Tetrameres numida n. sp. (Nematoda: Tetrameridae) from Helmeted guineafowls, *Numida meleagris* (Linnaeus, 1758), in South Africa

K. JUNKER and J. BOOMKER*

Department of Veterinary Tropical Diseases, University of Pretoria
Private Bag X04, Onderstepoort, 0110 South Africa

ABSTRACT

JUNKER, K. & BOOMKER, J. 2007. *Tetrameres numida* n. sp. (Nematoda: Tetrameridae) from Helmeted guineafowls, *Numida meleagris* (Linnaeus, 1758), in South Africa. *Onderstepoort Journal of Veterinary Research*, 74:115–128

Tetrameres numida n. sp. from the proventriculus of Helmeted guineafowls, *Numida meleagris*, in South Africa is described from eight male and four female specimens. The new species shares some characteristics with other *Tetrameres* species, but can be differentiated by a unique combination of characters. It bears two rows of cuticular spines extending over the whole length of the body and possesses two spicules. The left spicule measures 1 699–2 304 µm and the right one 106–170 µm. Caudal spines are arranged in three ventral and three lateral pairs and the tail is 257–297 µm long. Diagnostic criteria of some of the previously described species of the genus *Tetrameres* from Africa and other parts of the world have been compiled from the literature and are included here.

Keywords: Helmeted guineafowls, nematodes, *Tetrameres numida*

INTRODUCTION

The genus *Tetrameres* Creplin, 1846 are cosmopolitan parasites, infecting a variety of aquatic and terrestrial avian hosts. Females are usually located in the proventricular glands, and the males are found free in the lumen of the proventriculus (Anderson 1992).

Several *Tetrameres* species have been recorded from the African continent, of which *Tetrameres fissispina* (Diesing, 1861) Travassos, 1914 that parasitises ducks, pigeons and domestic chickens and *Tetrameres americana* Cram, 1927 that parasitises domestic chickens, turkeys and quails are the most commonly reported ones (Permin, Magwisha, Kassuku, Nansen, Bisgaard, Frandsen & Gibbons 1997; Poulsen, Permin, Hindsbo, Yelifari, Nansen & Bloch 2000).

Tetrameres coccinea (Seurat, 1914) Travassos, 1914 from the Greater flamingo, *Phoenicopterus ruber*, Linnaeus, 1758, Cattle egret, *Bubulcus ibis* (Linnaeus, 1758) and Eurasian spoonbill, *Platalea leucorodia* Linnaeus, 1758, as well as *Tetrameres lhuillieri* (Seurat, 1918) from the Rock partridge, *Alectoris graeca* (Meisner, 1804) and the Stock pigeon, *Columba oenas* Linnaeus, 1758 were recorded from Algeria (Yamaguti 1961). *Tetrameres nouveli* (Seurat, 1914) Travassos, 1914 was present in the Black-winged stilt, *Himantopus himantopus* (Linnaeus, 1758) in Algeria (Yamaguti 1961), and in Nigeria *Tetrameres plectropteri* Thwaite 1926 was found in the Spur-winged goose, *Plectropterus gambensis* (Linnaeus, 1766) (Yamaguti 1961).

* Author to whom correspondence is to be directed. E-mail: joop.boomker@up.ac.za

Accepted for publication date 4 April 2007—Editor

Both *Tetrameres paradisea* Ortlepp, 1932 and *Tetrameres prozeskyi* (Ortlepp, 1964) were described from South African hosts. *Tetrameres paradisea* was recovered from a Stanley's crane, *Anthropoides paradisea* (Lichtenstein, 1793) (Ortlepp 1932), and *T. prozeskyi* occurred in Red-billed hornbills, *Tockus erythrorhynchus* (Temminck, 1823) and Southern Yellow-billed hornbills, *Tockus leucomelas* (Lichtenstein, 1842) (= *Tockus flavirostris leucomelas*), respectively (Ortlepp 1964).

Previous records of *Tetrameres* spp. from guineafowls pertain mostly to studies in North and West Africa, *Tetrameres fissispina* being recorded from Helmeted guineafowls in these countries (Fabiyi 1972; Vercruysse, Harris, Bray, Nagalo, Pangui & Gibson 1985). Appleton (1983) found *Tetrameres* sp. females in Crested guineafowls, *Guttera edouardi* (Hartlaub, 1867) (= *Guttera pucherani*), in Natal (now KwaZulu-Natal Province), South Africa, but because males were not present, the species could not be determined.

We here describe a new species of the genus *Tetrameres* from Helmeted guineafowls in South Africa for which we propose the name *Tetrameres numida* n. sp.

With regards to the classification of the genus *Tetrameres* we have followed that of Chabaud (1975), placing the genus into the subfamily Tetramerinae Railliet, 1915 within the family Tetrameridae Travassos, 1914, which is one of four families comprising the superfamily Habronematoidea. At the time the genus had been divided into the subgenera *Tetrameres* s. str., *Gynaecophila* Gubanov, 1950, *Petrowimeres* Chertkova, 1953 and *Gubernacules* Rasheed, 1960. Chabaud (1975), arguing that this division could lead to errors and bore little phylogenetic significance, chose not to retain these, but divided the genus *Tetrameres* into the two subgenera *Tetrameres* (*Tetrameres*) Creplin, 1846 and *Tetrameres* (*Microtetrameres*) Travassos, 1915. In the light of new findings, especially concerning the morphology of adults and larval stages of these two subspecies, Anderson (1992), while retaining their position within the subfamiliy, recognized *Tetrameres* Creplin, 1846 and *Microtetrameres* Travassos, 1915 as two distinct genera, a generic classification that had been suggested by Skrjabin (1969). We adopt his view in the present paper.

MATERIAL AND METHODS

Fifteen Helmeted guineafowls, *Numida meleagris* (Linnaeus, 1758), were collected on a farm 60 km to the west of Musina (Messina), Limpopo Province, South Africa (22°22.139' S, 29°30.399' E) between July 2005 and November 2006. Ten of these were mature guineafowls and five were young birds, about 6–10 months old (Siegfried 1966).

Eight male *Tetrameres* sp. were recovered from the proventriculus, where they occurred free in the lumen and four females were dissected from the proventricular glands. Two guineafowls harboured a single male each, two hosts harboured two and three males respectively, and from a single host one male and four females were recovered. All hosts were mature guineafowls. The worms were fixed in 70 % ethanol and cleared in lactophenol for identification. All measurements, unless otherwise indicated, are in micrometres.

DESCRIPTION

***Tetrameres numida* n. sp.** (Fig. 1–3; Tables 1, 2)

With characters of the genus. Sexual dimorphism marked.

