Helminths of guineafowls in Limpopo Province, South Africa

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ABSTRACT

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Between July 2005 and November 2006 the gastro-intestinal helminths of 15 Helmeted guineafowls and a single Crested guineafowl from Musina, Limpopo Province were examined, and in July and August 2005 helminths were collected from five Helmeted guineafowls from Mokopane in the same province. The acanthocephalan *Mediorhynchus gallinarum*, the cestodes *Abuladzugnia gutterae*, *Davainea nana*, *Hymenolepis cantaniana*, *Numidella numida*, *Octopetalum numida*, *Ortleppolepis multiuncinata*, *Porogynia paronai*, *Raillietina angusta*, *Raillietina pintneri*, *Raillietina steinhardti* and *Raillietina* sp. and the nematodes *Ascaridia numidae*, *Cyrnea parroti*, *Gongylonema congolense*, *Hadjelia truncata*, *Sicarius caudatus*, *Subulura dentigera*, *Subulura suctoria*, *Subulura* sp., *Tetrameres numida* and an unidentified subulurid were recovered. A single trematode species, *Dicrocoelium macrostomum*, was present in the liver. *Mediorhynchus gallinarum*, *A. gutterae*, *O. multiuncinata*, *H. truncata* and *S. caudatus* are recorded for the first time from Helmeted guineafowls, as well as from South Africa. South Africa is a new geographic record for *D. macrostomum*, *G. congolense* and *D. nana*. *Subulura suctoria*, *G. congolense* and *H. truncata* from the Crested guineafowl constitute new host-parasite associations.

Keywords: Acanthocephalans, cestodes, guineafowls, *Guttera edouardi*, nematodes, *Numida meleagris*, trematodes

INTRODUCTION

Helmeted guineafowls, *Numida meleagris* (Linnaeus, 1758), are distributed throughout most of South Africa and almost the entire African continent (Del Hoyo, Elliot & Sargatal 1994). Studies to elucidate the helminth fauna of these hosts in South Africa have been undertaken by Saayman (1966), Crowe (1977) and Verster & Ptasinska-Kloryga (1987), but were restricted to the Eastern Cape, the Northern Cape and Gauteng Provinces.

Although relatively wide-spread in Africa, Crested guineafowls, *Guttera edouardi* (Hartlaub, 1867), are scarce and have a limited distribution within South Africa. They occur in the Limpopo, North West, Mpumalanga and KwaZulu-Natal Provinces and are listed as rare or accidental in Gauteng Province (Hockey, Dean & Ryan 2005; Lepage 2007). To date our knowledge concerning their helminth fauna is virtually non-existent.

Ortlepp (1937, 1938a,b, 1963) reported on the cestode and nematode parasites of guineafowls of southern Africa present in the National Collection of Animal Helminths, formerly known as the Onderstepoort Helminthological Collection, or material made

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available to him by various collectors. He described several new species of cestodes and nematodes and added numerous parasites to the host-parasite list of guineafowls in South Africa. His reseach, however, was of a taxonomic nature and the material at his disposal represented incidental findings rather than complete collections.

In this paper we present data obtained from 16 birds, including a single Crested guineafowl, at Musina, Limpopo Province, and from five Helmeted guineafowls at Mokopane, Limpopo Province, South Africa.

MATERIAL AND METHODS

In July and August 2005 a total of five Helmeted guineafowls were sampled in the vicinity of Mokopane (Potgietersrus), Limpopo Province. A complete helminth recovery was not possible, but some of the worms present in the small intestine of three of the birds, the complete caeca of one of them and part of the intestinal and caecal contents of another were collected and fixed separately in 70 % ethanol.

In July 2005 and in May, July and November 2006, three, five, three and four Helmeted guineafowls (eight males and seven females) were collected on a farm approximately 60 km west of Musina (Messina), Limpopo Province (22°22' S, 29°30' E, Altitude 700–800 m). The vegetation type in the study area is classified as Mopani veld (Acocks 1988).

The birds were aged according to the criteria established by Siegfried (1966) and in total ten adults and five juveniles were collected. The juveniles were between six and ten months old (Siegfried 1966). In November 2006 a single adult female Crested guineafowl, found moribund in a wire snare, was made available to us for examination.

The carcasses of the birds were opened according to standard techniques for necropsies of chickens, and the viscera removed. The trachea was opened and macroscopically examined for helminths.

The crop, proventriculus, gizzard, small intestine and caecum/colon were separated and individually washed over a 150 µm sieve. The livers of nine Helmeted guineafowls and the single Crested guineafowl were sliced into 5 mm wide sections and incubated in phosphate-buffered saline at 40°C for 30 min. Subsequently, the slices together with the saline were washed over a 150 µm sieve. The gastrointestinal and liver residues left on the sieves, as well as the organs themselves were fixed separately in 70 % ethanol and transported to the laboratory

at Onderstepoort. Each sample was examined under a stereoscopic microscope and the helminths removed.

Cestodes were stained in haematoxylin and mounted in Canada balsam or mounted and cleared in Hoyer's medium. Acanthocephalans were cleared in Hoyer's medium and studied as temporary mounts in the same medium. All nematodes were cleared in lactophenol for identification.

The ecological terms are used in accordance with the definitions of Margolis, Esch, Holmes, Kuris & Schad (1982).

RESULTS

All the guineafowls were infected and all were concurrently parasitized by acanthocephalans, cestodes and nematodes.

Data on the prevalence, intensity and habitat preference of the parasites from the Helmeted guineafowls in Musina are presented in Tables 1 and 2. Five of the nine hosts (55.6 %), whose livers were examined, harboured *Dicrocoelium macrostomum*, the intensity of infection ranging from 8 to 182 flukes. In addition, the livers of three of the nine birds yielded five, 11 and five young specimens of *Porogynia paronai*. These had the typical three circles of large hammer-shaped rostellar hooks and small, unarmed suckers. No differential development could be seen in any of the proglottids of the short strobilae which ranged from 2.3 to 3.8 mm (*n* = 5) in length. The scolices were 689–746 µm wide and the rostella were 261–329 µm wide.

