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University of Maryland, Ph.D., 1971
Zoology

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LARVAL IXODID TICKS OF INDONESIA (ACARINA: IXODIDAE)

by

Sampurno Kadarsan

Dissertation submitted to the Faculty of the Graduate School
of the University of Maryland in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
1971

APPROVAL SHEET

Title of Thesis: Larval ixodid ticks of Indonesia (Acarina: Ixodidae)

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ABSTRACT

Title of thesis: Larval ixodid ticks of Indonesia (Acarina: Ixodidae)
Sampurno Kadarsan, Doctor of Philosophy, 1971
Thesis directed by: Dr. George Anastos

The larvae of ixodid ticks of Indonesia were described and identified taxonomically on the basis of laboratory-reared and field-caught specimens. Twenty five species in the genera Amblyomma, Aponomma, Boophilus, Dermacentor, Haemaphysalis, Ixodes, and Rhipicephalus were studied by using the chaetotaxic method in combination with morphological characters.

Specimens of 19 of the 25 species were reared in the laboratory and 6 species were determined from field-caught specimens. Those reared in the laboratory are: Amblyomma geoemydae, A. helvolum, A. javanense, Aponomma lucasi, A. soembawensis, Boophilus microplus, Haemaphysalis bispinosa, H. cornigera, H. hystricis, H. koningsbergeri, H. obesa, H. papuana, H. sumatraensis, H. wellingtoni, Ixodes granulatus, I. kopsteini, Rhipicephalus haemaphysaloides, R. pilans, and R. sanguineus. The 6 species determined on the basis of field-caught specimens were designated with numerals, and are: Amblyomma sp. 1, Dermacentor sp. 1, Dermacentor sp. 2, Ixodes sp. 1, Haemaphysalis sp. 1, and Haemaphysalis sp. 2.

Generic characteristics were restudied and specific characteristics were determined. Additional character to distinguish the genus Aponomma from other genera was the chaetotaxy of the ventral surface of tarsus I. Each species was provided with a diagnosis, a description, and an illus-

tration of the dorsum and the venter. Keys were given to separate the 7 genera and the available species within each genus.

Other contributions to our understanding of the larval tick fauna of Indonesia were also significant. The larvae of R. haemaphysaloides, R. pilans, Dermacentor sp. 1, and Dermacentor sp. 2 provided some supporting evidence to clarify the species concept. Supplementary information also was provided by the larvae concerning their hosts, geographical and spatial distribution, and to a lesser extent the biology of the species.

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For much assistance, I am indebted also to the entire collecting team in Indonesia under the direction of Dr. S. Somadikarta.

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I. INTRODUCTION

Accumulated knowledge on adult ixodid ticks undoubtedly is impressive by most standards, but our knowledge of larval ticks is far less impressive. Since tick-borne diseases are essentially zoonotic diseases, with man and his domesticated animals being accidental victims, it is necessary to have knowledge of all stages, especially of the larval stage if these diseases are to be understood and controlled. Past studies on larval ticks have contributed to an understanding of some important aspects of their biology. Thus, it is known that a great many species of animals are hosts of larval ticks, but more importantly their range of hosts may be different entirely from that of the nymphal and the adult stages. Also, several pathogenic organisms can be transmitted transovarially from the parent ticks to the larvae, and transstadial passage has been demonstrated. These facts alone indicate the importance of this stage, but undoubtedly more detailed qualitative and quantitative studies are still needed to fill the gaps in our knowledge on the actual role of larval ticks in the maintenance and spread of the disease in nature.

For a long time, the most deterring factor in larval tick studies has been the inability to identify correctly the species of field-caught larvae because of a lack of good diagnostic characters. However, a beginning in this regard was made independently by Glashinskaya-Babenko (1949) and Clifford and Anastos (1960) who showed that chaetotaxy, in association with other morphological features, provides good

and reliable characters for larval differentiation. As a result, it is possible now to identify the larval tick fauna of a few regions of the world. However, many gaps still exist in our knowledge and the lack of knowledge of the Indonesian larval tick fauna is a case in point. Very little is known about the larval tick fauna of Indonesia even though the adult tick fauna is fairly well studied. Thirty-one species and subspecies of adult ixodid ticks in 7 genera were reported from Indonesia (Anastos 1950, 1956), but recent studies and studies presently in progress indicate that the total already has increased to 42 species as a result of discoveries of new taxons, revisional works, and other type of faunal studies (Trapido *et al.* 1964a, Hoogstraal *et al.* 1965a, 1965b, 1965c, 1966, Hoogstraal and Anastos 1968, Wilson *et al.* 1968, Hoogstraal *et al.* 1971a, 1971b, Hoogstraal (personal communication), and Anastos [unpublished data]).

The objective of the present study was to provide taxonomic identification and descriptions of all species of larval ixodid ticks in the Indonesian archipelago on the basis of laboratory-reared specimens. In this way, it would be possible to identify all field-caught larvae and to provide ancillary information on the hosts, geographical distribution, and seasonal occurence of each species. Unfortunately, it was impossible to obtain gravid females of all of the species known to occur in Indonesia. Also, difficulties were encountered in keeping some females alive long enough to oviposit in the laboratory. However, larvae of 19 species were reared in the laboratory and an additional 6 species were recognized from field-caught specimens. Even though the objective of the study was not realized fully, the available 25 species contribute significantly to our under-

standing of the larval ticks of this world. The study will be continued and it is anticipated that the larvae of all species eventually will be reared in the laboratory.

II. HISTORICAL REVIEW

A fairly large number of published reports deals with larval ticks from various parts of the world, but most of them have little if any value for the differentiation of species since the descriptions are inadequate and the illustrations are incomplete. However, during the last 20 years, the concept of using chaetotaxy for larval differentiation has resulted in reports of definite value. Therefore, the review of literature presented herein is limited to those reports which are relevant to the development and application of the chaetotaxic concepts and to the literature dealing specifically with the Indonesian larval tick fauna.

A. Development and application of the concept of chaetotaxy for differentiation of larval tick species.

Lototsky (1949) and Glashinskaya-Babenko (1949), working independently, first proposed a system of nomenclature for the setae found on the dorsal and ventral surface of the body. Glashinskaya-Babenko used this system, along with the distributional pattern of the setae, to classify 14 species of 6 genera, namely Ixodes, Haemaphysalis, Hyalomma, Boophilus, Dermacentor and Rhipicephalus. Distinct supra-generic and generic characteristics were observed among this material, and Glashinskaya-Babenko devised a key to separate different taxons. However, this key was unsatisfactory for specific separation except for a few species of the genus Ixodes. Reznik (1950) found that, in addition to the body setae, the shape of tarsus I, the form of the palps, and the distribution of the palpal setae were of value in

separating Dermacentor marginatus (Sulzer), D. pictus Hermann, and D. nuttalli Olenev. Filippova (1954a) applied the chaetotaxic pattern to describe Ixodes trianguliceps Birula and also noted a definite setal arrangement on the legs. Working with Ixodes ricinus (Linnaeus), I. laguri Olenev, I. persulcatus Schulze, Filippova (1954b) pointed out that the proportion in length between the scutal and the dorsal marginal setae was an important character in separating these 3 species. Serdyukova (1955) provided an account of the morphological features which were characteristic of the larvae and discussed the ontogeny of certain body structures, such as the palps, the legs, and the setae. Serdyukova also included a key to separate 7 genera, namely, Ceratixodes, Ixodes, Boophilus, Haemaphysalis, Dermacentor, Rhipicephalus, and Hyalomma. Shatas (1956) separated Rhipicephalus schulzei Olenev, Rh. rossicus Yakimov and Kohl-Yakimova, Rh. turanicus Pomerantzev, and Rh. sanguineus (Latreille) on the basis of the length of the posthypostomal setae and the width and shape of the infra internal setae on the 2nd palpal article. Cerny (1957a) utilized this concept to redescribe Ixodes apronophorus Schulze and separated D. marginatus from D. pictus (Cerny 1957b). In a study of larval Ixodes, Filippova (1957) utilized chaetotaxic features as well as other morphological features and divided the genus into 6 subgenera, namely, Ixodes s. str., Eschatocephalus Frauenfeld, Ixodiopsis Filippova, Pholeoixodes Schulze, Scaphixodes Schulze, and Exopalpiger Schulze. Most of these subgenera had been established earlier on the basis of adult characters, but larval characters lent additional support to this classificational system.

Unlike previous workers who worked with a limited number of species or within a restricted geographical region, Clifford and Anastos

(1960) undertook a study on a world-wide basis with 56 species which represented 10 genera. The setal nomenclature as proposed by Glashinskaya-Babenko (1949) was refined and other morphological and setal features were evaluated. New diagnostic characters of value were the dorsal sensillum saggitiforme on the idiosoma and the dorsal setal arrangement of tarsus I. A nomenclatorial system for the palpal setae was also proposed. Clifford and Anastos (1960) also demonstrated that when certain characters commonly used for adult descriptions such as the hypostome, basis capituli, coxal spurs, festoons, and others are incorporated with the setal features, it was possible to differentiate effectively and easily the species of larval ticks.

The findings of Clifford and Anastos stimulated the preparation of faunistic works in several parts of the world. Allred *et al.* (1960) studied taxonomically the larvae of 10 species of the genus Ixodes in Utah. All species of ixodid ticks which occur in the Eastern United States were differentiated by Clifford *et al.* (1961). A working classification for the genera in the Western United States was provided by Brinton and Beck (1963). Four species of Ixodes were described from Africa by Morel (1966). Twenty-nine of the 52 species of ixodid ticks in the Australian region were studied by Roberts (1969). On a world-wide basis, Senevet and Ripert (1967) worked with 67 species of the genus Ixodes.

Other morphological and chaetotaxic features of larval ticks were studied, but although these works provided new dimensions to the existing system, their contribution for intraspecific differentiation was limited. Allred *et al.* (1960) attempted to separate species of

the genus Ixodes on the basis of the length of the dorsal and ventral setae. Reznik (1961) considered the value of the distance between the posthypostomal setae as a distinguishing character. The use of the setal arrangement on the tibia was considered as another diagnostic character by Edwards and Evans (1967), but this system was useful only to separate tribes and subfamilies.

B. Indonesian studies on larval ticks.

Very little is known about the larval tick fauna of Indonesia. Taxonomic descriptions exist for a few species, namely Amblyomma testudinarium Koch, Ixodes kopsteini Oudemans, I. werneri Kohls, Boophilus microplus (Canestrini), Rhipicephalus sanguineus (Latreille), Haemaphysalis bispinosa Neumann, H. hystricis Supino, H. obesa Larrouse, H. papuana Thorell, H. renschi Schulze, H. traguli Oudemans, and H. wellingtoni Nuttall and Warburton. All of these species, with the exception of H. renschi, also occur outside of Indonesia and the descriptions were based on extraregional material.

Previous works relied only on morphological features for description and were often incomplete, and hence they have little value for recognizing and separating species. Nuttall and Warburton (1915) provided very short descriptions and inadequate illustrations for H. bispinosa, H. papuana, and H. wellingtoni, which are of little value for purposes of identification. Trapido *et al.* (1964b) partially illustrated H. bispinosa and H. wellingtoni and gave only key characters to identify these 2 species. Arthur (1960) described and illustrated B. microplus, but no effort was made to distinguish this species from others. A. testudinarium was described inadequately

and illustrated incompletely by Sugimoto (1937).

More complete descriptions which did not utilize the chaetotaxic method were given for H. traguli by Hoogstraal (1964), for H. hystricis by Hoogstraal *et al.* (1965b), for H. renschi by Hoogstraal and Anastos (1968), and for H. obesa by Hoogstraal *et al.* (1971a). Nevertheless, the accompanying illustrations were accurate, including the setae, and thus it was possible to make proper identification of these 4 species.

Chaetotaxy was used to describe 4 species: descriptions and illustrations were provided by Kohls and Clifford (1961) for I. kopsteini, by Keirans *et al.* (1970) for I. werneri, by Clifford *et al.* (1961) and Roberts (1969) for R. sanguineus and B. microplus.

III. MATERIALS AND METHODS

A. Nature and types of materials.

Some larval specimens were obtained by collecting in the field by means of running a piece of cloth over the surface of the ground (sweeping), and some were taken directly off the host. Other specimens were obtained by rearing procedures in the laboratory. Part of the larval specimens was collected and reared in Malaysia, Thailand, and Vietnam, and some came from Indonesia. Larvae collected in the field were preserved in 70% alcohol.

Larvae which were reared in Indonesia were obtained by placing field-caught engorged females, already detached from the hosts, in vials stoppered with cotton. These were kept at room temperature (27°C) and at ca. 85% relative humidity. Oviposition occurred within the vials. After the larvae hatched they were killed and stored in 70% alcohol.

B. Preparation of slides.

Specimens to be studied were mounted on slides. The mounting medium was Hoyer's solution. The formula for the solution is given below and the chemicals should be mixed in the following order.

50 grams distilled water
30 grams gum arabic (crystal)
200 grams Chloral Hydrate
20 grams Glycerine

The larvae were placed in a 5 cc beaker containing pure lactic acid. The beaker was then heated gently to a temperature just below boiling. For unengorged larvae 1 or 2 minutes after the 1st fumes

appeared was sufficient, but for engorged material a longer time was required. When the lactic acid cooled, the specimens were transferred to water to eliminate the excess lactic acid.

A drop of Hoyer's solution was placed in the center of the slide. The specimens were transferred to the mounting medium, oriented, and then covered with a circular No. 1 cover slip. The slides were placed in an oven at 40°C. for 24 to 48 hours to hasten the solidification of the medium. The completed slides were ringed with ordinary fingernail polish.

At least 1 set of slides consisting of 25 larvae was prepared for each species. These specimens were selected randomly from the progeny of a single female, if the parent tick had abundant larval offspring. If fewer than 25 specimens were available, all larvae were mounted. In either case, 3 to 4 specimens were mounted on a single slide.

Larvae which were taken off a host were mounted individually on a slide. Other field-caught larvae which were obtained by sweeping were mounted according to the procedure described previously for laboratory-reared specimens.

C. Study of specimens.

A stereoscopic dissecting microscope was used to examine unmounted specimens, and a compound, phase-contrast microscope was used to study mounted specimens. The phase-contrast microscope permits better observation of minute characters. The dissecting microscope facilitates the observation of certain structures, such as the cervical grooves and the anal grooves. However, comparative examination with both types of microscopes is necessary since specimens tend to

be depressed by the cover slip which causes some distortions. By using both types of microscopes erroneous interpretations can be avoided.

D. Drawing of specimens.

Drawings of the larvae were made from certain specimens selected from a series of slides. The outline of the specimen and certain structures were drawn by a microprojector attached to the phase-contrast microscope. Dorsal and ventral aspects of the body were drawn. Details of certain morphological structures were added to the sketch by examining the specimen under higher magnifications.

E. Material studied.

A total of 2773 specimens was studied, and consisted of 1220 laboratory-reared and 1553 field-caught larvae. The total number of specimens studied for each species is listed in Table 1.

F. Morphological terminology.

The terminology used in both the diagnoses and the descriptions was derived from the universally adopted terminology for adult ticks. The terms used below follow Arthur (1960) and Elbl and Anastos (1966) with the exception of sensillum sagittiforme which was defined originally by Schulze (1942). The list is arranged in alphabetical order. Plates 1 and 3 illustrate the location of the various structures for a hypothetical species of larval tick.

Anal groove.	A groove that encloses fully or partially the anus.
Anus	The posterior opening of the alimentary tract, situated caudally and ventrally on the median line.
Article.	A definite and distinct division of a jointed appendage.

Table 1. - Number of specimens studied for each species.

Species	Laboratory-reared	Field-caught
Amblyomma geoemydae	50	25
A. helvolum	50	14
A. javanense	50	23
Amblyomma sp. 1	—	285
Aponomma lucasi	50	27
A. soembawensis	25	—
Boophilus microplus	125	443
Dermacentor sp. 1	—	26
Dermacentor sp. 2	—	2
Haemaphysalis bispinosa	150	—
H. cornigera	25	236
H. hystricis	15	—
H. koningsbergeri	25	8
H. obesa	5	95
H. papuana	25	42
H. sumatraensis	25	—
H. wellingtoni	75	13
Haemaphysalis sp. 1	—	180
Haemaphysalis sp. 2	—	20
Ixodes granulatus	125	—
I. kopsteini	50	76
Ixodes sp. 1	—	10
Rhipicephalus haemaphysaloides	50	—
R. pilans	250	28
R. sanguineus	50	—

Auriculae. . . . . Paired ventral projections at the side of the basis capituli in some species of Ixodes.

Basis capituli . . . . . The basal portion of the capitulum to which the mouthparts are attached.

Capitulum. . . . . The anterior portion of the tick, including the basis capituli, palpi, hypostome, and chelicerae.

Cervical grooves . . . . . Paired anterior depressions in the scutum, varying in length, shape, and depth.

Chelicerae . . . . . Paired mouthparts located dorsally on the hypostome, each terminating in an internal and an external, serrated digit.

Corona . . . . . The apical portion of the hypostome, usually armed with many small denticles.

Cornuae. . . . . Caudad projections extending from the latero-posterodorsal angles of the basis capituli.

Coxae. . . . . The paired ventral plates to which the legs are movably attached. Beginning anteriorly they are designated as I, II, and III.

Coxal spurs. . . . . Spur-like or spine-like projections from the posterior surface or from the posterior margin of the coxae.

Denticles. . . . . The individual recurved teeth on the ventral side of the hypostome, usually arranged in parallel longitudinal rows or files.

Dentition. . . . . The arrangement of number of files of denticles on either side of the median line of the hypostome.

Festoons . . . . . Uniform, more or less rectangular areas separated by grooves, along the posterior submarginal area of the dorsum of all genera except Boophilus and Ixodes.

Femur. . . . . The sub-proximal segment of the leg.

Haller's organ . . . . . A small capsule containing sensory setae on the dorsal surface of tarsus I.

Hypostome. . . . . The median ventral member of the piercing mouthparts bearing rows or files of denticles.

Palps. . . . . The movable, paired appendages, parallel on each side of the hypostome. Each consists of 4 articles numbered from the base. The first article may be reduced or absent.

Parma. . . . . The most medially located festoon.

Pulvillus. . . . . A soft pad attached to the distal end of the tarsus.

Sensilla saggitiformia . . . . Four pairs of integumentary sense organs; three of them behind the coxae and the fourth on the dorsal, posterolateral surface of the body.

Scapulae . . . . . The anterior angles of the scutum projecting forward on either side of the basis capituli.

Scutum . . . . . The sclerotized plate covering the anterior portion of the dorsum.

Tarsus . . . . . The distal segment of the leg.

Tibia. . . . . The penultimate segment of the leg.

Trochanter . . . . . The second proximal segment of the leg.

G. Measurement.

Measurements are provided for some parts of the body and some groups of setae which are considered to be of diagnostic value. All measurements are in mm, and the bases for the measurements are as follows:

Length of body. . . . . From the points of the scapulae to the posterior margin of the opisthosoma.

Width of body	Measured at the area of the greatest width.
Length of scutum	From the points of the scapulae to the posterior border of the scutum.
Width of scutum	Measured at the area of the greatest width.
Length of capitulum	Measured dorsally, from the apex of the cheliceral shaft to the posterior margin of basis capituli.
Width of capitulum	Measured dorsally at the area of greatest width.
Length of palpi	From the posterior margin of the first article to the anterior margin of article III.
Width of palpi	Measured at the junction of articles II and III.
Length of hypostome	From the anterior end of the hypostome to its base.
Length of tarsus I	From the anterior border of the tibia to the tip of the tarsus. Claws and pulvillus excluded.
Width of tarsus I	Measured at the area of greatest width.
Length of seta	Measured from the proximal end of attachment with the cuticle to the apex.

H. Setal nomenclature.

The nomenclature of the setae follows Clifford and Anastos (1960). The individual setae within a given group are identified by numbers. Plates 2 and 3 illustrate the location of the setae listed below.

Dorsal surface of the body

Scutal (Sc)	Found on the scutum; up to 5 pairs.
Central dorsal (Cd)	Found on the central dorsal region of the body, posterior to the scutum; up to 6 pairs.

Marginal dorsal (Md). . . . . Found on the peripheral part of the body; up to 10 pairs.

Supplementary (S) . . . . . Found on the sub-peripheral surface of the body; up to 8 pairs.

Ventral surface of the body

Posthypostomal (Ph) . . . . . Found on the ventral surface of the basis capituli, posterior to the hypostome; up to 2 pairs.

Sternal (St). . . . . Found on the sternal region; always 3 pairs.

Preanal (Pa). . . . . Found on the ventral surface of the opisthosoma, anterior to the anus; up to 3 pairs.

Anal (A). . . . . Found on the anal valves; always 1 pair.

Marginal ventral (Mv) . . . . . Found on the peripheral surface of the opisthosoma; up to 5 pairs.

Premarginal (Pm). . . . . Found on the sub-peripheral surface of the opisthosoma; up to 12 pairs.

Dorsal surface of tarsus I

Prehalleral (Pha) . . . . . Found anterior to the Haller's organ.

Halleral (Ha) . . . . . Found on the region of the Haller's organ.

Posthalleral (Poh). . . . . Found posterior to the Haller's organ.

Ventral surface of tarsus I

Terminal (T). . . . . Found at the terminal area.

Median (M). . . . . Found at the median area.

Basal (B) . . . . . Found at the basal area.

I. Geographical designations.

Within the Indonesian archipelago, geographical names which are

used to indicate locality records refer to an island or a group of islands. Their spelling follows the National Geographic Society, Map of southeast Asia, 1968.

Outside of Indonesia, names not located on this map are taken from the National Geographic Society, Atlas of the World, 1966.

J. Nomenclature of the hosts.

The nomenclature of the hosts of the larval ixodid ticks are taken from different sources. The names of the reptilian hosts mostly follow Boettger (1893, Katalog der Reptilien-Sammlung im Museum der Senckenbergischen Naturforschenden Gesellschaft, Vol. I; 1898, Vol. II). The names of the avian hosts, which are very few, follow Peters (1934, Check-list of Birds; Vol. II), and Smythies (1960, The Birds of Borneo). The names of the mammalian hosts are taken from Ellerman and Morrison-Scott (1951, Check-list of Palaearctic and Indian Mammals) and Laurie and Hill (1954, List of mammals of New Guinea, Celebes and Adjacent Islands).

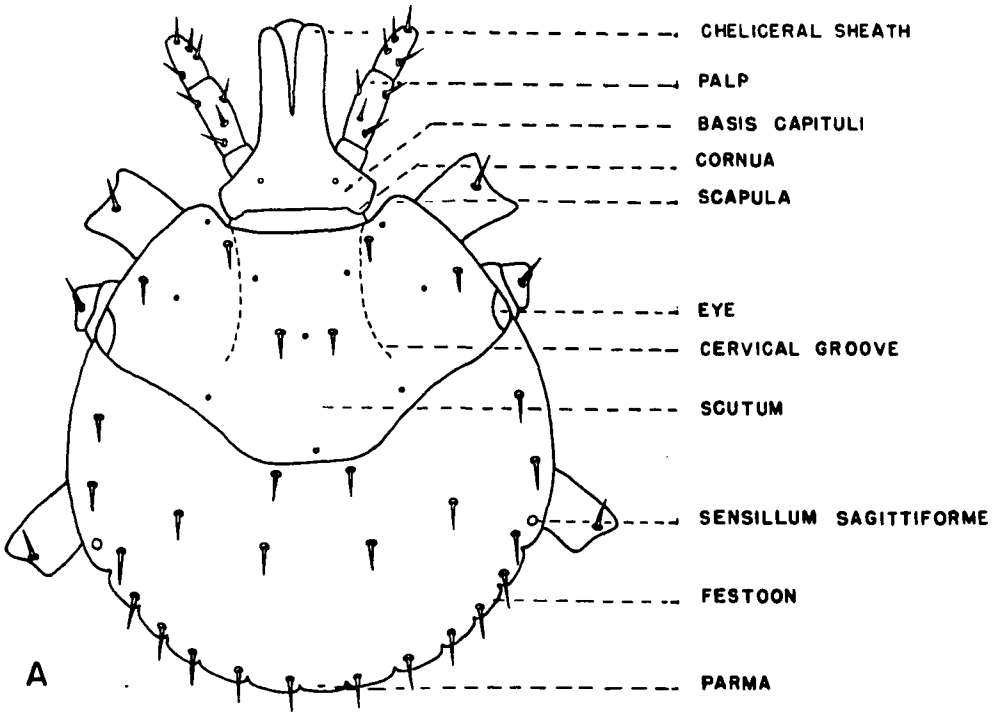
Plate 1

Principal characters of larval ticks.

Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.


CHELICERAL SHEATH
PALP
BASIS CAPITULI
CORNUA
SCAPULA
EYE
CERVICAL GROOVE
SCUTUM
SENSILLUM SAGITTIFORME
FESTOON
PARMA
A

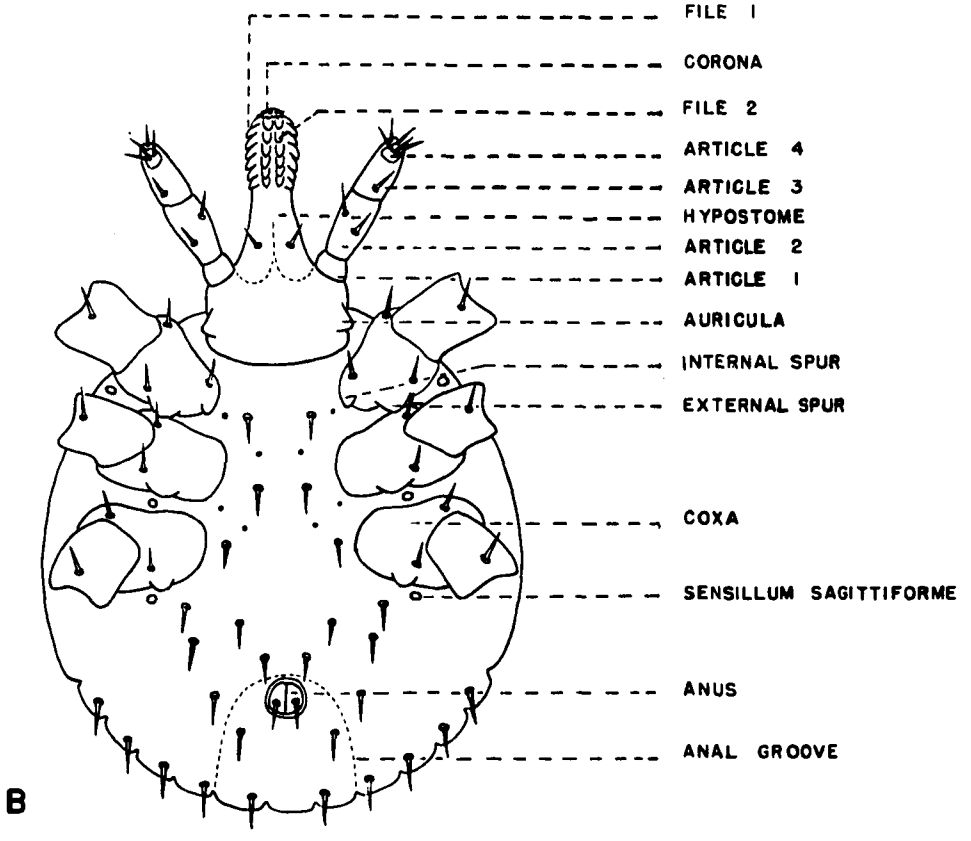

FILE 1
CORONA
FILE 2
ARTICLE 4
ARTICLE 3
HYPOSTOME
ARTICLE 2
ARTICLE 1
AURICULA
INTERNAL SPUR
EXTERNAL SPUR
COXA
SENSILLUM SAGITTIFORME
ANUS
ANAL GROOVE
B

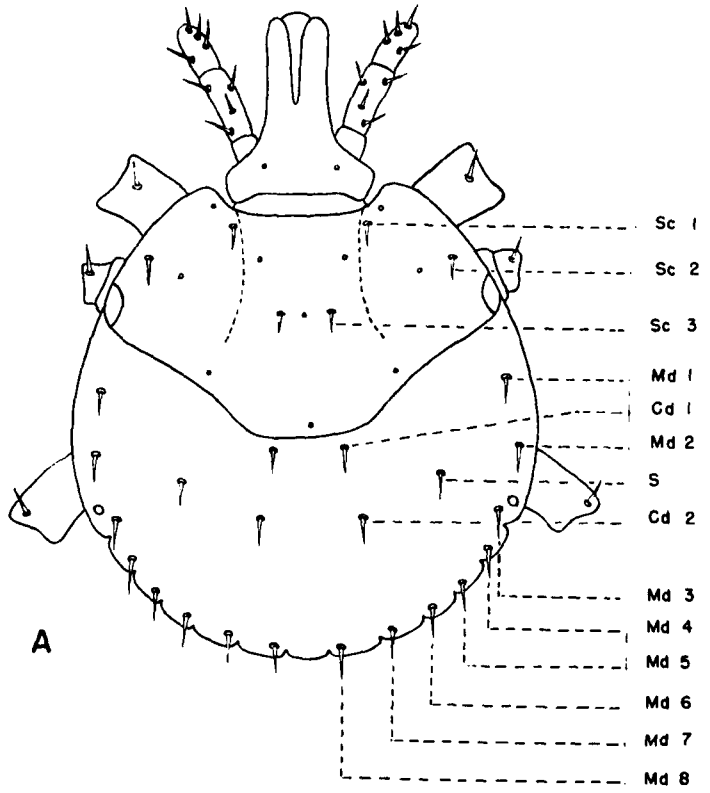
Plate 2

Chaetotaxy of larval ticks.

Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.


