STUDIES ON THE COMMON TICKS AFFECTING LIVE-STOCK IN KERALA

BY

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THESIS

Submitted in partial fulfilment of the

requirements for the degree

DOCTOR OF PHILOSOPHY

Faculty of Veterinary and Animal Sciences

Kerala Agricultural University

Department of Parasitology

COLLEGE OF VETERINARY AND ANIMAL SCIENCES

Mannuthy - TRICHUR

1980

CERTIFICATE

Certified that this thesis, entitled "Studies on the common ticks affecting live-stock in Kerala" is a record of research work done independently by Sri. K. Rajamohanan under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to him.

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M a n n u t h y,
21st March 1980.

DECLARATION

I hereby declare that this thesis entitled "Studies on the common ticks affecting live-stock in Kerala" is a bonafide record of research work done by me during the course of research, and that the thesis has not previously formed the basis for the award to me to any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

M a n n u t h y,
21st March 1980.

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ACKNOWLEDGEMENTS

I wish to record my sincere gratitude to Dr. R. Kalyana Sundaram, G.V.Sc., D.V.M., M.S., Ph.D., Professor of Parasitology, College of Veterinary and Animal Sciences, Mannuthy, under whose inspiring guidance this work was carried out.

I may express my heart-felt thanks to Dr. P.K. Abdulla, Dr. M. Krishnan Nair, Dr. E.P. Pally and Dr. M.K. Rajagopalan, the members of my Advisory Committee, for their valuable suggestions during all stages of this work.

I am deeply indebted to Dr. Vijay Dhanda, Asst. Director, National Institute of Virology, Pune, for helping in the identification of the ticks and also for imparting to me a short-term training in different laboratory proceedures relating to ticks.

I am also grateful to Mrs. C. Syamanthakam for help in the preparation of manuscript, to the staff of the department of Parasitology, College of Veterinary & Animal Sciences, Mannuthy for all the assistance rendered during the course of this research work, and to the Kerala Agricultural University for sanctioning this research project.

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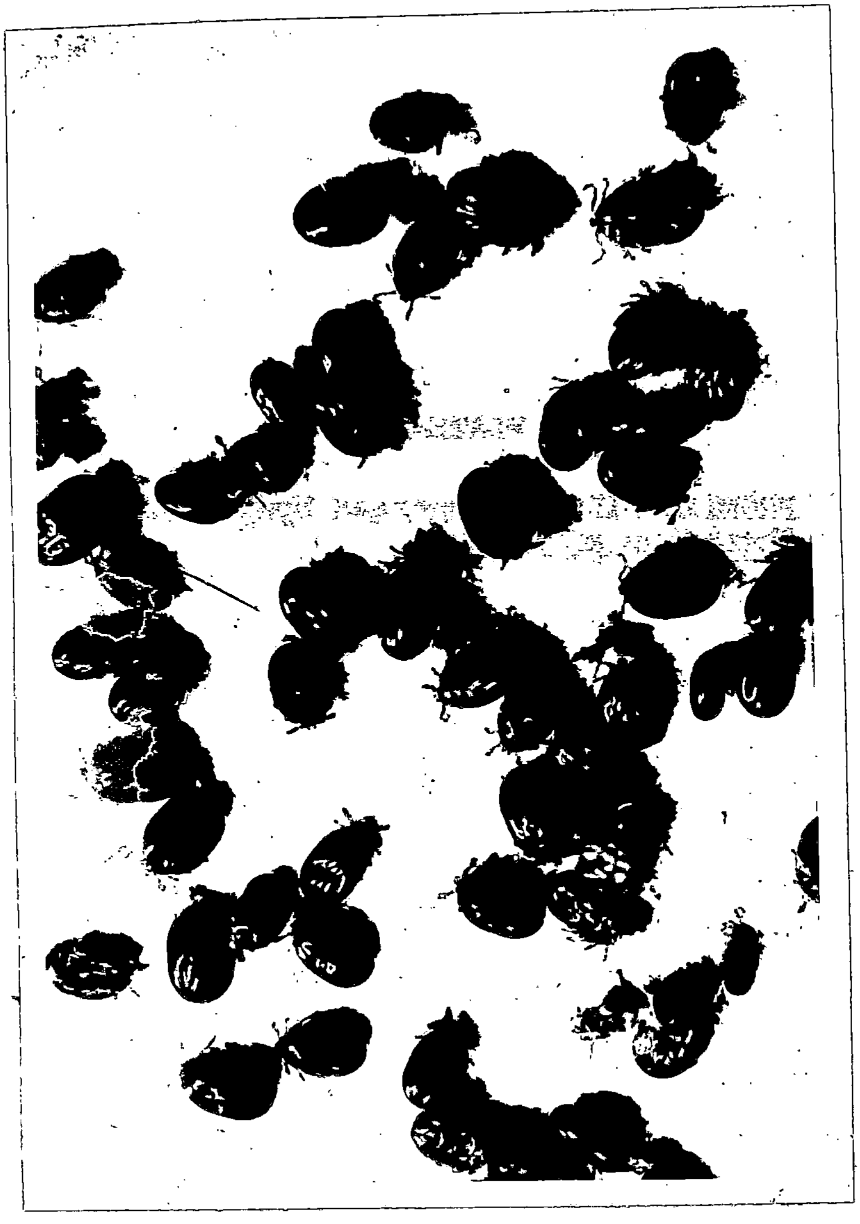
LIST OF ILLUSTRATIONS

KEY TO LETTERING

Acs	-	Accessory shield
As	-	Adanal shield
C I	-	Coxa-I
E	-	Eye
Lp	-	Large Punctations
PsI	-	Palpal segment I
PsII	-	Palpal segment II
PsIII	-	Palpal segment III
Sc	-	Scutum
Sp	-	Spiracular plate
Spu	-	Small punctations



INTRODUCTION

Ticks are obligate ecto-parasites. About 800 species of ticks are known, mostly from the tropics and sub-tropics and a few species in Penguin and Marine bird nests even in circumpolar region. Often great population densities of one or two species build up in temperate forests, prairies and steppes. Some tick-groups are adapte to deserts and semi-deserts where most other blood sucking arthropods fail to survive. Two Amblyomma species of marine amphibians like snakes and lizards are unaffected by sea water, proving the extent of their tenacity to remai as ecto-parasites.

Ticks are perhaps the most important haematophagus arthropods known. The role of ticks in human economy merit special consideration, for not only are they annoying pests but in temperate and tropical countries, they surpass all other arthropods in the number and variety of diseases whic they transmit to man and his domestic animals. As transmitters of human diseases alone, they run mosquitoes t a close second.

Regarding blood loss due to ticks alone, Hunter and Hooker (1907) estimated that about 200 pounds of blood may be sucked up from one large animal-host in a single season.

Anaemia and death due to blood loss are not un-common in tick infested domestic animals. Balashov (1969) has given a comparative statement of the amount of blood ingested by female ticks of different species from experimentally infected rabbits and bullocks. Jellison and Kohls (1938) recorded that one female of Dermacentor andersoni will suck 1.7 to 2 gms. of blood. The unfed and engorged ixodid weight difference does not reflect the exact amount of blood ingested during feeding because much blood is digested and assimilated during the feeding stage and also large quantities pass through the intestine in a slightly modified form and are excreted with the faeces while the tick is still on the host. The exact blood volume ingested is known only for females of four species (Dermacentor andersoni, Ixodes recinus, Haemaphysalis bispinosa and Boophilus microplus), and this quantity exceeds by several times the weight of completely engorged ticks.

The irritation and injury caused by tick bites lead to dermatitis and allergic reaction on the skin of the host. Pervomaisky et-al (1963) made detailed studies on the host skin reactions at the attachment sites of ticks. On rabbits experimentally infected with Hyalomma asiaticum, they recorded leucocytic infiltration, dermal oedema and rapid proliferation of connective tissues at attachment sites. Cutaneous reactions caused by repeated tick feeding, are

thought to be vertebrate host defence response after sensitisation by tick salivary antigens. The hide & skin enquiry committee of Government of India in their report remarked that ticks follow next to warble flies in causing damage to skins & hides. They estimated the damage to the hides and skins to the tune of several lakhs of rupees every year.

Together with it's antigenic effects, saliva undoubtedly causes general host toxicosis. In certain ixodids, the saliva contains a very strong toxin causing paralysis in domestic animals and man. Tick paralysis is common during parasitism by Dermacentor andersoni, D. variabilis, and Amblyomma maculatum in North America, Ixodes ribicundus in South Africa and Ixodes holocyclus in Australia (Arthur 1962, Gregson, 1962).

One of the most significant discoveries which probabl also stimulated further investigations into ticks was that of the transmission of the texas fever pathogen by Boophilu annulatus. This discovery made by Theobald Smith and Kilbourne (1893) was the first instance in history in which the transmission of a protozoan parasite by an arthropod was observed. It pre-dated the mosquito malaria hypothesis of Manson by one year. The study of tick borne diseases ha immeasurably advanced since the time of Smith and Kilbourne

The discovery that ticks in different parts of the world transmit pathogenic spirochaetes, bacteriae, virus, rickettsiae and protozoa has resulted in pathological investigation of affected hosts, the distribution of the disease in relation to different tick species, the method of transmission of the pathogens and of the behaviour of pathogens within the vector. The following list of pathogens transmitted by ticks will give a comprehensive idea about the importance of ticks in relation to disease transmission.

Viruses Transmitted by Ticks

1. Colorado Tick Fever (USA).
2. Spring summer encephalitis in Russia.
3. Kyasanur Forest Disease.
4. Japanese type 'B' encephalitis.
5. Four strains of haemorrhagic fever virus in Russia & Crimia.
6. Nairobi Sheep disease.
7. Louping ill
8. Equine encephalo myelitis
9. Ganjam virus.
10. Malaya virus.

Rickettssiae

1. Rickettssia rickettssi
2. Coxellia burneti
3. Rickettssia conori
4. R. ruminentium
5. R. bovis.
6. R. canis
7. R. australis
8. Anaplasma marginale
9. Anaplasma centrale

Spirochaets

1. Borrellia duttoni
2. B. anserina
3. B. gallinarum
4. Borrellia theileri
5. Leptospira ieterohaemorrhagiae
6. Leptospira pomona

Bacteria

1. Pasturella tularensis
2. Pasturella pestis
3. Brucella abortus
4. Brucella melitensis
5. Klebsiella paralytica

Protozoa

1. All *Babesia* sp.
2. All *theileria* sp.
3. *Aegyptionella* sp.
4. *Hepatozoan canis*

No systematic work has so far been conducted in Kerala to ascertain the prevalence, bionomics, control and other aspects of tick infestation, affecting the health and productivity of livestock.

An attempt was made, therefore, to ascertain the prevalance of the species of ticks parasitising livestock and measures of chemical control of the common species.

INCIDENCE OF TICKS IN LIVE-STOCK IN KERALA

REVIEW OF LITERATURE

According to Hoogstraal (1970-1972) about 800 species of ticks are known throughout the world. A comprehensive list of literature on the incidence, bionomics and disease relationship has been published by Hoogstral (1970-72). The first report on the incidence of an ixodid tick in India was that of Linnaeus (1758). Later Rudow (1870) described Amblyomma bengalensis from python in West Bengal. Warburton (1913) recorded Haemaphysalis aponommoides from Himalayan cattle in India. Patton and Cragg (1913) could collect nymphs and adults of Hyalomma savignyi from calves from Madras State. Later, Geiger (1915) published a list of parasites of domestic animals in India in which he mentioned a few ixodid ticks.

Sharif (1924) recorded Hyalomma savignyi from different domestic animals and camels and described the external morphological features of Hyalomma aegyptium. A revision of the Indian ixodidae with all details of the ticks recorded in India upto 1928 was published by Sharif (1928). He concluded that Boophilus microplus and Hyalomm aegyptuim are the commonest cattle ticks throughout India Naik (1931) recorded the ticks of domestic animals in the costal tract of Karnataka (North Canara District).

An investigation on the tick fauna of Tamil Nadu (Madras State) was conducted by Alwar (1960). He recorded four species of Amblyomma, three species of Haemaphysalis and a species of Dermacentor. Later, Nagar (1962) surveyed the tick fauna of domestic animals in Delhi State. Hoogstraal and Trapido (1963) redescribed all the stages of Haemaphysalis intermedia and their co-types from India and Ceylon. A survey on the ticks present in North-east Frontier Agency, India, was conducted by Dhanda and Ramachandra Rao (1964).

They recorded 17 species of Ixodid ticks belonging to 6 genera; and also described Haemaphysalis nepalensis Sp. n. from sheep. Kaiser & Hoogstraal (1964) published a list of Hyalomma ticks of Pakistan, India and Ceylon. They also gave a key for identification of the different species of Hyalomma. Rao et-al (1964) described Amblyomma mudaliari Sp. n. from cattle and buffaloes in Tamil Nadu. But subsequently this was identified as Amblyomma integrum at virus Research Centre, Pune.

Trapido et-al (1964) gave a complete description of all the stages of the ticks of the genus Haemaphysalis recorded in South India. Trapido and Hoogstraal (1964) described a new species, Haemaphysalis cornigera shimoga

from domestic animals in South India. Dhanda (1964-a) recorded the occurrance of Haemaphysalis howletti in areas near Poona. He (1964-b) further reported Haemaphysalis nepalensis from NEFA, India. Arthur and Chaudhuri (1965) collected Nosomma monstrosum from buffaloes at Izatnagar and Banaras. Dhanda (1966) recorded a new species of tick, Rhipicephalus ramachandrai from Indian Gerbil in Mysore, Maharashtra and Utter Pradesh. The ixodid ticks of domestic animals in Madras were enumerated by Kamath (1967) who could identify 6 species belong to 4 genera. Dhana and Bhat (1968-a) recorded Haemaphysalis garhwalensis from sheep and goat in U.P. and the same authors (1968-b), described again a new species, Haemaphysalis indoflava, from dogs, jackals, fox, bullock and man in Himalayan region of Utter Pradesh and Madras. The presence of Nosomma monstrosum on domestic animals in Gujarat was recorded by Hiregaudar (1969). Anantharaman (1969) and Chaudhuri (1969) reviewed the literature on the incidence of ixodid ticks in Tamil Nadu in India. The occurrence of Rhipicephalus turanicus in domestic animals in various part of India was reported by Dhanda and Ramachandra Rao (1969). Dhanda & Kulkarni (1969-a) could collect Haemaphysalis cornupunctata from domestic animals in Himachal Pradesh. The same authors (1969-b) recorded Ixodes himalayansis from small mammals in Himachal Pradesh.

Hoogstraal (1970) described Haemaphysalis davisi from wild and domestic animals in Northern India, Sikkim and Burma. Varma and Mahadevan (1970) identified Amblyomma integrum, A. testudinarium, Boophilus microplus, Dermacentor auratus, Ixodes acutitargus, I. japanensis, I. kashmirensis, Haemaphysalis aponommoides, H.bispinosa, H. wellingtoni, Hyalomma marginatum issaci, Rhipicephalus sanguineus and R. haemaphysaloides from domestic and wild animals in Eastern Himalayas.

Sharma & Das (1970) recorded Boophilus decoloratus from Kashmir. Dermacentor raskemensis was collected from sheep, goat and yalk at Himachal Pradesh, Jammu & Kashmir, by Dhanda et-al (1971).

Later, Dhanda & Bhat (1971) recorded Haemaphysalis sundrai from sheep in Western Himalayas, and Hoogstraal et-al (1972) could collect H. anomala in North-east India.

The occurrence of Amblyomma javanense in Mysore State, was reported by Sreenivasan & Geevarghese (1972)

Ramachandra Rao et-al (1973) conducted a survey of Haematophagous arthropods in Western Himalayas, Sikkim and hill districts of West Bengal. They could collect 54 species of ixodid ticks belonging to 9 genera.

An investigation on the ticks affecting domestic

animals in Tamil Nadu was made by Jaganath et-al (1973-c). They recorded Boophilus annulatus, B. microplus, Rhipicephalus sanguineus, R. haemaphysaloides, Haemaphysalis intermedia, H. bispinosa and Hyalomma marginatum issaci.

Dhanda & Ebeneser Raja (1974) described Hyalomma (Hyalommina) hystricis Sp. n. from porcupine in Madras State.

The tick fauna of North-western India was studied by Miranpuri et-al (1975), who could record 32 species of ticks belonging to 7 genera.

A list of ticks and their hosts recorded so far from different parts of India is given below. (compiled from V.R.C. Museum, Poona).

DISTRIBUTION AND HOSTS OF IXODID TICKS IN INDIA

Genus - Ixodes

Sr. No.	Species	Recorded from (State)	Hosts
1.	Ixodes acutitarsus	NEFA, Assam, W.Bengal, Sikkim	Cattle
2.	I. ceylonensis	Karnataka, Maharashtra	Rodents & insectivore
3.	I. granulatus	Naga Hills, Assam, W.Bengal	Rodents
4.	I. garhwalicus (known only from typematerial) probably synonym of I. ovatus	Uttar Pradesh	Sheep

Sr. No.	Species	Recorded from (State)	Hosts
5	I. holocyclus	Exact location not known	Rodents
6	I. ovatus (previously referred to as I. japonensis)	U.P., NEFA, W.Bengal, Sikkim	Domestic & Wild animals
7	I. petauristae	Karnataka	Rodents, insectivores & other wild animals
8	I. radfordi	Assam	Rodents
9	I. kashmiricus (often misidentified as I. ricinus or I. persulcatus)	J.K., Punjab	Rodents, insectivores, other domes and wild animals
10.	I. himalayensis	J. & K. & H.P.	Rodents and Insectivore
11	I. granulatus		
	Genus - Amblyomma		
1	Amblyomma clypeolatum	Gujarat	Tortoise, birds
2	A. hebraeum	Assam	Tiger
3	A. integrum	Tamil Nadu, Orissa, Karnataka	Domestic & wild animals
4	A. nitidum	Andamans island	Sea snake
5	A. helvalum	Nicobar island	Reptiles
6	A. javanense (previously referred to as A. sublaeve)	W.Bengal, Gujarath, Maharashtra, Karnataka.	Wild Animals
7	A. supinoi	West Bengal	Tortoise

Sr. No.	Species	Recorded from (State)	Hosts
8	A. testudinarium	Assam, W.Bengal, Karnataka, NEFA, Sikkim.	Domestic & Wild animals
9	A. mudaliari	Tamil Nadu	Cattle
	Genus - Haemaphysalis		
1	Haemaphysalis aborensis	Assam, NEFFA	Wild animals
2	H. aculeata	Karnataka	Wild animals
3	H. aponommoides	West Bengal, NEFA, Sikkim	Birds, rodent insectivores domestic & wi animals, incl ing man
4	H. anomala	Bihar, NEFA, U.P., H.P.	Rodents, bird domestic & wi animals.
5	H. birmaniae	Assam, W. Bengal	Domestic & wi animals
6	H. bispinosa	Throughout India	Domestic & wi animals
7	H. doenitzi (previously known as H. centropi)	Karnataka, Gujarath, Maharashtra	Birds
8	H. canestrinii	Throughout India	Mostly Carniv res, rodents Insectivores
9	H. cornigera cornigera	Assam	Wild animals
10	H. cornigera shimoga	Karnataka, Kerala, Assam	Domestic & wild animals

Sr. No.	Species	Recorded from (State)	Hosts
11	H. cornupunctata	Jammu & Kashmir, Himachal Pradesh, Nepal	Cattle, sheep & goats
12	H. campanulata	Kerala, Bihar	Wolf
13	H. cuspidata	Karnataka, Maharashtra	Domestic & wild animals
14	H. garhwalensis	U.P., Himachal Pradesh, Nepal	Rodents, domestic anim
15	H. himalaya	Uttar Pradesh, Himachal Pradesh, W. Bengal	Domestic and wild animals
16	H. hystricis	Assam, W.Bengal, NEFA	Tiger and Rodents
17	H. howletti	Maharashtra, J. & K.	Rodents and birds
18	H. indica (formerly known as H. leachi var indica)	Throughout India	Mostly Carniv res, rodents Insectivores
19	H. intermedia	Maharashtra, Karnataka, Orissa	Domestic & wi animals and birds
20	H. kashmirensis	Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh	Sheep & Goats Reptiles (immature Stage)
21	H. indoflava (previously misidentified as H. flava)	U.P., Tamil Nadu	Domestic and wild animals
22	H. kyasanurensis	Karnataka	Rodents, bird & wild animal
23	H. kutchensis	Gujarath, Rajasthan	Rodents, inse tivores, wild domestic anim & birds