Birds from Mokopane yielded the nematodes *Subulura suctoria*, *Subulura dentigera* and *Ascaridia numidae* and seven cestodes, namely *Ortleppolepis multiuncinata*, *Porogynia paronai*, *Raillietina steinhardti*, *Raillietina pintneri*, *Raillietina* sp., *Numidella numida* and *Octopetalum numida*.

Subulura dentigera and *S. suctoria* were co-specific in the two hosts from Mokopane. One of these harboured a total of 579 nematodes consisting of 142 male and 159 female *S. suctoria*, 134 male and 126 female *S. dentigera* and 18 immature *Suctoria spp.* These nematodes were suspended freely in the contents of the posterior saccate part of the caeca, virtually occupying the entire lumen (Fig. 2D).

Eight of the 15 helmeted guineafowls from Musina harboured *S. dentigera* and *S. suctoria* concurrently, and in all these hosts *S. suctoria* by far outnumbered

TABLE 1 The site preference, prevalence and intensity of infection of acanthocephalans and cestodes collected from 15 Helmeted guineafowls in Limpopo Province, South Africa. Additional data on guineafowl helminths in southern Africa from various authors are included for comparison

Parasite	This paper				Verster & Ptasinska-Kloryga (1987)			Saayman (1966)			Crowe (1977)	Ortlepp (1963)
	Site	Prevalence (%)	Intensity Mean (± SD)	Range	Prevalence (%)	Intensity Mean	Range	Prevalence (%)	Intensity Mean	Range	Presence	Presence
Acanthocephalans												
Mediorhynchus gallinarum	SI	100	55.7 (± 78.3)	2–231	–	–	–	–	–	–	–	–
Mediorhynchus numidae	SI	–	–	–	–	–	–	39	11.5	?–27	–	–
Mediorhynchus taeniatus	SI	–	–	–	27	1.7	0–22	–	–	–	+	–
Cestodes												
Abuladzugnia gutterae	SI	80	11.7 (± 8.2)	1–28	–	–	–	–	–	–	–	+
Abuladzugnia transvaalensis	SI	–	–	–	–	–	–	–	–	–	–	+
Davainea nana	SI	33	5.8 (± 4.4)	1–10	–	–	–	–	–	–	–	+
Hymenolepis cantaniana	SI	40	42.7 (± 70.4)	1–124	–	–	–	–	–	–	–	–
Numidella numida	SI	67	55.9 (± 72.7)	1–144	29	1.8	0–42	47	8.7	?–14	–	+
Octopetalum numida	SI	67	91.9 (± 110.7)	1–360	48	8	0–72	75	16.0	?	+	+
Ortleppolepis multiuncinata	SI	87	9.3 (± 5.2)	2–14	–	–	–	–	–	–	–	+
Paroniella sp.[a]	SI	–	–	–	25	1.5	0–17	–	–	–	–	–
Porogynia paronai	SI	47	12.3 (± 13.3)	5–39	–	–	–	75	?	?–5	+	+
Railletina angusta	SI	53	10.3 (± 7.9)	1–25	8	< 1.0	0–21	–	–	–	–	+
Raillietina pintneri	SI	80	5.3 (± 3.9)	2–12	44	3.9	0–45	36	6.3	3–27	+	+
Raillietina steinhardti	SI	53	49.0 (± 60.2)	4–137	31	1.9	0–20	–	–	–	–	+
Raillietina sp.	SI	73	15.8 (± 8.8)	6–28	–	–	–	–	–	–	–	–
Raillietina sp.[a]	SI	–	–	–	35	2.7	0–17	–	–	–	–	–
Skrjabinia deweti	SI	–	–	–	–	–	–	–	–	–	–	+

[a] Listed by Verster & Ptasinska-Kloryga (1987) as a new species, but were not subsequently described
SI = small intestine

TABLE 2 The site preference, prevalence and intensity of infection of nematodes collected from 15 Helmeted guineafowls in Limpopo Province, South Africa. Additional data on guinea-fowl nematodes in southern Africa from various authors are included for comparison

Nematodes	This paper				Verster & Ptasinska-Kloryga (1987)			Saayman (1966)			Crowe (1977)	Ortlepp (1937, 1938b, 1964)[b]
	Site	Prevalence (%)	Intensity		Prevalence (%)	Intensity		Prevalence (%)	Intensity		Presence	Presence
			Mean (± SD)	Range		Mean	Range		Mean	Range		
Ascaridia galli	SI	–	–	–	2	< 1	0–2	64	5.4	?–9	–	–
Ascaridia numidae	SI	6	4.0[a]	4[a]	13	< 1	0–19	–	–	–	–	+
Cyrnea parroti	Giz	100	13.8 (± 18.2)	2–75	13	< 1	0–16	–	–	–	–	+
Dispharynx nasuta	Prov	–	–	–	10	1.8	0–59	–	–	–	–	–
Gongylonema congolense	Crop	40	23.0 (± 22.0)	2–61	–	–	–	–	–	–	–	–
Gongylonema ingluvicola	Crop	–	–	–	–	–	–	–	–	–	–	+
Hadjelia inermis	Giz	–	–	–	–	–	–	–	–	–	–	+
Hadjelia truncata	Giz	53	1.6 (± 0.5)	1–2	–	–	–	–	–	–	–	–
Heterakis gallinarum	Caeca	–	–	–	4	< 1	0–2	?	148	?–257	–	+
Sicarius caudatus	Giz, SI	53	2.1 (± 1.7)	1–6	–	–	–	–	–	–	–	–
Subulura dentigera	Caeca	53	15.9 (± 13.4)	1–31	6	1.3	0–54	–	–	–	+	+
Subulura suctoria	Caeca	100	536.3 (± 589.2)	9–2 214	23	< 1	0–40	–	–	–	+	+
Subulura sp.	Caeca	40	44.0 (± 65.4)	1–170	10	< 1	0–4	–	–	–	–	–
Unidentified subulurid	SI	13	2.5 (± 0.7)	2–3	–	–	–	–	–	–	–	–
Tetrameres numida	Prov	33	2.4 (± 1.7)	1–5	–	–	–	–	–	–	–	–

a   Only a single host harboured this parasite
b   Including unpublished records of Ortlepp cited in Verster & Ptasinska-Kloryga (1987)
SI   = small intestine
Giz   = gizzard
Prov = proventriculus

