SECTION 2

PARASITES

OF

GAMEBIRDS

Introduction

In 1937 R.J. Ortlepp described the first worms from South African guineafowls. Since then, seven publications have appeared, approximately one every ten years. When Dr. Junker joined the Department of Veterinary Tropical Diseases, she started examining the helminths of guineafowls that had been collected over the years by Prof. I.G Horak, mainly from the KNP. The opportunity arose to extend the geographical range for this project to include hosts from Musina, Limpopo Province, in the northern part of the country, otherwise the date from these hosts would have been lost.

Infections with thorny-headed worms, tapeworms and roundworms are common in guineafowls and their helminth fauna is diverse. A total of 22 species were recovered from the alimentary canal, comprising eleven tapeworms, ten roundworms and a single thorny-headed worm. A single trematode (fluke) species was present in the liver.

I funded most of the project, and was also intimately involved with the collection of the helminths from Musina, and the preparation of the manuscripts. This part is divided into two chapters, one dealing with the descriptions of new species or re-descriptions of known ones, and the other dealing with the population dynamics of the worms. A check list of the parasites of guinea fowls is included in this section. The publications in the first chapter are listed in chronological order and thos in the second one by subject and then chronologically.

DESCRIPTIONS AND RE-DESCRIPTIONS OF PARASITES OF GAME BIRDS (P 429)

JUNKER, K. & BOOMKER, J. 2006. *Mediorhynchus gallinarum* (Acanthocephala: Gigantorhynchidae) in Helmeted guineafowls, *Numida meleagris*, in the Kruger National Park, South Africa. *Onderstepoort Journal of Veterinary Research*, 73, 283-292.

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

JUNKER, K., DAVIES, O.R., JANSEN, R., CROWE, T.M. & BOOMKER, J. 2008. Nematodes from Swainson's spurfowl *Pternistis swainsonii* and an Orange River francolin *Scleroptila levaillantoides* in Free State Province, South Africa, with a description of *Tetrameres swainsonii* n. sp.(Nematoda: Tetrameridae) *Journal of Helminthology,*82, 365 – 371.

POPULATION DYNAMICS (P 463)

JUNKER, K. & BOOMKER, J. 2007. Helminths of guineafowls in Limpopo Province, South Africa. *Onderstepoort Journal of Veterinary Research*, 74, 265-280.

JUNKER, K., DEBUSHO, L. & BOOMKER, J. 2008. The helminth community of Helmeted Guineafowls, *Numida meleagris* (Linnaeus, 1758), in the north of Limpopo Province, South Africa. *Onderstepoort Journal of Veterinary Research*, 75:225-235.

JUNKER, K. & BOOMKER, J. 2007. A check list of the helminths of guineafowls (Numididae) and a host list of these parasites. *Onderstepoort Journal of Veterinary Research*, 74, 315-337.

CHAPTER 1

Descriptions and re-descriptions

of

parasites of gamebirds

Onderstepoort Journal of Veterinary Research, 73:283–292 (2006)

Mediorhynchus gallinarum (Acanthocephala: Gigantorhynchidae) in Helmeted guineafowls, *Numida meleagris*, in the Kruger National Park, South Africa

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ABSTRACT

JUNKER, K. & BOOMKER, J. 2006. *Mediorhynchus gallinarum* (Acanthocephala: Gigantorhynchidae) in Helmeted guineafowls, *Numida meleagris*, in the Kruger National Park, South Africa. *Onderstepoort Journal of Veterinary Research*, 73:283–292

Mediorhynchus gallinarum was recovered from the small intestines of 36 of 50 Helmeted guineafowls sampled from August 1988 to May 1989. The intensity of infection ranged from 1–141 worms per host, with a mean intensity of 23.2 (± 34) and a median intensity of 5. The Wilcoxon-Mann-Whitney test revealed no significant differences between the mean worm burdens of male and female birds at the 5 % level ($P > 0.05$). Slightly more female than male acanthocephalans were collected. The majority (63.4 %) of females had eggs with fully-developed embryos, 9 % had immature eggs, 21.2 % had no eggs and the egg status of 6.4 % could not be determined. No seasonal pattern of intensity of infection emerged from the data, but worm burdens were markedly higher after good rains in February 1989. South Africa constitutes a new geographic record for *M. gallinarum*.

Keywords: Acanthocephala, Helmeted guineafowls, *Mediorhynchus gallinarum, Numida meleagris*

INTRODUCTION

The guineafowl family Numididae is widespread and common in the Afrotropical region, where they utilize a wide variety of habitats ranging from dense rainforest to semi-desert. Of the four genera of guineafowls, *Agelastes*, *Acryllium*, *Guttera* and *Numida*, the last-named's helminth fauna has been studied the most extensively. There are few references to cestodes and nematodes from *Guttera* (Crested guineafowl) and even fewer from *Acryllium* (Vulturine guineafowl) (Yamaguti 1959, 1961, 1963; Ortlepp 1963; Schmidt 1986). The authors are aware of only one publication pertaining to acanthocephalans from guineafowls other than *Numida,* namely *Mediorhynchus taeniatus* (syn. *Empodius segmentatus*) from *Guttera pucherani edouardi* in the former Belgian Congo (Southwell & Lake 1939).

Many of these studies were conducted in North and West Africa, where guineafowls are commercially reared as a source of protein and necessitated a more detailed knowledge of the birds and their parasites (Hodasi 1976). The possibility of wild guineafowls as alternative or reservoir hosts for helminths of domestic chickens and vice versa, also required investigation (Fatunmbi & Olufemi 1982). In South Africa three studies concerning the gastrointestinal worms of Helmeted guineafowls have been conducted, one each in the Eastern Cape Province, the Kimberly area in the Northern Cape Province and in the surroundings of Pretoria in Gauteng Province (Saayman 1966; Crowe 1977; Verster & Ptasinska-Kloryga 1987).

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The present paper describes a survey in which the acanthocephalan burdens of free-ranging guineafowls in the southern part of the Kruger National Park (KNP) were determined, as well as those of "scavenger" guineafowls frequenting the refuse dump at the Skukuza tourist rest camp. Some scanning electron micrographs and measurements intended to supplement the descriptions of *Mediorhynchus gallinarum* given by Bhalerao (1937) and Nath & Pande (1963) are included.

MATERIAL AND METHODS

Study site

The KNP is situated in the eastern part of Limpopo Province and the north-eastern part of Mpumalanga Province. It encompasses an area of 1 948 528 ha. The survey region in the southern part of the park (South of 24°50' S; Skukuza 24°50 S, 31°35' E) comprises vegetation classified as Lowveld Sour Bushveld and Arid Lowveld (Acocks 1975). Helmeted guineafowls are present throughout the study area. The refuse dump at Skukuza tourist rest camp offers easy foraging and attracts hundreds of birds (Horak, Spickett, Braack & Williams 1991).

Survey birds

Each month from August 1988 to May 1989, two Helmeted guineafowls on or near the refuse dump at Skukuza, and three at other sites in the southern part of the park were shot. An effort was made to shoot only adult birds, but two of the total of 50 birds were 7 to 10-month-old sub-adults. No birds were collected in March 1989, but of the ten guineafowls that were examined in February 1989, five were sampled in the beginning of the month and five were shot on 28 February. The latter birds are listed as hosts examined in March 1989.

Parasite collection

After the birds had been shot their carcasses were transported to the laboratory at Skukuza. The entire viscera were removed and placed in separate labelled bottles in which they were stored in 10 % buffered formalin. During 2005 and 2006 the lungs, crop, small intestine (SI) and the caecum-colon (CC) were removed from the bottles and separated. Macroscopically visible helminths were recovered from each of the organs and transferred to 70 % ethanol. Thereafter the content of each organ was washed with tap water over a 150 µm sieve. The residue on the sieve was transferred to a vessel containing 70 % ethanol and examined under a stereoscopic microscope for the presence of endoparasites.

Following the procedures described by Gibbons, Jones & Khalil (1996) some acanthocephalans were stained with aqueous aceto alum carmine and mounted in Canada balsam, while others were cleared in Hoyer's medium.

Specimens for scanning electron microscopy (SEM) were dehydrated through graded ethanol series and critical point dried from 100 % ethanol through carbon dioxide. They were mounted on viewing stubs and sputter-coated with gold. The photography was done using a Hitachi S-2500 scanning electron microscope.

In order to investigate differences in the worm burdens of male versus female hosts, the Wilcoxon-Mann-Whitney test for independent samples was used to compare the mean worm burden of the two groups at the 5 % level ($P > 0.05$) (Thrusfield 1995).

RESULTS

Mediorhynchus gallinarum (Bhalerao, 1937) van Cleave, 1947 (Fig. 1 & 2)

MORPHOLOGY

Mediorhynchus gallinarum is characterized by a so-called acanthopseudoannelid holdfast, an attachment mechanism involving proboscis hooks as well as pseudo-segmentation of the body, considered typical for Moniliformidae and some of the Gigantho-rhynchidae (Petrochenko 1956).

The trunk is elongate and tapers slightly towards the posterior end. The prominence of the pseudo-segmentation is influenced by the extent of muscle contraction: it can be conspicuous, as in craspedote cestodes or nearly smooth as in sebekiid pentastomes. Pseudo-segmentation also appears to be more pronounced in older, larger specimens. The most anterior part, and in some specimens the caudal tip, is usually unsegmented. Annulus counts range from 52 in a 48-mm-long male to 76 in a 61-mm-long female. In some specimens muscle contraction creates a neck-like zone behind the proboscis, which is absent in relaxed specimens. The protoboscis is almost conical in shape and the teloboscis is trapezoid.

The hooks on the protoboscis are arranged in 18–20 roughly longitudinal rows of 4–5 hooks each. The total length of the hooks, including their roots, ranges from 0.048–0.076 mm, with the hooks in the top

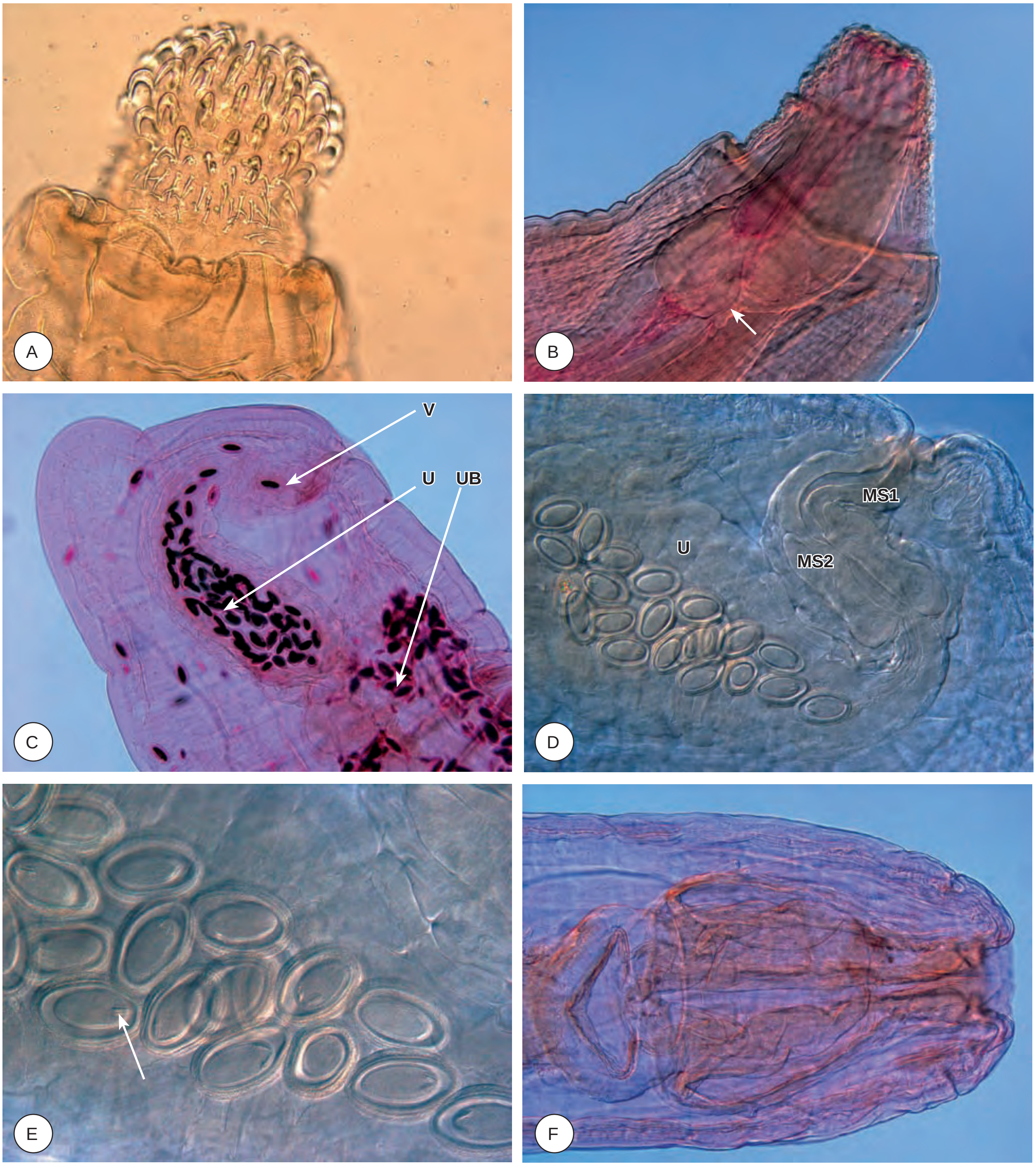

FIG. 1 *Mediorhynchus gallinarum*

A. Proboscis showing the hooks on the protoboscis and spines on the teloboscis; x 200. B. Proboscis receptacle. The muscular wall of the receptacle is visible together with the dorsal protrusor muscles (arrow), giving the impression of a double walled proboscis sheath; x 100. C. Female posterior end. Dark colouration of eggs due to staining. U = uterus, UB = uterine bell, V = vagina; x 100. D. Female posterior end. Detail of the two muscular sphincters (MS1, MS2) surrounding the vagina. U = uterus; x 200. E. Eggs with compact granular outer shell and fully developed embryo with anterior larval hooklets (arrow); x 400. F. Male posterior depicting terminal genital pore and copulatory bursa with complicated internal structure; x 100

row usually the shortest. Two longitudinal grooves extend from the base of the hook blade to its tip. The rootless spines on the teloboscis vary in length from 0.032–0.047 mm.

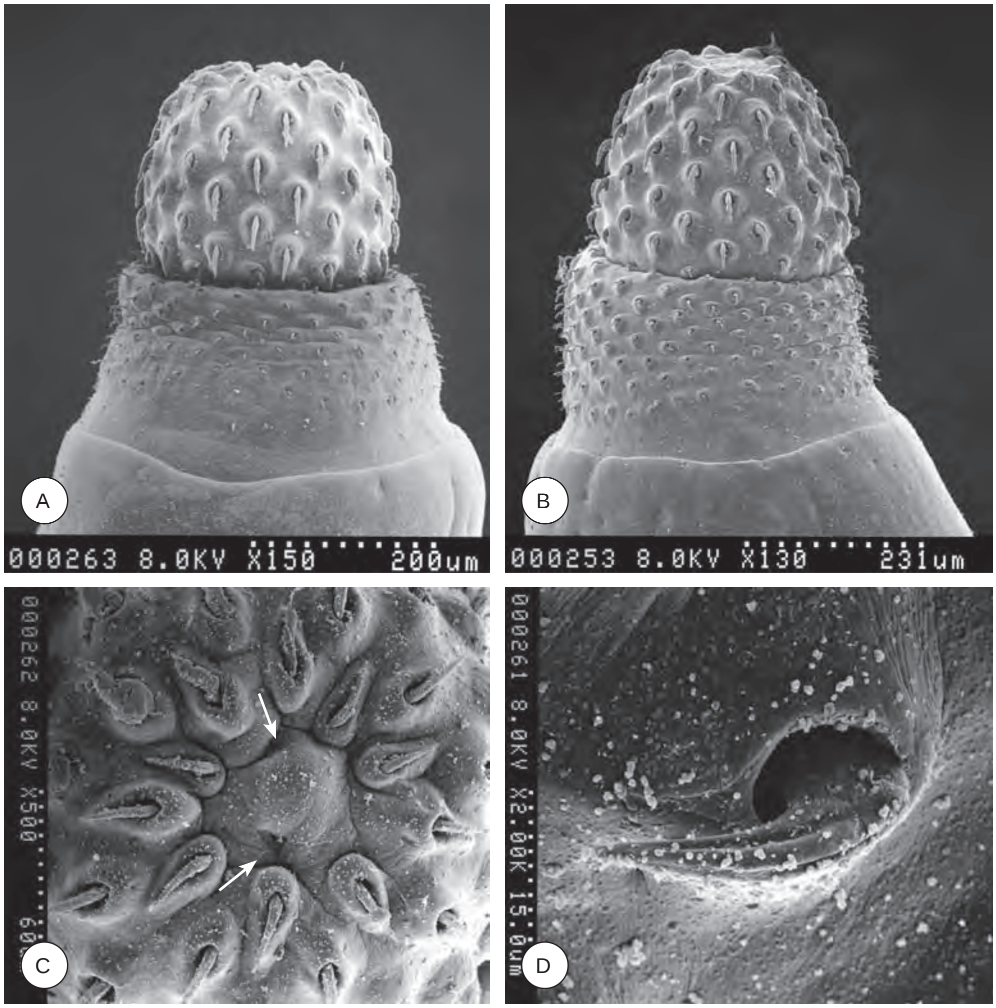

FIG. 2 *Mediorhynchus gallinarum*

A. Anterior part displaying the arrangements of hooks on the protoboscis and smaller spines on the teloboscis; x 150. B. Same specimen rotated 180°; x 130. C. En face view. The two apical pores of the apical organ are visible (arrows); x 500. D. Close-up of a hook partially retracted into the surrounding pouch. Note the grooved surface of the hook; x 2000

The lemnisci are slender and approximately 2.5-2.9 times longer than the proboscis receptacle. In some specimens up to six nuclei, possibly more, per lemniscus were counted. Lemniscus length ranged from 2.09 mm in a 13-mm-long male to 3.47 mm in a 50-mm-long male, but the length of the lemnisci did not necessarily increase with body length. The lemnisci ranged from 0.191–0.343 mm in width. No obvious differences were evident between males and females.

Females: The average body length is 32 ± 17 mm (*N* = 423), ranging from 4–110 mm, with a median of 35 mm. The maximum body width varies from 0.6–4 mm (mean = 1.4 ± 0.6 mm), with large gravid females, especially when the body was contracted, the widest.

The length of the proboscis receptacle ranges from 0.701 mm in a 6-mm-long female to 1.19 mm in a 48-mm-long female (mean = 1.0 ± 0.162 mm). The width of the proboscis receptacle varies from 0.296–0.554 mm, with an average of 0.399 ± 0.072 mm. Eggs with a compact, granular outer shell and fully developed embryos measure on average 0.049 mm (range: 0.043–0.052 mm) in width and 0.079 mm (range: 0.070–0.86 mm) in length. The embryo itself is 0.054 mm (range: 0.047–0.058 mm) long and 0.025 mm (range: 0.021–0.028 mm) wide.

Males: The mean body length is 25 ± 14 mm (*N* = 284) with a range of 3–70 mm. The median is 25 mm. The average maximum width ranges from 0.5–2.8 mm (mean = 1.1 ± 0.4 mm) and the measurements taken from 14 males are presented in Table 1.

TABLE 1 Morphological data of *Mediorhynchus gallinarum* males recovered from Helmeted guineafowls in the Kruger National Park. All measurements given in micrometer unless otherwise indicated

Spec. no.	Length (mm)	Width (mm)	PRL	PRW	PBL	TBL	TBA	TBP	RLL	LLL	LLW	ATL	PTL	CGL	SVL	CBL
GF38/8	6	0.8	609	311	318	332	369	591	2 341	nm	nm	369	321	362	367	531
GF3/13	12	0.7	786	nm	324	321	442	689	nm	nm	nm	815	800	nm	528	666
GF38/9	13	0.9	762	328	286	291	411	653	2 093	2 156	206	949	988	1 190	709	712
GF38/4	14	nm	791	333	339	316	378	685	2 470	2 713	nm	848	969	nm	742	892
GF38/6	24	1.1	967	359	299	312	470	668	2 291	2 573	nm	1 477	1 434	nm	1 002	1 079
GF3/8	33	1.4	1 170	nm	nm	nm	nm	nm	2 386	2 975	298	2 727	nm	nm	nm	nm
GF3/12	33	1.1	1 066	404	nm	nm	nm	nm	3 144	3 036	nm	2 008	2 038	2 871	1 379	1 401
GF3/6	37	1.6	938	371	nm	nm	nm	nm	2 166	2 447	313	2 478	nm	nm	nm	nm
GF4/7	40	1.6	nm	nm	nm	nm	nm	nm	nm	nm	nm	2 513	2 525	4 448	1 827	1 841
GF3/5	44	1.5	1 176	367	nm	nm	nm	nm	3 051	2 887	306	2 156	2 095	3 555	1 864	1 804
GF3/4	48	1.4	1 201	437	nm	nm	nm	nm	3 380	3 470	nm	3 023	2 915	4 640	1 494	1 741
GF1/1	50	1.5	1 226	416	nm	nm	nm	921	3 113	2 612	nm	2 715	3 015	2 715	1 825	1 659
GF3/11	53	1.8	nm	nm	nm	nm	nm	nm	nm	nm	nm	2 642	2 732	7 303	1 793	2 286
GF38/1	nm	1.1	1 067	330	nm	nm	nm	nm	nm	2 708	258	nm	nm	nm	nm	nm

ATL = Anterior testis length
CBL = Copulatory bursa length
CGL = Cement gland area length
LLL = Left lemniscus length
LLW = Left lemniscus width
nm = Not measured
PBL = Protoboscis length
PRL = Proboscis receptacle length
PRW = Proboscis receptacle width
PTL = Posterior testis length
RLL = Right lemniscus length
RLW = Right lemniscus width
SVL = Seminal vesicle length
TBA = Width of anterior border of teloboscis
TBL = Teloboscis length
TBP = Width of posterior border of teloboscis

Measurements of the proto- and teloboscis were only taken from specimens in which these features were fully extended.

The oblong shaped testes are located in the posterior third of the body. In young males the sexual organs are clustered in the caudal region. Testes move anteriorly and the gap between the anterior and posterior testis widens as the males grow larger.

Taxonomic remarks

Harris (1973) described *Mediorhynchus selengensis* from *Francolinus leucoscepus* in Kenya. In their revision of the genus *Mediorhynchus* Schmidt & Kuntz (1977) classified this species as a junior synonym of *M. gallinarum* after comparing material of *M. gallinarum* to the description of Harris (1973). Vercruysse, Harris, Bray, Nagalo, Pangui & Gibson (1985) chose to retain the name *M. selengensis* for acanthocephalans collected from guineafowls in Burkina Faso until such time as Asian and African material could be more thoroughly compared.

The main difference between our specimens and those of Harris (1973) is the number of proboscis spines. Harris (1973) described only two to three spines per row, whereas our specimens carry five to seven spines per row. Nevertheless, Harris' (1973) illustration suggests that more spines per row may be present. The remaining measurements overlap to a large extent. Not having examined Harris' specimens we would tend to agree with Schmidt & Kuntz (1977) and assign our specimens to *M. gallinarum*.

Epidemiology

Small numbers of acanthocephalans were recovered from the CC of six guineafowls, and these have been included in the SI counts.

The prevalence of infection with *M. gallinarum* was 72 %, i.e. of the 50 hosts examined 36 harboured parasites. A total of 846 worms were recovered from the 36 hosts. Worm burdens were usually low, with a median intensity of 5, and the intensity of infection ranged from 1–141, with a mean intensity of 23.2 ± 34. Hosts infected with less than 10 acanthocephalans accounted for 58 % of the total host population, hosts with a burden ranging between 10 and 20 parasites comprised 14 % and in 28 % of the guineafowls the worm burden exceeded 20. The mean intensity of infection of male and female birds was 19.8 ± 36.4 and 27 ± 31.8, respectively. No significant differences between the mean intensities of infection at the 5 % level, with a two-tailed P value of 0.2892, were observed with the Wilcoxon-Mann-Whitney test.

The mean intensity of infection with male and female acanthocephalans was 9 and 13, respectively, and the sex ratio favoured females (55.9 % versus 37.7 %). The small number of males and females recovered from the majority of hosts did not provide an adequate sample size for statistical testing. However, in nine of 10 hosts in the group harbouring more than 20 acanthocephalans, female parasites outnumbered males and constituted 60 % of the adult parasites in this group. Immature *M. gallinarum* comprised a mere 0.4 % of the infrapopulation, and the gender of 6 % of the acanthocephalans could not be determined because they were poorly preserved.

The uteri of the majority of the females (63.4 %) contained mature eggs, 9 % only immature eggs and 21.2 % contained no eggs. The status of eggs in the uteri of 6.4 % of females could not be determined.

The mean intensities of infection during the various months of collection are presented in Table 2, and the seasonal variation in infection in Fig. 3. Infection peaked during late summer and autumn, but becausee the sampling period did not cover a full year the seasonality of infection cannot be determined with certainty.