MALE: Body elongated, tapering towards both ends, posteriorly to a tail with a short, pointed tip. Cuticle with fine transverse striation and longitudinal cuticular grooves. Total length 4.3–4.5 mm; maximum width 0.16–0.17 mm. Inconspicuous lateral alae extending down the length of the body; parallell to these run two lateral rows of cuticular spines (Fig. 2F). One row of spines is situated dorsally, the second row ventrally to the lateral alae (Fig. 1B). A pair of deirids with apical spines is situated at approximately the height of the second pair of cuticular spines at a distance of 139–204 from the apex (Fig. 1B). Cuticular spines start at 93–154 from the apex, numbering approximately 42–47 per row. The nerve ring and excretory pore are 215–284 and 236–331 from the anterior extremity, respectively. The excretory pore is slightly posterior to the nerve ring. The triangular mouth is bounded by a pair of trilobed pseudolabia. The inner surface of each lobe carries two to four tooth-like processes. The precise number is difficult to assess in our specimens (Fig. 1A, 2A). Depth of buccal capsule 16–28, inner diameter 8–11. Oesophagus divided into muscular and glandular portion, 232–401 and 734–984, respectively. Total length of oesophagus 1 023–1 318. Spicules unequal and dissimilar. Right spicule tubular, with slight bend and spatulate tip, 106–170 long (Fig. 1C, 2D). Left spicule long and thin, trough-shaped, with spatulate tip. Shaft slightly twisted at 100–120 from proximal end. Total length 1 699–2 304 (Fig. 1D–F, 2C, 2E). A gubernaculum is absent. Tail

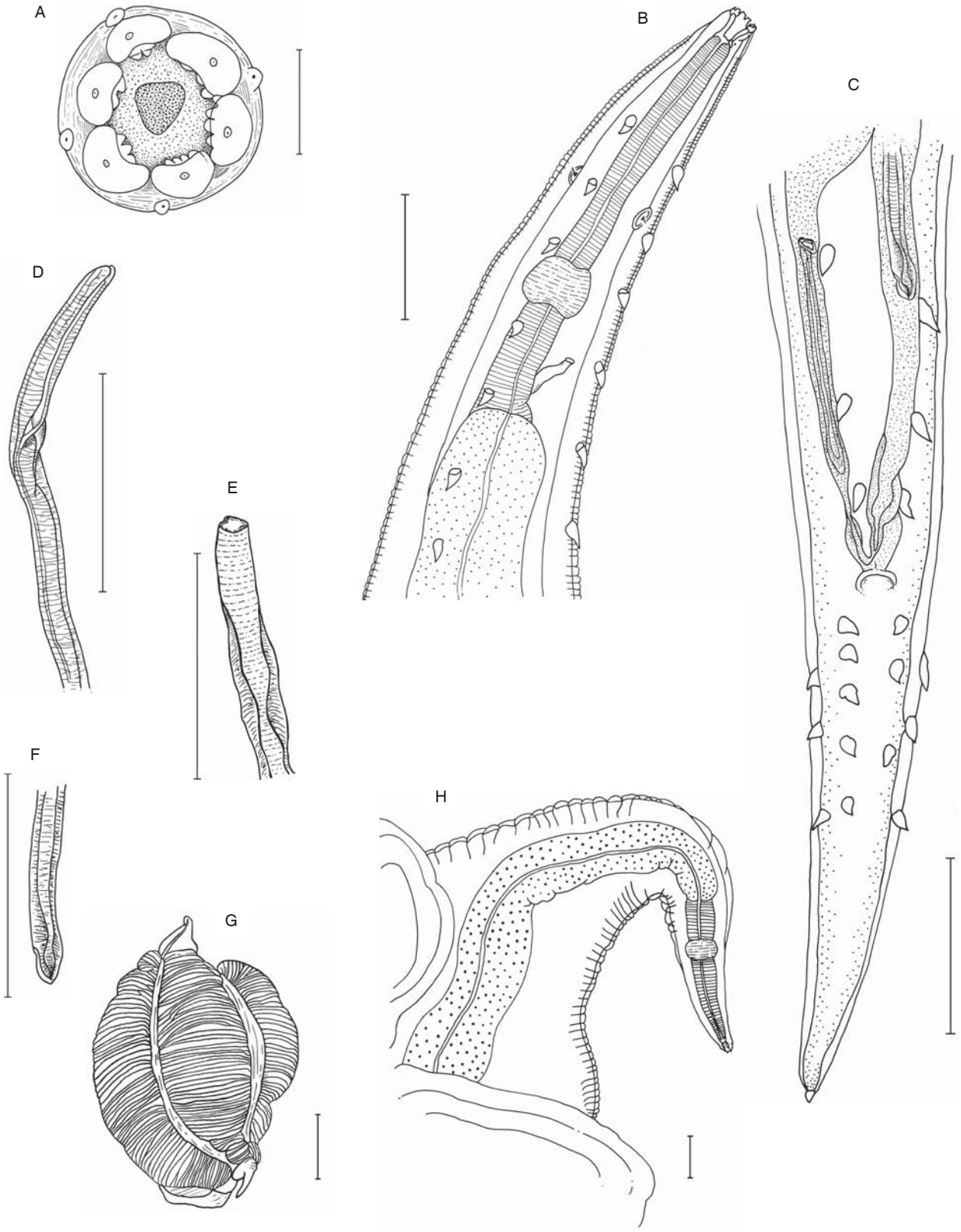

FIG. 1 *Tetrameres numida* n. sp. Male. A. Apical view of the trilobed pseudolabia surrounding the triangular mouth. Note the tooth-like processes (scale bar = 10 µm). B. Ventro-lateral view of the anterior end (scale bar = 100 µm). C. Ventral aspect of the posterior end (scale bar = 100 µm). D. Lateral view of the proximal end of the left spicule showing the slight twist (scale bar = 100 µm). E. Ventral view of the proximal end of the left spicule (scale bar = 100 µm). F. Distal end of the left spicule, ventral view (scale bar = 100 µm). Female. G. Complete female (scale bar = 1 mm). H. Anterior extremity (scale bar = 100 µm)