S. dentigera, the ratio ranging from 4.5:1 to 53:1. In the remaining hosts only *S. suctoria* was present (Fig. 2E, F).

The Crested guineafowl harboured a single acanthocephalan species, *Mediorhynchus gallinarum* (*n* = 48), five species of cestodes, namely *Abuladzugnia*

gutterae (*n* = 1), *N. numida* (*n* = 114), *O. numida* (*n* = 57), *O. multiuncinata* (*n* = 1) and *P. paronai* (*n* = 52), as well as three species of nematodes, *S. suctoria* (*n* = 260), *Gongylonema congolense* (*n* = 56) and *Hadjelia truncata* (*n* = 2), representing a total of 591 helminths.
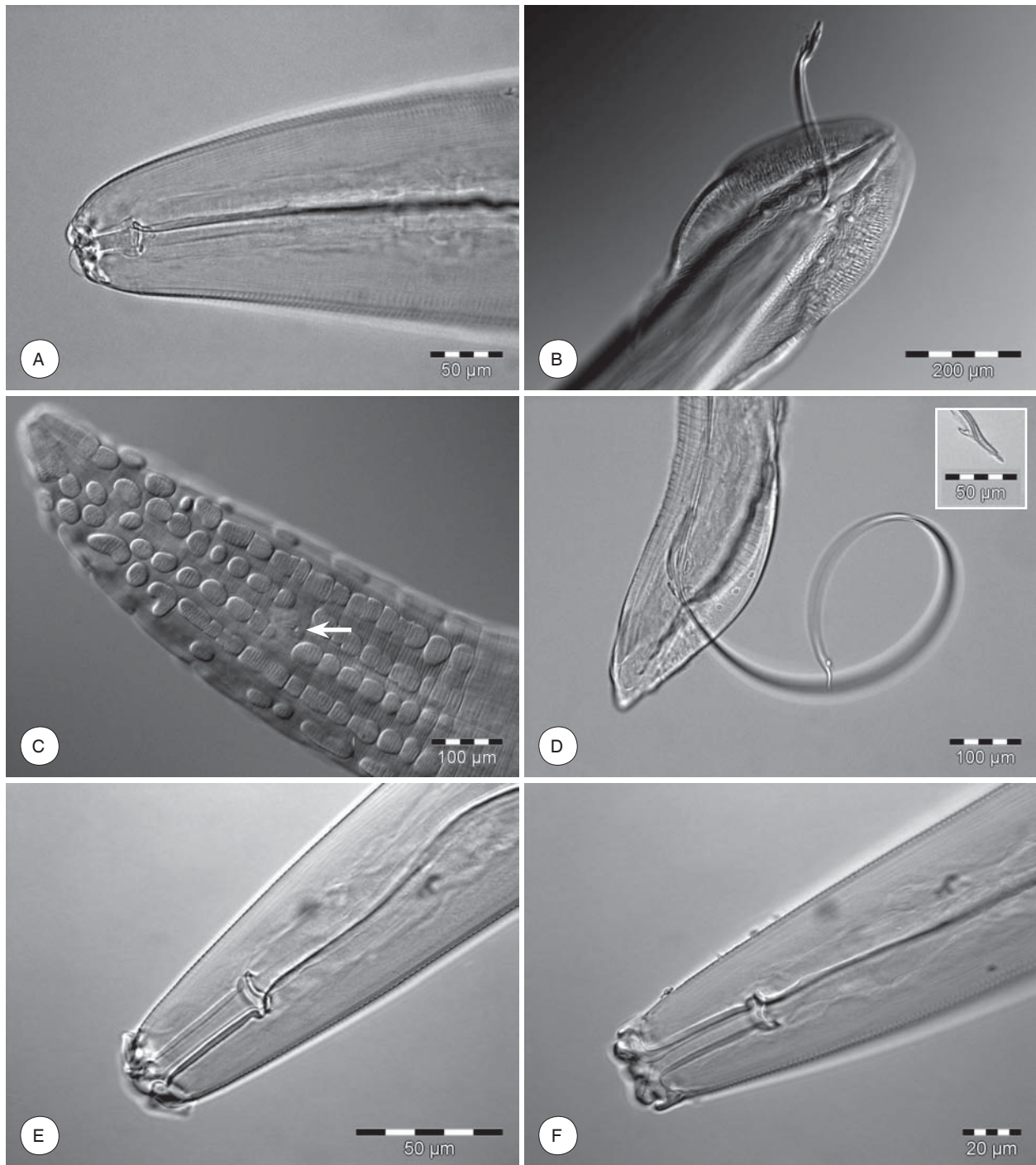

FIG. 1   A, B. *Cyrnea parroti* male. A. Anterior end. B. Posterior end. C, D. *Gongylonema congolense*. C. Anterior extremity of female, ventral view. The arrow points to the excretory pore. D. Posterior extremity of male. The inset illustrates the barbed tip of the long spicule. E, F. *Hadjelia truncata* male. E. Ventral view of anterior extremity. F. Lateral view of anterior extremity

Our finding of *M. gallinarum*, *A. gutterae*, *H. multiuncinata*, *H. truncata* and *Sicarius caudatus* in Helmeted guineafowls in South Africa constitutes new host associations, as well as new geographic records for these parasites. *Dicrocoelium macrostomum*, *G. congolense* and *Davainea nana* are recorded in South Africa for the first time, and the Crested guineafowl is a new host for the nematodes *S. suctoria*, *G. congolense* and *H. truncata*.