TABLE 2 The mean numbers of *Mediorhynchus gallinarum* recovered from 50 Helmeted guineafowls in the Kruger National Park

Collection date	Mean intensity of infection (range)	No. of birds infected/examined
Aug. 1988	7.8 (1–14)	4/5
Sep. 1988	3.5 (1–5)	4/5
Oct. 1988	2.5 (1–4)	2/5
Nov. 1988	4.0 (4)	1/5
Dec. 1988	6.2 (2–16)	5/5
Jan. 1989	4.3 (2–8)	4/5
Feb. 1989	41.0 (3–67)	5/5
Mar. 1989	74.4 (5–141)	5/5
Apr. 1989	26.5 (4–52)	4/5
May 1989	25.0 (2–48)	2/5

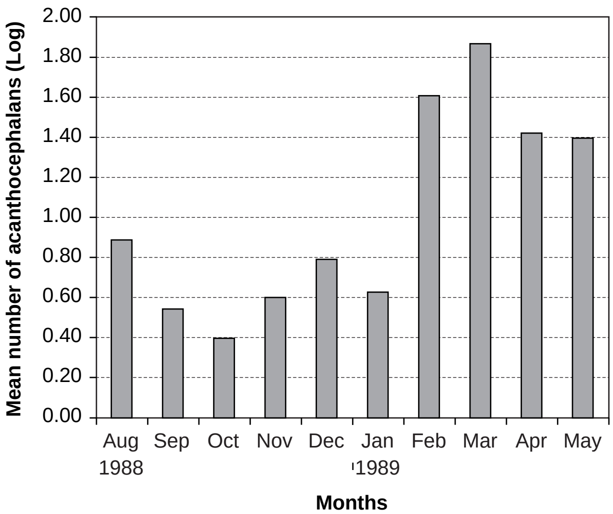

FIG. 3 The mean seasonal intensities of infection with *Mediorhynchus gallinarum* in Helmeted guineafowls in the Kruger National Park

Few hosts were examined from the different localities in the southern part of the KNP on the various collection dates. Consequently, data pertaining to differences in the mean intensities of infection at the different sites versus the dump at Skukuza should not be overinterpreted. However, in February and March 1989 the worm burdens of all six guineafowls sampled along the Lower Sabie Road were markedly lager than the overall mean intensity of 23.2, with individual burdens consisting of 51, 37, 48, 141, 86 and 119 worms. In contrast, the acanthocephalan burdens of four guineafowls sampled at the dump at Skukuza at the same time varied from far below to far above average, namely 76, 3, 5 and 21.

DISCUSSION

We have not been able to establish whether the grooves on the surface of the hooks of *M. gallinarum* are a unique feature of this parasite or genus or whether it is a characteristic with a wider taxonomic significance.

No grooves were seen on SEM photographs taken by Taraschewski, Sagani & Mehlhorn (1989, cited by Taraschewski 2000) of hooks of *Echinorhynchus truttae* and *Moniliformis moniliformis*. The function of these structures is open for speculation. They might simply improve the holdfast of the hooks in the surrounding host tissue. Alternatively, the increased surface area could assist in the uptake as well as secretion of substances. Polzer & Taraschewski (1992, cited by Taraschewski 2000) discuss the discharge of penetration enzymes through the hook pores of *Pomphorhynchus laevis*.

The majority of acanthocephalans in this study were recovered from the SI and only a small number were found in the CC. While the caecum is a predilection site of some acanthocephalans (De Buron & Nickol 1994), we are not sure whether our findings represent a true distribution pattern or are the result of contamination during the processing of the hosts. There is also the likelihood of post mortem migration. *Mediorhynchus gallinarum* parasitizing domestic fowls in Papua and New Guinea were confined to the mid and lower small intestine (Talbot 1971), and Crowe (1977) recovered *Mediorhynchus taeniatus* only from the small intestine of Helmeted guineafowls. We are not aware of any controlled studies concerning the site preferences of any members of the genus *Mediorhynchus*.

Morphologically *M. gallinarum* falls into the category of acanthocephalans with a short neck and the associated shallow mode of attachment as described by Taraschewski (2000). Histological examination of *M. gallinarum* in domestic fowls revealed that their attachment rarely penetrated below the muscularis mucosa (Nath & Pande 1963; Talbot 1971). Taraschewski (2000) states that non-perforating species remain mobile and can alter their point of attachment. They do not occupy extra-intestinal sites within their hosts. According to Kennedy & Lord (1982) acanthocephalans can successfully utilize a much larger region of the digestive tract than their predilection site, and at high levels of infection are known to expand their distributional range within the alimentary canal (Taraschewski 2000). The hosts from which acanthocephalans were collected from both the CC and the SI in the present study carried relatively low worm burdens (4, 4, 8, 36 and 67) and infections involving considerably higher intensities were restricted to the SI in some of the other hosts. In view of the above, post mortem migration appears the more probable explanation for the specimens we found in the CC.

Only a small percentage of *M. gallinarum* were immature, and this can be attributed to the short period of time required by the cystacanth, once ingested by a final host, to develop into an adult. In experimental infections of several species of woodpeckers with cystacanths of *Mediorhynchus centurorum* the mean prepatent period was 35 days (Nickol 1977).

More than 60 % of the female *M. gallinarum* examined during this study contained eggs with shelled embryos. This is contrary to Van Cleave's (1947a) report that fully grown female specimens of *Mediorhynchus* spp. recovered from a variety of birds invariably lacked embryonated eggs. His speculation that sterility might be seasonal, is not supported by our data in the case of *M. gallinarum*. We do, however, accept his view on sterility possibly being due to the absence of males or an indication of the unsuitability of a certain bird species as final host.

One of the hosts examined in this study was infected by a single large (6.5 cm) female containing only immature eggs, which in view of the many gravid females recovered from other guineafowls, we interpret as lack of fertilization. A relatively large female in another bird contained sterile eggs, despite the presence of a male. In the latter case it is possible that the male was acquired during a more recent infection. In pentastomid parasites copulation occurs when the uterus of the female is undeveloped and the sexes are of approximately equal size. As the uterus develops it becomes impossible for the male to deposit sperm in the female spermathecae (Riley 1986). As in pentastomes insemination in the acanthocephala is possibly restricted to a short critical period during female development. Riley (1986) suspects that the absence of male pentastomids retards female development. This does, however, not seem to be the case in the Acanthocephala.

Van Cleave (1947a), who examined collections of the genus *Mediorhynchus* from various parts of the world, found the intensity of infection to be extremely low in many avian hosts. Often a single worm was present. He saw this as an indication of the absence of reservoir hosts, reasoning that the normal final hosts of *Mediorhynchus* would not feed on possible reservoir hosts, i.e. animals large enough to consume the intermediate host (Van Cleave 1947a). Given the catholic diet of guineafowls, this argument would not be valid for this particular final host. Since nothing is known about the intermediate hosts of *M. gallinarum* in South Africa, it would be difficult to speculate whether the higher mean intensity of infection is due to the inclusion of reservoir hosts in the life-cycle, or is due to a wide range of possible intermediate hosts, or both.

According to Petrochenko (1956) most individual hosts harbour a single acanthocephalan species only, even if the particular host species serves as host for several different species of acanthocephalans. Our own data and the literature pertaining to guineafowls support this. *Mediorhynchus taeniatus* was the only acanthocephalan present in 42 guineafowls from Nigeria and 13 guineafowls from South Africa (Fabiyi 1972; Verster & Ptasinska-Kloryga 1987). Saayman (1966) recovered *Mediorhynchus numidae* (syn. *Empodisma numidae*) from 14 guineafowls, and Vercruysse *et al.* (1985) report only *M. selengensis* Harris, 1973 from guineafowls in Burkina Faso.

Compared to *Mediorhynchus* spp. infections in guineafowls in other African countries the prevalence of infection in the guineafowls in the Kruger National Park was high. *Mediorhynchus taeniatus* in *N. meleagris* in Nigeria had a prevalence of 26.6 % with the intensity ranging from two to 74 worms (Fabiyi 1972). The prevalence of *M. gallinarum* in guineafowls in Burkina Faso was 14 %, the intensity ranging from one to 142 (Vercruysse *et al*. 1985). In Ghana 16 % of the Helmeted guineafowls harboured *M. taeniatus*, with a maximum intensity of 15 worms (Hodasi 1976).

Mediorhynchus taeniatus has also been recorded from South Africa by Verster & Ptasinska-Kloryga (1987). This species differs from *M. gallinarum* in that it has less than 40 hooks and that the lemnisci are not much longer than the proboscis receptacle (Meyer 1932; Schmidt & Kuntz 1977). *Numida meleagris* shot in the Pretoria area (Gauteng Province) had burdens reaching up to 22 worms per bird, with a mean of 1.7. The prevalence of *M. taeniatus* was 27 % (Verster & Ptasinska-Kloryga 1987).

Saayman (1966) recovered *M. numidae* from Helmeted guineafowls in the Eastern Cape Province. This parasite is characterized by the absence of pseudo-segmentation and possesses only three hooks per row (Schmidt & Kuntz 1977). Intensity of infection ranged from one to 27 worms (mean = 11.5) and the prevalence was 39 %. It is interesting that in three different geographical regions in which guineafowls were examined in South Africa the genus *Mediorhynchus* is represented by three different species and that only one species was recovered per region. This, as well as the differences in prevalence and intensity of infection, might be the result of different climatological conditions, vegetation types and resulting differences in the arthropod fauna, suspected of being intermediate hosts, present at the three study sites.

While no pattern of seasonal abundance emerged from our data, worm burdens were markedly higher in guineafowls collected during February, April and May 1989. This coincides with the exceptionally high rainfall of 286.3 mm in February (Penzhorn, Horak, Spickett & Braack 1991). The annual mean rainfall for Skukuza recorded by Gertenbach (1980) is 546.3 mm. The high rainfall probably resulted in a rapid increase of insect and other arthropod populations ensuring a ready supply of intermediate hosts for *M. gallinarum* and a convenient source of infection for the final hosts.

All guineafowls are highly terrestrial and feed exclusively on the ground. They are omnivorous opportunists and the composition of their diet at any given moment is determined by the local abundance of the various food items (Del Hoyo, Elliot & Sargatal 1994). The overall diet is very varied and consists of plant matter such as leaves, roots, bulbs, seeds, fruits and flowers, as well as grit and animal food (Saayman 1966). The latter, while including a few vertebrates like small frogs, toads and lizards, is mainly made up of a wide array of insects, small molluscs, arachnids and millipedes.

About 12 % of the annual volume of food consumed by guineafowls consists of invertebrates, but Helmeted guineafowls, in particular, prefer to feed on insects when these are sufficiently abundant. The crop of a single Helmeted guineafowl yielded 5 100 harvester termites, *Hodotermes mossambicus* (Del Hoyo *et al*. 1994). Saayman (1966) reports that crops examined during the winter season yielded the highest average amount of live food, mainly because of the large numbers of *H. mossambicus*.

There is a marked individual variation in feeding intensity of guineafowls, and crop contents have been observed to vary considerably between individual members of the same flock (Saayman 1966). This might explain why some of the hosts from the same locality examined at the same time carried very low worm burdens while others harboured large numbers of acanthocephalans. It was especially evident in the guineafowls collected in February/March 1989 from the dump in Skukuza. Overdispersion is a well described phenomenon in parasitology, and amongst others, it is thought to reflect certain traits of individual hosts, such as behavioural differences or immune reactions (Horak & Boomker 2000).

Penzhorn *et al*. (1991) observed that the guineafowls foraging at the dump were able to maintain good body condition despite the fact that the mass of food-intake compared with veld-collected birds was low. They concluded that the refuse dump provided a rich source of food. The mean intensity of infection increased markedly in the free-ranging guineafowls after the good rains in February 1989, but not to the same extent in the birds frequenting the refuse dump. It therefore appears that the good quality diet that is continuously available for these "scavenging" guineafowls buffers the effects that environmental changes have on the free-ranging guineafowls in the rest of the study area, and that they are not as reliant on arthropods to supply their diet and hence are less likely to ingest the possible intermediate hosts of the acanthocephalans. Unfortunately, little is known about the intermediate hosts in the life cycle of *Mediorhynchus*. *Mediorhynchus grandis* develops to the infective stage in a variety of grasshoppers in the USA (Van Cleave 1947b) and it would certainly be interesting to investigate potential intermediate hosts for *M. gallinarum*.

Talbot (1971) reports that even in heavy infections of domestic fowls in Papua and New Guinea with *M. gallinarum* little evidence of severe pathology was seen during the histological examination and he concluded that *M. gallinarum* is not a parasite of major economic importance.

Louw, Horak, Meyer & Price (1993) when determining the lice burdens of the guineafowls examined in this study found no overt signs of distress when observing the birds prior to collection, and Penzhorn *et al.* (1991) found no indication of emaciation during their morphometric studies of the same birds. Crowe (1977) did not see any signs of gross pathological conditions in 206 Helmeted guineafowls, which amongst other helminth parasites, carried acanthocephalans. It would thus appear that guineafowls, at least under natural conditions, tolerate infections with *Mediorhynchus* well. One must, however, bear in mind, that, although not primary pathogens, these parasites compete with their host for nutrients and in the case of heavy infections might well be detrimental to the host's condition.

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

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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).

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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

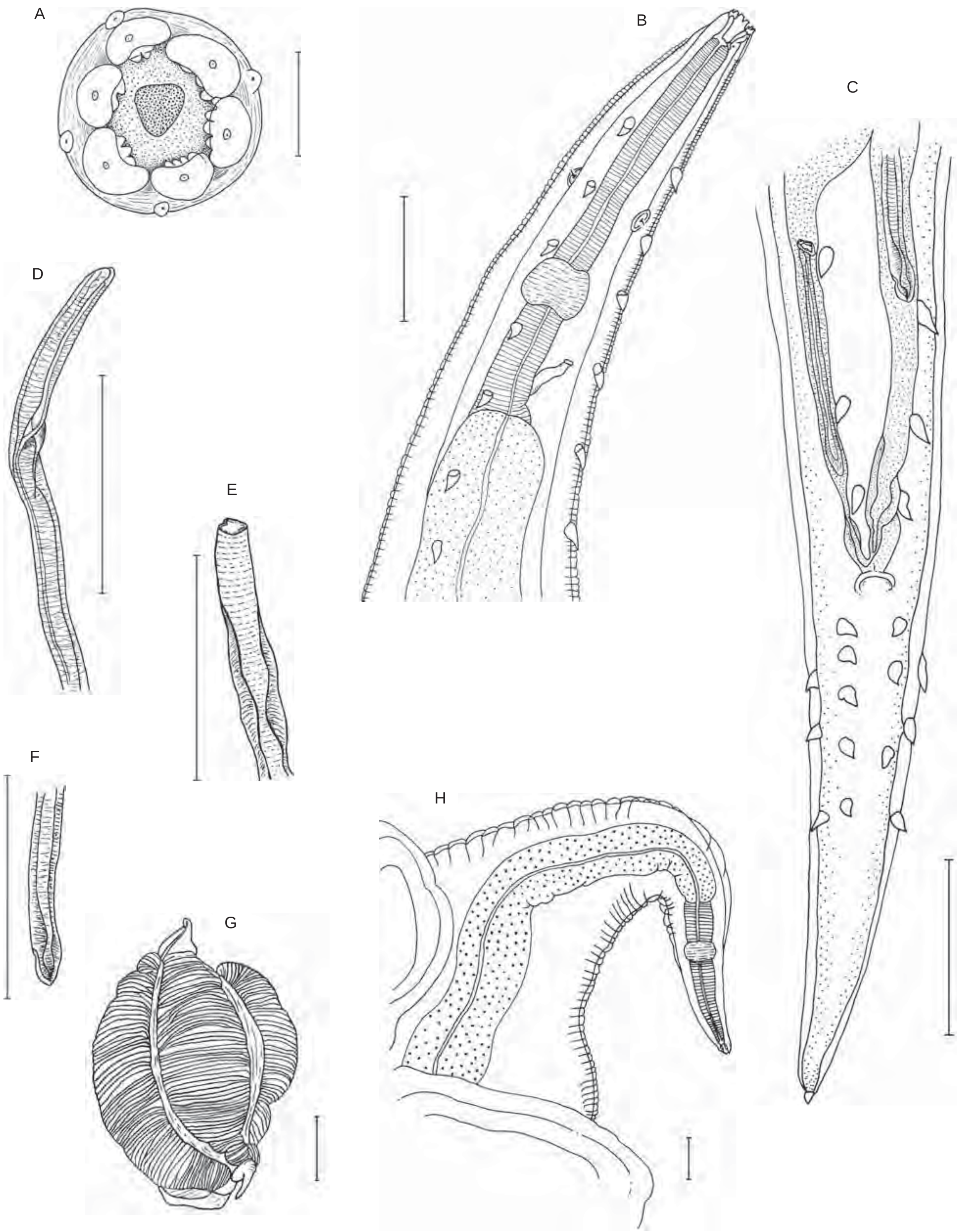

FIG. 1 *Tetrameres numida* n. sp. Male. A. Apical view of the trilobed pseudolabia surrounding the triangular mouth. Note the tooth-like processes (scale bar = 10 μm). B. Ventro-lateral view of the anterior end (scale bar = 100 μm). C. Ventral aspect of the posterior end (scale bar = 100 μm). D. Lateral 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)

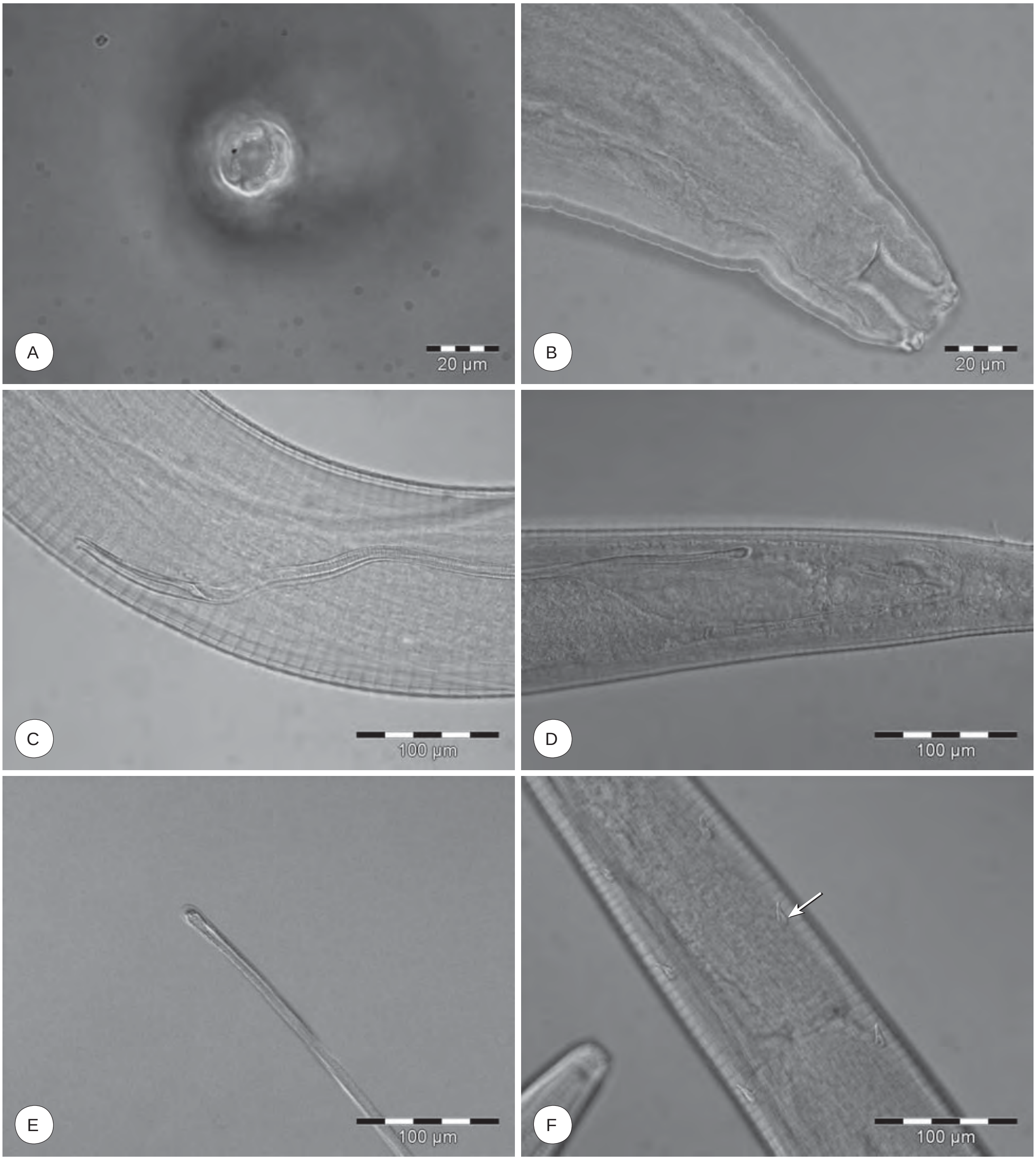

FIG. 2 *Tetrameres numida* n. sp. Male. A. Head, apical view. B. Anterior extremity, ventral view. C. Left spicule, anterior end. D. Posterior extremity with right spicule and distal tip of left spicule. E. Tip of left spicule. F. Body spines (see arrow)

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, Allotype 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 pairs illustrated; 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.

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Nematodes from Swainson's spurfowl *Pternistis swainsonii* and an Orange River francolin *Scleroptila levaillantoides* in Free State Province, South Africa, with a description of *Tetrameres swainsonii* n. sp. (Nematoda: Tetrameridae)

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Abstract

Five Swainson's spurfowl collected in Free State Province, South Africa, were examined for helminth parasites, and the nematodes *Acuaria gruveli*, *Cyrnea parroti*, *Gongylonema congolense*, *Subulura dentigera*, *Subulura suctoria* and a new *Tetrameres* species were recovered. Their respective prevalence was 100, 20, 80, 20, 20 and 20%. These nematodes are all new parasite records for Swainson's spurfowl, and *Acuaria gruveli* constitutes a new geographical record as well. A single specimen of *Cyrnea eurycerca* was found in an Orange River francolin, representing a new host and geographical record for this parasite. The new species, for which the name *Tetrameres swainsonii* is proposed, can be differentiated from its congeners by a combination of the following characters of males: two rows of body spines, a single spicule which is 1152–1392 μm long, and eight pairs of caudal spines arranged in two ventral and two lateral rows of four spines each. The single female has the globular shape typical of the genus.

Introduction

Swainson's spurfowl *Pternistis swainsonii* (Smith, 1836) (Phasianidae: spurfowls) is endemic to southern Africa. In South Africa it has undergone a major southward range expansion and can now be found east of approximately 23°E and south as far as 30°S in the Eastern Cape, Free State, Gauteng, Limpopo, Mpumalanga, Northern Cape and North West Provinces. It is absent from the coastal lowlands of KwaZulu-Natal Province (Little, 2005). Its preferred habitat in South Africa is dense grassland in proximity to cultivated lands, where it exploits crops and associated insects. While some authors refer to Swainson's spurfowl as one of the most water-dependent perdicine birds in Africa (del Hoyo *et al.*, 1994; Little, 2005), a study in Limpopo Province, South Africa, revealed no or little reliance on easily accessible drinking water and birds seldom drank (Jansen & Crowe, 2002).

The Orange River francolin *Scleroptila levaillantoides* (Smith, 1836) (Phasianidae: francolins) is found in two distinct geographical areas on the African continent

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(del Hoyo *et al.*, 1994). While it is a frequent to common bird in Ethiopia and Somalia, numbers appear to have declined in its southern population, especially in South Africa and Namibia. This is thought to be mainly due to habitat pressure following the conversion of natural grass- and woodland habitats into farmland, despite the fact that, like Swainson's spurfowl, it will forage at the edges of cultivated land (Little *et al.*, 2000). The natural range of Orange River francolin in South Africa used to be restricted to north-western Northern Cape Province (del Hoyo *et al.*, 1994), but it has expanded to include north-eastern Eastern Cape Province, and Free State and North West Provinces, as well as the region east of the highveld of Mpumalanga and Gauteng Provinces (Little *et al.*, 2000; Little, 2005).

Only incidental findings on helminth parasites of both these gamebirds in South Africa have been published. Oosthuizen & Markus (1967) collected *Subulura* sp. from a single Swainson's spurfowl, while the only record pertaining to helminths of *S. levaillantoides* is that of Bennett *et al.* (1992) who reported *Microfilaria* sp. when cataloguing haematozoa of sub-Saharan birds.

This paper reports on helminths collected from the gastrointestinal tract (GIT) of five Swainson's spurfowl and a single Orange River francolin in Free State Province, South Africa and describes a new nematode, *Tetrameres swainsonii*, from the proventriculus of the former.

Materials and methods

Five Swainson's spurfowl, a single second-year male and four adult females (at least third-year), and a single adult male Orange River francolin were collected during a gamebird hunt in the vicinity of Petrus Steyn (27°39′S; 28°8′E), Free State Province, in August 2007. The habitat in the survey area was made up primarily of cereal plantings (maize) and sunflower, in a mosaic of grazing land.

Within 4 hours of being shot, the entire GIT was removed from the birds and placed in a plastic tray. The crop was ligated at the entrance of the oesophagus and the entrance to the proventriculus. The proventriculus was separated from the gizzard, and the small intestine was separated from the gizzard and caeca. The GITs of the various birds were placed in individual containers, stored at 2°C overnight and then fixed in 70% ethanol.

Subsequently, the crop, proventriculus, gizzard, small intestine and caeca were washed separately over a 150 μm sieve and, together with the residue, examined under a stereoscopic microscope. Helminths in the gizzard usually only became visible after removal of the lining.