Sc 1
Sc 2
Sc 3
Md 1
Cd 1
Md 2
S
Cd 2
Md 3
Md 4
Md 5
Md 6
Md 7
Md 8
A

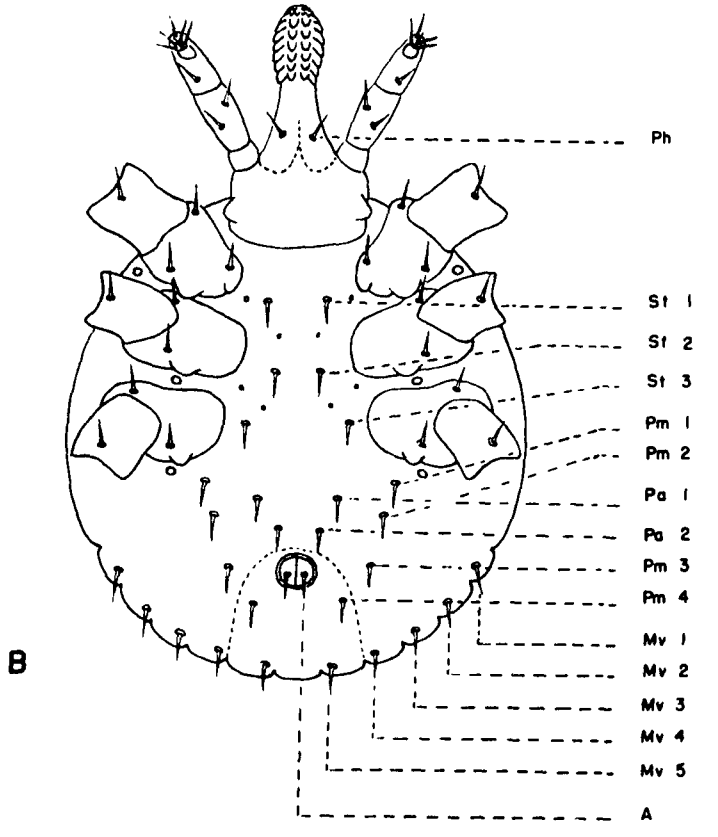

Ph
St 1
St 2
St 3
Pm 1
Pm 2
Pa 1
Pa 2
Pm 3
Pm 4
Mv 1
Mv 2
Mv 3
Mv 4
Mv 5
A
B

Plate 3

Chaetotaxy of tarsus I of larval ticks.

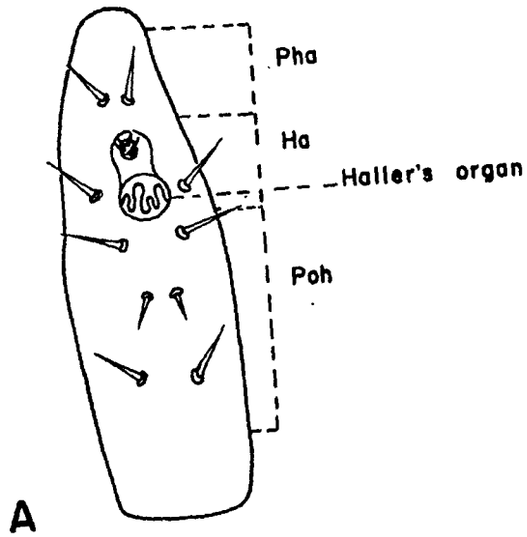
Description of figures:

A. Dorsal view: Pha (prehalleral) setae,
Ha (halleral) setae,
Poh (posthalleral) setae.

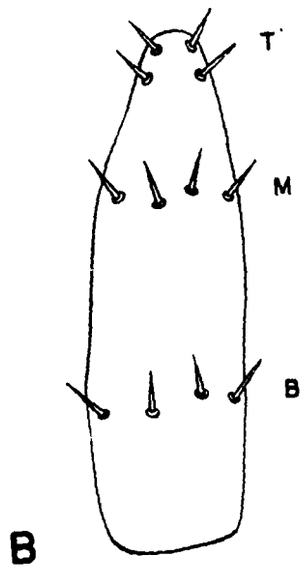
Drawn after Clifford and Anastos (1960).

B. Ventral view: T (terminal) setae,
M (median) setae,
B (basal) setae.

Modified after Clifford and Anastos (1960).



A



B

IV. DISCUSSION AND RESULTS

Ticks of the family Ixodidae occur in all parts of the world. The family consists of ca. 590 species which belong to 13 genera, namely, Ixodes Latreille, Amblyomma Koch, Aponomma Neumann, Dermacentor Koch, Anocentor Schulze, Haemaphysalis Koch, Rhipicephalus Koch, Boophilus Curtice, Margaropus Karsch, Cosmiomma Schulze, Hyalomma Koch, Nosomma Schulze, and Rhipicentor Nuttall and Warburton.

Morphologically, the larvae of ixodid ticks are characterized by the scutum which covers the dorso-anterior portion of the body and the terminally located capitulum. The chaetotaxic characters of the family have not been determined.

Most of the intra-familial categories of the larvae of ixodid ticks can be recognized on the basis of chaetotaxy. Glashinskaya-Babenko (1949) recognized the genera Ixodes, Haemaphysalis, Boophilus, Hyalomma, and Dermacentor, Rhipicephalus on the basis of the body chaetotaxy. Clifford and Anastos (1960) studied the same genera and 4 others, namely, Amblyomma, Anocentor, Margaropus, and Rhipicentor and were able to categorize better all of these genera on the basis of chaetotaxy in combination with morphological structures and to group the larvae of these genera into the previously established groups of Prostriata and Metastriata. Edwards and Evans (1967) studied the leg chaetotaxy of 6 genera and found that with this system the subfamilies and tribes to which these genera belong also may be determined.

The ixodid ticks in Indonesia are represented by the genera Ixodes, Boophilus, Dermacentor, Rhipicephalus, Aponomma, Amblyomma, and Haemaphysalis. All of these genera with the exception of the genus Aponomma were

characterized by Clifford and Anastos (1960) and can be differentiated on the basis of the key characters which they established. The larvae of the genus Aponomma were first characterized by Roberts (1969), but his diagnostic characters were unsatisfactory. It was found in the present study that Aponomma larvae could be distinguished from other genera on the basis of the chaetotaxy of tarsus I.

According to Clifford and Anastos (1960) the ventral setae on tarsus I in all genera are arranged in 3 groups namely the terminal, median, and basal groups, respectively. Each group consists of 4 setae and they are arranged in a straight line. In the present study it was found that the terminal setae in all genera were arranged in tandem of 2 instead of in a single line. The dorsal setae on tarsus I of all genera are in complete agreement with the descriptions given by Clifford and Anastos (1960). Plate 4 illustrates the setal arrangements of the dorsal and ventral surfaces of tarsus I in the 7 genera which occur in Indonesia.

The ixodid genera in Indonesia can be separated by the following key:

1. Sensilla sagittiformia present. Supplementary setae absent 2
   Sensilla sagittiformia absent. Supplementary setae present. . . . . Ixodes
2. Festoons present. 2 to 4 marginal dorsal setae anterior to sensilla sagittiformia on each side 3
   Festoons absent. 5 marginal dorsal setae anterior to sensilla sagittiformia

on each side. . . . . Boophilus

3. Palpi short and subtriangular, article 1 absent or indistinct. 4

Palpi elongate, article 1 distinct and well developed. 5

4. Eyes present. 4 marginal dorsal setae anterior to sensilla sagittiformia and 5 marginal ventral setae on each side . . . . . Rhipicephalus

Eyes absent. 2 marginal dorsal setae anterior to sensilla sagittiformia and 4 marginal ventral setae on each side . . . . . Haemaphysalis

5. Eleven festoons. 2 marginal dorsal setae anterior to sensilla sagittiformia on each side 6

Nine festoons. 3 marginal dorsal setae anterior to sensilla sagittiformia on each side . . . . . Dermacentor

6. Eyes present. Median setae on ventral surface of tarsus I generally in a single line . . . . . Amblyomma

Eyes absent. Median setae on ventral surface of tarsus I in tandem of 2 setae. . . . . Aponomma

A. Genus Amblyomma Koch.

The genus Amblyomma is represented by ca. 100 species throughout the world and is distributed in North and South America, Australia, Eurasia, and Africa. The chaetotaxy of the larvae of 9 species of Amblyomma from 3 different continents was studied by Clifford and Anastos (1960), and these form the basis of the diagnostic determination of the

Plate 4

Chaetotaxy of tarsus I of 7 genera of larval ticks.

Description of figures:

A. Dorsal view of tarsus I of Boophilus, Dermacentor, Rhipicephalus.

B. Dorsal view of tarsus I of Ixodes.

C. Dorsal view of tarsus I of Amblyomma, Aponomma.

D. Dorsal view of tarsus I of Haemaphysalis.

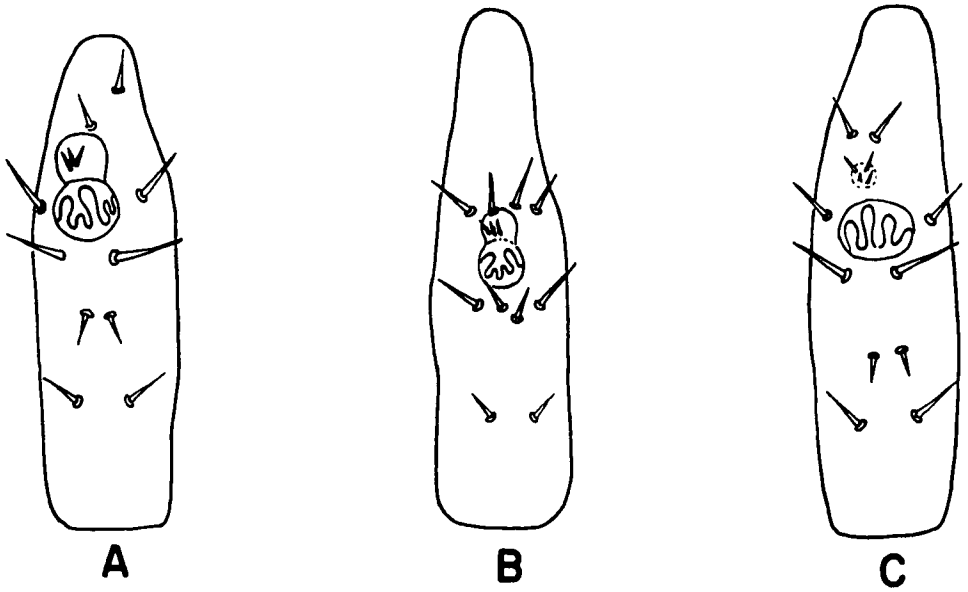
E. Ventral view of tarsus I of all genera, except Aponomma, and Amblyomma helvolum.

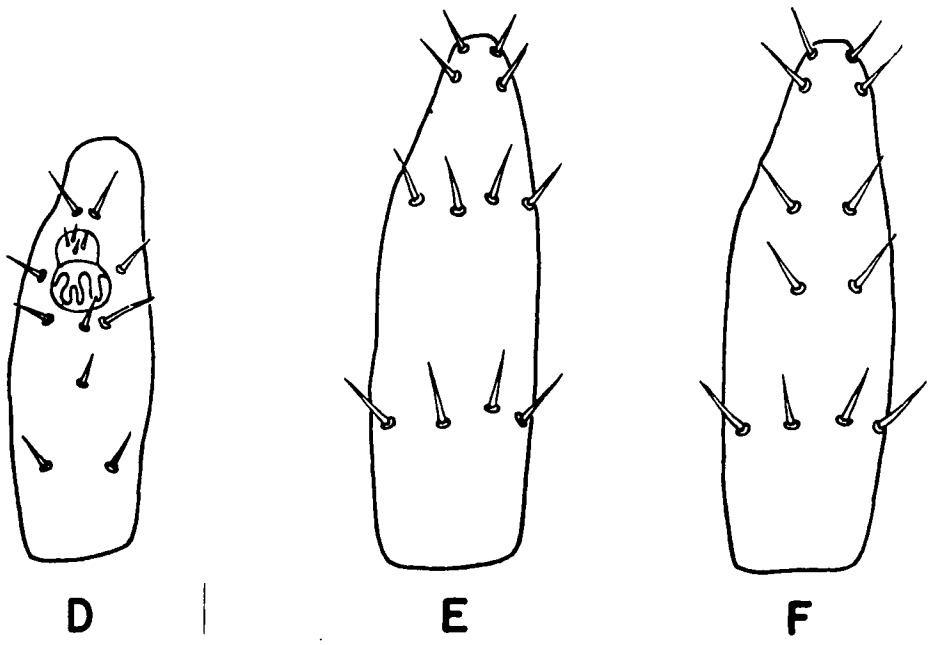
F. Ventral view of tarsus I of Aponomma.

Figs. A - D. Drawn after Clifford and Anastos (1960).

Fig. E. Modified after Clifford and Anastos (1960).

Fig. F. × 375.


A
B
C


D
E
F

genus. Four other species occuring in Australia were studied by Roberts (1969).

According to Clifford and Anastos (1960), the larvae of this genus can be distinguished by the presence of 1 pair of sensilla sagittiformia on the dorso-lateral surface of the body and by the 2 marginal dorsal (Md) setae located anterior to the sensilla on each side. Roberts (1969) reported that the location of Md 3, which is internal to the sensilla, is another important character.

Larval specimens of the genus Amblyomma from Indonesia agree in all key characters with the description given by Clifford and Anastos (1960) and Roberts (1969). In addition, the alignment of the median group of ventral setae on tarsus I is also a useful character for generic recognition; this character has never been used before. With the exception of A. helvolum, all other species of this genus in Indonesia have the 4 median setae placed in a straight line.

The diagnostic characters for the genus Amblyomma are as follows. Dorsal surface with 8 pairs of marginal dorsal (Md) setae and 2 pairs of central dorsal (Cd) setae. Ventrally with 2 pairs of preanal (Pa) setae, 4 pairs of premarginal (Pm) setae, and 5 pairs of marginal ventral (Mv) setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal (Ph) setae, and palpi with 12 setae. Coxa III with 2 setae. Tarsus I dorsally with 2 prehalleral (Pha) setae, 2 halleral (Ha), and 6 posthalleral (Poh) setae, placed in 3 groups of 2 setae each; ventrally, the median group of setae are generally in a straight line.

Nine species of the genus Amblyomma which are known to occur in Indonesia are: A. babirussae Schulze, A. cordiferum Neumann, A. crenatum

Neumann, A. cyprium Neumann, A. geoemydae (Cantor), A. helvolum Koch, A. javanense (Supino), A. robinsoni Warburton, and A. testudinarium Koch. Laboratory-reared specimens of A. geoemydae, A. helvolum and A. javanense were available for study. In addition, larvae of another species were collected in the field, but they could not be assigned definitely to any of the other species. Accordingly, these field-caught specimens are designated hereafter as Amblyomma sp. 1.

The 4 species available for study agree in all respects with the generic diagnosis of Clifford and Anastos (1960), and they can be separated by the following key.

1. Coxa I with 1 spur, scutum cordate . . . . . A. javanense
   Coxa I with 2 spurs, scutum subcordate 2
2. Coxa I with small spurs, internal spur not reaching internal margin of coxa . . . . . A. helvolum
   Coxa I with medium size spurs, internal spur reaching or extending beyond internal margin of coxa. 3
3. Palpi slender, hypostome clavate . . . . . A. geoemydae
   Palpi somewhat stout, hypostome subclavate . . . . . Amblyomma sp. 1

1. Amblyomma geoemydae (Cantor), Plate 5.—Amblyomma geoemydae occurs in southern Asia, but the full range of its distribution has not been determined. It is definitely known from Vietnam (Hoogstraal *et al.* 1968), Thailand (Gould 1970), Malay Peninsula (Kohls 1957), and parts of Indonesia. Although it prefers land turtles as host, it my be found occasionally on large snakes, lizards (Hoogstraal *et al.* 1968) and also

some birds (Gould 1970).

In Indonesia, the species has been recorded from Sumatra and Kalimantan (Anastos 1950, Anastos unpublished data), Sangihe (Anastos unpublished data). On the basis of larval records, the species is also found on Java. Adults and nymphs have been taken from tortoises, Geomyda spinosa (Gray) and Testudo emys Schlegel. Hosts of the larva are unknown.

Laboratory-reared specimens of A. geoemydae and a limited number of field-caught specimens were available for study.

DIAGNOSIS.—Body subcircular, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally triangular, ventrally subrectangular. Palpi slender and cylindrical. Coxa I with 2 spurs, internal spur reaching antero-internal margin of coxa; 3 setae. Coxae II and III each with a single spur, smaller and sharper in coxa III; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Subcircular, slightly longer than wide, widest posterior to midlength, from 0.544 to 0.616 mm long, average 0.580 mm, and from 0.544 to 0.693 mm wide, average 0.600 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.024, 0.024, 0.027, 0.027, 0.026, 0.027, 0.026, 0.027 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagitti-

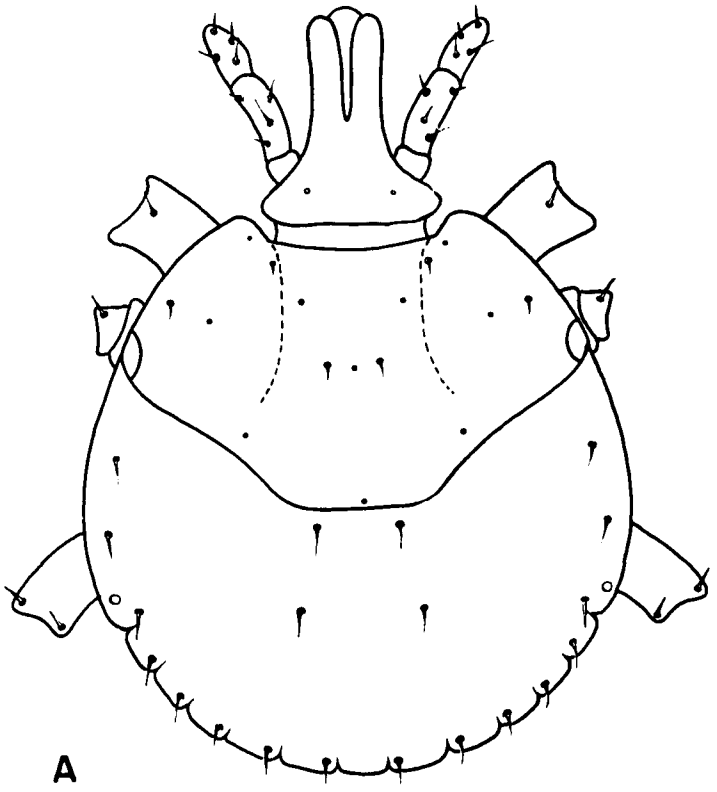
Plate 5

Amblyomma geoemydae (Cantor).

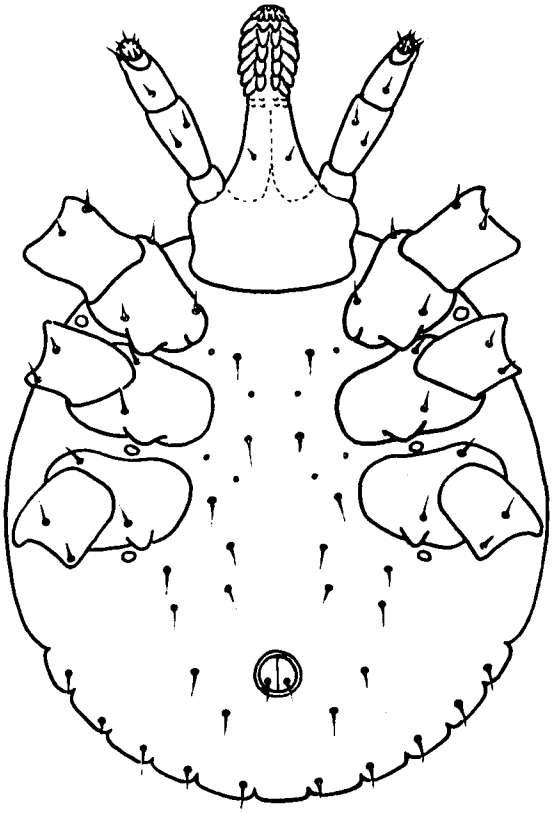
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

formia; 2 pairs of central dorsal setae, Cd 1-2 average 0.019 and 0.020 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.022, 0.024, 0.022 mm long, respectively; 2 pairs of preanal setae, average 0.019 and 0.020 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.024, 0.029, 0.031, 0.040 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.033, 0.035, 0.034, 0.031, 0.030 mm long, respectively; 1 pair of anal setae, average 0.022 mm long. Eleven festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.275 to 0.308 mm long, average 0.292 mm, and from 0.473 to 0.550 mm wide, average 0.519 mm. Cervical grooves deep, ca. 2/3 scutal length, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.023, 0.011, 0.021 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes flat, not extending beyond margin of body.

Capitulum.—From 0.231 to 0.253 mm long, average 0.247 mm, and from 0.181 to 0.203 mm wide, average 0.193 mm. Basis capituli dorsally triangular, postero-lateral margins bluntly rounded, posterior margin straight; ventrally subrectangular, lateral margins slightly sinuous in the middle, posterior margin weakly convex. Palpi slender, cylindrical, close to 5 times as long as wide, rounded distally. Article 1 distinct, article 2 about as long as article 3. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Clavate, average 0.171 mm long. Corona distinct. Dentition 2/2 with 5 or 6 large denticles per file. One pair of post-

hypostomal setae, average 0.034 mm apart and average 0.004 mm long.

Legs.—Coxa I with 2 subequal spurs, internal spur small, blunt, at antero-internal angle of coxa, never extending beyond internal margin of coxa, external spur larger than internal spur; 3 setae. Coxa II with a blunt, broadly triangular single spur; 2 setae. Coxa III with a single spur, smaller and sharper than in coxa II; 2 setae. Tarsus I tapering distally; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—Under uncontrolled laboratory condition, a single female began ovipositing 7 days after having detached from the host. The incubation period of the eggs was 49 days.

2. Amblyomma helvolum Koch, Plate 6.—Amblyomma helvolum has a wide distribution in southern Asia and has been recorded from Taiwan, Philippines, Vietnam, Thailand, Malaysia, and Indonesia. It is a parasite of large snakes and varanid lizards.

It is widely distributed in Indonesia and has been recorded from Sumatra (Neumann 1910, 1911, Vitzhum 1931, Schulze 1933, 1943, Anastos 1950, Anastos unpublished data), Simeuleu, Babi (Warburton 1926), Berhala (Oudemans 1928, Schulze 1933, Anastos unpublished data), Java (Neumann 1899, 1901, 1911, Robinson 1926, Oudemans 1929, Krijgsman and Ponto 1931, 1932, Schulze 1933, Anastos 1950, Anastos unpublished data), Sebesi, Rakata, Bawean, Madura, Celebes, Sula, Sumba, Timor (Anastos unpublished data), Komodo, Flores (Schulze 1933, Anastos unpublished data), Tanimbar (Hirst and Hirst 1910). Hosts of the adults and nymphs are a variety of snakes, skinks, and Varanus lizard species. Hosts of the larvae are

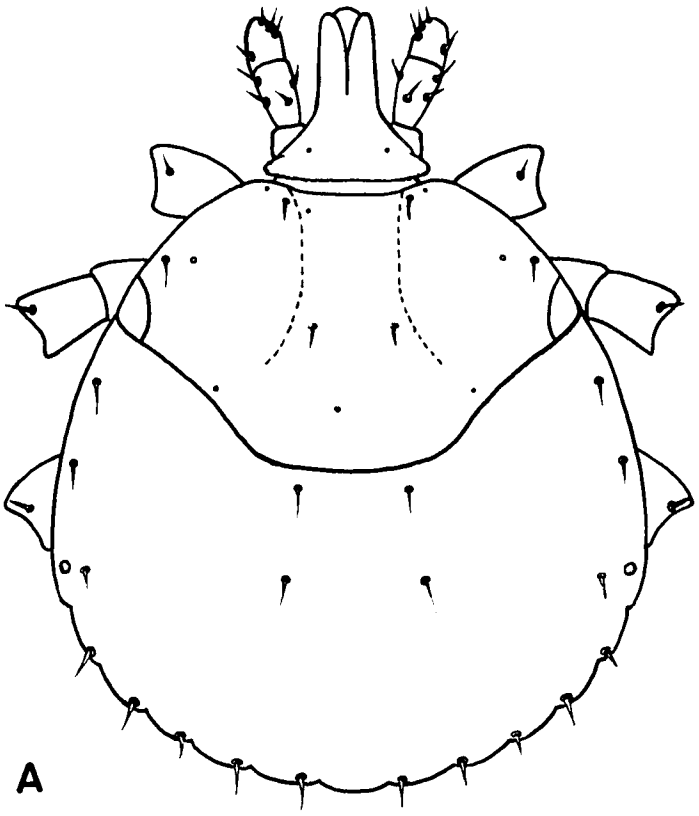
Plate 6

Amblyomma helvolum Koch.

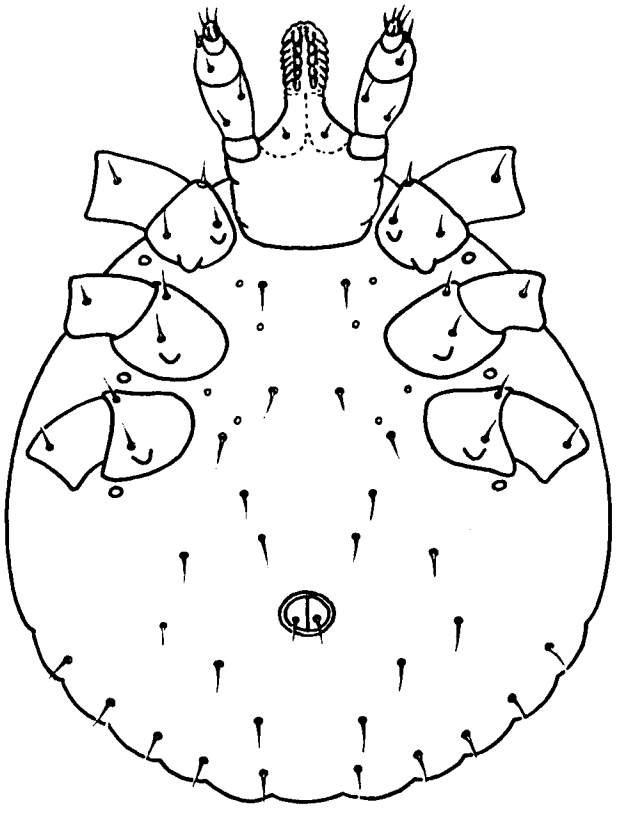
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

unknown.

Laboratory-reared larvae of A. helvolum and a limited number of field-caught specimens were available for study.

DIAGNOSIS.—Body subcircular, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally triangular, ventrally rectangular. Palpi somewhat slender and cylindrical. Coxa I with 2 subequal spurs, internal spur smaller and diagonally above external spur; 3 setae. Coxae II and III each with a small, blunt single spur; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Subcircular, slightly longer than wide, widest posterior to midlength, from 0.550 to 0.638 mm long, average 0.588 mm, and from 0.484 to 0.616 mm wide, average 0.556 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.007, 0.008, 0.008, 0.009, 0.010, 0.011, 0.011, 0.012 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.006 and 0.007 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.006, 0.008, 0.008 mm long, respectively; 2 pairs of preanal setae, average 0.006 and 0.009 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.007, 0.010, 0.011, 0.012 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.011, 0.011,

0.012, 0.011, 0.011 mm long, respectively; 1 pair of anal setae, average 0.012 mm long. Eleven festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.253 to 0.319 mm long, average 0.287 mm, and from 0.396 to 0.484 mm wide, average 0.441 mm. Cervical grooves deep anteriorly, shallow posteriorly, ca. 2/3 scutal length, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.006, 0.006, 0.007 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes flat, not extending beyond margin of body.

Capitulum.—From 0.121 to 0.176 mm long, average 0.162 mm, and from 0.143 to 0.165 mm wide, average 0.154 mm. Basis capituli dorsally triangular, postero-lateral margins subacute, posterior margin straight; ventrally rectangular, lateral margins slightly indented mid-anteriorly and mid-posteriorly, posterior margin straight. Palpi somewhat slender, cylindrical, slightly more than 3 times as long as wide, rounded distally. Article 1 distinct, article 2 about as long as article 3. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Clavate, average 0.104 mm long. Corona weakly developed. Dentition 2/2 with 5 or 6 denticles per file. One pair of posthypostomal setae, average 0.026 mm apart and average 0.005 mm long

Legs.—Coxa I with 2 small, blunt subequal spurs, internal spur diagonally above external spur, never extending beyond internal margin of coxa, external spur larger than internal spur; 3 setae. Coxa II with a small, blunt single spur; 2 setae. Coxa III similar to coxa II; 2

setae. Tarsus I tapering distally, ca. 4 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal and median groups in tandem of 2 setae.

BIOLOGY.—Under uncontrolled laboratory conditions 2 females started to oviposit 14 days after having detached from the host. The eggs hatched in 34 days.

3. Amblyomma javanense (Supino), Plate 7.—Amblyomma javanense is widely distributed in the Oriental Region, and is known from India, Ceylon, Burma, China, Vietnam, Thailand, Malaysia, parts of the Philippines, and Indonesia. It is generally associated with the pangolins, Manis spp., but it may occasionally attack reptiles also.

In Indonesia, this species has thus far been recorded only from Java (Neumann 1901, Krijgsman and Ponto 1931, 1932, Schulze 1934, Anastos unpublished data), and Sumatra (Neumann 1901, Anastos unpublished data). Adults and nymphs of this species were recorded from Manis javanica Desmarest, and larvae were also found on the same host.

Laboratory-reared as well as field-caught larvae of A. javanense were available for study.

