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LABORATORY INVESTIGATIONS ON THE LIFE-CYCLE OF *RHIPICEPHALUS THEILERI* BEDFORD & HEWITT, 1925 (IXODOIDEA: IXODIDAE)

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ABSTRACT

NEITZ, W. O., BOUGHTON, F. & WALTERS, H. S., Laboratory investigations on the life-cycle of *Rhipicephalus theileri* Bedford & Hewitt, 1925 (Ixodoidea: Ixodidae). *Onderstepoort J. vet. Res.* 39(2), 117-122 (1972).

Detailed data on the rearing of the progeny of a single *R. theileri* female for 7 generations at 25 to 26°C and 85 to 90% RH are presented in a series of tables and a figure. The average duration of the life-cycle is 491 days. The reason for the mortality rate of 96% of the immature stages in all batches during the prefeeding, feeding and premoulting stages is obscure.

INTRODUCTION

The description of the adult stages of *Rhipicephalus theileri* as a distinct species and as a parasite of the Cape ground squirrel, hedgehog and silver jackal in the Orange Free State by Bedford & Hewitt (1925) and Bedford (1932) was followed by a survey on the distribution of this species and its hosts by Theiler (1947, 1962). Specimens submitted for examination consisted of mature and immature stages. In the absence of reference specimens of larvae and nymphae we were approached to rear *R. theileri* under laboratory conditions. The successful breeding made it possible to supply all the developmental stages for taxonomic studies.

The published data as well as additional information on the distribution of immature stages supplied by Dr. G. Theiler, Veterinary Research Institute, Onderstepoort (personal communication, 1971) are listed in Table 1. The zoological nomenclature of the mammals is based on that proposed by Roberts (1951). The records show that *R. theileri* is widely distributed in South and South West Africa but in Rhodesia it has so far only been recorded in a single locality. Ticks have frequently been taken off wild carnivores and rodents but only once from an ox and twice from dogs. According to Theiler (1971) the record of "Chelonia - Tortoise" (Theiler, 1962) as a host is an incorrect entry.

Theiler (1947) concludes from her survey that this tick is apparently never abundant. This remark prompted us to extend the breeding programme with the hope of obtaining an explanation for the relatively low incidence of this species in nature.

MATERIALS AND METHODS

1. *Origin of the tick*

A single engorged *R. theileri* adult female, taken off a dog, was kindly supplied by Mr. J. S. Brown, P.O. Melville, Omaruru, South West Africa.

2. *Tick breeding*

The procedures for rearing three-host ixodid ticks described by Neitz, Boughton & Walters (1971), were employed. With the exception of the feeding periods, all the remaining developmental stages of *R. theileri* were maintained for 7 generations in the acaridarium at 25 to 26°C and 30 to 90% RH. The ticks were kept in glass tubes plugged with cotton wool and examined daily until metamorphosis had occurred. The dates of receipt, oviposition, hatching, infestation, detachment, moulting, the number of larvae, nymphae and imagines harvested and the identification numbers of the hosts were recorded in a tick register.

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3. *Tick hosts*

All stages were fed on the ears of female rabbits varying in age from 6 to 9 months. Ear-bags, secured around the base of the ears with Unna's paste, were used to retain the ticks on the hosts. From the 3rd day after infestation the ear-bags were opened daily for the collection of detached ticks. These were sorted out into tubes and retained in the acaridarium for further observation. Each rabbit was used once only for tick-feeding.

RESULTS

Details of the breeding results of 7 generations of *R. theileri* are listed in Tables 2 to 5. A summary of the results is presented schematically in Fig. 1.

Table 2 lists the observations on the duration of the oval, larval, nymphal and imaginal phases and those made on the number of immature and mature ticks harvested from each set of hosts. Table 3 gives the average duration of the 4 phases and the average numerical tick yield from individual hosts. In Table 4 appear the minimum, maximum and average durations of each phase used for determining the duration of the life-cycles. Table 5 records the numerical and percentage larval to nymphal, nymphal to imaginal and larval to imaginal decreases.