All helminths were stored in 70% ethanol. For identification purposes, nematodes were cleared in lactophenol and studied under a standard microscope. Intensity of infection, mean intensity of infection, mean abundance and prevalence are used in accordance with Margolis *et al.* (1982).

Results

All five Swainson's spurfowl harboured nematodes and a total of six species, *Acuaria gruveli* (Gendre, 1913), *Cyrnea parroti* Seurat, 1917, *Gongylonema congolense* Fain, 1955, *Subulura dentigera* Ortlepp, 1937, *S. suctoria* (Molin, 1860) and *T. swainsonii* n. sp., was recovered. Their habitat, prevalence, mean intensity of infection and mean abundance are listed in table 1. A single host harboured a total of four species, a second three, and three birds had two nematode species each. The mean species richness was 2.6 (SD = 0.9). The intensity of infection ranged from 3 to 68, with a mean intensity of 19 (SD = 27.7). The second-year male had the highest species diversity as well as highest intensity of infection.

Two nematode species were recovered from both the gizzard and caeca, and a single nematode species from the proventriculus and crop, respectively. No helminths were found in the small intestine.

With the exception of a single *C. eurycerca* Seurat, 1914 in its gizzard, the Orange River francolin harboured no helminth parasites.

The presence of *A. gruveli* in Swainson's spurfowl constitutes both a new host record and a new geographical record for this parasite, while *C. parroti*, *G. congolense* and *S. suctoria* are new parasite records for this host. This is the first report of *S. dentigera* from a host other than helmeted guineafowl *Numida meleagris* (Linnaeus, 1758) (Phasianidae: guineafowls). *Cyrnea eurycerca* is recorded from Orange River francolin as well as from South Africa for the first time.

Tetrameres swainsonii n. sp

Description. *Tetrameres swainsonii* is described from four males and one female from a single Swainson's spurfowl. Males were found free in the lumen of the proventriculus, while the female was dissected from the proventricular glands. All measurements are in micrometres unless otherwise stated (fig. 1).

Female. Bright red *in situ* as typical for the genus, damaged; only buccal capsule, 24 deep and 16 wide, maximum body width (3 mm) and length (4 mm) as

Table 1. Nematodes recovered from five Swainson's spurfowl *Pternistis swainsonii* in Free State Province, South Africa.

Nematode	Habitat	Prevalence (%)	Mean intensity (± SD)	Range	Mean abundance (± SD)
Acuaria gruveli	Gizzard	100	2.4 (0.9)	1–3	2.4 (0.8)
Cyrnea parroti	Gizzard	20	2.0	2	0.4 (0.8)
Gongylonema congolense	Crop	80	4.25 (5.9)	1–13	3.4 (4.8)
Subulura dentigera	Caeca	20	12.0	12	2.4 (4.8)
Subulura suctoria	Caeca	20	47.0	47	9.4 (18.8)
Tetrameres swainsonii n. sp.	Proventriculus	20	5.0	5	1.0 (2.0)

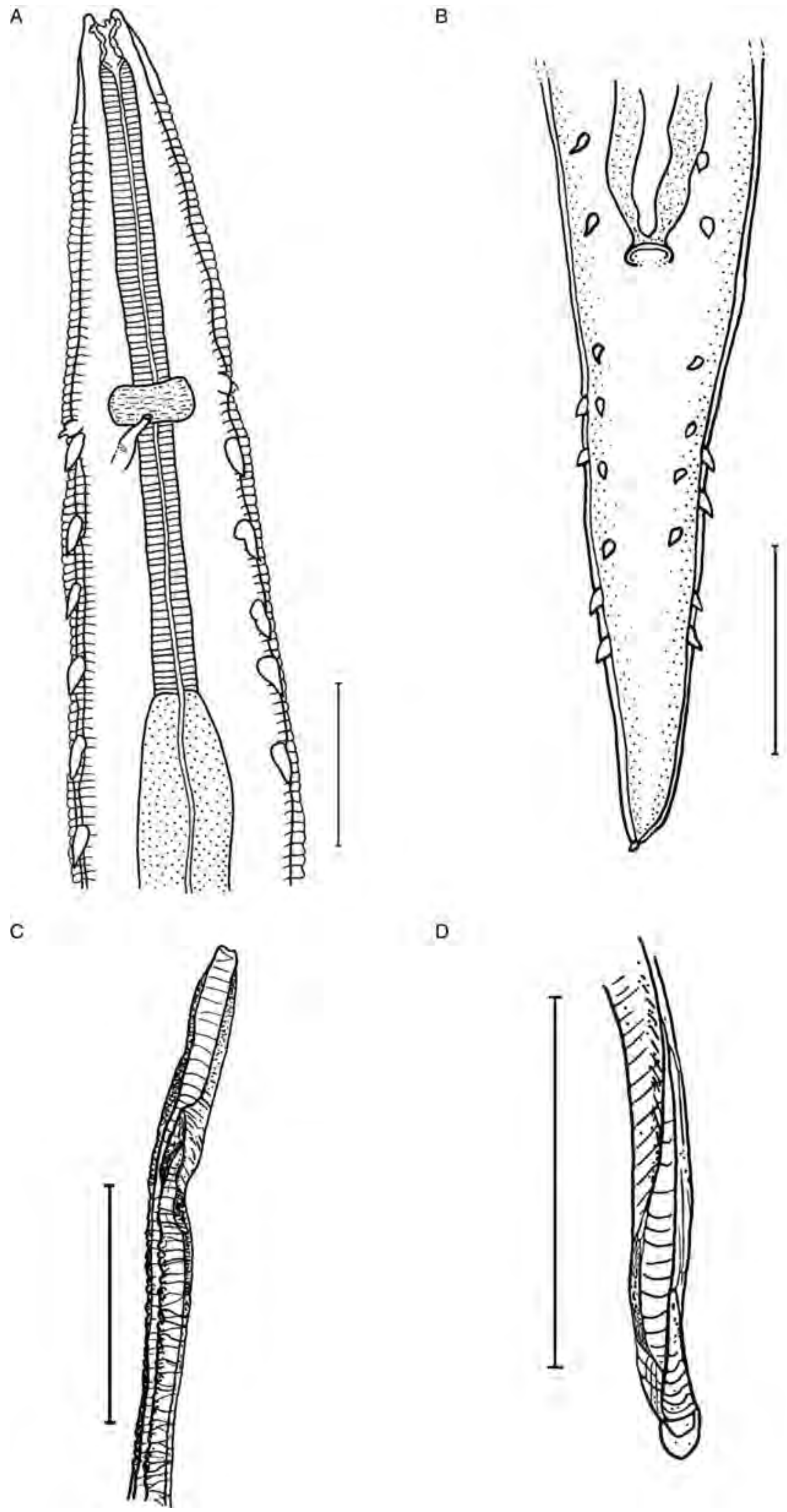

Fig. 1. *Tetrameres swainsonii* n. sp. male. (A) Ventral view of anterior extremity illustrating the position of the deirids, nerve ring, excretory pore and first pair of body spines. (B) Ventral view of posterior extremity showing the arrangement of the caudal spines. (C) Proximal end of the single spicule, lateral view. (D) Distal end of the spicule, lateral view. Scale bars = 100 μm.

well as egg length and width could be measured. Eggs ($n = 10$), length 49 (SD = 2.98), between 43 and 52, width 32 (SD = 1.47), between 30 and 34; polar filaments not seen. Body globular with anterior and posterior extremities forming short protuberances; surface divided into four segments by four conspicuous longitudinal cuticular grooves; each segment with numerous transverse striations.

Male. Measurements of holotype male given in text, those of two paratypes and a further specimen in table 2. Body elongated, tapered at both ends, 5.1 mm long and 188 wide. Cuticle striated transversely as well as longitudinally. Cuticular spines arranged in two lateral rows, one dorsal and one ventral to inconspicuous lateral alae; 41 spines per row in holotype, 40 to 43 in paratypes; first pair of spines at 269 and 285 from anterior extremity. Deirids with apical spines at 261 and 251 from anterior extremity. Nerve ring and excretory pore at 252 and 265 from apex, respectively. Deirids at approximately centre of nerve ring with first pair of cuticular spines in close proximity, but posterior to deirids. Excretory pore in same vicinity, sometimes slightly anterior, slightly posterior or on same level as first pair of cuticular spines (fig. 1A). Depth of buccal capsule 19, inner diameter 6. Oesophagus divided into muscular and glandular parts, 412 and 914, respectively; total length of oesophagus 1326. Single spicule, slender, 1384 long, trough-shaped with spatulate, almost square tip (fig. 1D); proximal tip slightly angled away from longitudinal axis (fig. 1C). Gubernaculum absent. Tail 330 long, with short pointed tip. Eight pairs of caudal spines arranged in two ventral and two lateral rows, containing four spines each (fig. 1B).

Specific diagnosis. *Tetrameres swainsonii* n. sp. is characterized by two rows of body spines, starting just posterior to the deirids situated at the level of the nerve ring. The single spicule is 1152 to 1392 long, and 16 caudal spines are arranged in two ventral and two lateral rows, each bearing four spines.

Host. Swainson's spurfowl *Pternistis swainsonii* (Smith, 1836).

Habitat. Males occur free in the lumen of the proventriculus, females are sedentary in proventricular glands.

Locality. Vicinity of Petrus Steyn (27°39′S; 28°8′E), Free State Province, South Africa.

Etymology. The specific epithet *swainsonii* refers to the host.

Deposition of type specimens. Holotype male: 2008.6.20.1, allotype female, paratype males: 2008.6. 20.2–5.

Taxonomy of Tetrameres

To date three species belonging to the genus *Tetrameres* have been described from avian hosts in South Africa, *Tetrameres paradisea* Ortlepp, 1932 from Stanley's crane *Anthropoides paradiseus* (Lichtenstein, 1793) (Gruidae: cranes), *Tetrameres prozeskyi* (Ortlepp, 1964) from red-billed and southern yellow-billed hornbills *Tockus erythrorhynchus* (Temminck, 1823) (Bucerotidae: typical hornbills) and *Tockus leucomelas* (Lichtenstein, 1842) (Bucerotidae: typical hornbills), respectively, and *Tetrameres numida* Junker & Boomker, 2007 from helmeted guineafowl. *Tetrameres paradisea* is similar to the new taxon in that it has two rows of cuticular spines and possesses a single spicule. However, Ortlepp (1932) illustrates three cuticular spines anterior to the deirids, with the latter placed well anterior to the nerve ring, whereas in the present specimens, the first pair of cuticular spines only appears posterior to the deirids, and both the first pair of cuticular spines and the deirids are in the immediate vicinity of the nerve ring. Moreover, the spicule length of *T. paradisea* only reaches 690 as opposed to a minimum length of 1152 in the present specimens.

In *T. prozeskyi* a single spicule measuring 230–260 is usually present and in those instances where a second spicule was found, it was shorter than the first (Ortlepp, 1964). A further distinguishing feature between *T. prozeskyi* and *T. swainsonii* n. sp. is the presence of four rows of cuticular spines in the former (Ortlepp, 1964) versus two rows in the latter. Only 12 caudal spines were reported for *T. prozeskyi* as well as for *T. paradisea* (Ortlepp, 1932, 1964) as opposed to the 16 caudal spines seen in the new taxon.

Like *T. swainsonii* n. sp., *T. numida* is characterized by two rows of cuticular spines, but the arrangement of the first pair of spines, the deirids and the nerve ring is

Table 2. Morphological characteristics of *Tetrameres swainsonii* n. sp. males from Swainson's spurfowl *Pternistis swainsonii*. All measurements in micrometres unless otherwise indicated.

Morphological criteria	Specimen A	Paratype 1	Paratype 2
Body length (mm)	4.7	4.8	5.1
Body width max.	203	200	216
Distance from apex to first pair of somatic spines	276; 260	250; 272	340; 340
Distance from apex to nerve ring	244	245	263
Distance from apex to deirids	243; 235	237; 242	268; 286
Distance from apex to excretory pore	282	275	310
Depth of buccal capsule	21	23	23
Width of buccal capsule (inner)	5	6	5
Muscular oesophagus	368	418	428
Glandular oesophagus	1005	914	1031
Oesophagus total length	1377	1285	1451
Length of tail	291	306	309
Length of single spicule	1152	1392	1183

distinctly different from that seen in the present specimens (Junker & Boomker, 2007a). The first pair of cuticular spines of *T. numida* is situated anterior to the deirids, which are approximately at the level of the second pair of cuticular spines, and the nerve ring is distinctly posterior to the deirids. Only 12 caudal spines are described for *T. numida* and, although additional ventral spines may occasionally be present, the two lateral rows consistently carried three spines each. In addition, *T. numida* possesses a right and a left spicule, ranging from 106 to 170 and from 1699 to 2304, respectively (Junker & Boomker, 2007a).

Of the 54 species of *Tetrameres* listed by Junker & Boomker (2007a), only *T. paradisea*, *Tetrameres grusi* Shumakovitsh, 1946, *Tetrameres pattersoni* Cram, 1933 and *Tetrameres puchovi* Gushanskaja, 1949 share the combination of two rows of cuticular spines and a single spicule with the present specimens. However, the spicules of *T. grusi* (638–783) and of *T. puchovi* (307–309) (Skrjabin & Sobolev, 1963) are distinctly shorter than those of *T. swainsonii* n. sp. (1152–1392). Moreover, the caudal spines of *T. grusi* are arranged in several irregular rows, and several pairs of cuticular spines originate anterior to the nerve ring (Skrjabin & Sobolev, 1963), whereas in *T. swainsonii* n. sp. the first pair of cuticular spines emerges posterior to the nerve ring. The distance from the apex to the deirids is 160 in *T. puchovi* (Skrjabin & Sobolev, 1963), which is considerably shorter than that observed in the new taxon, namely 235–286.

Tetrameres pattersoni is closest to *T. swainsonii* n. sp. in spicule length, with a single, strongly chitinized spicule of length 1200–1500; but it differs in the arrangement of caudal spines in three lateral and four subventral pairs, as opposed to four pairs each in the new taxon. The distance of the deirids from the apex, which is less than half that seen in *T. swainsonii* n. sp., namely 83–112 (Skrjabin & Sobolev, 1963), clearly separates *T. pattersoni* from *T. swainsonii* n. sp.

Discussion

The single second-year male Swainson's spurfowl yielded the largest number of helminth species as well as individuals. Phasianid chicks are reported to rely heavily on insect food in the early stages of their lives (del Hoyo *et al.*, 1994). Chicks of grey partridge *Perdix perdix* Linnaeus, 1758 (Phasianidae: partridges) in Europe, for example, consume a diet consisting of 80% insect matter for the first 2 weeks after hatching (del Hoyo *et al.*, 1994). Arthropods only make up approximately 7% of the crop weight of adult *P. swainsonii*, reaching a maximum of up to 20% in summer (del Hoyo *et al.*, 1994). Higher intake of live food by juvenile versus adult birds is likely to increase exposure to infected intermediate hosts, which, in turn, would result in higher worm burdens. However, because of the small sample size it is not possible to establish whether our findings are due to chance or reflect a true pattern in the helminth community of Swainson's spurfowl.

Only nematodes were collected from Swainson's spurfowl and the single Orange River francolin. This is noteworthy, especially taking into account that all nematodes collected from these two hosts are heteroxenous; that is, their life cycles include various arthropod intermediate hosts, such as orthopterans and coleopterans (Anderson, 1992), which in addition serve as intermediate hosts for cestodes and acanthocephalans (Moore, 1962; Reid, 1962). Moreover, helmeted guineafowl collected at the same locality during the course of this study harboured nematodes and cestodes as well as acanthocephalans (Davies *et al.*, in review), thereby confirming their presence in the environment.

While Swainson's spurfowl had a markedly less diverse helminth fauna than helmeted guineafowl at the study site, the former seem to be more suitable hosts of the gizzard nematode *A. gruveli*, since it was collected from all five spurfowl, but was absent in more than 40 helmeted guineafowl (Davies *et al.*, in review). Other galliform birds recorded as final hosts of *A. gruveli* include double-spurred spurfowl *Pternistis bicalcaratus* (Linnaeus, 1766) (= *Francolinus bicalcaratus*) (Phasianidae: spurfowls) in Togo (Quentin & Seureau, 1983), common quail *Coturnix coturnix* (Linnaeus, 1758) (Phasianidae: quails) in the Palearctic region (Baruš & Sonin, 1983) and red-legged partridge *Alectoris rufa* (Linnaeus, 1758) (Phasianidae: partridges) in Spain (Tarazona *et al.*, 1979), suggesting that perdicine birds feature more prominently in the life cycle of this parasite than do guineafowls.

A possible explanation for the presence/absence of helminths in Swainson's spurfowl versus helmeted guineafowl at the same locality might be a difference in their dietary preferences, which in turn would influence the probability of exposure to intermediate hosts of certain parasites. Moreover, differences in the immune competence of the two bird species might result in a higher resistance in guineafowl. Similarly, morphological differences between hosts, such as the nature of the gizzard lining, could prevent establishment of, for example, *A. gruveli* in guineafowl, but allow colonization of spurfowl.

Cyrnea parroti, *G. congolense* and *S. suctoria* collected from Swainson's spurfowl are also commonly found in other galliform birds (Junker & Boomker, 2007b). Contrary to this, *S. dentigera* had hitherto been recorded from helmeted guineafowl only.

Cyrnea eurycerca, which was present in the single Orange River francolin, seems a relatively common parasite in francolins and spurfowls, and has previously been collected from black francolin *Francolinus francolinus* (Linnaeus, 1766) (Phasianidae: francolins) in Italy, grey francolin *Francolinus pondicerianus* (Gmelin, 1789) (Phasianidae: francolins) in India and double-spurred spurfowl in Togo (Marconcini & Triantafillu, 1970; Jehan, 1974; Seureau & Quentin, 1983).

The low prevalence and intensity of infection of *T. swainsonii* n. sp. in Swainson's spurfowl is in keeping with data obtained for *T. numida* from helmeted guineafowls in Limpopo Province, as well as in the present study area (Junker & Boomker, 2007a; Davies *et al.*, in review). Similarly, only two of 158 bobwhite quail *Colinus virginianus* (Linnaeus, 1758) (Phasianidae: quails) examined in northern Florida harboured *T. pattersoni*, and intensity of infection ranged from 0 to 1 (Moore & Simberloff, 1990).

The overall low helminth diversity and intensity of infection seen in Swainson's spurfowl at the study site might be attributable to several factors. First, they occur in pairs or small family groups rather than in large flocks (Little, 2005; Jansen & Crowe, 2006), which would facilitate parasite transmission (Moore *et al.*, 1988). Jansen & Crowe (2002) reported a covey size ranging from 1 to 4. Second, the birds were collected in winter, when the volume of their diet consists mainly of grass seeds, weed seeds and agricultural seeds, while invertebrates play a minor role (Jansen & Crowe, 2006). In terms of crop volume, 5.74% is made up of invertebrates during the summer months and 3.64% during the winter months (Jansen & Crowe, 2006). Third, much of their habitat consisted of cultivated lands, the insect fauna of which might be depauperate because of low habitat diversity and the use of pesticides. In addition, while Swainson's spurfowl from a cereal-crop habitat, similar to that found in the current study area, ingested the greatest number and volume of invertebrates, when compared to savanna and a cotton habitat, more than 90% of the total number of invertebrates consumed consisted of lepidopteran larvae (Jansen & Crowe, 2006). The latter, however, have not been reported as intermediate hosts for nematode species recovered from Swainson's spurfowl and would thus have no influence on helminth diversity or intensity of infection in these birds.

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CHAPTER 2

Population dynamics

of

parasites of guineafowls

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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*, *Hispaniolepis multiuncinata*, *Hymenolepis cantaniana*, *Numidella numida*, *Octopetalum numida*, *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*, *H. 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 *Hispaniolepis 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		Prevalence (%)	Intensity		Prevalence (%)	Intensity		Presence	Presence
			Mean (± SD)	Range		Mean	Range		Mean	Range		
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	–	–	–	–	–	–	–	+
Hispaniolepis multiuncinata	SI	87	9.3 (± 5.2)	2–14	–	–	–	–	–	–	–	+
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	?	+	+
Paroniella sp.[a]	SI	–	–	–	25	1.5	0–17	–	–	–	–	–
Porogynia paronai	SI	47	12.3 (± 13.3)	5–39	–	–	–	75	?	?–5	+	+
Raillietina 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 guineafowl 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] 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), *H. multiuncinata* (*n* = 1), *N. numida* (*n* = 114), *O. numida* (*n* = 57) 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.

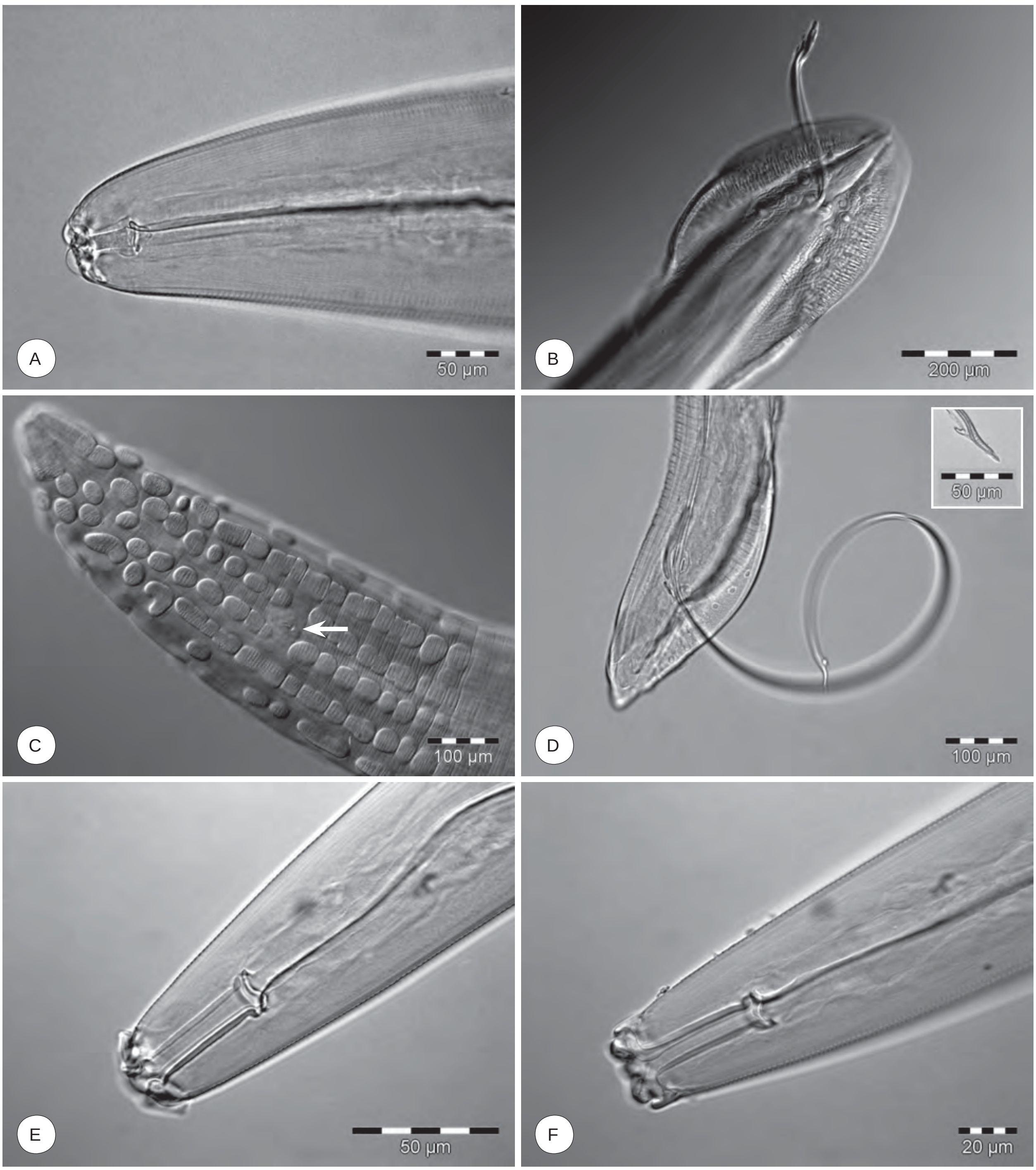

FIG. 1 A, B. *Cyrnea parroti* male. A. Anterior end. B. Posterior end. C, D. *Gongylonema congolense*. C. Anterior extremity of female, ventral view. The arrow points to the excretory pore. D. Posterior extremity of male. The inset illustrates the barbed tip of the long spicule. E, F. *Hadjelia truncata*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

