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STUDIES ON THE PARASITES OF ZEBRAS. III. NEMATODES OF THE MOUNTAIN ZEBRA FROM THE FARM "KELPIE" AND THE NAMIB-NAUKLUFT PARK, SOUTH WEST AFRICA/NAMIBIA

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ABSTRACT

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Twelve mountain zebra which were culled at monthly intervals on the farm "Kelpie" in South West Africa/Namibia were examined for helminths. The zebras varied in age from 2–15 years, the middle group of which, aged 4–7 years, had the highest worm burdens. Fourteen species of nematodes belonging to the families Atractidae, Strongylidae, Oxyuridae, Setariidae and Spiruridae were recovered. The highest worm burdens were those of *Crossocephalus* sp. with 692–61 066 680 and *Probstmayria vivipara* with 1 257 810–42 004 300. The predominance of the atractids is discussed. The nematodes consistently present were: *Cylicodontophorus* n. sp. (44–2 107), *Triodontophorus* spp. (2–934), *Cylindropharynx* spp. (20–2 332), *Crossocephalus* sp. and *P. vivipara*. Two new species, *Cylicostephanus longiconus* and *Cylicodontophorus* n. sp., were reported.

An additional 3 mountain zebra, culled in the Namib-Naukluft Park, were also examined for helminths. Of 3 zebras ranging in age from 2–7 years, the 2 older animals had the highest helminth burden. Ten species of the nematodes belonging to the same families mentioned above were recovered. The only Spiruridae present were 3 *Habronema majus* in 1 zebra. The highest worm burdens were those of *Crossocephalus* sp. with 64 052–883 070 and *P. vivipara* with 50 720–220 200. The nematodes consistently present were the same as those in the "Kelpie" zebra. In addition, a 2nd, new species of *Cylicodontophorus* was reported.

INTRODUCTION

Twelve mountain zebra, *Equus zebra hartmannae* (Matschie, 1898), which were culled on the farm "Kelpie" in South West Africa/Namibia (SWA/Namibia), were examined for helminths. This paper reports on the total worm burdens, prevalence and habitat preference of the nematodes of these zebra. Fourteen species of nematodes, including a new species *Cylicostephanus longiconus* (Scialdo-Krecek, 1983 b), were recovered from them.

In addition, 3 mountain zebra, *E.z. hartmannae*, culled in the Middelpos area in the Namib-Naukluft Park in SWA/Namibia, were also examined for helminths, and both total worm burdens and prevalence of nematodes are reported in this paper. Ten species of nematodes, including a second species of *Cylicodontophorus*, were recovered from the animals culled at Middelpos and "Kelpie".

MATERIALS AND METHODS

Study area

Twelve mountain zebra were culled on the farm "Kelpie" No. 287 in the Khomas Hochland (22° 43′S, 16° 43′E) (Fig. 1). The main type of vegetation is highland savanna, and other less predominant vegetation includes bergthorn *(Acacia hereroensis), Combretum apiculatum* and other *Acacia* spp. (Giess, 1971) (Fig. 2). According to Giess (1971), the grass cover consists of *Anthephora pubescens, Brachiaria nigropedata* and *Cymbopogon* spp. Two dams, the main source of drinking water for the zebra, are on the farm (Erns van der Merwe, personal communication, 1983).

In addition, 3 mountain zebra were culled in the Middelpos (farm) area in the neck of the Namib-Naukluft Park (24°9′S, 16°15′E) (Fig. 1). The main vegetation is semi-desert and savanna transition (Giess, 1971), while Joubert (1971) lists the prevalent grasses as *Eragrostis indensis, Enneapogon cenchroides* and *Aristida adscensionis*. The mountains in one part of the park have many springs, hence the zebra have many sources of ground water, even during dry periods (Eugene Joubert, personal communication, 1983).

Upon examination Zebra 6, 8 and 11 were lactating, Zebras 4 and 11 were pregnant and Zebra 12 was lame.

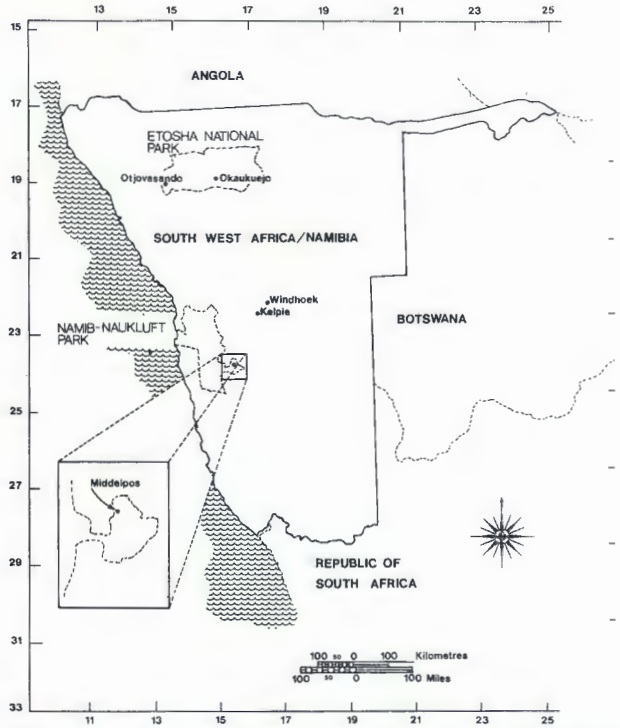

FIG. 1 South West Africa/Namibia showing collection sites on the farm "Kelpie" and in the Namib-Naukluft Park