DIAGNOSIS.—Body subcircular, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally triangular, ventrally rectangular. Palpi somewhat stout, cylindrical. Coxa I with a broadly triangular spur; 3 setae. Coxa II with a rounded spur; 2 setae. Coxa III, with a broadly triangu-

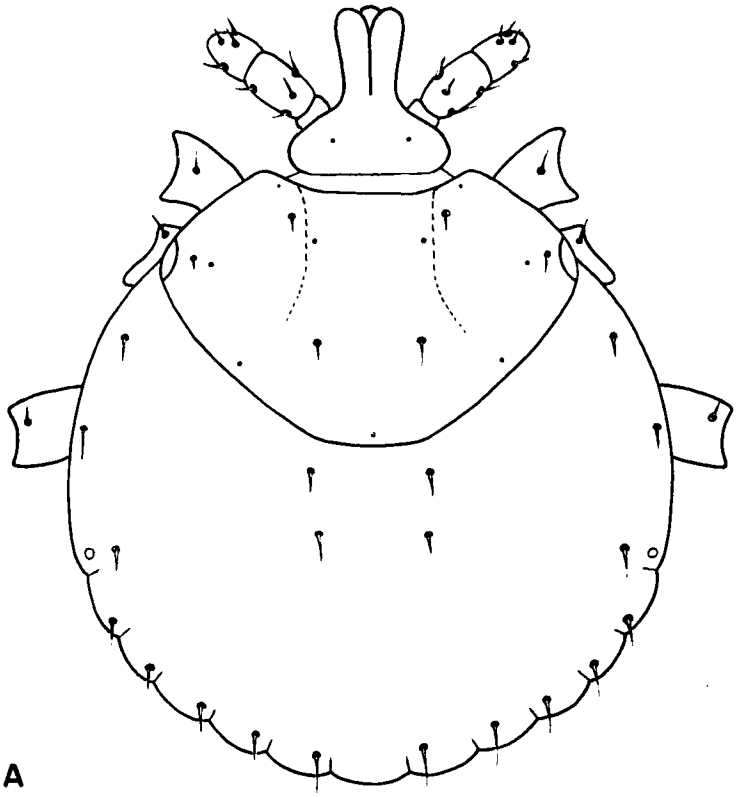
Plate 7

Amblyomma javanense (Supino).

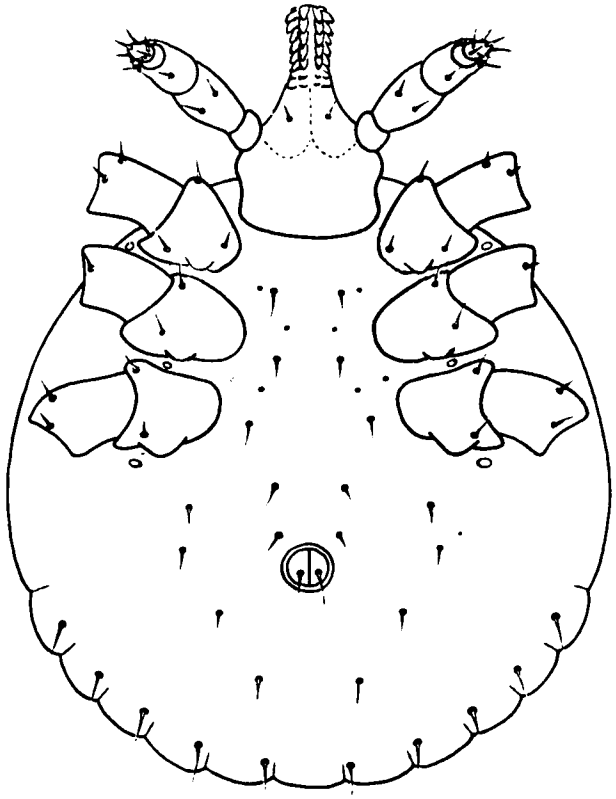
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

lar spur; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Subcircular, slightly longer than wide, widest posterior to midlength, from 0.715 to 0.858 mm long, average 0.768 mm, and from 0.671 to 0.869 mm wide, average 0.747 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.018, 0.019, 0.020, 0.027, 0.027, 0.027, 0.027. 0.029 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.017 and 0.015 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.021, 0.022, 0.022 mm long, respectively; 2 pairs of preanal setae, average 0.017 and 0.018 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.020, 0.022, 0.021, 0.019 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.019, 0.019, 0.020, 0.021, 0.022 mm long, respectively; 1 pair of anal setae, average 0.031 mm long. Eleven festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Cordate, much wider than long, from 0.297 to 0.352 mm long, average 0.328 mm, and from 0.462 to 0.627 mm wide, average 0.532 mm. Cervical grooves shallow, ca. 2/3 scutal length, parallel anteriorly diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.018, 0.011, 0.017 mm long, respectively; 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes flat, not extending beyond margin of body.

Capitulum.—From 0.220 to 0.242 mm long, average 0.233, and from 0.178 to 0.221 mm wide, average 0.202 mm. Basis capituli dorsally tri-

angular, postero-lateral margins broadly rounded, posterior margin straight; ventrally rectangular, lateral margins slightly sinuous in the middle, posterior margin weakly convex. Palpi somewhat stout, cylindrical, ca. 3 times as long as wide, rounded distally. Article I distinct, article 2 slightly longer than article 3. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.136 mm long. Corona indistinct. Dentition 2/2 with 5 or 6 denticles per file. One pair of posthypostomal setae, average 0.048 mm apart and average 0.011 mm long.

Legs.—Coxa I with a short, blunt, broadly triangular spur; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with a short, blunt, broadly triangular spur; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—Under uncontrolled laboratory condition, females started to oviposit 6 to 21 days after detaching from the host. The eggs hatched in 39 to 47 days.

All stages occur on the same species of host and A. javanense appears to be a one-host tick.

4. Amblyomma sp. 1, Plate 8.—Specimens of Amblyomma sp. 1 were collected from several localities and from a variety of habitats in Indonesia. Numerous specimens were collected by sweeping in deep forested lowland areas in Java and Kalimantan, from forest clearings in Sumatra,

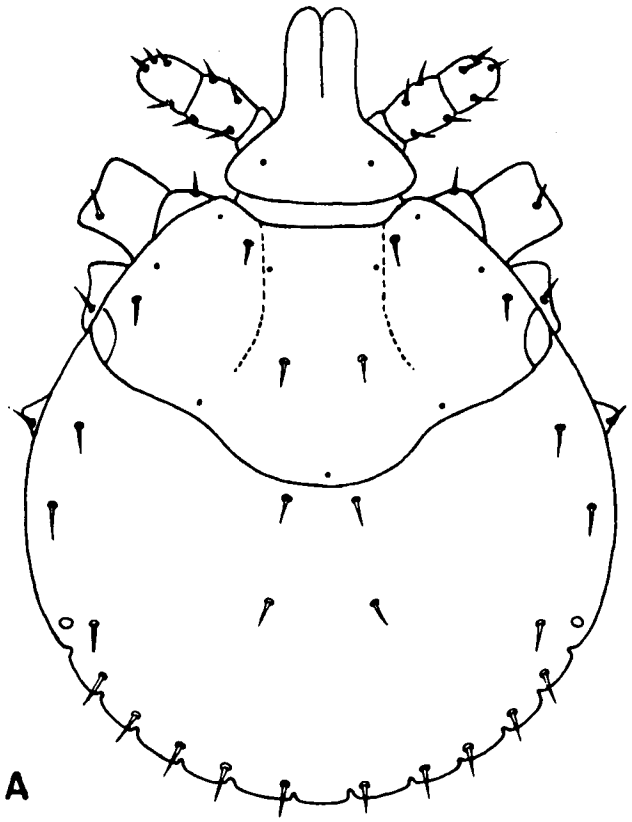
Plate 8

Amblyomma sp. 1.

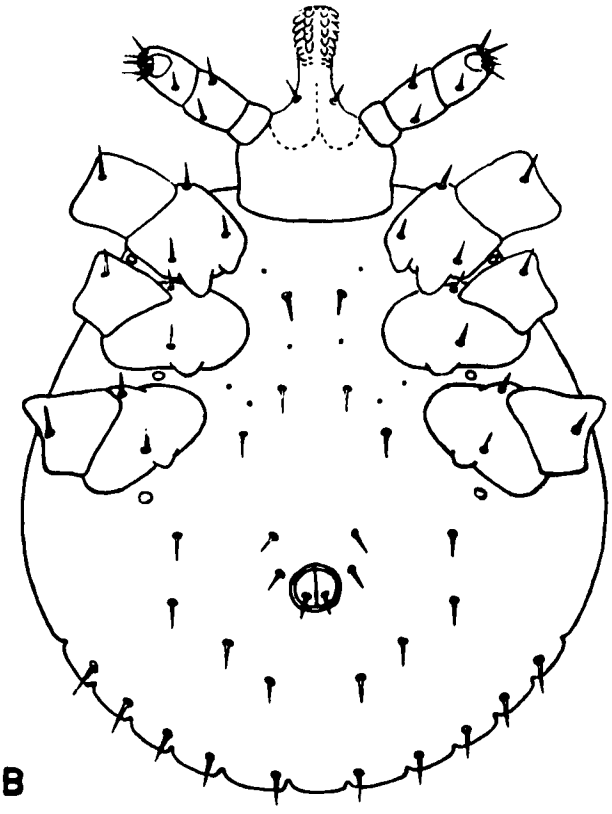
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

and from dry savannah areas in Komodo. Larvae of this species were also found parasitizing domestic chicken, a palm civet, Paradoxurus sp., and man.

The Amblyomma species of Indonesia are well defined, and as result, the specific identity of the larva of Amblyomma sp. 1 can be inferred on the basis of the host, and geographical distribution, and rarity or abundance. Thus, it is possible to eliminate A. babirussae which is restricted to Celebes, and A. cyprium which is confined to the northeastern section of the archipelago, from northern Celebes to New Guinea. Also, A. robinsoni is ruled out since it occurs only on Komodo and is a parasite of the giant lizard, Varanus komodoensis Ouwens. A. crenatum is eliminated since it is host specific to the rhinoceros, Rhinoceros sondaicus Desmarest in Indonesia and is known only from a small region on the island of Java.

The 2 remaining species to which the larvae of Amblyomma sp. 1 might belong are A. cordiferum and A. testudinarium. A. cordiferum can be ruled out since it is relatively rare in Indonesia and has a spotty distribution. A. cordiferum is recorded only from northern Sumatra (Anastos unpublished data), Krakatau (Krijgsman and Ponto 1932) and Banda (Neumann 1899), each about 1000 to 1500 miles apart.

Thus, the only remaining possibility is that Amblyomma sp. 1 is A. testudinarium. This species is the commonest and most widely distributed Amblyomma in Indonesia; it occurs in most major islands and has been found on a variety of large and medium size domestic and wild animals. Sugimoto (1937) provided a very brief description and a partial illustration of A. testudinarium, but unfortunately both were too inadequate for making comparison with the specimens presently being studied.

Nevertheless, until larvae of Amblyomma sp. 1 can be compared with laboratory-reared larvae of A. testudinarium, it is best to retain the numerical designation.

DIAGNOSIS.—Body subcircular, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally triangular, ventrally rectangular. Palpi somewhat stout, cylindrical. Coxa I with 2 small, blunt spurs; 3 setae. Coxae II and III each with a small, blunt, rounded or sometimes triangular spur; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Subcircular, slightly longer than wide, widest posterior to midlength, from 0.589 to 0.633 mm long, average 0.608 mm, and from 0.545 to 0.660 mm wide, average 0.588 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.020, 0.019, 0.030, 0.033, 0.033, 0.032, 0.033, 0.034 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.018 and 0.022 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.031, 0.032, 0.030 mm long, respectively; 2 pairs of preanal setae, average 0.020 and 0.022 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.023, 0.038, 0.033, 0.042 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.030,

0.032, 0.034, 0.036, 0.038 mm long, respectively; 1 pair of anal setae, average 0.013 mm long. Eleven festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, much wider than long, from 0.281 to 0.308 mm long, average 0.295 mm, and from 0.475 to 0.528 mm wide, average 0.492 mm. Cervical grooves deep anteriorly, shallow posteriorly, ca. 2/3 scutal length, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.015, 0.010, 0.014 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes flat, not extending beyond margin of body.

Capitulum.—From 0.176 to 0.220 mm long, average 0.192 mm, and from 0.184 to 0.202 mm wide, average 0.187 mm. Basis capituli dorsally triangular, postero-lateral margins broadly rounded, posterior margin straight; ventrally rectangular, lateral margins slightly sinuous in the middle, posterior margin weakly convex. Palpi somewhat stout, cylindrical, ca. 3 times as long as wide, rounded distally. Article 1 distinct, article 2 ca. 1 1/2 times as long as article 3. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.102 mm long. Corona slightly distinct. Dentition 2/2 with 5 or 6 denticles per file. One pair of posthypostomal setae, average 0.035 mm apart and average 0.007 mm long.

Legs.—Coxa I with 2 spurs, a small, blunt spur at antero-internal margin, and a large blunt spur at postero-internal margin; 3 setae. Coxa II with a small, bluntly rounded or sometimes triangular spur; 2 setae. Coxa III similar to coxa II; 2 setae. Tarsus I tapering distally,

slightly more than 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.— The biology of this species is unknown.

B. Genus Aponomma Neumann.—About 25 species of the genus Aponomma are recorded throughout the world. Representatives of the genus are known to occur in North America, Australia, the Orient, and Africa. By far the greatest number of species are found in the Oriental Region. The chaetotaxy of the larvae of the genus was described first on the basis of 3 Australian species by Roberts (1969).

Larvae of the genus Aponomma have 1 pair of sensilla sagittiformia on the dorsal surface of the body and 2 marginal dorsal (Md) setae located anterior to the sensilla on each side. Generic separation could not be done on these characters alone, and Roberts (1969) reported that the location of Md 3 setae which are external to the sensilla, is an additional characteristic of the genus.

Larval specimens from Indonesia showed that the Md 3 setae were located internal to the sensilla as in other genera which have 2 marginal dorsal setae anterior to the sensilla, but the alignment of the median group of ventral setae on tarsus I provides a more useful character for generic recognition. This group of setae, which consists of 4 setae, was placed in tandem of 2 setae.

The diagnosis for the genus Aponomma is as follows. Dorsal surface of body with 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, and 2 pairs of central dorsal (Cd) setae. Ventral surface with 2 pairs of preanal (Pa) setae, 4 pairs

of premarginal (Pm) setae, and 5 pairs of marginal ventral (Mv) setae. Scutum with 3 pairs of scutal (Sc) setae. Capitulum with 1 pair of posthypostomal (Ph) setae, and palpi with 12 setae. Coxa III always with 2 setae. Tarsus I dorsally with 2 prehalleral (Pha), 2 halleral (Ha), and 6 posthalleral (Poh) setae placed in 3 groups of 2 setae each; ventrally with the median group of setae placed in tandem of 2 setae.

The 5 species of Aponomma known to occur in Indonesia are A. komodoense Oudemans, A. kraneveldi Anastos, A. lucasi Warburton, A. soembawensis Anastos and A. fimbriatum (Koch). Larvae of A. lucasi and A. soembawensis were reared in the laboratory and field-caught specimens of A. lucasi were also available for study. The key given below separates the 2 laboratory-reared species.

Body subcircular, somewhat dorso-ventrally compressed; basis capituli ventrally with broadly rounded postero-lateral margins, lateral margins smooth; coxal spur I somewhat medial. . . . . .A. lucasi

Body circular; basis capituli ventrally with angular postero-lateral margins, lateral margins undulating; coxal spur I close to internal margin. . . . . A. soembawensis

1. Aponomma lucasi Warburton, Plate 9.—Aponomma lucasi has a wide distribution in the Oriental Region. It is definitely known from India, Ceylon, Burma, Thailand, Malay Peninsula, and Indonesia, including North Borneo, where it is commonly found on a variety of reptilian hosts.

In Indonesia, adults and nymphs of A. lucasi were recorded from Sumatra (Schulze 1933, Anastos unpublished data), Java (Neumann 1911,

Krijgsman and Ponto 1931, 1932, Schulze 1934, Anastos 1950, Anastos unpublished data), Dua (Anastos unpublished data), Kalimantan, Timor (Anastos unpublished data), Ternate and Babi (Vitzhum 1931). An additional locality record on the basis of larval specimens is Celebes. Hosts of the adults are several serpent species and monitor lizards (Anastos unpublished data). Larvae of this species have been found on the snakes, Python reticulatus (Schneider) and Elaphe flavolineata (Schlegel) and the lizards, Varanus indicus Daudin and V. salvator (Laurenti).

Laboratory-reared larvae of A. lucasi and some field-caught specimens were available for study.

DIAGNOSIS.—Body subcircular, somewhat dorso-ventrally compressed, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally triangular and ventrally rectangular with broadly rounded postero-lateral margins. Palpi elongate and cylindrical. Coxae I to III each with a short, blunt spur. Coxa I with 3 setae, coxae II and III each with 2 setae. Median group of ventral setae on tarsus I in tandem of 2 setae.

DESCRIPTION.—In all cases 25 specimens were examined and the average measurements are based upon this number.

Body.—Subcircular, somewhat dorso-ventrally compressed, widest at midlength, from 0.616 to 0.726 mm long, average 0.650 mm, and from 0.649 to 0.770 mm wide, average 0.676 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla

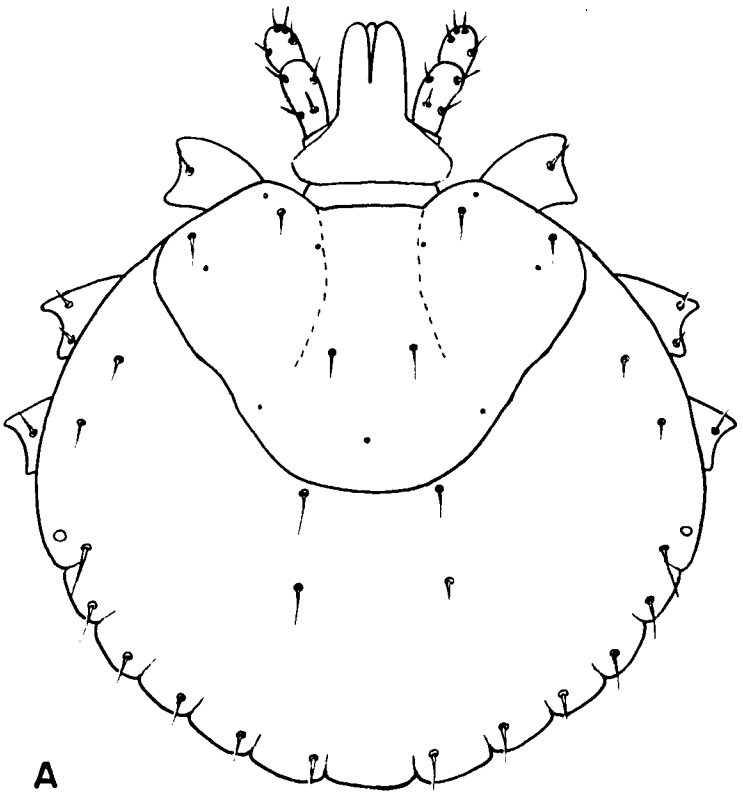
Plate 9

Aponomma lucasi Warburton.

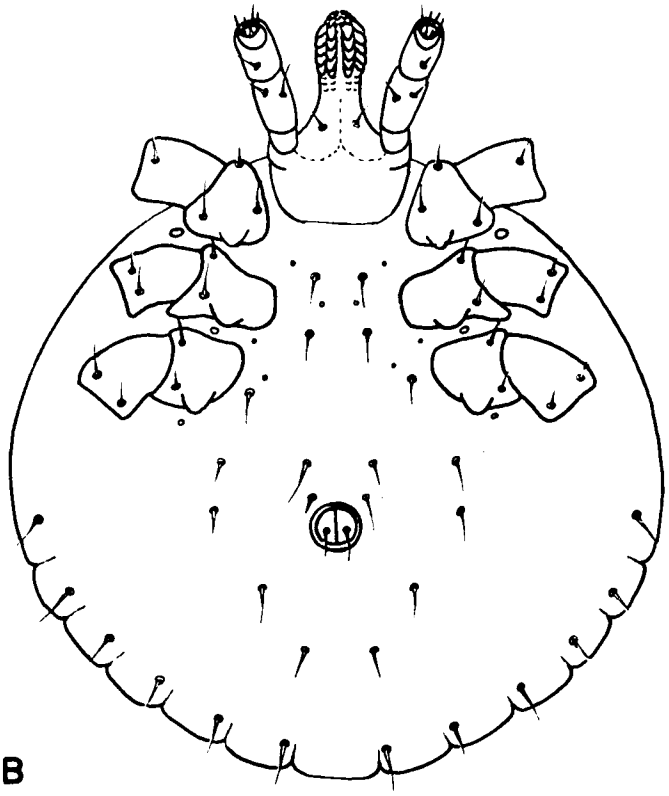
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.015, 0.017, 0.025, 0.026, 0.027, 0.027, 0.025, 0.025 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.011 and 0.014 mm long respectively; ventrally with 3 pairs of sternal setae, St 1-3 average 0.015, 0.015, 0.014 mm long, respectively; 2 pairs of preanal setae, average 0.011 and 0.012 mm long, respectively; 4 pairs of premarginal ventral setae, Pm 1-4 average 0.011, 0.013, 0.014, 0.017 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.014, 0.014, 0.015, 0.015, 0.015 mm long, respectively; 1 pair of anal setae, average 0.024 mm long. Eleven festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Cup-shaped, postero-lateral margins straight to slightly concave, wider than long, from 0.330 to 0.363 mm long, average 0.345 mm, and from 0.462 to 0.506 mm wide, average 0.474 mm. Cervical grooves deep anteriorly forming a pit, long, ca. 2/3 of scutal length, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.011, 0.008, 0.016 mm long, respectively; 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.165 to 0.242 mm long, average 0.190 mm, and from 0.165 to 0.187 mm wide, average 0.176 mm. Basis capituli dorsally triangular; postero-lateral margins broadly rounded, posterior margin straight; ventrally rectangular, lateral margins undulating, postero-lateral margins angular, posterior margin straight. Palpi elongate, cylindrical, ca. 4 times as long as wide, flatly rounded distally.

Article 1 distinct, article 2 about as long as article 3. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Clavate, average 0.121 mm long. Corona well developed with many distinct small denticles. Dentition 2/2 with 5 or 6 large denticles per file. One pair of posthypostomal setae, average 0.036 mm apart and average 0.004 mm long.

Legs.—Coxa I with a short, blunt triangular spur, somewhat medially located; 3 setae. Coxae II and III each with spur similar to coxa I; 2 setae. Tarsus I tapering distally; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae, in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae, the terminal and median groups in tandem of 2 setae.

BIOLOGY.—Little is known about the biology of this species. Because all stages of development occur on one host, this species is considered to be a one-host tick.

Two females reared in the laboratory under uncontrolled condition started to oviposit 3 to 6 days after detaching from the host The eggs hatched in 35 to 40 days.

2. Aponomma soembawensis Anastos, Plate 10.—Aponomma soembawensis is an endemic species and thus far has been recorded only from Soembawa Island in Indonesia (Anastos 1956). Hosts for the adults and nymphs are a snake, Python reticulatus and a lizard, Varanus salvator, and hosts for the larvae are not known.

Only laboratory-reared larvae of this species were available for study, and the female parent was taken off Python reticulatus in a zoo in Surabaja, Java.

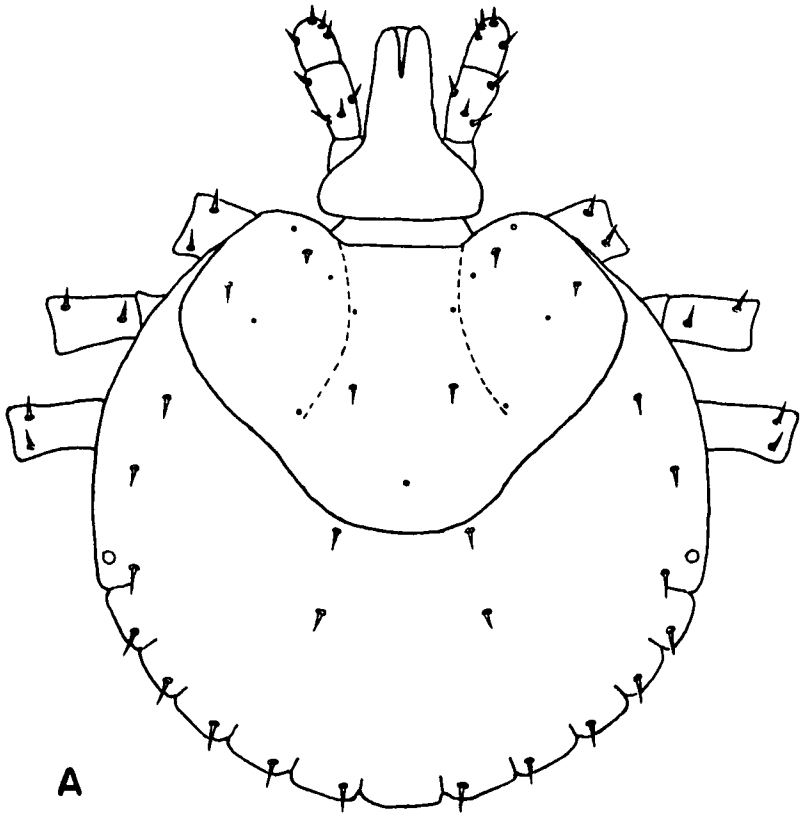
Plate 10

Aponomma soembawensis Anastos.

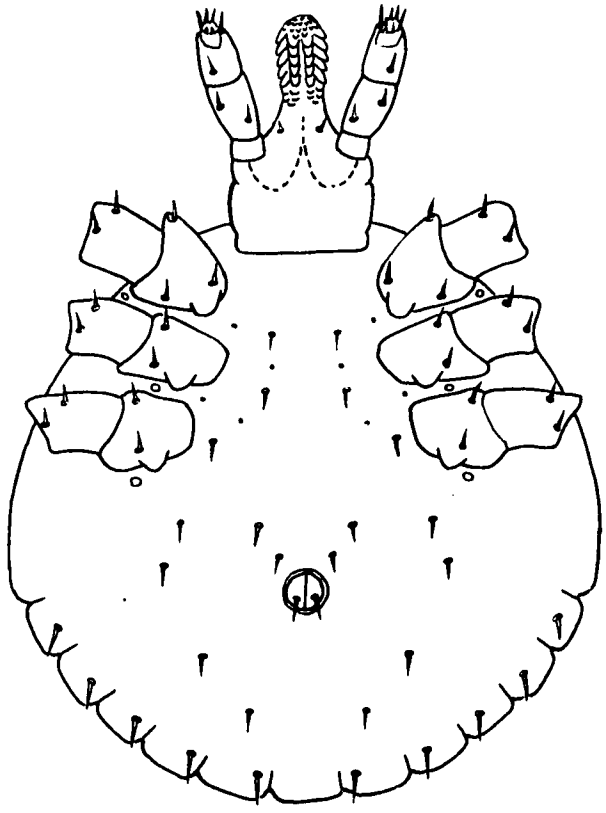
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

DIAGNOSIS.—Body subcircular, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally triangular; ventrally rectangular, lateral margins undulating. Palpi elongate, cylindrical. Coxae I to III each with a short, blunt, spur. Coxa I with 3 setae, coxae II and III each with 2 setae. Median group of ventral setae on tarsus I in tandem of 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Subcircular, from 0.550 to 0.638 mm long, average 0.597 mm, and from 0.572 to 0.638 mm wide, average 0.606 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.016, 0.018, 0.020, 0.022, 0.022, 0.022, 0.022, 0.023 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.014 and 0.016 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.013, 0.017, 0.015 mm long, respectively; 2 pairs of preanal setae, average 0.014 and 0.015 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.013, 0.015, 0.015, 0.013 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.016, 0.018, 0.018, 0.018, 0.018 mm long, respectively; 1 pair of anal setae, average 0.021 mm long. Eleven festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Cup-shaped, postero-lateral margins straight to concave, wider than long, from 0.286 to 0.330 mm long, average 0.310 mm, and from 0.385 to 0.429 mm wide, average 0.401 mm. Cervical grooves deep anteriorly forming a pit, long ca. 2/3 scutal length, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.016, 0.011, 0.016 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.165 to 0.209 mm long, average 0.187 mm, and from 0.143 to 0.187 mm wide, average 0.156 mm. Basis capituli dorsally triangular, postero-lateral margins rounded, posterior margin straight; ventrally rectangular, lateral margins undulating, postero-lateral margins angular, posterior margin straight. Palpi elongate, cylindrical, ca. 3 1/2 times as long as wide, flatly rounded distally. Article 1 distinct, article 2 longest, ca. 1 1/2 as long as article 3. Article 1 without setae; articles 2 and 3 each with 2 ventral setae and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Clavate, average 0.109 mm long. Corona well developed with many distinct small denticles. Dentition 2/2 with 5 or 6 large denticles per file. One pair of posthypostomal setae, average 0.037 mm apart and average 0.005 mm long.

Legs.—Coxa I with a short, bluntly rounded spur, close to internal margin of coxa; 3 setae. Coxae II and III each with a short, blunt triangular spur; 2 setae. Tarsus I tapering distally; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal and

median groups in tandem of 2 setae.

BIOLOGY.—The biology of this species is not known.

C. Genus Boophilus Curtice.—The genus Boophilus is relatively small in number of species. Arthur (1960) recognized only 3 species, but apparently omitted the species known to occur in the western Palaearctic region. Species of the genus are distributed in North America, Central and South America, Australia, the Orient, parts of Africa and Europe. At present 5 species are recognized, and Clifford and Anastos (1960) utilized these 5 species as a basis for the generic description of the larvae.