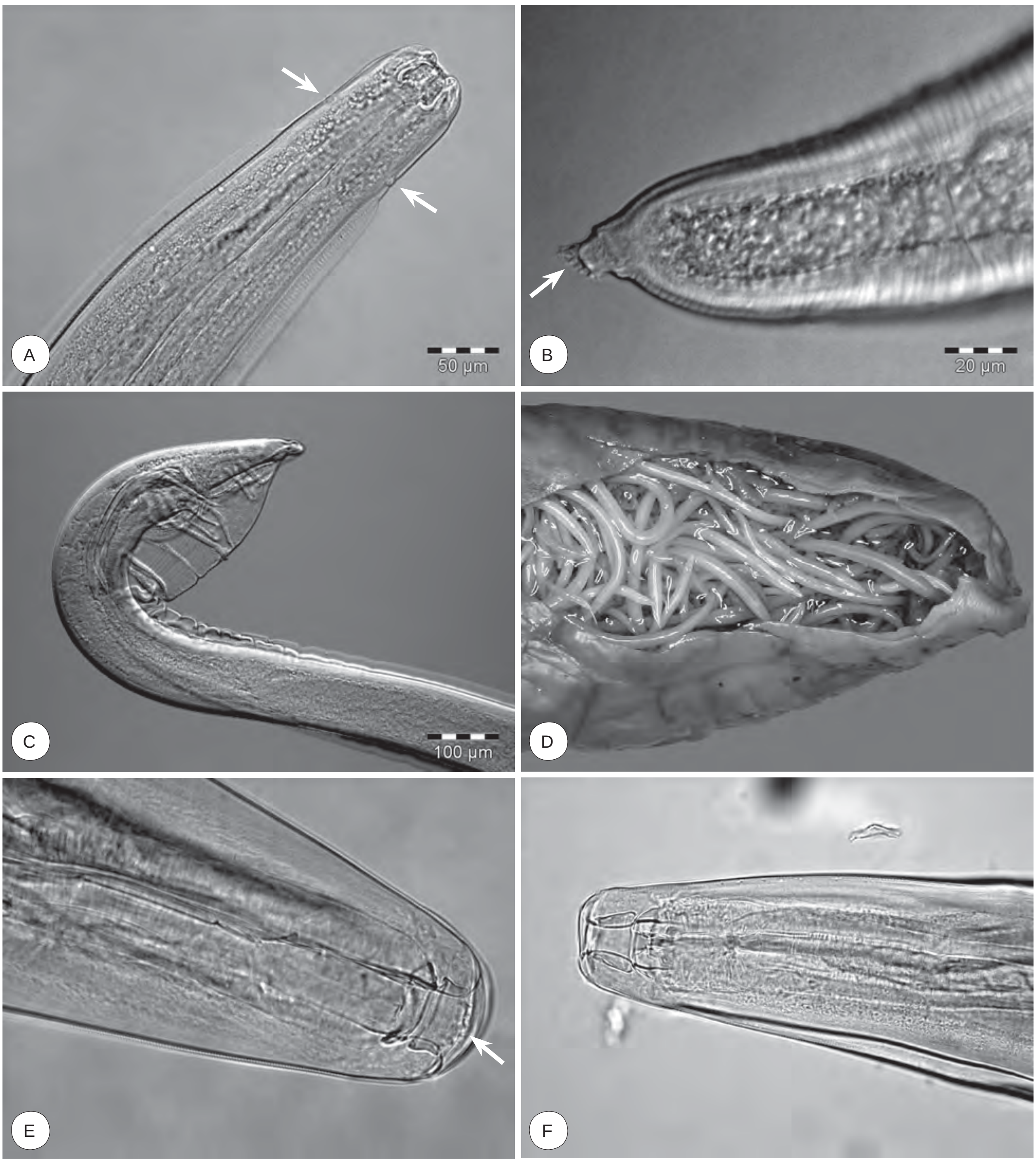

FIG. 2 A, B, C. *Sicarius caudatus*. A. Anterior extremity of male. The deirids are marked by arrows. B. Posterior extremity of female. Note the finger-like protruberances (arrow) at the tip of the tail. C. Posterior extremity of male. D. Distal part of guineafowl caecum filled with *Subulura* spp. E. *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 *C. 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 *Sicarius dipterum* is distinctly longer (660–670 µm) than that of our specimens, whereas the subequal spicules of *Sicarius 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 (26–1 071 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 1 452 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 remain 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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The helminth community of Helmeted Guineafowls, *Numida meleagris* (Linnaeus, 1758), in the north of Limpopo Province, South Africa

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ABSTRACT

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The helminths of 15 Helmeted Guineafowls were collected in the north of Limpopo Province, South Africa. A total of 11 cestode, ten nematode and a single acanthocephalan species were present. Species richness ranged from 8 to 16 species per host, and nine core and nine secondary species accounted for 40.9 % of the component parasite community. The remaining 18.2 % comprised satellite species. Core species represented 91 % of all the worms present. Individual intensities ranged from 66 to 2 724 per host and overdispersion was pronounced. There were no significant differences regarding the abundance and species richness between male and female hosts. The number of component species and overall abundance did not differ significantly between juvenile and adult hosts, but *Cyrnea parroti* was significantly more abundant, and the prevalence of *Hadjelia truncata* was higher in young birds than in adults. In contrast, *Gongylonema congolense* and *Porogynia paronai* were absent in juveniles, but had a prevalence of 60 % and 70 %, respectively, in adults. Pairwise Spearman's rank correlation yielded one positive and 10 negative significant species correlations. A single trematode, *Dicrocoelium macrostomum*, was collected from five of nine guineafowls, but was not included in the helminth community study.

Keywords: Acanthocephala, Cestoda, Helmeted Guineafowls, Nematoda, *Numida meleagris*

INTRODUCTION

Despite the remarkable diversity of South African birdlife, knowledge concerning their helminth parasites is scant (Ortlepp 1937, 1938a, b, 1963; Verster-Patsinska-Kloryga 1987) and even sparser on the structure of their helminth communities.

A first step was taken by Crowe (1977), who compared the influence of sex, age and habitat on the intestinal helminths of Helmeted Guineafowls, *Numida meleagris* (Linnaeus, 1758), at Kimberley, Northern Cape Province, South Africa. Thereafter, Alexander & McLaughlin (1997) provided a comprehensive analysis of the helminth communities of four species of ducks at Barberspan, South Africa. It is also apparent from Bush's (1990) chapter on helminth communities in avian hosts, that considerably more information on helminth community dynamics in birds from aquatic environments than those from terrestrial habitats is available.

This paper analyses the composition and structure of the helminth community of 15 Helmeted Guineafowls in the Limpopo Province, even though small numbers of hosts were available and a larger sample might have a different outcome. Data on the various

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helminth species collected have been presented in a companion publication (Junker & Boomker 2007a).

MATERIAL AND METHODS

During July 2005 to November 2006 the gastrointestinal helminths of 15 Helmeted Guineafowls on a farm about 60 km west of Musina (Messina), Limpopo Province (22°22' S, 29°30' E), were examined as detailed in Junker & Boomker (2007a). Three of the birds shot in May 2006 and two collected in July 2006 were young birds, between 6 and 10 months old (Siegfried 1966), the remainder were adults. Three of the juveniles were females and two males, and the adults comprised four females and six males.

The terms prevalence, intensity and abundance are used in accordance with the proposals of Margolis, Esch, Holmes, Kuris & Schad (1982) and Bush, Lafferty, Lotz & Shostak (1997). Infrapopulation and infracommunity follow Bush & Holmes (1986a, b), metapopulation follows Riggs & Esch (1987) and component parasite community is used as defined by Holmes & Price (1986). As suggested by Bush & Holmes (1986a) and Alexander & McLaughlin (1997), species with a prevalence of 70 % and higher, were categorized as core species, those with prevalences of < 40 % as satellite species and those with prevalences ≥40 % but < 70 % as secondary species. A summary of these definitions is to be found in Esch, Shostak, Marcogliese & Goater (1990).

A Wilcoxon rank sum test was performed to determine differences in species richness, as well as in the abundance of the various species between male and female hosts, juveniles and adults and between birds shot in winter and spring. A variance ratio test of Schluter (1984) and McCulloch (1985) was used to detect species association with presence-absence data for all parasites, parasites in the small intestine (SI) and parasites in the caeca.

Pairwise Spearman's rank correlation for every possible species combination in the small intestine, gizzard and caeca respectively were calculated. To avoid possible distortions inherent to this form of analysis, double zero matches, i.e. absence of both species from a host, were eliminated. Of the 14 helminth species present in the small intestine only the single acanthocephalan and the 12 cestodes were included in the analysis, because the occurrence of two nematodes, *Ascaridia numidae* and an unidentified subulurid, was restricted to one and two hosts respectively, while a third nematode, *Sicarius caudatus*, utilized the SI as well as the gizzard. We tested for a correlation between *Subulura dentigera* and *Subulura suctoria* from the caeca only, as *Subulura* sp. most probably represents either of the former two nematodes.

Significance was set at the 95 % level throughout. In the absence of scoleces, counts were not always possible for all the cestodes of a particular host. While these hosts were included in analyses based on presence/absence data, they were excluded from the sample pool in the Wilcoxon rank sum tests pertaining to the abundance of helminths at species level.

RESULTS

A total of 11 951 helminths representing ten nematode, 11 cestode and a single acanthocephalan species were recovered from the alimentary canal of the 15 guineafowls. Data on their prevalence, intensity of infection and abundance, as well as their feeding guild classification and status as core, secondary or satellite species are summarized in Table 1. In all likelihood, *Raillietina* sp. and *Subulura* sp. are representatives of the remaining species of these two genera listed in Table 1. A single trematode species, *Dicrocoelium macrostomum*, was present in five of nine guineafowls examined for this parasite. Although included in the general results and discussion, these trematodes do not form part of the community study outlined below.

Following the classification of Bush (1990) four feeding guilds, i.e. organisms using the same feeding-mode, without regard to their taxonomic affinity, were present in the helminth community. The trematode guild, feeding actively on semi-solid food materials such as blood, bile, mucus and intestinal debris as well as directly absorbing nutrients through their tegumental surface, was restricted to the liver and represented by a single species. The nematode guild, being mucosal and engulfing tissue and/or lumen contents, occupied the largest number of sites along the alimentary canal, namely the crop, proventriculus, gizzard as well as the small and large intestine. The females of *Tetrameres numida* are an exception in so far as they inhabit the glands of the proventriculus, where they suck blood.

The cestodes and acanthocephalans occurred in the small intestine only. *Mediorhynchus gallinarum* has a short neck and its attachment to the mucosa remains superficial. The larger part of its abdomen is suspended freely in the intestinal lumen, absorbing nutrients via the body surface (Junker & Boomker

TABLE 1 Helminths recovered from 15 Helmeted Guineafowls in Musina, Limpopo Province, South Africa

Parasite	Guild	Site	Status	No. of inf. hosts	Prev-alence (%)	Intensity				Abundance		
						Median	Mean	SD	Range	Median	Mean	SD
Acanthocephala												
Mediorhynchus gallinarum	L	SI	C	15	100	23	55.7	78.3	2–231	23	55.7	78.3
Cestoda												
Abuladzugnia gutterae	L	SI	C	12	80	13	11.7	8.2	1–28	7.5	9.2	8.8
Davainea nana	M	SI	Sat	5[a]	36	6	5.8	4.4	1–10	0	1.7	3.5
Hymenolepis cantaniana	M	SI	Sec	6	40	3	42.7	70.4	1–124	0	10.7	35.7
Numidella numida	L	SI	C	10	67	14	55.9	72.7	1–203	2.5	35.9	63.4
Octopetalum numida	L	SI	C	10	67	79	91.9	110.7	1–360	6	61.2	99.4
Ortleppolepis multiuncinata	M	SI	C	13	87	11	9.3	5.2	2–14	7	7	6.1
Porogynia paronai	L	SI	Sec	7	47	6.5	12.3	13.3	5–39	0	5.3	10.4
Raillietina angusta	L	SI	Sec	8	53	10	10.3	7.9	1–25	0.5	5.1	7.6
Raillietina pintneri	L	SI	C	12	80	4	5.3	3.9	2–12	2	3.8	4.1
Raillietina steinhardti	L	SI	Sec	8	53	27.5	49.0	60.2	4–137	0	17.8	41.2
Raillietina sp.	L	SI	C	11	73	13	15.8	8.8	6–28	8	10.9	10.5
Nematoda												
Ascaridia numidae	N	SI	Sat	1	6	4	4.0	0.0	4	0	0.3	1
Cyrnea parroti	N	Giz	C	15	100	7	13.8	18.2	2–75	7	13.8	18.2
Gongylonema congolense	N	Crop	Sec	6	40	19	23.0	22.0	2–61	0	9.2	17.6
Hadjelia truncata	N	Giz	Sec	8	53	2	1.6	0.5	1–2	1	0.9	0.9
Sicarius caudatus	N	Giz, SI	Sec	8	53	1.5	2.1	1.7	1–6	1	1.1	1.6
Subulura dentigera	N	Caeca	Sec	8	53	15	15.9	13.4	1–31	1	8.5	12.5
Subulura suctoria	N	Caeca	C	15	100	345	536.3	589.2	9–2 214	370	536.3	589.2
Subulura sp.	N	Caeca	Sec	6	40	15	44.0	65.4	1–170	0	17.6	45
Unidentified subulurid	N	SI	Sat	2	13	2.5	2.5	0.7	2–3	0	0.3	1.5
Tetrameres numida	N	Prov	Sat	5	33	2	2.4	1.7	1–5	0	0.8	1.4

[a] Data from 14 hosts only
L = lumenal absorber; M = mucosal absorber; N = nematode
SI = small intestine, Giz = gizzard, Prov = proventriculus
C = core species; Sat = satllite species; Sec = secondary species

2006). It is therefore included in Bush's (1990) category of lumenal absorbers, together with the majority of the larger cestodes. Small and delicate cestodes such as *Davainea nana*, *Hymenolepis cantaniana* and *Ortleppolepis multiuncinata*, whose entire body is virtually buried amongst the mucosal villi, constitute the fourth guild, namely that of mucosal absorbers.

Except for the monoxenous nematode *Ascaridia numidae*, all members of the component community have indirect life-cycles.

The component community comprised nine core species as well as nine secondary species, each representing 40.9 % of the total number of species, and four satellite species accounting for 18.2 % of the species present (Table 1). Despite their prevalence of 67 % being slightly below the 70 % threshold, we have arbitrarily included *Numidella numida* and *Octopetalum numida* with the core species, as they were two of the most numerous helminths recovered in this study. The core species accounted for 91 % of all individuals, the secondary species for

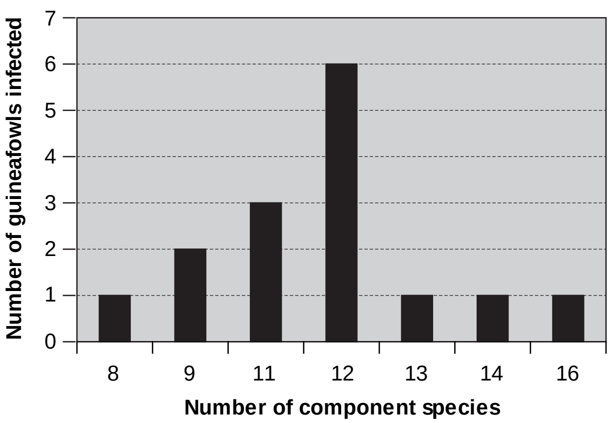

FIG. 1 Frequency distribution of the total number of helminth species found in Helmeted Guineafowls in Musina, Limpopo Province, South Africa. The number of individual hosts infected by a certain number of helminth species is indicated by the vertical bars

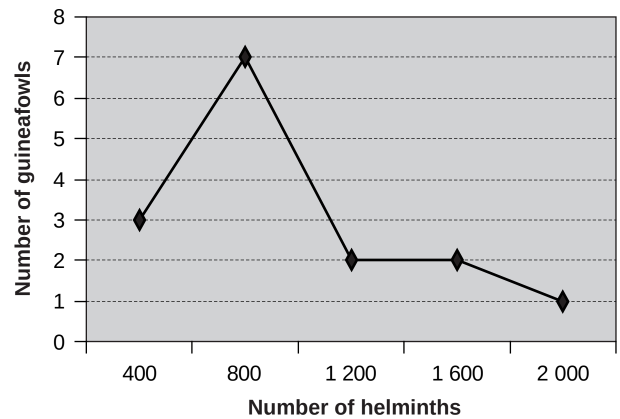

FIG. 2 The frequency distribution of the total number of helminths in individual Helmeted Guineafowls in Musina. Helminth burdens were grouped into size classes (0–400, 401–800, etc. to 2 000+ helminths per guineafowl) represented on the x-axis. The y-axis displays the number of guineafowls infected with a certain size class of helminth burdens

TABLE 2 Number of helminth species recovered from 15 Helmeted Guineafowls in Musina, Limpopo Province, South Africa

Host	Number of species			Total number of species
	Acanthocephalans	Cestodes	Nematodes	
GFM1	1	9	6	16
GFM2	1	7	4	12
GFM3	1	7	5	13
GFM4	1	7	4	12
GFM5	1	4	4	9
GFM6	1	5	6	12
GFM7	1	5	3	9
GFM8	1	5	6	12
GFM9	1	5	5	11
GFM10	1	5	2	8
GFM11	1	8	5	14
GFM12	1	6	5	12
GFM13	1	7	3	11
GFM14	1	5	5	11
GFM15	1	6	5	12
Average	1	6.1	4.5	11.6
SD	0	1.4	1.2	2.0
Range	1	5–9	2–6	8–16

TABLE 3 Pairwise Spearman's rank correlations for helminths in the small intestine of Helmeted guineafowls. Only species significantly correlated with at least one other species have been included. The correlation coefficients are displayed in the upper right corner of the matrix. The lower left half includes the respective p-values for each pair of species

		Core species					Secondary species				Satellite species
		1	2	3	4	5	6	7	8	9	10
1.	*Mediorhynchus gallinarum*		**0.576***	–0.464	0.096	0.060	–0.202	0.198	–0.165	–0.042	–0.427
2.	*Numidella numida*	**0.031***		**–0.662***	–0.570	–0.419	0.335	0.060	–0.282	–0.532	–0.457
3.	*Octopetalum numida*	0.082	**0.010***		0.303	0.356	**–0.835***	**–0.895***	0.035	0.275	–0.587
4.	*Ortleppolepis multiuncinata*	0.820	0.140	0.467		0.112	–0.664	–0.711	0.275	0.544	**–0.794***
5.	*Raillietina pintneri*	0.860	0.228	0.347	0.811		–0.447	**–0.696***	0.156	0.170	–0.439
6.	*Hymenolepis cantaniana*	0.528	0.463	**0.005***	0.150	0.267		0.105	**–0.782***	**–0.801**	0.800
7.	*Porogynia paronai*	0.498	0.879	**< 0.0001***	0.074	**0.025***	0.866		–0.446	**–0.817***	–0.112
8.	*Raillietina angusta*	0.574	0.375	0.915	0.550	0.689	**0.022***	0.196		–0.383	**–0.810***
9.	*Raillietina steinhardti*	0.092	0.113	0.474	0.343	0.717	**0.056**	**0.013***	0.349		**–0.846***
10.	*Davainea nana*	0.146	0.255	0.010	**0.033***	0.276	0.200	0.811	**0.008***	**0.016***	

* Data pertaining to significantly correlated pairs ($P < 0.05$) are in bold and marked with an asterisk

8.6 % and satellite species made up 0.4 % of the total worm count.

Infracommunities in the Helmeted Guineafowls from Musina were moderately species rich, ranging from 8 to 16 species, with a mean number of 11.6 ± 2. Sixty percent of the hosts were infected with 12 or more species (Table 2, Fig. 1). The total number of helminths in individual guineafowls was highly aggregated and ranged from 66 to 2 724. In ten of the 15 hosts the intensity of infection was below 800 (Fig. 2), but three guineafowls had worm burdens of 1 457, 1 496 and 2 724 worms and when combined, these accounted for 48 % of the component parasite community. *Subulura suctoria*, which was by far the most common of all the helminths recovered, constituted 86, 74 and 81 % of the total worm load of the above three hosts.

Excluding *S. suctoria*, the acanthocephalans and cestodes, especially *O. numida* and *N. numida*, occurred in higher numbers than nematodes. *Cyrnea parroti*, *Gongylonema congolense*, *S. dentigera* and *Subulura* sp. were moderately abundant with occasional high numbers in individual hosts. The abundance of the remaining nematodes was low, ranging from one to six in single hosts.

The Wilcoxon rank sum test yielded no significant evidence of differences between male and female hosts or between the winter and spring season in respect of species richness.

Despite the group of five juvenile Helmeted Guineafowls including the two birds with the lowest number of helminth species, and three of the five birds harboured a lower than average number of helminths, no significant differences were found between the number of component species and overall abundance seen in juvenile versus adult hosts.

However, when the Wilcoxon rank sum test was performed at species level, some differences related to host age became apparent. Of the gizzard nematodes, the abundance of *C. parroti* was significantly higher in young guineafowls, averaging 26.4 ± 27.7, than in adults, in which the mean abundance was 7.5 ± 6.6 ($P = 0.0312$), and, although not statistically significant, the prevalence of *Hadjelia truncata* was twice as high in young birds than in older ones (80 % vs 40 %). Conversely, *Gongylonema congolense* from the crop was absent in young birds, but had a prevalence of 60 % in adult guineafowls. The abundance of this parasite was thus significantly higher in adults ($P = 0.0451$). Similarly, the cestode *Porogynia paronai* occurred in 70 % of the adult birds, but was not found in the juveniles. Therefore, its abundance was significantly lower in the latter hosts ($P = 0.032$). The abundance of *Subulura* sp. was significantly higher in juvenile birds than in adults ($P = 0.0156$).

The pairwise Spearman's rank correlation test yielded 11 significantly correlated species pairs in the small intestine, of which one was positive and 10 negative. The results are presented in Table 3. The gizzard nematodes, *C. parroti* and *H. truncata*, were positively correlated, whereas *S. dentigera* and *S. suctoria* from the caeca were negatively correlated. Both results were, however, not significant.

DISCUSSION

Helmeted Guineafowls are non-selective omnivores feeding on a large variety of dietary items that, among others, include arthropods. Saayman (1966) recovered a wide variety of prey taxa, namely Orthoptera (four families), Coleoptera (five families), Isoptera, Hemiptera, Lepidoptera, Hymenoptera, Diptera, Myriapoda and Araneida, from the crops of 36 Helmeted Guineafowls in the Eastern Cape Province.

Notwithstanding their being a sedentary species, the birds can cover a considerable distance during their daily forays (Del Hoyo, Elliot & Sargatal 1994). These characteristics and a well structured, complex alimentary canal are among the major host factors contributing to parasite community richness (Kennedy, Bush & Aho 1986). This might explain why, despite the harsh climatic conditions and the largely undiversified mopani (*Colophospermum mopane*) veld habitat of the study area (Acocks 1988), the helminth community of Helmeted Guineafowls from Musina is diverse. The inclusion of live food in their diet, up to 12 % of the annual total, but higher during the summer months when insects are abundant (Mentis, Poggenpoel & Maguire 1975), may also account for the dominance of helminths with an indirect life cycle in the guineafowls.

We attribute the low prevalence and intensity of *D. nana* and especially of *A. numidae* to the arid environment characteristic of the study area. *Ascaridia* spp. were also the only nematodes with a direct life cycle recovered from guineafowls by Verster & Ptasinska-Kloryga (1987). Their eggs are resistant and can survive for several months in suitable moist soil conditions (Anderson 1992), but these were certainly not met in the present study area. Furthermore, earthworms can harbour eggs and larvae, thus serving as paratenic hosts (Anderson 1992), but environmental conditions were not conducive for this route of transmission either. No information is available as to the intermediate hosts of *D. nana*, but we assume that they are similar to those used by the congeneric *Davainea proglottina*, namely snails and slugs (Anderson 1992). Little evidence of these invertebrates was seen in or around water troughs and one would not expect them to occur in large number under the prevailing conditions. Thus, despite the high numbers of available final hosts, the scarcity of intermediate hosts seems to limit these parasites.

Similarly, the absence of the trematode guild from the small intestine of the guineafowls appears to be related to the availability of intermediate hosts. Most digeneans are dependant on molluscs or very rarely an annelid intermediate host for completion of their life cycles (Gibbons, Jones & Khalil 1996). Hence, they are more frequently associated with an aquatic habitat. Hodasi (1969, 1976) concluded that trematodes were rare parasites in gallinaceous birds.

It is difficult to determine the host specificity of helminths, and whether a certain parasite is regarded as a specialist or a generalist is often subjective, especially as helminths which are specialists in a certain host can nevertheless occur in other, often related hosts (Bush 1990). Based on the host-parasite check list of guineafowls of Junker & Boomker (2007b), we consider the following helminths as generalists: *S. suctoria*, *G. congolense*, *H. truncata* and possibly *A. numidae* as well as the cestode *H. cantaniana* and the acanthocephalan *M. gallinarum*. Each of these has been reported from a variety of hosts.

Many of the remaining helminths collected during this study are currently recorded from the guineafowl genera *Numida* and/or *Guttera* only, such as the nematodes *S. dentigera* and *T. numida* or the cestodes *O. numida*, *Raillietina angusta*, *Raillietina pintneri* and *Raillietina steinhardti*. *Numidella numida* which is equally common in guineafowls in the USA was also found in turkeys and domestic chickens in that country. However, failure to experimentally infect the latter hosts with the parasite (Jones 1933) led Reid (1962) to believe that chickens and turkeys were not natural hosts. While *S. dentigera*, *T. numida*, *N. numida*, *O. numida*, *R. angusta*, *R. pintneri* and *R. steinhardti* would therefore seem to be specialists in guineafowls, this, at best tentative, classification might simply reflect a general lack of data and could well change as more information on other gamebirds, such as korhaans, bustards, francolins, spurfowls and quails, becomes available. In an environment where high temperatures combined with low rainfall jeopardize successful completion of helminth life cycles, spreading the risk of transmission between various final hosts would appear a more reliable way to assure high parasite survival rates than a specialist approach. We would therefore expect the generalists to outweigh the specialists.