Sr. No.	Species	Recorded from (State)	Hosts
24	H. kinneari (previously referred to as H. papuana kinneari in the literature)	Karnataka	Domestic and wild animals.
25	H. megalaimae	Karnataka	Birds (small green Barbet)
26	H. montgomeryi	Uttar Pradesh, Jammu & Keshmir, Himachal Pradesh, Punjab	Rodents, insectivores, domestic & wild animals
27	H. mimuta	Karnatka, Maharashtra, Uttar Pradesh	Birds
28	H. nepalensis	NEFA	Domestic & wild animals
29	H. obesa	Assam, W. Bengal	Monkeys
30	H. paraturturis	Bihar, Andhra Pradesh, Maharashtra, M.P.	Domestic and wild animals
31	H. ramachandrai	West Bengal, Himachal Pradesh	Domestic animals
32	H. silvafelis	Andhra Pradesh, Maharashtra	Jungle cat and birds
33	H. spinigera	Karnatka, Maharashtra, Tamil Nadu, U.P., M.P., Orissa, Andhra Pradesh, W. Bengal, Andaman Nicobar, Himachal Pradesh	Rodents, Insectivores, Domestic & wil animals and birds and man
34	H. sundrai	Uttar Pradesh	Sheep & goats
35	H. tezuensis	NEFA	Host unknown
36	H. turturis	Kerala, Tamil Nadu, U.P., Karnataka	Rodents, insectivres, birds, domestic & wil animals & man

Sr. No.	Species	Recorded from (State)	Hosts
37	H. wellingtoni	Assam, Karnataka, Andaman islands	Birds, rarely small animals
38	H. devisi	NEFA	Domestic and wild animals
39	H. darjeeling	West Bengal, Assam	Wild animals
40	H. cholodkovskyi (Previously referred to as H.sewelli)	Jammu & Kashmir, H.P.	Domestic animals
41	H. sambar	Kerala	Sambar (deer)
42	H. ornithophila	U.P., W. Bengal	Birds
43	H. heinrichi	Of doubtful occurrence in India	Carnivores

Genus - Hyalomma

1	Hyalomma marginatum issaci	Delhi, Bihar, Orissa, W.Bengal, M.P., U.P., Maharashtra, Andhra Pradesh, Karnataka, Nammu & Kashmir, NEFA	Domestic and wild animals and birds
2	Hyalomma marginatum turanicum	Gujarath, Maharashtra	Cattle, camels.
3	H. anatolicum anatolicum	Delhi, Gujarath, M.P. A.P., Maharashtra, U.P.	Domestic animals
4	H. dromedarii	Gujarath, A.P., Delhi	Domestic anima mainly on cam
5	H. detritum	Delhi, Bihar, U.P.	Domestic and wild animals
6	H. brevipunctata	Bihar, W. Bengal, Delhi, orissa, M.P., A.P., Tamil Nadu, Maharashtra, Gujarath	Domestic and wild animals

Sr. No.	Species	Record from (state)	Hosts
7	H. hussaini	Bihar, Orissa, M.P., A.P., Tamil Nadu, Karnataka, Maharashtra, Gujarath	Domestic animals
8.	H. kumari	Assam, U.P., Bihar, Orissa, Delhi, Punjab, Kerala, Gujarath	Domestic and wild animals
9.	H. hystricis	Tamil Nadu	Porcupine
	Genus - Rhipicephalus		
1	Rhipicephalus haemaphysaloides	Throughout India	Domestic and wild animals
2	R. turanicus	Delhi, W. Bengal, Maharashtra	Dog
3	Rhipicephalus sanguineus	Throughout India	Domestic and wild animals
4.	R. ramachandrai	Maharashtra, Karnataka, U.P.	Rodents
5.	R. Scalpturatus	Assam	Not known
6.	R. tricuspis	Maharastra (of doubtful occurrence)	Rates (only one record probably misidentified
7.	R. breviceps		
	Genus - Nosomma		
1	Nosomma monstrosum	Bihar, W. Bengal, Maharastra, Karnataka.	Domestic and wild animals

Sr. No.	Species	Records from (State)	Hosts
	Genus - Dermacentor		
1	Dermacentor auratus	Assam, W. Bengal, Bihar, U.P., Karnataka, NEFA	Domestic and wild animals
2	D. raskemensis	J. & K., H.P.	Yak, other domestic animals
3	D. atrosignatus	U.P.	Not known
	Genus - Boophilus		
1	Boophilus microplus	Throughout India	Domestic and wild animals
2	Boophilus annulatus	Karnataka	Domestic animals
	Genus - Aponomma		
1	Aponomma gervaisis	Throughout India	Reptiles
2	A. gervaisis var lucasi	Throughout India	Reptiles
3	A. laeve	Karnataka, Tamil Nadu	Reptiles
4	A. pattoni		

The recorded incidence of ticks affecting domestic animals in Kerala, pertains to old Malabar, Cochin and Travancore of the erstwhile Madras Presidency. Among the species recorded were:-

1. Amblyomma integrum - Kerala (Alwar 1960)

2. Haemaphysalis bispinosa - Travancore (Nuttall and Warburton 1915)

3. Haemaphysalis campanulata - Travancore (Nuttall and Warburton 1915)

4. Haemaphysalis cornigera - Travancore (Nuttall and Warburton 1915)

5. Haemaphysalis turturis - Cochin (Sen 1938)

6. Hyalomma aegyptium - Cochin State (Sharif 1928)

7. Hyalomma (Hyalommina) kumari - Cochin (Sharif 1928)

MATERIALS AND METHODS

1. Examination of animals for collection of Ticks

The following domestic animals were examined for finding out tick infestation.

Cattle, buffaloes, dogs and goats.

Examination of animals and collection of ticks were carried out in Kerala for a period of 4½ years from 1974 to 1979. Regular examination of animals was carried out at Veterinary Hospital, Trichur. The two cattle farms under the Kerala Agricultural University i.e. Thiruvazhumkunnu and Thumboormuzhi were also visited at regular intervals for examination of animals. All the 11 districts of Kerala were covered for examination, and collection of ticks was carried out throughout the year except during the dry season of April/May. The following is a list of places visited for examination of animals and collection of ticks.

Trivandrum District

Coastal area	- Pettah, Sankumugham
Mid land	- Parassala, Neyyattinkara, Kudeppanakkunnu, Sreekaryam, Attingal, Nedumangad
High land	- Palode, Vithura

Quilon District

Coastal area	- Ochira, Thevally, Mangad
Mid land	- Karunagappally, Adoor, Kundara, Perinad
High land	- Punaloor, Kulathoopuzha, Ranni

Alleppey District

Coastal area	- Kayamkulam, Ambalapuzha, Sherthalai, Kuthiathode
Mid land	- Chengannoor, Pandalam
High land	- Nil

Kottayam District

Coastal	- Nil
Mid land	- Kottayam, Changanassery, Ettumannoor, Palai, Kanjirappilly, Kuravilangad
High land	- Erattupetta, Mundakkayam

Idukki District

Coastal	- Nil
Mid land	- Nil
High land	- Munnar, Peermedu, Kolahalamedu, Vagamon, Thodupuzha, Udumanchola

Ernakulam District

Coastal	- Palarivattom, Paravoor, Palluruthy
Mid land	- Alwaye, Perumbavoor, Angamally, Thripunnithura, Moovattupuzha, Puthencruz, Kothamangalam
High land	- Nil

Trichur District

Coastal	- Vadanappilli, Kanjany, Kodungallur, Kunnamkulam.
Mid land	- Cherpu, Mannuthy, Ammadam, Trikkur, Pazhayannur, Vadakkanchery, Pattikkad, Mannamangalam, Kannara, Thumburmuzhi, Pariyaram
High land	- Sholayar

Palghat District

Coastal	- Nil
Mid land	- Vaniampara, Kizhakkumcheri, Kannambra, Chittelanchery, Alathur, Nemmara, Shoranur, Paraly
High land	- Attappady, Kozhinjampara, Thathamangalam, Mudalamada

Malappuram District

Coastal	- Kuttippuram, Ponnani, Parappanagadi
Mid land	- Manjery, Pandikkad, Thiruvezhumkunnu
High land	- Edakkara, Nilambur

Calicut District

Coastal	- Badagara, Quilandi
Mid land	- Kuttiyadi, Balussery
High land	- Meppady, S. Battery, Panamaram, Kalpetta

Cannanore District

Coastal	- Manjeswaram, Kasargode, Kanjangad, Tellicherry
Mid land	- Kumbala, Thalipparamba
High land	- Iritty, Kartikulam

In the above centres, the local Veterinary Hospitals and a number of houses were visited to examine animals. A total number of 680 tick infested animals were examined from the 11 districts of Kerala. Another 300 collections were made from Veterinary Hospital, Trichur during all the months in 1977.

Adult ticks were collected from the body of the animals by hand-picking and also by using small forceps. For inducing easy detachment, a cotton plug soaked in ether or chloroform was pressed at the sight of attachment in some cases. This method was found useful in keeping the structures of the ticks intact. The ticks thus collected were killed in 70% alchohol and were preserved either in 70% alchohol or in 10% formalin.

To find out the presence of developmentals stages of ticks in grass-lands, the flag-dragging method was adopted. For this purpose, a flag, 50 x 25 cms. size made up of white flannel cloth was used. The rough

side of the flag was dragged on the grass-lands three or four times and then examined to find out the different stages of ticks entangled in the cotton fibres of the flag.

All the ticks thus collected and preserved were examined under binocular dissection microscope to study their general body characters. The detailed studies were made using binocular zoom microscope and compound microscope.

For specific identifications, keys and descriptions given by Arthur (1960) Shariff (1928) Trapido et-al (1964) and Kaiser and Hoogstraal (1964) were followed. Measurements and drawings were made with the help of projection microscope.

RESULTS

Examination of all the tick specimens collected from different parts of Kerala showed that 9 species of ticks belonging to 5 genera of the family ixodiae are prevalent in the State. The host-war, district war and region war distribution of these ticks are given in Table-I, II and III respectively. Observation made on the prevalence of ticks during all the 12 months of 1977 at Trichur is given in Table-IV. The following are the ticks identified from Kerala.

1. Boophilus annulatus
2. Rhipicephalus sanguineus
3. R. haemaphysaloides
4. R. turanicus
5. Haemaphysalis bispinosa
6. H. turturis
7. H. spinigera
8. Hyalomma anatolicum

BOOPHILUS ANNULATUS

(Plates I, II, III & IV)

Boophilus annulatus:

The most common among the ticks of cattle in Kerala was found to be Boophilus annulatus (Table II & III). The geographical distribution is shown in Map (Plate

INCIDENCE OF TICKS IN KERALA

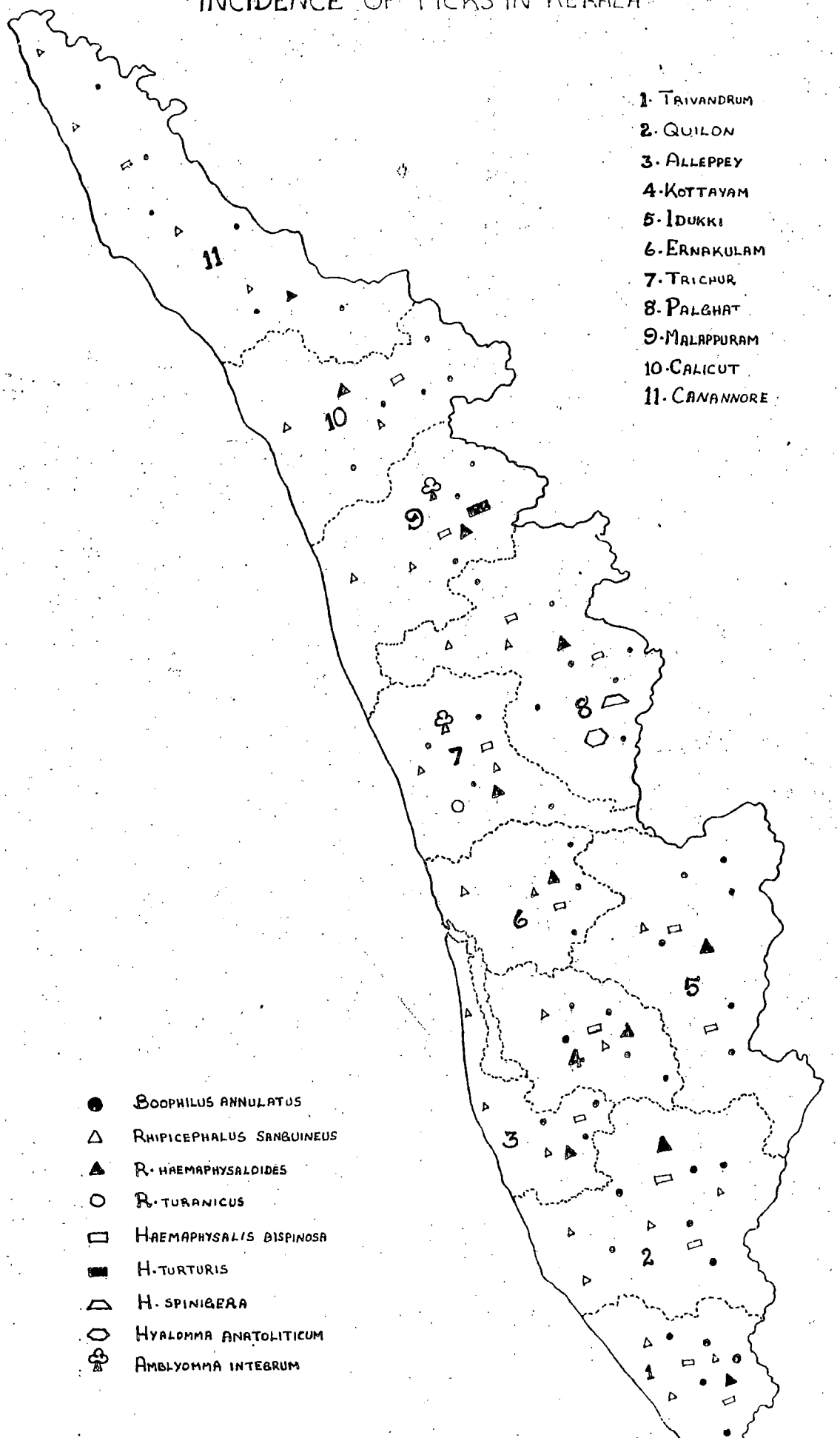


TABLE-I

Host-var distribution of ticks in Kerala.

*Host	B-annulatus	R.sanguineus	H.haemaphysaloides.	R.turanicus	H.bispinose	H.turturis	H.spinigera.	A.integrum	H.anatolitticum
Cattle	70%	4%	10%	..	15%	..	..	0.75%	0.25%
Buffalo	60%	..	..	..	39.5%	0.5%	..	..	..
Goat	30%	10%	8.3%	..	50%	..	1.7%	..	..
Dog	..	80%	..	20%	..	..	..	..	..

*Total number of animals from which collections were made:

Cattle - 400, Buffaloes - 20, Goats-60, Dogs-150.

TABLE-II

Overall district-var distribution of ticks in Kerala.

District	B-annulatus	R.sanguineus	R.haemaphysaloides.	R.turanicus	H.bispinosa	H.turturis	H.spinigera	A.integrum	H.anatoliticum
rivandrum	++++	+++	+	..	+	..	..	..	..
uilon	++++	+++	+	..	+	..	..	..	..
lleppey	++	+++	+	..	+	..	..	..	..
ottayam	++++	+++	+	..	++	..	..	..	..
dukki	+++++	++	+	..	++	..	..	..	..
rnakulam	++++	+++	+	..	+	..	..	..	..
richur	++++	+++	+	+	++	..	..	+	..
alappuram	++++	++	+	..	++	+	..	+	..
algha t	++++	++	+	..	++	..	+	..	+
alicut	++++	+++	+	..	++	..	..	..	..
annanore	++++	+++	+	..	++	..	..	..	..

below 10%, ++ between 10 to 30%, +++ between 30 to 50%, ++++ above 50% +++++ above 80%

TABLE-III

Region var distribution of ticks in Kerala

Sl. No.	Name of species	Coastal region.	Mid land region	High land region
1	Boophilus annulatus	++	+++	+++++
2	Rhipicephalus sanguineus	+++	+++	+++
3	R. haemaphysaloides	++	++	++
4	R. turanicus		+	
5	Haemaphysalis bispinosa	++	+++	++++
6	H. turturis		+	
7	H. spinigera		+	
8	Amblyomma integrum		+	
9	Hyalomma anatoli[illegible]cum		+	

+ below 10%, ++ between 10 to 30%, +++ between 30 to 50%

++++ above 50%, +++++ above 90%

TABLE-IV

*Percentage of tick infested animals among the animals randomly examined at Trichur in 1977

Period (1977)	Atmospheric temperature		Relative humidity.	Cattle	Buffalo.	Goat	Dog
	Max. (°F)	Min. (°F)	%	%	%	%	%
January	84.3	75.5	64.8	9	0	0	8
February	84.4	78.0	78.0	6	0	0	4
March	90.6	81.2	58.0	4	0	0	4
April	89.7	82.5	64.3	10	0	0	12
May	87.3	80.5	75.0	22	0	4	40
June	78.9	74.0	78.9	29	8	8	48
July	81.3	71.0	78.5	31	4	4	60
August	79.5	74.2	78.8	34	4	4	52
September	83.0	77.1	77.3	28	0	0	48
October	84.1	78.0	77.2	20	0	0	24
November	82.7	76.0	73.9	18	0	4	20
December	81.8	75.8	69.8	12	0	0	20

* Number of animals randomly examined monthly:-
Cattle - 100, Buffaloes - 25, Goats - 25, Dogs - 25.

They were found to be most abundant in the western ghats and hilly regions of Kerala. Heavy pure infestation with B. annulatus was recorded from Kolahalamedu, Kulathupuzha, Vagamon, Vithura, S. battery and Menanthody (Hill tracks). Combined infections with Haemaphysalis bispinosa, Rhipicephalus haemaphysaloides and R. sanguineus were also recorded from different areas of Kerala.

B. annulatus was found mainly on cattle let loose for grazing. In stall fed animals the incidence of infection was found to be nil. The incidence of infection in buffaloes was also very low. The observations made at Trichur during all the months in 1977 revealed that B. annulatus infection in buffaloes was only to a maximum of 8%. In many cattle sheds, buffaloes kept along with infested cattle were found to be free of infection with Boophilus. Among cattle, those with thick long hairs were found to be preferred by the ticks. In a heavy infestation, ticks were found on all the regions of the body, but they were found abundant on the dulap, perineal region, udder, ear, around the scrotum and axillary regions. As much as 60 nymphs could be collected from 1 sq. cm. area of skin in a naturally infested calf.

The male (Plate III Fig.1, Plate IV-B) The males were light brown in colour with glistening scutum. Their bodies were elongate and broadest at the region of opisthosoma. They measured on an average 2 mm x 1 mm in size. The eyes were prominent, white in colour arranged at the shoulders. Festoons were absent. There was no caudal appendage. The capitulum was short and small. The base was almost triangular with two slightly curved blunt arms. The palps were short, gradually tapering towards the tip. The segments were broader than long and their medial surfaces were distinctly excavated to accommodate the mouth parts. A small 4th segment which was very rudimentary, was also recognisable. The tip of the hypostome projected well above the level of the palps. The hypostomal dental formula was 4/4.

Short spurs were present at the posterior margins of all the 4 coxae. In the Ist coxa there was a hump anteriorly. The anal grove was not very distinct. On either sides of the anus, the adanal and accessory shields were present. These were very prominent chitinous structures found raised over the body surface. They were roughly triangular with broad posterior ends. The pointed external angle of the adanal sheild sometimes extended beyond the posterior margin of the body in preserved specimens.

