara* (Mustelidae) from Trinidad. The parasites of the Primates and of *N. narica* are differentiated by the shape of the gubernaculum, of which the proximal part is adorned with a hook while the parasite of *T. barbara* is characterized by rays 8 being much shorter than the dorsal ray. In the remaining two species, *Molineus barbaris* Cameron, 1936 from *T. barbara* from Trinidad and *Molineus vexillarius* (Dunn, 1961) from *Tamarinus nigricollis* (Primates) in Peru, like in the

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specimens of *Felis*, rays 4 are longer than two-thirds the length of rays 3. However, *M. barbaris* and *M. vexillarius* can be differentiated from *M. cati* in that rays 9 arise on the dorsal ray after the division of the latter whereas rays 9 arises at the level of the division in the parasites of the cat.

The parasites of *Felis cati* belong to a new species for which we propose the name *Molineus cati* n. sp.

It is interesting to note *M. cati* is closely related to *Molineus* spp. of the Neotropical region rather than the Afrotropical species but, since *Molineus cati* was found in a domestic host, it is not possible to draw conclusions on the origin of the parasite.

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