The larvae of the genus Boophilus can be recognized by the presence of 1 pair of sensilla sagittiformia on the postero-lateral surface of the body and the 5 marginal dorsal setae located anterior to sensilla on each side. According to Clifford and Anastos (1960), other chaetotaxic characters of the genus are the presence of 8 pairs of marginal dorsal (Md) setae, 2 pairs of central dorsal (Cd) setae, 2 pairs of preanal (Pa) setae, 4 pairs of premarginal (Pm) setae, and 4 to 5 pairs of marginal ventral (Mv) setae. Scutum with 3 pairs of scutal (Sc) setae. Capitulum with 1 pair of posthypostomal (Ph) setae, and palpi with 12 setae. Coxa III always with 2 setae. Dorsal surface of tarsus I with 2 prehalleral (Pha), 2 halleral (Ha), and 6 posthalleral (Poh) setae placed in 3 groups of 2 setae each.

The only species of the genus Boophilus in Indonesia is B. microplus. Laboratory-reared as well as field-caught larvae of this species were available for study. The chaetotaxic characters shown by this species are in agreement with the generic characters given by Clifford and Anastos (1960).

1. Boophilus microplus (Canestrini), Plate 11.—B. microplus is the only member of the genus which has a wide geographical distribution. It is reported to occur in Central and South America, Micronesia, Australia, Orient, South and East Africa (Roberts 1970). Records from North America are restricted to southern Florida. The primary host of this species is usually domestic cattle.

Within the Indonesian archipelago, B. microplus is distributed widely. Adults and nymphs are known to occur in Sumatra, Java, Karimundjawa, Madura, Celebes, Amboina, Lombok, Sumba, Flores, Bali, Timor (Anastos 1950, Anastos unpublished data), Butung, Sula, Sangihe, Halmahera, Saparua, Tanimbar, Nias, Irian (Anastos 1950), Bawean, Kalimantan, Natuna Selatan (Anastos unpublished data). Additional records based on larval specimens are Peutjang and Komodo.

In Indonesia, larvae of B. microplus have thus far only been collected from a buffalo, but adults and nymphs have been found on a variety of domestic animals such as cow, buffalo, horse, pig, goat, dog, and cat. Records from wild animals are mostly from ungulates (Anastos unpublished data). An unusual record for the adult was from a pangolin, Manis javanica Desmarest (Anastos unpublished data). This is of some interest although other unusual records were also known from a buzzard and a domestic chicken (Anastos 1950).

The larvae of B. microplus have been described previously. Arthur (1960) strictly utilized morphological characters for his description. Clifford *et al.* (1961) and Roberts (1969) used a combination of morphological and chaetotaxic characters. None of the Indonesian specimens which were examined differed from the descriptions of Clifford

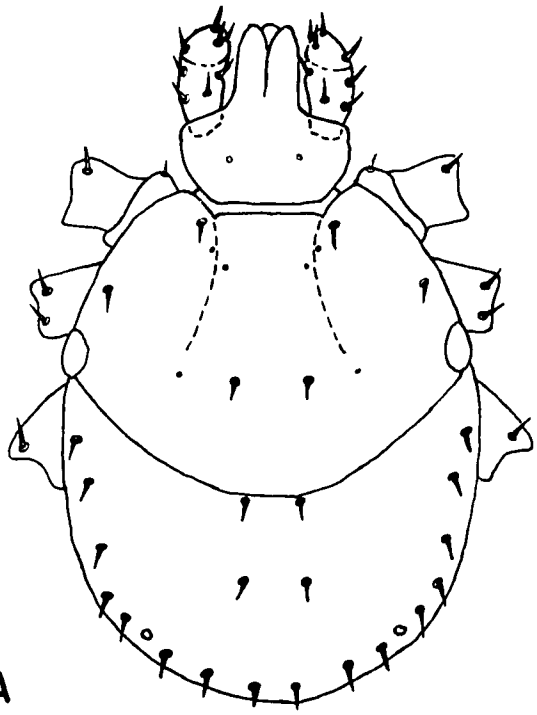
Plate 11

Boophilus microplus (Canestrini).

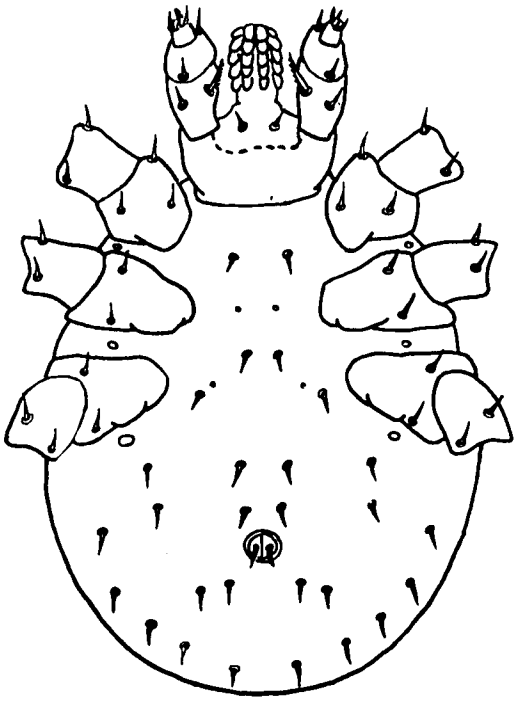
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

et al. (1961) and Roberts (1969).

DIAGNOSIS.—Body oval to subcircular, 8 pairs of marginal dorsal setae (Md), Md 1 to Md 5 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae. Basis capituli dorsally and ventrally subrectangular. Palpi somewhat elongate. Coxa I with a short, blunt, broadly triangular spur; 3 setae. Coxae II and III each with a shallow rounded spur, less developed in coxa III; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval to subcircular, longer than wide, widest at about midlength, from 0.440 to 0.506 mm long, average 0.478 mm, and from 0.357 to 0.434 mm wide, average 0.400 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.011, 0.010, 0.011, 0.014, 0.014, 0.014, 0.014, 0.013 mm long, respectively, Md 1 to Md 5 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.006 and 0.009 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.024, 0.023, 0.022 mm long, respectively; 2 pairs of preanal setae, average 0.022 and 0.024 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.023, 0.028, 0.024, 0.021 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.020, 0.019, 0.017, 0.018, 0.014 mm long, respectively; 1 pair of anal setae, average 0.018 mm long. Festoons absent, Anal grooves absent.

Scutum.—Somewhat trapezoid, with posterior margin deeply convex, wider than long, from 0.258 to 0.330 mm long, average 0.291 mm, and from 0.341 to 0.412 mm wide, average 0.377 mm. Cervical grooves shallow, short, reaching about scutal midlength, subparallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.022, 0.009, 0.009 mm long, respectively; 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae posterior to cervical grooves. Eyes oval, extending beyond margin of body.

Capitulum.—From 0.137 to 0.165 mm long, average 0.151 mm, and from 0.160 to 0.176 mm wide, average 0.163 mm. Basis capituli dorsally subrectangular, lateral margins slightly rounded, posterior margin straight; ventrally subrectangular, posterior margin straight. Palpi somewhat elongate, bluntly rounded distally, slightly more than 2 times as long as wide. Article 1 indistinct, probably fused with article 2, article 2 slightly longer than article 3. Articles 2 and 3 each with 2 ventral and 4 dorsal setae; article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.079 mm long. Dentition 2/2 with 5 or 6 denticles per file. One pair of posthypostomal setae, average 0.034 mm apart and average 0.018 mm long.

Legs.—Coxa I with a short blunt, broadly triangular spur; 3 setae. Coxa II with a shallow, rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthallereal setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species has been studied extensively in other parts of the world. All stages of the life cycle are

are known. The species is a one-host tick; the larvae remain on the host until mature. Arthur (1960) reviewed works previously done regarding the duration of each developmental stage and also the temperature and humidity requirements of each stage.

Very little work has been done on the biology of B. microplus in Indonesia. Under uncontrolled laboratory conditions, the larval progeny of 4 females hatched in from 23 to 28 days after eggs were laid. In nature, larvae are apparently active throughout the year. Numerous specimens were collected from April until December. The absence of records during the 1st quarter of the year does not necessarily indicate their absence in nature. The monsoon season which coincides with that period makes field work extremely difficult, and hence no collections were made.

In other parts of the world, B. microplus is an important vector in the transmission of Babesia bigemina, B. berbera, and Anaplasma marginale to cattle, B. ovis to sheep, and Nuttalia equi to horses (Arthur 1960). Hence, this species should be regarded as a possible vector in Indonesia.

D. Genus Dermacentor Koch.—The genus Dermacentor consists of about 30 species and subspecies (Wilson 1970a). Members of this genus occur in Eurasia, Africa, and America. In Indonesia, the genus Dermacentor has long been considered to be represented by only 1 species, namely D. auratus Supino. This species has a northernly distribution extending as far as Burma. Anastos (1950) considered adult specimens of Dermacentor from the islands of Java and Sumatra in Indonesia and from Burma (type locality) to be D. auratus. He also stated that this species showed great variation and that a more thorough study was needed

to determine if more than 1 species was involved. Kohls (1957), after studying many adult specimens from different localities in the Indo-Malayan region, recognized with certainty only D. auratus, and he too reported that considerable variation existed among specimens. Audy *et al.* (1960) reported the presence of 2 forms of Dermacentor in the Malay Peninsula, the adults of which could be separated on the basis of the spurs on coxa I. In one form, the spurs are rather short and widely separated, whereas in the other they are long and close together. The form with short, separated spurs was indistinguishable from the typical D. auratus and both forms may occur together on the same host. Hoogstraal *et al.* (1968) erected a species group, namely D. auratus group, to accommodate the different forms of the adult that exist in southern Asia. This view was shared by Wilson (1970a) who believed that more than one species of Dermacentor was present in Southeast Asia.

Apparently, the controversy regarding the specific validity of different forms started when D. compactus and D. atrosignatus were described by Neumann in 1901 and 1906, respectively, for adult specimens differing from D. auratus. The problem has existed ever since and became more controversial when different names could not be related with different host associations and types of life cycles. Kohls (1957) and Audy *et al.* (1960) suggested laboratory-rearing and comparison of the progeny of individual females as the only solution to the problem, but this has not as yet been done. However, Hoogstraal (personal communication) recognized the presence in Southeast Asia of 3 distinct adult types on morphological grounds and regarded them to be D. compactus, D. atrosignatus, and D. auratus.

In regard to the larvae of the genus Dermacentor, the chaetotaxy of 4 species of the Russian region was studied by Reznik (1950) and Cerny (1957b), and the larvae of 5 species, mostly from the American continent, were studied by Clifford and Anastos (1960) as a basis for generic diagnosis.

The larvae of the genus Dermacentor can be separated from other genera by the presence of 1 pair of sensilla sagittiformia on the dorsal surface of the body and 3 marginal dorsal (Md) setae located anterior to the sensilla on each side. Other diagnostic characters of the genus are the presence of 8 pairs of marginal dorsal (Md) setae, 2 pairs of central dorsal (Cd) setae, 2 pairs of preanal (Pa) setae, 4 pairs of premarginal (Pm) setae, and 5 pairs of marginal ventral (Mv) setae on the body. Also, 3 pairs of scutal (Sc) setae and 1 pair of posthypostomal (Ph) setae are present. Palpi with 12 setae. Coxa III always with 2 setae. Tarsus I dorsally with 2 prehalleral (Pha), 2 halleral (Ha), and 6 posthalleral (Poh) placed in 3 groups of 2 setae each.

No larval specimens of Dermacentor have been reared in the laboratory, but field-caught larvae from Java were available for study. These specimens were segregated easily into 2 distinct groups, but in the absence of laboratory-reared material it was impossible to assign specific names to them. Therefore, these two forms of Dermacentor larvae were designated as Dermacentor sp. 1 and Dermacentor sp. 2. The pronounced distinctness of these 2 species lends validity to the concept that at least 2 species of Dermacentor occur in Indonesia, namely D. atrosignatus and D. compactus, and possibly a third species,

D. auratus. A comparison of the larvae of Dermacentor sp. 1 and Dermacentor sp. 2 also indicates that their morphological features are more distinctive than those of the adult forms of the species of Dermacentor in Southeast Asia.

Both Dermacentor sp. 1 and Dermacentor sp. 2 agree in all chaetotaxic characters with the generic description given by Clifford and Anastos (1960) and can be separated by the following key.

Basis capituli dorsally widely triangular, lateral margins extending beyond scapular angle, posterior margin concave laterally; ventrally with 1 pair of acute retrograde spurs; coxal spur I long and acute. . . . . Dermacentor sp. 1

Basis capituli dorsally narrowly triangular, lateral margins not extending beyond scapular angle, posterior margin without concavity; ventrally without retrograde spurs; coxal spur I broadly triangular and blunt. . . . . Dermacentor sp. 2

1. Dermacentor sp. 1, Plate 12.—Specimens of Dermacentor sp. 1 were obtained by sweeping in a forested lowland area on the island of Java, and all specimens were in an unengorged state.

DIAGNOSIS.—Body broadly oval, postero-lateral margins more or less parallel, 8 pairs of marginal dorsal (Md) setae, Md 1 to Md 3 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally

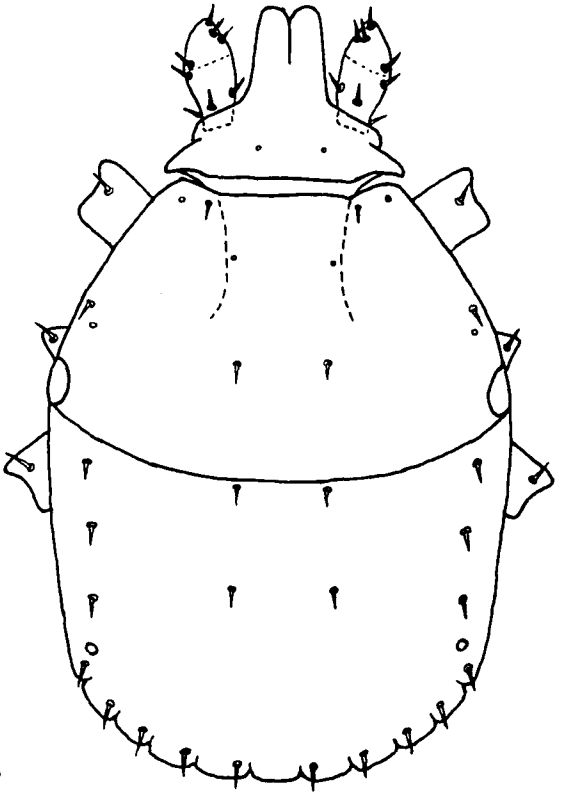
Plate 12

Dermacentor sp. 1.

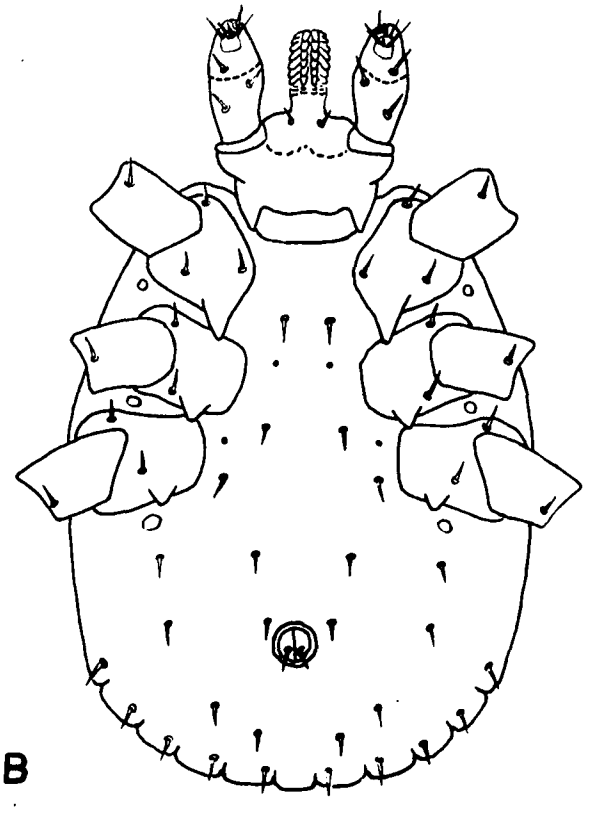
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

widely triangular, lateral margins acute, extending beyond scapular angle; ventrally with 1 pair of long, acute retrograde spurs. Palpi somewhat elongate, bluntly rounded distally. Coxa I with a long, acute spur; 3 setae. Coxae II and III each with a small triangular spur; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Broadly oval, longer than wide, widest at midlength, postero-lateral margins more or less parallel, from 0.550 to 0.594 mm long, average 0.572 mm, and from 0.418 to 0.440 mm wide, average 0.426 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.011, 0.014, 0.015, 0.014, 0.014, 0.014, 0.014, 0.014 mm long, respectively, Md 1 to Md 3 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.012 and 0.013 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.022, 0.018, 0.015 mm long, respectively; 2 pairs of preanal setae, average 0.017 and 0.016 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.026, 0.029, 0.035, 0.033 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.021, 0.019, 0.021, 0.021, 0.020 mm long, respectively; 1 pair of anal setae, average 0.012 mm long. Nine festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Trapezoid with posterior margin slightly convex, wider than long, from 0.231 to 0.308 mm long, average 0.288 mm, and from

0.396 to 0.429 mm wide, average 0.412 mm. Cervical grooves shallow, short, reaching scutal midlength, parallel anteriorly, slightly diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.010, 0.007, 0.010 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae posterior to cervical grooves. Eyes flat, not extending beyond margin of body.

Capitulum.—From 0.132 to 0.176 mm long, average 0.150 mm, and from 0.198 to 0.209 mm wide, average 0.199 mm. Basis capituli dorsally widely triangular, lateral margins acute, extending beyond scapular angle, posterior margin straight with lateral ends slightly concave embracing the curvature of scapulae; ventrally subrectangular, wider anteriorly than posteriorly, with 1 pair of acute, retrograde spurs at about midlength. Palpi somewhat elongate, bluntly rounded distally ca. 2 1/2 times as long as wide. Article 1 distinct, article 2 slightly longer than article 3. Article 1 without setae; articles 2 and 3 each with 2 ventral and 4 dorsal setae; article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.068 mm long. Dentition 2/2 with 6 or 7 denticles per file. One pair of posthypostomal setae, average 0.024 mm apart and average 0.005 mm long.

Legs.—Coxa I with a long, acute spur, extending beyond anterior margin of coxa II; 3 setae. Coxa II with a short, subacute, triangular spur; 2 setae. Coxa III with spur similar to coxa II; 2 setae. Tarsus I tapering distally, ca. 3 1/2 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species is unknown.

2. Dermacentor sp. 2, Plate 13.—Specimens of Dermacentor sp. 2 were obtained by sweeping in a forested lowland area on the island of Java, and all specimens were in an unengorged state.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 to Md 3 anterior to sensilla sagittiformia on each side, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally narrowly triangular, lateral margins not extending beyond scapular angle; ventrally smooth. Palpi somewhat elongate, flatly rounded distally. Coxa I with a broadly triangular spur; 3 setae. Coxae II and III each with a shallow rounded spur; 2 setae.

DESCRIPTION.—In all cases, 2 specimens were examined and the average measurements are based upon this number.

Body.—Broadly oval, longer than wide, widest at midlength, from 0.605 to 0.627 mm long, average 0.616 mm, and from 0.506 to 0.539 mm wide, average 0.522 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorsolateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.017, 0.016, 0.019, 0.022, 0.022, 0.022, 0.020, 0.019 mm long, respectively, Md 1 to Md 3 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.013 and 0.015 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.032, 0.026, 0.020 mm long, respectively; 2 pairs of preanal setae, both average 0.017 mm long; 4 pairs of premarginal setae, Pm 1-4 average 0.027, 0.031, 0.035, 0.035 mm long, respectively; 5 pairs of

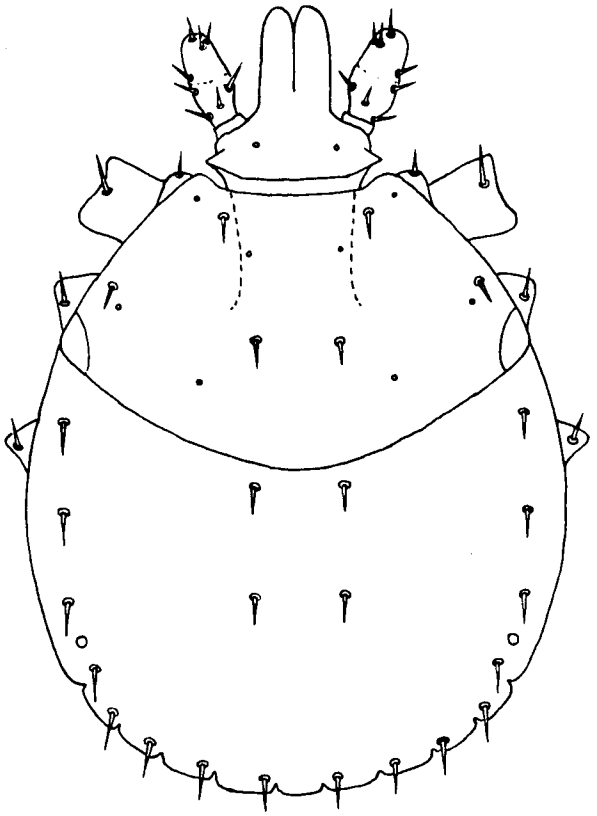
Plate 13

Dermacentor sp. 2.

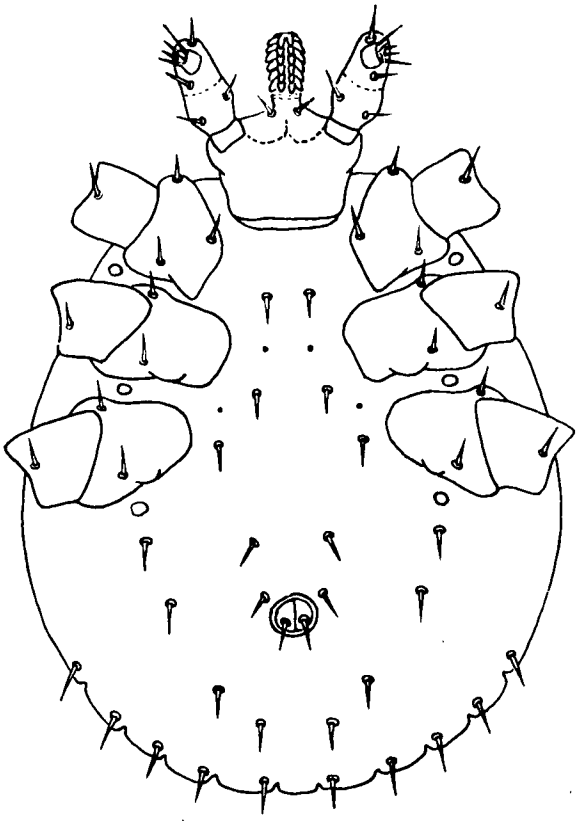
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

marginal ventral setae, Mv 1-5 average 0.026, 0.027, 0.030, 0.030, 0.026 mm long, respectively; 1 pair of anal setae, average 0.012 mm long. Nine festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Trapezoid with posterior margin deeply convex, wider than long, from 0.286 to 0.297 mm long, average 0.291 mm, and both specimens measured 0.451 mm wide. Cervical grooves shallow and short, reaching scutal midlength, parallel anteriorly, slightly diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.015, 0.015, 0.012 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae posterior to cervical grooves. Eyes flat, not extending beyond margin of body.

Capitulum.—From 0.143 to 0.176 mm long, average 0.159 mm, and both specimens measured 0.165 mm wide. Basis capituli dorsally narrowly triangular lateral margins acute, not extending beyond scapular angle, posterior margin slightly convex; ventrally subrectangular, wider anteriorly than posteriorly. Palpi somewhat elongate, flatly rounded distally, ca. 2 1/2 times as long as wide. Article 1 distinct, article 2 about as long as article 3. Article 1 without setae; articles 2 and 3 each with 2 ventral and 4 dorsal setae; article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.077 mm long. Dentition 2/2 with 6 or 7 denticles per file. One pair of posthypostomal setae, average 0.024 mm apart and average 0.008 mm long.

Legs.—Coxa I with a blunt, broadly triangular spur; 3 setae. Coxa II with a small, shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus

I tapering distally, ca. 3 times as long as wide; dorsal setal arrangement with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species is not known.

E. Genus Haemaphysalis Koch.—The genus Haemaphysalis contains ca. 125 species and subspecies which occur in all continents of the world (Hoogstraal 1965). Nineteen species are known to occur in Indonesia, about twice the number recorded earlier by Anastos (1950). This increase in number was the result of revisional works, discoveries of new taxons, and other types of faunal studies done in recent years. The number of species in the warm, humid areas of tropical Asia is estimated to be ca. 50 species (Hoogstraal 1965).

The larvae have been studied previously in several regions in the world. Pospelova-Shtrom (1940) studied the species in Russia, and Trapido *et al.* (1964b) studied the species of the Indian subregion, but they did not use the chaetotaxic method of characterizing the larvae. On a world-wide basis, the chaetotaxy of the larvae of this genus was studied by Clifford and Anastos (1960). This method also was used by Clifford *et al.* (1961) for the North American species and by Roberts (1969) for the Australian species.

Larvae of this genus are characterized by 1 pair of sensilla sagittiformia on the dorsal surface of the body, 2 marginal dorsal setae anterior to the sensilla, and 4 pairs of marginal ventral setae. According to Clifford and Anastos (1960), other chaetotaxic features of the genus are: body with 8 pairs of marginal dorsal (Md) setae, 2 pairs of central dorsal (Cd) setae, 2 pairs of preananal (Pa) setae, 4 pairs of premarginal (Pm) setae, and 4 pairs of marginal ventral

(Mv) setae, scutum with 3 pairs of scutal (Sc) setae, capitulum with 1 pair of posthypostomal (Ph) setae, palpi with 12 setae, coxa III always with 2 setae, tarsus I dorsally with 2 prehalleral (Pha), 2 halleral (Ha), and 6 posthalleral (Poh) setae in 3 groups of 3, 1, and 2 setae, respectively.

The species known to occur in Indonesia are: H. asiaticus Warburton and Nuttall, H. bartelsi Schulze, H. bispinosa Neumann, H. calvus Nuttall and Warburton, H. celebensis Hoogstraal, Trapido, and Kohls, H. cornigera Neumann, H. hirsuta Hoogstraal, Trapido, and Kohls, H. hylobatis Schulze, H. hystricis Supino, H. koningsbergeri Nuttall and Warburton, H. nadchatrami Hoogstraal, Trapido, and Kohls, H. obesa Larrouse, H. papuana Thorell, H. renschi Schulze, H. semermis Neumann, H. sumatraensis Hoogstraal, El Kammah, Kadarsan, and Anastos, H. toxopei Warburton, H. traguli Oudemans, and H. wellingtoni Nuttall and Warburton.

Of these 19 species, the larvae of H. bispinosa, H. cornigera, H. hystricis, H. koningsbergeri, H. obesa, H. papuana, H. sumatraensis, and H. wellingtoni were reared in the laboratory. Two other species were represented by field-caught larvae but since their identity could not be established positively they were designated as Haemaphysalis sp. 1 and Haemaphysalis sp. 2.

Larval specimens presently available are characterized by a lack of well-defined characters of specific value. Diagnosis is difficult, and in almost all cases it was necessary to rely on character gradation, on minor characters or a combination thereof. Similar problems were encountered by Trapido *et al.* (1964b) and Roberts (1969) when studying the Indian and Australian larvae, respectively.

The presently available species may be classified arbitrarily into 2 equal groups on the basis of presence or absence of cornuae on the postero-dorsal surface of the basis capituli. Those with cornuae show a graded series from strong cornuae, as distinct spurs, to weak cornuae which appear as very small, rounded bulges.

Other characters to separate species are based on viewing the specimens ventrally. Characters on the ventral side which are of specific value are the shape of palpal apices, the length of coxal spur I, the length of hypostome, and the shape of the basis capituli. The sharpness of the distal end of the palps is determined by the angle formed anteriorly at the junction of internal and external margins. The relative length of the hypostome in relation to the palp is measured by drawing a line connecting the apices of the palp; the hypostome extends beyond palpal apices if the anterior portion of the hypostome projects beyond this line. The shape of the ventral basis capituli is determined by the slope of the line connecting the base of the hypostome and the posterior margin of the palp and the lateral margins of the ventral basis capituli. This line may be somewhat diagonal, thus suggesting a subtriangular shape or somewhat horizontal or perpendicular for a rectangular shape. The relative length of coxal spur I is difficult to measure since the spur curves out from the margin of the coxa and its base cannot be defined clearly. However, its length is expressed in relation to the proximity of the apex to the anterior margin of coxa II.

The larvae of H. bispinosa, H. cornigera, H. hystricis, H. koningsbergeri, H. obesa, H. papuana, H. sumatraensis, H. wellingtoni,

Haemaphysalis sp. 1, and Haemaphysalis sp. 2 are all typical Haemaphysalis species. All agree in every respects with the generic diagnosis of Clifford and Anastos (1960) and may be separated by the following key.

1. With cornuae. 2
   Without cornuae 6
2. Cornuae strong. . . . . H. obesa
   Cornuae weak. 3
3. With 7 denticles per file on hypostome . . . . . .Haemaphysalis sp. 2
   With 6 denticles per file on hypostome 4
4. Basis capituli ventrally rectangular. . . .Haemaphysalis sp. 1
   Basis capituli ventrally subtriangular. 5
5. Coxal spur I long; ventrally, palpi bluntly rounded distally . . . . . H. papuana
   Coxal spur I short; ventrally, palpi acute distally. . . . . H. hystricis
6. Body elongate; posterior margin of article 2 with lobe-like projection ventrally . . . . . .H. koningsbergeri
   Body ovoid; posterior margin of article 2 without lobe like projection. 7
7. Scutum cordate. . . . . H. wellingtoni
   Scutum subcordate with postero-lateral margins sinuous 8

8. Hypostome not extending beyond palpal apices. . . . . H. bispinosa

   Hypostome extending beyond palpal apices. 9

9. With 7 denticles per file on the hypostome. . . . . H. cornigera

   With 6 denticles per file on the hypostome. . . . . H. sumatraensis

1. Haemaphysalis bispinosa Neumann, Plate 14.—Several species of the genus Haemaphysalis in Asia and Australia have long been confused taxonomically with Haemaphysalis bispinosa. Accordingly, the range of distribution of this species has been cited erroneously in the literature as being very widespread. Hoogstraal and Trapido (1965) determined that the nominal species of H. bispinosa is endemic to the Indian subregion, and it is a parasite of various wild and domestic mammals. All other species outside this subregion which were recorded previously as H. bispinosa were considered to be other species. Later, Hoogstraal *et al.* (1969) reported that H. bispinosa also occurs in the Malay Peninsula and North Kalimantan and gave evidence that in these 2 regions this species may have been introduced. However, the records from Kalimantan were considered doubtful and they believed that these samples did not indicate establishment of H. bispinosa on this island.