The females (Plate II. Fig.1. Plate III. Fig.2) The unengorged females measured 3.5 - 5 mm x 2 - 3.5 mm in size. They were light to dark brown in colour. The engorged females were greenish blue in colour. Their size varied according to the degree of engorgement, and a fully engorged female measured on an average 9 x 6 mm in size. The scutum was broadest, at the centre and gradually tappered to a blunt point towards the posterior end. The eyes were present on either side of the broadest portion of the scutum. Other features were similar to males excepting for the absence of ventral shields.

RHIPICEPHALUS SANGUINEUS

(Plate V, VI, VII & VIII)

Rhipicephalus sanguineus was found to be the most common dog-tick in Kerala. (Table-I) In abundance it was just second only to Boophilus annulatus. It was present during all months of the year, but prevalence was more during July and August (Table-IV).

It attacked dogs of all species but the pomeranian breed of dogs were found to suffer much because of the thick long hairs and small size. Extreme anaemea and death due to R. sanguineus infestation was reccrded in 5 dogs observed in 1977 at Veterinary

Hospital, Trichur. Some of the other important complications recorded were dermatitis, Otorrhoea and haematoma auris. Rubbing the anus on the ground was a common symptom in dogs, where ticks were found around the anus.

This species was found mainly on dogs but rarely on cattle and goats also. In dogs they were found attached on all parts of the body, but the ears and the interdigital space were found to be the most common sites of attachment.

These ticks were uniformaly distributed on the coastal mid-land and hilly regions of all the districts in Kerala. (Table-III)

The males (Plate VI, VIII-A) The male specimens were reddish brown in colour. They measured on an average 3 mm x 1.5 mm in size. The cervical groves just below the base were short and appeared as oval pits. Lateral groves were narrow, deep and elongate commencing at a point slightly behind the eyes and ending at the festoons. There was an elongate oval posterio median groove. On either sides of this groove, two small additional ones were found in some specimen. The punctations were of different sizes. The larger ones were few but the smaller ones were numerous. The number of punctations were more on the anterior half than

on the posterior half. At the posterior end, the margin of the scutum and the festoons was very distinct.

In a number of specimens a short caudal appendage was present, formed by the median festoon alone or sometimes along with the two adjacent festoons.

The ventral side was yellowish to brown in colour. The coxae were longer than broad. The Ist coxa appeared to be bifid because of the presence of two strong closely placed unequal spurs. Each of the coxae II & III possessed a short spur near the external angle and a small round spur on the internal angle. Coxa IV possessed two short spurs, one at the external and the other at the internal angles. The pad attained half the length of the claws.

The anal groove was distinct and was posterior to anus. The prominant adanal shields were placed on either side of the anus and were raised above the ventral surface. The internal margin of the adanal shields were notched in the middle just opposite to the anus. The poorly developed accessory shields were also present on the lateral sides of the adanal shields. Only the posterior ends of the accessory shields were clearly found as raised conical chitinised points. The spiracles were longer than broad and were coma shaped.

The basis capitulum was hexagonal in shape and was broader than long. At the anterior half, it was 3 times as broad as long. The posterior three sides of the base were concave but the anterio lateral sides were almost straight. The cornua were short and blunt. The palps were twice as long as broad. Article 1 was fused with article 2 on the ventral aspect, but dorsally they were separate. Articles 2 & 3 were sub-equal. Article 2 was slightly narrow towards the proximal end. Article 3 was slightly broader than long and the extreme tip was bluntly rounded. The hypostomal dental formula was 3/3 with six to eight rows of teeth.

The females (Plate V, VII-A) The unfed females were reddish brown in colour with an elongate oval body, gradually narrowing towards the anterior end. The size varied from 2.5 to 3.5 x 1.2 to 2.00 mm. The engorged ones were dark-brown in colour. The scutum was oval or slightly hexagonal. The cervical grooves were prominent with a slight curve at the centre and reached upto the posterior margin of the scutum. The lateral grooves appeared to be formed by the fusion of large punctations. The punctations were of various sizes. The larger ones were few in number and were particularly scanty at the posterio-medial aspect. The small punctations were abundant and were scattered unevenly.

The spiracles were sub-triangular with a well pronounced posterio-dorsal angle. The coaxal armature was similar to that in male.

The capitulum was comparatively stronger than that of the male. Its length varied from 0.5 mm to 0.7 mm. The base was broader than that of the male and its maximum breadth was at the centre. The porose areas were roughly circular. The hypostomal dentition was 3/3 with nine to ten rows of teeth.

RHIPICEPHALUS HAEMAPHYSALOIDES

(Plate VII-B)

Rhipicephalus haemaphysaloides

This species was recorded from all the districts in Kerala and was found only on cattle and goats. In abundance it occupied a fourth place (Table-I,II,III)

The males: The male specimens were light to dark brown in colour, with a body size ranging from 2.5 x 1.5 to 4 x 2.8 mm. The body was oval with narrow anterior end. The broadest region of the body was at the level of the spiracles. Eyes were flat and large. The cervical grooves were represented by short converging pits anteriorly and as the grooves continued posteriorly they diverged gradually till then terminal point at the posterior margin of the scutum. The lateral grooves

commenced a little behind the posterio lateral angles of the scutum and included one or two last festoons. They were narrow but deep and enclosed a few large punctations. The posterio median groove occupied the posterior 1/3 of the scutum and was broad posteirorly but narrow towards the anterior end. The larger punctations were few but very distinct. The finer punctations were numerous and minute so that they were hardly visible. No caudal appendage was present. Adanal shields were prominent, sickle-shaped and in some cases resembling that of R. sanguineus. The accessory shields were poorly developed. The spiracles were comma-shaped and were twice as long as broad. The coxal armature resembled that of R. sanguineus, but the spurs were better developed. The entire capitulum was longer than broad and its length varied from 0.5 mm to 0.65 mm. The base was a broad hexagon dorsally and was twice as broad as long. Its broadest portion was on the anterior 1/3. Cornua were distinct and strong. Palps were long with slight external saliences in articles 2 & 3. Ventrally article 1 & 2 were fused, but dorsally they were distinctly separate. Article 3 was broader than long and carried a spur like rudimentary segment. The hypostomal dentition was 3/3 with 9 to 10 teeth in each row.

The females: The females resembled those of R. sanguineus in most of their characters. But the arrnagement of punctations served to distinguish the species from R. sanguineus. The larger punctations were very distinct on the scutum and the finer punctations were almost not visible.

RHIPICEPHALUS TURANICUS (Plate-VIII-B)

Rhipicephalus turanicus

This species was found among the ticks collected from dogs in Trichur. They resembled R. sanguineus in almost all respects, but for the differences detailed below.

1. In the male, there was a small conical super-like projection on the internal margin of the adanal shield.

2. In the spiracular plate there was a definite depression in the posterior 1/3 of its dorsal margin. The posterior tip of the plate was bent dorsally.

Much variations were observed in the external morphology of R. sanguineus and R. turanicus and there were many specimens which were atypical.

HAEMAPHYSALIS BISPINOSA

Plate IX, XIII-A)

Haemaphysalis bispinosa

This species was found to be the 3rd in abundance and was collected from all the 11 districts of Kerala. (Table I, II, III) It was found on cattle, buffaloes, goats and

rarely in dogs.

The males: The males were light brown or yellow in colour, measuring 1.5 to 2.5 x 1 to 1.5 mm. in size. The body was elongate oval, and broadest at the middle. The scutum was uniformly punctate with medium sized punctations. Cervical grooves were faint, and the lateral grooves were prominent and long ending behind the spiracles. Eyes were absent and festoons were elongated. The basis capitulum was broadly rectangular with straight sides and stouty cornuae. Palps were only moderately broad at the centre. Articles 2 & 3 of the palps were almost equal in size with equal external angles. There were no spines on article 2, but on article 3 there were two short sharp spines, One each at the middle of the dorsal and ventral borders. Hypostomal dentition varied from 4/4 to 6/6.

The spiracles were white, sub-oval and broadest posteriorly. Coxa 1 possessed a medium sized sharp spur. Coxa II and III possessed small protuberances. No ventral plates were present. The anal groove was well defined and was posterior to anus.

The females: In unengorged specimen the scutum was yellow to brown. The engorged specimens were bluish-brown in colour. The cervical grooves were found to begi behind the anterior margin. They were fairly deep,

curved inwards and then outwards, reaching the posterio-lateral border. Punctations were numerous, medium sized, and regularly distributed. The basis capitulum was broader than in the male. The cornuae were short and blunt, and the porose areas were oval and set far apart.

HAEMAPHYSALIS SPINIGERA

(Plate X, XI, XIII - B)

Haemaphysalis spinigera:

2 males and 4 females of the species were collected from a goat at Kozhinjampara, in Palghat district.

They differed from H. bispinosa in the following characters.

1. The salience was very much broad.

2. Coxa IV possessed a prominant spur directed downwards.

HAEMAPHYSALIS TURTURIS

(Plate XII, XIII-C)

2 male and 7 females of this species were collected from a buffaloe at Nilambur, Malappuram district.

The specimens resembled H. bispinosa but for the following characters.

1. The palpal segment II was broad, with about half its breadth extending beyond the lateral margin of the base.

2. Palpal segment III possessed a dorsal broad median ridge like projection, slightly overlapping the apical margin of palpal Segment-II.

HYALOMMA ANATOLICUM

Hyalomma anatolicum:

4 males and 7 females of this species were collected from Kozhinjampara in Palghat district. The specimens were collected from the body of a buffalo and also from the wall of an old cattle shed in the area.

The males (Plate XIV. Fig. 2, XV-B) Dark brown in colour measuring 5 to 5.5 mm x 2.5 to 3 mm in size. The capitulum was long and measured 1 to 1.5 mm in length. No ornamentations were present on the scutum. The cervical and lateral grooves were prominent. The basis capitulum was roughly hexagonal dorsally. Eyes were white, prominent and raised over the surface.

The coxa I was bifid with two unequal portions. The anterior portion being broad and the posterior portion resembling a sharp spur. The genital and anal grooves were distinct. The adanal shields were prominent with a pointed anterior end and blunt posterior end. Their lateral margins were slightly curved and the inner margins possessed sharp projections at the middle which almost united together just below the anus.

The festoons were prominent and the spiracles were elongate oval with a long tail extending upto the posterio-lateral margin.

The females: (Plate XIV. Fig. 1, XV-A) They were dark brown in colour, measuring 5 mm x 2.5 mm in size. The scutum was oval with its posterior end reaching just above the middle of the body in unengorged specimens. The cervical grooves started just below the basis caputulum curved inwards and then diverged to end at the posterior border of the scutum. Eyes were present on either side at the broadest portion of the scutum. Lateral grooves were very inprominent. The first coxa was similar to that in males and the adanal shields were absent.

AMBLYOMMA INTEGRUM

Amblyomma integrum

This species were collected from Malappuram and Trichur districts; three specimens (two females and one male) from cows at Thiruvazhumkunnu Livestock Farm and one female from a cow at Mannuthy, Trichur.

The males(Plate XVI. Fig. 1) 4 x 3 mm in size. Scutum was yellowish with varigated irridiscent coloured ornaments. Punctations were coarse and sub-equal. The marginal groves were present. Eyes were oval, white, and prominent, and festoons were present. The capitulum was was 1.2 mm in length, and the base was rectangular. The

palps and hypostome were long. Palps measured 0.7 mm in length and hypostomal dentition was 3/3. First coxa possessed two strongly unequal spurs, the external one being long and sharp. Tarsi II & IV tapered almost gradually to a strong ventral spur. No ventral plates were present.

The female (Plate XVI. Fig. 2) Females measured 6 x 4 mm in size. Their body was more dark than the male and the scutum was silvery in colour with irridiscent coloured markings. Other characters resembled those of the males.

DISCUSSION

It may be seen from Table I, II & III that the only prevalent species under the genus Boophilus is B. annulatus in Kerala. As per the available records, the prevalent species in other parts of India is B. microplus. However rare cases of occurrence of B. annulatus has been confirmed by virus Research Centre, Poona, in the adjoining State of Karnataka. The species B. annulatus is considered to be mostly confined to North America. It is not commonly found in other parts of the world. In India too the species seems to be confined to Kerala (as per the present studies) and Karnataka (as confirmed by Virus Research Centre, Poona. It is observed that B. annulatus affects cattle during all seasons of the year, and is encountered in all the districts of Kerala. However it is more abundant in the hilly tracts; affecting free range cattle. The incidence of infection is found to be less in the coastal areas. The low rate of incidence of the tick in buffaloes kept along with infected cattle, as observed in the present study, is a valuable piece of information helping in the control of these ticks. Detailed morphological studies are made in the present study, which almost agree with the descriptions given by Hoogstraal (1956) and George Anasthos (1950). Identity of the species was also

confirmed by Virus Research Centre, Poona.

Rhipicephalus sanguineus is found to be the commonest dog tick in Kerala, uniformly distributed in all the districts. The morphological description reported here, closely concur with that given by Sharif (1928)

The incidence of R. haemaphysaloides, and R. turanicus is recorded for the first time in Kerala. The morphological details of R. haemaphysaloids agree with that given by Sharif (1928) and of R. turanicus with that of Dhanda & Ramachandra Rao (1969).

Four species of Haemaphysalis have already been recorded from wild animals at various forest areas of old Travancore and Cochin. They are H. bispinosa, H. compamulata, H. cornigera and H. turturis. In the present study 3 species of Haemaphysalis viz. H. bispinos H. turturis and H. spinigera are recorded in Kerala out of which H. spinegera is a new locality record. The morphological details of these three species agree with those given by Trapido et-al. (1964).

H. aegyptim and H. (Hyalommina) kumari are the two species of ticks under the genus Hyalomma recorded previously from wild animals at Parambikulam in Kerala. No species has been recorded from domestic animals.

The incidence of H. anatolicum in domestic animals is therefore a new record for Kerala. The morphological details of this species agree with those reported by Singh & Dhanda (1965).

Amblyomma integrum has already been recorded in Kerala by Alwar (1960). The morphological details as given in the present study agree with that given by Sharif (1928).

Zumpt (1958) while studying the host range of various ticks has reported that Boophilus sp. & Rhipicephalus haemaphysaloids are confined mainly to cattle and R. sanguineus to dogs. The present investigation agrees with the findings of Zumpt.