FIG. 2 Savanna highland vegetation of the farm "Kelpie" (F. S. Malan)

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Rainfall

The total rainfall at the weather station "Claratal", 10 km south-east of "Kelpie", was 324 mm for the period June 1979–June 1980 and 164 mm for the period June 1980–June 1981. The rainfall occurs in summer and consists of light rain which falls over several days. On 4 occasions 8 mm fell on a single day, but on the average less than 0,1 mm per day is recorded. The long-term rainfall for this area is 320 mm per annum (Windhoek Weather Bureau, unpublished data, 1977).

The total annual rainfall for Middelpos recorded at the nearest weather station, Naukluft, was 46 mm for 1981 and 211 mm for 1980. The long-term rainfall expected for this area is 100 mm per annum (Windhoek Weather Bureau, unpublished data, 1977).

Helminth collection

On the farm "Kelpie", 2 zebras were culled in June 1980. One zebra was culled in each subsequent month for a year (except in January 1981 when no animal was available). In the Namib-Naukluft Park 3 zebra were culled in August 1981 by the Department of Agriculture and Nature Conservation, SWA/Namibia, as part of a game management programme. The method of collection of nematodes from the zebra has been described by Malan, Reinecke & Scialdo (1981 a, b).

After all the specimens had been collected, those from the gastrointestinal tract were placed in separate, labelled plastic bags, 4 mm diameter, which were then tied off with stout twine. Each bag was placed in a plastic box* (35 × 33 × 13 cm) and frozen solid in a deep freezer for 24–48 h at −6 °C. All the specimens were packed in cardboard cartons (46 × 46 × 32 cm) lined with polystyrene (3 cm width) and air-freighted from Windhoek to Johannesburg. On arrival at Onderstepoort they were again stored in a deep freezer until required for worm recovery.

The specimens were thawed, fixed with formaldehyde added to the ingesta and sieved (150 apertures), and the residue on the surface of the sieve was placed in wide-mouthed glass jars (1ℓ) and preserved with 10 % formaldehyde.

After thawing, the stomach walls were examined for tumour-like swellings (granulomas). The glandular stomach was scraped and digested for 2 h in 1 % pepsin-3% HCl (Reinecke, 1973). Worms were collected on sieves (38 µm apertures), formalized and placed in specimen jars. The whole small intestinal, caecal and colonic walls were examined with a diamond sorting lamp, the larval stages in the wall were counted and the first 100 collected were placed in 70 % alcohol-5 % glycerine.

Total worm burdens were based on aliquots taken of the complete specimen. If, as in the case of *Crossocephalus*, high burdens were present, smaller aliquots, sometimes only 1/10 000 of the whole, were taken. Total counts were made and identified, identification being based on the first 100 worms removed from the appropriate specimen, wash or ingesta.

Fourth stage larvae (L_4), 4th moult (M_4), 5th stage and sexually mature adults were recorded separately. The L_4 were identified according to Lichtenfels (1975) and the descriptions listed in Table 1 were used to identify the other worms.

RESULTS

Farm "Kelpie"

Twelve genera of nematodes in the families Strongylidae, Atractidae, Oxyuridae, Setariidae and Spiruridae were identified to species level. Two genera, *Cylindropharynx* and *Crossocephalus*, were identified only to generic level. Only when 4 or more zebra were infected with a species was the site in the intestinal tract recorded (Fig. 3). Immature stages and adults were handled together because they showed similar habitat preferences. Prevalence and mean worm burdens of the Cyathostominae species are illustrated in Fig. 4. Total worm burdens and ranges, stages of development and number of zebra positive are recorded in Tables 2 & 3.

TABLE 1 Descriptions used in the identification of nematodes in the mountain zebra

	Boulenger (1920)	Cram (1924)	Díaz-Ungría (1964)	Le Van Hoa (1962)	Lichtenfels (1975)	Popova (1958)	Scialdo-Krecek (1983)	Theiler (1923)	Van den Berghe (1943)	Yeh (1959)
Cyathostominae										
Cyathostomum tetracanthum					+	+		+		
Cylicocyclus auriculatus					+	+		+		
Cylicocyclus adersi	+					+		+		
Cylicostephanus longiconus							+			
Cylindropharynx spp.		+						+		
Strongylinae										
Triodontophorus spp.			+		+					
Strongylus equinus					+			+		
Spiruridae										
Habronema longistoma									+	
Habronema majus					+			+		
Habronema muscae					+			+		
Atractidae										
Crossocephalus sp.				+				+		
Probstmayria vivipara					+			+		
Oxyuridae										
Oxyuris equi					+	+		+		
Setariidae										
Setaria equina								+		+