Data presented in these tables and figure are self-explanatory so that it will be only necessary to consider the outstanding observations made on (a) the life-cycles and (b) the tick harvests.

(a) *Duration of the life-cycles*

Table 2 shows that the progeny of the female, represented by 1 (F1), 2 (F2), 2 (F3), 1 (F4), 3 (F5), 1 (F6) and 1 (F7) batches were able to complete their life-cycles when maintained in the acaridarium over a period of 9 years.

Interesting observations are the wide variations in the duration of the oval phases and the feeding and premoulting periods even though the ticks had been maintained at constant temperature and relative humidity levels. The persistence of the adult feeding period for up to 26 days is the longest yet recorded for any of the laboratory bred *Rhipicephalus* spp.

It will be seen from Table 4 that no systematic attempts were made to determine the minimum and maximum duration of the prefeeding periods of the three stages. Had this been done the differences in the duration of the life-cycles would have been either greater or less. In all instances the lengths of the prefeeding periods were made to fit in with the laboratory routine and thus do not reflect the minimum hardening

TABLE 1 Hosts and distribution of *Rhipicephalus theileri*

Host			Region				
Class Order Family	Genus and species	Vernacular names	Tick stages and date of collection	Country	Province	District (Locality)	Authorities
Mammalia Lipotyphla Erinaceidae	*Aethechinus frontalis frontalis* (A. Smith) (= *Atelerix frontalis* = *Erinaceus frontalis* A. Smith)	South African hedgehog Krimpvarkie	♂♂ —	RSA	OFS	Petrusburg	Bedford & Hewitt, 1925; Bedford, 1932
Carnivora Viverridae	*Atilax paludinosus* (G. Cuvier)	Water mongoose Kommetjiegatmuishond	LL, NN 18.7.57	RSA	TVL	Pilgrim's Rest (Newington)	Theiler, 1971
	Cynictis penicillata (G. Cuvier)	Yellow mongoose Geelmeerkat Rooimeerkat	♀♀ *30.11.40 *30.11.41	RSA	OFS	Edenburg (Vaalbank) Jacobsdal (Rooidam)	Theiler, 1947
	Cynictis penicillata ogilbyi (A. Smith)	Yellow mongoose Geelmeerkat	♀♀, ♂♂, LL, NN 20.10.40	RSA	OFS	Edenburg (Vaalbank) Jacobsdal (Rooidam)	Theiler, 1947
	Cynictis sp.	Yellow mongoose	*LL, NN —	RSA	OFS	Luckhoff	Theiler, 1962
		Geelmeerkat	*NN —	Botswana	—	Ngamiland (Shushong, Toteng)	Theiler, 1962
			*NN —	SWA	—	Outjo (Franzfontein Reserve)	Theiler, 1962
	Suricata suricatta hamiltoni Thomas & Schwann	Suricate Graatjiemeerkat Stokstertmeerkat	♀♀ LL, NN *28.10.40 *16.11.40	RSA	OFS	Edenburg (Vaalbank)	Theiler, 1947
			♀♀ *30.11.40	,,	,,	Jacobsdal (Rooidam)	Theiler, 1947
	Suricata sp.	Suricate Stokstertmeerkat	LL, NN —	RSA	WCP	Gordonia (Vanzylsrus, Kuruman River)	Theiler, 1971
Canidae	*Canis familiaris* Linn	Dog Hond	*♀♀ *8.12.60	SWA	—	Omaruru (Melville)	Theiler, 1962
			LL, NN —	RSA	ECP	Adelaide (Makazana)	Theiler, 1971
	Vulpes (*Cynalopex*) *chama* (A. Smith) [= *Vulpes chama* (A. Smith)]	Silver jackal Cape Fox Silwerjakkals	♂♂ —	RSA	OFS	Petrusburg	Bedford & Hewitt, 1925 Bedford, 1932 Theiler, 1947
	Thos mesomelas mesomelas (Schreber) (= *Canis mesomelas* Schreber)	Black-backed jackal Rooijakkals	♂♂, ♀♀ —	RSA	OFS	Boshof (Du Toit's Kuilen)	Theiler, 1971
	Not stated	Jackal	NN —	SWA	—	Etosha Pan National Park	Theiler, 1971
	Not stated	Jackal	—	RSA	WCP	Gordonia (Kalahari National Gemsbok Park)	Theiler, 1971