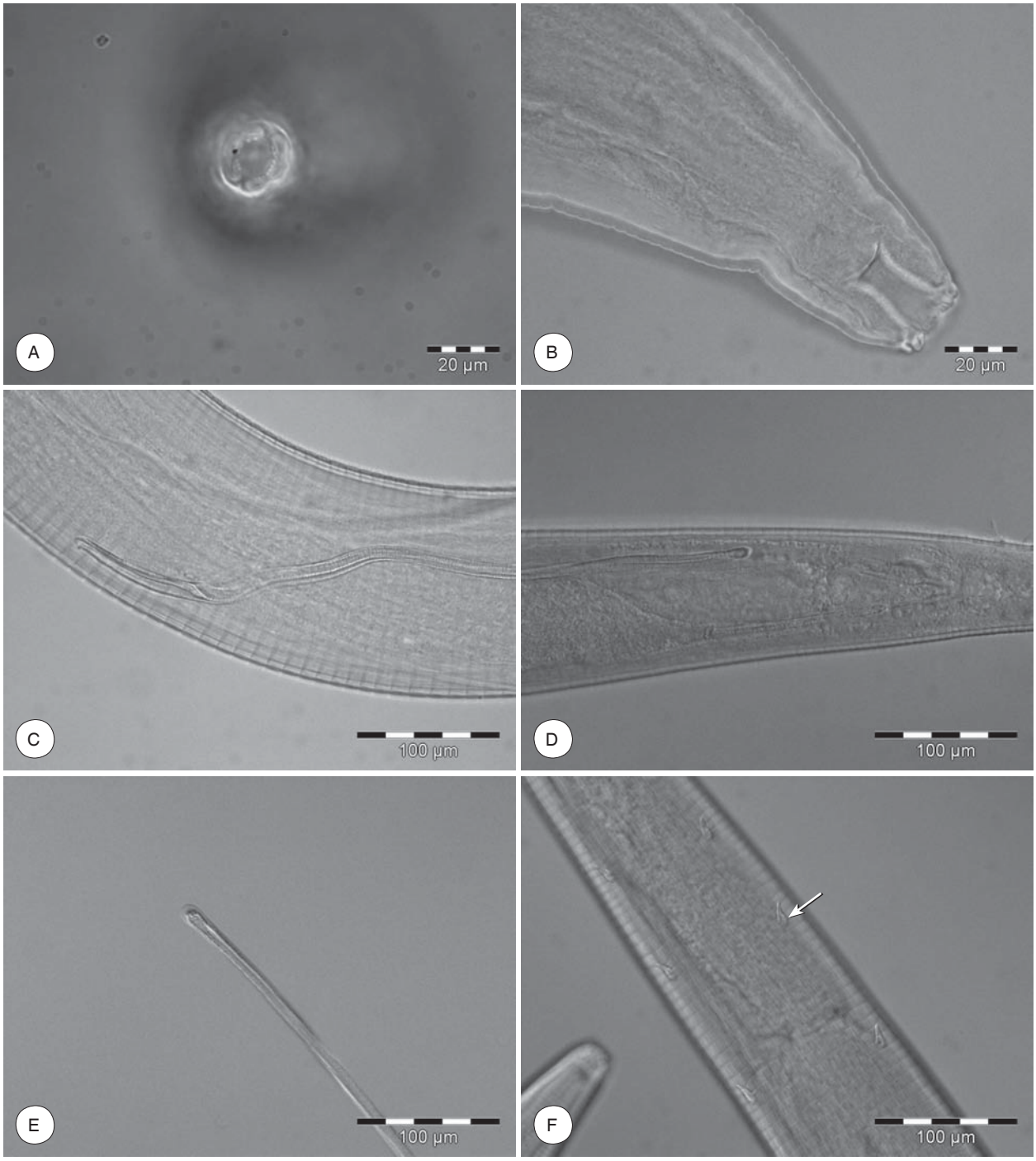

FIG. 2 *Tetrameres numida* n. sp. Male. A. Head, apical view. B. Anterior extremity, ventral view. C. Left spicule, anterior end. D. Posterior extremity with right spicule and distal tip of left spicule. E. Tip of left spicule. F. Body spines (see arrow)

length 257–297. Six pairs of caudal spines, three pairs each in two ventral and two lateral rows, respectively. One or two additional ventral spines may be present (Fig. 1C).

FEMALE: Specimens *in situ* red. A minute head and tail of regular nematode shape, but often twisted or bent, emerge at opposite sides from the central part of the body which is distinctly globular and slightly bent along the axis (Fig. 1G–H, 3A, 3C). The cuticle bears marked transverse striation and four longitudinal cuticular grooves. The latter divide the body into four segments of which the two segments following the outer curve are slightly longer (Fig. 1G). Much of the internal detail is obscured by the egg-

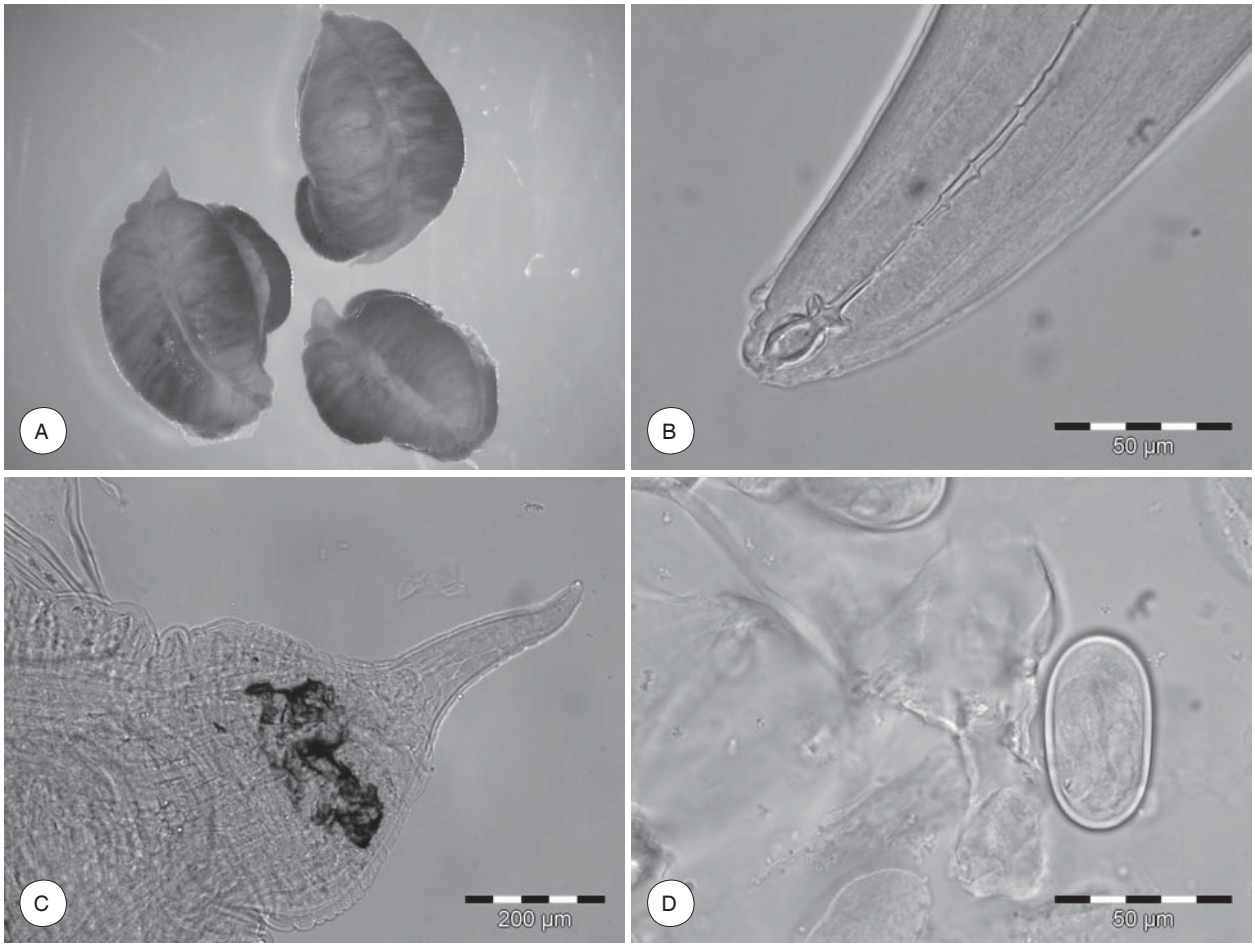

FIG. 3 *Tetrameres numida* n. sp. Female. A. Three whole specimens, approximately 4 mm in length. Note the globular shape. B. Anterior extremity. C. Posterior end. Note the digested blood showing as dark smudge. D. Egg containing fully developed larva