Similarly, helminths collected from the guineafowls in this study use a wide range of intermediate hosts and are often not limited to a specific host or even host taxon. *Numidella numida*, for example, is reported to use ground and dung beetles as well as grasshoppers (Reid 1962), and the common nematode, *S. suctoria* makes use of coleopterans, dermapterans and orthopterans (Anderson 1992). This strategy of spreading the risk of transmission between several intermediate hosts, all serving as prey to the final host, might well explain the aforementioned helminths' success in colonizing their final hosts, resulting in a prevalence of 100 % in *S. suctoria*, even under adverse environmental conditions. However, intermediate host data are usually very generalized in respect of the taxonomic status of the hosts. Hence, as more life cycle data become available especially elucidating parasite-intermediate host associations at species level, this picture of lack of specificity might change.

The aggregated pattern of dispersion seen in our data is common in parasite communities (Pielou 1974; Bush & Holmes 1986a, b; Alexander & McLaughlin 1997) and is a result of a number of factors, such as differences in the individual host's immune competence, feeding preferences and species specific host behaviour (Petney, Van Ark & Spickett 1990; Horak & Boomker 2000). Saayman (1966) demonstrated a pronounced difference in feeding-preferences between different members of the same guineafowl flock both in the amount of food consumed as well as the composition of crop contents. The higher the food intake and the higher the percentage of insect matter in the individual's diet, the higher the probability of ingesting an infected intermediate host and becoming infected.

A further reason for the aggregation of helminths in certain host individuals is the fact that a single infected guineafowl can excrete hundreds of nematode eggs in its faeces and a single tapeworm proglottid can contain hundreds of hexacanth larvae. Consequently, dung beetles, or other insects, feeding on contaminated faeces or around contaminated patches can be exposed to large numbers of parasite eggs during a single meal. Reid (1962) records up to 50 cysticercoids of *N. numida* in infected intermediate hosts, up to 930 cysticercoids of *Skrjabinia cesticillus* were present in a single beetle, while dung beetles have been found to contain 100 or more cysticercoids of *H. cantaniana*. Thus the ingestion of a single infected intermediate host can lead to the presence of a large number of helminths in individual final hosts.

Nine core species were identified within the helminth community of Helmeted Guineafowls at Musina. The helminth infracommunity of a single Crested Guineafowl, *Guttera edouardi*, from a nearby locality examined by Junker & Boomker (2007a) suggests a considerable overlap between the two parasite communities. Nine helminth species were present in the Crested Guineafowl, of which seven are core species and two are secondary species in Helmeted Guineafowls. This can probably be attributed to much the same feeding habits, exposing them to a similar pool of intermediate arthropod hosts.

Core species are usually the first to appear in juvenile birds (Hair 1975) and our data reflect the high colonization ability of these species, in that their proportional density in juvenile birds was distinctly higher than that seen in the overall host population (60.6 % vs 40.9 %). In contrast, the percentage of secondary species in juvenile birds was 34.8 % compared to 40.9 % in the overall population, and satellite species averaged 4.6 % in comparison with an overall average of 18.2 %.

Pairwise Spearman's rank correlation detected 11 significant correlations between helminth species in the small intestine. Of these, the only significant positive correlation occurred between the acanthocephalan *M. gallinarum* and the cestode *N. numida*, in that their intensities increased or decreased in unison. Positive associations between species can be due to several factors, amongst others the use of a common intermediate host. In this case a positive association in the source community would merely be transferred to the target community and would not necessarily reflect an interaction of the two species in the final host (Lotz & Font 1994). As is the case with many of the other parasite species collected in our study, there is no data on the intermediate hosts used by *M. gallinarum* in South Africa. Its North American counterpart, *Mediorhynchus grandis*, however, has been reported to use several species of grasshoppers as intermediate hosts (Moore 1962), and grasshoppers also form part of the life cycle of *N. numida* (Mohler 1936; Reid 1962). Whether a source community is the origin of the positive correlation between these two species, or if one parasite indeed changes the habitat in the final host in such a way as to facilitate the colonization by the other, would necessitate experimental studies. Conversely, *N. numida* had a significant negative correlation with *O. numida*, which also uses orthopterans as intermediate hosts (Gwyun & Hamilton 1935), and *O. numida* was negatively, albeit not significantly so, correlated with *M. gallinarum*.

Another positive correlation, although not significant ($P = 0.0819$), was found between *C. parroti* and *H. truncata* in the gizzard. The few data available on their intermediate hosts suggest that these do not overlap. *Cyrnea parroti* has been reported from orthopteran intermediate hosts and *H. truncata* from beetles (Anderson 1992). Their positive correlation might be a result of the fact that both seem to make use of a window period during the development of their host in which the latter is more susceptible to infection (see below).

Negative correlations between species, where an increased intensity of the one leads to a decreased intensity of the other, may result from competition for resources such as carbohydrates or attachment sites (Smyth & McManus 1989). Or it could indicate that the presence of one species alters the habitat to such an extent that it is less suitable for the other. Smyth & McManus (1989) report a number of substances that are produced by *Hymenolepis diminuta* and which might act as inhibitory factors, producing a crowding effect. Moreover, the host's immune response triggered by a certain species could well make this host less susceptible to subsequent colonization by other parasites.

Some of the factors influencing parasite community patterns in other hosts seem to be of little importance in structuring the helminth communities of Helmeted Guineafowls. One of these is age. Moore, Freehling, Horton & Simberloff (1987) concluded that age can occasionally have an important influence on the prevalence and intensity of helminth infections of Bobwhite Quail, *Colinus virginianus* (Linnaeus, 1758), and Pence (1990) reported changes in host age over seasons to be one of the factors most frequently cited when discussing prevalence and intensity. However, in the present study neither overall abundance nor species richness in juvenile guineafowls differed significantly from those in adults.

In contrast, Crowe (1977) reported that juvenile Helmeted Guineafowls, i.e. birds younger than 10 months, from the Kimberley district, South Africa had significantly higher burdens of cestodes and acanthocephalans than adults, and Davies, Junker, Jansen, Crowe & Boomker (in preparation) found higher burdens of *S. suctoria*, *O. numida* and *M. gallinarum* in juveniles during a study on Helmeted Guineafowls in the Free State Province. Forrester, Conti, Bush, Campbell & Frohlich (1984) found no significance in the differences between the prevalence of helminth species in chick and adult bobwhites, but the intensity of infection of a single helminth species was higher in chicks than in adults. When studying the helminth communities in willets, *Tringa semipalmatus* (Gmelin, 1789) (= *Catoptrophorus semipalmatus*), both on their breeding grounds (freshwater) and in their wintering habitat (saltwater), Bush (1990) found young birds to be depauperate, but within the course of 2 weeks the diversity of their helminth communities increased considerably and, in the case of helminths with freshwater life cycles, at 3 months of age no longer differed from those of adult birds.

Several factors could influence the prevalence and intensity of helminths in guineafowls of different ages. Young birds might well be more susceptible to helminth infections when compared to adults, as has been suggested by a number of authors (Ackert & Reid 1937; Biester & Schwarte 1959; Soulsby, 1969). However, this would be counterbalanced by a time-dependant higher probability of previous exposure to infected intermediate hosts, and thus to the various parasites, in older birds, therefore evening out differences between different ages on component community level. On the other hand, it is well documented that the diet of juvenile Helmeted Guineafowls and other gamebirds consists of a larger percentage of arthropods than that of adults (Del Hoyo *et al*. 1994; Crowe 2000), increasing their exposure to possible intermediate hosts.

Some age-related differences on metapopulation level, i.e. when singling out certain parasite species from the Musina hosts, were observed. *Cyrnea parroti*, whose predilection site is under the lining of the gizzard, was significantly more abundant in juvenile birds. We observed a distinct hardening of the gizzard lining in adult guineafowls which was not nearly as pronounced in the younger birds and which could easily impede establishment of this parasite in older hosts. This phenomenon might also explain why the prevalence of *H. truncata*, using the same site, decreased from 80 % in juveniles to only 40 % in older guineafowls. Dogiel (1964) suggested that the normal development of a host, such as a thickening of skin, could result in a habitat being no longer suitable for the parasite, hence leading to resistance against the latter.

The same mechanism is obviously not in play with *G. congolense*, which lives in tunnels under the crop mucosa. While the observed thickening of the mucosa should make colonization with *G. congolense* more difficult with increasing host age, this parasite was not found in any of the younger birds, but was present in 60 % of the older hosts. A possible explanation might be that *G. congolense* is only a secondary species indicating that its prevalence in the entire ecosystem is lower than that of a core species such as *C. parroti.* Consequently, age, if seen as an increase of the probability of prior exposure to a certain parasite with time, might have a more pronounced influence on the distribution pattern of this particular parasite. Using the same reasoning, one could expect the prevalence of *H. truncata*, also a secondary species, to increase in adult birds. As has been discussed this is not the case. However, the hardening of the crop mucosa never seems as pronounced as that of the gizzard's and, while the latter would seem likely to form a suitable barrier against the establishment of parasites, this is not necessarily so in the former.

Similarly to *C. congolense*, the cestode *P. paronai* had a significantly higher abundance in adult guineafowls, being absent in young birds. Little is known about the life cycle of this parasite except that it is one of the cestodes making use of sites other than the small intestine, in this case the bile ducts of guineafowls (Smyth & McManus 1989). Junker & Boomker (2007a) have reported immature stages of this parasite from the liver/bile ducts and adults from the small intestine of Helmeted Guineafowls. Whether morphological changes, such as the size of the bile ducts, or biochemical changes, such as the bile composition, during the ontogenesis of the guineafowl hosts in some way facilitate the migration and establishment of developing *P. paronai* has to remain speculation. On the other hand, a change in the prey preference in growing birds, possibly taking larger prey items not formerly included in the diet, may expose older guineafowls to a wider range of parasites.

The significantly higher abundance of *Subulura* sp. in juvenile birds can be attributed to the fact that the population of *Subulura* spp. in these hosts was mainly represented by infective larvae that do not yet display sufficient diagnostic characters to distinguish between the two species *S. dentigera* and *S.*

suctoria. We consider this a result of the fact that infections in the juvenile hosts had been recently acquired, thus comprising a high number of immatures, as opposed to the more mature infections found in older guineafowls.

Host gender was another determinant that had no significant influence on the distribution of worm burdens and species richness within the guineafowl population from Musina. Similar results were obtained by Crowe (1977), who attributed the absence of sexual variation in helminth infections to the fact that there is little behavioural or dietary difference between sexes outside the breeding season. All hosts in our and also Crowe's (1977) study were collected during the non-breeding season, extending from March to October in South Africa (Del Hoyo *et al*. 1994). Helmeted Guineafowls collected in the Free State Province during August 2007, however, showed sex related differences regarding the intensities of some helminths (Davies *et al*. in preparation). Possible reasons for this given by the latter authors are a difference in the length of the small intestine and caeca between males and females, as demonstrated by Prinsloo (2003), resulting in a larger habitat in the females. Moreover, females have a relatively higher intake of insects prior to breeding, which is often aided by the male's foraging for its mate (Hockey, Dean & Ryan 2005).

When discussing helminth communities in avian hosts, Bush (1990) concluded that host age and sex played a minor role, whereas the overall environment and habitat diversity therein exercised a major influence on the patterns of helminth communities. He argued that the latter would directly influence the "supply" of helminths available in the system. Keeping in mind that the current set of data was based on a limited number of hosts, and that a larger sample size might change the emerging picture, it nevertheless suggests that Helmeted Guineafowls are no exception to this general pattern.

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A check list of the helminths of guineafowls (Numididae) and a host list of these parasites

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ABSTRACT

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Published and personal records have been compiled into a reference list of the helminth parasites of guineafowls. Where data on other avian hosts was available these have been included for completeness' sake and to give an indication of host range. The parasite list for the Helmeted guineafowls, *Numida meleagris*, includes five species of acanthocephalans, all belonging to a single genus, three trematodes belonging to three different genera, 34 cestodes representing 15 genera, and 35 nematodes belonging to 17 genera. The list for the Crested guineafowls, *Guttera edouardi*, contains a single acanthocephalan together with 10 cestode species belonging to seven genera, and three nematode species belonging to three different genera. Records for two cestode species from genera and two nematode species belonging to a single genus have been found for the guineafowl genus *Acryllium*. Of the 70 helminths listed for *N. meleagris*, 29 have been recorded from domestic chickens.

Keywords: Acanthocephalans, cestodes, check list, guineafowls, host list, nematodes, trematodes

INTRODUCTION

Guineafowls (Numididae) originated on the African continent, and with the exception of an isolated population of Helmeted guineafowls in north-west Morocco, their natural distribution is restricted to sub-Saharan Africa (Del Hoyo, Elliott & Sargatal 1994). In the wake of commercial game bird farming, but also as ornamental birds in aviculture, they have been introduced to many other parts of the world, such as France, Hungary, Italy, Greece, the United Kingdom, the USA, Australia and different regions of the former USSR (Haziev & Khan 1991). According to Belshaw (1985) guineafowls were imported into the southern Mediterranean region several millennia before turkeys and hundreds of years before junglefowls from which today's domestic chickens were derived. Currently four genera of guineafowls are recognized, namely *Acryllium* Gray, 1840, *Agelastes* Bonaparte, 1850, *Guttera* Wagler, 1832 and *Numida* Linnaeus, 1766 (Del Hoyo *et al.* 1994).

Many publications on the helminth fauna of guineafowls originate from northern and western Africa, where, second only to the introduced and native domestic fowls, they are farm-reared as a source of protein. The economic importance of guineafowls and domestic fowls within the poultry industry, as well as the fact that domestic fowls are kept by many private households to augment their income, necessitated a better understanding of factors, such as gastro-intestinal parasites, influencing the success-

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ful rearing of these birds. Consequently studies have been conducted to assess the extent to which guineafowls and domestic fowls can serve as alternative hosts for their respective helminths and possibly be adversely affected by them (Hodasi 1969, 1976; Fabiyi 1972; Fatunmbi & Olufemi 1982; Vercruysse, Harris, Bray, Nagalo, Pangui & Gibson 1985).

In southern Africa Ortlepp (1937, 1938a, b, 1963), Saayman (1966), Crowe (1977) and Verster & Ptasinska-Kloryga (1987) have published on the helminth fauna of guineafowls. No data on the helminths infecting species of the guineafowl genus *Agelastes* could be found, and we are of the opinion that the comparatively short parasite lists for the genera *Acryllium* and *Guttera* reflect a lack of data rather than an absence of parasites.

The check list herein is intended as a quick reference aid and is split into two sections. The first section contains the parasites listed under their scientific names and authorities. Synonyms are provided either as generic synonyms in the case where whole genera have been synonymized or specific synonyms. The second section lists the hosts and their synonyms alphabetically, together with their respective parasites, also in alphabetical order.

The synonymy of the acanthocephalan genus *Mediorhynchus* Van Cleave 1916 is as given by Van Cleave (1947) and Schmidt & Kuntz (1977) and specific synonymy is according to Yamaguti (1963). For an in-depth review of the involved history of this genus's nomenclature the reader is referred to Van Cleave (1947).

The taxonomy of digenean trematodes follows Yamaguti (1958), but since the application of molecular techniques to this group has recently led to many changes, the reader is encouraged to consult the latest literature.

The classification of cestodes is based on the works of Khalil, Jones & Bray (1994). Information on generic synonyms and type species follows Khalil *et al.* (1994), while that on other species as well as the hosts and geographic distribution has mainly been derived from Yamaguti (1959), Schmidt (1986) and additional published records.

As regards nematode taxonomy, the authors have followed the CIH Keys to the nematode parasites of vertebrates (Anderson, Chabaud & Willmott, 1974–1983) and, where differences have occurred, have accepted the validity of genera and species as listed by Gibson (2005). With regard to generic synonyms, only synonyms listed in the CIH keys and by Gibson (2005) have been included in the check list. Specific synonyms, Type species and other species, as well as much of the data on hosts and geographic distribution are according to Yamaguti (1961) and Gibson (2005). Host and geographic data have been supplemented by including additional literature references.

The families and subfamilies of cestodes and nematodes are listed according to the system of Khalil *et al*. (1994) and the CIH Keys, respectively, but genera within these families are presented in alphabetical order. Synonyms have been arranged chronologically. The hosts and geographic localities per author are listed alphabetically. If several authors made reference to the same host, the authors are listed in chronological order.

The nomenclature and taxonomy of the avian hosts mainly follows Peterson (1999) and has been supplemented by Lepage (2007). Avian orders and families, as well as the nomenclature of southern African hosts follow Hockey, Dean & Ryan (2005).

In order to avoid excessive duplication, Helmeted guineafowls are listed below as *N. meleagris* only without regards to the subspecies. A total of nine subspecies of *N. meleagris* are currently recognized (Del Hoyo *et al.* 1994, Peterson 1999). These are: *N. m. coronatus* Gurney, 1868, *N. m. galeatus* Pallas, 1767, *N. m. marungensis* Schalow, 1884, *N. m. meleagris* (Linnaeus, 1758), *N. m. mitratus* Pallas, 1767, *N. m. papillosus* Reichenow, 1894, *N. m. reichenowi* Ogilvie-Grant, 1894, *N. m. sabyi* Hartert, 1919 and *N. m. somaliensis* Neumann, 1899. Del Hoyo *et al*. (1994) give a detailed list of the geographic range of the various subspecies of Helmeted guineafowls.

In the case of the Crested guineafowls, *Guttera edouardi* (Hartlaub, 1867) we follow Hockey *et al.* (2005) and Lepage (2007). Crowe (1978, cited in Hockey *et al.* 2005) had synonymized *G. edouardi* with *Guttera pucherani* (Hartlaub, 1861), but this decision was reversed and *G. edouardi* reinstated (Little & Crowe 2000, cited in Hockey *et al.* 2005). Peterson (1999) still lists *G. edouardi* as a subspecies of *G. pucherani*.

Hosts listed in the literature as *Gallus domesticus* or *Gallus gallus domesticus* are referred to below as domestic chicken. Lepage (2007) lists domestic chicken as unconfirmed subspecies, *G. g. domesticus* (no authority given), of the Red Junglefowl, *Gallus gallus* (Linnaeus, 1758). However, this subspecies is not included in the five subspecies listed by Peterson (1999).

PARASITE/HOST CHECK LIST

PHYLUM ACANTHOCEPHALA

Class Archiacanthocephala

Order Gigantorhynchidea

Family GIGANTORHYNCHIDAE Hamann, 1892

GENUS *MEDIORHYNCHUS* VAN CLEAVE 1916

Echinorhynchus Zoega in Müller, 1776, in part; *Gigantorhynchus* Hamann,1892, in part; *Heteroplus* Kostylev, 1914; *Empodius* Travassos, 1916; *Micracanthorhynchus* Travassos, 1917; *Leiperacanthus* Bhalerao, 1937; *Disteganius* Lehmann, 1953, *nomen nudum; Empodisma* Yamaguti, 1963

Type species: *Mediorhynchus papillosus* Van Cleave, 1918

1. *Mediorhynchus empodius* (Skrjabin, 1913) Meyer, 1933

   Ardea, Ardeotis arabs, Numida meleagris
   Yamaguti (1963), Belgium, Russia

2. *Mediorhynchus gallinarum* (Bhalerao, 1937) Van Cleave, 1947

   Domestic chicken
   Yamaguti (1963), India, Philippines
   Talbot (1971), Papua and New Guinea

   Gallinaceaous birds
   Schmidt & Kuntz (1977), (East-) Africa, India, Papua and New Guinea, Philippines

   Numida meleagris
   Junker & Boomker (2006), South Africa

3. *Mediorhynchus numidae* (Baer, 1925) Meyer, 1933

   Numida meleagris
   Meyer (1932), Namibia
   Oosthuizen & Markus (1967), South Africa

4. *Mediorhynchus selengensis* Harris, 1973

   Numida meleagris
   Vercryusse *et al.* (1985), Burkina Faso

   Schmidt & Kuntz (1977) synonymized this species with *M. gallinarum*.

5. *Mediorhynchus taeniatus* (Von Linstow, 1901) Dollfus, 1936

   Empodius segmentatus De Marval, 1902

   Ardeotis arabs
   Dollfus (1951) in Yamaguti (1963), Mauritania

   Chlamydotis undulata
   Dollfus (1951) in Yamaguti (1963), Morocco

   Guttera edouardi
   Southwell & Lake (1939), Democratic Republic of the Congo

   Numida meleagris
   Von Linstow (1901), Kenya
   Meyer (1932), Africa, Malawi
   Southwell & Lake (1939), Democratic Republic of the Congo
   Graber (1959), Chad
   Fabiyi (1972), Nigeria
   Hodasi (1976), Ghana
   Crowe (1977), South Africa

   Burhinus oedicnemus, *Chlamydotis macquenii*, *Otis tarda*
   Meyer (1932), Africa, Malawi

PHYLUM PLATHYHELMINTHES

Class Trematoda

Order Digenea

Family BRACHYLAEMIDAE Joyeaux & Foley, 1930

GENUS *POSTHARMOSTOMUM* WITENBERG, 1923

Type species: *Postharmostomum gallinum* (Witenberg, 1923)

1. *Postharmostomum gallinum* (Witenberg, 1923)

   Crested guineafowl
   Khan, Khan & Rayaz (1984), Pakistan

   Domestic chicken
   Yamaguti (1958), Hawaii, Japan, Russian Turkestan

   Numida meleagris
   Yamaguti (1958), North Africa

Family DICROCOELIIDAE Odhner, 1911

GENUS *DICROCOELIUM* DUJARDIN, 1845

Type species: *Dicrocoelium lanceatum* Stiles & Hassal, 1898

1. *Dicrocoelium macrostomum* Odhner, 1911

   Coturnix coturnix
   Yamaguti (1958), Russia

   Numida meleagris
   Lesbouyries (1941), Egypt
   Junker & Boomker (2007b), South Africa

GENUS *LUTZTREMA* TRAVASSOS, 1941

Type species: *Lutztrema olliquum* (Travassos, 1917)

Numida meleagris
Hodasi (1976), Ghana

Class Cestoda

Subclass Eucestoda

Order Cyclophyllidea

Family DAVAINEIDAE Braun, 1900

Subfamily Davaineinae Braun, 1900

GENUS *ABULADZUGNIA* SPASSKII, 1973

Type species: *Abuladzugnia gutterae* (Ortlepp, 1963)

1. *Abuladzugnia gutterae* (Ortlepp, 1963)

   Cotugnia gutterae Ortlepp, 1963

   Guttera edouardi
   Ortlepp (1963), Mozambique

   Numida meleagris
   Junker & Boomker (2007b), South Africa

2. *Abuladzugnia transvaalensis* (Ortlepp, 1963)
   Cotugnia transvaalensis Ortlepp, 1963
   Numida meleagris
      Ortlepp (1963), South Africa

GENUS *COTUGNIA* DIAMARE, 1893

Ershovitugnia, Spasskii, 1973; *Pavugnia* Spasskii, 1984; *Rostelugnia* Spasskii, 1984

Type species: *Cotugnia digonopora* (Pasquale, 1890) Diamare, 1893

1. *Cotugnia crassa* Fuhrmann, 1909
   Guineafowl
      Hudson (1934), East Africa
      Bwangamoi (1968), Uganda
   Numida meleagris
      Fuhrmann (1909) in Ortlepp (1963), the White Nile
      Baer (1925), Namibia
      Baer (1926), East Africa, West Africa
      Ortlepp (1963), Tanzania

      The White Nile rises from Lake Victoria in Uganda and enters the Sudan where it joins the Blue Nile in Karthoum to form the Nile. White Nile is one of the states of Sudan.
2. *Cotugnia digonopora* (Pasquale, 1890) Diamare, 1893
   Taenia digonopora Pasquale, 1890
   Anser, *Columba livia*, *Gallus gallus*, *Numida meleagris*
      Schmidt (1986), Africa, Burma, India, Indonesia, Philippines
   Guineafowl
      Baylis (1934), Uganda
3. *Cotugnia meleagridis* Joyeux, Baer & Martin, 1936
   Numida meleagris
      Joyeux, Baer & Martin (1936), Northern Somaliland
      Graber (1959), Chad
      Fabiyi (1972), Nigeria
      Hodasi (1976), Ghana
4. *Cotugnia shohoi* Sawada, 1971
   Acryllium vulturinum
      Schmidt (1986), Somalia
5. *Cotugnia tuliensis* Mettrick, 1963
   Numida meleagris
      Schmidt (1986), Zimbabwe

GENUS *DAVAINEA* BLANCHARD, 1891

Type species: *Davainea proglottina* (Davaine, 1860) Blanchard, 1891

1. *Davainea nana* Fuhrmann, 1912
   Guttera edouardi
      Ortlepp (1963), Zambia
   Numida meleagris
      Fuhrmann (1912), Northern Africa
      Junker & Boomker (2007b), South Africa
   Vanellus cinereus
      Schmidt (1986), Africa, Japan
2. *Davainea paucisegmentata* Fuhrmann, 1909
   Numida meleagris
      Baer (1926), Sudan, West Africa
      Schmidt (1986), Africa, Europe
3. *Davainea paucisegmentata* var. *dahomeensis* Joyeux & Baer, 1928
   Numida meleagris
      Schmidt (1986), France
4. *Davainea proglottina* (Davaine, 1860) Blanchard, 1891
   Taenia proglottina Davaine, 1860; *Davainea varians* Sweet, 1910; *Davainea dubius* Meggitt, 1916
   Alectoris graeca, *Bonasa umbellus*, *Gallus gallus*, *Perdix perdix*
      Schmidt (1986), Cosmopolitan
   Domestic chicken
      Baer (1926), South Africa
      Magwisha, Kassuku, Kyvsgaard & Permin (2002), Tanzania
   Numida meleagris
      Nfor, Ajanusi, Agbede & Esievo (1999), Nigeria