Despite the generally high helminth burdens, the Helmeted guineafowls were in good physical condi-
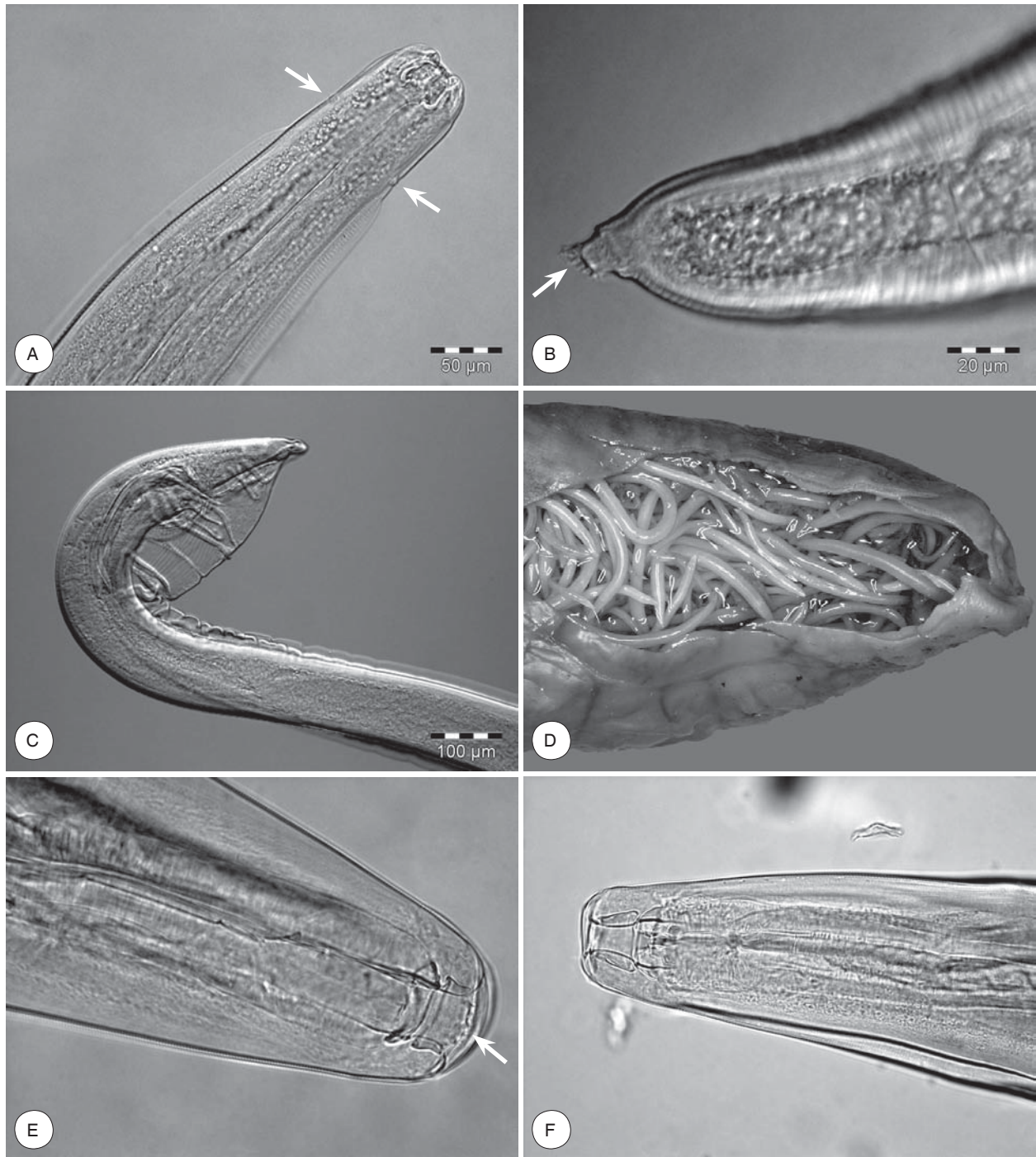

FIG. 2   A, B, C. *Sicarius caudatus*. A. Anterior extremity of male. The deirids are marked by arrows. B. Posterior extremity of female. Note the finger-like protruberances (arrow) at the tip of the tail. C. Posterior extremity of male. D. Distal part of guineafowl caecum filled with *Subulura* spp. E. *Subulura dentigera* female, anterior part. The arrow indicates the cuticular denticles as described by Ortlepp (1937); x 400. F. *Subulura suctoria* female, anterior part; x 400

tion and no obvious lesions were associated with the presence of helminths. The crop mucosa of a single bird from Musina had an inflamed appearance. This, however, did not seem to be related to *G. congolense* living in shallow tunnels under the crop lining, but rather to the presence of numerous thorny seeds of *Tribulus terrestris*.

TAXONOMIC REMARKS

Cyrnea parroti Seurat, 1917 (Table 3; Fig. 1A, B)

Ortlepp (1938b) described *Habronema numidae* from Helmeted guineafowls in Malawi, South Africa and Swaziland. This nematode has subsequently been included in the genus *Cyrnea* Seurat, 1914, but it is still listed under its original name in Yamaguti (1961) as well as in Verster & Ptasinska-Kloryga (1987).

In his work on the Habronematinae, Chabaud (1958) divided the genus *Cyrnea* into two subgenera, *Procyrnea* Chabaud, 1958 and *Cyrnea* Chabaud, 1958, which he later raised to genus level (Chabaud 1975). Following an in-depth study of the cephalic structures, he synonymized *Cyrnea* (*Cyrnea*) *numidae* (Ortlepp, 1938) with *Cyrnea* (*Cyrnea*) *parroti* Seurat, 1917 (Chabaud 1958).

Specimens from our hosts mounted *en face* show the same arrangement of submedian lobes and simple lips as illustrated for *C. parroti* by Chabaud (1958) and otherwise conform well with the description and measurements supplied by Ortlepp (1938b) for *C. numidae*. The range of measurements in our specimens was, however, generally wider than that provided by the latter author (Table 3). Ortlepp (1938b) himself stated that his new species most closely resembled *Cyrnea eurycerca* and *C. parroti* and that the arrangement of the caudal papillae in the males as well as the spicules were very similar.

Gongylonema congolense Fain, 1955 (Table 4; Fig. 1C, D)

This parasite was first described by Fain (1955a) from domestic chickens, a single duck, *Cairina moschata domestica* and from *N. meleagris* from the Democratic Republic of the Congo and Rwanda. Subsequently it has been recorded from *N. meleagris* in Burundi, Nigeria, Ethiopia, Ghana and Burkina Faso (Fain & Thienpont 1958; Fabiyi 1972; Graber 1976; Hodasi 1976; Vercruysse, Harris, Bray, Nagalo, Pangui & Gibson 1985).

