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ECOLOGICAL STUDIES ON *IXODES* (*AFRIXODES*) *MATOPI* SPICKETT, KEIRANS, NORVAL & CLIFFORD, 1980 (ACARINA: IXODIDAE)

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ABSTRACT

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Ixodes (*Afrixodes*) *matopi* occurs in association with the klipspringer (*Oreotragus oreotragus*) in rocky areas in Zimbabwe. The adult ticks are specific parasites of this antelope and the immature stages feed on klipspringers, hyraxes (*Procavia capensis* and *Heterohyrax brucei*) and red rock hares (*Pronolagus crassicaudatus*). Adults are active only in the wet season and prior to feeding are found on bushes growing adjacent to rocks. The ticks aggregate on twigs which have been marked with the secretions of the pre-orbital glands of klipspringers. Larvae are evident in greatest numbers in the latter part of the wet season and nymphs in the cool dry season. Unfed larvae and nymphs occur predominantly on mats of humid leaf litter in the cracks and gaps between rocks, and both show well-defined patterns of daily activity.

Résumé

ETUDES ECOLOGIQUES DES IXODES (AFRIXODES) MATOPI *SPICKETT, KEIRANS, NORVAL & CLIFFORD*, 1980 (*ACARINA: IXODIDAE*)

Les Ixodes (Afrixodes) matopi *surviennent en association avec l'antilope klipspringer* (Oreotragus oreotragus) *dans les régions rocheuses de Zimbabwe. Les tiques adultes sont des parasites spécifiques de cette antilope et les stades immatures s'alimentent sur les klipspringers, les hyraxes* (Procavia capensis *et* Heterohyrax brucei) *et les lièvres rouges de rocher* (Pronolagus crassicaudatus). *Les adultes sont seulement actifs pendant la saison humide et on les trouve, avant le moment de leur alimentation, sur les buissons qui poussent à proximité des rochers. Les tiques se concentrent sur les touffes qui ont été marquées avec les sécrétions des glandes pré-orbitales des klipspringers. Les larves sont évidentes en plus grand nombre pendant la dernière partie de la saison humide et les nymphes pendant la saison sèche et fraîche. Des larves et des nymphes se trouvent en prédominance sur les couvertures de débris de feuilles humides dans les crevasses et les espaces entre les rochers, et ces deux stades montrent des genres d'activité journalière bien définis.*

INTRODUCTION

Ixodes (*Afrixodes*) *matopi* is a newly-described tick parasite of the klipspringer antelope (*Oreotragus oreotragus*) and is known to occur at 2 localities in Zimbabwe (Spickett, Keirans, Norval & Clifford, 1981). The species is closely related, both morphologically and in its habitat associations, to *Ixodes* (*Afrixodes*) *neitzi* Clifford, Walker & Keirans, 1977, which was collected from mountain reedbuck (*Redunca fulvorufula*) in the Loskop Dam Nature Reserve, Transvaal, South Africa (Clifford *et al.*, 1977). Because of the morphological similarity between these 2 species, specimens of *I. matopi*, which were collected in the Rhodes Matopos National Park in Zimbabwe, were initially identified as *I. neitzi* by Clifford *et al.* (1977).

Rechav, Norval, Tannock & Colborne (1978) demonstrated that a highly specific relationship exists between *I. matopi* (referred to as *I. neitzi*) and klipspringers within the rocky habitats in which both occur. It was shown that adult ticks aggregate on twigs that have been marked with the substance produced by the pre-orbital glands of klipspringers. The marking of twigs is a means of intraspecific communication in klipspringers (Dunbar & Dunbar, 1974) and the response of the ticks to this klipspringer secretion is a specific and unique method of host location.