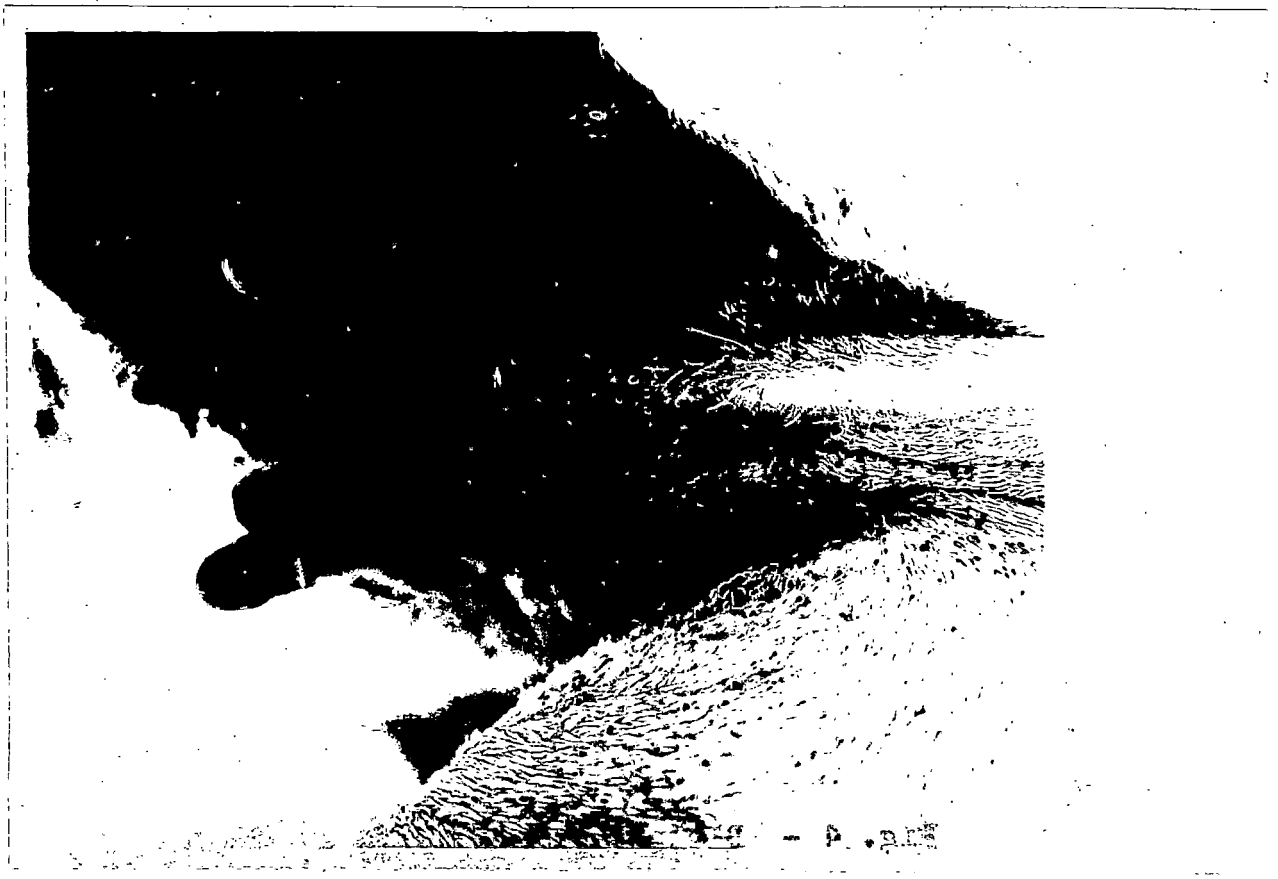


Fig. 1

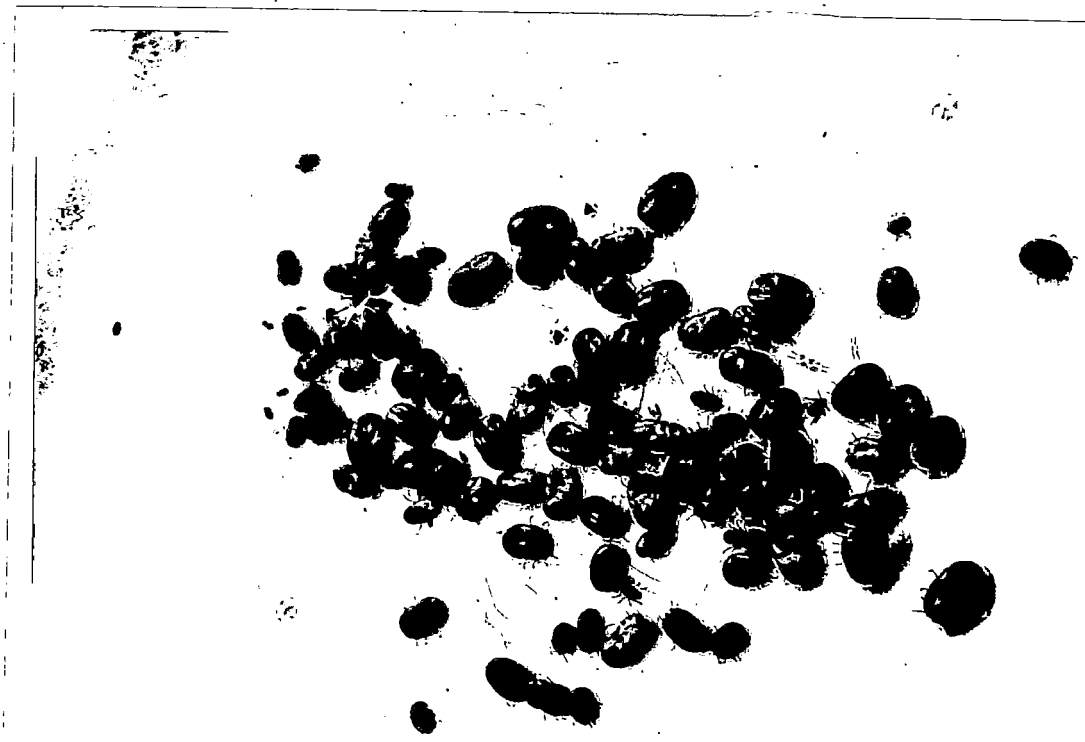
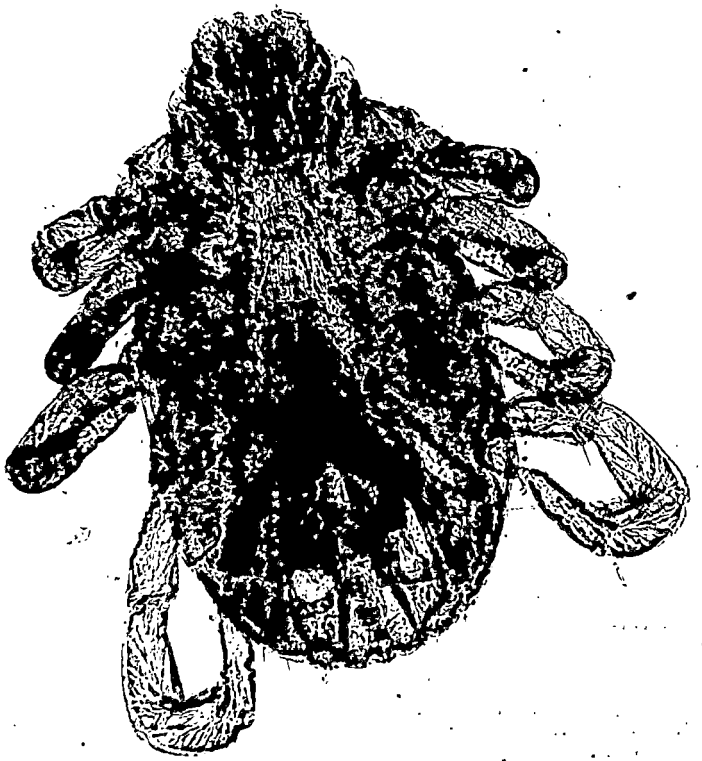
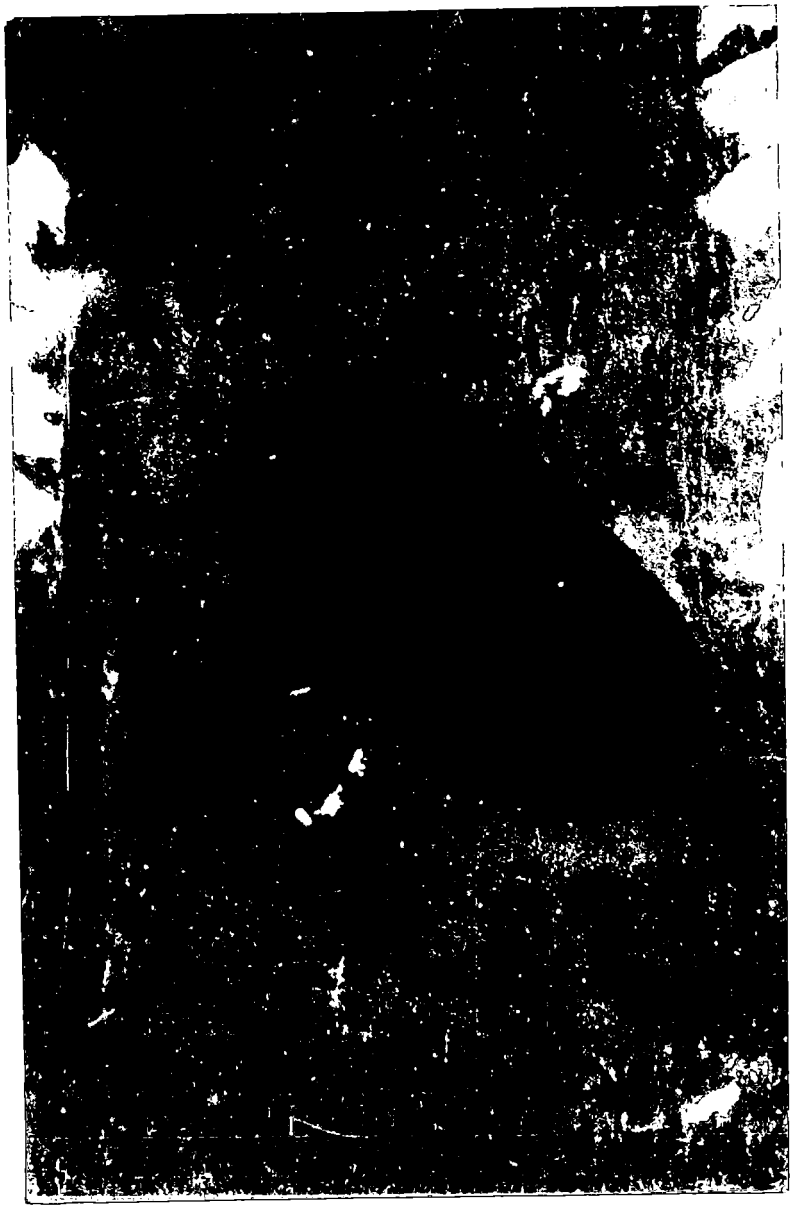
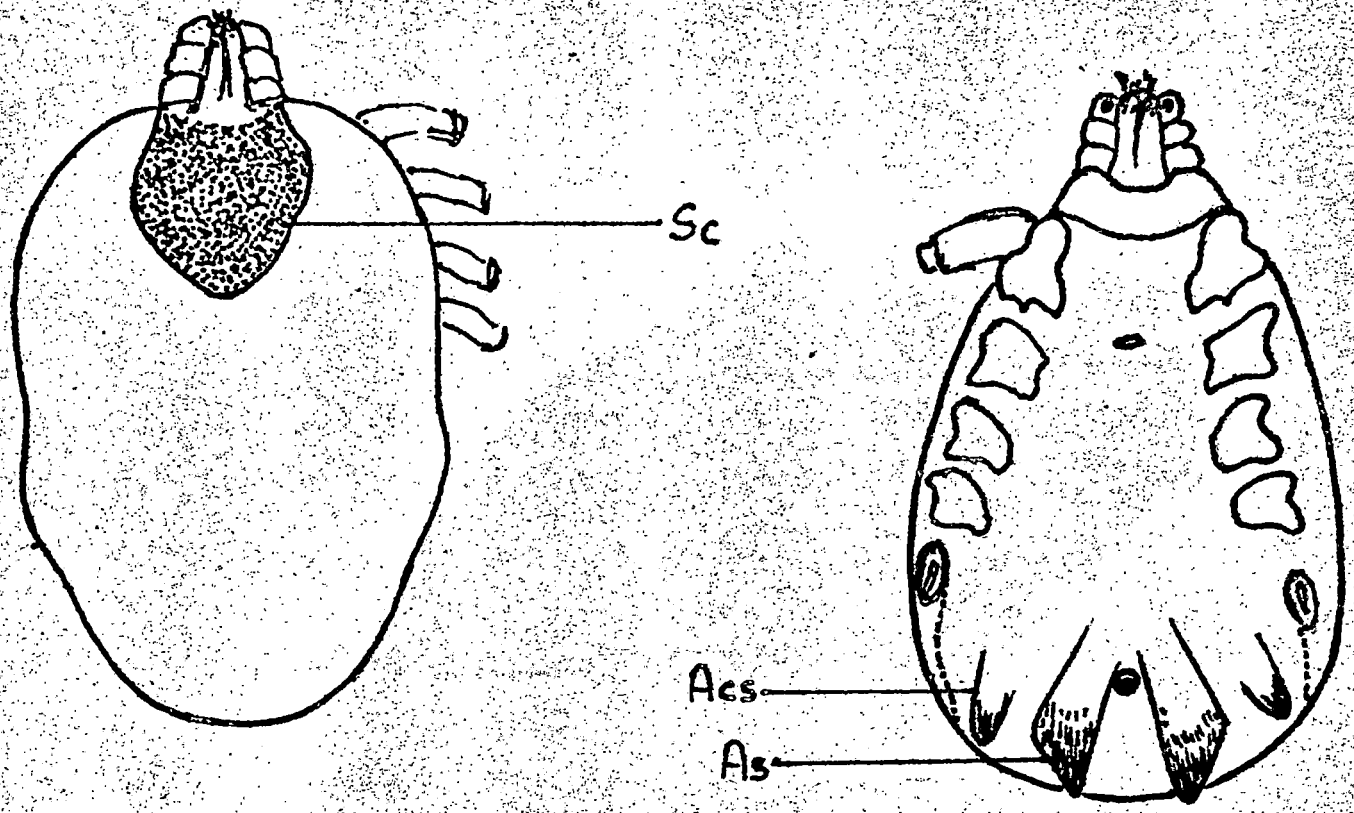


Fig.2

Fig.1



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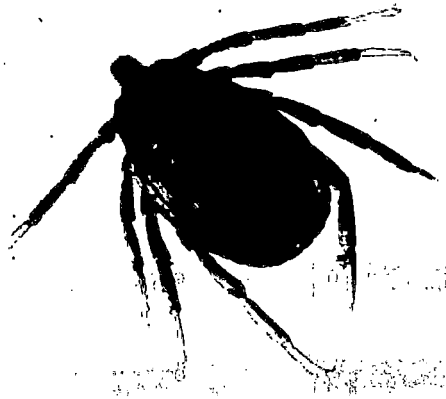


Fig.1

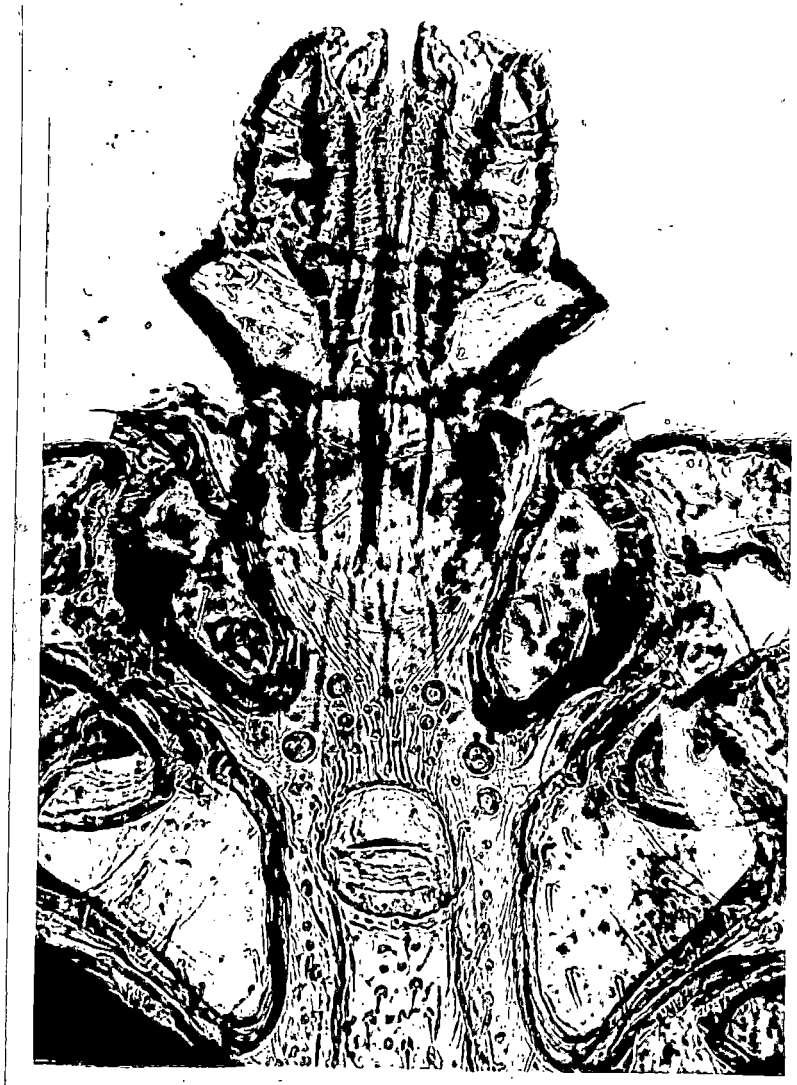


Fig.2

PLATE IX

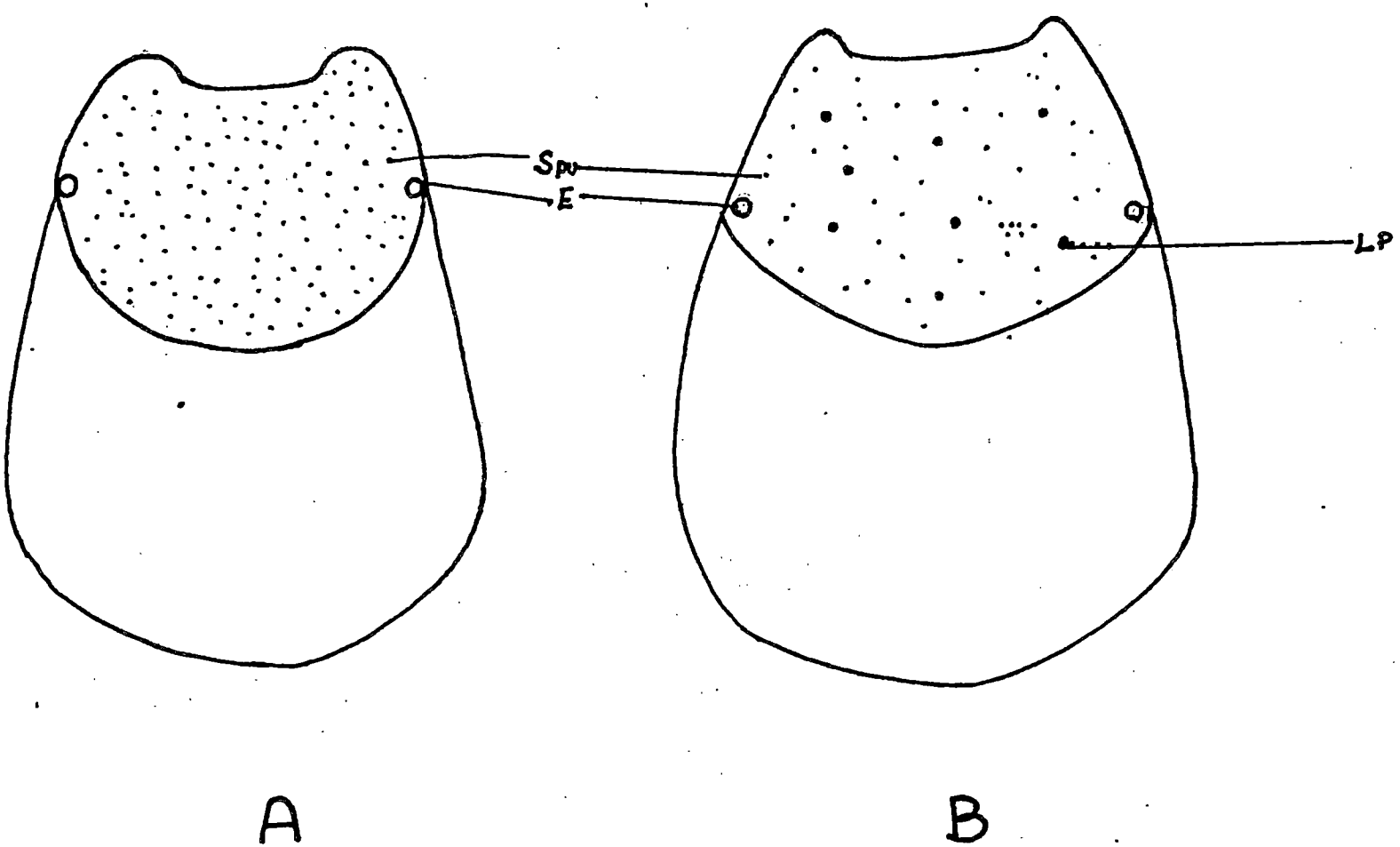
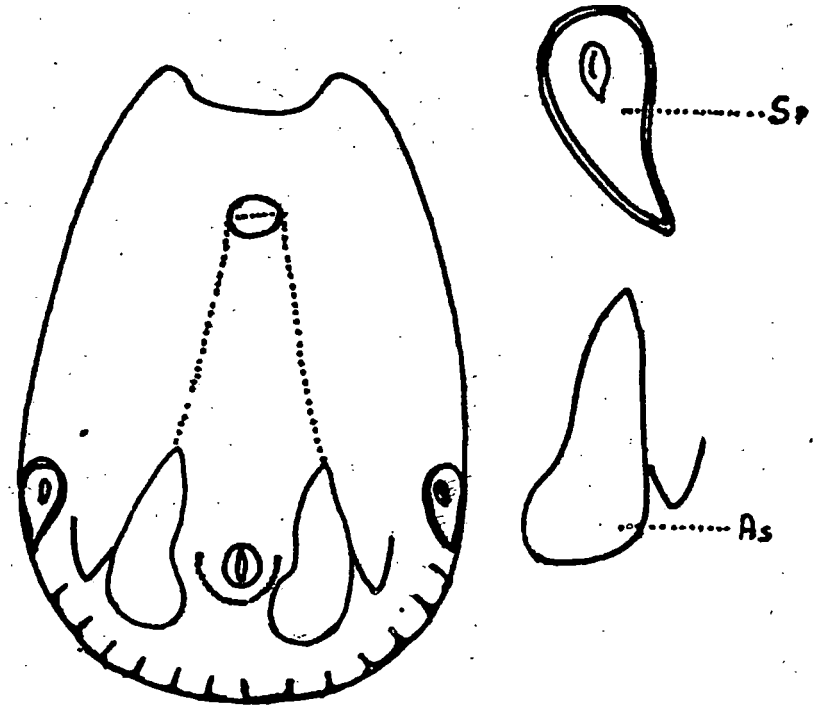
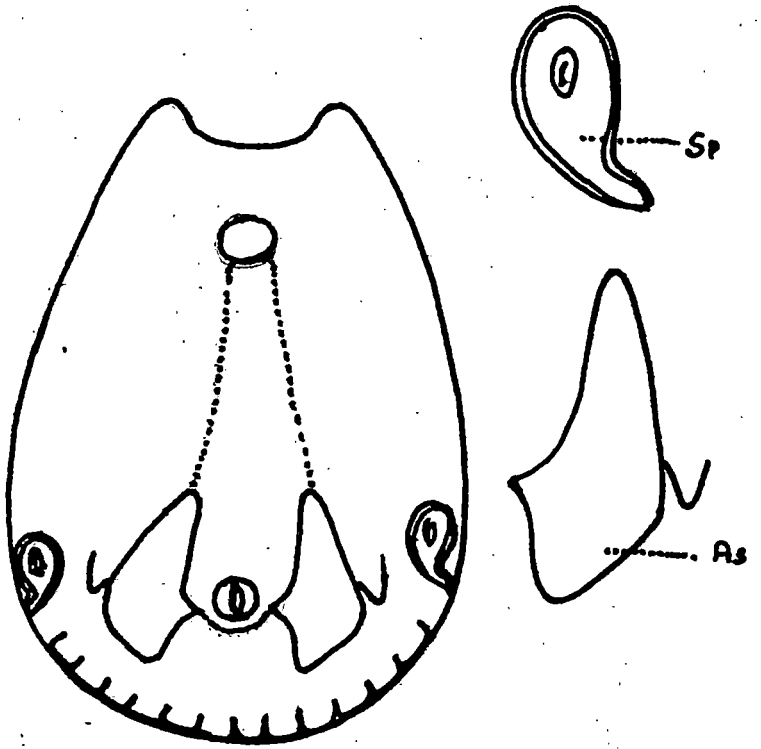