* Tupperware, Dart Industries (Pty) Ltd, Tupperware Division, Nova Constantia, Constantia, Cape

TABLE 2 Worm burdens and faecal worm egg counts of predominant nematodes recovered from mountain zebra on the farm "Kelpie"

Zebra		3	2	6	5	4	11	1	8	10	9	12	7			
Age (yr)/Sex**		2/F	3½/M	4/F	4½/F	5/F	6/F	7/M	7/F	7/M	10–12/M	14/M	15/M			
Date killed		7/80	6/80	10/80	9/80	8/80	5/81	6/80	12/80	3/81	2/81	6/81	11/80	Total burden	Zebras positive	Range
Eggs per gram of faeces (e.p.g.)		500	800	450	850	1 500	650	500	—	1 300	—	250	—			
L4*Cyathostominae		6 153	2 830	11 476	7 585	3 110	9 949	3 810	1 375	718	118	5 812	477	53 413	12	118–11 476
Cyathostominae																
Cyathostomum tetracanthum	A†	4 954	317	6 710	2 151	4 159	9 204	311	3 328	2 469	121	—	10 481	44 205	11	121–10 481
	5††	551	50	3 983	395	9	327	669	3	—	2	—	40	6 029	10	2– 3 983
	M_4†††	400	2	50	350	—	—	114	—	—	—	40	—	956	6	2– 400
Cylicocyclus auriculatus	A	402	440	4 506	167	3 354	45	—	902	1 450	41	—	—	11 307	9	41– 4 506
	5	—	10	538	53	312	—	—	—	16	—	—	—	929	5	10– 538
Cylicocyclus spp.		—	—	—	100	—	—	5	—	30	—	—	—	135	3	5– 100
Cylicocyclus adersi	A	—	—	1 535	240	239	1 422	—	674	2 389	673	—	11	7 183	8	11– 2 389
	5	—	—	7	—	—	—	—	216	—	105	—	—	328	3	7– 216
	M_4	—	—	—	—	—	—	—	100	—	2	—	—	102	2	2– 100
Cylicodontophorus n.sp.	A	462	44	1 344	1 638	1 717	2 107	255	1 360	949	101	1 171	466	11 614	12	44– 2 107
	5	85	50	4	23	16	58	12	48	31	55	250	50	682	12	4– 250
	M_4	—	—	—	—	2	—	4	—	—	—	—	—	6	2	2– 4
Cylicostephanus longiconus	A	1 340	771	3 316	798	376	4 500	2 493	2 650	2	—	2 840	3 888	22 974	11	2– 4 500
	5	77	253	—	95	48	147	496	222	—	—	205	116	1 659	9	48– 496
	M_4	—	—	—	—	—	10	1	—	—	—	—	—	11	2	1– 10
Cylindropharynx spp.	A	20	150	513	477	57	477	260	2 332	955	1 030	163	686	7 120	12	20– 2 332
	5	—	—	356	200	1	—	—	116	—	50	—	150	873	6	1– 356
	M_4	—	—	—	133	—	—	—	—	—	—	—	—	133	1	
Strongylinae																
Triodontophorus spp.	A	137	117	502	336	934	118	162	205	547	2	8	520	3 588	12	2– 934
	5	70	50	2	214	3	—	—	—	100	—	—	—	439	6	2– 214
	M_4	—	—	—	10	—	—	1	—	—	—	—	—	11	2	1– 10
Strongylus equinus	5	—	—	—	—	—	—	1	—	—	—	—	—	1	1	
Oxyuridae																
Oxyuris equi	A	—	—	—	—	335	—	—	—	22	—	—	—	357	2	22– 335
	L_4	—	—	—	100	38	7	—	—	—	—	—	—	145	3	7– 100
Spiruridae																
Habronema longistoma		—	—	—	—	—	—	1	—	—	—	—	—	1	1	
Habronema majus		1	—	17	3	—	8	—	10	3	34	21	30	127	9	1– 34
Habronema muscae		—	1	—	1	—	—	1	—	—	—	—	—	3	3	1– 1
Habronema spp.		—	—	4	—	—	—	—	—	5	3	12	—	24	8	3– 12

L4* = 4th stage larvae
A† = adult
5†† = 5th stage
M_4††† = 4th moult
**F = Female M = Male