With the exception of *Ixodes rubicundus* Neumann, 1904, which is of significant economic importance and has been studied in detail by Stampa (1959), little is known about the ecology of African species of the genus *Ixodes*. One reason for this is that most African *Ixodes* species have specialized host and habitat requirements and are seldom encountered by man or in domestic animals. A likely cause of the high degree of specialization is that these ticks are extremely susceptible to desiccation (Lees, 1946; Balashov, 1968) and can only survive in a limited range of habitats in harsh African conditions. The survival of a tick species within a restricted habitat necessitates a specific relationship with the host or hosts which occur within that habitat. In the case of *I. matopi* it has already been shown that a specialized and specific relationship exists between the ticks and their klipspringer hosts. This paper covers a wider study of the ecology of *I. matopi* and includes data on the microhabitats in which the different stages of the life cycle occur, their daily and seasonal activity patterns and their host relationships. Various behavioural mechanisms favouring the survival of the species are discussed in relation to the environment in which the tick exists.

THE STUDY AREA

The study area was situated in the vicinity of Maleme Dam in the Rhodes Matopos National Park in south-western Zimbabwe (20° 32′ S, 28° 30′ E). The rugged topography of the area features large granite hills or koppies, separated by gorges or narrow strips of grassland/savanna. The study was carried out along the lower reaches of koppies where large trees, forming a dense canopy, grow amongst boulders of various sizes. The ground cover between the boulders consists of thick mats of leaf litter, out of which grow a variety of bushes and shrubs. In and between the boulders are numerous cracks and holes.

The mean annual rainfall for the area is 665 mm, with most rain falling between mid-November and the end of April. The mean annual temperature is 18,0 °C, with a mean monthly maximum of 21,5 °C in October and a mean monthly minimum of 11,8 °C in June. As a result of the interactions between temperature and rainfall the year can be divided into 3 distinct seasons: (1) a 'warm wet' season lasting from mid-November

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until April, (2) a 'cool dry' season lasting from May until August and (3) a 'hot dry' season lasting from September until early November.

Materials and Methods

To obtain data for each of these 3 seasons sampling was carried out in June, September and February (1977/78). Larvae and nymphs were sampled by flagging with a 30×90 cm flannelette 'flag' attached to a 2 m long flexible pole. Habitats sampled were bare rock, cracks and holes in the rock, leaf litter and bushes. To quantify the sampling procedure in the rough terrain, each sample consisted of a series of sweeps taken during a period of 30 seconds. This ensured coverage of an area of approximately 5 m^2. Samples were taken 3 times per day, early morning (06h00–09h00), the middle of the day (10h00–18h00) and evening (20h00–24h00).

Adult ticks did not cling to the flags, so they had to be searched for in the bushes during daylight hours and collected by hand.

Microclimatic temperatures and relative humidities were recorded at ground level in the early morning, at noon, and in the evening in 4 different habitats (exposed rock, shaded rock, litter and cracks/holes) in each season of the year. Temperatures were recorded using an Ultrakust Thermophil* temperature recorder with an H 112 CF probe, and relative humidities were recorded with a Rotronic Hygroscop** BT humidity measuring instrument using a Rotronic air probe, type CH-8047.

Hosts were collected by shooting, and ticks were removed in a field laboratory.

Results

Microclimatic records (Fig. 1)

The microhabitat in which the highest noon temperatures and consistently lowest relative humidities were recorded was exposed rock. On shaded rock there were large daily fluctuations in relative humidity, but considerably lower noon temperatures. In cracks and holes in the rock there were large daily fluctuations in temperatures. The most stable microclimates, in which consistently high relative humidities were recorded, were those of the litter zone.

All the microhabitats showed similar daily fluctuations in temperature and relative humidity. That is, temperatures were generally lowest in the early morning and reached a peak at noon, while relative humidities, which were lowest at noon, rose after sunset to reach a peak in the early morning.

Seasonal activity

Both larvae and nymphs showed a clear pattern of seasonal activity (Fig. 2). Of all the larvae sampled by flagging, 61,1% were collected in February, 26,5% in June and 12,4% in September. By contrast, no nymphs were collected in February and the numbers collected in June (61,0%) were considerably higher than those collected in September (39,0%). Host data (Table 3) confirm that larval numbers were higher in February and June than in September, and that nymphs were absent in February and abundant in June and September.

Adults showed an even clearer seasonal activity pattern, being absent from both bushes (Table 1) and hosts (Table 2) in June and September and present on both in February.

