Quantitative and qualitative aspects of the parasite burdens of rock dassies (*Procavia capensis* Pallas, 1766) in the Mountain Zebra National Park

L.J. Fourie*
Department of Zoology & Entomology, University of the O.F.S., P.O. Box 339, Bloemfontein, 9300 Republic of South Africa

I.G. Horak
Tick Research Unit, Rhodes University, Grahamstown

Evelyn Visser
Department of Helminthology, Veterinary Research Institute, Onderstepoort

Received 24 February 1986; accepted 12 September 1986

Seasonal variation in the densities of parasites of dassies and variation in these densities between sexes were determined. Female dassies showed significant seasonal differences in tick and biting lice densities. In comparison with males, female dassies had significantly higher densities of biting lice during the summer. With the exception of biting lice, juveniles had significantly higher ectoparasite densities than adults when compared on a monthly basis. No significant seasonal differences in endoparasite densities for the different sexes were evident. In comparison with the endoparasite densities of adults and sub-adults, juveniles had significantly higher densities of *Crossophorus collaris* and *Nouvelnema cyclophoron*. Seasonal variation in parasitic densities between the sexes is interpreted in terms of the physiological condition and social organization of dassies.

Seisoenale variasie in die parasietdigthede van dassies asook verskille tussen geslagte is ondersoek. Wyfiedassies het betekenisvolle seisoenale verskille getoon ten opsigte van bosluis- en bytende luisdigthede. In vergelyking met mannetjies het wyfiedassies betekenisvolle hoër digthede bytende luise gedurende die somer. Met die uitsondering van bytende luise het jong dassies betekenisvolle hoër maandelikse ektoparasietdigthede vergeleke met volwassenes. Geen betekenisvolle seisoenale verskille in endoparasietdigthede tussen die geslagte kon geïdentifiseer word nie. In vergelyking met die endoparasietdigthede van volwassenes en sub-volwassenes het jong dassies betekenisvolle hoër digthede van *Crossophorus collaris* en *Nouvelnema cyclophoron*. Seisoenale variasie in parasietdigthede tussen die geslagte word geïnterpreteer in terme van die fisiologiese kondisie en sosiale organisasie van dassies.

*To whom correspondence should be addressed

Stability of host-parasite systems is often reflected in minimal inconvenience to the life and survival of the host and is dependent upon a balanced relationship not only between individual hosts and individual parasites, but also between populations of each (Wakelin 1984). The protective responses which allow hosts to regulate the levels of infestation to which they are subject are important in maintaining such a balanced relationship. Owing to changes in the host's environment, and to population fluctuations and behavioural aspects, mammalian hosts are subjected to various degrees of stress which affect their natural and acquired resistance to parasites (Chandler 1953). This may lead to higher levels of parasitic infestation affecting the host's viability and ultimately result in mortality (Nelson, Bell, Clifford & Keirans 1977; Lightfoot & Norval 1981). In this respect Young (1969) and Melton & Melton (1982) consider that parasites (and diseases) can play an important role in the regulation of wild mammal populations and this may explain why certain wild populations have failed to increase as expected.

As part of a study on the population dynamics of the rock dassie (*Procavia capensis*) in the Mountain Zebra National Park (MZNP) the parasite burdens of these animals were investigated. Ecto- and endoparasites infecting dassies in the MZNP were identified and their seasonal abundance quantified. The relationship between dassie sex, age and parasite density was also determined. The ultimate objective was to elucidate the possible involvement of parasites in population regulatory mechanisms.

Study area

The study was conducted in the MZNP (32°15'S/25°41'E), comprising an area 6536 ha in extent situated 24 km southwest of Cradock in the Cape Province, Republic of South Africa. The climate is semi-arid with 70% (276 mm) of the rain falling during the summer months, predominantly in February and March. In addition to marked variation in daily temperatures major seasonal variations are also evident. Highest maximum temperatures (37°C) were recorded in January and February whereas June and August had the lowest minimum temperature of −7°C.

Thirty-three small mammal species are listed as occurring in the MZNP (De Graaff & Nel 1970; Nel & Pretorius 1971). Additions and amendments to the lists of mammals, birds and reptiles are given by Grobler & Bronkhorst (1981a, b). The estimated size of the dassie population in the Park is 12 763 animals (pre-reproductive) giving an approximate crude density of 1,95 dassie/ha (Fourie 1983). The most abundant large mammals based on ground counts conducted during February 1983 are mountain reedbuck (500 – 690), springbok (400 – 500) and Cape mountain zebra (210).