One of the main morphological characteristics of this species is the hook situated at a distance of about

50 µm from the distal tip of the left spicule (Fain 1955a) (Fig. 1D). The hook itself carries three fine barbs. In our specimens the barbed hook of the tip of the left spicule was often difficult to see, but in specimens where the distance could be determined it varied from 31 to 46 µm.

It is not always easy to judge whether the left spicule is intact or damaged, which could lead to measuring errors. There are, however, sufficient other characteristics, such as the gubernaculum, the extent and arrangement of the cuticular plaques (Fig. 1C), as well as the length of the right spicule to differentiate *G. congolense* from other species utilizing avian hosts (Fain 1955a).

While our specimens fit in well with Fain's (1955a, b) description of *G. congolense*, we have not been able to confirm that the excretory pore opens on a transversally elongated plaque as was described by him. In our specimens it would seem that the two median ventral longitudinal rows of plaques are interrupted, leaving a plaque-free zone immediately anterior and posterior to the excretory pore (Fig. 1C).

Measurements of our specimens and those of Fain (1955a) taken from guineafowl hosts are presented in Table 4. These indicate that there is little geographic variation in the morphology of *G. congolense* from the same host species.

Hadjelia truncata (Creplin, 1825) (Table 5; Fig. 1E, F)

The most obvious differences between *H. truncata* and sympatric specimens of *C. parroti* are the position of the vulva and the winged appearance of the lips of *H. truncata* in ventral view (Fig. 1E, F). In *H. truncata* the vulva is distinctly anterior and positioned in front of the posterior end of the oesophagus. These characteristics are in accordance with the generic diagnosis of *Hadjelia* provided by Yamaguti (1961).

Measurements of the specimens from the guineafowls fall well within the range of measurements provided by Ortlepp (1964) for *Hadjelia inermis* (Gedoelst, 1919) (Table 5). *Hadjelia inermis* had been synonymized with *H. truncata* by Chabaud & Campana (1950), and Ortlepp (1964) commented on this, but chose to retain the former species. He lists his own measurements for *H. inermis* collected from Red- and Yellow-billed hornbills from South Africa, together with measurements for *H. inermis* taken from Gedoelst (1919) and for *H. inermis* and *H. truncata* as provided by Cram (1927, cited by Ortlepp

TABLE 3   The main morphological criteria of *Cyrnea parroti* Seurat, 1917 from Helmeted guineafowls. The range of measurements is provided. All measurements in micrometres unless otherwise stated

Source	Present study		Ortlepp (1938b)	
Morphological criteria	Males (*n* = 6)	Females (*n* = 4)	Males	Females
Body length (mm)	9–11	11–16	11–13	18–19
Maximum width	229–274	232–380	180–210	300–360
Distance apex to nerve ring	187–262	237–263	210–240	210–240
Distance apex to deirids	220–370	309–364	–	–
Distance apex to excretory pore	220–362	311–357	250–290	250–290
Depth of buccal capsule	29–36	34–45	30	36
Width of buccal capsule (inner)	10–15	12–16	10	12
Muscular oesophagus	304–393	–	270–300	330
Glandular oesophagus	2 234–2 526	–	1 700–2 000	2 400–2 600
Oesophagus total length	2 284–2 830	2 039–3 056	–	–
Length of tail	120–193	128–150	–	126–130
Distance vulva to posterior end	–	661–897	–	~ 750
Egg length x egg width	–	45–46 x 25–27	–	42–45 x 24
Length of right spicule	410–510[a]	–	420–438	–
Length of left spicule	834–1 354[a]	–	1 080–1 110	–
Length of gubernaculum	63–84[a]	–	70	–
Length of caudal alae	437–618	–	420–520	–

a   Measurements of the spicules and the gubernaculum are derived from ten males

TABLE 4 The main morphological criteria of *Gongylonema congolense* Fain, 1955 males from Helmeted guineafowls from South Africa (present study, GFM/N represents our specimen number), and from the Democratic Republic of the Congo and Rwanda (Fain 1955a). All measurements in micrometres unless otherwise stated

Source	Present study								Fain (1955b)
Morphological criteria	GFM3/N1	GFM1/N16	GFM1/N17	GFM1/N21	GFM1/N22	GFM1/N23	GFM1/N24	GFM1/N25	(n = 5)
Body length (mm)	17	15	14	13	–	14	17	–	12–24
Maximum width	266	228	244	215	–	230	247	230	170–200
Distance apex to deirids	84	70; 86	107	88	98	109; 104	96; 83	–	85–125
Distance apex to nerve ring	210	190	232	188	224	223	191	–	196–235
Distance apex to excretory pore	305	303	355	322	340	362	337	–	310–350
Distance apex to end of plaques	440	385	484	470	–	486	500	–	450–475
Distance apex to cervical ailes	102; 110	118	153	107; 123	–	150; 141	125; 123	–	125–175
Depth of buccal capsule	31	–	30	30	–	34	31	–	30–45
Muscular oesophagus	–	362	216	304	431	387	332	–	290–400
Glandular oesophagus	–	2 967	3 934	3 075	3 879	3 417	3 523	–	2 520–3 920
Oesophagus total length	4 125	3 407	4 150	3 379	4 310	3 804	3 853	–	–
Length of tail	207	173	183	170	–	197	202	165	185–200
Caudal alae (left; right)	600 (left)	–	–	–	–	–	630; 583	–	575–700; 450–500
Length of gubernaculum	87	73	85	87	82	–	80	80	68–85
Length of right spicule	98	101	79	86	99	98	100	94	104–140
Length of left spicule (mm)	8.7	–	4.8	5.5	7.4	5.5	8.1	8.2	7–11

TABLE 5 The main morphological criteria of *Hadjelia truncata* (Creplin, 1825) from Helmeted guineafowls. The range of measurements is provided. All measurements in micrometres unless otherwise stated