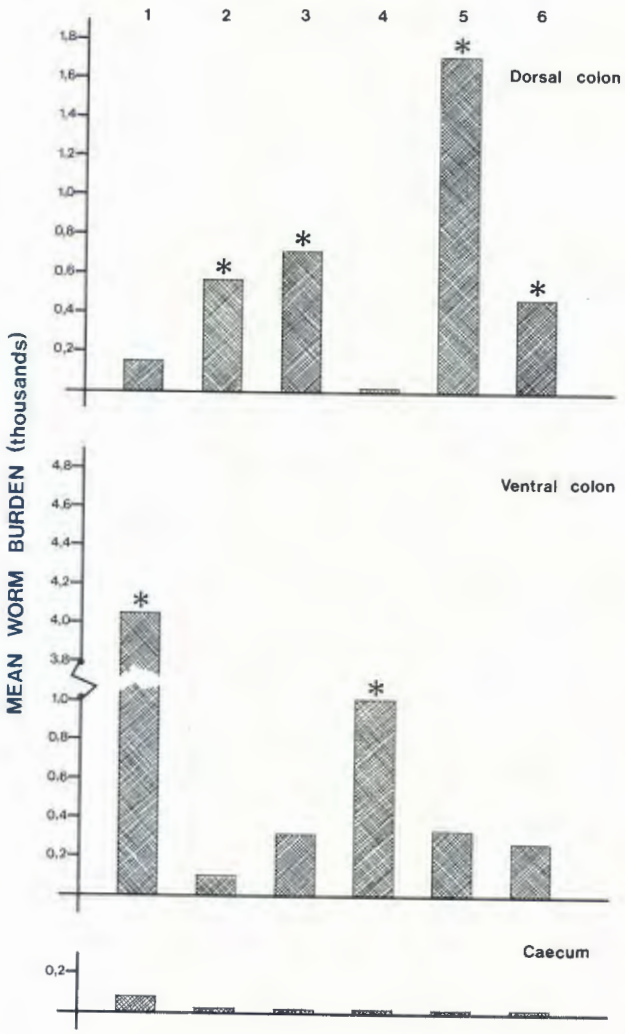

FIG. 3 Site distributions of Cyathostominae in the large intestines of zebra culled on the farm "Kelpie", South West Africa/Namibia. * = preferred site. 1. *Cyathostomum tetracanthum;* 2. *Cylindropharynx* spp.; 3. *Cylicodontophorus* n. sp. (1); 4. *Cylicocyclus auriculatus;* 5. *Cylicostephanus longiconus;* 6. *Cylicocyclus adersi*

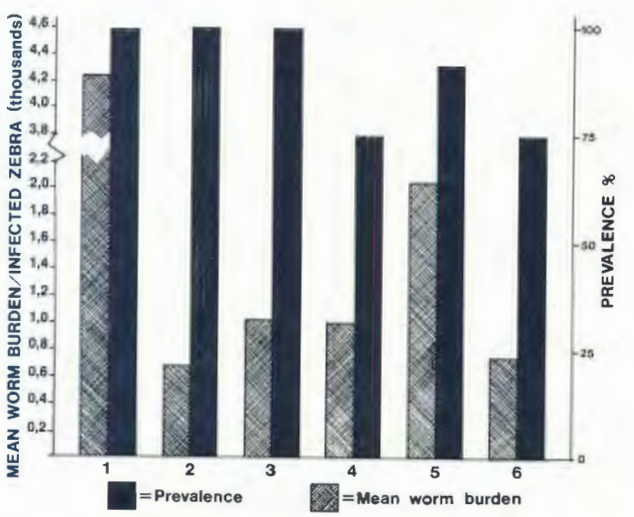

FIG. 4 The prevalence and relative abundance of 6 species of Cyathostominae found in zebra culled on the farm "Kelpie", South West Africa/Namibia. 1. *Cyathostomum tetracanthum;* 2. *Cylindropharynx* spp.; 3. *Cylicodontophorus* n.sp. (1); 4.*Cylicocyclus auriculatus;* 5. *Cylicostephanus longiconus;* 6. *Cylicocyclus adersi*

TABLE 3 The Atractidae burdens recovered from 12 mountain zebra on the farm "Kelpie". Burdens are listed from youngest zebra to the oldest

Zebra No.	*Crossocephalus* sp.	*Probstmayria vivipara*
3	1 260 790	1 997 650
2	2 035 707	9 160 422
6	2 569 890	5 439 750
5	35 852	42 004 300
4	1 883 500*	1 924 340
11	61 066 680	13 918 400
1	3 866 032*	6 390 160
8	2 570 531	10 403 740
10	2 117 057*	4 488 720
9	1 110 691*	1 527 550
12	692*	1 257 810
7	5 125 747	2 382 210
Total	83 643 169	100 895 052
Range	692–61 066 680	1 257 810–42 004 300

* In addition to these numbers, large plaques containing numerous *Crossocephalus* were present in the ventral colon wall (See Fig. 3)

Cyathostominae

High numbers of 4th stage (L_4) Cyathostominae were recovered from the gut walls (Fig. 5).