The vegetation in the MZNP is defined as Karroid Merxmuellera Mountain Veld which is replaced by Karoo on the higher slopes and False Karroid Broken Veld in the northern sections (Acocks 1975). A detailed phytosociological reconnaissance of the Park has been conducted by Van der Walt (1980).

Methods

Sampling procedure

Six dassies were shot monthly in the MZNP for a period of 13 consecutive months (March 1980 – March 1981). It was attempted to shoot three juveniles and three adults (including sub-adults) at each occasion. Immediately after the dassie had been shot, age (Fourie 1983) and sex were recorded. Their carcasses were placed separately in undamaged plastic bags and transported to the laboratory where they were processed for the recovery of ecto- and endoparasites.

Ectoparasites

At the laboratory the insecticide Diazinon (Agricura Ltd), at a concentration of 1 ml/l of water, was poured into each plastic bag until the dassie was thoroughly wet. The dassies were left in the bags for approximately 1 h after which they were removed and the excess insecticide was drained back into the bags. The contents of each plastic bag were poured separately through a sieve with 150-µm apertures and the bags were rinsed with water, which was also poured through the sieve, to ensure that all parasites were collected. Thereafter the dassies were individually placed in large plastic trays, and their skins were removed in such a manner as to prevent parasites sticking to the exposed subcutis. A steel brush with 30-mm bristles was used to scrub the skins in the plastic trays. Each skin was then thoroughly washed in a bucket of tap water, and this water, together with the contents of the plastic tray, was poured through the sieve. Scrubbing, washing and sieving were repeated three times and after careful examination of the skins for parasites (including ears and other protected regions), the skins were discarded. The parasites recovered were transferred to individually labelled bottles and preserved in 10% formalin.

Endoparasites

The lungs, livers and gastrointestinal tracts of the dassies were removed at necropsy. The liver and lungs were cut into slices approximately 5 mm thick. These were placed in warm 0,9% saline solution in a bottle maintained at approximately 40°C for a period of 2 h, after which the slices were washed and the washings and contents of the bottles sieved on a sieve with 38-µm apertures. The contents of the sieve were transferred to individually labelled bottles and preserved in 10% formalin. This labelling and preservation method was used throughout.

The stomach was carefully opened and the contents spread out in a plastic tray and visually examined for the presence of worms. These, together with the stomach wall, and any ingesta that had remained attached to it were placed in bottles.

The small intestine was opened and repeatedly run between thumb and index finger, thus removing the contents, which was collected in bottles. The contents of the bile duct were placed with the contents of the small intestine.

The caeca and colon were opened and the contents collected in bottles. The rectum was discarded.

Analysis of data

To rationalize the comparison of parasite loads, the species and numbers of parasites recovered from each hyrax were expressed in terms of density (number of parasites/kg body mass of the dassie). Only adult (> 24 months) and sub-adult dassies (13 – 24 months) were used for comparisons between sexes of the seasonal abundance of parasites since the object was to correlate seasonal differences in parasite burdens to changes in physiological condition. These age-related categories of dassies undergo seasonal variations in physiological condition related to physiologically stressful periods (rutting, gestation and lactation). The physiological condition of juvenile dassies (0 – 12 months), however, stays consistently low. Deposited fat reserves served as an index of physiological condition (Fourie & Perrin 1985). To compare the seasonal burdens of parasites on dassies two broad seasons were defined:

(i) Summer (October – April) with a mean maximum temperature higher than 20°C receiving *c.* 70% of the annual rainfall;
(ii) Winter (May – September) with a mean maximum temperature lower than 20°C and little rainfall.

Results

Ectoparasites

The species composition of ectoparasites collected from the 27 juvenile (15♀♀ and 12♂♂), nine sub-adult (4♀♀ and 5♂♂) and 41 adult (25♀♀ and 16♂♂) dassies sampled, is given in Table 1. All dassies examined ($n = 77$) were infested with either larval, nymphal or adult ticks. Engorged ticks were noticeably prevalent around wounds, lips and the anogenital region. One juvenile dassie harboured no biting lice and another juvenile had no fleas. All dassies examined were infested with sucking lice.