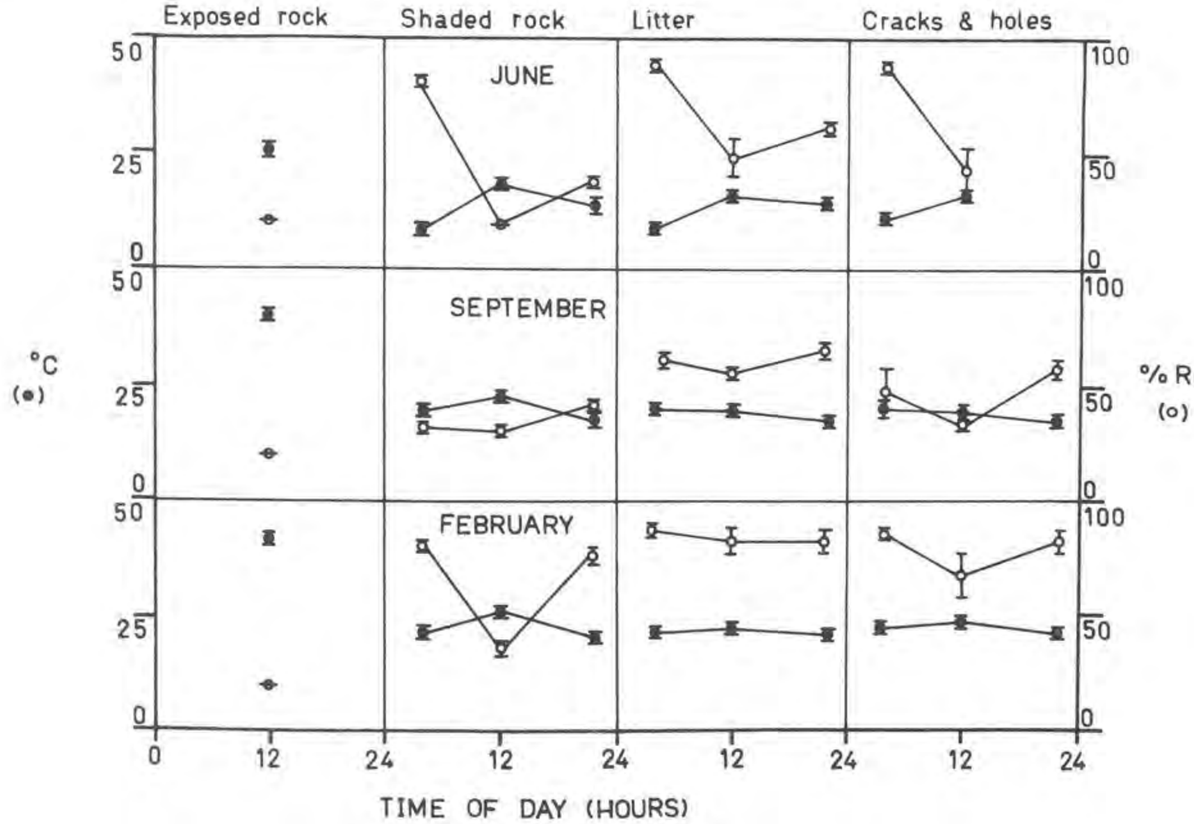

FIG. 1 Microclimatic temperatures and relative humidities recorded in 4 habitats in the Rhodes Matopos National Park in June, September and February 1977/78. Vertical lines indicate standard error

* Ultrakust—Geratebau GMBH & Co., K.G., W. Germany
** Rotronic Ag. Switzerland

TABLE 1 The seasonal occurrence of adults of *Ixodes* (*Afrixodes*) *matopi* in the Rhodes Matopos National Park. Data are based on visual searches of bushes on which the presence of klipspringer mark sites was also recorded

	June		September		February	
	No. of bushes	No. with ticks	No. of bushes	No. with ticks	No. of bushes	No. with ticks
Marked bushes...............	77	0	47	0	48	20
Unmarked bushes.............	64	0	52	0	131	32

TABLE 2 The occurrence of *Ixodes* (*Afrixodes*) *matopi* on hosts sampled in the Rhodes Matopos National Park