Source	Present study					Gedoelst (1919)		Ortlepp (1964)	
Morphological criteria	Males		Females			Males	Females	Males	Females
	GFM9/1	GFM/11	GFM1/10	GFM1/14	GFM6/1				
Body length (mm)	7	8	10	–	11	6.1–6.45	18–21.8	6–7	17–19
Maximum width	160	145	209	217	140	140–144	240–260	–	–
Distance apex to nerve ring	208	212	185	159	–	180–215	260–275	–	–
Distance apex to deirids	237; 239	238; 231	206; 204	160; 161	257; 259	210–260	330	–	–
Distance apex to excret. pore	275	259	234	179	290	220–275	360	–	–
Depth of buccal capsule	44	42	39	40	41	–	–	40–50	47–52
Width of buccal capsule (inner)	5	7	5	7	6	–	–	10	12
Muscular oesophagus	369	397	358	346	495	–	–	230–280	400–450
Glandular oesophagus	1 750	1 927	1 948	2 076	1 988	–	–	1 900–2 200	2 000–2 300
Oesophagus total length	2 119	2 324	2 306	2 422	2 483	2 000	2 400–3 600	2 130–2 480	2 400–2 750
Distance apex to vulva	–	–	1 698	1 691	2 238	–	1 860–2 970	–	2 200–2 500
Length of tail	–	–	138	–	121	120	90–120	120–140	110–120
Egg length x egg width	–	–	50 x 32	53 x 35	–	–	54–57 x 30–32	–	32–37 x 25–27
Length of left spicule	1 346	1 434	–	–	–	1 600–1 900	–	1 200–1 500	–
Length of right spicule	271	254	–	–	–	200	–	215–280	–

TABLE 6 Morphological criteria of *Sicarius dipterum* (Popova, 1927), *Sicarius hoopoe* Sharma, 1971, *Sicarius caudatus* Quentin & Wertheim, 1975 and *Sicarius renatae* Cancrini, Balbo & Iori, 1991 described from avian hosts. All measurements in micrometres unless otherwise stated

Source	Ali (1961)		Sharma (1971)		Quentin & Wertheim (1975)		Present study		Cancrini, Balbo & Iori (1991)	
Morphological criteria	*Sicarius dipterum*		*Sicarius hoopoe*		*Sicarius caudatus*		*Sicarius caudatus*		*Sicarius renatae*	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Body length (mm)	10.2–11.9	12.9–16.1	6.7–9.4	11.2–18.2	7.3	13.3	5.9	8.3	4.9	7.3
Distance apex to deirids	70–74[a]	80–90[a]	60–70	50–60	85	85	63; 68	78; 87	68; 70	65; 75
Distance apex to nerve ring	180–200	240–260	110–140	165–210	215	250	208	226–227	150	165
Distance apex to excret. pore	240–260	280–320	130–180	180–220	270	310	–	278–298	–	–
Depth of buccal capsule	43–45	52–58	14–17	25	28	38	28	31–33	25	25
Muscular oesophagus	510–530	560–610	240–320	320–380	380	410	–	–	250	236
Glandular oesophagus	2 880–2 920	3 160–3 910	2 800–3 040	3 200–3 600	2 170	2 900	–	–	1 950	2 365
Oesophagus total length	3 400–3 500	3 700–4 500	–	–	2 550	3 310	2 535	2 722	2 200	2 601
Length of tail	210	185–210	176–208	167–256	190	250	161	168	–	110
Length of right spicule	93–160	–	440–560	–	170–190	–	171	–	175	–
Length of left spicule	620–690	–	470–600	–	400–450	–	413	–	360	–
Distance vulva to tip of tail	–	5 000	–	–	–	4 950	–	2 960	–	2 800
Egg length	–	38–40	–	33–46	–	43	–	38	–	37–40
Egg width	–	30–37	–	29–39	–	30	–	29	–	25–27
Max. width of alae	–	–	–	–	45	45	36	40–50	–	–
Extension alae	Whole body	Whole body	Whole body	Whole body	Whole body	Whole body	Whole body	Whole body	Whole body	Whole body

a Cervical papillae in Ali (1961) interpreted here as deirids

1964) (Table 5). As we have not been able to examine the type specimens of either species, we have chosen to adopt the conclusion of the in-depth morphological study of Chabaud & Campana (1950).

The single complete specimen in our collection appears slightly shorter than previously described ones. The depth of the buccal cavity of our specimens corresponds with the lower range of the pharynx sizes provided by Ortlepp (1964) and all three authors he quoted.

The oesophagus length is relatively uniform in all the sources quoted by Ortlepp (1964). In our specimens the total length of the oesophagus only reached 2.1 and 1.9 mm which, considering that these specimens are short, does not seem extraordinary. The egg size is very similar to that of *H. inermis* as recorded by Gedoelst (1919) and Cram (1927, cited by Ortlepp 1964), but larger than given by Ortlepp (1964). Ortlepp (1964) pointed out that this was the only noteworthy difference between his specimens and those described by Gedoelst (1919).

According to Chabaud (1958) the genus *Hadjelia* has been described from numerous birds, especially Coraciiformes, from Europe, Asia and Africa. Data pertaining to African hosts mainly list Bucerotiformes (Ortlepp 1964) and we are aware of only one reference to *Hadjelia* from galliform birds, namely *Hadjelia lhuillieri* Seurat, 1916 from *Alectoris barbara* (= *Caccabis petrosa* from Algeria in Seurat 1916). Incidentally, Chabaud (1958) speculated that the latter species might be identical with *H. truncata*, but thought that the characteristics of the single known female specimen of *H. lhuillieri* were not sufficient to draw a final conclusion.

Sicarius caudatus Quentin & Wertheim, 1975
(Table 6; Fig. 2A, B, C)

Four species of the genus *Sicarius* are known from avian hosts, namely *Sicarius dipterum* (Popova, 1927), *Sicarius hoopoe* Sharma, 1971, *Sicarius caudatus* Quentin & Wertheim, 1975 and *Sicarius renatae* Cancrini, Balbo & Iori, 1991. The left spicule of *S. dipterum* is distinctly longer (660–670 μm) than that of our specimens, whereas the subequal spicules of *S. hoopoe* are 440–560 and 470–600 μm in length (Cancrini, Balbo & Iori 1991). Our specimens best fit the description of *S. caudatus*, as they have six pairs of caudal papillae as opposed to the eight pairs of *S. renatae* (Cancrini *et al.* 1991).

According to Quentin & Wertheim (1975) the deirids in *S. caudatus* are situated at the origin of the lateral alae. In some of our specimens, we have observed the same arrangement, but in one male and one female the right and left deirids emerge 11 and 27 μm, and 17 and 37 μm anterior to the origin of the alae (Fig. 2A). We have too little material to comment on the significance of this observation.