PLATE-X



A



B

PLATE-XI

PLATE-XII

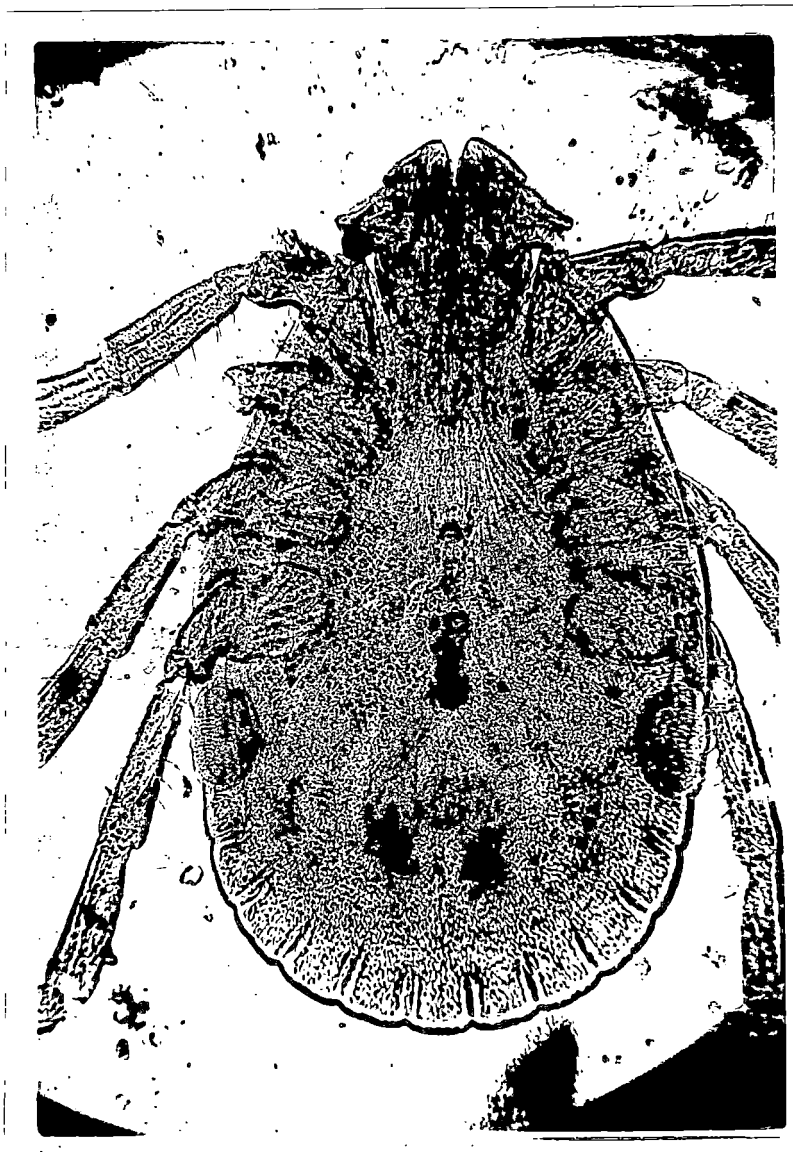


PLATE-XIII

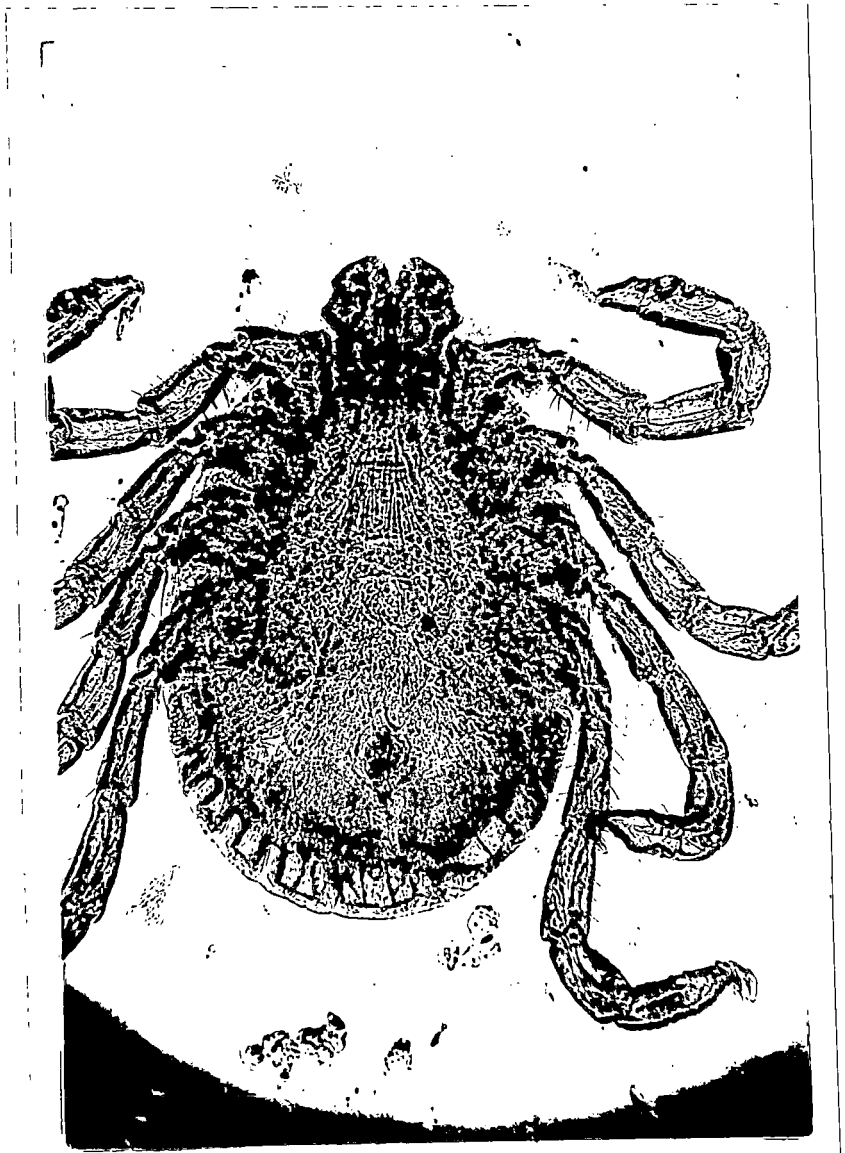
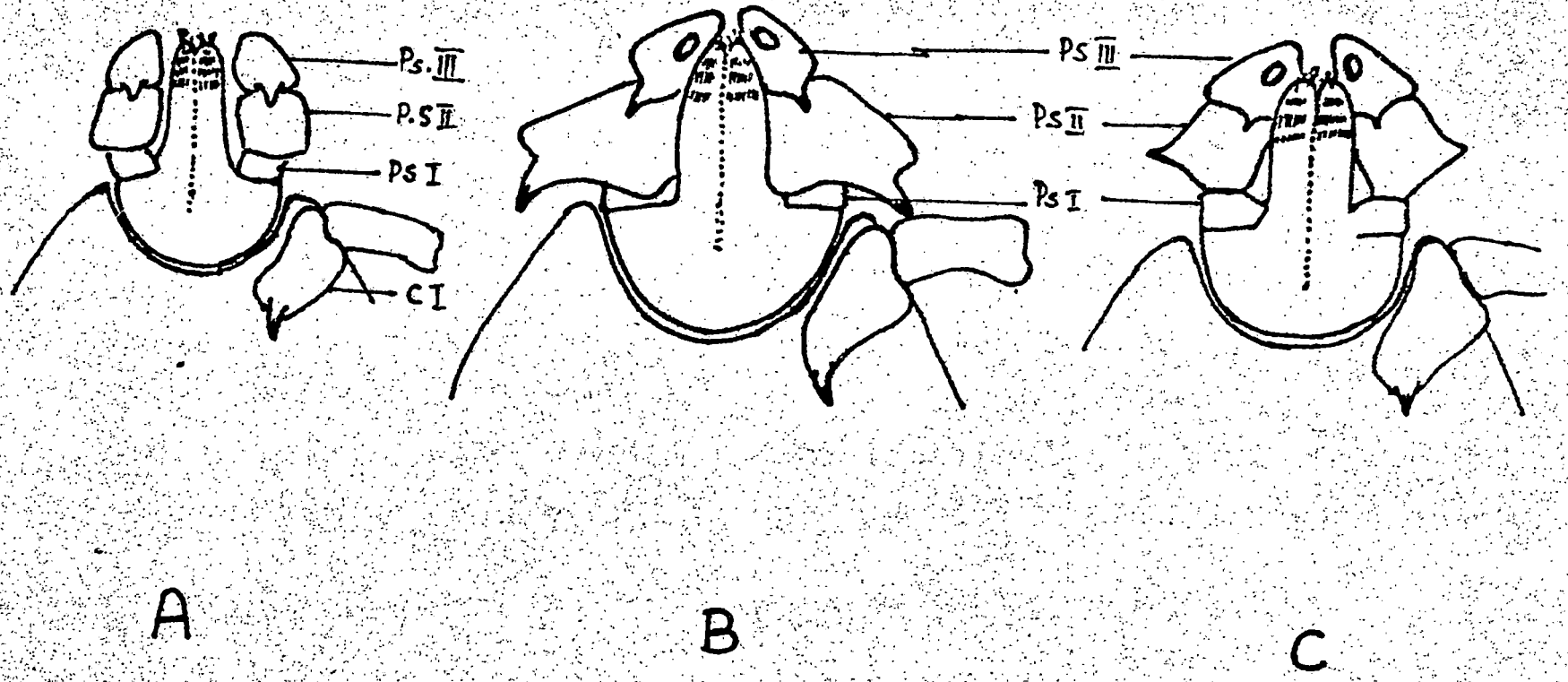


Fig.1

Fig.2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Ps I
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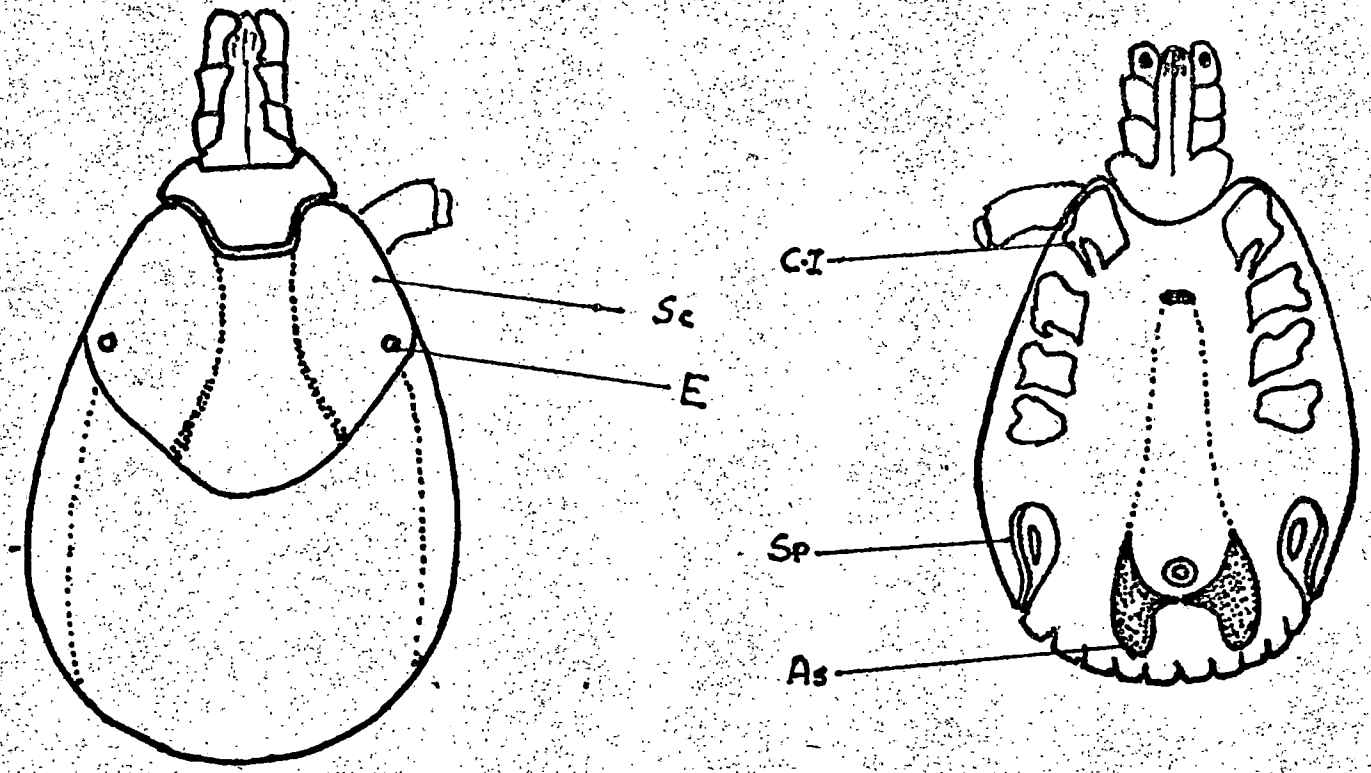
Ps III
Ps II
Ps I
A
B
C

Fig. 1

Fig. 2



A

B

PLATE-XVIII

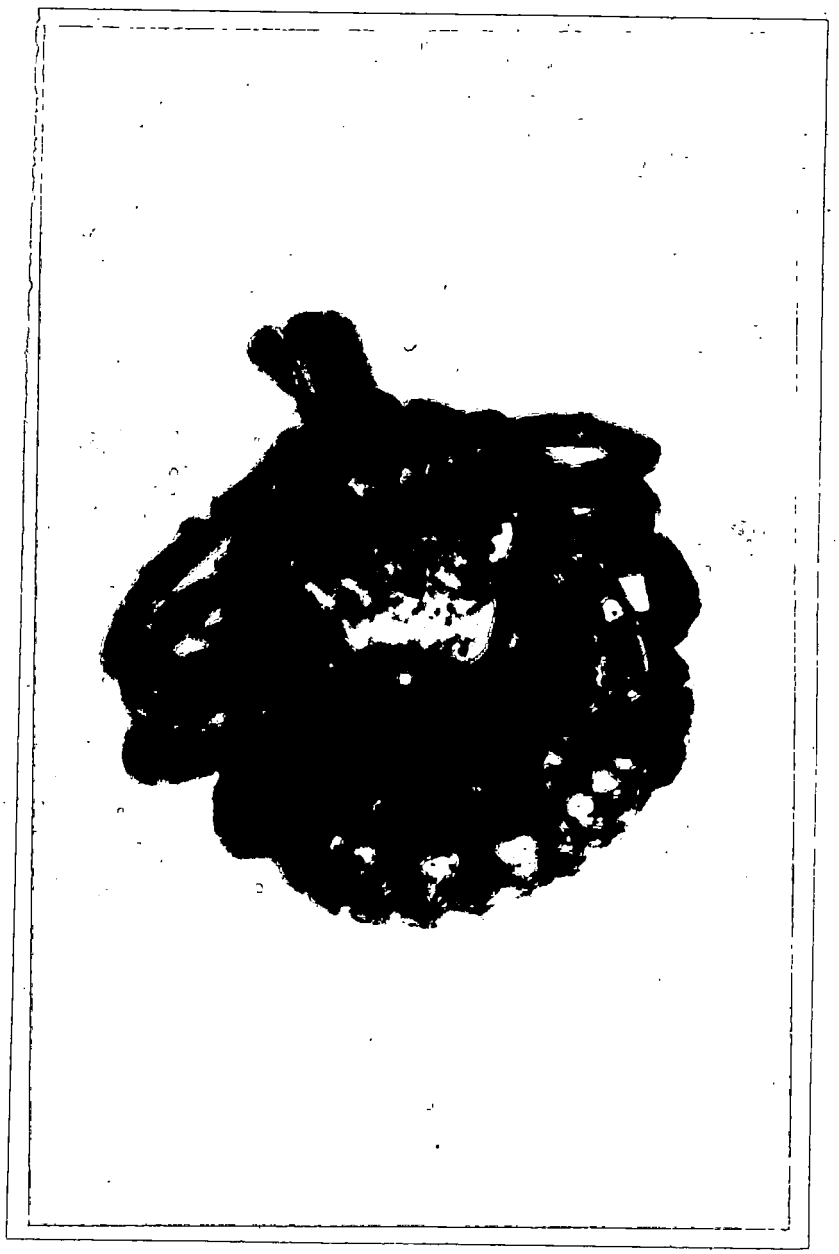


PLATE-XIX

BIOLOGY OF
BOOPHILUS ANNULATUS

REVIEW OF LITERATURE

Much work has been done on the biology of Boophilus microplus throughout the world. Graybill and Lewellen (1912) worked out certain aspects of the life-cycle of B. microplus in U.S.A. Bishopp (1932) made observations on the oviposition of B. microplus and found that the average number of eggs laid by females, was 2967 with a maximum of 4547. Mohler (1932) found that the period of oviposition was 4 to 8 days in summer and 2 weeks or more in autumn. The number of eggs laid varied from 1500 to 3000 and the incubation period was 13 days to 6 weeks. He further observed that the unfed larvae survived for 3 to 4 months and the life-cycle of B. microplus could be completed in 6 to 10 weeks during summer.

De Jesus (1934) worked out the life-cycle of B. microplus in Philippines and found that the life-cycle could be completed in an average period of 49.5 days of which the parasitic stage was 28 days. Legg (1930) studied the life-cycle of B. microplus in detail and has given the following data.

Average number of eggs produced 2579, period of incubation 15 to 55 days; larval engorgement 5 days; moulting after 2 days; Nymphal engorgement 12 days, and

moulting after 5 days. Average length of parasitic life 22 to 35 days and maximum longivity of larva under laboratory condition 154 days.

Sapre (1940) studied the biology of B. australis at Mukteswar, situated 7500 feet above sea level. He found that the number of eggs deposited by a female varied from 200 to 4725 with an average of 2551.7. The average duration of the larval stage was 38.57 days at 22°C. On the host (cattle) the larvae fed for 7 days, the nymph for 7 to 9 days and the adult for 10 to 11 days. The average pre-oviposition period was 4.4 days and the average oviposition period 18 days. Detailed work on the life-cycle of B. annulatus has been conducted by Hunter & Hooker (1907). They have given the following data on the life-cycle of this tick.

Pre-oviposition	.. 3 - 4 days (20 - 30 days in winter)
Oviposition period	.. 8 - 9 days in summer (upto 42 days in winter)
Average number of eggs	.. 1911 (maximum 3806)
Incubation period	.. 17 to 21 days (5 to 6 months in winter)
Larval engorgement	.. 7 to 12 days
Nymphal engorgement	.. 5 to 10 days.

Works on the biological aspects of various ixodid ticks have been done in India by various workers. Sapre (1945) studied, certain aspects of the bionomics of Haemaphysalis bispinosa. Srivastava and Varma (1964) studied the full life-cycle of Rhipicephalus sanguineus. Avsatthi & Hiregaudar (1969) and Chaudhuri et-al (1969) worked out certain details in the life-cycle of Hyalomma anatolicum anatolicum. Avsatthi and Hiregauder (1971) completed in the laboratory, the life-cycle of Nosoma monstorosum in 61 - 75 days. Bhat (1971) made important observations on the breeding characters of Haemaphysalis bispinosa in cattle sheds. Sardey & Rao (1971) studied in detail the bionomics of Rhipicephalus sanguineus. Sardey and Ghafoor (1971) reported that Hyalomma anatolicum anatolicum acted as a 2 host tick on experimental animals. Jagannath et-al (1972) reported certain details in the life-cycle of Haemaphysalis intermedia. Das & Subramanian (1973) made studies on the biology of Hyalomma dromedarii. Later Das et-al (1973) described the larval and nymphal stages of Hyalomma marginatum issaci. Jagannath et-al (1973-a) worked out the biology of Hyalomma marginatum issaci in the laboratory. Later they (1973-b) completed the life-cycle of Rhipicephalus haemaphysaloides for the first time. Kumar and Ruprah (1973) made observations

on the effect of temperature and humidity in the oviposition of Hyalomma anatolicum excavatum. Sardey & Rao (1973) studied the feeding periods of the larvae of Rhipicephalus sanguineus. Jagannath et-al (1974) worked out the relation between the weight of engorged female and the egg out put.

In India no work seems to have been carried out on the life-cycle of B. annulatus, perhaps due to the absence of this tick from most parts of India. Being the only available species of tick under the genus Boophilus in this part of India, detailed life-cycle studies were undertaken on this tick. The pattern of life-cycle of B. annulatus in a temperate and humid tropical location in India as referred to here is the first observation under such climatic condition. In view of the disease transmission potentialities of this tick in cattle, a thorough knowledge on its bionomics in Kerala is very essential to control it. Hence a study was undertaken for the Ist time in Kerala on the life-cycle of B. annulatus.