Seasonal abundance

The mean monthly ectoparasite densities of the dassies examined are summarized in Table 2. Since juveniles become infested with ectoparasites soon after birth, the burdens of juveniles were grouped with those of the adults and sub-adults.

Variation in parasitic densities on females ($n = 29$) between seasons for sub-adult and adult dassies showed significantly higher ($p < 0,025$) tick (all developmental stages) and biting lice densities during the summer months. No significant difference was found between the summer and winter densities of ticks and biting lice on males ($n = 21$).

Table 1 List of ectoparasite species recovered from 77 rock dassies in the Mountain Zebra National Park (March 1980 – March 1981)

Species	Developmental stage
Ixodid ticks	
Amblyomma marmoreum	larvae, nymphae
Haemaphysalis hyracophila	larvae, nymphae, adults
Hyalomma truncatum	adult (♀) (one hyrax)
Ixodes sp.	larva (one hyrax)
Margaropus winthemi	larva, nymph (one hyrax)
Rhipicephalus arnoldi	larvae, nymphae
Rhipicephalus sp.	(near *R. capensis*) — adult (♀) (one hyrax)
Rhipicephalus distinctus	larvae, nymphae, adults
Rhipicephalus evertsi evertsi	larvae (one hyrax)
Rhipicephalus glabroscutatum	larvae (one hyrax)
Biting lice	
Dasyonyx (Dasyonyx) sp.	
Procavicola (Condylocephalus) lindfieldi	
Procavicola (Procavicola) sp. (There may be more than one species present).	
Procaviphilus serraticus	
Other species of biting lice may also be present.	
Sucking lice	
Prolinognathus caviaecapensis	
Prolinognathus sp. (possibly a new species)	
Other species of sucking lice may also be present.	
Fleas	
Procaviopsylla creusae	

Table 2 Mean monthly ectoparasite densities (numbers per kg body mass) for 77 rock dassies examined in the Mountain Zebra National Park during March 1980 – March 1981

		Ixodid ticks											
		Larvae		Nymphae		Adults		Biting lice		Sucking lice		Fleas	
Month	*n*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
March	6	69,3	26,8	16,2	4,3	0	–	106,3	48,7	54,8	25,6	17,5	5,6
April	6	36,3	13,7	3,0	0,7	0,7	0,2	106,8	42,2	171,8	107,5	21,7	4,1
May	6	55,7	29,0	5,3	1,7	3,8	3,3	56,2	44,2	44,3	7,4	16,8	8,1
June	6	18,5	9,1	15,2	3,7	1,5	0,8	52,0	44,3	158,3	66,8	35,8	12,5
July	6	0,7	0,3	1,8	0,5	2,5	0,7	107,5	50,7	37,2	15,2	7,8	1,5
August	6	1,0	0,3	4,5	2,7	14,8	3,9	109,0	39,4	13,0	2,7	8,0	2,8
September	6	3,7	1,7	6,5	3,7	6,2	2,2	14,5	10,0	121,5	52,8	18,8	6,1
October	6	4,5	3,2	4,0	1,3	6,3	1,9	44,0	25,7	52,2	18,0	13,0	6,3
November	6	15,8	7,5	6,3	3,2	13,3	3,2	205,3	66,7	130,3	57,0	6,3	2,6
December	6	205,3	69,1	29,3	9,1	12,8	5,0	93,5	47,0	195,7	85,8	25,3	5,4
January	6	243,0	69,3	17,0	6,6	5,7	1,7	265,7	116,3	373,0	249,7	35,2	15,1
February	6	63,7	33,2	2,7	0,9	0	–	82,8	21,3	44,2	21,0	9,3	1,8
March	5	218,0	98,3	17,6	5,4	2,4	1,5	210,6	145,2	58,6	16,6	6,8	2,0

Table 3 Mean monthly densities of ectoparasites (numbers per kg body mass) for juvenile ($n = 27$), sub-adult and adult ($n = 50$) rock dassies sampled in the Mountain Zebra National Park during March 1980 – March 1981