Concurrent with the actual state of knowledge on H. bispinosa, previous numerous records from many islands in Indonesia must be reexamined. Nevertheless, the limited occurence of this species in Kalimantan warrants the inclusion of H. bispinosa in the fauna of Indonesia.

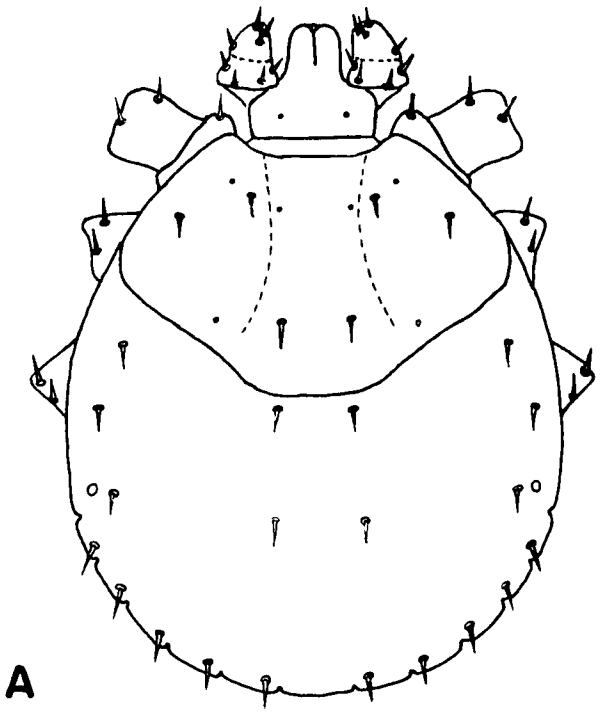
Plate 14

Haemaphysalis bispinosa Neumann.

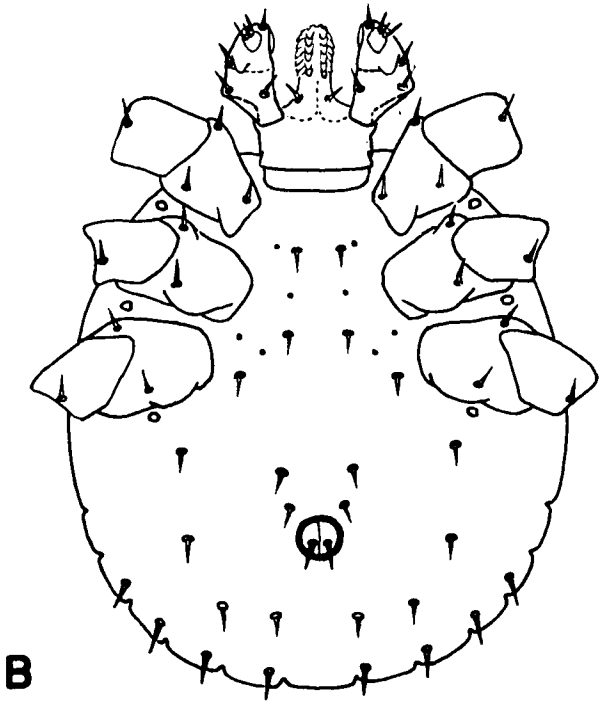
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

Only laboratory-reared specimens of H. bispinosa were available for study. These were the progeny of females collected in Malaysia.

Reared larvae of H. bispinosa were illustrated partially and were studied on a morphological basis by Trapido *et al.* (1964b). Specimens which were used in the present study are in agreement with the partial description and illustration of Trapido *et al.* (1964b). However, they differ from the specimens studied by Nuttall and Warburton (1915) which showed no spurs on coxae II and III, and these authors may have illustrated another species.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally subrectangular and ventrally rectangular, cornuae absent. Palpi compact, broadly rounded distally, very weakly salient postero-laterally, ventral retrograde spur on article 3 short and blunt. Hypostome subclavate and not extending beyond palpal apices, dentition 2/2 with 6 denticles per file. Coxa I with a relatively long, broad triangular spur; 3 setae. Coxae II and III each with a shallow rounded spur, less developed in coxa III; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest posterior to midlength, from 0.462 to 0.506 mm long, average 0.480 mm, and from 0.385 to 0.418 mm wide, average 0.403 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-

lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.016, 0.017, 0.019, 0.019, 0.020, 0.021, 0.021, 0.021 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, both average 0.011 mm long. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.027, 0.017, 0.017 mm long, respectively; 2 pairs of preanal setae, average 0.016 and 0.017 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.019, 0.023, 0.027, 0.026 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.025, 0.025, 0.025, 0.026 mm long, respectively; 1 pair of anal setae, average 0.014 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.198 to 0.220 mm long, average 0.212 mm, and from 0.297 to 0.319 mm wide, average 0.309 mm. Cervical grooves deep and long, almost reaching latero-posterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.011, 0.010, 0.011 mm long, respectively; 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.088 to 0.110 mm long, average 0.103 mm, and from 0.110 to 0.121 mm wide, average 0.116 mm. Basis capituli dorsally subrectangular, cornuae absent; ventrally rectangular, about twice as wide as long, with a horizontal ridge over entire width anterior to posterior margin, distance from anterior margin to ridge ca. 2/3 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudo-auriculae. Palpi compact, broadly rounded distally, very weakly salient postero-laterally. Sutures between articles weak;

article 1 as an elevated pedicel; article 2 ca. 2/3 as long as article 3, external margin mildly concave at about midlength; article 3 broadly triangular, external margin deeply convex, broadly rounded distally, ventrally with a short, blunt retrograde spur at latero-posterior margin slightly overlaying anterior end of article 2. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.060 mm long, not extending beyond palpal apices. Corona mild. Dentition 2/2 with 6 denticles per file. One pair of posthypostomal setae, average 0.028 mm apart and average 0.010 mm long.

Legs.—Coxa I with a relatively long, broadly triangular spur; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.--Thirteen females were reared under uncontrolled laboratory condition. Female ticks started to oviposit 7 to 10 days after detaching from the host, and the eggs hatched in 19 to 21 days.

2. Haemaphysalis cornigera Neumann, Plate 15.—Haemaphysalis cornigera is known to occur in India, Burma, Indochina, Malaysia, Philippines, and Indonesia. Records of distribution within the Indonesian archipelago are from Sumatra (Neumann 1897, Warburton and Nuttall 1909, Warburton 1926, Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Amboina (Oudemans 1927), Karimundjawa, Kalimantan, Bali, Sumbawa (Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Java, Sumba

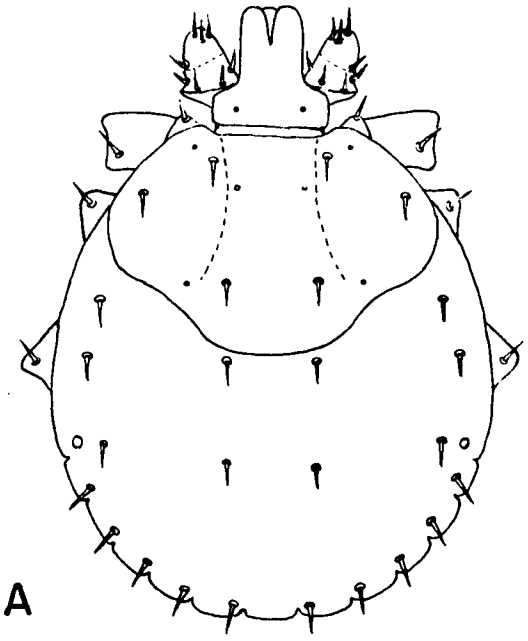
Plate 15

Haemaphysalis cornigera Neumann.

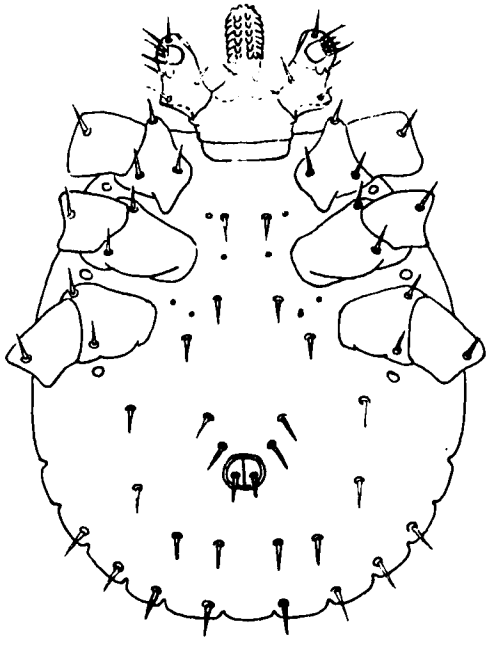
Description of figures:

A. Dorsum, χ 187.5.

B. Venter, × 187.5.



A



B

(Krijgsman and Ponto 1931, 1932, Anastos 1950, Anastos unpublished data), Lombok, Timor (Anastos unpublished data). No new locality records were added on the basis of larval specimens which were collected during the course of the present study.

The adults of H. cornigera have been taken from tiger, and domestic and wild herbivores. The hosts of the larvae are not known.

Laboratory-reared specimens and numerous field-caught larvae were available for study.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally and ventrally subrectangular, cornuae absent. Palpi compact somewhat flatly rounded distally, mildly salient posterolaterally, ventral retrograde spur on article 3 short and blunt. Hypostome clavate, reaching beyond palpal apices, dentition 2/2 with 7 denticles per file. Coxa I with a relatively long, narrowly triangular spur; 3 setae. Coxae II and III each with a shallow, rounded spur, less developed in coxaIII; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest posterior to midlength, from 0.352 to 0.396 mm long, average 0.367 mm, and from 0.308 to 0.343 mm wide, average 0.323 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorsolateral surface of body. Dorsally with 8 pairs of marginal dorsal

setae, Md 1-8 average 0.015, 0.016, 0.019, 0.018, 0.019, 0.019, 0.017, 0.017, mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.009 and 0.010 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.022, 0.015, 0.013 mm long, respectively; 2 pairs of preanal setae, both average 0.013 mm long; 4 pairs of premarginal setae, Pm 1-4 average 0.016, 0.020, 0.022, 0.021 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.023, 0.022, 0.023, 0.023 mm long, respectively; 1 pair of anal setae, average 0.011 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.149 to 0.176 mm long, average 0.167 mm, and from 0.246 to 0.290 mm wide, average 0.255 mm. Cervical grooves deep and long, almost reaching latero-posterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, all three average 0.010 mm long, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.079 to 0.105 mm long, average 0.096 mm, and from 0.079 to 0.096 mm wide, average 0.089 mm. Basis capituli dorsally subrectangular, about twice as wide as long, cornuae absent; ventrally subrectangular, about twice as wide as long, with a horizontal ridge over entire width anterior to posterior margin, distance from anterior margin to ridge ca. 2/3 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudo-auriculae. Palpi compact, somewhat flatly rounded distally, mildly salient posterolaterally. Sutures between articles weak; article 1 as a pedicel;

article 2 slightly shorter than article 3, external margin mildly concave at about midlength, posterior margin slightly wider than anterior margin; article 3 broadly triangular, external margin deeply convex anteriorly, somewhat flatly rounded distally, ventrally with a short, blunt retrograde spur at latero-posterior margin, slightly overlaying anterior end of article 2. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Clavate, average 0.054 mm long, extending beyond palpal apices. Corona mild. Dentition 2/2 with 7 denticles per file. One pair of posthypostomal setae, average 0.020 mm apart and average 0.007 mm long.

Legs.—Coxa I with a relatively long, narrowly triangular spur; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—Two females taken off a buffalo were reared in the laboratory. Under uncontrolled condition, these females started to oviposit 3 to 4 days after having detached from the host and the eggs hatched in 25 to 30 days.

Localities from which field-caught larval specimens were collected indicate that H. cornigera might be confined to lowland areas. Four localities on the island of Java produced numerous

larvae by sweeping. These places were deep forested areas located near sea-level.

3. Haemaphysalis hystricis Supino, Plate 16.—Haemaphysalis hystricis has long been confused taxonomically with several other species of the genus Haemaphysalis. As a result of this confusion, the distribution of the species accordingly was cited erroneously. The species was considered wide-spread in temperate and tropical Asia and in numerous nearby islands. In Indonesia, this species was reported to occur in Celebes and some other localities west of the Wallace line. (Nuttall and Warburton 1915, Warburton 1926, Krijgsman and Ponto 1931, 1932, Anastos 1950).

Hoogstraal *et al.* (1965b) clarified the taxonomic status of H. hystricis and reported that this species is actually restricted to the southern belt of Asia between latitude 16° and 27°N. Its range of distribution extends from India to the coast of Vietnam, Fukien Province of China, Taiwan, and the Ryukyu Islands. Adults of H. hystricis have a fairly wide host range among medium size to large carnivores, deer, and boar.

An outlying population of H. hystricis, however, was recognized in Indonesia by Hoogstraal *et al.* (1965b). This occurs in Bengkulen, southern Sumatra, and is possibly of limited extent. Other previous records from Indonesia must be considered erroneous or highly suspect. Adults in this localized population in Sumatra were found on the hog-badger, Arctonyx collaris Cuvier. Host of the larvae are unknown.

Only laboratory-reared specimens of H. hystricis were available for study. These were the progeny of a female collected in Vietnam.

Larvae of H. hystricis were also studied by Hoogstraal *et al.* (1965b) on the basis of their association with the adults and nymphs;

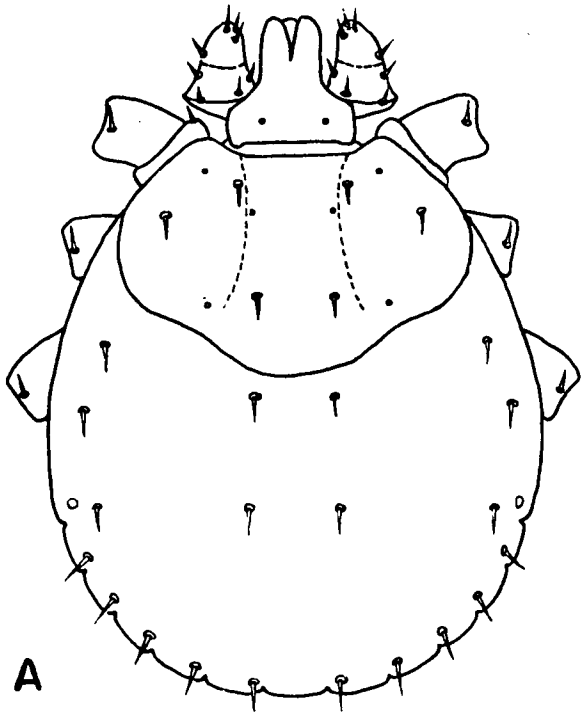
Plate 16

Haemaphysalis hystricis Supino.

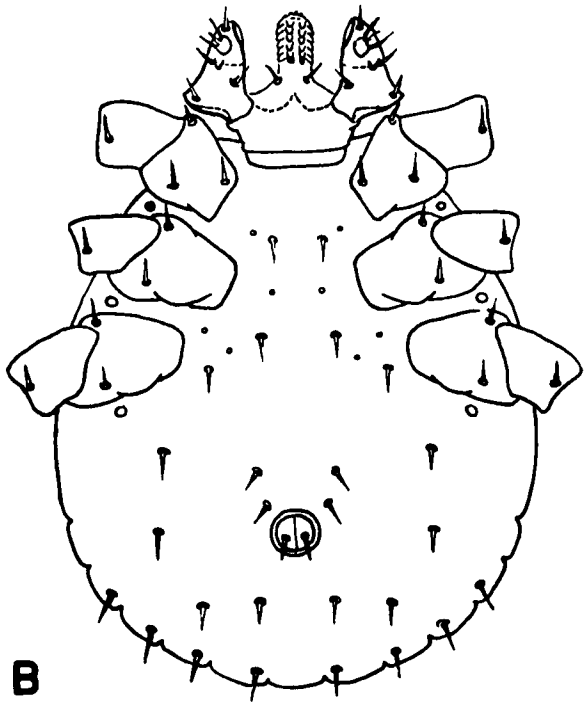
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

although chaetotaxy was not used to describe the larvae, the figure shows agreement in the body setae with the specimens presently studied. Differences were found in the number of ventral setae of palpal article 2, and also in the shape of ventral basis capituli. Hoogstraal *et al.* (1965b) illustrated 3 ventral setae on palpal article 2 and a more compact ventral basis capituli. The presently available specimens have 2 ventral setae on palpal article 2 and a more laterally elongate ventral basis capituli. Other body features and chaetotaxy are in agreement.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally subrectangular and ventrally subtriangular, cornuae weak and reduced to small, rounded bulges. Ventrally palpi acute distally, moderately salient postero-laterally, ventral retrograde spur on article 3 somewhat acute. Hypostome subclavate, slightly extending beyond palpal apices; dentition 2/2 with 6 denticles per file. Coxa I with a short, broadly triangular spur; 3 setae. Coxae II and III each with a shallow rounded spur, less developed in coxa III; 2 setae.

DESCRIPTION.—Fifteen specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest posterior to midlength, from 0.492 to 0.536 mm long, average 0.508 mm, and from 0.404 to 0.448 mm wide, average 0.430 mm. Four pairs of sensilla sagittiformia,

3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.012, 0.013, 0.017, 0.016, 0.017, 0.016, 0.016, 0.017 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.009 and 0.011 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.026, 0.013, 0.012 mm long, respectively; 2 pairs of preanal setae, average 0.011 and 0.013 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.013, 0.016, 0.021, 0.020 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.022, 0.024, 0.024, 0.026 mm long, respectively; 1 pair of anal setae, average 0.010 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.193 to 0.220 mm long, average 0.206 mm, and from 0.299 to 0.334 mm wide, average 0.314 mm. Cervical grooves deep and long, almost reaching latero-posterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.006, 0.005, 0.010 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.096 to 0.132 mm long, average 0.107 mm, and from 0.114 to 0.123 mm wide, average 0.118 mm. Basis capituli dorsally subrectangular, about twice as wide as long, cornuae weak and reduced to small rounded bulges; ventrally subtriangular, ca. 2 1/2 times as wide as long, with a horizontal ridge over entire width anterior to posterior margin, distance from anterior margin to ridge ca. 2/3 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudo-

auriculae. Palpi triangular, acute distally, moderately salient posterolaterally. Sutures between articles weak; article 1 as a pedicel; article 2 slightly shorter than article 3, external margins concave near midlength, posterior margin ca. 1 1/2 times as wide as anterior margin; article 3 triangular, external margin slightly convex, acute distally; ventrally with a short, somewhat acute retrograde spur at latero-posterior margin slightly overlaying anterior end of article 2. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.059 mm long, slightly extending beyond palpal apices. Corona mild. Dentition 2/2 with 6 denticles per file. One pair of posthypostomal setae, average 0.026 mm apart and 0.006 mm long.

Legs.—Coxa I with a short, broadly triangular spur; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral 2 halleral, and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species is not known.

4. Haemaphysalis koningsbergeri Nuttall and Warburton, Plate 17.—In the past, the taxonomic status of Haemaphysalis koningsbergeri was confused and the locality records also were uncertain. Anastos (1950) and Kohls (1957) found it difficult to delineate the actual range of distribution, but stated that this species probably occured in the Malay Peninsula and parts of Indonesia. Hoogstraal *et al.* (1965d) re-

ported that this species indeed has a localized distribution and is confined only to Borneo, Indonesia and the Malay Peninsula.

In Indonesia, H. koningsbergeri has been recorded from Sumatra (Nuttall and Warburton 1915, Warburton 1926, Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Simeuleu (Warburton 1926, Krijgsman and Ponto 1931, 1932), Java (Warburton and Nuttall 1909, Nuttall and Warburton 1915, Schulze, 1934, Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Bawean (Krijgsman and Ponto 1931, 1932), Kalimantan (Anastos unpublished data). All larval materials which were used in the present study came from previously recorded localities.

Hosts of the adults are mostly forest inhabiting small and medium size carnivores, but an unusual record was from a lizard, Varanus sp. (Anastos unpublished data). Larvae were found on Varanus sp., a palm civet, Paguma larvata Hamilton-Smith, the crested pheasant, Lophura ignata (Shaw and Nodder), and the crestless pheasant, L. erythropthalma (Raffles), and by sweeping.

Laboratory-reared larvae and some field-caught specimens of H. koningsbergeri were available for study.

DIAGNOSIS.—Body oval and elongate, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally subrectangular and ventrally subtriangular; cornuae absent. Palpi widely triangular, subacute distally, strongly salient postero-laterally, ventral retrograde spur on article 3 short and blunt, posterior margin of article 2 with

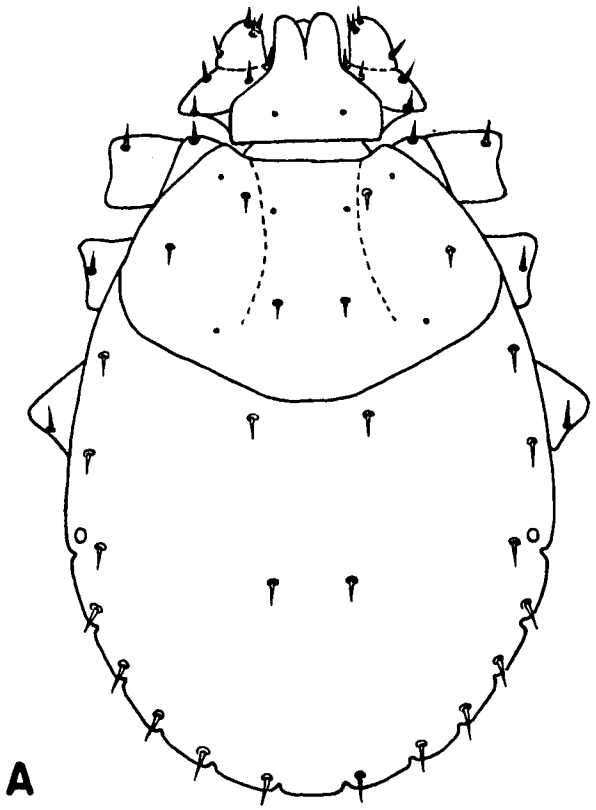
Plate 17

Haemaphysalis koningsbergeri Nuttall and Warburton.

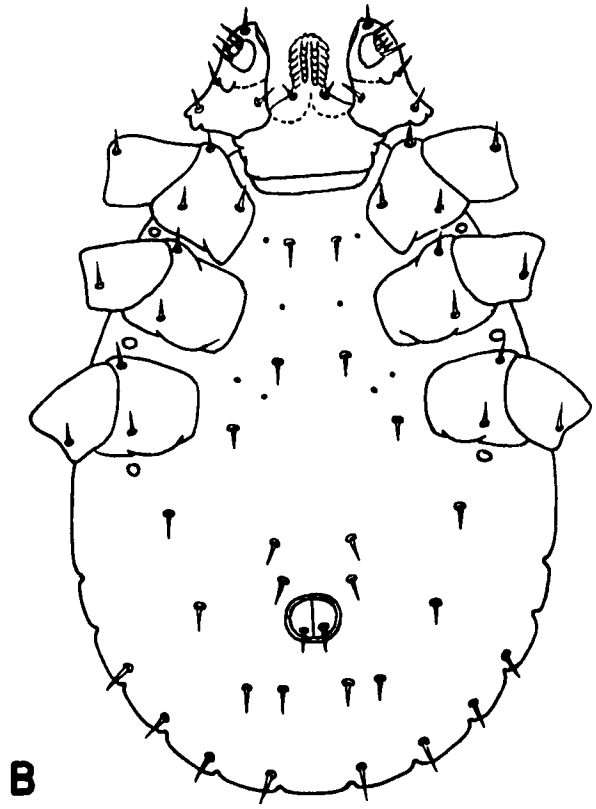
Description of figures

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

a small lobe-like projection ventrally. Hypostome subclavate. not reaching palpal apices, dentition 2/2 with 6 denticles per file. Coxa I with a relatively long, broadly triangular spur; 3 setae. Coxae II and III each with a shallow rounded spur, less developed in coxa III; setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval and elongate, much longer than wide, widest posterior to midlength, from 0.496 to 0.550 mm long, average 0.523 mm, and from 0.374 to 0.451 mm wide, average 0.424 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.014, 0.015, 0.016, 0.017, 0.018, 0.017, 0.017, 0.017 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.010 and 0.011 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.016, 0.009, 0.010 mm long, respectively; 2 pairs of preanal setae, average 0.010 and 0.011 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.012, 0.012, 0.014, 0.012 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.016, 0.015, 0.016, 0.015 mm long, respectively; 1 pair of anal setae, average 0.010 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.187 to 0.242 mm long, average 0.216 mm, and from 0.297 to 0.363 mm wide, average

0.334 mm. Cervical grooves shallow and long, almost reaching latero-posterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.010, 0.010, 0.009 mm long, respectively; 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.099 to 0.132 mm long, average 0.120 mm, and from 0.121 to 0.154 mm wide, average 0.132 mm. Basis capituli dorsally subrectangular, ca. 2 1/2 times as wide as long, cornuae absent; ventrally subtriangular ca. 2 1/2 times as wide as long, with a horizontal ridge over entire width anterior to posterior margin, distance from anterior margin to ridge ca. 3/4 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudo-auriculae. Palpi widely triangular, subacute distally, strongly salient postero-laterally. Sutures between articles weak; article 1 short and hidden; article 2 ca. 3/4 as long as article 3, external margin more or less straight, strongly converging anteriorly forming a wide angle at articulation with article 3, posterior margin ca. 1 1/2 times as wide as anterior margin with a distinct lobe-like projection ventrally; article 3 triangular, external margin slightly convex anteriorly, subacute distally, ventrally with a short, blunt retrograde spur at latero-posterior margin slightly overlaying anterior end of article 2. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.056 mm long, not reaching palpal apices. Corona mild. Dentition 2/2 with 6 denticles per

file. One pair of posthypostomal setae, average 0.029 mm apart and average 0.009 mm long.

Legs.—Coxa I with a relatively long, broadly triangular spur; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 2 1/2 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—A single female reared under uncontrolled laboratory condition started to oviposit 22 days after having detached from the host. The incubation period of the eggs was 50 days.

5. Haemaphysalis obesa Larrouse, Plate 18.—Hoogstraal *et al.* (1971a) reported that the distribution of Haemaphysalis obesa is confined to a narrow belt in southern Asia. This species has been recorded from India and Thailand, and the most southern limit of its known distribution was Perlis, the most northern state of Malaysia. It is a common species in these areas and is collected abundantly from cattle and by sweeping of forest vegetation. However, H. obesa was collected recently in Indonesia from a buffalo on the island of Sumbawa (Anastos unpublished data) and numerous larvae were collected by sweeping in Java. These records indicate clearly that H. obesa is more widely distributed than thought previously.

The larva of H. obesa was described and illustrated by Hoogstraal *et al.* (1971a) on the basis of laboratory-reared speci-

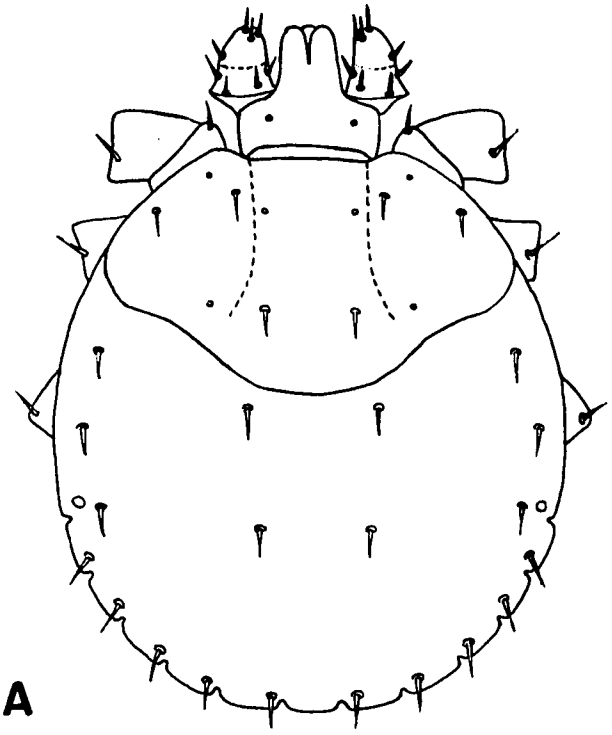
Plate 18

Haemaphysalis obesa Larrouse.