filled uterus coils surrounding a large sacular intestine. Body length 4.2–5.3 mm, maximum width 2.6–3.5 mm. The following measurements were derived from a single specimen: The deirids are at 179 and 190 and the nerve ring at 215 from the apex, respectively. The excretory pore could not be located. Depth of buccal capsule 23, inner diameter 7. Muscular part of oesophagus 333, the distal part of the glandular oesophagus obscured by the uterus. Eggs are elongate with near parallel sides, polar filaments were not seen (Fig. 3D). Eggs containing fully developed larvae are 56–59 long and 31–34 wide. Anus and vulva appeared to be confined in body folds. Emerging from the last body fold is a tail approximately 336 long with a simple tip.

SPECIFIC DIAGNOSIS: *Tetrameres numida* is differentiated from other members of the genus, by the possession of two rows of somatic spines and the arrangement of its caudal spines in two ventral and two lateral rows with usually three pairs of spines each, although deviation might occur. A short right and a long left spicule are present, ranging from 106–131 and from 1 699–2 304 in length, respectively.

HOST: *Numida meleagris* (Linnaeus, 1758), Helmeted guineafowl.

SITE: Males occur free in the lumen of the proventriculus, females are situated in the proventricular glands.

LOCALITY: Musina (Messina), Limpopo Province, South Africa (22°22.139' S, 29°30.399' E).

ETYMOLOGY: The specific epithet *numida* refers to the host.

Types deposited in the National Collection of Animal Helminths at the Onderstepoort Veterinary Institute, Pretoria, South Africa. Holotype male: T.2191, Alotype female: T.2192, Paratype males: T.2193–T.2195.

TABLE 1 The morphological characteristics of *Tetrameres numida* sp. n. males from Helmeted guineafowls, compared to *Tetrameres paradisea* Ortlepp, 1932 and to *Tetrameres prozeskyi* (Ortlepp, 1964), all described from South African hosts. All measurements in micrometres unless otherwise indicated

Morphological criteria	**GFM1/N4**	**T.2191**	**T.2193**	**T.2194**	**T.2195**	**GFM11/1**	**GFM12/1**	***Tetrameres paradisea***	***Tetrameres prozeskyi***
Source	This paper	This paper	This paper	This paper	This paper	This paper	This paper	Ortlepp (1932)	Ortlepp (1964)
Body length (mm)	4.3	4.4	4.4	4.3	4.3	n	4.5	5.8	1.3–2.4
Body width maximum	n	n	160	160	164	170	162	140	60-70
Distance apex to first somatic spine	n	126 & 117	96 & 100	102 & 93	105 & 94	131 &154	96 & 113	n	n
Distance apex to deirids	n	174 &180	139 & 149	179 & 172	165 & 177	174 & 181	175 & 204	85	~ 50–60
Distance apex to nerve ring	n	256	215	234	244	284	264	n	~ 150–160
Distance apex to excretory pore	268	307	236	287	296	331	316	n	n
Depth of buccal capsule	22	25	28	23	21	22	16	25	5.0–7.0
Width of buccal capsule (inner)	n	10	10	8	8	11	8	12	11.0–13.0
Muscular oesophagus	n	351	304	232	260	401	400	310	160–210
Glandular oesophagus	n	734	769	984	781	812	918	900	300–400
Oesophagus total length	n	1085	1073	1216	1023	1213	1318	1210	n
Length of tail	284	297	287	257	296	n	290	115	140–160
Length of right spicule	131	130	106	110	131	120	170	Absent	Usually absent[b]
Length of left spicule	1 988	2 103	2 304	2 169	1 699	n	2 204	690; 504–626[a]	230–260

n Data not available

[a] Range given by Mollhagen (1976) in Cremonte *et al.* (2001)

[b] A right spicule was present in three of more than 30 males

TABLE 2 A comparison of morphological characteristics of some species of the genus *Tetrameres Creplin*, 1846

Species	Bodylength of male (mm)	Number of rows of somatic spines	Length of rows of somatic spines	Number of spicules	Spicule length (mm)	Arrangement of caudal spines or papillae	Polar filaments on eggs	Source
Tetrameres americana Cram, 1927	5–5.5	4	n	2	Left: 0.29–0.31; right: 0.1–0.13	5 ventral pairs, no lateral pairs	n	Schmidt (1962); Gibbons *et al.* (1996)
Tetrameres araliensis Efimov & Rijowa, 1939	2.55	4	Whole body length	2	Long: 0.913 ; short: 0.22	2 ventral pairs and 2 sublateral rows with 6 and 7 spines, respecitvely. Two lateral tail papillae also present	n	Skrjabin & Sobolev (1963)
Tetrameres australis Johnston & Mawson, 1941	7.8–9.0	2	Whole body length	2	Long: 5.8–6.3; short: 0.8	5 to 6 small spines	n	Skrjabin & Sobolev (1963)
Tetrameres biziurae Johnston & Mawson, 1941	4.2–4.4	4	Whole body length	2	Long: 0.25–0.26; short: 0.07	n	n	Skrjabin & Sobolev (1963)
Tetrameres calidris Mawson, 1968	2.2–2.5	4/2	4 rows anteriorly, from glandular oesophagus onwards only 2	2	Left: 0.75–1.0; right: 0.08–0.09	5 ventral pairs, 2 lateral pairs	Only males known	Mawson (1968)
Tetrameres cardinalis Quentin & Barre, 1976	4.2–4.95	2	Whole body length	2	Left: 0.365–0.400; right: 0.065–0.085[a]	4–5 pairs of postcloacal spines	Present	Quentin & Barre (1976)
Tetrameres cladorhynchi Mawson, 1968	2.0–2.9	4	Whole body length	1	Left: 1.0–1.37	3 subventral pairs, 3 sublateral pairs	Present	Mawson (1968); Pence *et al.* (1975); Cremonte *et al.* (2001)
Tetrameres coloradensis Schmidt, 1962	2.05	4	Whole body length	2	Left: 0.777; right: 0.067	4 ventral pairs, 3 lateral pairs	Present	Schmidt (1962)
Tetrameres confusa Travassos, 1919	4.0–5.0	4	n	2	Long: 0.291; short: 0.068	3 ventral pairs, 3 lateral pairs		Skrjabin & Sobolev (1963)
Tetrameres cordoniferens Rasheed, 1960	n	4	n	n	Left spicule: 0.40	n	n	Pence *et al.* (1975)
Tetrameres crami Swales, 1936	2.9–4	4	n	2	Left: 0.27–0.35; right: 0.136–0.185	n	n	Schmidt (1962); Gibbons *et al.* (1996)
Tetrameres crami asiatica Ryjikov, 1963	3.25–3.6	4	Whole body length	2	Long: 0.238–0.254; short: 0.099–0.106	5 ventral pairs, 3 lateral pairs	n	Skrjabin & Sobolev (1963)