MATERIALS AND METHODS

Collection of engorged females:

Fully engorged female ticks were collected by hand-picking from naturally infected cattle at Vagamon, Kolahalamedu, Trichur and Chalakudy. These specimens were used initially for the collection of eggs and larvae. Later, engorged females dropped from experimentally infected calves were collected and made use of for further life-cycle studies.

Collection of eggs:

The engorged females were kept, one each, in small penicillin vials or specimen vials and the mouth of the vials were covered with muslin cloth. In order to prevent the seed ticks from migrating out, the muslin cloth pieces were fastened with adhesive plaster or rubber bands.

Incubation of eggs:

The vials were incubated at 70%, 80%, 90% & 100% relative humidities at ambient temperature. The various humidity levels were obtained in dessicators using potassium hydroxide solution. The cultures were aerated for 5 minutes daily to admit fresh air.

The weight of the engorged females were recorded using singlepan balance. The daily out-put of eggs were

transferred to a clean petridish using a camel-hair brush and were counted under a binocular dessection microscope. The measurements of the eggs and larvae were taken using projection microscope fitted with callibered screen. The details of the larvae were studied using compound microscope and projection microscope.

Infection of calves:

Clean male calves, 4 months old, kept at University Livestock Farm, Mannuthy were used to study the life-cycle of the tick. The larvae were starved for 3 to 5 days before they were released on the experimental host. After releasing the larvae on the body of the calves, they were kept in a clean shed under strict observation. The experimental animals were examined regularly and specimens were collected from them to study the developments of the parasite.

To study the comparative affinity of the larvae towards hairy and non-hairy portions of the body, a portion of skin of the experimental host (about 15 cm. square area) was cleanly shaved before the larvae were released on the host.

The dropping characters of the engorged females were studied by keeping the Boophilus infested experimental animals in separate sheds. To observe

the dropping characters on grass, fresh green guinea grass was cut and spread on the floor of one of the shed and the dropped females were collected and counted at fixed intervals, and compared with that in the other shed (control.)

RESULTS

pre-oviposition period:

Pre-oviposition period varied from 1 to 6 days. The shortest period was 1 day, which was during the month of May (Temp. max. 87.3°F and min. 80.5 F). The longest period, 6 days, was observed in January (Temp. max. ~~8xk~~ 84.3°F. min. 75.5°F).

Oviposition (Plate XVII.Fig.1)

Oviposition lasted for 5 to 9 days. The longest oviposition period was observed in January and the shortest in May. No difference could be observed in the period of oviposition under different relative humidities.

The eggs (Plate XVII. Fig. 2, XVIII)

The number of eggs produced was found to be directly proportional to the weight of the engorged tick. (Table). The maximum number of eggs produced by one tick was observed to be 1420, and the minimum 680. The daily egg count showed that the maximum number of eggs were laid on the Ist three days of oviposition. While depositing the eggs, the ticks were found to move gently backwards so that the eggs were collected as a bunch at the anterior end of the tick.

The eggs were brownish, glistening globular or sub-globular bodies, attached with one another by a sticky substance extruded by the females during oviposition. The eggs could be separated by a camel hair brush without much difficulty. The shell was composed of small plaques and was opaque. The eggs were oval, measuring 463 microns to 525 microns by 325 microns to 402 microns (average 475 microns x 375 microns).

Incubation period:

The incubation period varied from 16 to 30 days depending on the room temperature (Table V). Variation in relative humidity had little influence on the incubation period as mentioned supra.

The larvae:(Plate XIX)

The larvae after hatching were found to collect themselves in groups on the walls of the container especially near its mouth. At room temperature the larvae showed little movement but when the vials were handled or the temperature raised by cupping the vials between palms or fingers, the seed ticks were found to be greatly excited and active. The measurements of the larvae (average) are given below:

Total length - 576 - 603 microns (Ave. 585 microns)
Breadth - 396 - 414 microns (Ave. 405 microns)
Capitulum - 135 - 144 microns (Av. 138 microns)

The length of the legs varied from 405 microns to 603 microns. Prominent pads were present at the tip of all the 3 pairs of legs. The pads measured 63 microns in size.

Longivity of the seed ticks was determined by maintaining a brood of larvae at room temperature and at a humidity level of 80%. The maximum survival time of the seed ticks was found to be 115 days.

After releasing on the experimental host, the larvae buried themselves into the hairy coat within 3 to 5 minutes. No larva was found to prefer the hairless area (shaved area) of the skin.

The seed tick engorged in 4 to 7 days time. They were found to moult on the 8th to 12th day of infection.

The nymphs engorged on the 10th to 14th day. The engorged nymphs measured 3 x 1.5 mm. on an average. Their scutum measured 0.5 to 0.6 mm in length and was conical posteriorly (Plate IV-A). The engorged body had a small constriction at the posterior 1/3 of the body, just below the level of the spiracles. At the level of the spiracles the body was however slightly bulging on either sides. The capitulum and the coxae resembled those of the adults. No differentiation of sex could be made at this stage.

Nymphal moulting was observed from the 15th to 19th day of infection. While moulting, the whole covering of the body along with the scutum was casted off.

The engorged adults could be seen from the 20th day of infection onwards. The detachment and dropping of the engorged females started from the 21st day and lasted upto the 26th day. Though, they detached during all the hours of the day, maximum numbers dropped during day time. The dropped females crawled away from the host to hide under objects close to the walls of the shed. One of the interesting observation, made was that the presence of fresh green grass stimulated the detachment of the engorged females. When fresh green grass was spread on the floor of the shed where the infected animals were kept, all the fully engorged females detached at once and fell down over the grass (Table-VI Plate XXII Fig.2). As much as 119 engorged & dropped females could be counted on the grass in only 5 minutes whereas without the grass, only 9 ticks dropped in 30 minutes. The engorged females were bluish green in colour measuring 7 to 10 mm x 3 to 7 mm in size. The weight of engorged females ranged from 240 mg. to 380 mg. The life-cycle pattern could be summarised as follows:

TABLE-V

Pattern of egg laying of Boophilus annulatus

Wt. of Engorged female	Number of eggs laid											Total Number of eggs	Weight of spent female	Month of observation.
	Ist day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	9th day	10th day	11th day			
240 mg.	135	180	185	95	60	40	25	0	..	..	..	720	65 mg	January 1978
320 mg.	220	245	260	200	180	100	75	50	20	0	..	1350	80 mg	,,
250 mg.	160	180	180	130	50	10	0	..	..	..	..	710	70 mg	,,
300 mg.	200	240	285	200	150	90	35	0	..	..	..	1200	85 mg.	,,
350 mg.	200	285	265	230	200	165	55	20	..	..	..	1420	100 mg	,,
330 mg.	290	420	375	180	55	0	..	..	..	..	..	1350	90 mg	May 1978
250 mg.	160	140	155	120	80	25	..	...	..	..	..	680	75 mg	,,
310 mg.	310	400	350	185	50	5	0	..	..	..	..	1300	85 mg.	,,
320 mg.	330	375	360	200	60	25	0	...	..	..	..	1350	75 mg.	,,
250 mg.	150	180	180	145	90	35	0	..	..	..	..	780	65 mg	,,

TABLE-VI

The detachment character of fully engorged female B. annulatus from experimental calves

Sl. No.	Date	Ticks dropped from Experimental calf			Ticks dropped from control.		
		6 p. m. to 8 a. m.	8.00 a.m. to 8.30 a.m.	8.30 a.m. to 8.35 p.m. (with green grass on floor.	6 p.m. to 8 a.m.	8.00 a.m. to 8.30 a.m.	8.30 a.m. to 8.35 a.m. (without green grass on floor)
1	9-7-1979	18	4	53	24	5	1
2	10-7-1977	23	9	119	16	4	2
3	11-7-1977	12	9	82	8	1	0
4	12-7-1977	3	0	14	5	0	1

Pre oviposition	1 to 6 days
Oviposition	5 to 9 days
Incubation period	16 to 30 days
Larval fasting (pre-feeding)	2 to 5 days
Larval feeding	4 to 7 days
Larval moulting	8th to 12th day of infection
Nymphal feeding	3 to 6 days
Moulting of Nymph	15 to 19th day of infection
Adult feeding	5 to 10 days
Detachment of female	From 20th day of infection onwards.

The whole life cycle could be completed in as short a period as 42 days, under experimental conditions.

DISCUSSION

There is no published report on the details of life-cycle of B. annulatus under Indian conditions. The most common Boophilus species reported in India so far is B. microplus. In Kerala, however, B. annulatus is the only species encountered. The shortest period of life-cycle of B. annulatus as described by Hunter and Hooker (1907) is 40 days from the Ovigerous adult to engorged Nymphal stage. In the present study the same part of the life cycle was seen to have been completed in 35 days. The entire life-cycle lasted for only 42 days, which is the shortest period for B. annulatus recorded so far.

One of the important observations made in the present study is the character of the larvae in selecting the site of attachment. They prefer hairy areas of the body (Plate XXII. Fig. 2). This is a new piece of observation in the habits of seed ticks. Another interesting observation is the detachment character of engorged females when they sense green grass. Perhaps they have an extremely keen sense of surroundings, which also explai the natural tendency of these ticks to fall and hide among grass and to propagate in the grass land. It is hoped that this piece of information will be of interest to acarologists, and Ecologists since a natural or

instinctive preference is shown by the ticks to breed on grass.

Details on the morphology of the larvae and adults are also given in the present study.

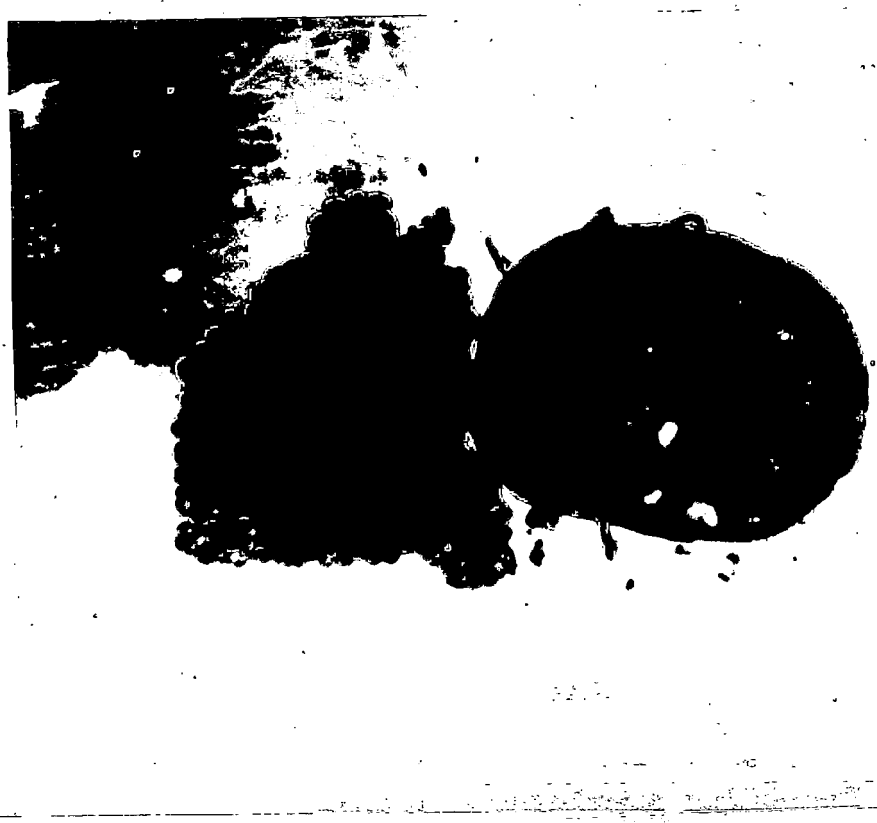


Fig.1

Fig.2

PLATE-XXI

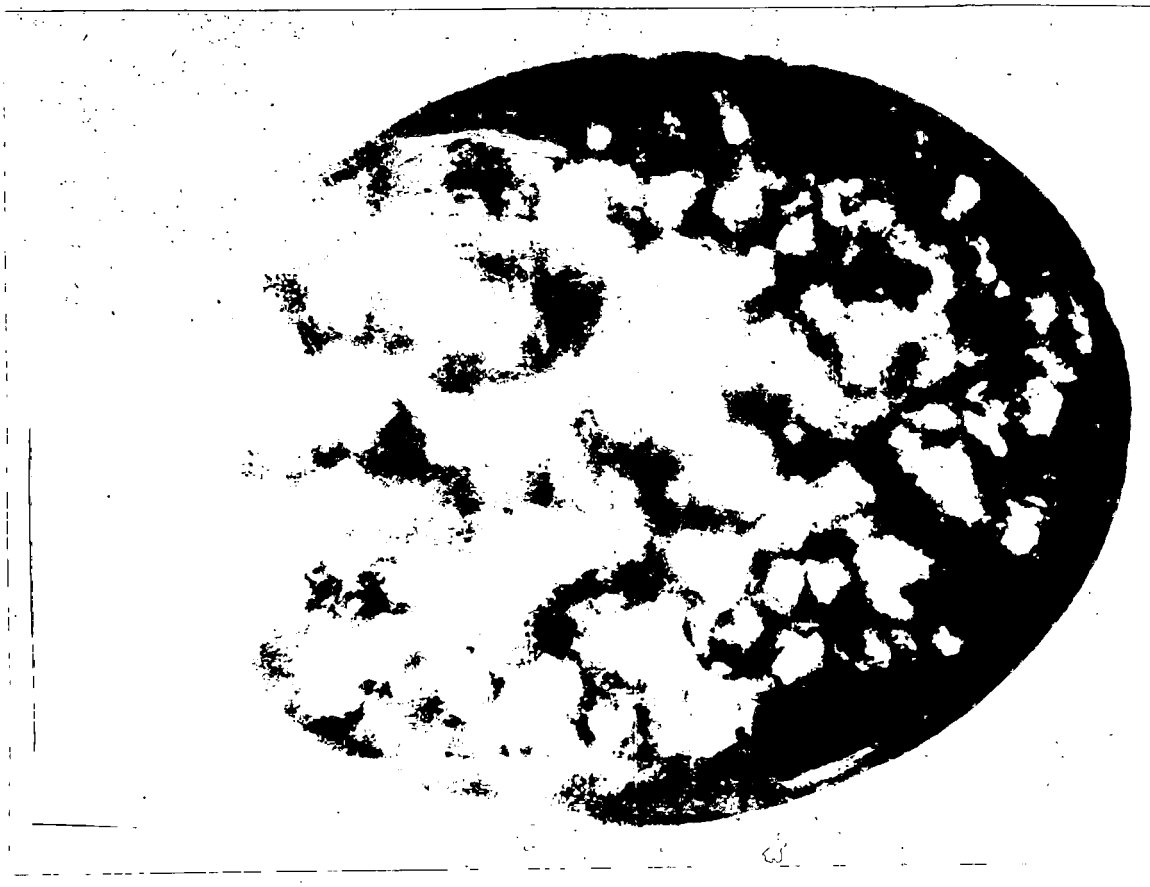


Fig. 1

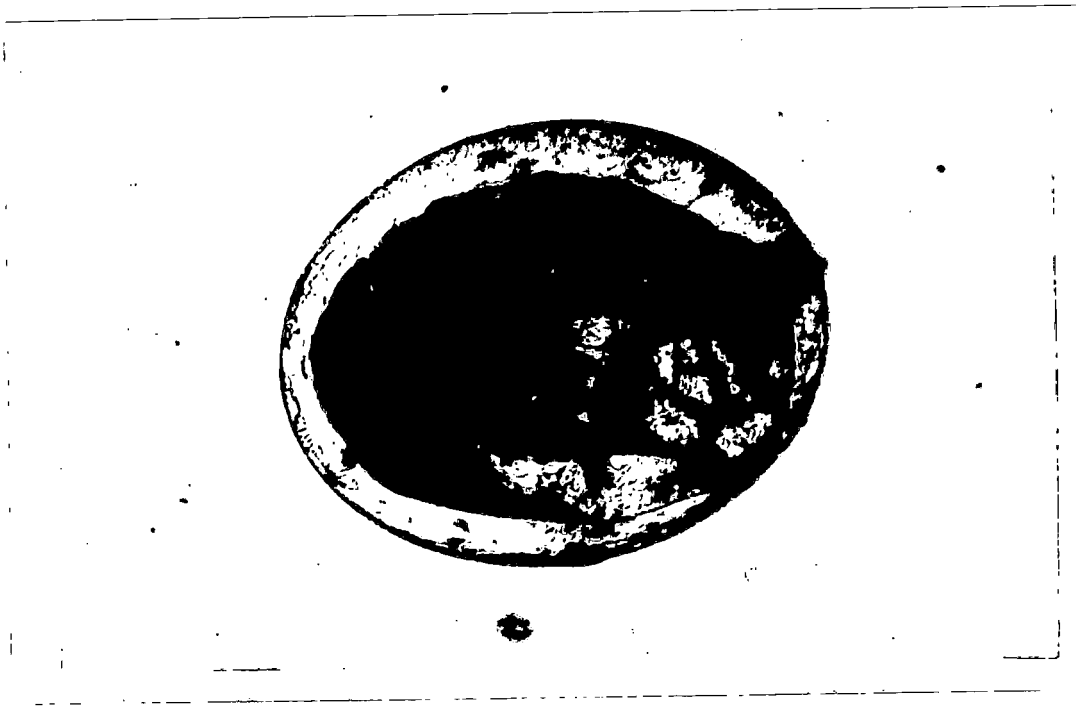


Fig.2

PLATE-XIII

Fig.1

Fig.2

PLATE-XXIII

Fig.1

Fig.2

PLATE-XXIV

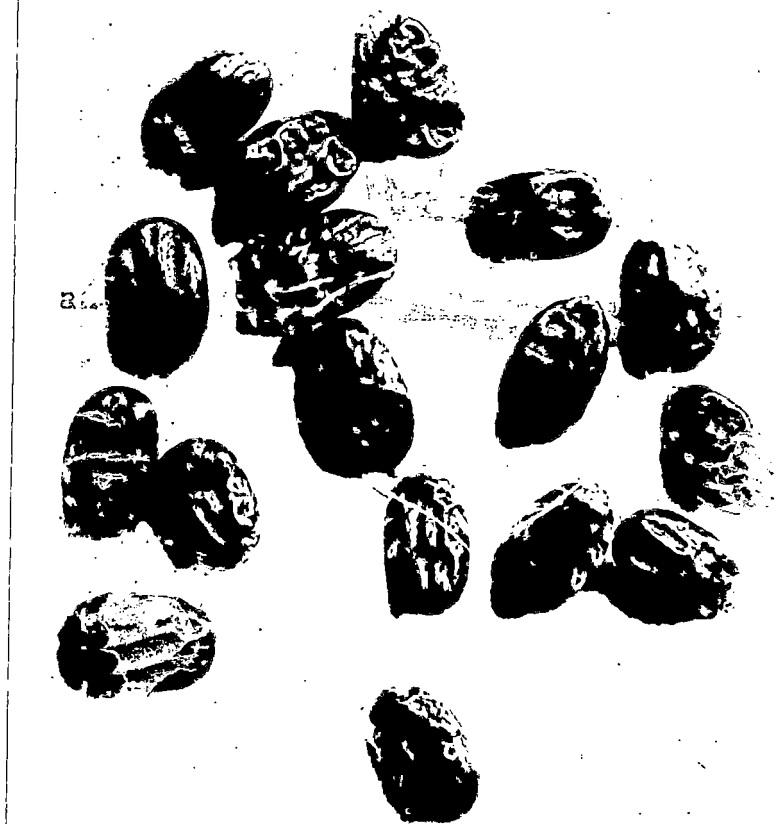


PLATE-XXV

Fig.1

Fig.2

CONTROL OF TICKS USING ORGANO-PHOSPHORUS INSECTICIDES

INTRODUCTION

Control of ticks affecting live-stock continues to be a problem for the cattle owners and veterinarians for centuries together. Of the different modes of treatment, direct application of insecticides on the body of infested animals is the only sure method yielding desirable results. The selection of insecticides, however, creates problems on account of their toxicity to man and animals, low degradation leading to environmental pollusion or leading to the development of resistant species of ticks. Among the older types of insecticides, arsenic was once used successfully against ticks for a long period. But the development of resistance towards arsenic by the ticks and its recidual toxicity in meat and hide weighed heavily against arsenic as a tickicide.