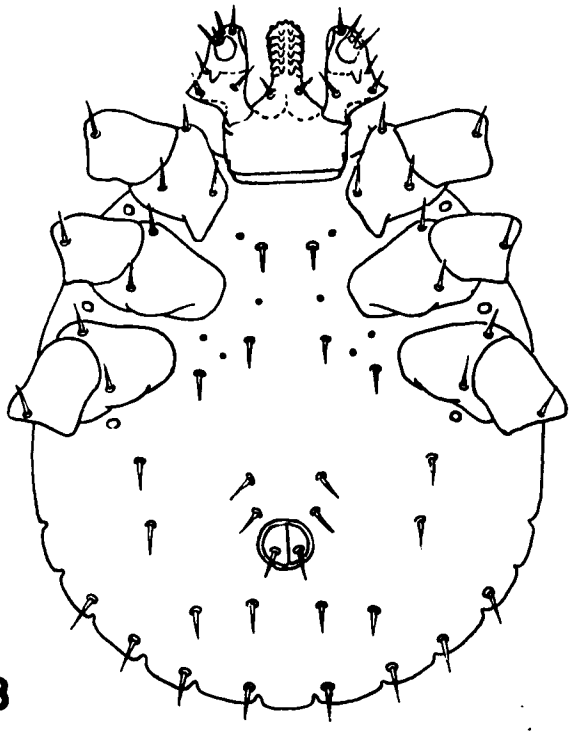
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

mens from Thailand. The same reared material was used in the present study. Hoogstraal *et al.* (1971a) illustrated palpal article 2 erroneously with 3 setae dorsally, whereas actually 4 setae are present. As a matter of fact, all species of larval ixodid ticks have 4 setae on palpal article 2. All other features, morphological as well as chaetotaxic, were in complete agreement.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally subrectangular and ventrally rectangular, cornuae distinct as long spurs. Palpi compact, bluntly rounded distally, mildly salient postero-laterally, ventral retrograde spur on article 3 long and sharp. Hypostome subclavate, reaching palpal apices, dentition 2/2 with 6 denticles per file. Coxa I with sharp, relatively long, narrowly triangular spur; 3 setae. Coxae II and III each with a shallow rounded spur, less developed in coxa III; 2 setae.

DESCRIPTION.—Five specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest posterior to midlength, from 0.519 to 0.528 mm long, average 0.521 mm, and from 0.457 to 0.466 mm wide, average 0.460 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.021, 0.023, 0.024, 0.023,

0.024, 0.025, 0.026, 0.024 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.014 and 0.013 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.034, 0.020, 0.019 mm long, respectively; 2 pairs of preanal setae, average 0.019 and 0.021 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.021, 0.023, 0.034, 0.030 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.034, 0.036, 0.033, 0.036 mm long, respectively; 1 pair of anal setae, average 0.005 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, all specimens measured 0.220 mm long and 0.369 mm wide. Cervical grooves deep and long, almost reaching latero-posterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.007, 0.009, 0.011 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.114 to 0.132 mm long, average 0.123 mm, and from 0.114 to 0.123 mm wide, average 0.120 mm. Basis capituli dorsally subrectangular, about twice as wide as long, cornuae distinct as long spurs; ventrally rectangular, about twice as wide as long, with a horizontal ridge over entire width anterior to posterior margin, distance from anterior margin to ridge ca. 4/5 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudoauriculae. Palpi compact, bluntly rounded distally, mildly salient postero-laterally. Sutures between articles weak; article 1 as a

pedicel; article 2 ca. 1/2 as long as article 3, external margin deeply concave at about midlength, posterior margin slightly wider than anterior margin; article 3 broadly triangular, external margin deeply convex anteriorly, bluntly rounded distally, ventrally with a long, sharp retrograde spur at latero-posterior margin overlaying about the anterior 1/2 of article 2. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.079 mm long, reaching palpal apices. Corona mild. Dentition 2/2 with 6 denticles per file. One pair of posthypostomal setae, average 0.027 mm apart and average 0.011 mm long.

Legs.—Coxa I with a relatively long, narrowly triangular spur, sharp at the apex; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca 3 1/2 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 halleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The life cycle of this species has been studied previously. Hoogstraal *et al.* (1971a) cited studies made in Thailand and India in the laboratory, where the life cycle was completed in 100 and 131 days, respectively. At 20°C the eggs hatched in 43 to 45 days and at ambient room temperature (22 to 31°C) hatching occured in 26 to 27 days. Larvae did not attach to the host until 5 days after hatching. The nymphs attached within 3 to 5 days after molting from the larval stage.

Field-caught specimens collected on the island of Java suggest that H. obesa occurs only in the lowland. Four localities from which the specimens were obtained by sweeping are all located near sea level. This confirms previous findings presented by Hoogstraal *et al.* (1971a) that the known range of H. obesa is from sea level to ca. 2,000 ft. altitude.

6. Haemaphysalis papuana Thorell, Plate 19.—Haemaphysalis papuana is another of several species of the genus Haemaphysalis in southern Asia which has had a confusing taxonomic status. Previously, it was recoreded as being wide-spread in distribution and extending from India to New Guinea. Trapido *et al.* (1964a) clarified the taxonomic status of H. papuana and reported that it was restricted geographically to Vietnam, Thailand, Malaysia, Philippines, Indonesia, and New Guinea. It is found mostly on pigs.

In Indonesia, H. papuana was recorded from Sumatra (Nuttall and Warburton 1915, Anastos 1950, Trapido *et al.* 1964a, Anastos unpublished data), Java (Nuttall and Warburton 1915, Krijgsman and Ponto 1931, 1932, Anastos 1950, Trapido *et al.* 1964a, Anastos unpublished data), Sumbawa, Sula, Sangihe, Alor (Krijgsman and Ponto 1931, 1932), Halmahera, Amboina, Saparua (Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Timor and Celebes (Anastos 1950), Bali, Komodo, Natuna Selatan (Anastos unpublished data). Hosts of larvae are unknown, but adults have been found on dog, domestic and wild pigs; nymphs were recorded from dog.

Larvae of H. papuana were reared in the laboratory and some field-caught specimens were also available for study.

Nuttall and Warburton (1915) briefly described and illus-

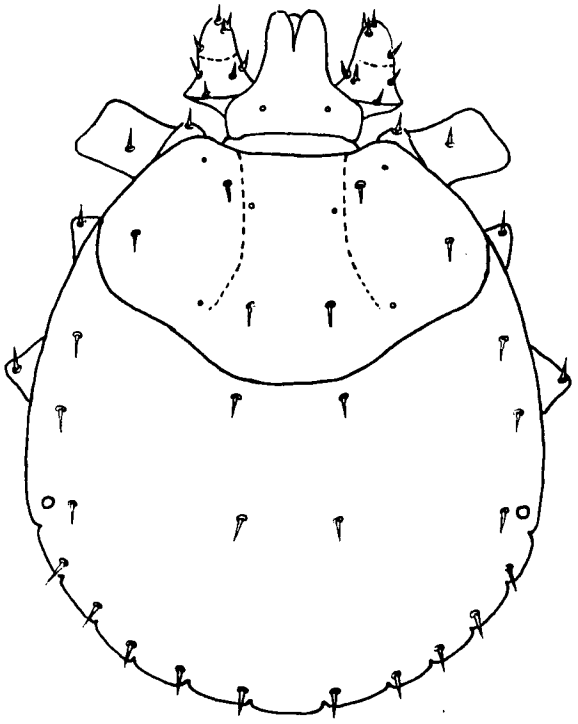
Plate 19

Haemaphysalis papuana Thorell.

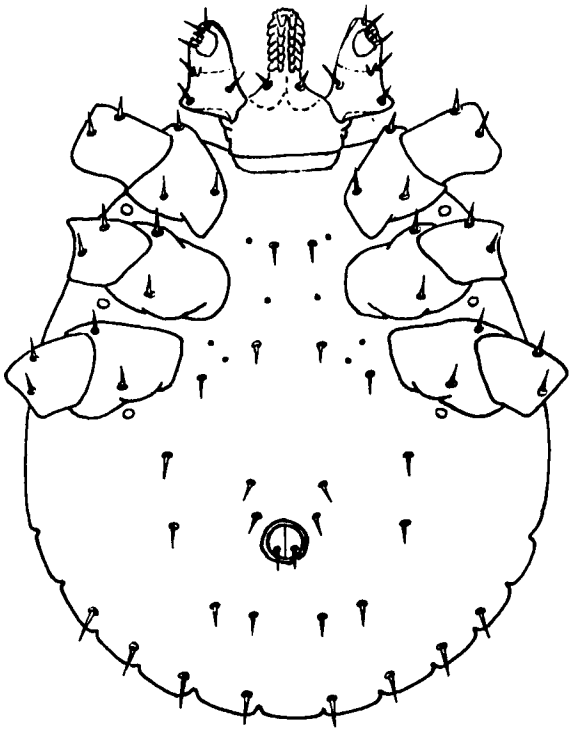
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

trated inadequately the larva of H. papuana on the basis of its association with adult specimens. Specimens presently being studied have spurs on coxae II and III whereas Nuttall and Warburton incorrectly illustrated them as being absent.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally subrectangular and ventrally subtriangular; cornuae weak and reduced to small, rounded bulges. Ventrally palpi bluntly rounded distally, moderately salient posterolaterally, ventral retrograde spur on article 3 short and blunt. Hypostome subclavate, slightly extending beyond palpal apices, dentition 2/2 with 6 denticles per file. Coxa I with a relatively long, broadly triangular spur; 3 setae. Coxae II and III each with a shallow, rounded spur, less developed in coxa III; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest posterior to midlength, from 0.484 to 0.528 mm long, average 0.506 mm, and from 0.407 to 0.440 mm wide, average 0.426 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.010, 0.011, 0.014, 0.013 0.014, 0.015, 0.014, 0.014 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae,

average 0.010 and 0.012 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.022, 0.013, 0.011 mm long, respectively; 2 pairs of preanal setae, average 0.011 and 0.014 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.013, 0.016, 0.020, 0.018 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.018, 0.019, 0.024, 0.022 mm long, respectively; 1 pair of anal setae, average 0.011 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.198 to 0.220 mm long, average 0.203 mm, and from 0.308 to 0.341 mm wide, average 0.319 mm. Cervical grooves shallow and long, almost reaching latero-posterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.005, 0.004, 0.009 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.099 to 0.110 mm long, average 0.104 mm, and from 0.110 to 0.121 mm wide, average 0.116 mm. Basis capituli dorsally subrectangular, about twice as wide as long, cornuae weak and reduced to small, rounded bulges; ventrally subtriangular slightly more than 2 times as wide as long, with a horizontal ridge over entire width anterior to posterior margin, distance from anterior margin to ridge ca. 2/3 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudo-auriculae. Palpi narrowly triangular, bluntly rounded distally, moderately salient postero-laterally. Sutures between articles weak; article 1 as

a short pedicel; article 2 about as long as article 3, external margins concave at about midlength, posterior margin ca.1 1/2 times as wide as anterior margin; article 3 triangular, external margins slightly convex, bluntly rounded distally, ventrally with a short, blunt retrograde spur at latero-posterior margin, slightly overlaying anterior end of article 2. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.056 mm long, slightly extending beyond palpal apices. Corona mild. Dentition 2/2 with 6 denticles per file. One pair of posthypostomal setae, average 0.026 mm apart and average 0.007 mm long.

Legs.—Coxa I with a relatively long, broadly triangular spur; 3 setae. Coxa II with a shallow, broad spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species is not known.

7. Haemaphysalis sumatraensis Hoogstraal, El Kammah, Kadarsan, and Anastos, Plate 20.—Haemaphysalis sumatraensis is the most recently described species in the genus, and thus far has been recorded only from southern Sumatra in Indonesia. Adults of this species were found on sambar deer, Cervus unicolor equinus Cuvier, wild pig, Sus scrofa vittatus Boie, and tiger, Felis tigris sumatrae (Pocock)

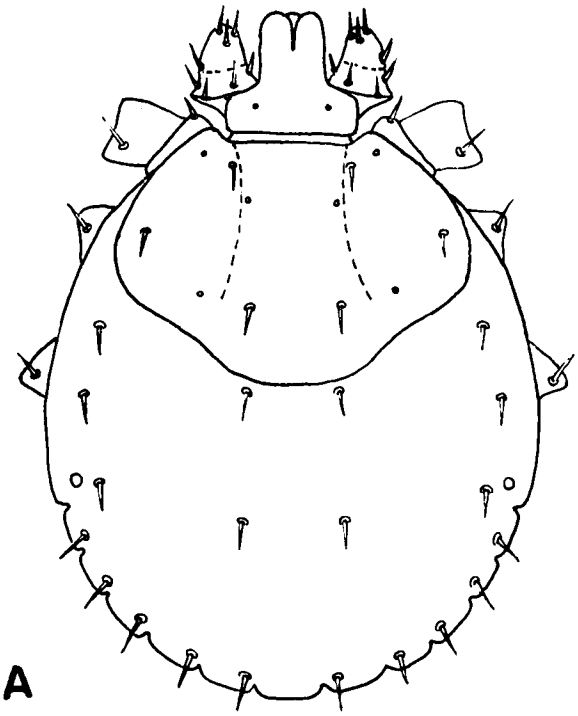
Plate 20

Haemaphysalis sumatraensis Hoogstraal, El Kammah, Kadarsan, and Anastos.

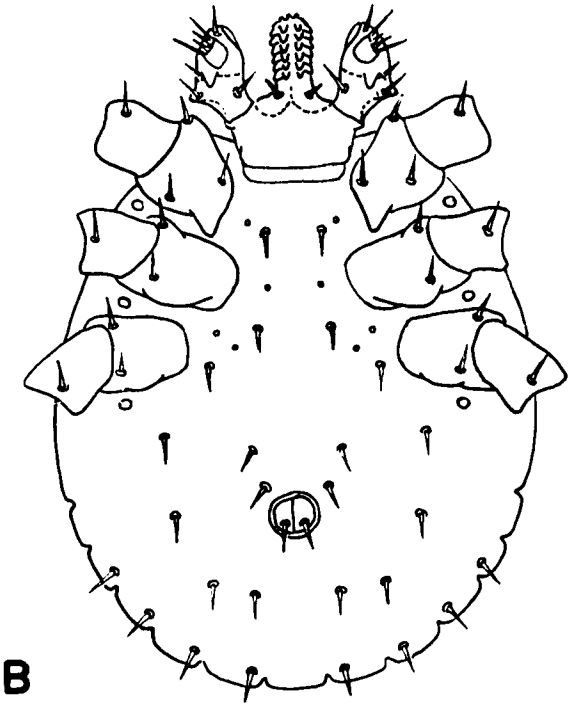
Description of figures:

A. Dorsum, × 187.5

B. Venter, × 187.5



A



B

(Hoogstraal *et al.* 1971b). Hosts of the larvae are unknown.

Larvae of H. sumatraensis were reared in the laboratory, and they were available for study.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally and ventrally subrectangular, cornuae absent. Palpi compact, bluntly rounded distally, mildly salient postero-laterally, ventral retrograde spur on article 3 long and sharp. Hypostome subclavate, slightly extending beyond palpal apices, dentition 2/2 with 6 denticles per file. Coxa I with a sharp, relatively long, narrowly triangular spur; 3 setae. Coxae II and III each with a shallow rounded spur, less developed on coxa III; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body. Oval, longer than wide, widest posterior to midlength, from 0.475 to 0.510 mm long, average 0.492 mm, and from 0.396 to 0.431 mm wide, average 0.422 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.014, 0.014, 0.018, 0.016, 0.017, 0.018 0.018, 0.018 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.008 and 0.010 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.023, 0.014, 0.013 mm long, respectively; 2 pairs of preanal setae, average 0.013 and 0.014 mm long, respectively;

4 pairs of premarginal setae, Pm 1-4 average 0.015, 0.020, 0.022, 0.022 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.022, 0.023, 0.024, 0.024 mm long, respectively; 1 pair of anal setae, average 0.011 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.211 to 0.228 mm long, average 0.218 mm, and from 0.299 to 0.325 mm wide, average 0.311 mm. Cervical grooves deep and long, almost reaching latero-posterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.009, 0.006, 0.010 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.105 to 0.123 mm long, average 0.114 mm, and from 0.114 to 0.123 mm wide, average 0.116 mm. Basis capituli dorsally subrectangular, about twice as wide as long, cornuae absent; ventrally subrectangular about twice as wide as long, with a horizontal ridge over entire width anterior to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudo-auriculae, distance from anterior margin to ridge ca. 3/4 to posterior margin. Palpi compact, bluntly rounded distally, mildly salient postero-laterally. Sutures between articles weak; article 1 as a pedicel; article 2 ca. 1/2 as long as article 3, external margin concave at about midlength, posterior margin slightly wider than anterior margin; article 3 broadly triangular, external margin deeply convex anteriorly, bluntly rounded distally, ventrally with a long, sharp retrograde spur at

latero-posterior margin overlaying about anterior half of article 2. Article 1 without setae; article 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.061 mm long, extending slightly beyond palpal apices. Corona mild. Dentition 2/2 with 6 denticles per file. One pair of posthypostomal setae, average 0.027 mm apart and average 0.009 mm long.

Legs.—Coxa I with a relatively long, narrowly triangular spur, sharp at the apex; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species is not known.

8. Haemaphysalis wellingtoni Nuttall and Warburton, Plate 21.—Haemaphysalis wellingtoni is distributed widely in the Orient, and has been recorded from India, Burma, Thailand, Indochina, Malaysia, Indonesia, and New Guinea. It is usually a parasite of fowl-like birds.

In Indonesia, H. wellingtoni has been recorded from Sumatra (Nuttall and Warburton 1915, Anastos 1950, Anastos unpublished data), Java (Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Siberut, Bawean, Madura, Natuna Selatan, Kalimantan (Anastos unpublished data). Additional locality records were not provided by the material available for study.

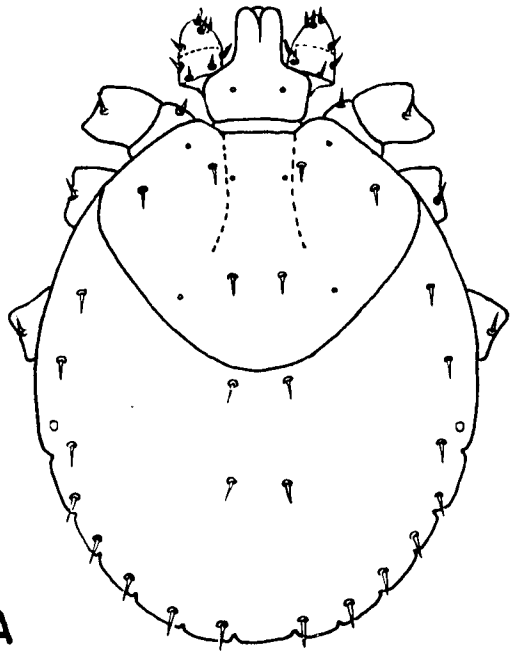
Plate 21

Haemaphysalis wellingtoni Nuttall and Warburton.

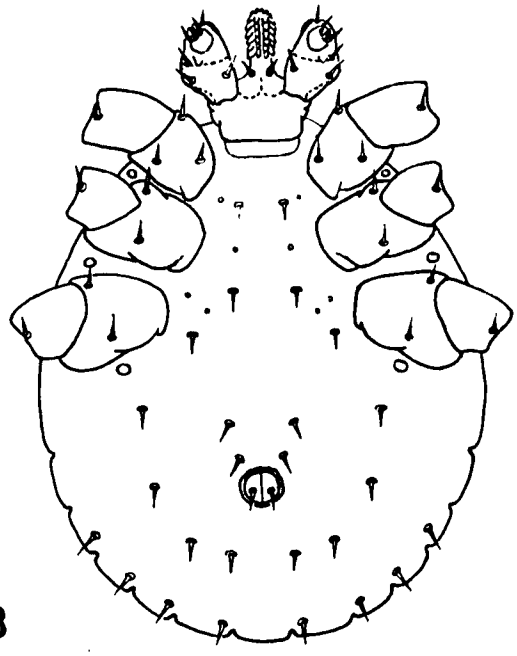
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

Adults and nymphs of this species have been found on domestic fowl, duck, wild pheasant, dog and rat. Larvae were recorded from domestic chicken, peafowl, Pavo muticus Linnaeus, argus pheasant, Argusianus argus (Linnaeus) and the crested pheasant, Lophura ignata (Shaw and Nodder).

Laboratory reared larvae and some field-caught specimens of H. wellingtoni were available for study.

The larva of H. wellingtoni was figured and described briefly by Nuttall and Warburton (1915) based on a specimen taken in association with the adults. Trapido *et al.* (1964b) also studied and illustrated the morphological features of reared larvae of this species. The morphology of the specimens presently studied revealed no differences between the descriptions given by Nuttall and Warburton (1915) and Trapido *et al.* (1964b).

DIAGNOSIS.--Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum cordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally and ventrally subrectangular, cornuae absent. Palpi compact, flatly rounded distally, not salient postero-laterally, ventral retrograde spur on article 3 short and blunt. Hypostome subclavate, slightly extending beyond palpal apices, dentition 2/2 with 6 denticles per file. Coxa I with a relatively long, narrowly triangular spur; 3 setae. Coxae II and III each with a shallow, rounded spur, less developed in coxa III; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest at midlength, from 0.407 to 0.484 mm long, average 0.451 mm, and from 0.374 to 0.451 mm wide, average 0.410 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.018, 0.020, 0.024, 0.021, 0.022, 0.022, 0.022, 0.021 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.010 and 0.012 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.026, 0.017, 0.015 mm long, respectively; 2 pairs of preanal setae, average 0.017 and 0.018 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.019, 0.023, 0.026, 0.024 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.026, 0.025, 0.026, 0.026 mm long, respectively; 1 pair of anal setae, average 0.013 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Cordate, wider than long, from 0.187 to 0.220 mm long, average 0.206 mm, and from 0.286 to 0.341 mm wide, average 0.313 mm. Cervical grooves deep and short, reaching about scutal midlength, parallel, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.014, 0.012, 0.011 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae posterior to cervical grooves. Eyes absent.

Capitulum.—From 0.088 to 0.121 mm long, average 0.100 mm, and from 0.088 to 0.121 mm wide, average 0.109 mm. Basis capituli dorsally subrectangular, about twice as wide as long, cornuae absent; ventrally subrectangular, slightly less than twice as wide as long, with a horizontal ridge over entire width anterior to posterior margin, distance from anterior margin to ridge ca. 2/3 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudo-auriculae. Palpi compact, flatly rounded distally, not salient postero-laterally. Sutures between articles weak; article 1 as an elevated pedicel; article 2 about as long as article 3, external margin practically straight, posterior margin almost as wide as anterior margin; article 3 broadly triangular, external margin deeply convex anteriorly, flatly rounded distally, ventrally with a short, blunt retrograde spur at latero-posterior margin slightly overlaying anterior end of article 2. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.055 mm long, slightly extending beyond palpal apices. Corona mild. Dentition 2/2 with 6 denticles per file. One pair of posthypostomal setae, average 0.024 mm apart and average 0.009 mm long.

Legs.—Coxa I with a relatively long, narrowly triangular spur; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each,

the terminal one in tandem of 2 setae.

BIOLOGY.—Under uncontrolled laboratory condition, females started to oviposit 5 to 8 days after detaching from the host. The eggs hatched in 30 to 36 days.

Since all stages of H. wellingtoni have been found frequently on domestic fowls, it should not be a difficult task to study the entire life cycle of this species on that host.

9. Haemaphysalis sp. 1, Plate 22.—Specimens of Haemaphysalis sp. 1 were collected from Java, Peutjang, Sumatra, and Komodo, all by means of sweeping.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally subrectangular and ventrally rectangular, cornuae weak and reduced to small bulges. Palpi compact, bluntly rounded, mildly salient postero-laterally; ventral retrograde spur on article 3 moderately long and somewhat sharp. Hypostome subclavate, slightly extending beyond palpal apices, dentition 2/2 with 6 denticles per file. Coxa I with a relatively long, narrowly triangular spur, blunt at apex; 3 setae. Coxae II and III each with shallow rounded spur, less developed in coxa III; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest posterior to midlength, from 0.501 to 0.536 mm long, average 0.519 mm, and from 0.440 to 0.466

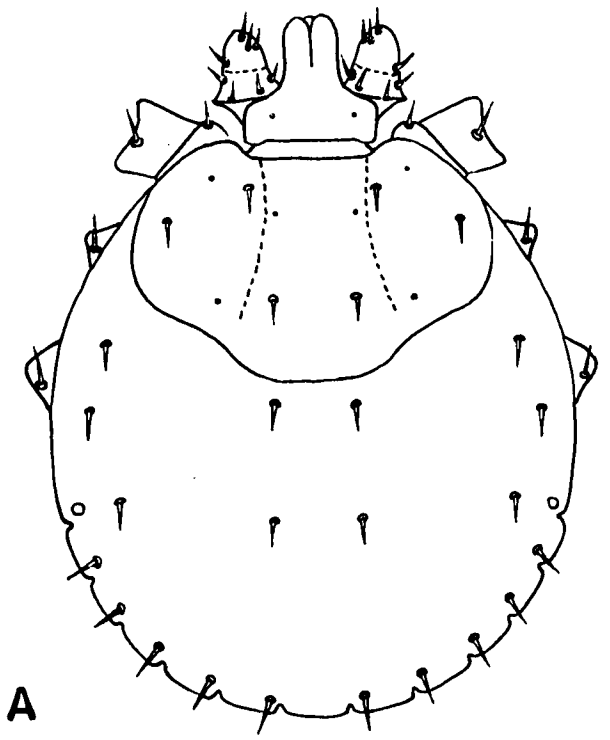
Plate 22

Haemaphysalis sp. 1.

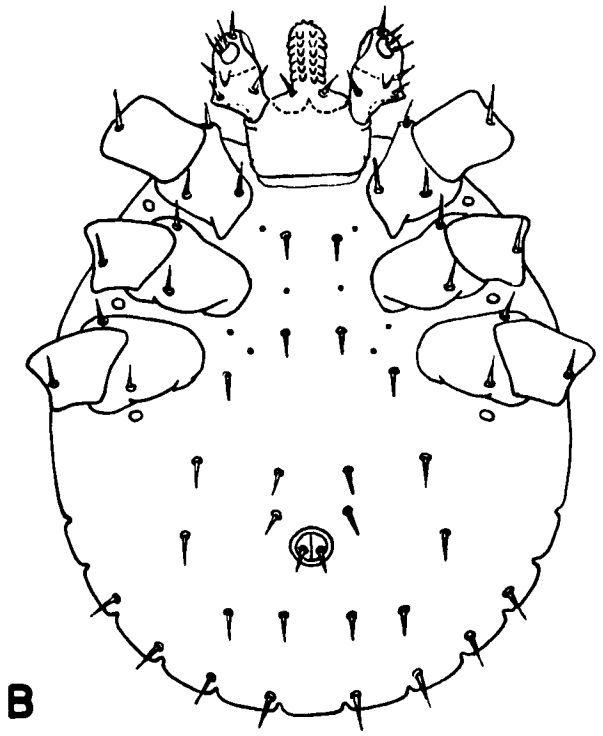
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

mm wide, average 0.451 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorsolateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.017, 0.017, 0.022, 0.022, 0.23, 0.024, 0.022, 0.022 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.009 and 0.011 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.021, 0.017, 0.014 mm long, respectively; 2 pairs of preanal setae, average 0.013 and 0.015 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.014, 0.021, 0.024, 0.022 mm long, respectively; 4 pairs of marginal ventral setae, all average 0.028 mm long; 1 pair of anal setae, average 0.008 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.202 to 0.228 mm long, average 0.216 mm, and from 0.308 to 0.325 mm wide, average 0.314 mm. Cervical grooves deep and long, almost reaching lateroposterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.005, 0.006, 0.009 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum—From 0.096 to 0.123 mm long, average 0.116 mm, and from 0.114 to 0.123 mm wide, average 0.120 mm. Basis capituli dorsally subrectangular about twice as wide as long, cornuae reduced to small bulges; ventrally rectangular, about twice as wide as long with a horizontal ridge over entire width anterior to posterior

margin, distance from anterior margin to ridge ca. 4/5 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudoauriculae. Palpi compact, bluntly rounded distally, mildly salient postero-laterally. Sutures between articles weak; article 1 as a pedicel; article 2 ca 1/2 as long as article 3, external margins concave at about midlength, posterior margin slightly wider than anterior margin; article 3 broadly triangular, external margins deeply convex anteriorly, bluntly rounded distally; ventrally with a moderately long and somewhat sharp spur at latero-posterior margin, overlaying about anterior 1/3 of article 2. Article 1 without setae, articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.060 mm long, slightly extending beyond palpal apices. Corona mild. Dentition 2/2 with 6 denticles per file. One pair of posthypostomal setae, average 0.029 mm apart and average 0.010 mm long.

Legs.—Coxa I with a relatively long, narrowly triangular spur, blunt at the apex; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, slightly more than 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species is not known.

10. Haemaphysalis sp. 2, Plate 23.—Larvae of Haemaphysalis sp. 2 were collected on the island of Java by sweeping.

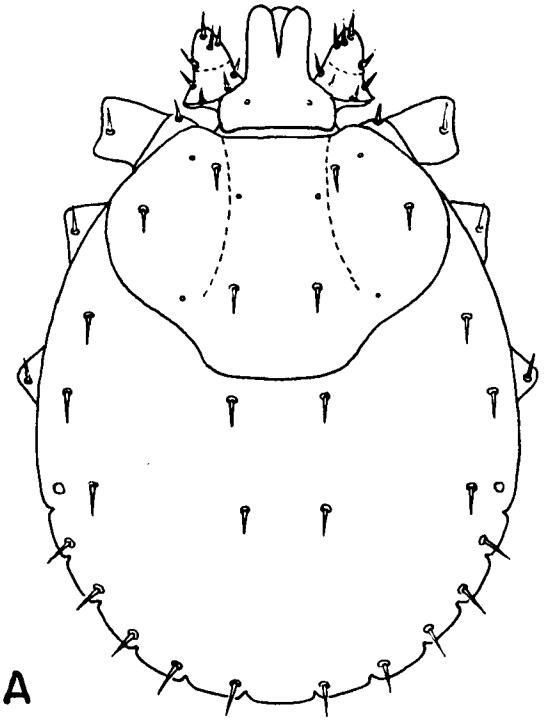
Plate 23

Haemaphysalis sp. 2.