TABLE 2 (*cont.*)

Species	Bodylength of male (mm)	Number of rows of somatic spines	Length of rows of somatic spines	Number of spicules	Spicule length (mm)	Arrangement of caudal spines or papillae	Polar filaments on eggs	Source
Tetrameres cygni Ryjikov & Kozlov, 1960	n	4	n	2	Left: about one half the length of that of *T. tinamicola*	3 rows of 5 caudal papillae	n	Pence et al. (1975)
Tetrameres dubia Travassos, 1917[b]	1.35–2.28	4/2	Dorsolateral rows reach only the level of the posterior end of the glandular oesophagus	2	Long: 0.71–0.77; short: 0.06–0.08	4 ventral pairs, 3 lateral pairs	Present	Mamaev (1959) cited by Skrjabin & Sobolev (1963)
Tetrameres fermini Vigueras, 1935	2.5	n	n	2	Long: 0.073; short: 0.023	3 pairs of postcloacal spines	n	Skrjabin & Sobolev (1963)
Tetrameres fissispina (Diesing, 1861) Travassos, 1914	3.0–6.0	n	n	2	Left: 0.82–1.5; right: 0.28–0.49	8 pairs of postanal spines	n	Gibbons *et al.* (1996)
	3.2–3.9	4	n	2	Long: 0.37–0.49; short: 0.165–0.198	3 ventral pairs, 5 lateral pairs	n	Skrjabin & Sobolev (1963)
Tetrameres galericulatus Oschmarin, 1956	3.4	4	Whole body length	2	Longer: 0.450; short: 0.086	Present	n	Skrjabin & Sobolev (1963)
Tetrameres gigas Travassos, 1919	7.5	4	Whole body length	2	Long: 0.74; short: 0.016	Tail papillae have not been found	n	Skrjabin & Sobolev (1963)
Tetrameres globosa (Von Linstow, 1879)	3.6–3.75	4	Whole body length, sparser in posterior half	2/1	Long: 0.3; short spicule rudimentary	Small spines posterior to cloaca	n	Skrjabin & Sobolev (1963)
Tetrameres grusi Shumakovitsh, 1946	3.45–4.40	2	2 distinct rows, but spines scattered anterior to nerve ring and posterior to anus	1	0.638–0.783	Several irregular rows of spines	n	Skrjabin & Sobolev (1963); Bush *et al.* (1973); Pence *et al.* (1975)
Tetrameres gubanovi Shigin, 1957	6.67	2	Whole body length, starting at transition from muscular to glandular oesophagus	2	Long: 3.996; short: 0.131	4 ventral pairs of conical papillae, 3 lateral pairs of stalked papillae	n	Skrjabin & Sobolev (1963)
Tetrameres hagenbecki Travassos & Vogelsang, 1930	3.1–3.4	2?	Rows of cuticular spines along lateral fields (2 rows illustrated)		Long spicule: thin and ending as a spur, proximal 0.07–0.08 twisted. Short spicule 0.032–0.04	4 ventral pairs, 2 lateral pairs	n	Skrjabin & Sobolev (1963)
Tetrameres lhuillieri (Seurat, 1918)	n	4	n	1	0.48	n	Present	Ortlepp (1964)

TABLE 2 (*cont.*)

Species	Bodylength of male (mm)	Number of rows of somatic spines	Length of rows of somatic spines	Number of spicules	Spicule length (mm)	Arrangement of caudal spines or papillae	Polar filaments on eggs	Source
Tetrameres lobibycis Mawson, 1968	1.5	4/2	4 rows anteriorly, from nerve ring onwards only 2	1	Left: 0.73	6 subventral pairs	Only male known	Mawson (1968)
Tetrameres megaphasmidiata Cremonte, Digiani, Bala & Navone (2001)	1.94–2.03	4	Whole body length	1	Left: 0.96–1.22	6 subventral pairs, 2 lateral pairs	n	Cremonte *et al.* (2001)
Tetrameres micropenis Travassos, 1915	4.0–5.0	2	Whole body length	2	Long: 0.355; short: 0.056	2 ventral pairs	n	Ortlepp (1932); Skrjabin & Sobolev (1963)
Tetrameres microspinosa Vigueras, 1935	3.0	2	Whole body length	2	Long: 1.135; short: 0.065	5 ventral pairs	Absent	Skrjabin & Sobolev (1963)
Tetrameres mohtedai Bhalerao and Rao, 1944	4.27–5.8	4/2	Submedian spines end posterior to middle of glandular oesophagus	2	Long: 0.397–0.430; short: 0.142–0.160	5 subventral pairs	n	Skrjabin & Sobolev (1963)
Tetrameres nouveli (Seurat, 1914)	1.0–2.4	4	Whole body length	1	Left: 350–580[c]	3 or 4 subventral pairs, 2 or 3 sublateral pairs	Present	Ortlepp (1932); Mawson (1968); Cremonte *et al.* (2001)
	2.16	4	Whole body length	1	0.480; second spicule rudimentary (Seurat 1914, cited by Skrjabin & Sobolev 1963)	4 venral and 3 lateral pairsillustrated;according to text 2 papillae in posterior third of tail	Present	Skrjabin & Sobolev (1963)
Tetrameres numenii Mamaev, 1959	1.64–2.4	4/2	Dorsolateral rows reach only the level of the posterior part of the oesophagus	2	Long: 1.08–1.24; short: 0.08–0.10	4 ventral pairs, 3 lateral pairs	Absent	Skrjabin & Sobolev (1963)
Tetrameres numida n. sp.	4.3–4.4	2	Whole body length	2	Left: 1.699–2.304; right: 0.106–0.131	3 ventral pairs, 3 lateral pairs	Absent	This paper
Tetrameres oxylabiatus Oschmarin, 1956	5.0	n	Whole body length	2	Long: 0.940; short: 0.125	Extend posteriorly to middle of tail, getting very small	n	Skrjabin & Sobolev (1963)
Tetrameres paraaraliensis Oschmarin, 1956	1.71	4	Whole body length	1	0.405–0.420	n	n	Skrjabin & Sobolev (1963); Mawson (1968); Mollhagen (1976) in Cremonte *et al.* (2001)

TABLE 2 (*cont.*)