Artiodactyla Bovidae	*Bos taurus* Linn	Ox Bees	* ♀♀ *8.12.60 *♀♀, NN *3.5.61	SWA	—	Omaruru (Melville)	Theiler, 1962
Rodentia Sciuridae	*Geosciurus inauris* (Zimmermann) [= *Geosciurus capensis* Thomas = *Xerus capensis* Jentink = *Xerus inauris* (Zimmermann)]	Ground squirrel Waaierstertmeerkat	♂♂, ♀♀ *15.8.21 ♀♀ *20.10.45 ♀♀ *30.11.41 * ♀♀ *22.5.56	RSA „ „ „	OFS „ „ WCP	Bloemfontein (Glen) Bloemfontein (Elandsbult) Jacobsdal (Rooidam) Gordonia (Kalahari Gemsbok National Park. Rooiputs, Nossob River. Ellis-Kolk)	Bedford & Hewitt, 1925; Bedford, 1932 Theiler, 1947 Theiler, 1947 Theiler, 1962
	Geosciurus sp.	Ground squirrel Waaierstertmeerkat	*LL, NN — *LL, NN — *NN *24.2.50	RSA SWA „	WCP — —	Gordonia (Vanzylsrus) Gibeon (Gibeon) Gobabis (Otjimukande 178, Reitz, 23)	Theiler, 1962 Theiler, 1962 Theiler, 1947
	Geosciurus sp.	Ground squirrel Waaierstertmeerkat	*LL, NN — * NN *17.2.50 * ♀♀, NN *22.3.50	SWA „ „ „	— — —	Karibib (Otjimbojo 47) Windhoek (Onderkaremba, Progress) Rehoboth (Tsumis 147)	Theiler, 1962 Theiler, 1962 Theiler, 1962
	Paraxerus cepapi cepapi (A. Smith) [= *Paraxerus cepapi* (A. Smith)]	Smith's bush squirrel Yellow-footed squirrel Geelpoot-eekhorinkie	LL, NN 15.8.57 LL, NN —	RSA Rhodesia	TVL —	Pilgrims's Rest (Newington) Gwelo (Brockly Estate)	Theiler, 1971 Theiler, 1971
Otomyidae	*Otomys irroratus* Brants	Vlei otomys, Swamp rat Vleimuis	NN 12.6.41	RSA	ECP	Port Alfred	Theiler, 1971
	Otomys sp.	Vlei otomys Vleimuis	NN January, 1942	RSA	WCP	Clanwilliam (Lamberts Bay)	Theiler, 1971
	Myotomys sp.	Bush otomys Boskaroomuis	NN September, 1941	RSA	ECP	Uniondale	Theiler, 1971
Muridae	*Aethomys namaquensis namaquensis* (A. Smith) (= *Rattus namaquensis*)	Namaqua rock mouse Golden rat Namakwalandse klipmuis	*NN —	SWA	—	Okahandja (Okahandja)	Theiler, 1962

Legend: OFS = Orange Free State
TVL = Transvaal
ECP = Eastern Cape Province
WCP = Western Cape Province

RSA = Republic of South Africa
SWA = South West Africa
LL = Larvae
NN = Nymphae

♂♂ = Adult males
♀♀ = Adult females
* = Additional data supplied by Theiler, 1971