Host	Date	Infestation			
		♂♂	♀♀	N	L
Procavia capensis..	7/VI/77			2	6
	7/VI/77			25	5
	8/VI/77			16	89
	8/VI/77			2	35
	6/IX/77			5	1
	6/IX/77			5	
	6/IX/77			7	
	31/I/78				44
	1/II/78				1
	6/II/78				4
	6/II/78				2
	8/II/78				
	3/III/79			1	306
	3/III/79				92
Heterohyrax brucei...	6/IX/77			2	
	31/I/78				20
Pronolagus crassicaudatus...................................	8/VI/78			48	13
	8/VI/78			16	11
	7/IX/77			74	25
	3/III/79				41
Oreotragus oreotragus.......................................	8/IX/77			69	1
	7/II/78	7	22		

Daily activity patterns

By flagging at different times of day (Fig. 2), it was established that both larvae and nymphs have well-defined daily activity patterns. Of all the larvae sampled only 14,7% were collected during the middle of the day. This was significantly less (P=0,005) than the number collected either in the early morning (46,7%) or evening (38,4%). Likewise, the number of nymphs sampled in the early morning (56,1%) was significantly greater (P=0,005) than the number sampled in the middle of the day (22,0%). The number of nymphs sampled in the evening (22,0%), however, was the same as the number sampled during the middle of the day.

Although quantitative data on the daily activity patterns of adults were not obtained, it was observed that individuals which were present on the tips of twigs in the early morning and evening frequently moved away during the heat of the day. Searches revealed the ticks under leaves or on shaded areas of the twigs as much as 15 cm away from the tips.

Distribution of larvae and nymphs

The frequency distributions of larvae and nymphs in the 4 habitats sampled are shown in Fig. 2. The habitat in which the greatest numbers of both larvae and nymphs were collected was litter (49,2% and 65,9% respectively). This was followed by bare rock (30,8%) and bushes (17,9%) in the case of larvae, and bushes (22,0%) and bare rock (12,2%) in the case of nymphs. No nymphs and only 2% of larvae were collected in cracks and holes amongst boulders. Although the trends were fairly consistent from season to season, the few anomalies that existed can probably be attributed to the low numbers of ticks sampled and their clumped distribution in the environment.

Distribution of adults

Adults were found only on the shrubs and bushes (predominantly *Securinega virosa*) which grew from cracks in rocks or close to rocks. The ticks were present both on bushes which had been marked by klipspringers and on unmarked bushes. The percentage of marked bushes on which the ticks were present (41,7%) was, however, significantly higher (P=0,05) than the percentage of unmarked bushes on which ticks were present (24,4%). On marked bushes the number of ticks collected from marked twigs was also significantly higher (P=0,007) than the number collected from unmarked twigs. There was, however, no significant difference (P=0,394) between the numbers of ticks per twig on marked and unmarked bushes. Out of a sample of 102 twigs on which ticks were present, 84% were located directly above rock and 16% above litter. The mean height of ticks above the substrate was 44,2 cm and the mean height of marked twigs above the substrate was 55 cm.