Species	Bodylength of male (mm)	Number of rows of somatic spines	Length of rows of somatic spines	Number of spicules	Spicule length (mm)	Arrangement of caudal spines or papillae	Polar filaments on eggs	Source
Tetrameres paradisea Ortlepp, 1932	5.8	2	Whole body length	1	Left: 0.69[d]	3 ventral pairs, 3 dorso-external pairs	Absent	Ortlepp (1932)
Tetrameres paradoxa (Diesing, 1835)	12–15	2	n	2	Long: 3.0 or longer ; short: 0.480	Drashe (1884) illustrated a very small pair of ventral papillae and 3 and 4 lateral papillae respectively	n	Skrjabin & Sobolev (1963), Drashe (1884) cited by Skrjabin & Sobolev (1963)
Tetrameres pattersoni Cram, 1933	4.2–4.6	2	Whole body length	1	1.2–1.5	n	n	Skrjabin & Sobolev (1963)
Tetrameres paucispina Sandground, 1928	n	2	Few, only in posterior 2/3	2	Left: 0.328–0.371; right:0.012–0.154[e]	3 caudal papillae	n	Bush *et al.* (1973); Quentin & Barre (1976)
	3.1–4.5	1	1 row in median ventral field, not more than 25 spines, only in post 2/3	2	Long: 0.328–0.371; short: 0.154	3 caudal papillae	n	Skrjabin & Sobolev (1963)
Tetrameres pavlovskii Iygis, 1965	n	4	n	1	n	4 ventral pairs, 4 lateral pairs	n	Pence *et al.* (1975)
Tetrameres pavonis Tschertkova, 1953	4.7	n	Irregular and dense anteriorly, in middle and posterior part almost invisible	2	Long: 0.43; short: 0.105	4 rows of spines, and 3 papillae: 1 lateral pair, 1 unpair median papilla	n	Skrjabin & Sobolev (1963)
Tetrameres phaenicopterus Ali, 1970	n	4	n	2	n	n	n	Pence *et al.* (1975)
Tetrameres plectropteri Thwaite, 1926	n	n	n	n	Left: 0.85	n	n	Ortlepp (1964)
Tetrameres prozeskyi (Ortlepp, 1964)	1.3–2.4	4	Whole body length	1	Left: 0.23–0.26[f]	3 ventral pairs, 3 lateral pairs[g]	n	Ortlepp (1964)
Tetrameres puchovi Gushanskaja, 1949	3.86–4.339	2	Whole body length	1	0.307–0.309; second spicule rudimentary: 0.008	n	n	Skrjabin & Sobolev (1963)
Tetramers ryjikovi Chuan, 1961	4.5	4	Whole body length	2	Long: 0.208; short: 0.062	4 ventral pairs, 3 lateral pairs	n	Skrjabin & Sobolev (1963)
Tetrameres sakharowi Petrow, 1926	9.47	4	n	2	Left: 0.195; right: 1.021	n	n	Skrjabin & Sobolev (1963)

TABLE 2 (*cont.*)

Species	Bodylength of male (mm)	Number of rows of somatic spines	Length of rows of somatic spines	Number of spicules	Spicule length (mm)	Arrangement of caudal spines or papillae	Polar filaments on eggs	Source
Tetrameres scolopacidis Mawson, 1968	1.06–1.8	4/2	4 rows anteriorly, from end of oesophagus only 2 rows	2	Left:0.70–0.85; right: 0.07–0.105	4 subventral pairs, 3 sublateral pairs	Present	Mawson (1968)
Tetrameres somateriae Ryjikov, 1963	4.8	4	No spines in the middle part of the body	2	Long: 0.576; short: 0.086	5 ventral pairs, 4 lateral pairs	n	Skrjabin & Sobolev (1963)
Tetrameres spirospiculum Pinto & Vincente, 1995	2.52–4.06	n	Thinly dispersed and poorly developed	2	Left: 0.82–1.08; right: n	n	n	Pinto & Vicente (1995)
Tetrameres skrjabini Panowa, 1926	2.6	4	Whole body length	2	Long: 1.543; short: 0.103	Not found	n	Skrjabin & Sobolev (1963)
Tetrameres tetrica Travassos, 1917	2.6	4	Dissapear near last quarter of body length	2	Long: 0.2; short: 0.022	4 lateral pairs, 4 sublateral pairs	n	Skrjabin & Sobolev (1963)
Tetrameres timopheewoi Travassos, 1950	4.7	n	Whole body length	2	Long: 0.421; short: 0.189	n	n	Skrjabin & Sobolev (1963)
Tetrameres tinamicola Pence, Mollhagen & Prestwood, 1975	6.52	4	Ventral rows whole body length, dorsal rows end 1.02 mm from apex	2	Left: 2.26; right: 0.207	5 subventral pairs, 3 ventro-lateral pairs	Absent	Pence *et al.* (1975)
Tetrameres uxorius Mamaev, 1959	n	4	n	2	Left: 2.1–2.3[h]; right: 0.088	4 ventrolateral pairs, 2 subdorsal pairs	Absent	Mamaev (1959); Pence *et al.*(1975)
	4.76–5.0	4/2	Dorsolateral rows reach only the beginning of the glandular oesophagus	2	Long: 2.1–2.24; short: 0.086–0.088	4 ventrolateral pairs, 2 subdorsal pairs	Absent	Skrjabin & Sobolev (1963)
Tetrameres vietnamensis Fan the Viet, 1968	n	4	n	2	Left: 1.28; right: 0.148	5 ventral pairs (lateral absent)	n	Fan the Viet (1968) in Helminthological Abstracts (1970), Pence *et al.* (1975)

n No information at our disposal

[a] The original reads 65-350 µm. We consider this a typing error and include the range of single measurements provided by Quentin & Barre (1976)

[b] Skrjabin & Sobolev (1963) also include a description after Cram (1927), which differs slightly from that of Mamaev (1959)

[c] Cremonte *et al.* (2001) give a range of 0.312–0.587 mm

[d] Cremonte *et al.* (2001) quote Mollhagen (1976) giving a range of 0.504–0.626 mm

[e] The length provided by Quentin & Barre (1976) is 12–154 µm. We consider this an error. Skrjabin & Sobolev give the width of the right spicule as 12 µm

[f] According to Ortlepp (1964) in three of about 30 males a right spicule was present

[g] Cremonte *et al.* (2001) quote Mollhagen (1976) as *T. prozeskyi* having varying caudal papillae (3/0, 3/3, 4/1, 4/2)

[h] Calculated from a 1:24 to 1:26 ratio between right and left spicule

DISCUSSION

Some of the main morphological characteristics of many of the species belonging to the genus *Tetrameres* are listed in Table 2.

Of the *Tetrameres* species with two rows of cuticular spines, *Tetrameres pattersoni* Cram, 1933, *T. paradisea* and *Tetrameres grusi* Shumakovitsh, 1946 have only one spicule and the spicule measurements of the latter two species differ distinctly from those in our specimens (Ortlepp 1932; Schmidt 1962; Bush, Pence & Forrester 1973).

Tetrameres gubanovi Shigin, 1957 bears two rows of body spines, but has seven pairs of caudal papillae (Pence *et al*. 1975), as opposed to six pairs of caudal spines in *T. numida* n. sp.