During World War II, the first of the Chlorinated hydrocarbons like D.D.T. and B.H.C. were developed. The introduction of these insecticides eased the problem of arthropod control considerably for some time. Later organophosphorus and carbamate insecticides took their place, owing to their higher efficacy and low toxicity to domestic animals and man. Both carbamates and O.P. compounds act by inhibiting cholinestrase at neuro motor

junctions of body muscels of arthropodes and animals. This anticholinestrase activity is irreversible in the case of O.P. compounds, but irreversible in carbanates.

Among the different insecticides, those tested on large scale against ticks are shown below.

Inorganic compounds:

Arsenic

Organochlor compounds:

D.D.T., Aldrin, Dieldrin, Heptachlor. Benzene Hexachloride, Lindate, Chlordane, Chlorinated camphene, Methoxychler. Toxaphene.

Carbamates:

Carbaryl (sevin).

Organophosphorous compounds:

1. Malathion
2. Fenitrothion (sumithion)
3. Coumaphos (co-Ral, Asuntol)
4. Diazinon
5. Chlorfenvinphos (supona)
6. Bromophos ethyl
7. Trichlorphon (Chlorophos (Dipterex, Neguvan)
8. Dursban (Diethyl trichloropyidyl phosphorothioate)
9. Ciodrin (shell 4294)

10. Polychloropyrine
11. Banol
12. Bayer 39007
13. Bromophos
14. Dichlorvos (D.D.V.P. Vapona)
15. Phosphotioate
16. Amitraz
17. Fenchlorphos (Dow ET 14, Ronnd)
18. Phoxim
19. Dicresyl
20. Elimix
21. Dioxathion (Delnav, polythion)
22. Ethion
23. Estrella
24. Famphur
25. Crufomate (Ruelene)
26. Phosmet (Imidan)
27. Chlorpyriphos
28. Benoxaphos
29. Propoxur
30. Clenpyrine (cyclicamidin)
31. Oxinothiophos
32. Crotoxyphos
33. Benzophosphate (Phosalone)
34. Nuvanol (Iodofenphos)

35. Chlorphoxim

36. Permethrin

37. Abate

38. Naphthalophos (Rametin)

Trials with the various O.P. compounds against ticks have been made by various workers the world over. But the only systematic study done in India is of Drummond et-al (1969) where they have tested the efficacy of malathion against cattle tick and compared it with carbaryl and organochlor compounds. In Kerala, Madhusoodanan Pillai (1969) has done some work with Sumithion. In view of the intensity of the problem of tick affection in domestic animals, it was found essential that a detailed and systematic study should be made on the control of ticks using the readily available O.P. compounds in Kerala.

REVIEW OF LITERATURE

One of the earliest acaricide to be used in veterinary field was arsenic. However, the development of resistance by ticks to arsenic was reported as early as in 1953 by Boero. He had reported that Boophilus microplus of cattle in Argentina became resistant to arsenic in 6 years. This was overcome by the use of Benzene hexachloride and chlorinated camphene. Anon (1954) summarised the different control methods against cattle tick, B. microplus. However, he did not recommend complete eradication of ticks because of the fear of cattle losing their immunity to tick-fever.

Hunter et-al (1954) described the results of plot tests of certain acaricides. They found that Dieldrin applied as a dust at the rate of 0.5 to 1 pound per acre was more effective in controlling Amblyomma americanum than D.D.T., heptachlor, sulphone, neotran or N-butyl acetanilide. Harding (1955) reported the efficacy of an organo-phosphorus compound, Malathion, against the fowlmite. Legg et-al (1955) reported the appearance of D.D.T. resistant cattle tick Boophilus microplus in Queensland. Legg (1956) conducted trials with two organo phosphorus compounds Diazinon and

Malathion against cattle tick. He found that Diazinon 0.05% was completely effective, but Malathion 1.25% was not fully effective. Both were as toxic as D.D.T. and residual effect was not noted beyond 1 to 2 days.

Whitehead (1956) recorded D.D.T. resistance in Blue tick, Boophilus decolorates, March et-al (1956) studied the fate of p^{32} labelled Malathion spray on Jersey heifer calves. They found that 0.5% Malathion was non-toxic, rapidly absorbed, metabolished and eliminated. Stone and Meyera (1957) reported the presence of Dieldrin resistant Boophilus microplus in Queensland.

Barnett (1961) gave a detailed account of the acaricides used for tick control. He discussed the progress in control starting from chlorinated hydrocarbons, to carbamates and organophosphorous compounds.

Baker & Thompson (1966) compared supona 0.01, 0.02 & 0.05% with Delnav and toxaphene. Supona was found better and gave excellent results as an acaricide.

Roth & Eddy (1966) applied 10% toxaphere at the usual sites to tick affected in cattle and found that it caused a great reduction of ticks and the action prolonged for two weeks more than that afforded by conventional spray methods.

Bromophos-ethyl, a new O.P. compound for control of ticks on livestock was evaluated in laboratory dipping tests by Fiedler & Vanvuuren (1966). It was found effective against all species at a concentration of 0.05% of active ingredient.

Drummond et-al (1967-a) controlled the ear tick of cattle with different insecticides, coumaphose, Trichlorphon, Dursban, Ciodrin & Imidan.

Roulston & Wharton (1967) identified a strain of B. microplus, resistant to O.P. compounds. But this strain was susceptable to Imidan and C 8514 which are not anticholinetrase.

Badalov (1967) controlled cattle ticks by spraying with 2% aquous emulsion of Polychlorpinene mixed with a prolonging agent, 5% polyvenyl acetate emulsion.

Drummond et-al (1967-b) tested Banol, Bayer 39007, Bromophos, Carbaryl, Ciodrin, Chlorfenvinphos, Coumaphos, Diazinon, Dursban, Imidan, Shell SD 8447, Shell SD 8448, Trichlorphon and Toxaphene against lone-star tick of cattle and found them useful at different degrees.

Fielder (1968) evolved a method for evaluation of acaricides against ticks. The larvae of ticks were enclosed in special envelops of rice paper and were treated with insecticide fluids without direct handling

of larvae. Thompson and Baker (1968) found that Supona (chlorfenvinphos) as a 0.05% dip was excellent against Boophilus decolorates. Rhipicephalus evertsi, R. appendiculates, and Amblyomma hebraeum.

Wade (1968) reported that a dip containing 0.05% diethyl- 3, 5, 6 trichloropyridyl phosphorothioate could effect a 100% tick control.

Hadani et-al (1968) described a method for studying the efficacy of ixodicides in the laboratory. He dipped unfed nymphs of Hyalomma excavatum in varying concentrations of the ixodicides tried. The method was found useful for screening acaricides.

Dzasokhov et-al (1968) reported the acaricidal action of Co-ral, Ciodrin, chlorophos, sevin and the dicresylester of N. methyl carbaminic acid against Ixodes recinus. The authors found that co-Ral (coumaphos) 0.5% spray was active for 9 days. Chlorophos (Trichlorphon) was effective at 0.75% to 1.0% concentration. Sevin killed 91-100% of Ixodes at 1% concentration.

Thorburn (1968) gave a detailed account on the use of different concentrations of Supona (chlorfenvinphos) against ticks. Washes containing

0.05% Supona gave good control of all stages of single and multi-host ticks, and produced no adverse effect even in young calves. Madhusoodanan Pillai (1969) tested, Sumithion against ticks of cattle and dogs at 1% concentration and found it safe and effective. Drummond et-al (1969) evaluated different ixodicides, in area treatment, laboratory tests and on animal application.

Shaw (1970) made observations on the effect of modern methods of treatment for tick control. He observed that weekly treatment with pesticides affected the most sensitive stage (larvae) and, engorged females, and moulting nymphs were the stages least susceptable to insecticides.

Treeby (1970) reported the efficacy of Dursban (Diethyl trichloropyridyl phosphorothieate) against Ixodes recimus.

Rupes (1970) determined the lethal concentrations of fenitrothion, D.D.T., Bromophos, Dieldrin, Diazenon, Malathion and Lindane against the nymphs of I. reumis in the laboratory. The nymphs were placed on inner surfaces of test-tubes impregnated with the insecticides. Sensitivity to Fenitrothion and D.D.T. were lowest.

Wharton et-al (1970) described a method for assessing the efficacy of acaricides. He made counts of the engorged female B. microplus on cattle, which were expected to drop off in the following morning, before and every second day upto 21 days after treatment with various acaricides. The acaricides were applied as hand sprays, plunge dips or spray race treatment.

Mount et-al (1971) compared the effectiveness of twenty two insecticides against Amblyomma americanum, and found that Phoxim was most effective.

Nepoklonov & Kan (1970) found that Dicresyl wettable power at 1% concentration was 100% effective against ticks.

Mohamed (1970) could control cattle ticks in Nigeria, by weekly sprays for 14 weeks during the dry season, with 0.05% to 0.25% solutions of Supona.

Drummond et-al (1971-a) described a method for the laboratory testing of insecticides against ticks. They dipped the engorged females of Dermacentor albipictus in 29 insecticide solutions and their effects on estimated reproduction were determined (ER = g. eggs/g. tick body wt x % hatch of eggs x 20,000).

Grillo Torrado and Gutierrez (1971) tested coumaphos, Elimix, Dursban, Chlorfenvinphos, Dioxathion, Ethion, Estrella, Diazinon and a mixture of Bromophos-ethyl and chlorphenvinphos against nymphs of B. microplu and found that none of them could eliminate young females.

Drummond et-al (1971-b) compared the effects of 28 pesticides on the estimated reproduction of tropical horse tick in the laboratory.

Thomson and Bryson (1972) recorded for the first time in Rhodesia the resistance of B. decoloratus to arsenic.

Said et-al (1971) reported that Asuntol 0.016% and Bercotox (dioxathion) 0.045% used as sprays at 10 days interval were efficient in the control of Boophilus on large animals.

Hedge et-al (1972) applied Sumithion (Fenitrothion 50% EC) as a 0.25% to 0.5% spray on cattle and dogs and as a 0.125% spray on fowls, and reported the efficacy against various lice and ticks.

Gladney et-al (1972) reported the results of feeding systemic insecticides to cattle for the control of the tropical horse tick. They found that Famphur at 5 mg/kg daily for 1-5 days gave the best results follow by fenchlorphos, crufomate, coumaphos and phosmet.

Loomis et-al (1972) found that pour-on formulations of phosmet (40 mg/kg) and chlorpyriphos (60 mg/kg) gave the best control of ticks, out of nine preparations tested. However chlorpyriphos caused damage to skin.

Nayar & Isa (1973) tested the efficacy of various acaricides against the larvae of Rhipicephalus evertsi and Amblyomma variegatum. They found that sevin, Asuntol, Delnav, supamix and Pyrithrum were equally and highly effective against the tick larvae.

Bonin et-al (1973) found that the O.P. compound Benoxaphos was active against B. microplus when applied to individual ticks in concentration between 0.01 to 0.1%.

Humke (1973) used Benoxaphos on cattle in Kenya and found that at 0.49% concentration it was more effective than 0.25% toxophane against ticks.

Knowles and Roulston (1973) tested 29 formamidines and related compounds against ticks, and recorded some activity against engorged female cattle ticks.

Drummond and Whetstone (1973) used an immersion technique to evaluate 33 veterinary acaricides for the control of Amblyomma americanum by recording the inhibition of estimated reproduction.

Gusein Ajiyev (1973) reported the efficacy of Benzophosphate (Phosalone) against tick infestations of cattle. An emulsion of 0.05 to 0.5% of this O.P. pesticide killed larvae of B. calcaratus and H. anatolicum in the laboratory within 48 hrs. and engorged females within 16 to 20 days. Ovicidal action was evident at 0.25% level. Sprays on infested cattle with 0.25% emulsion killed unfed or partly fed ticks within 12 hrs. and the animals were completely free from ticks after 36-48 hrs. Recidual acaricidal activity on the hair-coat protected cattle against Hyalomma for 7 days and against R. burza for 11 days. Emulsions containing 2% or more of phosalone were toxic to cattle.

Kigaye & Matthysse (1973) developed a method for testing the acaricidal property of insecticides. Larval ticks were lead into disposable pasteur pipettes treated with acaricides. The differential count of the live and dead ticks were tkaen after 24 hrs. Percentage mortality was plotted against acaricides concentration, and lethal concentrations were thus calculated. Carbaryl and Malathion were used as examples in this test.

Gladney et-al (1974) recorded the detachment stimulating property of chlordimeform. A 0.05 to 1%

solution of the substance in acetone, made most of the adult Dermacentor andersoni on guinea-pigs to detach in 2 hrs.

Schanzel & Chemtai (1974) made comparative trials on the efficacy and toxicity of toxophene, chlorfenvinphos and Oxinothiophos. They found Oxinothiophos superior to the other two.

Nepoklonov et-al (1974) tested Nuvanol-N (iodofenphos) against Ixodes recinus on cattle, and found it effective at 0.25% level, repeated 4 to 5 times at weekly intervals.

Schutner et-al (1974) found that Piperonylbutoxide was toxic to B. microplus at a concentration greater than 0.02%.

Smith (1975) found that Dioxathion had the longest residual action for 7 days against B. microplus. Chlorfenvinphos had an initial quick kill of ticks, but with short recidual action similar to carbaryl.

Andrews and Stendel (1975) made studies on the mechanism of action of clenpyrin on B. microplus. The Australian Biarra strain of B. microplus, which was resistant to numerous O.P. compounds and carbamates, was exposed to an emulsion of clenpyrin. The treatment caused paralysis of tick muscles within hours and an

abrupt decrease in Oxygen consumption.

Horak (1976) controlled R. sanguineus with plastic collars impregnated with 9.4% propoxur.

Amitraz 0.05% was found to be effective against Ixodes recinus by Griffiths (1975).

Roysmith (1975) got excellent results with Amitraz against B. microplus.

Polyakov and Samirnova (1976) observed that successive generations of Rhipicephalus bursa, Hyalomma asiaticum, and H. anatolicum developed resistance to carbaryl and trichlorphon.

Stendel (1976) effectively controlled the resistant ixodid ticks using cyclic amidine, clenpyrin.

Atef and El-say (1976) found that the ticks in Egypt were mainly Hyalomma, Rhipicephalus and Boophilus sp. and they could be controlled with B.H.C. and Organophosphorous compounds.

Drummond et-al (1976) found that at least 4 strains of B. microplus were not resistant to 9 common acaricides. The acaricides included chlorpyriphos, chlorfenvinphos, Triton and Phosmet.

Gladney & Dawkins (1976) conducted laboratory tests with acaricides against R. sanguineus. The engorged R. sanguineus larvae were enclosed in envelops similar to tea bags, allowed to moult to nymph and then held dipped in the acaricide for 24 hrs. before mortality rate was detected. Of the 31 acaricide tested, the most effective were FMC 26021, phoxim, chlorphoxim and permethrin.

Allen and Palmer (1976) tested the efficacy of different formulations of Amitraz against B. microplus. The most successful formulation was 5 G. of Amitraz in 100 ml. of sunflower seed oil and liquid paraffin.

Platt (1976) evaluated amitraz against the sheep tick Ixodes recinus and found that the acaricide gave satisfactory control for at least 4 weeks after the dip.

Norval (1976) recorded the effect of cessation of cattle dipping for two years in Rhodesia. No significant changes were seen in the first year. But in the next, there was a sharp rise in tick infestation followed by cattle mortality.

Gusein Ajiyev & Kan (1976) found that Phosalone (Benzophosphate) applied as a 0.25% spray or dip protected animals from infestation by Ixodid ticks and

did not adversely affect the general condition or their epidermal tissues.

Camoens (1977) made observations on the prevalence and control of ticks in Malayasia. The common ticks identified were B. microplus, H. bispinosa, R. sanguineus and A. testudinarium. Traditional 3 weekly acaricide application to cattle did not control ticks, because the local climatic conditions made the larval ticks to be continuously available. A method of pasture tick control was therefore suggested. Acaricides used were coumaphos, Ethion, Chlorpyriphos and Malathion.

Hammont (1977) reported the development of arseni resistance by ticks, and use of Dioxathion against ticks in Rhodesia. Hammont and Matthewson (1977) further reported the spread of O.P. resistant strain of B. microplus in Rhodesia.

Grillo Torrado and Perez Arrieta (1977) identifie a strain of ticks in Argentina, which were having lower acetyl cholinestrase activity, higher resistance to diazinon, dioxathion and chlorpyriphos and higher susceptability to coumaphos and Bromophos ethyl.

Niyazov et-al (1977) found that metallic complexes of Naphthenes were highly active as 5 - 10% emulsion, against larvae and adults of ticks.

Rawlins and Mansigh (1978) studied the susceptability of 5 strains of B. microplus from four Caribbean countries. Carbamates were found to be the most potent acaricides and the Guyanse strain was the most susceptable.

Dimitriev (1978) carried out tests in USSR with 6 organophospherous compounds as emulsion concentrates and a pyrethroid as dust against the common ticks in USSR. High acaricidal effect was shown by phenthoate, trichlor metaphos-3, fenitrothion, chlorpyriphos and Malathion.

Rechav et-al (1978) made studies on the relation between time of application of O.P. acaricides, and mortality rate of tick larvae. The results showed that at 2.00 p.m. the larvae were sensitive to acaricide treatment than at other times of the day.

MATERIALS AND METHODS

The efficacy of 4 organophosphorous compounds were evaluated against the commonly occuring ticks of domestic animals i.e. Boophilus annulatus Rhipicephalus sanguineus and Haemaphysalis bispinosa. The following compounds were used for the trials.

1. 'Cythion' (Cyanamid India Ltd.)

It is a 50% emulsifiable concentrates of Malathion. The chemical name of Malathion is diethylmercapto succinate, S-ester with O, O-dimethyl phosphoro dithoate. 'Cythion' is a pale yellow oily liquid with an offensive smell. On mixing with water it readily turns into a milky-white emulsion. The oral LD 50 of Malathion to rats is 2800 mg/kg. For testing the acaricidal properties, 0.5% and 1% aquous emulsion of Cythion were used.

2. 'Nuvan' (Ciba Ltd.)

It is a 100% w/v emulsifiable concentrate of Dichloophs (2,2 - dichlorovinyl dimethyl phosphate or D.D.V.P.). It is available as a blue coloured solution. On mixing with water it gives a bluish white emulsion. It has no bad smell, but the substance volatilizes quickly. Hence, it is highly

penetrating and has high vapour toxicity. Its absorption into the animal body and excretion are reported to be quick. Its oral LD 50 to rats is 56 to 80 mg/kg. Aquous emulsions (0.2% & 0.3%) were used for trials.

3. 'Zolone':

This contains the compound phosalone which is having the chemical formula C_{12} H_{15} $ClNO_4$ PS_2. 35% & 20% emulsifiable concentrates are available in the market. It is a light straw coloured liquid with a light puggent smell. On mixing with water it becomes a milky emulsion. It is comparatively less toxic to mammals and its oral LD 50 to mouse is 180 mg/kg. 0.2 and 0.3% emulsions of 35% EC. of Zolone were used for the trials.

4. Sumithion (Fenitrothion)

(Dimethyl-3 methyl-4 nitrophenyl phosphorothione

It is Fenitrothion 50% EC which is a light yellow oily liquid with an offensive smell. 0.5 to 1% emulsions in water were used for the trials. Its oral LD 50 to rats is 250 to 500 mg/kg.

Exposure of ticks and their life-cycle stages to insecticides:

Most of the stages in the life-cycle of ticks viz. adults, eggs, seed-ticks, and nymphs were laboratory raised, and used for the experiment. All stages in the life-cycle, viz. egs, seed-ticks, nymphs and adults of B. annulatus, H. bispinosa and R. Sanguineus were exposed to insecticides. The adult, eggs and larval stages of B. annulatus and eggs and seed-ticks of H. bispinosa and R. sanguineus were raised in the laboratory. The nymphs and adults of H. bispinosa and R. sanguineus were collected from naturally infested animals. The ticks were exposed within 2 hours after collection.