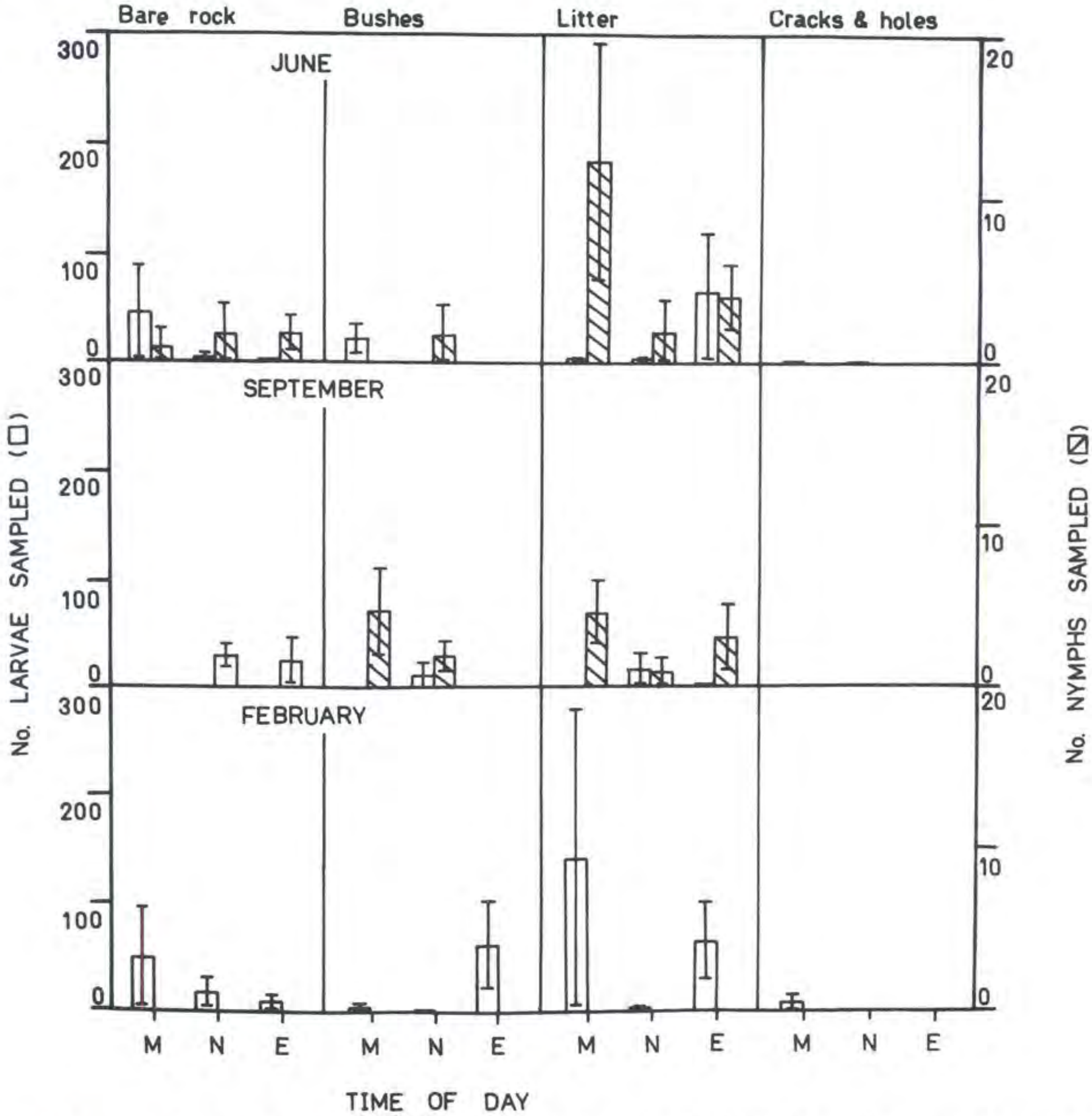

FIG. 2 The numbers of larvae and nymphs of *Ixodes* (*Afrixodes*) *matopi* collected by flagging (5 × 30 second sweeps) in 4 habitats in the Rhodes Matopos National Park in June, September and February 1977/78. Vertical lines indicate standard error

Hosts

Of the 15 vertebrate species sampled in the Rhodes Matopos National Park between 1975 and 1979, only 4 were parasitized by *I, matopi* (Table 3). These were klipspringers, red rock hares (*Pronolagus crassicaudatus*) and 2 species of hyraxes (*Procavia capensis* and *Heterohyrax brucei*), all of which live in the rocky habitats in which *I. matopi* occurs. With the exception of leopard and bushpig, all the vertebrate species on which *I. matopi* was not found live almost exclusively in the grassland and woodland areas between koppies.

Quantitative records of the occurrence of *I. matopi* on individual hosts, collected in each season, are given in Table 2. Adult males and females were found only on klipspringers. Larvae and nymphs were found on klipspringers, red rock hares and hyraxes. The largest infestation of larvae on a single host was recorded on a hyrax (*P. capensis*), while the largest infestation of nymphs on a single host was recorded on a red rock hare.