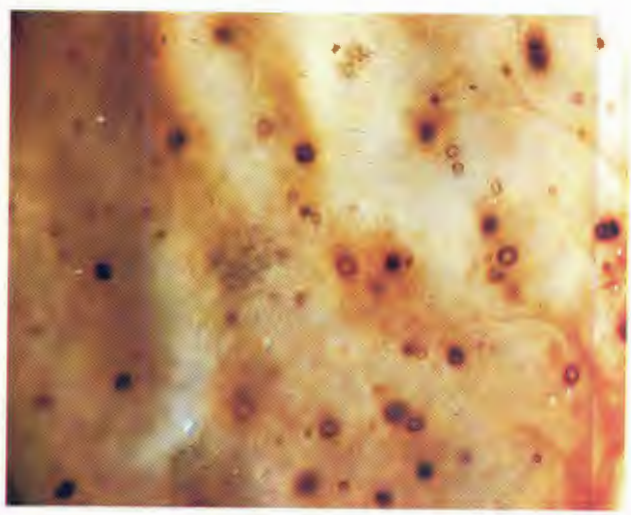

FIG. 5 Fourth stage larval nodules in small intestinal wall of mountain zebra

The genus *Cyathostomum* is represented by *Cyathostomum tetracanthum,* which was present in 11 of the zebra and evidenced a preference for the ventral colon. Fifth stages were present in 10 of the animals.

Cylicocyclus auriculatus was recorded in more zebras and in higher numbers than *Cylicocyclus adersi*. Both were recovered from the ventral and dorsal colon.

Both adult and 5th stages of *Cylicodontophorus* n. sp. were present in the ventral and dorsal colon of all the animals.

Cylindropharynx spp. was found mainly in the dorsal colon and, to a lesser extent, in the ventral colon.

Strongylinae

Triodontophorus spp. was recovered from all 12 of the zebra, the habitat with the highest burdens being the ventral colon. A single 5th stage *Strongylus equinus* was present in only 1 zebra.

Oxyuridae

Oxyuris equi was recovered from the dorsal colon in 4 of the 12 zebra, L_4 in 3 animals and adult worms in 2.

Setariidae

Setaria equina was present in only 1 zebra with a burden of 20 worms.

Spiruridae

Three species of *Habronema* were recovered from 11 of the zebra. *Habronema majus* was present in low numbers in 9 zebra. *Habronema longistoma* and *Habronema muscae* were recovered in 1 and 3 zebra respectively. *Habronema* spp., present in 4 zebra, were damaged and could not be assigned to a species.

Atractidae

Both *Crossocephalus* sp. and *Probstmayria vivipara* were present in large numbers in all the zebra. The highest number of *Crossocephalus* was 61 066 690 and of *P. vivipara* 42 004 300. While these 2 nematodes were present in all parts of the large intestine, they showed a preference for the ventral colon. In addition to the burdens in the lumen of the intestine, large plaques containing numerous *Crossocephalus* were present in the ventral colon wall (Fig. 6).

Crossocephalus were divided into males, females containing larvae (Fig. 7), females without larvae, and larvae. In 7 of the 12 zebra the majority of the nematodes contained no larvae (non-gravid); in 2 the majority of the females contained larvae, in another 2 males predominated, while larvae outnumbered adults in another.

FIG. 6 Raised plaques of mass of *Crossocephalus* sp. in ventral colon wall

Middelpos, Namib-Naukluft Park

Eight genera of nematodes belonging to the families Strongylidae, Atractidae, Oxyuridae and Spiruridae were identified to species level. The abundance of each species in the dorsal and ventral colon and in the caecum is depicted in Fig. 8. Prevalence and mean worm burdens for each strongyle species are depicted in Fig. 9. As no difference between site preference of immatures or adults was evident, they were all grouped together. The total worm burdens and ranges as well as the number of zebra that were positive are summarized in Table 4.

Cyathostominae

Fourth stage (L_4) Cyathostominae were recovered in great numbers from the gut walls.

The genus *Cyathostomum*, represented by 1 species, was present in all 3 zebra, and showed a preference for the ventral colon. *Cyathostomum tetracanthum* had higher burdens than any one species of Strongylidae, Oxyuridae and Spiruridae.

Two species of *Cylicocyclus*, *C. auriculatus* and *C. adersi* were present in all the animals. While *C. auriculatus* showed a preference for the ventral colon, *C. adersi* preferred the dorsal colon.