		Juveniles									Sub-adults & adults							
		Ticks		Biting lice		Sucking lice		Fleas			Ticks		Biting lice		Sucking lice		Fleas	
Month	*n*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	*n*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
March	3	116,7	54,7	10,7	4,1	93,3	41,8	25,7	9,1	3	52,3	5,5	202,7	50,6	16,3	7,4	9,3	3,2
April	2	92,5	75,2	12,0	2,0	363,0	336,0	26,5	4,5	4	18,3	5,9	154,3	47,0	76,3	32,4	19,3	3,8
May	3	123,7	42,0	2,5	0,3	56,3	8,8	29,3	13,0	3	5,7	0,9	110,0	82,9	32,3	7,1	4,3	2,4
June	3	49,7	18,5	2,7	1,2	230,7	126,5	44,0	21,0	3	12,3	2,3	101,3	86,0	86,0	33,2	14,0	4,9
July	1	6,0	–	21,0	–	105,0	–	13,0	–	5	4,8	0,9	124,8	58,2	23,6	8,3	6,8	1,4
August	1	41,0	–	27,0	–	23,0	–	19,0	–	5	16,2	5,0	105,2	45,0	11,0	2,1	5,8	2,1
September	3	28,0	11,3	0,7	0,3	236,0	28,0	22,3	11,9	3	4,7	0,3	28,3	17,6	7,0	4,5	15,3	5,4
October	3	18,3	10,2	2,3	0,9	87,3	17,5	16,3	12,9	3	11,3	2,3	85,7	39,6	17,0	9,3	9,7	4,6
November	2	21,0	13,0	14,0	4,0	200,0	54,2	4,0	4,0	4	36,8	17,3	301,0	44,6	95,5	80,1	7,5	3,2
December	2	412,0	173,0	8,5	1,5	425,0	155,5	20,0	13,0	4	164,8	38,5	136,0	61,0	81,0	35,4	28,0	6,1
January	2	257,0	43,1	17,5	4,5	19,0	4,0	75,5	27,6	4	270,0	112,8	389,8	135,7	23,8	5,4	15,0	5,9
February	1	226,0	–	2,0	–	19,0	–	13,0	–	5	34,4	9,1	99,0	16,9	49,2	24,9	8,6	2,0
March	1	597,0	–	11,0	–	43,0	–	4,0	–	4	148,3	59,9	260,5	176,4	62,5	20,9	7,5	2,4

Dassie age and sex and ectoparasite densities

The mean monthly ectoparasite densities of juveniles and sub-adult and adult dassies are summarized in Table 3. Juveniles had, except for biting lice, significantly higher ($p < 0,025$) ectoparasite densities than sub-adults and adults. In the case of biting lice sub-adults and adults had significantly higher ($p < 0,005$) densities than juveniles.

Comparisons between the ectoparasite densities of sub-adult and adult male ($n = 13$) and female ($n = 18$) dassies within the seasons showed significantly higher densities ($p < 0,025$) of biting lice on females during the summer. No significant differences were found during winter.

Endoparasites

The species composition of the endoparasites recovered from the dassies examined is given in Table 4. No attempt was made to identify cestodes to species level.

No parasites were recovered from the lungs or liver tissue, or the stomach contents of any of the dassies. Large infestations of cestodes nearly occluding the duodenum and bile ducts were observed [there is no gall bladder in the dassie (Owen 1932; Grassé 1955)]. These cestode infestations extended into the intrahepatic ampullary dilation but did not occur within the hepatic tissues.

Only three juvenile dassies, representing 4% of the total

Table 4 List of endoparasites recovered from 77 rock dassies in the Mountain Zebra National Park (March 1980 – March 1981)

Small intestine and bile duct
Cestodes
Inermicapsifer spp.

Sacculated caecum and colon
Nematodes
Crossophorus collaris
Trichuris sp.
Theileriana spp.
Nouvelnema cyclophoron

Table 5 Mean monthly endoparasite densities (numbers per kg body mass) for juvenile (n = 27), sub-adult and adult (n = 50) rock dassies sampled in the Mountain Zebra National Park (March 1980 – March 1981)