GENUS *NUMIDELLA* SPASSKAYA & SPASSKII, 1971

Type species: *Numidella numida* (Fuhrmann, 1912) Spasskaya & Spasskii, 1971

1. *Numidella numida* (Fuhrmann, 1912) Spasskaya & Spasskii, 1971
   Davainea numida Fuhrmann, 1912; *Raillietina* (*Paroniella*) *numida* (Fuhrmann, 1912) Fuhrmann, 1920; *Raillietina* (*Paroniella*) *magninumida* Jones, 1930
   Guineafowl
      Baylis (1934), Uganda
   Guttera, *Numida meleagris*
      Schmidt (1986), Africa, Cuba, North America
   Guttera
      Baer (1933), Zimbabwe

      Baer (1933) lists '*Guttera eduardi* Elliot' as host. None of the subspecies of *Guttera edouardi* listed in Lepage (2007) has been described by Elliot, but Lepage (2007) lists *Guttera pucherani verreauxi* (Elliot, 1870).
   Meleagris gallopavo, *Numida meleagris*
      Jones (1930), North America
   Numida meleagris
      Baer (1925), Namibia
      Ortlepp (1963), South Africa
      Fabiyi (1972), Nigeria

GENUS *POROGYNIA* RAILLIET & HENRY, 1909

Polycoelia Fuhrmann, 1907, preoccupied

Type species: *Porogynia paronai* (Moniez, 1892) Railliet & Henry, 1909

1. *Porogynia paronai* (Moniez, 1892) Railliet & Henry, 1909
   Taenia paronai Moniez, 1892; *Linstowia lata* Fuhrmann, 1901; *Polycoelia lata* (Fuhrmann, 1901) Fuhrmann, 1907; *Malika numida* Woodland, 1929; *Raillietina* (*Paroniella*) *woodlandi* Baylis, 1934

Guttera edouardi, *Numida meleagris*, *Pternistis natalensis*
Schmidt (1986), Africa, Europe

Guineafowl
Woodland (1928), Sudan
Baylis (1934), Uganda

Guttera edouardi
Ortlepp (1963), Zambia

Numida meleagris
Baer (1925), Namibia
Baer (1926), East Africa, West Africa
Woodland (1928), Sudan
Ortlepp (1963), South Africa, Swaziland
Cruz e Silva (1971), Mozambique
Fabiyi (1972), Nigeria

GENUS *RAILLIETINA* FUHRMANN, 1920

Kotlania López-Neyra, 1929; *Nonarmiella* Movsesyan, 1966; *Nonarmina* Movsesyan, 1966; *Kotlanotaurus* Spasskii, 1973; *Roytmania* Spasskii, 1973; *Skrjabinotaurus* Spasskii & Yurpalova, 1973; *Oschmarinetta* Spasskii, 1984

Type species: *Raillietina tetragona* (Molin, 1858)

1. *Raillietina angusta* Ortlepp, 1963

Raillietina (*Raillietina*) *angusta* Ortlepp, 1963

Numida meleagris
Ortlepp (1963), South Africa

2. *Raillietina cohni* (Baczynska, 1914) Fuhrmann, 1924

Davainea cohni Baczynska, 1914; *Raillietina* (*Ransomia*) *cohni* (Baczynska, 1914) Fuhrmann, 1920; *Raillietina* (*Raillietina*) *cohni* (Baczynska, 1914) Fuhrmann, 1924

Gallus gallus, *Numida meleagris, Pterocles exustus*, *Pterocles orientalis arenarius*
Schmidt (1986), Africa, Nepal

Domestic chicken
Baer (1926), East Africa

3. *Raillietina echinobothrida* (Megnin, 1880) Fuhrmann, 1924

Taenia echinobothrida Megnin, 1880; *Taenia botrioplites* Piana, 1881; *Davainea parechinobothrida* Magalhães, 1898; *Davainea penetrans* Baczynska, 1914; *Raillietina* (*Johnstonia*) *echinobothrida* (Megnin, 1880) Fuhrmann, 1920; *Raillietina* (*Raillietina*) *echinobothrida* (Megnin, 1880) Fuhrmann, 1924; *Raillietina* (*Fuhrmannetta*) *echinobothrida* (Megnin, 1880) Stiles & Orleman, 1926

Columba livia, *Gallus gallus*, *Gallus gallus bankiva*, *Meleagris gallopavo*, *Numida meleagris*, *Perdix perdix*, *Phasianus colchicus*
Schmidt (1986), Cosmopolitan

Domestic chicken
Baer (1926), West Africa
Le Roux (1926), South Africa
Joyeux *et al.* (1936), Northern Somalia
Poulsen, Permin, Hindsbo, Yelifari, Nansen & Bloch (2000), Ghana
Magwisha *et al.* (2002), Tanzania
Permin, Esmann, Hoj, Hove & Mukaratirwa (2002), Zimbabwe

Gallus gallus bankiva
Baer (1933), Zimbabwe

Numida meleagris
Baer (1933), Zimbabwe
Southwell & Lake (1939), Democratic Republic of the Congo
Cruz e Silva (1971), Mozambique
Ayeni, Dipeolu & Okaeme (1983), Nigeria

4. *Raillietina pintneri* (Klaptocz, 1906) Fuhrmann, 1924

Davainea pintneri Klaptocz, 1906; *Raillietina* (*Ransomia*) *pintneri* (Klaptocz, 1906) Fuhrmann, 1920; *Raillietina* (*Raillietina*) *pintneri* (Klaptocz, 1906) Fuhrmann 1924; *Kotlania pintneri* (Klaptocz, 1906) López-Neyra, 1931

Guttera
Baer (1933), Zimbabwe

Baer (1933) lists '*Guttera eduardi* Elliot' as host. None of the subspecies of *Guttera edouardi* listed in Lepage (2007) have been described by Elliot, but Lepage (2007) lists *Guttera pucherani verreauxi* (Elliot, 1870).

Guttera edouardi, *Numida meleagris*
Schmidt (1986), Africa

Guttera edouardi
Ortlepp (1963), Mozambique, Zambia

Numida meleagris
Baer (1925), Namibia
Baer (1926), Sudan, West Africa
Graber (1959), Chad
Ortlepp (1963) South Africa, Swaziland
Fabiyi (1972), Nigeria

5. *Raillietina somalensis* Sawada, 1971

Raillietina (*Raillietina*) *somalensis* Sawada, 1971

Acryllium vulturinum
Schmidt (1986), Somalia

6. *Raillietina steinhardti* Baer, 1925

Raillietina (*Ransomia*) *steinhardti* Baer, 1925

Guttera edouardi
Ortlepp (1963), Mozambique, Zambia

Numida meleagris
Yamaguti (1959), Africa
Verster & Ptasinska-Kloryga (1987), South Africa

7. *Raillietina tetragona* (Molin, 1858) Fuhrmann, 1924

Taenia tetragona Molin, 1858; *Taenia longicollis* Molin, 1858; *Davainea tetragona* (Molin, 1858) Blanchard, 1891; *Davainea bothrioplitis* Fillippi, 1892; *Raillietina* (*Ransomia*) *tetragona* (Molin, 1858) Fuhrmann, 1920; *Raillietina (Raillietina) tetragona* (Molin, 1858) Fuhrmann, 1924; *Kotlania tetragona* (Molin, 1858) López-Neyra, 1931; *Raillietina* (*Raillietina*) *galli* (Yamaguti, 1935) Sawada, 1955

Gallus gallus, *Guttera edouardi*, *Lagopus lagopus*, *Lagopus muta*, *Meleagris gallopavo*, *Numida meleagris*, *Pavo cristatus*, *Pavo muticus*
Schmidt (1986), Cosmopolitan

Domestic chicken
Baer (1926), East Africa, West Africa
Le Roux (1926), South Africa
Poulsen *et al.* (2000), Ghana

Magwisha *et al.* (2002), Tanzania
Permin *et al.* (2002), Zimbabwe

Numida meleagris
Baer (1926), East Africa, West Africa
Ayeni *et al.* (1983), Nigeria
Haziev & Khan (1991), Republic of Bashkortostan

8. *Raillietina tetragonoides* (Baer, 1925) Fuhrmann, 1932

Raillietina (*Ransomia*) *tetragonoides* Baer, 1925; *Raillietina* (*Raillietina*) *tetragonoides* (Baer, 1925) Fuhrmann, 1932; *Raillietina* (*Raillietina*) *tetragona* var. *cohni* (Baczynska, 1914) López-Neyra, 1944

Numida meleagris
Baer (1925), Namibia
Schmidt (1986), Africa

9. *Raillietina toyohashiensis* Sawada & Chikada, 1972

Numida meleagris
Schmidt (1986), Japan (zoo)

GENUS *SKRJABINIA* FUHRMANN, 1920

Raillietina (*Skrjabinia*) Fuhrmann, 1920; *Brumptiella* López-Neyra, 1929; *Armacetabulum* Movsesyan, 1966; *Markewitchella* Spasskii & Spasskaya, 1972; *Daovantienia* Spasskii & Spasskaya, 1976

Type species: *Skrjabinia cesticillus* (Molin, 1858) Fuhrmann, 1920

1. *Skrjabinia cesticillus* (Molin, 1858) Fuhrmann, 1920

Taenia cesticillus Molin, 1858; *Davainea cesticillus* Blanchard, 1891; *Raillietina (Raillietina) mutabilis* Rüther, 1901; *Raillietina* (*Skrjabinia*) *cesticillus* (Molin, 1858) Fuhrmann, 1920

Colinus virginianus, *Coturnix coturnix*, *Gallus gallus*, *Lagopus lagopus*, *Lagopus lagopus scotica*, *Lyrurus tetrix*, *Meleagris gallopavo*, *Numida meleagris*, *Perdix perdix*, *Phasianus colchicus*, *Tetrao urogallus*, *Tetrastes bonasia*
Schmidt (1986), Cosmopolitan

Domestic chicken
Baer (1926), West Africa
Le Roux (1926), South Africa
Joyeux *et al.* (1936), Northern Somalia
Poulsen *et al.* (2000), Ghana
Magwisha *et al.* (2002), Tanzania
Permin *et al.* (2002), Zimbabwe

Numida meleagris
Nfor *et al.* (1999), Nigeria

2. *Skrjabinia deweti* Ortlepp, 1938

Numida meleagris
Ortlepp (1938a), South Africa

Subfamily Idiogeninae Fuhrmann, 1907

GENUS *IDIOGENES* KRABBE, 1867

Ersinogenes Spasskaya, 1961; *Paraidiogenes* Movsesyan, 1971

Type species: *Idiogenes otidis* Krabbe, 1867

1. *Idiogenes* sp.

Numida meleagris
Hodasi (1976), Ghana

Family DILEPIDIDAE Railliet & Henry, 1909

GENUS *CHOANOTAENIA* RAILLIET, 1896

Type species: *Choanotaenia infundibulum* (Bloch, 1779) Railliet, 1896

1. *Choanotaenia infundibulum* (Bloch, 1779) Railliet, 1896

Taenia infundibulum Bloch, 1779

Domestic chicken
Poulsen *et al.* (2000), Ghana
Magwisha *et al.* (2002), Tanzania

Numida meleagris
Haziev & Khan (1991), Republic of Bashkortostan
Nfor *et al.* (1999), Nigeria

Family PARUTERINIDAE Fuhrmann, 1907

GENUS *OCTOPETALUM* BAYLIS, 1914

Type species: *Octopetalum gutterae* Baylis, 1914

1. *Octopetalum gutterae* Baylis, 1914

Ascometra gutterae (Baylis, 1914) Baer,1955

Guttera edouardi, *Numida meleagris*
Baer (1926), East Africa
Baer (1955), Democratic Republic of Congo, Malawi, South Africa
Schmidt (1986) Africa, France

2. *Octopetalum numida* (Fuhrmann, 1909) Baylis, 1914

Rhabdometra numida Fuhrmann, 1909; *Octopetalum longicirrosum* Baer, 1925; *Unciunia sudanea* Woodland, 1928; *Ascometra numida* (Fuhrmann, 1909) Baer, 1955

Guineafowl
Baylis (1934), Uganda

Guttera edouardi
Baer (1955), Sub-Saharan Africa
Ortlepp (1963), South Africa, Zambia

Numida meleagris
Baer (1925), Namibia
Baer (1926), Sudan, West Africa
Woodland (1928), Sudan
Baer (1955), Sub-Saharan Africa
Ortlepp (1963), Central Africa, North Africa, South Africa, southern Africa, Swaziland
Fabiyi (1972), Nigeria
Hodasi (1976), Ghana

GENUS *METROLIASTHES* RANSOM, 1900

Hexaparuterina Palacios & Barroeta, 1967

Type species: *Metroliasthes lucida* Ransom, 1900

1. *Metroliasthes lucida* Ransom, 1900

Alectoris graeca, *Alectoris rufa*, *Coturnix coturnix*, *Gallus gallus*, *Gallus gallus bankiva*, *Guttera edouardi*, *Meleagris gallopavo*, *Numida meleagris*, *Perdix perdix*
Schmidt (1986), Africa, Australia, Europe, India, North and South America, Russia

Numida meleagris
Southwell & Lake (1939), Democratic Republic of Congo

Family HYMENOLEPIDIDAE Ariola, 1899

Subfamily Hymenolepidinae Perrier, 1897

GENUS *ECHINOLEPIS* SPASSKII & SPASSKAYA, 1954

Type species: *Echinolepis carioca* (Maghalães, 1898) Spasskii & Spasskaya, 1954

1. *Echinolepis carioca* (Maghalães, 1898) Spasskii & Spasskaya, 1954

   Davainea carioca Maghalães, 1898; *Taenia conardi* Zürn, 1898; *Hymenolepis carioca* (Maghalães, 1898) Ransom, 1902; *Hymenolepis pullae* Cholodkovsky, 1913; *Weinlandia rustica* Meggitt, 1926; *Hymenolepis rustica* Fuhrmann, 1932; *Dicranotaenia carioca* (Maghalães, 1898) Skrjabin & Mathevossian, 1945; *Dicranotaenia rustica* (Meggitt, 1926) Skrjabin & Mathevossian, 1945

   Alectoris graeca, *Bonasa umbellus*, *Colinus virginianus*, *Coturnix coturnix*, *Gallus gallus*, *Meleagris gallopavo*
   Schmidt (1986), Cosmopolitan

   Domestic chicken
   Le Roux (1926), South Africa
   Magwisha *et al.* (2002), Tanzania

   Numida meleagris
   Baer (1926), West Africa

GENUS *HYMENOLEPIS* WEINLAND, 1858

Triorchis Clerc, 1903 preoccupied; *Cloacotaenia* Wolffhügel, 1938; *Amphipetrovia* Spasskii & Spasskaya, 1954; *Australiolepis* Spasskii & Spasskaya, 1954; *Orlovilepis* Spasskii & Spasskaya, 1954; *Staphylepis* Spasskii & Oshmarin, 1954; *Arhynchotaenia* Saakova, 1958 *nec* Pagenstecher, 1877; *Schmelzia* Yamaguti, 1959; *Woodlandia* Yamaguti, 1959; *Arhynchotaeniella* Schmidt, 1986; *Cloacotaeniella* Schmidt, Bauerle & Wertheim, 1988; *Amazilolepis* Schmidt & Daily, 1992

Type species: *Hymenolepis diminuta* (Rudolphi, 1819) Weinland, 1858

1. *Hymenolepis cantaniana* (Polonio, 1860) Ransom, 1909

   Taenia cantaniana Polonio, 1860; *Davainea oligophora* Maghalães, 1898; *Davainea cantaniana* Railliet & Lucet, 1899; *Hymenolepis inermis* (Yoshida, 1910) Fuhrmann, 1932

   Colinus virginianus, *Coturnix coturnix*, *Gallus gallus*, *Meleagris gallopavo*, *Numida meleagris*, *Pavo cristatus*, *Perdix perdix*, *Phasianus colchicus*, *Tetrao parvirostris*, *Tetrastes bonasia*, *Turnix suscitator*
   Schmidt (1986), Cosmopolitan

   Domestic chicken
   Le Roux (1926), South Africa
   Magwisha *et al.* (2002), Tanzania

   Le Roux (1926) chose to retain the name *H. inermis* for his unarmed specimens and not to accept the synonymy of *H. inermis* and *H. cantaniana* since the latter had been described as having an armed rostellum.

   Numida meleagris
   Hodasi (1976), Ghana
   Junker & Boomker (2007b), South Africa

GENUS *HISPANIOLEPIS* LÒPEZ-NEYRA, 1942

Satyolepis Spasskii, 1965

Type species: *Hispaniolepis villosa* (Bloch, 1782) López-Neyra, 1942

1. *Hispaniolepis falsata* (Meggitt, 1927) López-Neyra, 1942

   Hymenolepis falsata Meggitt, 1927.

   Numida meleagris
   Myers, Wolfgang & Kuntz (1960), Sudan

   Chlamydotis undulata
   Schmidt (1986), Egypt

2. *Hispaniolepis fedtschenkoi* (Solowiow, 1911) López-Neyra, 1942

   Hymenolepis fedtschenkoi Solowiow, 1911; *Hymenolepis gwiletica* Dinnik, 1938

   Gallus gallus, *Lyrurus tetrix*, *Numida meleagris*, *Tetraogallus himalayensis*, *Tetraogallus caucasicus*, *Tetrastes bonasia*
   Schmidt (1986), Russia, Europe, Asia, Africa

3. *Hispaniolepis hilmyi* (Skrjabin & Mathevossian, 1942) López-Neyra, 1942

   Hymenolepis tetracis Hilmy, 1936

   Numida meleagris
   Schmidt (1986), Liberia

4. *Hispaniolepis villosa* (Bloch, 1782) López-Neyra, 1942

   Numida meleagris
   Baer (1926), East Africa

GENUS *ORTLEPPOLEPIS* SPASSKII, 1965

Type species: *Ortleppolepis multiuncinata* (Ortlepp, 1963) Spasskii, 1965

1. *Ortleppolepis multiuncinata* (Ortlepp, 1963) Spasskii, 1965

   Hispaniolepis multiuncinata Ortlepp, 1963

   Guttera edouardi
   Ortlepp (1963), Zambia

   Numida meleagris
   Junker & Boomker (2007b), South Africa

PHYLUM NEMATHELMINTHES

Class Nematoda

Subclass Adenophorea

Order Enoplida

Superfamily Trichinelloidea Hall, 1916

Family TRICHURIDAE (Ransom, 1911) Railliet, 1915

Subfamily Capillariinae Railliet, 1915

GENUS *AONCHOTHECA* LÓPEZ-NEYRA, 1947

Avesaonchotheca auct.; *Baruscapillaria* auct.; *Capillaria* auct.; *Pterothomix* auct.; *Skrjabinocapillaria* Skarbilovich, 1946

1. *Aonchotheca caudinflata* (Molin, 1858)

Calodium caudinflata Molin, 1858; *Capillaria blomei* Travassos, 1915; *Trichosoma longicollis* Rudolphi, 1819

Chrysolophus, *Columba*, *Coturnix*, *Gallus*, *Lagopus*, *Lyrurus*, *Otis*, *Numida meleagris*, *Passer*, *Perdix*, *Phasianus*, *Sturnus*, *Tetrao*, *Turdus*
Yamaguti (1961), Europe, North America

Yamaguti (1961) lists *Aonchotheca caudinflata* from *Otis* without giving the host's species name. It is therefore not clear whether *Otis* refers to the current genus *Otis*, *Ardeotis*, *Neotis* or *Chlamydotis*.

Domestic chicken
Magwisha *et al.* (2002), Tanzania

Numida meleagris
Ayeni *et al*. (1983), Nigeria

Genus *Capillaria* Zeder, 1800

Trichosoma Rudolphi, 1819; *Trichosomum* Creplin, 1829; *Thominx* Dujardin, 1845; *Tridentocapillaria* Barus & Sergeeva, 1990; *Aonchotheca* auct; *Baruscapillaria* auct.; *Ptherominx* auct.; *Trichocephalus* auct.

Type species: *Capillaria anatis* (Schrank, 1790) Travassos, 1915

1. *Capillaria anatis* (Schrank, 1790)

Trichocephalus capillaris Rudolphi, 1809

Anas, *Anser*, *Clangula*, *Lyrurus*, *Melanitta*, *Merganser*, *Perdix*, *Phasianus*
Yamaguti (1961), Europe, Sakhalin, Siberia

Domestic chicken
Magwisha *et al.* (2002), Tanzania

Numida meleagris
Nfor *et al.* (1999), Nigeria

Genus *Eucoleus* Dujardin, 1845

Capillaria auct.; *Thominx* auct.; *Trichocephalus* auct.

1. *Eucoleus annulatus* (Molin, 1858)

Trichosoma annulatus Molin, 1858

Bonasa, *Chrysolophus*, *Colinus*, *Gallus*, *Lyrurus*, *Meleagris*, *Numida meleagris*, *Perdix*, *Phasianus*, *Syrmaticus*, *Tetrao*
Yamaguti (1961), Asia, Europe, North and South America

Domestic chicken
Magwisha *et al.* (2002), Tanzania

Numida meleagris
Fabiyi (1972), Nigeria
Hodasi (1976), Ghana
Vercruysse *et al.* (1985), Burkina Faso

Subclass Secernentea

Order Rhabditida

Superfamily Rhabditoidea

Family STRONGYLOIDIDAE Chitwood & McIntosh, 1934

Genus *Strongyloides* Grassi, 1879

1. *Strongyloides avium* Cram, 1929

Gallus
Yamaguti (1961), North America, Puerto Rico

Numida meleagris
Fabiyi (1972), Nigeria

Order Strongylida

Superfamily Strongyloidea

Family SYNGAMIDAE Leiper, 1912

Subfamily Syngaminae Baylis & Daubney, 1926

Genus *Syngamus* Siebold, 1836

Cyathostoma auct.; *Ornithogamus* Ryjikov, 1948

Type species: *Syngamus trachea* (Montagu, 1811) Siebold, 1836

1. *Syngamus trachea* (Montagu, 1811) Siebold, 1836

Fasciola trachea Montagu, 1811; *Syngamus trachealis* Siebold, 1836; *Strongylus trachealis* Nathusius, 1937 in Ortlepp (1923); *Strongylus pictus* Creplin, 1849; *Sclerostomum syngamus* Diesing, 1951 in Ortlepp (1923); *Syngamus furcatus* Theob., 1896; *Syngamus primitivus* Molin, 1861; *Syngamus sclerostomum* Molin, 1861

Galliformes, Passeriformes; rarely Anseriformes, "Ardeiformes", "Pelicaniformes", Piciformes, Otidiformes
Yamaguti (1961), Africa, Australia, Europe, India, North and South America

Domestic chicken
Magwisha *et al.* (2002), Tanzania

Numida meleagris
Hodasi (1976), Ghana
Nfor *et al*. (1999), Nigeria

Order Ascaridida

Superfamily Heterakoidea

Family HETERAKIDAE Railliet & Henry, 1912

Subfamily Heterakinae Railliet & Henry, 1912

Genus *Heterakis* Dujardin, 1845

Ganguleterakis Lane, 1914; *Raillietakis* Freitas, 1956; *Inglisakis* Freitas, Vicente & Santos, 1969

Type species: *Heterakis vesicularis* (Frölich, 1791)

1. *Heterakis vesicularis* (Frölich, 1791)

Ascaris vesicularis Frölich, 1791; *Ascaris papillosa*, Bloch, 1782, in part

Anas, *Colinus*, *Coturnix*, *Cygnus*, *Gallus*, *Lagopus*, *Meleagris*, *Numida meleagris*, *Oreortyx pictus*, *Otis*, *Pavo*, *Perdix*, *Phasianus colchicus*, *Polyplectron*, *Tetrao*
Yamaguti (1961), Africa, Europe, North America

Lophophorus, *Lophura*
Yamaguti (1961), Nepal

Yamaguti (1961) lists *Heterakis vesicularis* from *Otis* without giving the host's species name. It is therefore not clear whether *Otis* refers to the current genus *Otis*, *Ardeotis*, *Neotis* or *Chlamydotis*.

2. *Heterakis brevispiculum* Gendre, 1911

Domestic chicken, *Numida meleagris*, *Pternistis bicalcaratus*

Yamaguti (1961), Africa, Puerto Rico, South America

Numida meleagris
Fabiyi (1972), Nigeria
Hodasi (1976), Ghana

3. *Heterakis dispar* (Schrank, 1790)

Ascaris dispar Schrank, 1790

Alectoris, *Anas*, *Anser*, *Anser cygnoides*, *Branta, Bernicla*, *Cairina*, *Chloephaga*, *Glaucidium*, *Numida meleagris*, *Strix*, *Surnia*, *Tadorna*
Yamaguti (1961), Cosmopolitan

Domestic chicken
Permin, Magwisha, Kassuku, Nansen, Bisgaard, Frandsen & Gibbons (1997), Tanzania

4. *Heterakis gallinarum* (Schrank, 1788)

Ascaris gallinarum Schrank, 1788; *Heterakis gallinae* Gmelin, 1790; *Heterakis longicaudata* Von Linstow, 1879

Acryllium, *Alectoris*, *Anas*, *Anser*, *Bonasa*, *Cairina*, *Chrysolophus*, *Colinus*, *Corvus*, *Coturnix*, *Cupidonia*, domestic chicken, *Francolinus*, Houbara, *Lagopus*, *Lophophorus*, *Lophura*, *Lyrurus*, *Meleagris*, *Otis*, *Pavo*, *Pedioecetes*, *Perdix*, *Phasianus*, *Pterocles*, *Strix*, *Syrmaticus*, *Tetrao*, *Tragopan*, *Tympanuchus*
Yamaguti (1961), Cosmopolitan

Yamaguti (1961) lists *Heterakis gallinarum* from *Otis* without giving the host's species name. It is therefore not clear whether *Otis* refers to the current genus *Otis*, *Ardeotis*, *Neotis* or *Chlamydotis*.