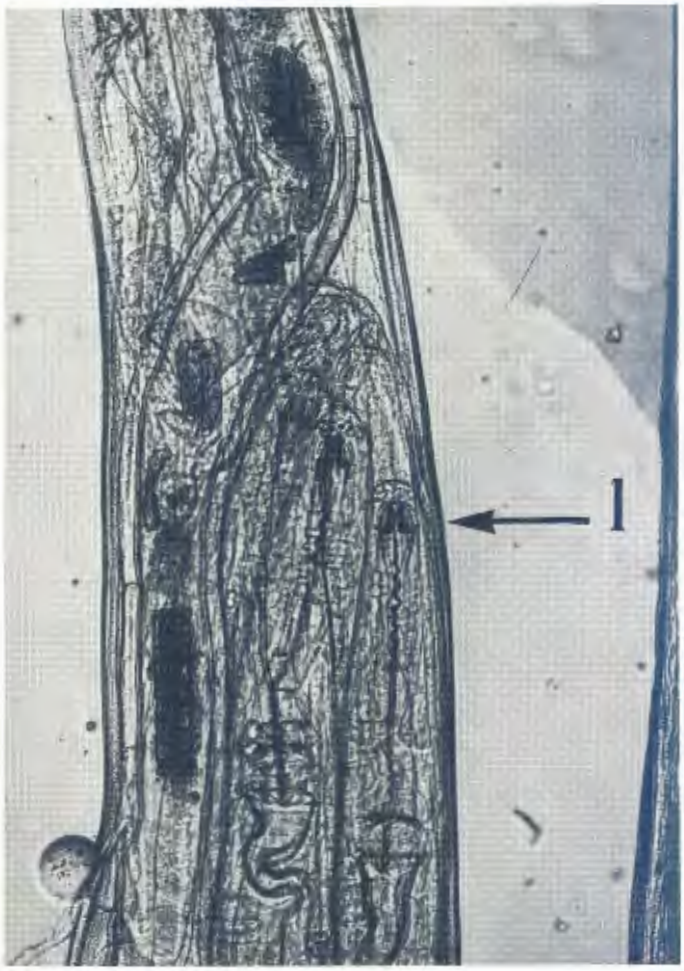

FIG. 7 *Crossocephalus* sp. female containing a number of larvae (1): H.E. × 50

Cylicostephanus longiconus was present in high burdens in all the zebra, those from the dorsal colon being predominant.

Cylicodontophorus n. sp. (1) was present in all the zebra and occurred throughout the large intestine. *Cylicodontophorus* n. sp. (2), present in very low numbers in 1 zebra, inhabits both the caecum and ventral colon.

Cylindropharynx spp. was present in all the zebra and showed a preference for the dorsal colon.

Strongylinae

Triodontophorus spp. were recovered in all the zebra and showed a preference for the ventral colon in 2 of the 3 zebra. In the 3rd zebra, three worms were recovered from the dorsal colon.

The genus *Strongylus*, represented by *S. equinus* in moderate numbers, was present in 1 zebra.

Oxyuridae

Oxyuris equi was recovered from the dorsal colon of 2 zebra, the younger animal having a higher burden.

Spiruridae

One species of *Habronema, namely, H. majus*, was recovered in small numbers of 1 of the 3 zebra.

Atractidae

Both *Crossocephalus* and *Probstmayria vivipara* were present with moderately high burdens in all the zebra, both having a preference for the ventral colon.

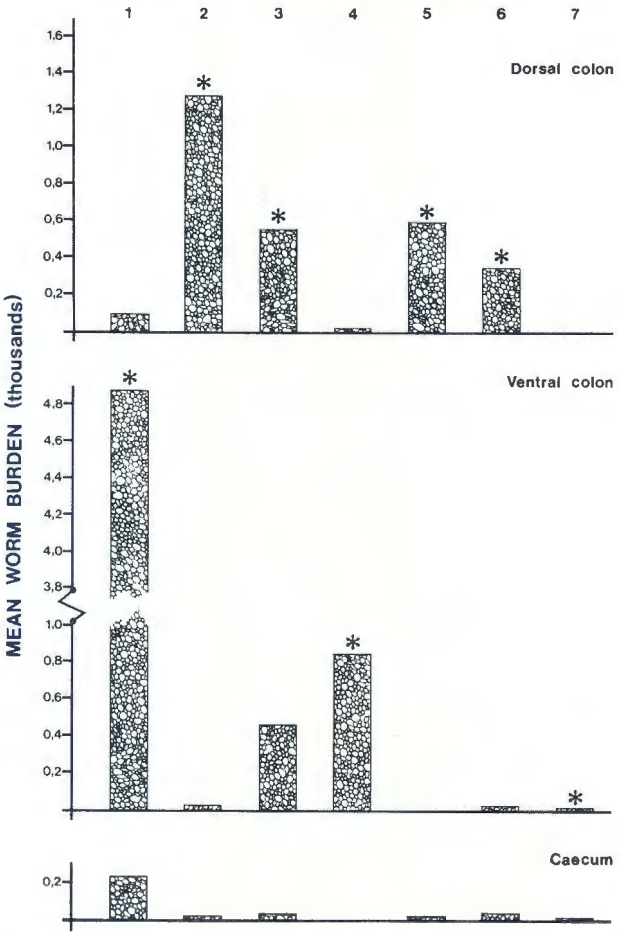

FIG. 8 Prevalence of Cyathostominae in different parts of the large intestines of zebra culled in the Namib-Naukluft Park, South West Africa/Namibia. * = preferred site. 1. *Cyathostomum tetracanthum;* 2. *Cylindropharynx* spp.; 3. *Cylicodontophorus* n. sp. (1); 4. *Cylicocyclus auriculatus;* 5. *Cylicostephanus longiconus;* 6. *Cylicocyclus adersi;* 7. *Cylicodontophorus* n. sp. (2)