TABLE 2 Observations on the life-cycle of *Rhipicephalus theileri*

Rearing of ticks for 7 generations (Gen) on rabbits (R). Duration of the pre-oviposition (Pre-ov), oviposition plus hatching (Ovip & Hatch), *prefeeding (Pref.), feeding (Feed), premoulting (Prem) periods is given in days. Total number (No) of ticks harvested from each host group is listed

Batch No.	Date	Gen	Oval phases		Larval phases					Nymphal phases					Imaginal phases			
			Pre-ov	Ovip & Hatch	Pref	Hosts	Feed	No.	Prem	Pref	Hosts	Feed	No.	Prem	Pref	Hosts	Feed	No.**
2521	3.12.60	1	13–21	47–50	8	2R	4–12	371	17	24	2R	4–12	160	17–18	47–149	4R	5–11	42 & 26
2591	22.2.61	2	11–14	66–68	62	7R	4–12	3074	20–21	171	5R	5–14	249	35–36	11–14	4R	8–17	42 & 42
2616	1.11.61	2	12	66	22	2R	4–9	305	17–18	343	1R	8–12	42	26	226	1R	10–14	4 & 4
2757	2.2.63	3	15	92	183	1R	5–10	216	14	37	2R	6–12	46	27	175	1R	11	1 & 1
2758	4.2.63	3	11	56	183	1R	4	18	20	32	1R	5–12	18	32	346	1R	4	1 & 1
2849	17.2.64	4	11–14	55–59	55	2R	5–13	905	21	140	4R	4–13	419	33–36	318	3R	9–14	18 & 13
3005	3.12.65	5	7–14	53–54	38–66	4R	4–12	1147	26–28	87	4R	4–14	292	17–25	243–244	4R	8–16	11 & 10
3008	3.12.65	5	9–10	47–61	59	1R	4–12	1283	22	121–344	2R	6–12	258	23–24	218–515	3R	15–26	8 & 11
3009	6.12.65	5	13	43	59	2R	4–12	902	22	344	1R	8–12	6	25	117	1R	9	2 & 2
3106	28.6.67	6	5–15	49–66	40–46	2R	5–11	726	13	27–123	6R	4–15	603	21–23	69–196	7R	5–20	77 & 46
3137	6.3.68	7	12	63	70	2R	4–11	570	14	14	3R	7–16	113	21–25	21	2R	9–10	6 & 4

*See comments in text
**42 & 26 = 42 females and 26 males

TABLE 3 Average and total duration in days of the different developmental phases and total number of immature and mature ticks harvested

Developmental phases	Pre-oviposition period			Oviposition & hatching period			Prefeeding period			Feeding period	Premoultin period			Total period	No of ticks harvested			Average life-span
	Total	Sub-B	Av	Total	Sub-B	Av	Total	Sub-B	Av	Av	Total	Sub-B	Av		Total	Sub-B	Av	
Oval	354	30	12	1668	29	58	—	—	—	—	—	—	—	70	—	—	—	
Larval	—	—	—	—	—	—	1553	26	60	8	498	25	20	88	9517	26	366	491
Nymphal	—	—	—	—	—	—	3586	32	112	10	831	31	27	149	2206	31	71	
Imaginal	—	—	—	—	—	—	6933	40	173	11	—	—	—	184	372	31	12	

Legend: Av = Average
Sub-B = Sub-batches

TABLE 4 The possible minimum, maximum and average duration of the life-span in days of *R. theileri* based on that of the different developmental phases