		Cestodes		*Crossophorus collaris*		*Trichuris* sp.		*Theileriana* spp.		*Nouvelnema cyclophoron* (× 10^5)	
Month	n	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*	$\bar{x}$	*SE*
Juveniles											
March	3	12,3	4,7	0,7	0,7	0	–	0	–	2,9	0,6
April	2	52,5	45,6	2,0	–	0	–	20,0	–	1,9	–
May	3	28,0	14,5	2,9	1,0	0,8	0,8	32,3	13,0	2,7	0,6
June	3	18,3	6,0	5,3	1,7	0	–	45,5	9,5	3,0	1,2
July	1	37,0	–	6,4	–	0,9	–	9	–	2,1	–
August	1	236,0	–	14,0	–	0,7	–	110,0	–	2,1	–
September	3	74,7	35,1	2,2	0,4	0,7	0,7	110,3	23,3	2,7	0,2
October	3	95,7	72,9	2,7	0,9	0,2	0,1	238,3	136,8	1,1	0,2
November	2	97,0	31,1	2,1	0,9	0,4	0,4	261,5	76,7	1,2	0,2
December	2	25,0	25,0	0	–	0	–	0	–	1,9	1,6
January	2	0	–	2,8	2,8	0	–	23,4	12,7	4,0	1,1
February	1	5,0	–	0	–	0	–	77,0	–	1,5	–
March	1	43,0	–	2,2	–	0	–	11,0	–	1,2	–
Sub-adults and adults											
March	3	34,4	23,9	0,5	0,4	0	–	69,0	3,5	1,2	0,4
April	4	32,8	5,5	1,0	0,4	0,3	0,1	129,7	21,0	0,7	0,1
May	3	60,0	10,7	1,1	1,0	0,4	0,4	100,0	22,9	1,1	0,6
June	3	66,3	30,2	0,3	0,3	0	–	95,5	21,6	1,3	0,5
July	5	55,6	24,6	1,5	1,0	0,2	0,2	143,2	17,1	1,8	0,5
August	5	130,6	38,7	0,7	0,6	0,3	0,3	94,0	17,8	1,1	0,2
September	3	28,3	8,7	1,1	1,1	0	–	72,7	30,7	1,3	0,2
October	3	33,7	15,5	3,1	1,4	0,2	0,1	72,7	19,4	1,1	0,2
November	4	68,5	22,5	0,4	0,4	1,0	0,5	86,0	24,6	1,4	0,3
December	4	114,3	56,1	1,0	0,5	2,0	0,9	125,5	49,1	2,0	0,7
January	4	101,5	28,1	0	–	0,6	0,6	67,3	26,6	0,9	0,6
February	5	48,0	10,3	1,4	0,7	0,1	0,1	127,0	32,9	0,5	0,2
March	4	43,3	23,2	0,9	0,4	0,1	0,1	74,5	52,7	1,5	0,7

sample, were not infested with cestodes. Sixty-two per cent of dassies were infested with *Crossophorus collaris*, 34% with *Trichuris* sp., 97% with *Theileriana* spp. and 99% with *Nouvelnema cyclophoron*.

Seasonal abundance

Juvenile dassies do not acquire infestations with certain helminth species before they are a few months old; the analysis of the parasite densities of these animals was thus done separately from that of adults. The mean monthly densities for endoparasites recovered from the 77 dassies examined are summarized in Table 5. With the exception of *Crossophorus collaris* and *Trichuris* sp., large monthly mean densities of helminths were recorded.

Winter and summer endoparasitic densities of sub-adult and adult male and female dassies did not differ significantly.

Dassie age and sex and endoparasite densities

Twenty-five per cent of juveniles became infested with cestodes, and the nematode *Crossophorus collaris* within the first two months of age, whereas 50% were infested with *Theileriana* spp. and 100% with *Nouvelnema cyclophoron* by this age. Infestation of juveniles with *Trichuris* sp. was only observed at ages exceeding about 5 months. Juveniles had significantly ($p < 0{,}001$) larger densities of *Crossophorus collaris* and *Nouvelnema cyclophoron* than did sub-adults and adults.

Discussion

Ectoparasites

The significantly higher tick densities of female dassies during the summer months can be related to the structure of the dassie population. Adult and sub-adult female dassies form part of a multi-female kinship group that is matrilocal whereas the majority of adult and sub-adult males become territorial or peripheral (Hoeck, Klein & Hoeck 1982; Fourie 1983). Hence the large number of females present at a particular site could lead to a marked increase in the number of parasites present at such a site and hence an increase in infestation rate. In addition adult females show a significant decrease in physiological condition during summer (Fourie & Perrin 1985) which may affect their resistance to parasitic infestation. It is possible that the high tick densities during summer may affect female resilience and fitness. These high tick densities represent an additional energy burden during a period (late pregnancy and lactation) when the energy requirements of adult female mammals are already high (Migula 1969; Moen 1973).