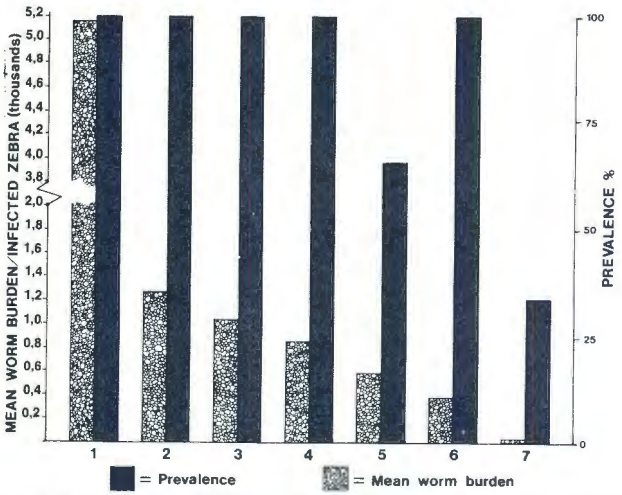

FIG. 9 The prevalence and relative abundance of 7 species of Cyathostominae found in zebra culled in the Namib-Naukluft Park, South West Africa/Namibia. 1. *Cyathostomum tetracanthum;* 2. *Cylindropharynx* spp.; 3. *Cylicodontophorus* n. sp. (1); 4. *Cylicocyclus auriculatus;* 5. *Cylicostephanus longiconus;* 6. *Cylicocyclus adersi;* 7. *Cylicodontophorus* n. sp. (2)

DISCUSSION

This is the first report of *Habronema longistoma, H. majus, H. muscae, Crossocephalus* sp. and *Probstmayria vivipara* from the mountain zebra. Three new species, *Cylicostephanus longiconus* (Scialdo-Krecek, 1983 b), *Cylicodontophorus* n. sp. (1) and *Cylicodontophorus* n. sp. (2), were present.

In the ''Kelpie'' zebra, the highest worm burdens and also the highest number of eggs per gram (e.p.g.) were recorded in animals in the middle age group, viz., 4–7 years. The 2 oldest Middelpos zebra, 2½ and 7 years of age respectively, also had higher burdens and higher e.p.g. counts than the zebra of 2 years. It appears from the ''Kelpie'' zebra that older animals develop some immunity which results in lower worm burdens and, in a few cases, the absence of some species.

TABLE 4 Total worm burdens of nematodes in mountain zebra collected on Middelpos

Zebra	13	14	15			
Age (years)	2	2½	7			
Eggs per gram of faeces (e.p.g.)	250	850	500	Total	No. zebra positive	Range
Cyathostominae						
L_4 Cyathostominae	1 284	10 080	6 242	17 606	3	1 284–10 080
Cyathostomum tetracanthum	565	1 370	13 482	15 417	3	565–13 480
Cylicocyclus auriculatus	182	2 065	106	2 353	3	106– 2 065
Cylicocyclus adersi	17	603	461	1 081	3	17– 603
Cylicocyclus spp.	100	0	0	100	1	
Cylicostephanus longiconus	365	1 445	5 850	7 660	3	365– 5 850
Cylicodontophorus n. sp. (1)	50	463	2 576	3 089	3	50– 2 576
Cylicodontophorus n. sp. (2)	0	8	0	8	1	
Cylindropharynx spp.	419	2 779	660	3 858	3	419– 2 779
Strongylinae						
Triodontophorus spp.	453	734	3	1 190	3	3– 734
Strongylus equinus	0	0	62	62	1	
Oxyuridae						
Oxyuris equi	455	0	7	462	2	
Atractidae						
Crossocephalus sp.	64 052	883 070	64 246	1 011 368	3	64 052–883 070
Probstmayria vivipara	221 200	50 720	208 912	480 831	3	50 720–221 200
Spiruridae						
Habronema majus	0	0	3	3	1	

It must be borne in mind that e.p.g. counts are generally not a true reflection of the worm burdens in equids. Round (1968) states that, although high egg counts can be an indication of large adult worm burdens, a low count in a healthy animal can suggest that parasitism has little effect. However, the case of a sick animal or one in poor condition with a low egg count should be viewed with caution. Round (1968) showed experimentally that ponies, grazing heavily infested pasture, though exhibiting severe clinical signs, had low or negative faecal egg counts.

The burdens of the families Strongylidae, Atractidae, Spiruridae and Setariidae from 2 different environments, arid and wet, are compared in Table 5. In the arid environment of the "Kelpie" study, the burdens of Atractidae were 4–60 times higher than in Burchell's zebra in the Kruger National Park (KNP) which has a mean annual rainfall of 398 mm (Scialdo, Reinecke & De Vos, 1982). In contrast to this there were higher numbers of strongyles in Burchell's zebra in the KNP. In the Middelpos area the difference between the numbers of strongyles and atractids was not as great. There appears to be an inverse relationship between the 2 families from the contrasting environments. The atractids appear to be more successful in an arid climate while the strongyles favour a wet climate.