The use of the term caudal spines or caudal papillae is not always clear. Pence *et al*. (1975) use the term caudal papillae for several species in their publication. They list *T. paradisea* as well as *T. prozeskyi* as having caudal papillae, but in the original descriptions Ortlepp (1932, 1964) clearly refers to cuticular spines. Thus, Pence *et al*. (1975) seem to use the term indiscriminately. Mawson (1968), however, describes *T. nouveli* as having caudal spines, but points out that in *Tetrameres lobibycis* Mawson, 1968 the spines are more like elongate papillae, and refers to *Tetrameres calidris* Mawson, 1968 and *Tetrameres scolopacidis* Mawson, 1968 as having papillae.

The left spicules of *Tetrameres cardinalis* Quentin & Barre, 1976 and *Tetrameres paucispina* Sandground, 1928 are much shorter than those measured in our specimens (Quentin & Barre 1976). *Tetrameres micropenis* Travassos, 1915 has been recovered from ciconiiform hosts, *Nyctanassa violacea* (Linnaeus, 1758) and *Cochlearius cochlearia* (Linnaeus, 1766) (Yamaguti 1961), whose geographic distribution is restricted to North and South America (Lepage 2006).

Tetrameres fissispina has been recorded from guineafowls in Africa (Fabiyi 1972; Vercruysse *et al.* 1985) and, like *T. americana*, has a high prevalence in domestic chickens, whose nematode fauna is similar to that of guineafowls (Mukaratirwa, Hove, Esmann, Hoj, Permin & Nansen 2001; Magwisha, Kassuku, Kyvsgaard & Permin 2002). *Tetrameres fissispina* distinguishes itself from the new species by its shorter spicules and the larger number of caudal spines. *Tetrameres americana* differs not only in the spicule size and the number and arrangement of caudal spines, but also in its four rows of somatic spines (Schmidt 1962; Gibbons, Jones & Khalil 1996).

The head of the female and the apical view of the head of the male of *T. numida* n. sp. most closely resemble *Tetrameres tinamicola* Pence, Mollhagen & Prestwood, 1975. The authors of the latter species describe the male head as possessing a triangular mouth surrounded by a pair of trilobed structures originating from the inner surface of the pseudolabia. Each lobe bears a pair of tooth-like processes in *T. tinamicola.* Similar processes can be seen in our specimens, but it is difficult to determine their exact number. However, there seem to be three or four per lobe. Pronounced lateral alae, as illustrated by Pence *et al.* (1975), were not found in our specimens. Moreover, *T. tinamicola* has a total of four rows of cuticular spines and the deirids are without apical spines. While the length of the left spicule of both species is similar, the right spicule of *T. numida* is only approximately half the length of *T. tinamicola*.

Ortlepp (1932) described the buccal capsule of *T. paradisea* as having trilobed structures showing two to three bright refringent markings towards its posterior border. This, as well as other features of our specimens such as the transverse grooves anterior to the cloaca and the size of the spines, appeared so similar to *T. paradisea* that we initially considered assigning them to *T. paradisea*, especially in view of the fact that both were recovered from South African hosts. Close examination has nevertheless revealed distinct differences between the two. *Tetrameres paradisea* possesses a single spicule, whereas in our males two spicules are consistently present. While the arrangement of caudal spines is nearly identical and both carry three pairs of ventral and three pairs of externo-dorsal or lateral spines, the tail of *T. paradisea* is considerably shorter than that of our specimens (see Table 1).

Ortlepp (1932) described and illustrated two rows of body spines found in *T. paradisea* and he uses this criterion to distinguish his species from *Tetrameres nouveli* which he lists as possessing four rows of spines. Cremonte, Digiani, Bala & Navone (2001) record *T. paradisea* as having four rows of spines, but cite Mollhagen (1976) as describing the dorsal rows of spines as very short, ending at 94–155 from the anterior end.

When comparing *T. paradisea* to *T. prozeskyi*, Ortlepp (1964) lists the length of the left spicule of the former species as 0.48 mm, but his original description of *T. paradisea* (Ortlepp, 1932) clearly states the length of the spicule as 0.69 mm. We list *T. pro-*

zeskyi as monospicular, which differentiates it from our bispicular specimens. As regards *T. prozeskyi* it should be borne in mind that Ortlepp (1964) found a well-chitinized right spicule in three of the more than 30 males he examined.

In the summary of the description of *Tetrameres cardinalis* Quentin & Barre, 1976, the range of the length of the right spicule is given as 65–350 µm (Quentin & Barre 1976). As this seems erroneous, we decided to include the range provided in the same paper, namely 365–400, in Table 2. Similarly, we consider the first measurement these authors provide for the short spicule of *T. paucispina* as incorrect and believe it should read 120 instead of 12.

Apart from *T. numida* n. sp., only *T. tinamicola* and *Tetrameres uxorius* Mamaev, 1959 have a left spicule that reaches 2 mm in length, while in the remaining *Tetrameres* spp. the long spicule usually does not exceed 1 mm (Mamaev 1959; Pence *et al*. 1975). Relative to body length, however, there are other species with long spicules, such as *T. lobibycis* where the single spicule reaches about half of the body length (1.5 mm) and *T. scolopacidis* where the spicule length reaches almost two thirds of the body length (1.06–1.8 mm) (Mawson 1968).

To our knowledge, *Tetrameres phaenicopterus* Ali, 1970 is the only member of the genus *Tetrameres* possessing a gubernaculum (Pence *et al.* 1975) and *Tetrameres greeni* Mawson, 1979 is unique in the genus *Tetrameres* in that it has caudal alae (Mawson 1979). *Tetrameres spirospiculum* Pinto & Vicente, 1995 is distinguished from our specimens and all the other species of *Tetrameres* by the spiral shaped distal end of the longer of its two spicules (Pinto & Vicente 1995).

The numbers of *T. numida* n. sp. recovered from the guineafowl hosts from Musina (Messina) were low, and the parasite was only found in the older birds, being absent in young adults. While it is possible that guineafowls are not the main host for this parasite, we attribute the low intensity of infection to the fact that the area had been experiencing a severe drought during the past years. This would decrease the survival rates of nematode eggs while at the same time causing the numbers of possible intermediate hosts necessary for the completion of the life-cycle to decline. While differences in the immune status between guineafowls of different age might play a role in the intensity of infection, we believe that the presence of *T. numida* n. sp. in older hosts simply reflects the increased possibility of prior exposure to the parasite as a function of time.

ACKNOWLEDGEMENTS

The authors are indebted to Dr S. Sokolov of the Institute of Parasitology, Russian Academy of Science, Moscow, for obtaining the extensive chapter on the genus *Tetrameres* in "Principles of nematodology XI" (Skrjabin & Sobolev 1963) and to Dr D.A. Apanaskevich, Georgia Southern University, for the translation from the original Russian into English. The authors thank Mr K. Meyer and Mr M. Storm, the previous and current owners of the farm Sandown, Musina (Messina), respectively, for placing the guineafowls at our disposal and Mr H.E. Hattingh, University of Limpopo, for collecting them. Dr W.J. Luus-Powell, University of Limpopo, has kindly facilitated the co-operation. Ms D.T. Durand, University of Pretoria, photographed the three complete females of *T. numida*. This research was made possible through a Claude Leon Foundation Postdoctoral Fellowship grant to the first author.