Domestic chicken
Poulsen *et al.* (2000), Ghana
Magwisha *et al.* (2002), Tanzania
Permin *et al.* (2002), Zimbabwe

Numida meleagris
Ayeni *et al*. (1983), Nigeria
Verster & Ptasinska-Kloryga (1987), South Africa
Haziev & Khan (1991), Republic of Bashkortostan
Santa Cruz, Ortis de Rott & Resoagli (1998), Argentina

5. *Heterakis tenuicauda* Von Linstow, 1883

Alectoris graeca, *Alectoris graeca saxatilis*
Yamaguti (1961), Turkestan

Acryllium vulturinum
Canavan (1929) in Yamaguti (1961), East Africa

Family ASCARIDIIDAE Travassos, 1919

GENUS *ASCARIDIA* DUJARDIN, 1845

Cotylascaris Sprent, 1971

Type species: *Ascaridia hermaphrodita* (Frölich, 1789) Railliet & Henry, 1914

1. *Ascaridia calcarata* (Gendre, 1909)

Numida meleagris
Yamaguti (1961), Africa

Junior synonym of *Ascaridia numidae* (Leiper, 1908) according to Sprehn (1932) in Yamaguti (1961).

2. *Ascaridia compar* (Schrank, 1790) Travassos, 1913

Ascaris compar Schrank, 1790

Alectoris, Coturnix, Gallus, Lyrurus, Numida meleagris, Oreortyx pictus, Perdix, Tetrao, *Tetrastes*
Yamaguti (1961), America, Europe, India, Philippines

3. *Ascaridia galli* (Schrank, 1788) Freeborn, 1932

Ascaris galli Schrank, 1788; *Fusaria inflexa* Zeder, 1800 (Baylis 1932, cited in Yamaguti 1961); *Fusaria reflexa* Zeder, 1800, in part; *Fusaria strumosa* Zeder, 1800, in part (López-Neyra 1946, cited in Yamaguti 1961); *Heterakis brasiliensis* Magalhães, 1892 (Pinto & Lins de Almeida 1935, cited in Yamaguti 1961); *Heterakis granulosa* Von Linstow, 1906 (Baylis 1932, cited in Yamaguti 1961); *Ascaridia hamia* Lane, 1914

Domestic chicken, guineafowl
Yamaguti (1961), Europe, Japan

Alectoris, *Bonasa*, *Cairina*, *Colinus*, duck, *Ithaginis*, *Lyrurus*, *Meleagris*, *Numida meleagris*, *Perdix*, *Phasianus*, *Streptopelia*, *Tetrao*, *Tympanuchus*
Yamaguti (1961), Cosmopolitan

Domestic chicken
Poulsen *et al.* (2000), Ghana
Magwisha *et al.* (2002), Tanzania
Permin *et al.* (2002), Zimbabwe

Numida meleagris
Ayeni *et al.* (1983), Nigeria
Verster & Ptasinska-Kloryga (1987), South Africa
Haziev & Khan (1991), Republic of Bashkortostan

4. *Ascaridia lineata* (Schrank, 1866)

Ascaris lineata Schrank, 1866

Alectoris, *Anas*, *Anser*, *Bonasa*, duck, *Francolinus*, *Gallus*, goose, *Meleagris*, *Meleagris ocellata*, *Numida*, partridge, *Phasianus*, pigeon, *Tympanuchus*
Yamaguti (1961), Africa, Brazil, China, Cuba, Europe, Formosa, India, Malaya, North America, Philippines, Puerto Rico, Turkestan

Domestic chicken
Le Roux (1926), South Africa

5. *Ascaridia numidae* (Leiper, 1908) Travassos, 1913

Heterakis numidae Leiper, 1908

Alectoris, Guttera
Yamaguti (1961), Africa

Guineafowl
Yamaguti (1961), Puerto Rico
Bwangamoi (1968), Uganda

Numida meleagris
Graber (1959), Chad
Yamaguti (1961), Africa, the White Nile
Myers *et al*. (1960), Sudan
Fabiyi (1972), Nigeria
Hodasi (1976), Ghana
Vercruysse *et al.* (1985), Burkina Faso
Verster & Ptasinska-Kloryga (1987), South Africa

The White Nile rises from Lake Victoria in Uganda and enters the Sudan where it joins the Blue Nile in Karthoum to form the Nile. White Nile is one of the states of Sudan.

6. *Ascaridia perspicillum* (Rudolphi, 1803)
   Ascaris perspicillum Rudolphi, 1803

   Anas acuta, domestic chicken, *Meleagris gallopavo*, *Numida meleagris*, *Pavo cristatus*, *Tetrao urogallus*, *Tetrastes bonasia rupestris*, *Turdus viscivorus*
   Yamaguti (1961), Europe, Hawaii, India, Indonesia, Japan, Malaya

Superfamily Subuluroidea

Family SUBULURIDAE (Travassos, 1914) Yorke & Maplestone, 1926

Subfamily Subulurinae Travassos, 1914

GENUS *SUBULURA* MOLIN, 1860

Allodapa auct.

Type species: *Subulura acutissima* Molin, 1860

1. *Subulura acuticauda* (Von Linstow, 1901) Railliet & Henry, 1914
   Oxysoma acuticauda Von Linstow, 1901; *Heterakis acuticauda* (Von Linstow, 1901) Von Linstow, 1909

   Numida meleagris
   Von Linstow (1901), Kenya
   Yamaguti (1961), Africa

2. *Subulura brumpti* (Lopez-Neyra, 1922)
   Allodapa brumpti Lopez-Neyra, 1922

   Alectoris graeca, *Anas*, *Colinus virginianus texanus*, domestic chicken, *Meleagris gallopavo*, *Numida*, *Perdix perdix*, *Streptopelia orientalis*
   Yamaguti (1961), Europe, Palestine, Cyprus, Cuba, Puerto Rico, Panama, North America, Africa, China

   Domestic chicken
   Hodasi (1969), Ghana
   Mukaratirwa, Hove, Esmann, Hoj, Permin & Nansen (2001), Zimbabwe

   Numida meleagris
   Graber (1959), Chad
   Hodasi (1976), Ghana
   Nfor *et al.* (1999), Nigeria

3. *Subulura dentigera* Ortlepp, 1937
   Numida meleagris
   Ortlepp (1937), South Africa

4. *Subulura differens* (Sonsino, 1890)
   Heterakis differens Sonsino, 1890

   Alectoris graeca, *Centropus phasianus*, domestic chicken, *Euplectes orix*, *Numida meleagris*, *Perdix perdix canescens*, *Pternistis bicalcaratus*
   Yamaguti (1961), Cosmopolitan

5. *Subulura suctoria* (Molin, 1860)
   Heterakis suctoria Molin, 1860; *Ascaris forcipata* Rudolphi, 1819, in part

   Caprimulgus, *Podager*, *Nyctibius*
   Yamaguti (1961), Brazil

   Burhinus, *Coturnix*, *Numida*, *Pternistis*
   Yamaguti (1961), South Africa (Transvaal)

   Coturnix coturnix, *Lagopus lagopus*, *Phasianus colchicus*, *Phasianus colchicus mongolicus*, *Phasianus colchicus principalis*
   Yamaguti (1961), Russia, Turkestan

   Domestic chicken
   Permin *et al.* (1997), Tanzania
   Permin *et al.* (2002), Zimbabwe

   Guttera edouardi
   Junker & Boomker (2007b), South Africa

   Numida meleagris
   Ortlepp (1937), South Africa
   Fabiyi (1972), Nigeria
   Vercruysse *et al.* (1985), Burkina Faso

6. *Subulura strongylina* (Rudolphi, 1819)
   Ascaris strongylina Rudolphi, 1819; *Strongylus spiculatus* Cobbold, 1861 (Boughton 1939, cited in Yamaguti 1961)

   Bonasa, *Bucco*, *Callipepla*, *Caprimulgus*, *Chelidoptera*, *Colinus*, *Cuculus*, *Gallus*, *Malocoptila*, *Monasa*, *Nonnula*, *Numida meleagris*, *Odontophorus*, *Perdix*, *Podager*, *Tetrao*, *Tympanuchus*
   Yamaguti (1961), North America, Puerto Rico

   Crypturellus, *Odontophorus capueira*, *Tinamus*
   Yamaguti (1961), Brazil

   Domestic chicken
   Permin *et al.* (1997), Tanzania
   Poulsen *et al.* (2000), Ghana

Order Spirurida Diesing, 1861

Superfamily Thelazioidea

Family THELAZIIDAE Skrjabin, 1915

GENUS *OXYSPIRURA* DRASCHE IN STOSSICH, 1897

Cramispirura Skrjabin, 1931

Type species: *Oxyspirura cephaloptera* (Molin, 1860)

1. *Oxyspirura mansoni* (Cobbold, 1879)
   Filaria mansoni Cobbold, 1879; *Spiroptera emmerezii* Emmerez & Mégnin, 1901 (Marotel & Carougeau 1902, cited in Yamaguti 1961)

   Domestic chicken, *Gallus gallus*, *Meleagris gallopavo*, *Pavo cristatus*
   Yamaguti (1961), Atlantic and Pacific islands, Australia, Democratic Republic of Congo, Formosa, India, Japan, North America

   Numida meleagris
   Hodasi (1976), Ghana

Superfamily Spiruroidea

Family GONGYLONEMATIDAE (Hall, 1916, subfam.) Sobolev, 1949

GENUS *GONGYLONEMA* MOLIN, 1857

Type species: *Gongylonema musculi* (Rudolphi, 1819) Neumann, 1894

1. *Gongylonema ingluvicola* Ransom, 1904
   Gongylonema sumani Bahlerao, 1933 (Baylis 1939, cited in Yamaguti 1961)

Gallus, *Meleagris*, pheasants
Yamaguti (1961), Cosmopolitan

Domestic chicken
Poulsen *et al.* (2000), Ghana
Magwisha *et al.* (2002), Tanzania
Permin *et al.* (2002), Zimbabwe

Numida meleagris
Nfor *et al.* (1999), Nigeria

2. *Gongylonema congolense* Fain, 1955

Cairina moschata
Fain (1955), Democratic Republic of the Congo

Gallus
Fain (1955), Burundi, Democratic Republic of the Congo, Rwanda

Guttera edouardi
Junker & Boomker (2007b), South Africa

Numida meleagris
Fain (1955), Burundi, Democratic Republic of the Congo, Rwanda
Fabiyi (1972), Nigeria
Graber (1976), Ethiopia
Hodasi (1976), Ghana
Vercruysse *et al.* (1985), Burkina Faso
Junker & Boomker (2007b), South Africa

Scleroptila levaillantii
Fain (1955), Rwanda

3. *Gongylonema sumani* Bhalerao, 1933

Gallus gallus
Bhalerao (1933), India

Numida meleagris
Fain & Thienpont (1958), Burundi

Superfamily Habronematoidea

Family HABRONEMATIDAE (Chitwood & Wehr, 1932) Ivaschkin, 1961

Subfamily Habronematinae Chitwood & Wehr, 1932

GENUS *CYRNEA* SEURAT, 1914

Seurocyrnea Strand, 1929; *Skrjabinochona* Guschkanskaja, 1931; *Chenspirura* Hsü, 1957 *nec* Kou, 1958

Type species: *Cyrnea eurycerca* Seurat, 1914

1. *Cyrnea eurycerca* Seurat, 1914

Alectoris, *Coturnix*, *Francolinus*, *Phasianus*, *Merops*
Yamaguti (1961), Africa, Europe

Numida meleagris
Ortlepp (1938a), Southern Africa

Alectoris rufa ("*Perdix rouge*" in Yamaguti [1961])
Yamaguti (1961), Corsica

2. *Cyrnea parroti* Seurat, 1917

Cyrnea seurati Lopéz-Neyra, 1918; *Habronema numidae* Ortlepp, 1938; *Cyrnea numidae* (Ortlepp, 1938)

Alectoris barbara
Yamaguti (1961), Algeria

Alectoris rufa
Yamaguti (1961), Spain

Numida meleagris
Ortlepp (1938b), Malawi, South Africa, Swaziland
Fabiyi (1972), Nigeria
Vercruysse *et al.* (1985), Burkina Faso

Chabaud (1958) divided the genus *Cyrnea* into the two subgenera *Procyrnea* Chabaud, 1958 and *Cyrnea* Chabaud, 1958, subsequently raising them to genus level (Chabaud, 1975). He also synonymized *Cyrnea* (*Cyrnea*) *numidae* Ortlepp, 1938 and *Cyrnea* (*Cyrnea*) *seurati* Lopéz-Neyra, 1918 with *Cyrnea* (*Cyrnea*) *parroti* Seurat, 1917. Our specimens of *Cyrnea parroti* collected from *Numida meleagris* in South Africa comply with Ortlepp's (1938b) description of *C. numidae*, but the arrangement of cephalic structures in apical view is that of *C. parroti.* Not having examined Otlepp's (1938b) specimens we adopt the classification of Chabaud (1958) and list Ortlepp's specimens as *C. parroti*.

GENUS *SICARIUS* LI, 1934

Type species: *Sicarius dipterum* (Popova, 1927) Li, 1934

1. *Sicarius caudatus* Quentin & Wertheim, 1975

Numida meleagris
Junker & Boomker (2007b), South Africa

Pycnonotus capensis
Quentin & Wertheim (1975), Israel

Quentin & Wertheim (1975) described *S. caudatus* from *P. capensis* present in the collection of the "Helminthological Laboratory Jerusalem" and list Jerusalem as locality. It should be noted that *P. capensis* is endemic to South Africa (Lepage 2007). We therefore conclude that the authors were either looking at birds kept in captivity in Israel, making it difficult to determine the geographic origin of the parasites or did not have any information on the original locality if the birds had been collected in South Africa.

2. *Sicarius renatae* Cancrini, Balbo & Iori, 1991

Acryllium vulturinum
Cancrini, Balbo & Iori (1991), Somalia

Subfamily Histiocephalinae Gendre, 1922

GENUS *HADJELIA* SEURAT, 1916

Gilsonia Gedoelst, 1919; *Stellobronema* Guschanskaja, 1937; *Sobolevicephalus* Parukhin, 1964

1. *Hadjelia truncata* (Creplin, 1825)

Spiroptera truncata Creplin, 1825; *Hadjelia inermis* (Gedoelst, 1919)

Aceros corrugatus
Ortlepp (1964), Malucca Islands, Indonesia

Columba livia
Tadros & Iskander (1975), Egypt

Guttera edouardi, *Numida meleagris*
Junker & Boomker (2007b), South Africa

Tockus erythrorhynchus, *Tockus leucomelas*
Ortlepp (1964), South Africa

Tockus fasciatus semifasciatus
Cram (1927, cited in Ortlepp 1964), Africa

Coracias benghalensis, *Halcyon smyrnensis*, *Upupa epops*
Singh (1949), India
Chabaud & Campana (1950) synonymized *H. inermis* with *H. truncata.* Ortlepp (1964) did not follow this and recorded his specimens as *H. inermis.* Tadros & Iskander (1975) synonymized *H. inermis*, *H. parva* and *H. lhuillieri* with *H. truncata*, designating *H. truncata* as the new type species of the genus.

Family TETRAMERIDAE Travassos, 1914

Subfamily Tetramerinae Railliet, 1915

GENUS *TETRAMERES* CREPLIN, 1846

Tropisurus Diesing, 1835; *Tropidurus* Wiegmann, 1835, preoccupied; *Gynaecophila* Gubanov, 1950; *Petrowimeres* Tschertkova, 1953; *Microtetrameres* auct.

Type species: *Tetrameres paradoxa* (Diesing, 1835)

1. *Tetrameres fissispina* Diesing, 1861
Acanthophorus horridus Von Linstow, 1876; *Acanthophorus tenuis* Von Linstow, 1876; *Filaria pulicis* Von Linstow, 1894
Alectoris, *Anas acuta*, *Anas clypeata*, *Anas platyrhynchos*, *Anas querquedula*, *Aythya ferina*, *Bucephala clangula*, *Columba livia*, *Cygnus melanocoryphus*, *Fulica atra*, *Gallus*, *Melanitta fusca*, *Meleagris*, *Meleagris gallopavo*, *Mergus merganser*, *Nycticorax nycticorax*, *Perdix*, *Somateria molissima*, *Tachybaptus fluviatilis*
Yamaguti (1961), Africa, Canton, Europe, Formosa, Guam, India, Malaya, North and South America, Philippines, Russian Turkestan, Siberia, Turkey
Domestic chicken
Le Roux (1926), South Africa
Poulsen *et al.* (2000), Ghana
Magwisha *et al.* (2002), Tanzania
Guineafowl
Le Roux (1926), South Africa
Numida meleagris
Fabiyi (1972), Nigeria
Hodasi (1976), Ghana
Vercruysse *et al.* (1985), Burkina Faso
2. *Tetrameres numida* Junker & Boomker 2007
Numida meleagris
Junker & Boomker (2007a), South Africa
Chabaud (1975) divided the genus *Tetrameres* into the two subgenera *Tetrameres* (*Tetrameres*) Creplin, 1846 and *Tetrameres* (*Microtetrameres*) Travassos, 1915. We adopt the view of Anderson (1992) and consider the two as valid genera.

Superfamily Acuarioidea

Family Acuariidae (Railliet, Henry & Sisoff, 1912, subfam.)

Subfamily Acuariinae Railliet, Henry & Sisoff, 1912

GENUS *ACUARIA* BREMSER, 1811

Cheilospirura auct.

Type species: *Acuaria anthuris* (Rudolphi, 1819)

1. *Acuaria hamulosa* (Diesing, 1851)
Spiroptera hamulosa Diesing, 1851; *Cheilospirura hamulosa* Diesing, 1861; *Spiroptera perforans* Centoscudi, 1911
Coturnix coturnix, *Gallus gallus*, *Meleagris*, pheasant
Yamaguti (1961), Cosmopolitan
Domestic chicken
Le Roux (1926), South Africa
Poulsen *et al.* (2000), Ghana
Magwisha *et al.* (2002), Tanzania
Numida meleagris
Fabiyi (1972), Nigeria
Hodasi (1976), Ghana

GENUS *SYNHIMANTUS* RAILLIET, HENRY & SISOFF, 1912

Type species: *Synhimantus laticeps* (Rudolphi, 1819)

1. *Synhimantus spiralis* (Linstow, 1883)
Dispharagus spiralis Linstow, 1883
Accipiter, *Alectoris*, *Bonasa*, *Ciconia*, *Colinus*, *Columba*, *Coracias*, *Corvus*, *Gallus*, *Meleagris*, *Metopidius*, *Numida meleagris*, *Passer*, *Perdix*, *Phasianus*, *Quiscalus*, *Turdus*, *Turdus migratorius*
Yamaguti (1961), Cosmopolitan
Numida meleagris
Fabiyi (1972), Nigeria
Hodasi (1976), Ghana
Vercruysse *et al.* (1985), Burkina Faso

GENUS *DISPHARYNX* RAILLIET, HENRY & SISOFF, 1912

Type species: *Dispharynx nasuta* (Rudolphi, 1819)

1. *Dispharynx nasuta* (Rudolphi, 1819)
Spiroptera nasuta Rudolphi, 1819
Passer domesticus
Yamaguti (1961), Europe
Gallus gallus
Yamaguti (1961), Africa, America, Australia, Ceylon, Cuba, Formosa
Domestic chicken, turkeys
Gibbons, Jones & Khalil (1996), no geographic data given
Numida meleagris
Verster & Ptasinska-Kloryga (1987), South Africa

HOST/PARASITE CHECK LIST

Order Tinamiformes

Family Tinamidae (Tinamous)

GENUS *TINAMUS* HERMANN, 1783

Subulura strongylina

GENUS *CRYPTURELLUS* BRABOURNE & CHUBB, 1914

Crypturus
Subulura strongylina

Order Galliformes

Domestic chicken

Mediorhynchus gallinarum
Postharmostomum gallinum
Choanotaenia infundibulum
Davainea proglottina
Echinolepis carioca
Hymenolepis cantaniana
Raillietina cohni
Raillietina echinobothrida
Raillietina tetragona
Skrjabinia cesticillus
Acuaria hamulosa
Aonchotheca caudinflata
Ascaridia galli
Ascaridia lineata
Ascaridia perspicillum
Capillaria anatis
Dispharynx nasuta
Eucoleus annulatus
Gongylonema ingluvicola
Heterakis brevispiculum
Heterakis dispar
Heterakis gallinarum
Oxyspirura mansoni
Subulura brumpti
Subulura differens
Subululra strongylina
Subulura suctoria
Syngamus trachea
Tetrameres fissispina

Gallinaceaous birds, galliformes

Mediorhynchus gallinarum
Syngamus trachea

Family Numididae (Guineafowls)

Crested guineafowl

Postharmostomum gallinum

Guineafowl

Cotugnia crassa
Cotugnia digonopora
Numidella numida
Octopetalum numida
Porogynia paronai
Ascaridia galli
Ascaridia numidae
Tetrameres fissispina

GENUS *NUMIDA* LINNAEUS, 1766

1. *Numida meleagris* (Linnaeus, 1758) (Helmeted Guineafowl)

Phasianus meleagris

Numida meleagris galeatus Pallas, 1767

Numida galeata

Numida meleagris meleagris (Linnaeus, 1758)

Numida ptilorhyncha

Numida meleagris mitratus Pallas, 1767

Numida mitrata

Numida meleagris marungensis Schalow, 1884

Numida frommi, Numida marungensis, Numida meleagris bodalyae, Numida meleagris frommi, Numida meleagris maxima, Numida meleagris rikwae, Numida mitrata frommi, Numida mitrata maximia, Numida mitrata rikwae, Numida rikwae

Mediorhynchus empodius
Mediorhynchus gallinarum
Mediorhynchus numidae
Mediorhynchus selengensis
Mediorhynchus taeniatus
Dicrocoelium macrostomum
Lutztrema sp.
Postharmostomum gallinum
Abuladzugnia gutterae
Abuladzugnia transvaalensis
Choanotaenia infundibulum
Cotugnia crassa
Cotugnia digonopora
Cotugnia meleagridis
Cotugnia tuliensis
Davainea nana
Davainea paucisegmentata
Davainea paucisegmentata var. dahomeensis
Davainea proglottina
Echinolepis carioca
Hispaniolepis falsata
Hispaniolepis fedtschenkoi
Hispaniolepis hilmyi
Hispaniolepis villosa
Hymenolepis cantaniana
Idiogenes sp.
Metroliasthes lucida
Numidella numida
Octopetalum gutterae
Octopetalum numida
Ortleppolepis multiuncinata
Porogynia paronai
Raillietina angusta
Raillietina cohni
Raillietina echinobothrida
Raillietina pintneri
Raillietina steinhardti
Raillietina tetragona
Raillietina tetragonoides
Raillietina toyohashiensis
Skrjabinia cesticillus
Skrjabinia deweti
Acuaria hamulosa
Ascaridia calcarata
Ascaridia compar
Ascaridia galli
Ascaridia lineata
Ascaridia numidae
Ascaridia perspicillum
Aonchotheca caudinflata
Capillaria anatis
Cyrnea eurycerca

Cyrnea parroti
Eucoleus annulatus
Gongylonema congolense
Gongylonema ingluvicola
Gongylonema sumani
Hadjelia truncata
Heterakis brevispiculum
Heterakis dispar
Heterakis gallinarum
Heterakis vesicularis
Oxyspirura mansoni
Sicarius caudatus
Sicarius renatae
Subulura acuticauda
Subulura brumpti
Subulura dentigera
Subulura differens
Subulura strongylina
Subulura suctoria
Strongyloides avium
Syngamus trachea
Dispharynx nasuta
Synhimantus spiralis
Tetrameres fissispina
Tetrameres numida

GENUS: *GUTTERA* WAGLER, 1832

Numidella numida
Raillietina pintneri
Ascaridia numidae

1. *Guttera edouardi* (Hartlaub, 1867) (Crested Guineafowl)

Numida edouardi (Hartlaub, 1867); *Guttera pucherani edouardi* (Hartlaub, 1867)

Mediorhynchus taeniatus
Abuladzugnia gutterae
Davainea nana
Metroliasthes lucida
Octopetalum gutterae
Octopetalum numida
Ortleppolepis multiuncinata
Porogynia paronai
Raillietina pintneri
Raillietina steinhardti
Raillietina tetragona
Gongylonema congolense
Hadjelia truncata
Subulura suctoria

GENUS: *ACRYLLIUM* GRAY, 1840

Heterakis gallinarum

1. *Acryllium vulturinum* Gray, 1840 (Vulturine Guineafowl)

Cotugnia shohoi
Raillietina somalensis
Heterakis tenuicauda
Sicarius renatae

Family ODONTOPHORIDAE (New World quails)

GENUS *OREORTYX* BAIRD, 1858

Ortyx in Yamaguti (1961)

1. *Oreortyx pictus* (Douglas, 1829) (Mountain Quail)

Ortyx picta
Ascaridia compar
Heterakis vesicularis

GENUS *CALLIPEPLA* WAGLER, 1832

Lophortyx
Subulura strongylina

GENUS *COLINUS* GOLDFUSS, 1820

Ascaridia galli
Eucoleus annulatus
Heterakis vesicularis
Heterakis gallinarum
Subulura strongylina
Synhimantus spiralis

1. *Colinus virginianus* (Linnaeus, 1758) (Northern Bobwhite)

Tetrao virginianus
Echinolepis carioca
Hymenolepis cantaniana
Skrjabinia cesticillus

1a. *Colinus virginianus texanus* Lawrence, 1853

Subulura brumpti

GENUS *ODONTOPHORUS* VIEILLOT, 1816

Subulura strongylina

1. *Odontophorus capueira* (Spix, 1825) (Spot-winged Wood-quail)

Perdix capueira
Subulura strongylina

Family PHASIANIDAE (Partridges, francolins, spurfowls, pheasants, etc.)