Although little is known about the life cycle of *Crossocephalus* sp., the atractids are known to be viviparous (Yamaguti, 1961) and the entire life cycle is thought to be completed inside the host. The strongylids' life cycle includes parasitic stages inside and free-living stages outside the host. Since the developing free-living stages of the equine nematodes require a wet environment, rainfall influences the time of development to the infective stage (Ogbourne, 1972) as well as the emergence and migration of infective larvae (Ogbourne, 1973). We suggest that the trends observed are a result of several factors: (1) the environmental conditions directly influencing the free-living stages (i.e. Strongylidae); (2) the environmental conditions inside the host, both the immune response and the changing internal environment; (3) the effects of nematode interaction about which little is known. It is possible that a family *v.* family or a species *v.* species may have an adverse influence on each other's burdens inside the host, a type of interspecific or interfamily competition.

The spirurids and setariids, too, present a picture similar to that of the atractids and strongylids mentioned above. The life cycle of these nematodes requires an intermediate host. Stages of development, both internal and external to the definitive host, depend again on the climatic conditions, especially since the intermediate host includes several genera of arthropods (Levine, 1980). With the moister conditions in the KNP the spirurid and setariid burdens are higher than in either the "Kelpie" or Middelpos populations (Table 4). In an arid environment, a smaller diversity of nematode species is present. While Scialdo *et al.* (1982) and Scialdo-Krecek (1983 a) reported 22 species in a wet climate the "Kelpie" zebra harboured 14 and the Middelpos 13 species.

The cyathostome with the highest burden was *Cyathostomum tetracanthum*, but this nematode has not been recovered in such high numbers from any other population of zebras. It appears therefore that this species is successful in an arid environment. In some aliquots, such as those of the ventral colon ingesta, this nematode accounted for 99 % of the cyathostomes identified. This percentage was confirmed by an examination of further aliquots.

Theiler (1923) reported the distribution of 12 species of Strongylidae in the large intestine of 3 Burchell's zebra in South Africa. In the present investigation, the site of distribution for *Cylindropharynx* and *Cylicocyclus adersi* was the dorsal colon and for *Cyathostomum tetracanthum* the ventral colon. In both studies *Crossocephalus* preferred the ventral colon. These findings agree with Theiler (1923).

In the majority of the zebras examined, females were the predominant sex of *Crossocephalus* sp. Females removed from plaques in the ventral colon wall contained eggs rather than larvae (Fig. 6). These females free in the lumen of the gut contained larvae (Fig. 7). Possibly the stage in the gut wall represents an earlier stage of development than those free in the lumen.

Scialdo *et al.* (1982) confirmed the results of Ogbourne (1971) and Poynter (1954) that 4th stage larvae (L_4) overwintering in the caecal and colonic walls, emerge to develop into adults in the spring. They reported a similar phenomenon in the Burchell's zebra in the KNP. In the Middelpos study, zebra were killed in August, also a winter month, and the number of larvae in the gut wall was high. High numbers of 4th stage larvae and 5th stages of all cyathostome species were also present free in the lumen of the gut.

The eggs of *O. equi* require a moist environment and, according to Levine (1980), are not resistant to desiccation. The adults are the prevalent stage in this study and worm burdens were 0, 7 and 455 in the Middelpos zebra. The highest burden was recovered from the youngest zebra (2 years) which lived under very arid conditions throughout almost its entire life. We are unable, therefore, to confirm Levine's (1980) statement.

The problem of transporting specimens long distances to the laboratory was solved by freezing the ingesta and gut wall into solid blocks. Even if the cartons containing the specimens were to fall from the hold of the aircraft to the runway, the specimens would not break or burst

TABLE 5 A comparison of worm burdens in mountain zebra from the farm "Kelpie", SWA/Namibia and Burchell's zebra in the Kruger National Park (KNP)

	KNP	"Kelpie"
Atractidae		
Crossocephalus sp.	0– 1 947 474	692–61 066 680
Probstmayria vivipara	56 370–10 038 506	1 257 810–42 004 300
Strongylidae*		
Cyathostomum tetracanthum	6– 13 723	121– 10 481
Cylindropharynx spp.	63– 19 875	21– 2 688
Spiruridae	73– 4 496	1– 37
Setariidae	1– 11	0

* These are the 2 strongyles with the highest burdens in both zebra populations

open. The light weight of plastic bags, Tupperware boxes, cardboard cartons and polystyrene reduces air freight charges. Even in mid-summer when temperatures in the shade can exceed 35 °C, a delay of 4–6 h in the middle of the day has little effect on the specimens, and even after 18 h the blocks have not thawed. The worms were well preserved, easy to clear and identify, and the authors recommend this system for transporting specimens long distances.

In this investigation, a comparison was drawn between 2 species of zebra, the mountain zebra from South West Africa/Namibia and the Burchell's zebra from the KNP. Studies are in progress that will determine host species differences. Mountain and Burchell's zebra, both of which share the same habitat, are being compared. Horses from the farm "Kelpie" will be compared with those described in the present paper. Zebra from higher rainfall areas in SWA/Namibia will be compared with those in the present investigation.

As Scialdo-Krecek (1983 a) points out, the *H. muscae* from zebra differ somewhat from those from horses. *Triodontophorus* appears to include 2 species, but further study is required to determine their status. The new species of *Cylicodontophorus* have yet to be described.

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