Quentin & Wertheim (1975) describe the cuticular processes in the tail of *S. caudatus* as atrophied, the tail consisting merely of a smooth stump, which at best has rugged edges. Our specimens possess about seven distinct, albeit short, cuticular extensions similar to those illustrated by Cancrini *et al.* (1991) for *S. renatae* (Fig. 2B). Despite these differences we have allocated our specimens to *S. caudatus*. Apart from the original description and their inclusion in some taxonomic reviews (Chabaud 1958; Ali 1961), we have not found any other references to *S. caudatus* in the literature. The measurements of the specimens collected during this study are included in Table 6.

DISCUSSION

Despite the fact that various studies on the helminths of guineafowls in South Africa have been conducted, direct comparisons between the results of these studies are not always possible, as they had different objectives. Ortlepp (1937, 1938a, b, 1963) studied the helminths of all the organs and the entire alimentary canal, but his work was of a taxonomic nature, based on incidental findings, and presented no epidemiological data. Crowe (1977) listed the helminth species recovered from the small intestine, caeca and rectum of guineafowls, but in his subsequent analysis grouped them as acanthocephalans, cestodes and nematodes respectively. The two studies providing data on the prevalence and intensity of the helminths are those of Saayman (1966) and Verster & Ptasinska-Kloryga (1987). However, Saayman (1966) only examined the intestinal tract and Verster & Ptasinska-Kloryga (1987) collected helminths from the gizzard, intestine and caeca. Thus, their data on species richness would not reflect worms located in e.g. the crop or proventriculus.

The study conducted on guineafowls in Burkina Faso by Vercruysse *et al.* (1985) lends itself best to comparison with ours, as they examined the complete alimentary tract, including the crop and proventriculus. Of the total of 13 helminth species collected by these authors, eight species coincide with species recovered from our hosts. If the single acanthocephalan present in the birds from Burkina Faso

is taken into account, this number will increase by one. Vercruysse *et al.* (1985) record the acanthocephalan *Mediorhynchus selengensis*, which has been synonymized with *M. gallinarum* by Schmidt & Kuntz (1977), and the nematodes *Cyrnea parroti*, *S. suctoria*, *G. congolense* and *A. numidae*, which are also recorded in this study. In addition to these species, Vercruysse *et al.* (1985) recorded the cestode *Cotugnia digonopora* and the nematodes *Eucoleus annulatus*, *T. fissispina* and *Dispharynx spiralis*.

Nematodes

Cyrnea

With the exception of *C. parroti*, helminths were recovered from their usual predilection sites. According to Anderson (1992) members of the genus *Cyrnea* occur in the proventriculus of birds and he records *Cyrnea colini* in the wall of the proventriculus near the gizzard of Bobwhite quails. We did not recover *C. parroti* from the proventriculus, but in all infected guineafowls the parasites were situated under the gizzard lining and could only be seen after the horny layer had been removed. There seemed, however, to be a preference for the proventricular-gizzard isthmus as described for *Cyrnea neeli* from wild turkeys in the south-eastern United States (Davidson, Hon & Forrester 1977). Similarly, *C. parroti* recovered from Helmeted guineafowls in Burkina Fasso were also present in the gizzard (Vercuysse *et al.* 1985).

Subulura

The genus *Subulura* has a wide distribution in gallinaceaous birds on the African continent and records exist from Zimbabwe, Tanzania, Ghana, Nigeria and Somalia (Nicholls, Bailey, Gibbons, Jones & Samour 1995; Nfor, Ajanusi, Agbede & Esievo 1999; Poulsen, Permin, Hindsbo, Yelifari, Nansen & Bloch 2000; Permin, Esmann, Hoj, Hove & Mukaratirwa 2002; Magwisha, Kassuku, Kyvsgaard & Permin 2002). However, the genus is not restricted to the African continent and, according to Yamaguti (1961) is a cosmopolitan species.

Ortlepp (1937) recovered *S. suctoria* in association with *S. dentigera* from guineafowls from various regions in South Africa and Swaziland and concluded that the two species had a wide distribution. Contrary to our findings, he found *S. dentigera* to be far more abundant than *S. suctoria*.

Verster & Ptasinska-Kloryga (1987) collected helminths from 48 guineafowls in the vicinity of Pretoria.

Subulura suctoria was present in 11 and *S. dentigera* in three of the hosts examined. From these and our own results it is apparent that the two species, *S. suctoria* and *S. dentigera* often share the same habitat. It is difficult to judge from our data whether these two species are interactive and compete for the same resources. If so, *S. suctoria* would seem the stronger competitor as it consistently occurred in higher numbers than *S. dentigera*. However, the numbers of *S. dentigera* were not greater in hosts with relatively low burdens of *S. suctoria*, but rather the numbers of *S. dentigera* were low in these hosts as well. It is possible, that this association is similar to the major-minor species concept, as seen with *Theladorsagia circumcincta* and *Theladorsagia davtiani* in sheep and goats.

A literature study confirms the dominance of *S. suctoria* in guineafowls and Vercruysse *et al.* (1985) recorded a 100 % prevalence of *S. suctoria* from 103 Helmeted guineafowls in Burkina Faso. In addition to being the most prevalent nematode, these authors also found *S. suctoria* to be one of the most numerous parasites (26–1071 worms per host). *Subulura dentigera* was not reported from these hosts.

Ascaridia numidae

Ascaridia numidae is another nematode commonly encountered in Helmeted guineafowls and has been recorded from various geographic localities in Africa. The prevalence and intensity of this parasite varies greatly from 98.1 % with a range of intensity from 1 to 1452 in hosts in Burkina Faso (Vercruysse *et al.* 1985) and 86.7 % with intensities ranging from 1 to 504 in birds in Ghana (Hodasi 1976) to a low prevalence of 13 % with a maximum of 19 worms per host in South Africa (Verster & Ptasinska-Kloryga 1987). In the present study *A. numidae* was present in a single host only.