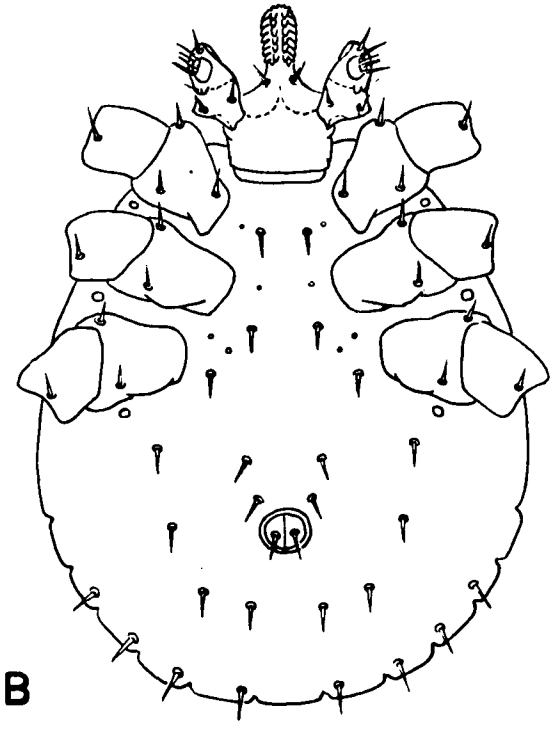
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

DIAGNOSIS.--Body oval, 8 pairs of marginal dorsal (Md) setae, Md 1 and Md 2 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum subcordate and with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally and ventrally subrectangular, cornuae weak and reduced to small, rounded bulges. Palpi compact, bluntly rounded distally, mildly salient postero-laterally, ventral retrograde spur on article 3 short and blunt. Hypostome clavate, reaching beyond palpal apices, dentition 2/2 with 7 denticles per file. Coxa I with a relatively long, narrowly triangular spur; 3 setae. Coxae II and III each with a shallow, rounded spur, less developed in coxa III; 2 setae.

DESCRIPTION.—In all cases, 20 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest posterior to midlength, from 0.440 to 0.501 mm long, average 0.463 mm, and from 0.316 to 0.440 mm wide, average 0.404 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.017, 0.018, 0.023, 0.021, 0.022, 0.021, 0.020, 0.020 mm long, respectively, Md 1 and Md 2 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, both average 0.011 mm long. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.027, 0.016, 0.015 mm long, respectively; 2 pairs of preanal setae, average 0.015 and 0.016 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.015, 0.020, 0.021, 0.020 mm long, respectively; 4 pairs of

marginal ventral setae, Mv 1-4 average 0.021, 0.022, 0.023, 0.024 mm long, respectively; 1 pair of anal setae, average 0.012 mm long. Eleven festoons, festoon 1 without ventral setae, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Subcordate, wider than long, from 0.211 to 0.237 mm long, average 0.222 mm, and from 0.308 to 0.334 mm wide, average 0.319 mm. Cervical grooves deep and long, almost reaching latero-posterior margins of scutum, parallel anteriorly, diverging posteriorly. Three pairs of scutal setae, Sc 1-3 average 0.011, 0.010, 0.012 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.096 to 0.132 mm long, average 0.114 mm, and from 0.105 to 0.123 mm wide, average 0.112 mm. Basis capituli subrectangular, about twice as wide as long, cornuae weak and reduced to small, rounded bulges; ventrally subrectangular, about twice as wide as long with a horizontal ridge over entire width anterior to posterior margin, distance from anterior margin to ridge ca. 3/4 to posterior margin, lateral ends of ridge somewhat bulging suggesting pseudo-auriculae. Palpi compact, bluntly rounded distally, mildly salient postero-laterally. Sutures between articles weak; article 1 as a pedicel; article 2 slightly shorter than article 3, external margin mildly concave at about midlength, posterior margin slightly wider than anterior margin; article 3 subtriangular, bluntly rounded distally, external margin moderately convex anteriorly, ventrally with a short blunt retrograde spur at latero-posterior margin, slightly overlaying anterior end of article 2. Article 1 without setae,

articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Clavate, average 0.069 mm long, extending beyond palpal apices. Corona very mild to almost absent. Dentition 2/2 with 7 denticles per file. One pair of posthypostomal setae, average 0.025 mm apart and average 0.009 mm long.

Legs.—Coxa I with a relatively long, narrowly triangular spur, blunt at the apex; 3 setae. Coxa II with a shallow, broadly rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 3, 1, and 2 setae, respectively; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species is unknown.

F. Genus Ixodes Latreille.—Approximately 220 species of the genus Ixodes are now recognized throughout the world. The larval fauna of this genus has been studied partially in different regions. The larval chaetotaxy of species occuring in the American continent was studied by Allred *et al.* (1960) and Clifford *et al.* (1961); 9 species in Russia were studied by Filippova (1954a, 1954b), Serdyukova (1955), and Reznik (1961); 4 species in Africa were studied by Morel (1966); and the 13 species in Australia were studied by Roberts (1969).

The larvae of the genus Ixodes are separated easily from other genera by the absence of sensilla sagittiformia. Clifford and Anastos (1960) studied the larvae of 31 species of the genus on a world-wide basis and concluded that in addition to the sensilla sagit-

tiformia, other chaetotaxic differentiating characters are the 2 pairs of posthypostomal (Ph) setae and the alignment of the dorsal setae on tarsus I. Also, each group of the dorsal and ventral body setae may show a variation in number. Roberts (1969) studied 9 more species of the genus Ixodes from Australia and noted some differences in the number of pairs of scutal (Sc) setae and Ph setae; each was one pair below the range of variation and the premarginal (Pm) setae were 5 pairs above the range of variation given by Clifford and Anastos (1960). The setae on coxa III have never been included as a generic character, but it is apparent from the illustrations given by Clifford *et al.* (1961), that this leg segment may have 2 to 3 setae. Thus, the following chaetotaxic features may be given as a generic diagnosis. Dorsal surface of body with 6 to 10 pairs of marginal dorsal (Md) setae, 2 to 6 pairs of central dorsal (Cd) setae, 0 to 8 pairs of supplementary (S) setae. Ventral surface of body with 1 to 3 pairs of preanal (Pa) setae, 3 to 12 pairs of Pm setae, 3 to 5 pairs of marginal ventral (Mv) setae. Scutum with 2 to 5 pairs of Sc setae and the capitulum has 1 to 2 pairs of Ph setae. Palpi with 12 to 13 setae and coxa III with 2 to 3 setae. Dorsal surface of tarsus I with 2 prehalleral (Pha), no halleral (Ha) and 6 posthalleral (Poh) setae placed in 2 groups of 4 and 2 setae, respectively.

The 4 species of the genus Ixodes which are known to occur in Indonesia are I. granulatus Supino, I. kopsteini Oudemans, I. spinicoxalis Neumann and I. werneri Kohls. The larvae of 3 species were available for study. Larvae of I. granulatus and I. kopsteini were reared in the laboratory. A 3rd species of larval Ixodes was collected in the field but it is not possible to determine whether it

is I. spinicoxalis or I. werneri. Accordingly this species is designated hereafter as Ixodes sp. 1.. The chaetotaxic features of these 3 species agree in all aspects with the characters given for the genus

The presently available species can be separated by the following key.

1. Capitulum long, palpi elongate, 2 pairs of posthypostomal setae. 2
   Capitulum short, palpi stout and rectangular, 1 pair of posthypostomal setae . . . . . I. kopsteini
2. Coxa I with internal spur of medium size and blunt, hypostome with 2/2 dentition; 4 to 5 pairs of central dorsal setae. . . . . I. granulatus
   Coxa I with internal spur long and acute; hypostome with 3/3 dentition in part; 2 pairs of central dorsal setae . . . . . Ixodes sp. 1

1. Ixodes granulatus Supino, Plate 24.—Ixodes granulatus has been recorded in Indonesia from Java (Neumann 1911, Krijgsman and Ponto 1932, Schulze 1934, Anastos unpublished data), Sumatra (Warburton 1926, Anastos unpublished data), and Bawean (Krijgsman and Ponto 1932), but the range of its distribution in Indonesia has not been work out completely. It has been recorded also from the Malay Peninsula and North Borneo (Kohls 1957), Thailand (Gould 1970), Indo-China, and the Yunan and Fukien Provinces in China (Kohls 1957), Burma, eastern India, and the Philippines (Anastos 1950, Kohls 1957) and

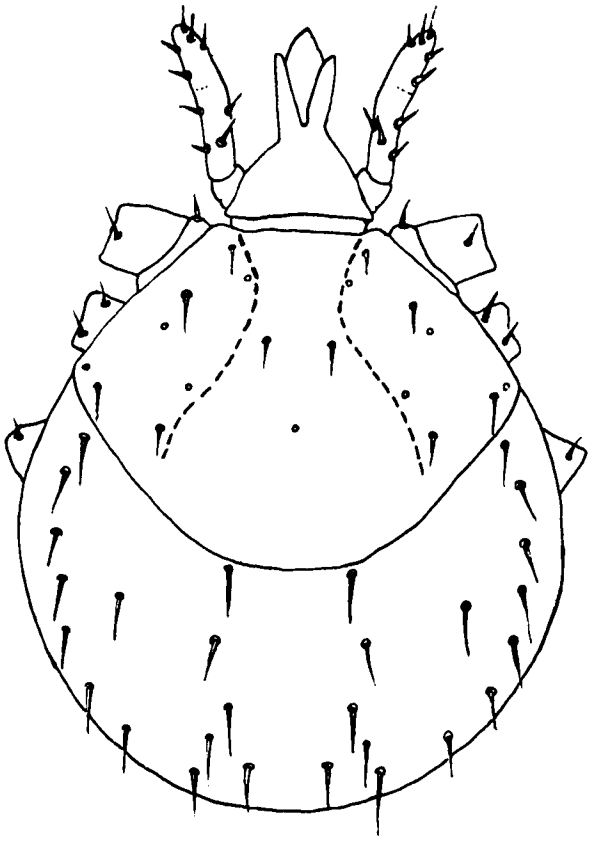
Plate 24

Ixodes granulatus Supino.

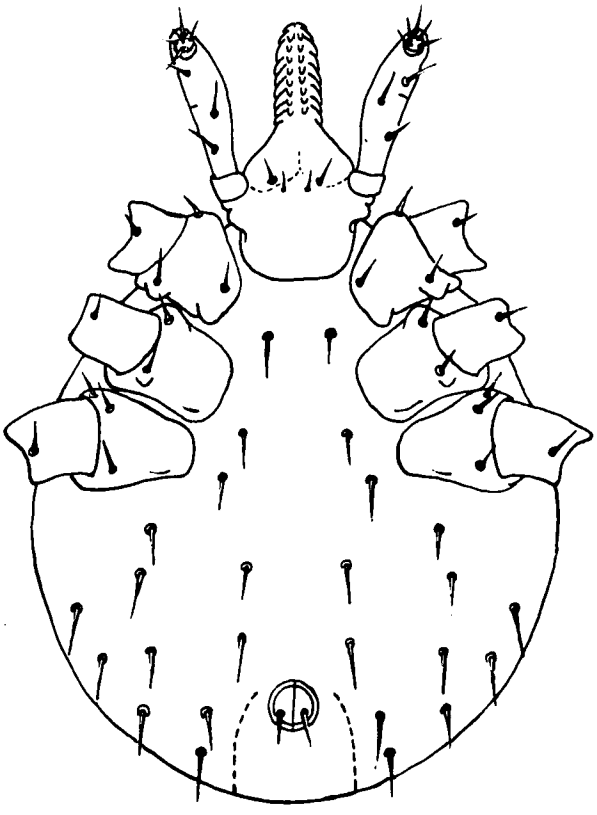
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



A



B

Okinawa (Kohls 1957).

The hosts of the larvae are unknown, but the adults have been found on a variety of rodent species, insectivores, carnivores, and man (Anastos 1950, Kohls 1957, Gould 1970).

Only laboratory-reared larvae were available for study. I. granulatus is a typical Ixodes and agreed in all respects with the generic characters given by Clifford and Anastos (1960).

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal setae, 1 pair of supplementary setae, 4 to 5 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae. Scutum somewhat hexagonal, broadly rounded posteriorly, 4 to 5 pairs of scutal setae. Capitulum long, palpi elongate, palpal article 3 with 5 dorsal setae; hypostome lanceolate, 2/2 dentition, 2 pairs of posthypostomal setae. Coxa I with 2 blunt spurs, external spur smaller than internal spur; 3 setae. Coxa II with 2 spurs, internal spur rudimentary to almost absent, and a small, blunt external spur; 2 setae. Coxa III with a trace of a single spur; 3 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest about midlength, from 0.495 to 0.539 mm long, average 0.518 mm, and from 0.407 to 0.456 mm wide, average 0.431 mm. Sensilla sagittiformia absent. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.070, 0.077, 0.069, 0.068, 0.072, 0.073, 0.065, 0.061 mm long, respectively; 4 to 5 pairs of central dorsal setae, Cd 1-5 average 0.041, 0.035, 0.042, 0.053, 0.047 mm long, respectively, central dorsal setae 5 may or may not be present; 1 pair of supplementary setae, average

0.048 mm long. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.040, 0.036, 0.036 mm long, respectively; 2 pairs of preanal setae, average 0.038 and 0.044 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.045, 0.048, 0.058, 0.060 mm long, respectively; 4 pairs of marginal ventral setae, Mv 1-4 average 0.063, 0.071, 0.064, 0.055 mm long, respectively; 1 pair of anal setae, average 0.019 mm long. Festoons absent. Anal grooves open anteriorly.

Scutum.—Somewhat hexagonal, with posterior margin broadly rounded wider than long, from 0.291 to 0.335 mm long, average 0.300 mm, and from 0.357 to 0.407 mm wide, average 0.378 mm. Cervical grooves shallow and long, almost reaching posterior margins of scutum, converging to ca. 1/3 scutal length, diverging posteriorly. Four to 5 pairs scutal setae, Sc 1-5 average 0.015, 0.016, 0.015, 0.015, 0.016 mm long, respectively, scutal setae 1 may or may not be present; 3 to 4 pairs of scutal setae external to cervical grooves; 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.220 to 0.258 mm long, average 0.241 mm and from 0.121 to 0.137 mm wide, average 0.131 mm. Basis capituli dorsally triangular, postero-lateral margins acute, posterior margin straight; ventrally subrectangular, wider anteriorly than posteriorly, postero-lateral margins rounded, auriculae distinct. Palpi elongate, ca. 4 1/2 times as long as wide. Article 1 distinct; article 2 slightly longer than article 3, suture between them slightly distinct. Article 1 without setae; article 2 with 2 ventral and 4 dorsal setae; article 3 with 2 ventral and 5 dorsal setae; article 4 with several terminal setae.

Hypostome.—Lanceolate average 0.104 mm long. Dentition 2/2 with 8 to 9 denticles per file; file 1 with sharp denticles; file 2

with blunt denticles. Two pairs of posthypostomal setae; posthypostomal setae one 0.057 mm apart, average 0.007 mm long; posthypostomal setae two 0.030 mm part, average 0.005 mm long.

Legs.—Coxa I with 2 blunt spurs, a medium size, internal spur and a smaller external spur; 3 setae. Coxa II with 2 spurs, internal spur rudimentary to almost absent, if present forming a weak ridge, and a small blunt external spur; 2 setae. Coxa III with a trace of a single spur; 3 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsal setal arrangement with 4 prehalleral, no halleral, and 6 posthalleral setae in 2 groups of 4 and 2 setae, respectively; ventral setal arrangement with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—Very limited information is available on the biology of this species. In the laboratory with uncontrolled condition, 2 females began ovipositing 10 to 11 days after detachment from the host. The incubation period of the eggs was 41 to 42 days.

2. Ixodes kopsteini Oudemans, Plate 25.—In Indonesia, adults, nymphs, and larvae of Ixodes kopsteini were found on an unspecified species of bat on the island of Amboina (Kohls and Clifford 1961) and on another bat, Tadarida plicata (Buchanan), on the island of Java, each about 1500 miles apart and separated by a large body of sea and numerous islands. In nearby regions,this species has been recorded from New Guinea on the bats T. colonicus (Thomas) and Nyctophilus sp. (Roberts 1969) and from the Malay Peninsula and North Borneo on a bat, Cheiromeles torquatus Horsfield, and an unspecified species of bat, respectively (Kohls and Clifford 1961). Records from Thailand are from the bats, T. plicata and Taphozous theobaldi Dobson (Gould 1970). Outside the region, the species is

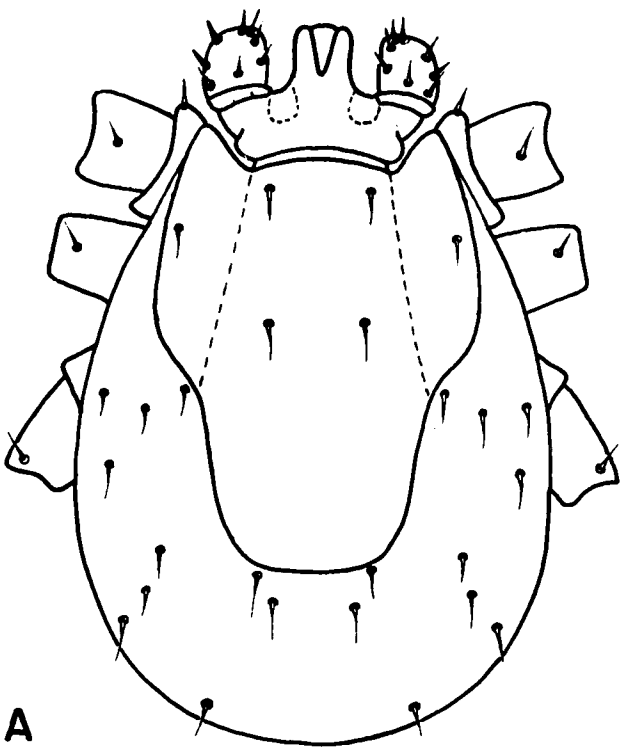
Plate 25

Ixodes kopsteini Oudemans.

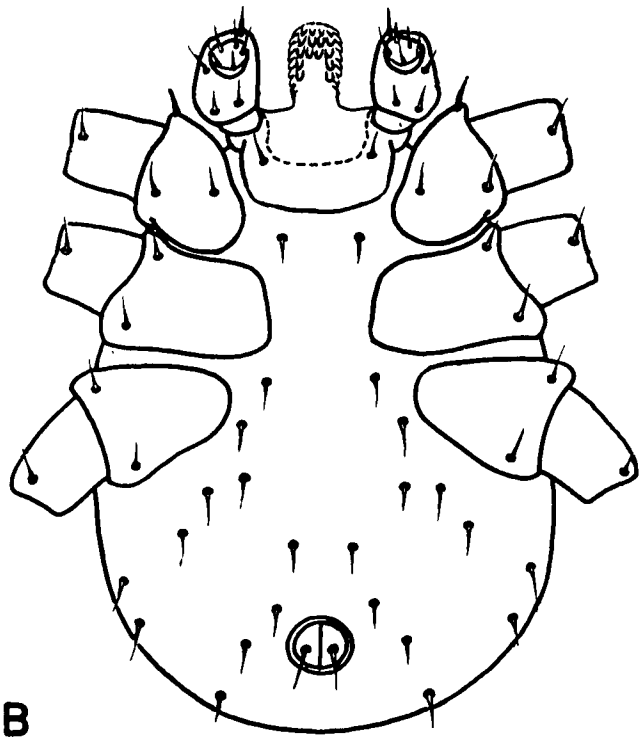
Description of figures:

A. Dorsum, × 375.

B. Venter, × 375.



A



B

also recorded on a bat from the Congo (Kohls and Clifford 1961). On the basis of its known distribution in Indonesia, this species probably occurs throughout the entire Indonesian archipelago. The only known hosts are bats, and more than likely, I. kopsteini is host specific for bats. The occurrence of this species in 2 very widely separated faunal regions is of considerable interest. At least two bat infesting Ixodes species, namely I. verspertilionis Koch and I. simplex Neumann are also known to be distributed widely (Wilson 1970b).

Kohls and Clifford (1961) described the larva of this species for the first time on the basis of partially engorged specimens and their association with the adults. Also, they mentioned the presence of 6 pairs of marginal dorsal (Md) setae and 2 to 3 pairs supplementary (S) setae. Roberts (1969) also had partially engorged specimens from Nyctophilus sp. and confirmed the finding of Kohls and Clifford in regard to the Md setae. Roberts stated that the central dorsal (Cd) setae may vary from 2 to 3 pairs. However, the Indonesian specimens only showed 4 pairs of Md setae and 4 pairs of S setae; the Cd setae were consistently 2 pairs. Actually, the difference between the specimens of Kohls and Clifford (1961) and Roberts (1969) and those from Indonesia are due to the state of engorgement. The Indonesian specimens were laboratory-reared and hence unfed; consequently they showed the normal distribution and arrangement of setae. Those of Kohls and Clifford (1961) and Roberts (1969) were partially engorged, and in the consequent distortion of the body due to feeding, the anterior pair of S setae shifted toward the margin and were erroneously regarded by them as Md setae. None of

the Indonesian specimens had more than 2 pairs of Cd setae and possibly the 2 to 3 pairs reported by Roberts (1969) for specimens from New Guinea may be characteristics of that population.

DIAGNOSIS.—Body oval, 4 pairs of marginal dorsal setae, 4 pairs of supplementary setae, 3 pairs of marginal ventral setae. Scutum pyriform, 3 pairs of scutal setae. Capitulum short, palpi stout, hypostome subclavate, dentition 3/3 anteriorly, 2/2 near midlength, 1/1 posteriorly, 1 pair of 4 posthypostomal setae. Dorsal surface of scutum, ventral surface of basis capitulum, and legs are scale-like in appearance. Coxa I with a very weak rounded to almost absent spur; 3 setae. Coxae II and III without spurs; each with 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest at about midlength, from 0.229 to 0.259 mm long, average 0.246 mm, and from 0.172 to 0.213 mm wide, average 0.198 mm. Sensilla sagittiformia absent. Dorsally with 4 pairs of marginal dorsal setae, Md 1-4 average 0.013, 0.015, 0.014, 0.015 mm long, respectively; 2 pairs of central dorsal setae, average 0.013 and 0.014 mm long, respectively; 4 pairs of supplementary setae, S 1-4 average 0.014, 0.015, 0.015, 0.015 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.014, 0.020, 0.021 mm long, respectively; 2 pairs of preanal setae, both average 0.018 mm long; 4 pairs of premarginal setae, Pm 1-4 average 0.018, 0.018 0.018, 0.021 mm long, respectively; 3 pairs of marginal ventral setae, all average 0.016 mm long; 1 pair of anal setae, average 0.018 mm long. Festoons absent. Anal grooves indistinct.

Scutum.—Pyriform, longer than wide, ca. 3/4 length of body; from 0.156 to 0.189 mm long, average 0.173 mm, and from 0.121 to 0.143 mm wide, average 0.131 mm. Surface scale-like. Anteriorly deeply invaginated to accommodate ca. 1/3 capitular length, scapular angle subacute. Cervical grooves shallow, straight, and long, reaching scutal margin beyond midlength. Three pairs of scutal setae, Sc 1-3 average 0.009, 0.010, 0.010 mm long, respectively; 1 pair of scutal setae external to cervical grooves, 2 pairs of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.072 to 0.083 mm long, average 0.77 mm, and from 0.062 to 0.070 mm wide, average 0.065 mm. Basis capituli dorsally subrectangular, lateral margins deeply concave, posterior margin weakly concave; ventrally subrectangular, posterolateral margins rounded, auriculae absent surface scale-like in appearance. Palpi stout, almost rectangular, broadly and flatly rounded distally, twice as long as wide. Article 1 distinct, article 2 and 3 more or less fused, suture between them indistinct. Article 1 without setae; articles 2 and 3 each with 4 dorsal and 2 ventral setae; article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.034 mm long. Dentition 3/3 near distal end, 2/2 near midlength, and 1/1 at base. Seven to 8 denticles in file 1; 4 to 5 denticles in file 2; and 3 to 4 denticles in file 3. One pair of posthypostomal setae, average 0.041 mm apart and 0.008 mm long.

Legs.—Scale-like in appearance. Coxa I with a very weak, shallow, and broadly rounded to almost absent spur; 3 setae. Coxae II and III without spurs; 2 setae. Tarsus I tapering distally, ca. 3 1/2 times as long as wide; dorsal setal arrangement with 4 prehal-

leral, no halleral, and 6 posthalleral setae, in 2 groups of 4 and 2 setae, respectively; ventral setal arrangement with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The reproductive behavior of I. kopsteini is different from all other ixodid ticks in that external oviposition does not occur. Many gravid females were found with the anterior portion of the body ruptured along a definite contour-line. Within the body were fully developed larvae, egg-shells, and eggs in various stages of embryonal development. Apparently, the uterus may have ruptured as soon as sufficient mature eggs developed, the female died, and the body merely serves as an "egg-case." Further development of the eggs into larvae takes place within the dead body of the female. Upon hatching, the larvae exit through the anterior opening of the female's body.

The apparent absence of ovipostion is correlated with the absence of porose areas on the dorsal surface of basis capituli of the female of this species and this is the only ixodid tick which does not have porose areas. Porose areas in female ixodid ticks are associated with the site of Gene's organ which secrete a waxing substance for the eggs (Arthur 1960, Feldman-Muhsam 1964). Since the eggs are not deposited in the external environment, the coating of eggs with a protective waxy covering is unnecessary.

3. Ixodes sp. 1, Plate 26.—Some larval specimens were collected in the field and their identity could not be determined positively at the present time. These larvae differed morphologically in chaetotaxic pattern from I. granulatus and I. kopsteini. Consequently, they are either I. spinicoxalis or I. werneri, the 2 remaining Ixodes species known to occur in Indonesia. However, since no laboratory reared spe-

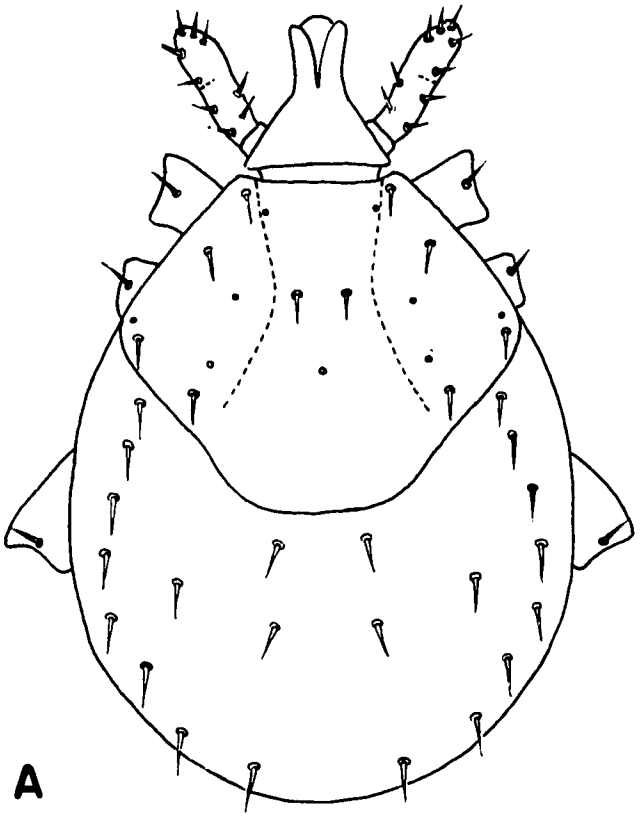
Plate 26

Ixodes sp. 1.

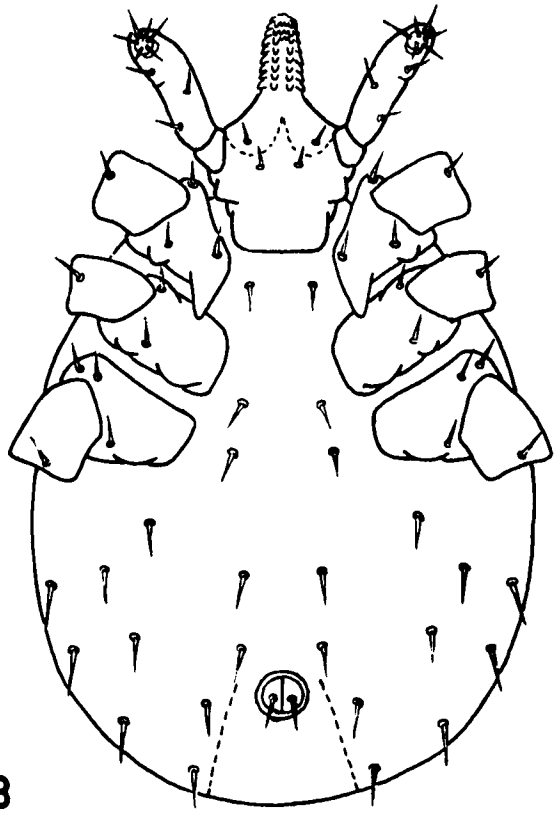
Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5



A



B

mens of I. spinicoxalis and I. werneri are available for comparison, these specimens are designated as Ixodes sp. 1.

Larvae of Ixodes sp. 1 are recorded from Java and Kalimantan and were found on Rattus exulans Peale, and another rat, Rattus sp., and on 2 unidentified species of birds.

Keirans *et al.* (1970) described and illustrated one larval specimen and identified it as Ixodes werneri on the basis of its association with the nymphs and the adults. The specimen was obtained from R. exulans in Central Java. The larvae of Ixodes sp. 1 when compared with Keiran's single larval specimen agree in all respects in the chaetotaxic as well as morphological features.