Laboratory treatment with insecticides:

Emulsions of the insecticides were made in water freshly for every test. The ticks were taken in cup-shaped seives with fine mesh and held dipped in the insecticide emulsion for the specific period and then transferred to a petridish provided with filter paper at its bottom. For treatment of larval ticks, the seive was fitted with a piece of muslin cloth, to prevent the larvae from entangling themselves in the meshes of the sieves. After transfering to the

petridish, the ticks were examined using a hand lens. The adults and nymphs were kept on their dorsum in the petridish and observed till they turned themselves up to natural position. This enabled the observations to be made on the in-co-ordination of legs or paralysis. The ticks were considered to be dead when no apparent movement of either the legs or the body was visible.

Testing the ovicidal action:

Eggs of ticks were collected in the laboratory and batches of about 500 eggs of each species of ticks were taken in separate petridishes. The insecticide emulsion was poured into each petridish, so as to immerse the contained eggs. After the required period of treatment, the eggs were transferred to clean filter papers using a camel hair brush, for drying the eggs. These treated eggs were then put in separate glass vials and kept for hatching at room temperature and at 100% relative humidity. The eggs were examined daily for hatching, for a period of 4 months.

Treatment of animals:

For treating the animals, the insecticide emulsions were sprayed using knapsac sprayer or hand

pressure sprayer. For an adult cow 0.7 to 1 litre of the emulsion was used. For dogs 100 ml. was the maximum quantity required. Ticks were collected from different regions of the body at intervals and the dead and live counts were made.

RESULTS

Ovicidal action of the acaricides:

The comparative ovicidal property of the four Organophosphorous compounds under trial is shown in Table-VII. Nuvan 0.2 and 0.3% and Zolone 0.2 and 0.3% showed 100% ovicidal activity against the ova of B. annulatus, R. sanguineus and H. bispinosa even with 1 mt. of treatment. Cythion 0.5% and Sumithion 0.5% had only 50 to 60 efficacy after the same length of treatment. However when the concentration of these two compounds were increased to 1% each, 100% efficacy could be noted. All the formulations had complete ovicidal action when treated for 5 mts.

Larvicidal action:

Results are shown in Table-VIII.

Nuvan 0.2 to 0.3% and Zolone 0.2 to 0.3% had 100% larvicidal action against the larvae of B. annulatus, R. sanguineus, and H. bispinosa even on treatment for a duration of 1 mt. All the formulations except cythion 0.5% and sumithion 0.5% showed 100% activity against all species of seed ticks, at the end of 5 minutes of treatment, and the larvicidal action was 100%, for all the formulations when the exposure time was increased to 10 minutes. Cythion 0.5% had only 58% to 60% efficacy on 1 mt. treatment, but on 5 mts.

TABLE - VII

Ovicidal property of the four organophosphorous compounds on the eggs of ticks

Insecticide	1 mt. treatment			5 mts. treatment			10 mts treatment.		
	B-annulatus	R.sanguineus	H.bispinosa.	B.annulatus.	R.sanguineus	H.bispinose	B.annulatus.	R.sanguineus	H.bispinosa.
.5% Cythion	50%	60%	60%	100%	100%	100%	100%	100%	100%
% Cythion	100%	100%	100%	100%	100%	100%	100%	100%	100%
.2% Nuvan	100%	100%	100%	100%	100%	100%	100%	100%	100%
.3% Nuvan	100%	100%	100%	100%	100%	100%	100%	100%	100%
2% Zolone	100%	100%	100%	100%	100%	100%	100%	100%	100%
.3% Zolone	100%	100%	100%	100%	100%	100%	100%	100%	100%
.5% Sumithion	60%	50%	50%	100%	100%	100%	100%	100%	100%
% Sumithion	100%	100%	100%	100%	100%	100%	100%	100%	100%

TABLE-VIII

Percentage of Mortality of seed ticks treated with the insecticides.

Insecticide	1 mt. treatment			5 mts. treatment			10 mts treatment		
	B.annu-latus	R.sang-uineus	H.bis-pinosa	B.annu-latus	R.sang-uineus	H. bis-pinosa	B.annu-latus	R.sang-uineus	H-big-pinosa
.5% cythion	60%	58%	60%	100%	90%	100%	100%	100%	100%
% Cythion	84%	90%	90%	100%	100%	100%	100%	100%	100%
.2% Nuvan	100%	100%	100%	100%	100%	100%	100%	100%	100%
.3% Nuvan	100%	100%	100%	100%	100%	100%	100%	100%	100%
.2% Zolone	100%	100%	100%	100%	100%	100%	100%	100%	100%
.3% Zolone	100%	100%	100%	100%	100%	100%	100%	100%	100%
.5% Sumithion	60%	50%	54%	100%	84%	96%	100%	100%	100%
% Sumithion	80%	74%	80%	100%	100%	100%	100%	100%	100%

treatment the efficacy increased to 90 to 100%. Cythion 1% had 84 to 90% efficacy on 1 minute treatment which increased to 100% efficacy when the exposure time was 5 minutes. Sumithion 0.5% was effective only 50 to 60% on 1 minute treatment, but on 5 minutes exposure the efficacy increased to 84 to 100%. Sumithion 1% was only 74 to 80% effective on 1 minute treatment but on 5 minutes of exposure the efficacy reached 100% against all species of larvae.

Action on Nymphs:

The percentage of mortality of nymphs of B. annulatus, R. sanguineus and H. bispinosa treated with the acaricides under study are given in Table-IX. Among the different formulations, 0.3% zolone was most effective. In 1 mt. treatment it was 60 to 70% effective and in 5 mts. treatment it was 100% effective. Zolone 0.2% had 40 to 50% efficacy on 1 minute treatment, 60 to 80% efficacy on 5 minutes treatment and 100% efficacy on 10 minutes treatment. Cythion 1%, Nuvan 0.2% and Cythion 1% also showed 100% efficacy when the nymphs were exposed for 10 minutes. The efficacy of the insecticides based on the present trials could be summarised as, 0.3% zolone > 0.2% Nuvan > 0.2% Zolone > 1% Cythion > 1% sumithion > 0.1% Nuvan > 0.5% cythion > 0.5% sumithion.

TABLE-IX

*Percentage of Mortality of Nymphs of ticks treated with the insecticides

Insecticides	1 mt. treatment			5 mts treatment			10 mts treatment		
	B.annu-latus	R.sang-uineus.	H.bis-pinosa	B.annu-latus	R.sang-uineus	H.bis-pinosa	B.annu-latus.	R.san-guineus	H.bis-pinosa
5% Cythion	20%	Nil	10%	50%	50%	50%	90%	80%	90%
% Cythion	30%	20%	30%	80%	60%	80%	100%	100%	100%
.2% Nuvan	30%	10%	10%	50%	30%	50%	80%	80%	80%
.3% Nuvan	50%	30%	40%	100%	80%	80%	100%	100%	100%
.2% Zolone	50%	40%	50%	60%	60%	80%	100%	100%	100%
.3% Zolone	60%	60%	70%	100%	100%	100%	100%	100%	100%
.5% Sumithion	10%	Nil	10%	40%	30%	40%	80%	80%	70%
% Sumithion	20%	20%	10%	80%	70%	80%	100%	100%	100%

* Number of Nymphs used for each test - 10.

Action on engorged females:

The results of the laboratory tests against engorged females of B. annulatus, is shown in Table-X. The comparative efficacy was Zolone 0.3% > Nuvan 0.3% > Zolone 0.2% > Nuvan 0.2% > Cythion 1% > Sumithion 1% > Sumithion 0.5% > Cythion 0.5%. None of the formulations showed 100% efficacy at 1 mt. and 5 mts. of treatment. Zolone 0.3% was 100% effective in 10 mts. and Nuvan 0.3% was 80 to 100% effective in 10 mts. of treatments. In 5 mts. treatment, Zolone 0.3% produced 70 to 80% mortality and Nuvan 0.3% produced 50 to 70% mortality. Cythion 1% and Sumithon 1% were 40 to 60% effective in 5 mts. of treatment. In 1 mt. treatment, none of the formulations were effective above 50% till of adult ticks. Maximum efficacy in this group was shown by Zolone 0.3% with 30 to 50% mortality of engorged females.

Field trials:

The results of the filed trials are given in Table XI. The efficacy gradient was Zolone > Nuvan > Sumithion > Cythion. The acaricidal property was found to be directly proportional to the concentration of the compound and the period of exposure to th insecticides. The ticks which were hiding under thick coat of hairs and at concealed areas were not

TABLE-X

Percentage of Mortality of Engorged female ticks treated with insecticides.

Insecticides	1 mt. treatment			5 mts treatment			10 mts treatment		
	B.annu-latus	R.sang-uineus	H.bis-pinosa	B.annu-latus	R.sang-uineus	H.bis-pinosa	B.annu-latus.	R.sang-uineus	H.bis-pinosa
Cythion	Nil	Nil	Nil	30%	30%	20%	50%	50%	60%
Cythion	20%	10%	20%	50%	40%	50%	90%	90%	80%
Nuvan	10%	10%	20%	40%	30%	30%	60%	50%	50%
Nuvan	20%	10%	20%	70%	50%	60%	100%	80%	100%
Zolone	20%	10%	10%	50%	50%	50%	80%	60%	60%
Zolone	50%	30%	40%	80%	70%	80%	100%	100%	100%
Sumithion	Nil	Nil	Nil	20%	20%	30%	70%	60%	70%
Sumithion	10%	Nil	10%	60%	40%	60%	100%	80%	100%

TABLE-XI.

Ixodicidal activity of the four insecticides in field trials.

Insecticides	% of mortality of ticks 10 mts after treatment.			% of mortality of ticks 1 hr. after treatment.			% of mortality of ticks 24 hrs. after treatment		
	B.annu-latum	R.sang-uineus.	H-bis-pinosa	B.annu-latus	R.sang-uineus	H-bis-pinosa	B.annu-latus	R.sang-uineus	H.bis-pinosa
0.5% Cythion	Nil	Nil	Nil	30%	20%	20%	50%	40%	40%
1% Cythion	10%	10%	10%	60%	40%	60%	80%	60%	60%
0.1% Nuvan	Nil	Nil	Nil	20%	Nil	20%	40%	20%	20%
0.3% Nuvan	50%	40%	50%	80%	80%	90%	90%	80%	80%
0.2% Zolone	40%	40%	30%	60%	40%	40%	60%	50%	60%
0.3% Zolone	80%	80%	80%	80%	70%	80%	90%	80%	90%
0.5% Sumithion	Nil	Nil	Nil	20%	20%	20%	40%	30%	50%
1% Sumithion	20%	20%	10%	60%	50%	50%	80%	80%	70%

easily acted upon by the acaricides and hence, they were found to be alive even after 24 hrs. of spraying. Thus, live ticks could be collected from the axillary region, inner aspect of thighs, folds of the tails, udder, and inner side of ears.

All the formulations used were found to be safe to the domestic animals i.e. cattle, buffaloes, goats and dogs. Signs of poisoning were found in cases where there were small and large wounds on the body, debility, and also when the compounds were rubbed forcefully over the body. Maximum toxicity was produced by Nuvan (Table-XII). At 0.5% level it produced salivation and shivering in animals. But cythion 2% and sumithion 2% did not show any toxi signs except for a transient anorexia in one case. Zolone was the least toxic and even at 4 times the normal concentration i.e. 1.2%, it did not produce any toxic symptoms in a period of 10 minutes.

TABLE-XII

Details of toxicity produced in cattle treated with Zolone & Nuvan during field trials at Vagamon.

Sl. No.	Name & concentration of Acaricide used.	No. of animals treated	No. showed symptoms of toxicity	Remarks.
1	0.2% Zolone	7	Nil	
2	0.3% Zolone	7	Nil	
3	0.2% Nuvan	7	Nil	
4	0.3% Nuvan	7	Two	There were small aberrations & wounds on the body of the animals that showed symptoms of toxicity. In one case the acaricide was rubbed forcefully on the body.

DISCUSSION

No systematic study is seen made in India on the use of organophosphrous insecticides against the ixodid ticks of domestic animals. The work of Madhusoodan Pillai (1969) and Hedge et-al (1972) touch some aspects of the acaricidal acrivity of Sumithion (Fenithorthion). The present work is thus the first systematic study to evolve a suitable control measure for ticks of domestic animals.

Acaricidal activity of malathion have been studies by Legg (1956) Camones (1977) and Dimitriev (1978). The present study is only partially in confirmity with the above workers.

The results obtained in the studies with Sumithion (Fenitrothion) almost agree with those of Madhusoodanan Pillai (1969) and Hegde et-al (1972).

No work is seen in literature on the use of Dichlorvos against ixodid ticks. But there are a number of reports on its high efficacy against Gastromphilus larvae, Oestrus ovis larvae, lice of goats, mites of mouse and dog fleas, as reported by Harry & Fly (1968), Drudge et-al (1972) Nepoklonov & Bukstitynov (1972), Darrow (1973) Fraster et-al (1974) and Bennet et-al (1975). Thus the present

study indicates new use for Dichlorvos.

Acaricidal property of Zolone has been studied by Gusein Ajiyev (1973) and Gusein - Adzhiev & Kan (1976). The present results agree with those of the above workers. The highest efficacy, lowest toxicity and the longest residual action makes Zolone the acaricide of choice for use against ticks in Kerala, assuming that, resistance to this insecticide would not develop in the near future.

SUMMARY

No systematic study has so far been undertaken in Kerala on the ticks affecting live-stock. Hence a detailed investigation was undertaken for a period of 5 years from 1974 to 1979 on the common ticks affecting live-stock in Kerala.

Tick collections were made from all the 11 districts of Kerala. The coastal, midland and highland areas in Kerala State were covered. Cattle, buffaloes, goats and dogs were the different types of animals examined. Seasonal incidence of ticks was also studied by regular examination of animals throughout one year (1977) at Veterinary Hospital, Trichur.

Nine species of ticks belonging to five genera were identified from the collections made. They were Boophilus annulatus, Rhipicephalus sanguineus, R. haemaphysaloides, R. turanicus, Haemaphysalis bispinosa H. turturis, H. spinigera, Hyalomma anatolicum and Amblyomma integrum. The commonest ticks distributed through-out the State was found to be Boophilus annulatus. It was found more concentrated at hilly areas on free range cattle. Rhipicephalus sanguineus was the second in abundance and it was found mainly on

dogs. The third in abundance was Haemaphysalis bispinosa. The other species were of low or rare occurrance. Cattle and dogs were the animals mainly infested with ticks. The infestation was found to be less in goats and buffaloes. Buffaloes kept along with tick infested cattle were found free of infection, proving that buffaloes are only least affected.

Seasonal incidence was evident in the present study. Maximum incidence was found in the months of July, August, September, October and November.

The life-cycle of the commonest species B. annulatus was studied in detail for the first time in India.

The number of eggs produced by engorged females were found to be directly proportional to the weight of engorged females. The maximum number of eggs produced by one female was 1420 and the minimum 680. The incubation period varied from 16 to 30 days and it was mainly dependent on room temperature. Variation in humidity had little influence on incubation period.

On releasing to experimental hosts, the larvae preferred hairy areas of the body for attachment, and seldom attached to hairless areas. The engorged females were found to drop off quickly when the

experimental animal was kept on floor spreaded with green grass. The life-cycle pattern could be summarised as:-

Pre-oviposition	.. 1 to 6 days
Oviposition	.. 5 to 9 days
Incubation period	.. 16 to 30 days
Larval fasting	.. 2 to 5 days
Larval feeding	.. 4 to 7 days
Larval moulting	.. 8 to 12th day of infection.
Nymphal feeding	.. 3 to 6 days
Moulting of nymph	.. 15th to 19th day of infection
Adult feeding	.. 5 to 10 days
Detatchment of female	.. From 20th day of infection onwards.

The whole life-cycle could be completed in as short a period as 42 days under laboratory conditions.

Acaricidal properties of four organophosphrous compounds were tested and compared to evolve a suitable chemical control measure against ticks. Cythion (Malathion) 0.5% & 1%, Sumithion (Fenitrothion) 0.5% & 1%, Nuvan (Dichlorvos) 0.1% & 0.2% and Zolone (Phosalone) 0.2% & 0.3% were the formulations tried.

In-vitro studies were made on the efficacy of these formulations on eggs, larvae, nymphs and adults of B. annulatus, R. sanguineus and H. bispinosa. The efficacy of these compounds were found to be directly proportional to the concentration of the compound and the period of contract with the insecticide preparation. In field trials, the compounds gave different degrees of effectiveness. Their efficacy could be summarised as Zolone > Nuvan > Sumithion > Cythion. All the formulations tested were found to be safe to domestic animals i.e., cattle, dogs, buffaloes and goats. At higher concentrations Nuvan caused toxic effects in a few animals. Thus the acaricide of choice to be used in Kerala against ticks was found to be Zolone 0.3%, as no toxic hazards followed the use of this insecticide even at high concentration and 100% clearance of ticks at normal dilution could be observed.

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ABSTRACT

An investigation was conducted for a period of 5 years from 1974 to 1979 into the incidence of ticks on domestic animals in Kerala, the biology of the most common species, and their susceptibility to four commonly available organophosphorous compounds.

Nine different species of ticks belonging to 5 genera were collected from cattle, buffaloes, goats and dogs in different localities of the eleven districts of Kerala. The species of ticks identified were Boophilus annulatus, Rhipicophalus sanguineus, R. haemaphysaloides, R. turanicus, Haemaphysalis bispinosa, H. turturis, H. spinigera, Hyalomma anatolicum and Amblyomma integrum. The commonest among them was Boophilus annulatus which found on cattle. The incidence of this tick was very high in the hilly areas and in the western ghat regions. The other common ticks found on cattle were Rhipicephalus haemaphysalcides and Haemaphysalis bispinosa. Tick infestation was found to be rare in buffaloes and goats and the common species found on them were Haemaphysalis bispinosa and B. annulatus. In dogs the common species recorded in the present study were of rar occurrance in the State. Variations in incidence was evidenced from the present study. The maximum

incidence was found in the months of July, August, September, October and November.

The life-cycle of B. annulatus was completed experimentally in a period of 44 days. The maximum number of eggs produced by one tick was 1420 and minimum 680. The incubation period was dependent on the room temperature and variation in humidity had little influence. The larvae were found to prefer hairy areas of the body for attachment, and they did not attach at the hairless and exposed areas. The engorged females were found to drop off quickly when green grass was spread on the floor of the experimental animal's shed.

The life-cycle pattern could be summarised as:

Pre-oviposition	.. 1 to 6 days.
Oviposition	.. 5 to 9 days
Incubation period	.. 16 to 30 days
Larval fasting	.. 2 to 5 days
Larval feeding	.. 4 to 7 days
Larval moulting	.. 8th to 12th day of infection
Nymphal feeding	.. 3 to 6 days
Moulting of Nymph	.. 15 to 19th day of infection
Adult feeding	.. 5 to 10 days
Detatchment of female	.. From 20th day of infection onwards.

Four organophosphorous compounds viz. Malathion, Fenitrothion, Dichlorvos and Phosalone were tested for their action on ticks. The ovicidal and Larvicidal actions and the lethal effects on nymphs and engorged females of B. annulatus, R. sanguinius and H. bispinosa were studied in the laboratory. Cythion (Malathion 50%) 0.5 to 1%, Sumithion (Fenitrothion 50%) 0.5 to 1%, Dichlorvos (Nuvan) 0.1 to 0.2%, and Zolone (Phosalone 35%) 0.2 to 0.3% were found effective at different degrees. The efficacy was directly proportional to the concentration of compound and the duration of treatment. Phosalone showed maximum efficacy followed by Dichlorvos.

In field trials, all the four compounds gave satisfactory results, but phosalone showed maximum efficacy and least toxicity to animals. Nuvan was also effective but was the most toxic among the four compounds. Thus the acaricide of choice for routine use in Kerala was determined to be Phosalone (35%) at a concentration of 0.3% to be used as a spray or wash.