REFERENCES

ANDERSON, R.C. 1992. *Nematode parasites of vertebrates, their development and transmission*, 1st ed. Wallingford and New York: CAB International.

APPLETON, C.C. 1983. Tetrameriasis in Crested guineafowl from Natal. *Ostrich*, 54:238–240.

BERGAN, J.F., RADOMSKI, A.A., PENCE, D.B. & RHODES, O.E. Jr. 1994. *Tetrameres* (*Petrowimeres*) *striata* in ducks. *Journal of Wildlife Diseases*, 30:351–358.

BUSH, A.O., PENCE, D.B. & FORRESTER, D.J. 1973. *Tetrameres* (*Gynaecophila*) *williamsi* sp. n. (Nematoda: Tetrameridae) from the White ibis, *Eudocimus albus*, with notes on *Tetrameres* (*Tetrameres*) *grusi* Shumakovich from Sandhill crane, *Grus canadensis*. *Journal of Parasitology,* 59:788–792.

CREMONTE, F., DIGIANI, M.C., BALA, L.O. & NAVONE, G.T. 2001. *Tetrameres* (*Tetrameres*) *megaphasmidiata* n. sp. (Nematoda: Tetrameridae), a parasite of the Two-banded plover, *Charadrius falklandicus,* and White-rumped sandpiper, *Calidris fuscicollis*, from Patagonia, Argentina. *Journal of Parasitology*, 87:148–151.

FABIYI, J.P. 1972. Studies on parasites of the grey-breasted helmet guineafowl (*Numida meleagris galeata* Pallas) of the Vom area of the Benue Plateau State, Nigeria. I. Helminth parasites. *Bulletin of Epizootic Diseases of Africa*, 20:235–238.

FAN THE VIET 1968. [Two new species of spirurates (Nematoda, Spirurata) from birds of Vietnam], in *Helminthological Abstracts* 1970, 39:187.

GIBBONS, L.M., JONES, A. & KHALIL, L.F. 1996. *Manual of the 8th international training course on identification of helminths of economic importance*. St. Albans: International Institute of Parasitology.

HELMINTHOLOGICAL ABSTRACTS 1970. Series A. Animal and human helminthology. Commonwealth Agricultural Bureaux.

LEPAGE, D. 2006. Avibase hosted by Bird Studies Canada, BirdLife International. www.bsc-eoc.org/avibase.

MAGWISHA, H.B., KASSUKU, A.A., KYVSGAARD, N.C. & PERMIN, A. 2002. A comparison of the prevalence and burdens of helminth infections in growers and adult free-range chickens. *Tropical Animal Health and Production*, 34:205–214.

MAMAEV, Y.L. 1959. New helminths from birds of eastern Siberia. *Trudi Gelmintologicheskoi Laboratorii. Akademiya Nauk SSSR*, 9:175–187.

MAWSON, P.M. 1968. Nematodes from Australian waders. *Parasitology*, 58:277–305.

MAWSON, P.M. 1979. Some Tetrameridae (Nematoda: Spirurida) from Australian birds. *Transactions of the Royal Society of South Australia*, 103:177–184.

MUKARATIRWA, S., HOVE, T., ESMANN, J.B., HOJ, C.J., PERMIN, A. & NANSEN, P. 2001. A survey of parasitic nematode infections of chickens in rural Zimbabwe. *Onderstepoort Journal of Veterinary Research*, 68:183–186.

ORTLEPP, R.J. 1932. A new species of *Tetrameres* (*Tetrameres paradisea* sp. nov.) from Stanley Cranes. *18th Report of the Director of Veterinary Services and Animal Industry, Union of South Africa, August, 1932*.

ORTLEPP, R.J. 1964. Some helminths recorded from Red- and Yellow-Billed hornbills from the Kruger National Park. *Onderstepoort Journal of Veterinary Reseach*, 31:39–52.

PENCE, D.B., MOLLHAGEN, T. & PRESTWOOD, A.K. 1975. *Tetrameres* (*Tetrameres*) *tinamicola* sp. n. from the Crested tinamou, *Eudromia elegans*, with comments on the subgenus *Petrowimeres* (Nematoda: Tetrameridae). *Journal of Parasitology*, 61:825–829.

PERMIN, A., MAGWISHA, H., KASSUKU, A.A., NANSEN, P., BISGAARD, M., FRANDSEN, F. & GIBBONS, L. 1997. A cross-sectional study of helminths in rural scavenging poultry in Tanzania in relation to season and climate. *Journal of Helminthology*, 71:233–240.

PINTO, R.M. & VICENTE, J.J. 1995. *Tetrameres* (*Tetrameres*) *spirospiculum* n. sp. (Nematoda, Tetrameridae) from the buff-necked ibis, *Theristicus caudatus caudatus* (Boddaert) (Aves, Threskiornithidae). *Memórias do Instituto Oswaldo Cruz*, 5:615–617.

POULSEN, J., PERMIN, A., HINDSBO, O., YELIFARI, L., NANSEN, P. & BLOCH, P. 2000. Prevalence and distribution of gastro-intestinal helminths and haemoparasites in young scavenging chickens in upper eastern region of Ghana, Africa. *Preventative Veterinary Medicine*, 45:237–245.

QUENTIN, J.C. & BARRE, N. 1976. Description et cycle biologique de *Tetrameres* (*Tetrameres*) *cardinalis* n. sp. *Annales de Parasitologie humaine et comparée (Paris)*, 51:65–81.

SCHMIDT, G.D. 1962. *Tetrameres coloradensis* n. sp., a nematode parasite of the common snipe *Capella gallinago delicata. Journal of Parasitology*, 48:850–851.

SCHMIDT, G.D. 1977. Observations on the type specimens of two species described by Lauro Travassos. *Journal of Parasitology,* 63:343.

SIEGFRIED, W.R. 1966. Growth, plumage development and moult in the Crowned Guineafowl *Numida meleagris coronata* Gurney. *Department of Nature Conservation Investigational Report No. 8*.

SKRJABIN, K.I. (Ed.). 1969. *Key to parasitic nematodes. Vol. 1, Spirurata and Filariata.* Translated and edited by M. Raveh, 1991. Leiden: E.J. Brill Publishing Company.

SKRJABIN, K.I. & SOBOLEV, A.A. 1963. *Principles of nematodology XI. Spirurata of animals and man and the diseases caused by them Part I (Spiruroidea)*. Moscow: Izdatelstv Akademii Nauk SSSR (Russian).

VERCRUYSSE, J., HARRIS, E.A., BRAY, R.A., NAGALO, M., PANGUI, M. & GIBSON, D.I. 1985. A survey of gastrointestinal helminths of the common helmet guinea fowl (*Numida meleagris galeata*) in Burkina Faso. *Avian Diseases*, 29:742–745.

YAMAGUTI, S. 1961. *Systema Helminthum.* The nematodes of vertebrates. Vol. III, Parts I & II. New York: Interscience Publishers.