Sub-adult and adult males show a significant reduction in physiological condition during winter (after the rutting period) but no significant increase in parasite densities. The absence of an increase in tick densities during winter is not unexpected because of low environmental temperatures and low rainfall; these factors are known to affect the hatching of tick eggs (Chandler & Read 1961).

Mammalian lice are particularly dependent on the microclimate furnished by the host (Nelson, Keirans, Bell & Clifford 1975). Although lice are susceptible to heat, especially in the presence of high humidity (Chandler & Read 1961), the dassie, by virtue of its behavioural mode of thermoregulation (Sale 1965; Fourie 1983), avoids extreme temperatures. The significantly higher biting-lice densities of female dassies during summer thus probably indicate more favourable conditions for the reproduction of lice. In addition the gregarious nature of female dassies may also facilitate transmission of these parasites.

With the exception of biting lice, the ectoparasite densities of juveniles were significantly higher than those of the older dassies. A possible reason for this may be that the physical nature of the juvenile skin is more favourable for parasite attachment and feeding than that of the adult dassies. The relatively low densities of biting lice and the high densities of sucking lice on juveniles are certainly indicative of this. Other possible reasons for the higher ectoparasite loads on juveniles can be attributed to the aggregation of juveniles in dens, and possibly also their lower resistance and hence higher susceptibility to parasites. Various factors influencing resistance or susceptibility such as repellent host pheromones, serum antibody components, key enzymes involved in the inflammatory process, blood-feeding stimulants and serum inhibitors of parasite digestive enzymes (Nelson *et al.* 1977) may take time to produce responses, thus accounting for the higher densities on the young animals.

Juvenile dassies have a rapid growth rate during their first year and have little or no stored body fat (Fourie 1983). Consequently high ectoparasite densities, particularly large numbers of blood feeding sucking lice, may seriously affect their resilience. The high neonatal mortality of dassies in the MZNP during the drought of 1983 (Fourie 1983) may partly be due to the primary or secondary effects of high parasitic densities. While these high parasite densities may not have been the chief cause of death they could have contributed to it by increasing total energy requirements at a time when energy supplies were limited.

In a study on the condition and mortality of waterbuck (*Kobus ellipsiprymnus*) in the Umfolozi Game Reserve it was suggested that severe tick infestations were the proximate cause of the high non-predatory mortalities of juveniles (Melton & Melton 1982). The important effect of high juvenile mortality on waterbuck population growth has been emphasized by Melton (1983). In elucidating the population crash of reedbuck (*Redunca arundinum*) in the Kyle National Park (Zimbabwe), Ferrar & Kerr (1971) indicated that one of the prime density-dependant factors affecting mortality was high parasite densities. As far as the dassie is concerned, Hoeck (1982) has shown that the sarcoptic mange mite is an important cause of mortality, especially in *Procavia johnstoni*. Unfortunately Hoeck (1982) provided no information on the age specificity of mortalities.

Biting lice, although they occur in large numbers on adult and sub-adult dassies, feed mainly on skin debris (Nelson *et al.* 1975) and are unlikely to have significant detrimental and nutritional effects on their hosts.

Endoparasites

The absence of any significant seasonal differences in endoparasitic densities for adult and sub-adult male and female dassies, possibly indicates a high degree of resistance to these parasites particularly considering that both sexes undergo marked changes in physiological condition. It might, however, also indicate that few infective stages of the endoparasites were available at the time dassies were entering a period of stress. In female wood mice (*Apodemus sylvaticus*) the increase in number of endoparasites is correlated to their greater food requirements during the breeding season (Langley & Fairley 1982). This was also shown to be the case for wood ducks (*Aix sponsa*) where the greater relative density of parasites (Platyhelminths) in females was the result of differences in their food preference and feeding behaviour (Drobney, Train & Frederickson 1983). In both the above cases, the invertebrates consumed by the mice and ducks acted as vectors of the parasites. The dassie, however, is an exclusive herbivore. In addition the paucity of information on the intermediate hosts of many of the endoparasites of dassies, as well as possible sex-related differences in feeding behaviour, preclude definitive explanations.