Gongylonema

Both Hodasi (1976) and Vercruysse *et al.* (1985), record *G. congolense* from hosts they examined, with a prevalence of 48.9 and 73.8 %, respectively. This indicates that *G. congolense* not only forms a regular part of the helminth community of guineafowls in South Africa, but throughout the African continent. With the exception of *Gongylonema ingluvicola* allegedly recorded by Ortlepp ("1937, 1938, unpublished records" cited by Verster & Ptasinska-Kloryga 1987), the absence of this genus in previous reports on helminths of guineafowls in South

Africa, is most likely due to the fact that earlier authors did not examine the crop of the hosts in their studies.

Tetrameres

While *Tetrameres numida* was recovered in low numbers from the Musina guineafowls, none of the more commonly reported species of this genus was present in our material. A second species, which has been recorded from guineafowls and is also a common parasite of domestic chickens, is *Tetrameres fissispina* Diesing, 1861. Vercruysse *et al.* (1985) report a 48.5% prevalence and an intensity of infection ranging from 1 to 146 worms per host from Helmeted guineafowls in Burkina Faso, and 23.3% of 126 Helmeted guineafowls in Nigeria were infected with *T. fissispina* (Fabiyi 1972). In Ghana the prevalence of infection in the same host was 8.9% with a mean worm burden of 2.8, ranging from one to eight. Young scavenging chickens in Ghana had a prevalence of *T. fissispina* of 58% (Poulsen *et al.* 2000).

We are aware of a single record of three females of *T. fissispina* from a single Helmeted guineafowl in South Africa (Le Roux 1926), and the same author reports a high percentage of infection (78%) in 60 domestic chickens in the same country. The proventriculus of a single, heavily infected host contained a minimum of 150 females (Le Roux 1926).

A third species commonly infecting domestic chickens, namely *Tetrameres americana,* which had a 60 and 62% prevalence in adult chickens in Tanzania and Zimbabwe, respectively (Permin, Magwisha, Kassuku, Nansen, Bisgaard, Frandsen & Gibbons 1997; Permin *et al.* 2002), has not yet been recorded from guineafowls.

From the literature cited above it would appear that the prevalence of the genus *Tetrameres* is slightly higher in domestic chickens than in Helmeted guineafowls. Since the data above concerning the domestic chickens above pertain to free-ranging or scavenging chickens, guineafowls and domestic fowls probably had an equal chance of exposure to the parasite. Whether the higher infection rates in chickens are a result of higher host densities or whether guineafowls are generally more resistant towards helminth infections remains speculation.

Trematodes

The literature contains few reports of trematodes from guineafowl hosts, but a number of trematodes have been listed as parasitizing not only the digestive tract and urogenital system, but also the respiratory system of domestic fowls (Soulsby 1968). To our knowledge the only published records of trematodes from the liver of guineafowls are those of *D. macrostomum*, that occurs in the gall bladder and bile ducts of *N. meleagris* (= *N. ptilorhyncha*) in Egypt (Lesbouyries 1941) and *Lutztrema* sp. from the gallbladder of Helmeted guineafowls in Ghana (Hodasi 1976). The former parasite has also been found in the liver of Helmeted guineafowls in the Kruger National Park (Horak 2007, personal communication) and was present in the Musina hosts. The results of this study and unpublished data of Horak (2007) suggest that *D. macrostomum* is not uncommon in South African guineafowls and can reach high intensities in individual hosts.

Postharmostomum gallinum has been reported from the gastro-intestinal tract from Crested guineafowls in Pakistan (Khan, Khan & Rayaz 1984). Hodasi (1969, 1976) collected *Postharmostomum ntowi* and *Episthmium ghanense* and *Episthmium africanus* from the gastro-intestinal tracts of domestic chickens. Intensities and prevalences were low and the latter author concluded that trematodes were rare parasites in gallinaceous birds.

The fact that the intermediate hosts of trematodes are mainly molluscs or rarely annelids (Gibbons, Jones & Khalil 1996), both of which are typically associated with moist environmental conditions, might well explain why trematodes played a minor role as parasites of the guineafowls in our dry study area.

Cestodes

Porogynia

The presence of young stages of *Porogynia paronai* in the liver of infected hosts is unusual. Hodasi (1976), however, recovered adult *Cotugnia meleagridis* from the small intestine of Helmeted guineafowls in Ghana, and recorded numerous young forms of this parasite from the host's gallbladder. Since the life cycle of *Porogynia* is not known, one can only speculate on the presence of immatures in the liver.

During the normal course of cestode development in avian hosts, the cysticercoid is freed from the arthropod intermediate host in the intestine as a result of mechanical and chemical actions. Subsequently, the scolex evaginates and the cysticercoid attaches itself to the gut wall (Reid 1962). The fact that young *P. paronai* were recovered from the liver of three birds and in relatively high numbers, in addition to

their uniform stage of development, suggests that their presence is not a result of post-mortem migration. Whether the newly freed cysticercoid, assuming that an arthropod is the intermediate host, migrates up the common bile duct to mature to a certain stage, before leaving the liver to resume its final maturation in the small intestine, or whether we have observed aberrant migration of juvenile stages will remain speculation until the development of *P. paronai* can be studied in more detail.

Abuladzugnia

Interestingly, the cestode *A. gutterae,* which was common in the guineafowls examined by us was not found in any of the previous surveys. Ortlepp (1963) originally described this species as *Cotugnia gutterae* from three specimens that had been collected from Crested guineafowls in Mozambique. Since then there seem to have been no further records of this parasite. Spasskii (1973) created the genus *Abuladzugnia* to accommodate *A. gutterae* and another of Ortlepp's (1963) species formerly described as *Cotugnia transvaalensis*.

Conclusion

The above findings suggest, that despite geographical variation in the prevalence and intensity of individual helminth species, probably caused by environmental conditions, such as temperature, rainfall and soil conditions, the helminth community of guineafowls in Africa is composed of a relatively stable body of core and secondary species enriched by satellite species. The latter probably depend on local conditions and can be influenced by abiotic conditions, but also the presence or absence of certain intermediate hosts and other terrestrial birds which may serve as reservoir hosts for certain parasites. We interpret the relative uniformity in the helminth community of Helmeted guineafowls in Africa as flowing from a long host/parasite association during which parasites have spread in conjunction with their hosts.

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