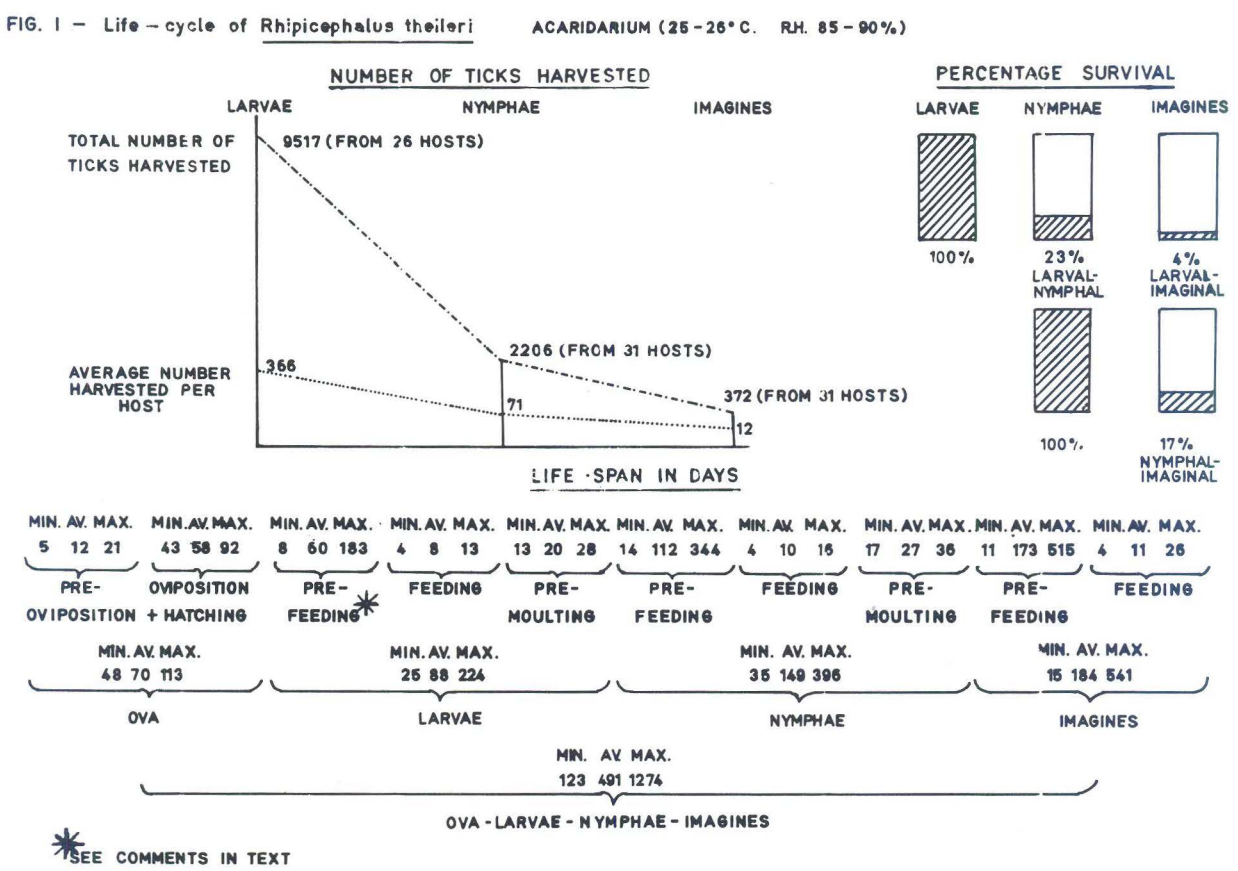
Developmental phases		Periods			Total duration for each phase		
		Min	Max	Av	Min	Max	Av
Oval	Pre-oviposition	5	21	12	48	113	70
	Oviposition & hatching	43	92	58			
Larval	Prefeeding	8	183	60	25	224	88
	Feeding	4	13	8			
	Premoulting	13	28	20			
Nymphal	Prefeeding	14	344	112	35	396	149
	Feeding	4	16	10			
	Premoulting	17	36	27			
Imaginal	Prefeeding	11	515	173	15	541	184
	Feeding	4	26	11			
	Total periods	123	1274	491	123	1274	491
Total periods excluding prefeeding periods							146