The delayed acquisition of *Trichuris* sp. infestation by juvenile dassies is perhaps an indication of the slow development to infectivity of eggs of this genus (Chandler & Read 1961). Since the egg and not the larval stage is infective in the *Trichuris* life cycle (Chandler & Read 1961) the dassie has to ingest infective eggs from the ground. Larvae mature and moult to adulthood from 1 – 3 months after infestation depending on the species (Soulsby 1968). As no technique for the specific recovery of these larvae was employed in the present study they may have been present in dassies from an early age and only became obvious when they moulted to adulthood. Although juveniles had significantly heavier densities of *Crossophorus collaris* and *Nouvelnema cyclophoron* than older animals, the former helminth was even then only present in relatively low numbers. No ill effects caused by parasites belonging to the same group as *Nouvelnema cyclophoron* have been reported in any of their hosts even though they may occur in very large numbers (Soulsby 1968).

Since dassies in poor condition and about to die probably crawl into crevices or holes or are eaten by predators their bodies cannot be obtained for necropsy purposes. Hence the comments on the effects of high parasitic burdens are mainly conjecture. However, necropsies performed by Fox (1933) on dassies which had died in captivity revealed that in those cases in which high endoparasitic loads were present, death was due to anaemia, degeneration of the liver and malnutrition. In one case severe clogging of the bile ducts with cestodes caused these structures to rupture.

In addition to the parasites mentioned in this study *Procavia capensis* in South West Africa/Namibia have been reported to be hosts of the protozoan parasite *Leishmania* (Ledger 1976). Rock dassies are known to be the hosts of the blood parasite *Babesia thomasi* (Jansen 1952; Irwin, Sale & Purnell 1973). Occasional epidemics such as bubonic plague have also been reported as killing large numbers of dassies (Kingdon 1971).

Conclusion

An ecologist with an interest in the demographic tendencies of natural mammal populations must necessarily be interested in key factors which can influence the dynamics of such populations. He is confronted by the presence on mammals of parasites which in many cases are minute and therefore difficult to find. To aggravate the problem, few carcasses are found for post mortem examination because predators and scavengers remove weak animals and carcasses. Remarks regarding parasites on mammals are frequently cursory and parasite burdens are expressed in broad terms like heavy or light. Nevertheless, it is clear from the literature that heavy burdens can cause mortality because of primary or secondary effects. The interrelationship between parasite populations and hosts is complex and in many cases poorly understood. Greater clarity on the role of parasites in population regulatory processes can only be acquired if the relationship between parasite burdens, physiological condition, age and behaviour can be elucidated. The conclusions regarding the dassie and its parasites are in many cases speculative. Nevertheless it is a first step in the process of understanding the factors which may cause mortality and which could be key factors in population regulation.

Acknowledgements

The authors wish to thank the Board of Trustees, National Parks Board, for financial support and permission to conduct the study in the Mountain Zebra National Park. Many thanks also to Prof. M.R. Perrin and Dr J.H. Grobler for continual support and guidance throughout the field research programme.

References

ACOCKS, J.P.H. 1975. Veld Types of South Africa with accompanying veld type map. *Mem. Bot. Surv. S. Afr.* 40: 128 pp.

CHANDLER, A.C. 1953. The relation of nutrition to parasitism. *J. Egypt. Med. Assoc.* 36: 811 – 834.

CHANDLER, A.C. & READ, C.P. 1961. Introduction to parasitology. John Wiley & Sons, New York.

DE GRAAFF, G. & NEL, J.A.J. 1970. Notes on the smaller mammals of the Eastern Cape National Parks. *Koedoe* 13: 147 – 149.

DROBNEY, R.D., TRAIN, C.T. & FREDERICKSON, L.H. 1983. Dynamics of the Platyhelminth fauna of wood ducks in relation to food habits and reproductive state. *J. Parasitol.* 69: 275 – 380.

FERRAR, A.A. & KERR, M.A. 1971. A population crash of the reedbuck (*Redunca arundinum*) (Boddaert) in Kyle National Park, Rhodesia. *Arnoldia* (Rhod.) 5: 1 – 19.

FOURIE, L.J. 1983. The population dynamics of the rock hyrax *Procavia capensis* (Pallas, 1766) in the Mountain Zebra National Park. Ph.D. thesis, Rhodes University.

FOURIE, L.J. & PERRIN, M.R. 1985. Seasonal change in the body fat of the hyrax *Procavia capensis* (Pallas, 1766) using a body fat rating index. *Koedoe* 28: 61 – 67.

FOX, H. 1933. Some notes upon the nature, health and maintenance of the hyrax. *Proc. Am. phil. Soc.* 72: 1 – 25.