Partridge

Ascaridia lineata

Pheasant

Acuaria hamulosa
Gongylonema ingluvicola

Turkey

Dispharynx nasuta

GENUS *MELEAGRIS* LINNAEUS, 1758

Acuaria hamulosa
Ascaridia galli
Ascaridia lineata
Eucoleus annulatus
Gongylonema ingluvicola
Heterakis vesicularis
Heterakis gallinarum
Synhimantus spiralis

Tetrameres fissispina

1. *Meleagris gallopavo* Linnaeus, 1758 (Wild Turkey, Common Turkey)

   Echinolepis carioca
   Hymenolepis cantaniana
   Metroliasthes lucida
   Numidella numida
   Raillietina echinobothrida
   Raillietina tetragona
   Skrjabinia cesticillus
   Ascaridia perspicillum
   Oxyspirura mansoni
   Subulura brumpti
   Tetrameres fissispina

2. *Meleagris ocellata* Cuvier, 1820 (Ocellated Turkey)

   Agriocharis ocellata

   Ascaridia galli

Genus *Bonasa* Stephens, 1819

Ascaridia galli
Ascaridia lineata
Eucoleus annulatus
Heterakis gallinarum
Subulura strongylina
Synhimantus spiralis

1. *Bonasa umbellus* (Linnaeus, 1766) (Ruffed Grouse)

   Tetrao umbellus

   Davainea proglottina
   Echinolepis carioca

Genus *Tetrastes* Keyserling & Blasius, 1840

Ascaridia compar

1. *Tetrastes bonasia* (Linnaeus, 1758) (Hazel Grouse)

   Bonasa bonasia, Bonasia bonasia, Tetrao bonasia

   Hispaniolepis fedtschenkoi
   Hymenolepis cantaniana
   Skrjabinia cesticillus

1a. *Tetrastes bonasia rupestris* (Brehm, 1831)

   Ascaridia perspicillum

Genus *Tetrao* Linnaeus, 1758

Aonchotheca caudinflata
Ascaridia compar
Ascaridia galli
Eucoleus annulatus
Heterakis vesicularis
Heterakis gallinarum
Subulura strongylina

1. *Tetrao urogallus* Linnaeus, 1758 (Western Capercaillie)

   Tetrao major

   Skrjabinia cesticillus
   Ascaridia perspicillum

2. *Tetrao parvirostris* Bonaparte, 1856 (Black-billed Capercaillie)

   Tetrao urogalloides

   Hymenolepis cantaniana

Genus *Lyrurus* Swainson, 1832

Aonchotheca caudinflata
Ascaridia compar
Ascaridia galli
Capillaria anatis
Eucoleus annulatus
Heterakis gallinarum

1. *Lyrurus tetrix* (Linnaeus, 1758) (Black Grouse)

   Tetrao tetrix

   Hispaniolepis fedtschenkoi
   Skrjabinia cesticillus

Genus *Tympanuchus* Gloger, 1841

Cupidonia

Ascaridia lineata
Heterakis gallinarum

1. *Tympanuchus phasianellus* (Linnaeus, 1758) (Sharp-tailed Grouse)

   Pedioecetes phasianellus (Linnaeus, 1758), *Tetrao phasianellus*

   Ascaridia galli
   Ascaridia lineata
   Heterakis gallinarum
   Subulura strongylina

Genus *Lagopus* Brisson, 1760

Aonchotheca caudinflata
Heterakis gallinarum
Heterakis vesicularis

1. *Lagopus lagopus* (Linnaeus, 1758) (Willow Ptarmigan)

   Tetrao lagopus

   Raillietina tetragona
   Skrjabinia cesticillus
   Subulura suctoria

1a. *Lagopus lagopus scotica* (Latham, 1787)

   Lagopus scotica

   Skrjabinia cesticillus

2. *Lagopus muta* (Montin, 1781) (Rock Ptarmigan)

   Raillietina tetragona

Genus *Tetragallus* Gray, 1832

1. *Tetraogallus caucasicus* (Pallas, 1811) (Caucasian Snowcock)

   Tetrao caucasica

   Hispaniolepis fedtschenkoi

2. *Tetraogallus himalayensis* Gray, 1843 (Himalayan Snowcock)

   Megaloperdix nigelli

   Hispaniolepis fedtschenkoi

Genus *Alectoris* Kaup, 1829

Caccabis in Yamaguti (1961)

Ascaridia compar
Ascaridia galli
Ascaridia numidae
Cyrnea eurycerca
Heterakis dispar
Heterakis gallinarum
Synhimantus spiralis
Tetrameres fissispina

1. *Alectoris barbara* (Bonnaterre, 1792) (Barbary Partridge)

   Caccabis petrosa, Perdix barbara

   Cyrnea parroti

2. *Alectoris graeca* (Meisner, 1804) (Rock Partridge)

   Perdix graeca

   Davainea proglottina
   Echinolepis carioca
   Metroliasthes lucida
   Heterakis tenuicauda
   Subulura brumpti
   Subulura differens

2a. *Alectoris graeca saxatilis* (Bechstein, 1805)

   Caccabis saxatilis chukar

   Heterakis tenuicauda

   Lepage (2007) states that the original *Alectoris graeca* has been split into four species, namely *Alectoris graeca*, *Alectoris chukar* (Gray, 1830), *Alectoris philbyi* Lowe, 1934 and *Alectoris magna* (Prjevalski, 1876).

3. *Alectoris rufa* (Linnaeus, 1758) (Red-legged Partridge)

   Caccabis rufa, Coturnix rufa, Tetrao rufus

   Metroliasthes lucida
   Cyrnea eurycerca
   Cyrnea parroti

GENUS *FRANCOLINUS* STEPHENS, 1819

Ascaridia lineata
Cyrnea eurycerca
Heterakis gallinarum

GENUS *SCLEROPTILA* BLYTH, 1852

1. *Scleroptila levaillantii* (Valenciennes, 1825) (Red-winged Francolin)

   Francolinus levaillantii, *Perdix levaillantii*

   Gongylonema congolense

GENUS *PTERNISTIS* WAGLER, 1832

Subulura suctoria

1. *Pternistis natalensis* (Smith, 1834) (Natal Spurfowl)

   Francolinus natalensis, *Pternistes natalensis*

   Porogynia paronai

2. *Pternistis bicalcaratus* (Linnaeus, 1766) (Double-spurred Spurfowl)

   Francolinus bicalcaratus, *Tetrao bicalcaratus*

   Heterakis brevispiculum
   Subulura differens

GENUS *PERDIX* BRISSON, 1760

Aonchotheca caudinflata
Ascaridia compar
Ascaridia galli
Capillaria anatis
Eucoleus annulatus
Heterakis vesicularis
Heterakis gallinarum
Subulura strongylina
Synhimantus spiralis
Tetrameres fissispina

1. *Perdix perdix* (Linnaeus, 1758) (Grey Partridge)

   Tetrao perdix

   Davainea proglottina
   Hymenolepis cantaniana
   Metroliasthes lucida
   Raillietina echinobothrida
   Skrjabinia cesticillus
   Subulura brumpti

1a. *Perdix perdix canescens* Buturlin, 1906

   Subulura differens

GENUS *COTURNIX* BONNATERRE, 1791

Aonchotheca caudinflata
Ascaridia compar
Cyrnea eurycerca
Heterakis gallinarum
Heterakis vesicularis
Subulura suctoria

1. *Coturnix coturnix* (Linnaeus, 1758) (Common Quail)

   Tetrao coturnix

   Dicrocoelium macrostomum
   Echinolepis carioca
   Hymenolepis cantaniana
   Metroliasthes lucida
   Skrjabinia cesticillus
   Acuaria hamulosa
   Subulura suctoria

GENUS *ITHAGINIS* WAGLER, 1832

Ascaridia galli

GENUS *TRAGOPAN* CUVIER, 1829

Ceriornis

Heterakis gallinarum

GENUS *LOPHOPHORUS* TEMMINCK, 1813

Heterakis gallinarum
Heterakis vesicularis

GENUS *GALLUS* BRISSON, 1760

Aonchotheca caudinflata
Ascaridia compar
Ascaridia lineata
Eucoleus annulatus
Gongylonema congolense

Gongylonema ingluvicola
Heterakis vesicularis
Strongyloides avium
Subulura strongylina
Synhimantus spiralis
Tetrameres fissispina

1. *Gallus gallus* (Linnaeus, 1758) (Red Junglefowl)

Gallus ferrugineus, *Phasianus gallus*

Davainea proglottina
Echinolepis carioca
Hispaniolepis fedtschenkoi
Hymenolepis cantaniana
Metroliasthes lucida
Raillietina cohni
Raillietina echinobothrida
Raillietina tetragona
Skrjabinia cesticillus
Acuaria hamulosa
Dispharynx nasuta
Gongylonema sumani
Oxyspirura mansoni

1a. *Gallus gallus bankiva* Temminck, 1813

Metroliasthes lucida
Raillietina echinobothrida

GENUS *LOPHURA* FLEMING, 1822

Gennaeus

Heterakis gallinarum

1. *Lophura nycthemera* (Linnaeus, 1758) (Silver Pheasant)

Euplocamus nycthemerus, Gennaeus nycthemerus, Phasianus nycthemerus

Heterakis vesicularis

GENUS *SYRMATICUS* WAGLER, 1832

Graphophasianus

Eucoleus annulatus

1. *Syrmaticus soemmeringii* (Temminck, 1830) (Copper Pheasant)

Graphophasianus soemmeringii, Phasianus soemmeringii

Heterakis gallinarum

GENUS *PHASIANUS* LINNAEUS, 1758

Aonchotheca caudinflata
Ascaridia galli
Ascaridia lineata
Capillaria anatis
Cyrnea eurycerca
Eucoleus annulatus
Heterakis gallinarum
Synhimantus spiralis

1. *Phasianus colchicus* Linnaeus, 1758 (Common Pheasant, Ring-necked Pheasant)

Hymenolepis cantaniana
Raillietina echinobothrida
Skrjabinia cesticillus
Heterakis vesicularis
Subulura suctoria

1a. *Phasianus colchicus mongolicus* Brandt, 1844

Phasianus mongolicus turkestanicus

Subulura suctoria

1b. *Phasianus colchicus principalis* Sclater, 1885

Phasianus principalis

Subulura suctoria

GENUS *CHRYSOLOPHUS* GRAY, 1834

Thaumalea

Aonchotheca caudinflata
Eucoleus annulatus
Heterakis gallinarum

GENUS *POLYPLECTRON* TEMMINCK, 1807

Heterakis vesicularis

GENUS *PAVO* LINNAEUS, 1758

Heterakis gallinarum
Heterakis vesicularis

1. *Pavo cristatus* Linnaeus, 1758 (Indian Peafowl)

Hymenolepis cantaniana
Raillietina tetragona
Ascaridia perspicillum
Oxyspirura mansoni

2. *Pavo muticus* Linnaeus, 1766 (Green Peafowl)

Raillietina tetragona

Order Anseriformes

Syngamus trachea

Family ANATIDAE (Ducks, geese and swans)

Duck

Ascaridia galli
Ascaridia lineata

Goose

Ascaridia lineata

GENUS *ANSER* BRISSON, 1760

Cotugnia digonopora
Ascaridia lineata
Capillaria anatis
Heterakis dispar
Heterakis gallinarum

1. *Anser cygnoides* (Linnaeus, 1758) (Swan Goose)

Cygnopsis cygnoides

Heterakis dispar

GENUS *BRANTA* SCOPOLI, 1769

Heterakis dispar

1. *Branta bernicla* (Linnaeus, 1758) (White-bellied Brant)

Anas bernicla
"Bernicla"
Heterakis dispar

Genus *Cygnus* Bechstein, 1803

1. *Cygnus atratus* (Latham, 1790) (Australian Black Swan)

   Chenopsis atrata

   Heterakis vesicularis

2. *Cygnus melanocoryphus* (Molina, 1782)

   Tetrameres fissispina

Genus *Chloephaga* Eyton, 1838

Heterakis dispar

Genus *Tadorna* Boie, 1822

Todorna

Heterakis dispar

Genus *Cairina* Fleming, 1822

Ascaridia galli
Heterakis dispar
Heterakis gallinarum

1. *Cairina moschata* (Linnaeus,1758) (Muscovy Duck)

   Gongylonema congolense

Genus *Anas* Linnaeus, 1758

Ascaridia lineata
Heterakis dispar
Heterakis gallinarum
Heterakis vesicularis
Subulura brumpti

1. *Anas platyrhynchos* Linnaeus, 1758 (Mallard)

   Anas boschas

   Tetrameres fissispina

2. *Anas clypeata* Linnaeus, 1758 (Northern Shoveler)

   Anas spathula, Spatula clypeata

   Tetrameres fissispina

3. *Anas acuta* Linnaeus, 1758 (Northern Pintail)

   Dafila acuta

   Ascaridia perspicillum
   Tetrameres fissispina

   According to Lepage (2007) *A. acuta* has been split into *A. acuta* and *Anas eatoni*, but some authors consider *A. eatoni* a subspecies *of A. acuta.* Peterson (1999) lists the two as separate species.

4. *Anas querquedula* Linnaeus, 1758 (Garganey)

   Querquedula querquedula

   Capillaria anatis
   Tetrameres fissispina

Genus *Aythya* Boie, 1822

1. *Aythya ferina* (Linnaeus, 1758) (Common Pochard)

   Anas ferina, Aristonetta ferina, Nyroca ferina

   Tetrameres fissispina

Genus *Somateria* Leach, 1819

1. *Somateria mollissima* (Linnaeus, 1758) (Common Eider)

   Anas mollissima

   Tetrameres fissispina

Genus *Melanitta* Boie, 1822

Oedemia, Oidemia

Capillaria anatis

1. *Melanitta fusca* (Linnaeus, 1758) (Velvet Scooter)

   Anas fusca, *Oidemia fusca*

   Tetrameres fissispina

Genus *Clangula* Leach, 1819

1. *Clangula hyemalis* (Linnaeus, 1758) (Oldsquaw, Long-tailed Duck)

   Anas hyemalis, *Harelda hyemalis*, *Ereunetes occidentalis*

   Capillaria anatis

Genus *Bucephala* Baird, 1858

1. *Bucephala clangula* (Linnaeus, 1758) (Common Gold-eneye)

   Anas clangula, *Clangula clangula*, *Glaucionetta clangula*

   Tetrameres fissispina

Genus *Mergus* Linnaeus, 1758

Merganser
Capillaria anatis

1. *Mergus merganser* Linnaeus, 1758 (Common Merganser)

   Tetrameres fissispina

Order Turniciformes

Family TURNICIDAE (Buttonquail)

Genus *Turnix* Bonnaterre, 1791

1. *Turnix suscitator* (Gmelin, 1789) (Barred Buttonquail)

   Tetrao suscitator

   Hymenolepis cantaniana

Order Piciformes

Syngamus trachea

Order Galbuliformes

Family BUCCONIDAE (Puffbirds)

Genus *Bucco* Brisson, 1760

Subulura strongylina

Genus *Malocoptila* Gray, 1841

Subulura strongylina

GENUS *NONNULA* SCLATER, 1854

Subulura strongylina

GENUS *MONASA* VIEILLOT, 1816

Subulura strongylina

GENUS *CHELIDOPTERA* GOULD, 1837

Subulura strongylina

Order Bucerotiformes

Family BUCEROTIDAE (Hornbills)

GENUS *ACEROS* HODGSON, 1844

1. *Aceros corrugatus* (Temminck, 1832) (Wrinkled Hornbill)
   Buceros corrugatus, Rhyniceros corrugatus
   Hadjelia truncata

GENUS *TOCKUS* LESSON, 1830

1. *Tockus erythrorhynchus* (Temminck, 1823) (Red-billed Hornbill)
   Buceros erythrorhynchus
   Hadjelia truncata
2. *Tockus fasciatus semifasciatus* (Hartlaub, 1855) (Allied Hornbill)
   Lophoceros semifasciatus
   Hadjelia truncata
3. *Tockus leucomelas* (Liechtenstein, 1842) (Southern Yellow-billed Hornbill)
   Buceros leucomelas
   Hadjelia truncate

   Some authors consider *T. leucomelas* a subspecies of *Tockus flavirostris* (Rüppell, 1853) (Lepage 2007)

Order Upupiformes

Family UPUPIDAE (Hoopoes)

GENUS *UPUPA* LINNAEUS, 1758

1. *Upupa epops* Linnaeus, 1758 (Hoopoe)
   Hadjelia truncata

Family CORACIIDAE (Rollers)

GENUS *CORACIAS* LINNAEUS, 1758

Synhimantus spiralis

1. *Coracias benghalensis* (Linnaeus, 1758) (Indian Roller)
   Corvus benghalensis
   Hadjelia truncata

GENUS *HALCYON* SWAINSON, 1821

1. *Halcyon smyrnensis* (Linnaeus, 1758) (White-throated Kingfisher)
   Hadjelia truncata

Family MEROPIDAE (Bee-eaters)

GENUS *MEROPS* LINNAEUS, 1758

Cyrnea eurycerca

Order Cuculiformes

Family CUCULIDAE (Cuckoos, coucals, anis, roadrunners, couas, etc.)

GENUS *CUCULUS* LINNAEUS, 1758

Subulura strongylina

GENUS *CENTROPUS* ILLIGER, 1811

1. *Centropus phasianinus* (Latham, 1802) (Pheasant Coucal)
   Cuculus phasianinus
   Subulura differens

Order Strigiformes

Family STRIGIDAE (Typical owls)

GENUS *STRIX* LINNAEUS, 1758

Heterakis dispar
Heterakis gallinarum

GENUS *SURNIA* DUMERIL, 1805

Heterakis dispar

GENUS *GLAUCIDIUM* BOIE, 1826

Heterakis dispar

Family NYCTIBIIDAE (Potoos)

GENUS *NYCTIBIUS* VIEILLOT, 1816

Subulura suctoria

Family CAPRIMULGIDAE (Nightjars)

GENUS *PODAGER* WAGLER, 1832

Subulura strongylina
Subulura suctoria

GENUS *CAPRIMULGUS* LINNAEUS, 1758

Subulura strongylina
Subulura suctoria

Order Columbiformes

Family COLUMBIDAE (Pigeons and doves)

Pigeon
Ascaridia lineata

GENUS *COLUMBA* LINNAEUS, 1758

Aonchotheca caudinflata
Synhimantus spiralis

1. *Columba livia* Gmelin, 1785 (Rock Pigeon)

Cotugnia digonopora
Raillietina echinobothrida
Hadjelia truncata
Tetrameres fissispina

GENUS *STREPTOPELIA* BONAPARTE, 1855

Spilopelia
Ascaridia galli

1. *Streptopelia orientalis* (Latham, 1790) (Oriental Turtle-Dove)
   Columba orientalis, *Turtur orientalis*
   Subulura brumpti

Order Gruiformes

Family RALLIDAE (Rails, crakes, moorhens and coots)

GENUS *FULICA* LINNAEUS, 1758

1. *Fulica atra* Linnaeus, 1758 (Common Coot)
   Tetrameres fissispina

Family OTIDIDAE (Bustards and korhaans)

Yamaguti (1961) lists *Aonchotheca caudinflata*, *Heterakis gallinarum* and *Heterakis vesicularis* from *Otis* without giving the host's species name. It is therefore not clear whether *Otis* refers to the current genus *Otis*, *Ardeotis*, *Neotis* or *Chlamydotis*.

Otidiformes in Yamaguti (1961)
Syngamus trachea

GENUS *OTIS* LINNAEUS, 1758

1. *Otis tarda* Linnaeus, 1758 (Great Bustard)
   Mediorhynchus taeniatus

GENUS *ARDEOTIS* LE MAOUT, 1853

1. *Ardeotis arabs* (Linnaeus, 1758) (Arabian Bustard)
   Choriotis arabs, Otis arabs
   Mediorhynchus empodius
   Mediorhynchus taeniatus

GENUS *CHLAMYDOTIS* LESSON, 1839

Houbara
Hetrakis gallinarum

According to Lepage (2007) the common name Houbara has been split into *Chlamydotis undulata* and *Chlamydotis macqueenii*.

1. *Chlamydotis undulata* (Jacquin, 1784) (Houbara Bustard)
   Otis houbara, *Psophia undulata*
   Mediorhynchus taeniatus
   Hispaniolepis falsata
2. *Chlamydotis macqueenii* Gray, 1832 (Macqueen's Bustard)
   Otis macqueenii
   Mediorhynchus taeniatus

Order Charadriiformes

Family PTEROCLIDIAE (Sandgrouse)

GENUS *PTEROCLES* TEMMINCK, 1815

Calopterocles
Heterakis gallinarum

1. *Pterocles exustus* Temminck, 1825 (Chestnut-bellied Sandgrouse)
   Pteroclidurus exustus, *Pterocles senegalensis*
   Raillietina cohni
   Lepage (2007) lists *Pterocles senegalensis* as synonym for *Pterocles exustus*.
2. *Pterocles orientalis arenarius* (Pallas, 1775) (Eastern Black-bellied Sandgrouse)
   Pterocles arenarius
   Raillietina cohni
   Lepage (2007) and Peterson (1999) list *Pterocles arenarius* as subspecies of *Pterocles orientalis* (Linnaeus, 1758).

Family JACANIDAE (Jacanas)

GENUS *METOPIDIUS* WAGLER, 1832

Synhimantus spiralis

Family BURHINIDAE (Thick-knees)

GENUS *BURHINUS* ILLIGER, 1811

Oedicnemus
Subulura suctoria

1. *Burhinus oedicnemus* (Linnaeus, 1758) (Eurasian Thick-knee)
   Charadrius oedicnemus, *Oedicnemus crepitans*
   Mediorhynchus taeniatus

Family CHARADRIIDAE (Plovers, dotterels, lapwings)

GENUS *VANELLUS* BRISSON, 1760

1. *Vanellus cinereus* (Blyth, 1842) (Grey-headed Lapwing)
   Hoplopterus cinereus, *Microsarcops cinereus, Pluvianus cinereus*
   Davainea nana

Order Falconiformes

Family ACCIPITRIDAE (Eagles, hawks, buzzards, kites, vulures)

GENUS *ACCIPITER* BRISSON, 1760

Synhimantus spiralis

Order Ciconiiformes

Family PODICIPEDIDAE (Grebes)

GENUS *TACHYBAPTUS* REICHENBACH, 1853

1. *Tachybaptus novaehollandiae* (Stephens, 1826) (Australian Grebe)

Podiceps fluviatilis, Podiceps novaehollandiae

Tetrameres fissispina

Family ARDEIDAE (Herons, egrets and bitterns)

"Ardeiformes"

Syngamus trachea

GENUS *ARDEA* LINNAEUS, 1758

Mediorhynchus empodius

GENUS *NYCTICORAX* FORSTER, 1817

1. *Nycticorax nycticorax* (Linnaeus, 1758) (Black-crowned Night-Heron)

   Ardea nycticorax

   Tetrameres fissispina

Family PELECANIDAE (Pelicans)

"Pelicaniformes"

Syngamus trachea

Family CICONIIDAE (Storks)

GENUS *CICONIA* BRISSON, 1760

Synhimantus spiralis

Order Passeriformes

Syngamus trachea

Family CORVIDAE (Crows and ravens)

GENUS *CORVUS* LINNAEUS, 1758

Heterakis gallinarum

Synhimantus spiralis

Family PYCNONOTIDAE

GENUS *PYCNONOTUS* BOIE, 1826

1. *Pycnonotus capensis* (Linnaeus, 1766) (Cape Bulbul)

   Sicarius caudatus

Family MUSCICAPIDAE (Old World flycatchers)

GENUS *TURDUS* LINNAEUS, 1758

Aonchotheca caudinflata

Synhimantus spiralis

1. *Turdus viscivorus* Linnaeus, 1758 (Mistle Thrush)

   Ascaridia perspicillum

2. *Turdus migratorius* Linnaeus, 1766 (American Robin)

   Planesticus migratorius

   Synhimantus spiralis

Family STURNIDAE (Starlings)

GENUS *STURNUS*

Aonchotheca caudinflata

Family PASSERIDAE (Old World sparrows, sowfinches and relatives)

GENUS *PASSER* BRISSON, 1760

Aonchotheca caudinflata

Synhimantus spiralis

1. *Passer domesticus* (Linnaeus, 1758) (House Sparrow)

   Fringilla domestica

   Dispharynx nasuta

GENUS *EUPLECTES* SWAINSON, 1829

1. *Euplectes orix* (Linnaeus, 1758) (Red Bishop)

   Pyromelana oryx

   Subulura differens

Family FRINGILLIDAE (Canaries and buntings)

GENUS *QUISCALUS* VIEILLOT, 1816

Synhimantus spiralis

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