Legend: Min = Minimum
Max = Maximum
Av = Average

TABLE 5 The numerical and percentage stage to stage decreases of ticks

No of ticks harvested			Numerical decrease			Percentage decrease		
L	N	I	L to N	N to I	L to I	L to N	N to I	L to I
9517	2206	372	7311	1834	9145	77	83	96

Legend: L = Larvae
N = Nymphae
I = Imagines



or maximum survival periods for each stage. The results nevertheless show that there is a marked difference between the two extremes. Within these routine laboratory restrictions the prefeeding periods for larvae varied from 8 to 183 days, for nymphae from 14 to 344 days and for imagines from 11 to 515 days. The average duration of the life-cycle was 491 days, that of the total enforced prefeeding period 345 days which occupied a significant portion of the life-span.

(b) *Tick harvests*

A total of 17 adult females was used for breeding. Egg production by a single female was estimated to vary approximately between 1500 to 2000. Hatching as judged from the large number of egg shells in relation to the small number of partially dehydrated eggs was good but the mortality rate of larvae during the prefeeding period was estimated to be more than 50%.

The number of immature and mature ticks harvested from each set of hosts (Table 2) and from individual animals (Table 3) varied a great deal. A variable number died during the feeding period and soon after detachment. As many as 1283 engorged larvae, 136 engorged nymphae and 12 replete adult females were harvested from individual animals. The average yield per animal was 366 larvae, 71 nymphae and 12 adults.

The numerical and percentage decreases from larval to nymphal, nymphal to imaginal and larval to imaginal stages are recorded in Table 5 and Fig. 1. The mortality rate was extremely high among the immature stages and the percentage decrease from larvae to imagines was 96%.

Although large numbers of larvae, nymphae and adults were fed on 88 rabbits none of them showed any sign of illness other than small raised areas at the tick-infestation sites. Relatively few suppurated and healing was complete within 10 days after tick detachment.

Discussion and Conclusion

The breeding results of *R. theileri* presented in Fig. 1 show that this species possesses features which make it possible for it to complete its life-cycle at 25 to 26°C and 85 to 90% RH.

The larval hatchings were good but reasons for the high mortality of the immature stages during prefeeding, feeding and premoulting stages are obscure. Furthermore, no explanation can be given for the marked differences between the minimum and maximum duration of the life-cycles.

The specified temperature and humidity levels for tick-breeding were maintained throughout the course of these studies. In contrast the climate in the natural habitats of hosts and ticks is subject to a great deal of variation. In mongoose, suricate, ground squirrel and jackal burrows it can be expected that the temperature and humidity levels would be stable but less so in the grass nests or shelters constructed over shallow holes or between rocks and in the intercurrent tunnels consisting of matted vegetation built by vlei and bush otomyses and Namaqua rock mice. Around the haunts the climate would vary according to the unpredictable combinations of temperature, humidity and solar radiation from one season to another.

Although the tick-breeding results cannot be said to give a true reflection of the behaviour of ticks under all climatic conditions, they nevertheless do reveal hitherto unknown facts about the duration of the developmental phases which give an explanation for the survival of *R. theileri* under adverse conditions.

The micro-climate in the burrows, holes and grass structures would promote the development of ticks. The development of ticks exposed to adverse conditions around the haunts would in these circumstances be delayed. An extended duration of the developmental phases would offer additional protection to larval embryos and to engorged larvae and nymphae during the premoulting stage until the advent of warmer weather when hatching and moulting would occur under favourable conditions. The different tick stages would then be able to search for hosts in order to continue their development.

Summary

1. The known distribution of *R. theileri* and its hosts in South and South West Africa and Rhodesia is presented in tabular form.
2. Attempts to rear this species for 7 generations at specified and constant temperature and humidity levels were successful.
3. Rabbits were used to feed the immature and mature stages.
4. A series of tables and a figure are included to show the duration of the four developmental phases and the number of ticks harvested.
5. Reasons for the high mortality among the immature and mature stages and the variation in the duration of the life-cycles of the tick batches are obscure.

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