GRASSÉ, P.P. 1955. Orde des hyracordes on hyraciens. In: Traite de Zoologie 17. Mammiféres. (Ed.) Grassé, P.P. pp. 878 – 879. Masson, Paris.

GROBLER, J.H. & BRONKHORST, P.J. 1981a. Additions and amendments to the bird and mammal lists of the Mountain Zebra National Park. *Koedoe* 24: 199 – 203.

GROBLER, J.H. & BRONKHORST, P.J. 1981b. A preliminary checklist of reptiles and amphibians in the Mountain Zebra National Park. *Koedoe* 24: 193 – 197.

HOECK, H.N. 1982. Population dynamics, dispersal and genetic isolation in two species of hyrax (*Heterohyrax brucei* and *Procavia johnstoni*) on habitat islands in the Serengeti. *Z. Tierpsychol.* 59: 177 – 210.

HOECK, H.N., KLEIN, H. & HOECK, P. 1982. Flexible social organization in hyrax. *Z. Tierpsychol.* 59: 265 – 298.

IRWIN, A.D., SALE, J.B. & PURNELL, R.E. 1973. *Babesia thomasi* from rock hyraxes in Kenya. *J. Parasitol.* 59: 203 – 204.

JANSEN, B.C. 1952. *Babesia thomasi* sp. nov., an intraerythrocytic parasite of the Cape dassie (*Procavia capensis*) (Pallas). *Onderstepoort. J. vet. Res.* 25: 3 – 6.

KINGDON, J. 1971. East African Mammals. Vol. 1. Academic Press, London.

LANGLEY, R. & FAIRLEY, J.S. 1982. Seasonal variations in infestations of parasites in a wood mouse *Apodemus sylvaticus* population in the west of Ireland. *J. Zool., Lond.* 198: 249 – 261.

LEDGER, J.A. 1976. Vectors of leishmaniasis in South West Africa. *Proc. Int. Symp. S. Afr.* 577 – 583.

LIGHTFOOT, C.J. & NORVAL, R.A.I. 1981. Tick problems in wildlife in Zimbabwe 1. The effects of tick parasitism on wild ungulates. *S. Afr. J. Wildl. Res.* 11: 41 – 45.

MELTON, D.A. & MELTON, C.L. 1982. Condition and mortality of waterbuck (*Kobus ellipsiprymnus*) in the Umfolozi Game Reserve. *Afr. J. Ecol.* 20: 89 – 103.

MELTON, D.A. 1983. Population dynamics of waterbuck (*Kobus ellipsiprymnus*) in the Umfolozi Game Reserve. *Afr. J. Ecol.* 21: 77 – 91.

MIGULA, P. 1969. Bioenergetics of pregnancy and lactation in European common vole. *Acta. Theriol.* 14: 167 – 179.

MOEN, A.N. 1973. Wildlife ecology. W.H. Freeman & Company, San Francisco.

NEL, J.A.J. & PRETORIUS, J.J.L. 1971. A note on the smaller mammals of the Mountain Zebra National Park. *Koedoe* 14: 99 – 110.

NELSON, W.A., BELL, J.F., CLIFFORD, C.M. & KEIRANS, J.E. 1977. Review article: interactions of ectoparasites and their hosts. *J. Med. Ent.* 13: 389 – 428.

NELSON, W.A., KEIRANS, J.E., BELL, J.F. & CLIFFORD, C.M. 1975. Review article: host-ectoparasite relationships. *J. Med. Ent.* 12: 143 – 166.

OWEN, R. 1832. On the anatomy of the Cape hyrax. *Proc. Comm. Sci. Corres. Zool. Lond.* 2: 202.

SALE, J.B. 1965. Some aspects of the behaviour and ecology of the rock hyraces (genera *Procavia* and *Heterohyrax*). Ph.D. thesis, University College Nairobi.

SOULSBY, E.J.L. 1968. Helminths, arthropods and protozoa of domesticated animals. Bailliere, Tindall & Cassell, London.

VAN DER WALT, P.T. 1980. A phytosociological reconnaissance of the Mountain Zebra National Park. *Koedoe* 23: 1 – 32.

WAKELIN, D. 1984. Immunity to Parasites. Edward Arnold, London.

YOUNG, E. 1969. The significance of infectious diseases in African game populations. *Zool. Afr.* 4: 275 – 281.