The attachment site of larvae and nymphs on all the hosts sampled was the feet and lower legs. On hyraxes a few larvae were also found in the anal region. On klipspringers the adult females were found attached on the underside of the body (chest, belly and groin) where the hair was sparse. The mouthparts of the females were deeply imbedded into the skin of the host and the sites of attachment were swollen and inflamed. Males were found unattached in the thick hair on the upper parts of the hind legs.

Sex ratios and mating

The ratio of males to females on the host was 1/3,1 as opposed to 1/1,4 on bushes. None of the males removed from the host were observed to be copulating, with females, nor were any of the males which were found on twigs. On 8 occasions, however, males and females which had been removed from twigs were seen to copulate in collection bottles.

TABLE 3 Infestations of *Ixodes* (*Afrixodes*) *matopi* on hosts collected in the Rhodes Matopos National Park

Hosts sampled	No. sampled	Infestation by *Ixodes matopi*		
		Nil	Immatures	Adults
RODENTIA				
Pedetes capensis (spring hare)	2	+		
LAGOMORPHA				
Pronolagus crassicaudatus (red rock hare)	4		+	
HYRACOIDEA				
Procavia capensis (rock dassie)	14		+	
Heterohyrax brucei (yellow-spotted dassie)	4		+	
ARTIODACTYLA				
Potamochoerus porcus (bushpig)	5	+		
Oreotragus oreotragus (klipspringer)	2		+	+
Aepyceros melampus (impala)	4	+		
Hippotragus niger (sable antelope)	10	+		
Damaliscus lunatus (tsessebe)	2	+		
Connochaetes taurinus (wildebeest)	4	+		
Taurotragus oryx (eland)	1	+		
Syncerus caffer (buffalo)	2	+		
PERISSODACTYLA				
Ceratotherium simum (white rhino)	7	+		
CARNIVORA				
Panthera pardus (leopard)	2	+		
STRUTHIONIFORMES				
Struthio camelus (ostrich)	4	+		

Discussion

This study has confirmed the finding of Rechav *et al.* (1978) that adults of *I. matopi* are specific parasites of klipspringers and are attracted to twigs that have been marked by these animals. Their response to the klipspringer secretion results in a clumped distribution of ticks on marked bushes and marked twigs and increases the probability of host location, as mark sites are frequently visited by klipspringers. On unmarked bushes, host location is facilitated by the migration of ticks to branches which occur directly above rocks and are frequently browsed by klipspringers. The height at which the ticks occur above the rock ensures contact with passing hosts.

Unlike the adults, the immature stages of *I. matopi* are not exclusively parasitic on klipspringers. Heavy infestations of larvae and nymphs frequently occur on hyraxes and red rock hares, which are present in large numbers in the rocky habitats. Parasitism of these hosts, which frequently use the litter-filled cracks and gaps between rocks as transit routes, is facilitated by the occurrence of larvae and nymphs on the litter. The nocturnal (red rock hares) and semi-noctural (hyraxes) habits of the hosts also coincide with the daily activity patterns of the ticks.

The stable humid microclimate of the leaf litter zone, together with the daily and seasonal activity patterns of the unfed ticks, are probably the most important factors ensuring the survival of the non-parasitic stages. The decline in larval and nymphal activity during the heat of the day when atmospheric humidity is low, was probably due to the ticks retreating into the more favourable microclimatic conditions within the mats of litter, in the same way that adults are observed to retreat from the exposed tips of twigs. The leaf litter zone probably also provides the microclimatic conditions in which oviposition, egg hatching and moulting can be successfully completed. The rigid seasonal cycle of *I. matopi*, in which adults occur only in the wet season, ensures that eggs are laid and larvae hatch at the time of year when microclimatic conditions are most humid. The highest numbers of nymphs occur in the 'cool dry' season when the leaf litter remains fairly humid. The 'hot dry' season, when microclimatic relative humidities drop considerably, is survived by the engorged nymphs which have an extremely long premoult period and can tolerate drier conditions than the other developmental stages (Colborne & Norval, unpublished data).

The limited distribution of *I. matopi* is undoubtedly accounted for by its specialized host and habitat requirements. The species is unlikely to survive outside areas in which large numbers of klipspringers, hyraxes and/or rock hares occur in a rocky environment and where suitable microclimatic conditions exist for the survival of the non-parasitic stages.

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