On the basis of their material, Keirans *et al.* (1970) also concluded that I. werneri has a wider distribution than originally assumed. The species was formerly recorded from Palawan, Philippines (type locality), and Selangor State in Malaysia. If Keiran's larval identification is correct, other locality records may be added on the basis of similarity shown between Ixodes sp. 1 and his single specimen. Six specimens of Ixodes sp. 1 were collected in West Java and 4 specimens in Kalimantan. The record from Kalimantan, thus would link the northern and southern ranges of distribution of the species.

Keirans *et al.* (1970) also reported that in Indonesia and the nearby regions, the other Ixodes species closely resembling I. werneri was I. granulatus. The larvae were compared on the basis of their chaetotaxic pattern, and differences were found only among the number of pairs of the central dorsal and premarginal setae. In the larva of the I. werneri, the central dorsal and premarginal

setae number 2 and 4 pairs, respectively, whereas in I. granulatus these are 4 and 3 pairs, respectively. Comparison of all Indonesian larval specimens of Ixodes sp. 1 with laboratory-reared larvae of I. granulatus reveals that not only the number of pairs of the central dorsal setae are different, but so are some other morphological features. The larvae of Ixodes sp. 1 have 2 pairs of central dorsal and 4 pairs of premarginal setae, have 3/3 dentition anteriorly and 2/2 posteriorly on the hypostome, and have a long, acute internal spur and more or less developed spurs on coxae II and III. Laboratory reared larvae of I. granulatus have 4 to 5 central dorsal setae, 2/2 dentition throughout the hypostome, a medium size blunt internal spur, and more or less rudimentary spurs on coxae II and III. All other features of the 2 species are similar.

Specimens of Ixodes sp. 1 were collected in 2 types of habitats. Collections on the island of Java came from forested areas in the mountain whereas those from Kalimantan came from a forest clearing in a lowland area.

The evidence given earlier for Ixodes sp. 1 with regard to morphological, chaetotaxic similarity, and geographical distribution is indicative of Ixodes sp. 1 being conspecific with I. werneri. However,the exact identity can only be determined if progeny of positively identified females of I. werneri can be compared with larval specimens of Ixodes sp. 1.

Too little is also known about the larvae of the Ixodes species occuring in Indonesia and the nearby region to determine relationships. The differences shown by the larvae of I. granulatus and Ixodes sp. 1 are too distinct to prevent their being closely related.

Therefore, the relationship of one species to the other could only be determined accurately when larval forms of all species are available for study.

DIAGNOSIS.—Body oval, 8 pairs of marginal dorsal setae, 1 pair of supplementary setae, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 4 pairs of marginal ventral setae. Scutum somewhat hexagonal, 5 pairs of scutal setae. Capitulum long, palpi elongate, palpal article 3 with 5 dorsal setae; hypostome lanceolate, 3/3 dentition anteriorly, 2/2 posteriorly; 2 pairs of posthypostomal setae. Coxa I with 2 spurs, a long acute internal spur and a short, blunt external spur; 3 setae. Coxa II with 2 spurs, a shallow broadly rounded internal spur and a smaller rounded external spur; 3 setae.

DESCRIPTION.--In all cases, 10 specimens were examined and the average measurements are based upon this number. The specimens were in various stages of engorgement.

Body.--Oval, longer than wide, widest about midlength; from 0.554 to 0.792 mm long, average 0.661 mm, and from 0.440 to 0.598 mm wide, average 0.506 mm. Sensilla sagittiformia absent. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.065, 0.072, 0.073, 0.068, 0.071, 0.069, 0.063, 0.060 mm long, respectively; 2 pairs of central dorsal setae, average 0.052 and 0.046 mm long, respectively; 1 pair of supplementary setae, average 0.068 mm long. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.037, 0.038, 0.038 mm long, respectively; 2 pairs of preanal setae, average 0.038 and 0.047 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.040, 0.044, 0.047, 0.042 mm long, respectively; 4 pairs of

of marginal ventral setae, Mv 1-4 average 0.061, 0.063, 0.058, 0.049 mm long, respectively; 1 pair of anal setae, average 0.020 mm long. Festoons absent. Anal grooves open anteriorly.

Scutum.—Somewhat hexagonal with posterior margin broadly rounded, wider than long, from 0.272 to 0.299 mm long, average 0.286 mm, and from 0.272 to 0.369 mm wide, average 0.341 mm. Cervical grooves shallow and long, almost reaching posterior margin of scutum, subparallel to about midlength, diverging posteriorly. Five pairs of scutal setae, Sc 1-5 average 0.018, 0.021, 0.024, 0.020, 0.030 mm long, respectively, 4 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae internal to cervical grooves. Eyes absent.

Capitulum.—From 0.114 to 0.140 mm long, average 0.128 mm, and from 0.132 to 0.140 mm wide, average 0.135 mm. Basis capituli dorsally triangular, postero-lateral margins acute, posterior margin straight; ventrally subrectangular, wider anteriorly than posteriorly, postero-lateral margins rounded, auriculae distinct. Palpi elongate, ca. 4 1/2 times as long as wide. Article 1 distinct, article 2 slightly longer than article 3, suture between them slightly distinct. Article 1 without setae, article 2 with 2 ventral and 4 dorsal setae, article 3 with 2 ventral and 5 dorsal setae, article 4 with several terminal setae.

Hypostome.—Lanceolate, average 0.088 mm long. Dentition 3/3 anteriorly and 2/2 posteriorly. Eight to 9 denticles in file 1 and 2, 2 to 3 denticles in file 3. Two pairs of posthypostomal setae, post-hypostomal setae 1 average 0.052 mm apart and average 0.008 mm long, posthypostomal setae 2 average 0.029 mm apart and average 0.007 mm long.

Legs.—Coxa I with 2 spurs, a long, acute internal spur, ex-

tending beyond anterior margin of coxa II, and a short, blunt external spur; 3 setae. Coxa II with 2 spurs, a shallow, broadly rounded internal spur and a smaller, rounded external spur; 2 setae. Coxa III with a shallow broadly rounded single spur; 3 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 4 prehalleral, no halleral, and 6 posthalleral setae in 2 groups of 4 and 2 setae; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of this species is not known.

G. Genus Rhipicephalus Koch.--The genus Rhipicephalus includes ca. 44 species and subspecies. The genus is most highly developed in continental Africa where 39 species are recognized; the remaining species are distributed over the Orient and Europe, including Russia (Hoogstraal 1956). In addition, R. sanguineus (Latreille) is cosmopolitan in distribution. In Indonesia, 3 species of the genus Rhipicephalus are now recognized, namely, R. haemaphysaloides Supino, R. pilans Schulze, and R. sanguineus.

Adults of R. haemaphysaloides and R. pilans resemble each other closely and were long considered to be subspecies of R. haemaphysaloides (Anastos 1950, Kohls 1950, 1957, Audy *et al.* 1960); however, they are now considered separate species on the basis of new information relative to their geographical distribution and their larval morphology. R. h. haemaphysaloides was considered to occupy more or less the nothern range of the Oriental region from India to the Malay Peninsula, whereas R. h. pilans was considered to occupy the southern range which covers most of Indonesia and the Philippines. The line of separation of their distribution was set arbitrarily in central Sumatra

(Anastos 1950). However, this allopatric distribution is now questionable since adults of R. h. haemaphysaloides were colleted recently from Celebes. Therefore, R. h. haemaphysaloides has a more easternly distribution than previously known and probably occurs in the area west of Celebes as well. R. h. pilans already is recorded from the area west of Celebes. Also, Krijgsman and Ponto (1931, 1932) reported R. h. haemaphysaloides in southeast Kalimantan, but it is not known whether they were dealing with typical R. haemaphysaloides or R. pilans. The actual distribution of these 2 species must await further collections.

In addition to their allopatric existence, R. h. haemphysaloides and R. h. pilans were considered subspecies because of the lack of distinct morphological differences between the adults. Males and females of these 2 subspecies can be separated only on the basis of the degree of scutal texture and pilosity of the body. However, laboratory-reared larvae of R. haemaphysaloides and R. pilans are distinguished easily by the shape of the body and the palpal apices, by the width of the dorsal surface of the basis capituli in relation to the anterior margin of the scutum, and by the degree of development of coxal spur III. The marked differences between the larvae of these 2 species offer strong evidence for considering R. haemaphysaloides and R. pilans as separate species rather than as subspecies.

The larvae of 17 species of the genus Rhipicephalus from 3 different faunal regions have been studied previously (Shatas 1956, Clifford and Anastos 1960, Roberts 1969). Clifford and Anastos (1960) utilized the chaetotaxy of 10 species to establish the generic characteristics.

The larvae of this genus are separated from other genera by

the presence of 1 pair of sensilla sagittiformia of the dorsal surface of the body and the 4 marginal dorsal setae located anterior to sensilla on each side. Other chaetotaxic characters of the genus as given by Clifford and Anastos (1960) are: body dorsally with 8 pairs of marginal dorsal (Md) setae, 2 pairs of central dorsal (Cd) setae; ventrally with 2 pairs of preanal (Pa) setae, 4 pairs of premarginal (Pm), and 5 pairs of marginal ventral (Mv) setae; scutum with 3 pairs of scutal (Sc) setae; capitulum with 1 pair of posthypostomal (Ph) setae, and palpi with 12 setae; coxa III always with 2 setae, and tarsus I dorsally with 2 prehalleral (Pha), 2 halleral (Ha) and 6 posthalleral (Poh) setae placed in 3 groups of 2 setae each.

The larvae of the 3 species of genus Rhipicephalus which occur in Indonesia, namely R. haemaphysaloides, R. pilans, and R. sanguineus, were available for study. All were reared in the laboratory, and a limited number of field-caught larvae of R. pilans were also available for study.

The larvae of R. haemaphysaloides, R. pilans, and R. sanguineus agree with the generic description of Clifford and Anastos (1960) and are separated by the following key.

1. Coxal spur III rudimentary or not developed; palpi broadly triangular, stout; basis capituli dorsally as wide as ventrally. . . . . R. sanguineus

   Coxal spur III weakly developed or well developed; palpi subtriangular or narrowly triangular; basis capituli wider dorsally than ventrally. 2

2. Palpi acutely pointed distally; posterior margin of basis capituli wider than anterior margin of scutum. . . . . R. pilans

Palpi bluntly pointed distally; posterior margin of basis capituli as wide as anterior margin of scutum. . . . . R. haemaphysaloides

1. Rhipicephalus haemaphysaloides Supino, Plate 27.—Rhipicephalus haemaphysaloides is indigenous to the Oriental region. It occurs in India, Ceylon, Burma, Southern China, Indochina, Formosa, Thailand, Malay Peninsula, and parts of Indonesia where it is usually found on large wild and domestic animals. Record from Thailand, however, show that this species may also be found on a variety of rodent species and primates, including man (Gould, 1970).

Within the Indonesian archipelago, adults and nymphs of R. haemaphysaloides were recorded formerly only from upper Sumatra (Neumann 1897, 1904, 1911, Krijgsman and Ponto 1931, 1932, Schulze 1936, Anastos 1950). New records of adults are from Celebes (Anastos unpublished data).

Hosts of the larvae are not known, but adults and nymphs have been recorded from several species of ungulates, carnivores, and a rodent species (Anastos unpublished data).

Only laboratory-reared larvae of R. haemaphysaloides were available for study.

DIAGNOSIS.—Body broadly oval, 8 pairs of marginal dorsal (Md) setae, Md 1 to Md 4 anterior to sensilla sagittiformia, 2 pairs of

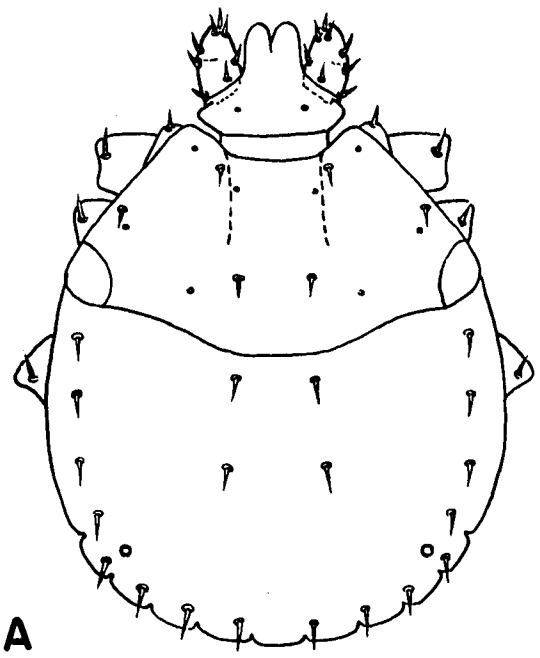
Plate 27

Rhipicephalus haemaphysaloides Supino.

Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



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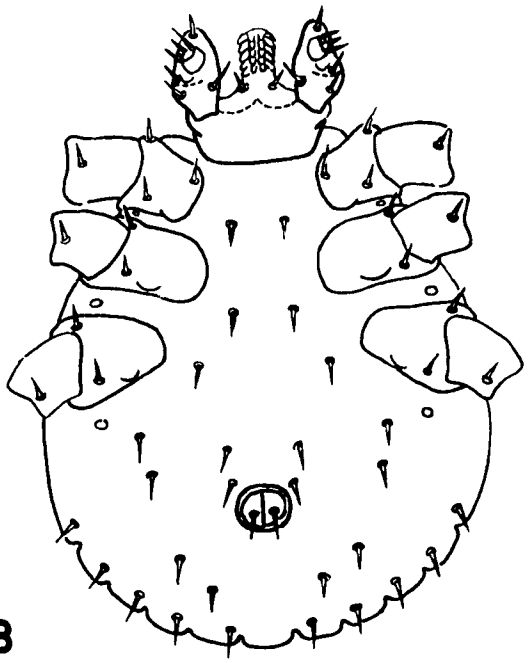


B

central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally slightly wider than ventrally, posterior margin as wide as anterior margin of scutum. Palpi subtriangular, bluntly pointed distally. Coxal spur I with a broadly rounded spur: 3 setae. Coxae II and III each with a small rounded spur, less developed in coxa II; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Broadly oval, longer than wide, widest at about mid-length, from 0.561 to 0.616 mm long, average 0.587 mm, and from 0.473 to 0.506 mm wide, average 0.501 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.023, 0.026, 0.027, 0.025, 0.024, 0.024, 0.025, 0.026 mm long, respectively, Md 1 to Md 4 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.020 and 0.021 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.046, 0.032, 0.032 mm long, respectively; 2 pairs of preanal setae, average 0.027 and 0.029 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.026, 0.032, 0.027, 0.023 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.027, 0.026, 0.027, 0.028, 0.027 mm long, respectively; 1 pair of anal setae, average 0.020 mm long. Nine festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Much wider than long, from 0.231 to 0.253 mm long,

average 0.243 mm, and from 0.440 to 0.473 mm wide, average 0.458 mm. Cervical grooves shallow, parallel, and extending to midlength. Three pairs of scutal setae, Sc 1-3 average 0.024, 0.017, 0.020 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae posterior to cervical grooves. Eyes flat, slightly extending beyond margin of body.

Capitulum.—From 0.110 to 0.143 mm long, average 0.125 mm, and from 0.154 to 0.176 mm wide, average 0.168 mm. Basis capituli dorsally hexagonal, lateral margins subacute, posterior margin as wide as anterior margin of scutum; ventrally subrectangular, wider anteriorly than posteriorly; dorsal surface slightly wider than ventral surface. Palpi subtriangular, ca. 2 times as long as wide. Article 1 indistinct; sutures between articles 2 and 3 slightly distinct; article 2 ca. 2/3 as long as article 3; article 3 subtriangular, bluntly pointed distally, and with a blunt ventral retrograde spur near latero-posterior margin. Articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.065 mm long. Dentition 2/2 with 5 or 6 denticles per file. One pair of posthypostomal setae, average 0.028 mm apart and 0.014 mm long.

Legs.—Coxa I with a broadly rounded spur; 3 setae. Coxa II with a small rounded spur; 2 setae. Coxa III with spur similar to coxa II, but less developed spur; 2 setae. Tarsus I tapering distally, ca. 3 1/2 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae, in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—Information on the biology of R. haemaphysaloides is

restricted to rearing of the larval stage. Five females, under uncontrolled laboratory conditions, started to oviposit 6 days after having detached from the host. The eggs hatched in 33 to 36 days.

The introduction of domestic animals which have proven to be suitable hosts have facilitated the spread of this species more rapidly. Anastos (1950) reported that it is second in importance to Boophilus microplus as a pest of livestock.

2. Rhipicephalus pilans Schulze, Plate 28.—The distribution of Rhipicephalus pilans is restricted to the southern and eastern part of the Oriental region, more specifically in the Philippines and most of the Indonesian region. It is a common parasite of many of the larger wild and domestic animals.

In Indonesia, adults and nymphs of R. pilans have been recorded from Sumatra (Krijgsman and Ponto 1931, 1932, Anastos 1950, Anastos unpublished data), Java (Krijgsman and Ponto 1931, 1932, Anastos 1948, 1950, Anastos unpublished data), Bawean (Anastos unpublished data), Madura (Krijgsman and Ponto 1931, 1932, Anastos 1950), Kalimantan (Krijgsman and Ponto 1931, 1932, Kohls 1957, Anastos unpublished data), Celebes (Krijgsman and Ponto 1931, 1932, Anastos 1950), Bali (Anastos 1950, Anastos unpublished data), Lombok (Schulze 1936, Anastos unpublished data), Sumbawa, Sumba (Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Komodo (Anastos unpublished data), Flores (Schulze 1936), Sawu, Roti, Timor, Alor (Krijgsman and Ponto 1931, 1932). Available larval specimens do not contribute additional locality records.

The host of the adults are a variety of domestic animals, namely, cow, buffalo, horse, pig, sheep, goat, and dog, and among wild

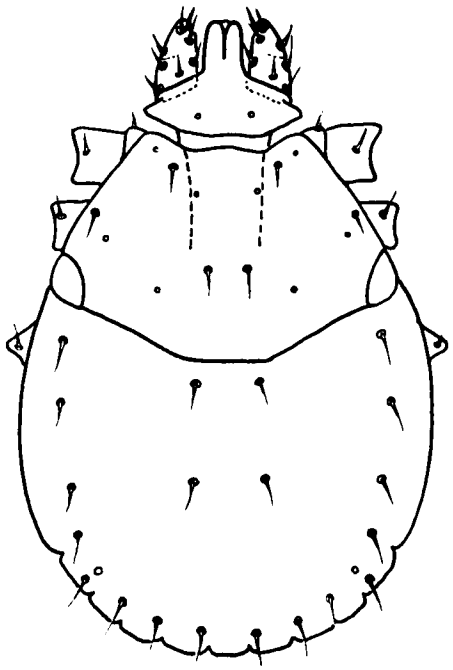
Plate 28

Rhipicephalus pilans Schulze.

Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



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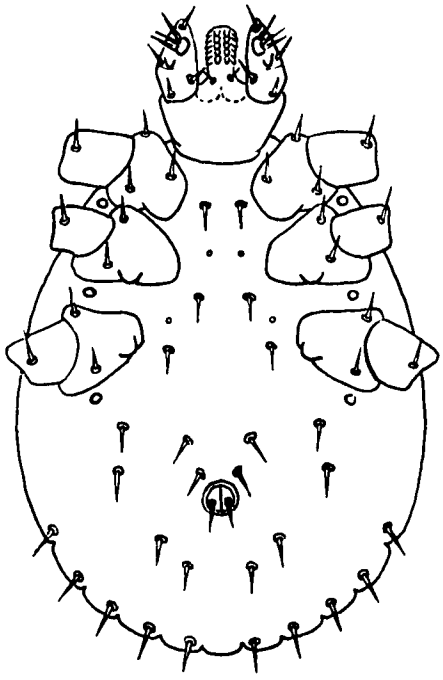

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animals are ungulates, carnivores, and a bat (Anastos 1950, Anastos unpublished data). Larvae of this species thus far are recorded only from a horse and a rat, Rattus sp.

Laboratory-reared larvae of R. pilans as well as some field-caught specimens were available for study.

DIAGNOSIS.—Body narrowly oval, 8 pairs of marginal dorsal (Md) setae, Md 1 to Md 4 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal ventral setae, Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally much wider than ventrally, posterior margin much wider than anterior margin of scutum. Palpi narrowly triangular, acutely pointed distally. Coxa I with a broadly rounded spur; 3 setae. Coxae II and III each with a small rounded spur; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.--Narrowly oval, longer than wide, widest at about mid-length, from 0.423 to 0.495 mm long, average 0.462 mm, and from 0.335 to 0.407 mm wide, average 0.366 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.017, 0.018, 0.019, 0.016, 0.017, 0.017, 0.016, 0.017 mm long, respectively, Md 1 to Md 4 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, both average 0.016 mm long. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.035, 0.025, 0.027 mm long, respectively; 2 pairs of preanal setae, average 0.024 and 0.023 mm long, respectively; 4 pairs of premarginal setae

Pm 1-4 average 0.027, 0.028, 0.024, 0.030 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.017, 0.017, 0.017, 0.017, 0.019 mm long, respectively; 1 pair of anal setae, average 0.016 mm long. Nine festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Much wider than long, from 0.187 to 0.209 mm long, average 0.198 mm and from 0.297 to 0.330 mm wide, average 0.325 mm. Cervical grooves shallow, parallel, and extending to midlength. Three pairs of scutal setae, Sc 1-3 average 0.022, 0.015, 0.015 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae posterior to cervical grooves. Eyes flat, rarely extending beyond margin of body.

Capitulum.—From 0.099 to 0.115 mm long, average 0.106 mm, and from 0.148 to 0.165 mm wide, average 0.153 mm. Basis capituli dorsally hexagonal, lateral margins acute, posterior margin wider than anterior margin of scutum; ventrally subrectangular, wider anteriorly than posteriorly; dorsal surface much wider than ventral surface. Palpi narrowly triangular, slender, ca. 2 times as long as wide. Article 1 indistinct, sutures between articles 2 and 3 slightly distinct, article 2 ca. 1/2 as long as article 3, article 3 triangular, acutely pointed distally, with a blunt retrograde ventral spur near latero-posterior margin. Articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.044 mm long. Dentition 2/2 with 5 or 6 denticles per file. One pair of posthypostomal setae, average 0.021 mm part and average 0.011 mm long.

Legs.—Coxa I with a broadly rounded spur; 3 setae. Coxa II with a small rounded spur; 2 setae. Coxa III with spur similar to coxa II, close to internal margin of coxa; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—Little is known about the biology of R. pilans. Under uncontrolled laboratory condition 4 females started to oviposit 3 to 6 days after having detached from the host. The incubation period of the eggs was 23 to 25 days.

3. Rhipicephalus sanguineus (Latreille), Plate 29.—Rhipicephalus sanguineus is a cosmopolitan species and is recorded practically from all countries lying between lat. 50°N and 35°S. It is a parasite mainly on dogs, but it is also found occasionally parasitizing other carnivores, primates, and herbivores.

In Indonesia R. sanguineus was recorded from Sumatra (Neumann 1911, Nieschulz 1924, Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Java (Neumann 1911, Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Madura, Alor, Amboina, Saparua (Krijgsman and Ponto 1931, 1932), Sumba, Timor (Krijgsman and Ponto 1931, 1932, Anastos unpublished data), Sumbawa (Anastos 1950), Celebes (Anastos 1950, Anastos unpublished data), and Bali (Anastos unpublished data).

The hosts of the adults and nymphs are common domestic animals such as dog, goat, pig, cow, and buffalo; and one record from a wild animal was from a deer, Cervus unicolor equinus Cuvier (Anastos 1950, Anastos unpublished data). Hosts of the larvae are unknown.

Larvae of R. sanguineus from different regions have been des-

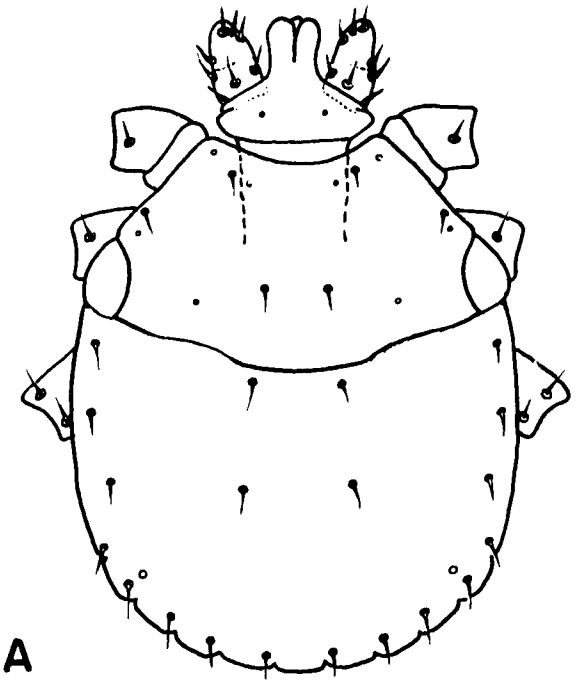
Plate 29

Rhipicephalus sanguineus (Latreille).

Description of figures:

A. Dorsum, × 187.5.

B. Venter, × 187.5.



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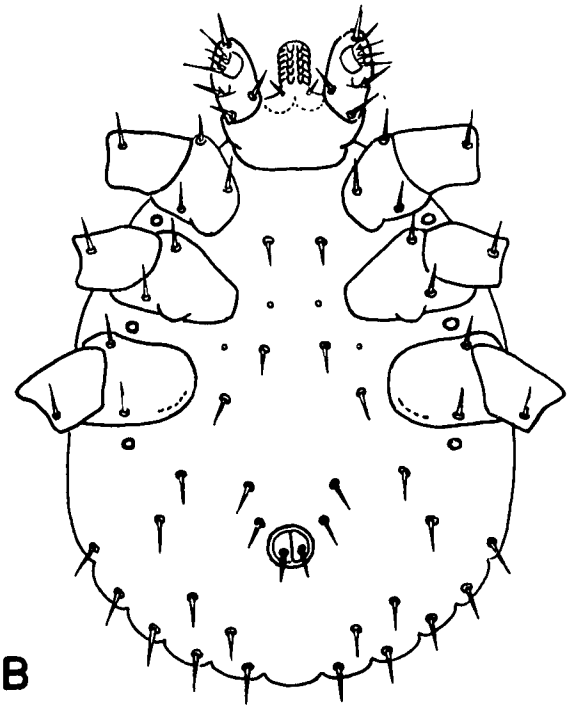

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cribed previously. Shatas (1956) described the species occurring in Russia and gave attention more to the capitular, coxal, and tarsal I structures; chaetotaxy was studied and illustrated for the palpi only. Clifford *et al.* (1961) studied the chaetotaxy of the species in America, and Roberts (1969) studied the Australian form.

Only laboratory-reared specimens from Indonesia were available for study. Morphological variations were observed among the larvae of this species from America, Australia, and Indonesia. The American species has the spur on coxa III well developed, and it is as developed as coxal spur II (Clifford *et al.* 1961). In the Australian species, the spur on coxa III is less developed than coxal spur II (Roberts 1969). In the Indonesian form, the spur on coxa III is rudimentary. Other characters are similar for the forms from the 3 geographical regions. The variations in the shape of the spur on coxa III probably represent populational variations.

DIAGNOSIS.—Body broadly oval, 8 pairs of marginal dorsal (Md) setae, Md 1 to Md 4 anterior to sensilla sagittiformia, 2 pairs of central dorsal setae, 2 pairs of preanal setae, 4 pairs of premarginal setae, and 5 pairs of marginal setae. Scutum with 3 pairs of scutal setae. Capitulum with 1 pair of posthypostomal setae; basis capituli dorsally as wide as ventrally, posterior margin as wide as anterior margin of scutum. Palpi broadly triangular, stout, bluntly pointed distally. Coxal spur I with a broadly rounded spur; 3 setae. Coxa II with a small rounded spur; 2 setae. Coxa III with a rudimentary spur; 2 setae.

DESCRIPTION.—In all cases, 25 specimens were examined and the average measurements are based upon this number.

Body.—Oval, longer than wide, widest at about midlength, from

0.440 to 0.517 mm long, average 0.472 mm, and 0.363 to 0.418 mm wide, average 0.385 mm. Four pairs of sensilla sagittiformia, 3 pairs of sensilla posterior to each coxa, 1 pair of sensilla on dorso-lateral surface of body. Dorsally with 8 pairs of marginal dorsal setae, Md 1-8 average 0.020, 0.021, 0.022, 0.020, 0.020, 0.020, 0.020, 0.021 mm long, respectively, Md 1 to Md 4 anterior to sensilla sagittiformia; 2 pairs of central dorsal setae, average 0.016 and 0.022 mm long, respectively. Ventrally with 3 pairs of sternal setae, St 1-3 average 0.035, 0.023, 0.028 mm long, respectively; 2 pairs of preanal setae, average 0.023 and 0.020 mm long, respectively; 4 pairs of premarginal setae, Pm 1-4 average 0.023, 0.025, 0.025, 0.026 mm long, respectively; 5 pairs of marginal ventral setae, Mv 1-5 average 0.020, 0.019, 0.020, 0.021, 0.022 mm long, respectively; 1 pair of anal setae, average 0.016 mm long. Nine festoons, parma without ventral and dorsal setae. Anal grooves absent.

Scutum.—Much wider than long, from 0.198 to 0.236 mm long, average 0.210 mm, and from 0.352 to 0.390 mm wide, average 0.374 mm. Cervical grooves shallow, parallel, and extending to midlength. Three pairs of scutal setae, Sc 1-3 average 0.024, 0.018, 0.016 mm long, respectively, 2 pairs of scutal setae external to cervical grooves, 1 pair of scutal setae posterior to cervical grooves. Eyes flat, extending beyond margin of body.

Capitulum.—From 0.099 to 0.126 mm long, average 0.110 mm, and from 0.137 to 0.154 mm wide, average 0.144 mm. Basis capituli dorsally hexagonal, lateral margins subacute, posterior margin as wide as anterior margin of scutum; ventrally subrectangular, wider anteriorly than posteriorly; dorsal surface as wide as ventral surface. Palpi broadly

triangular, stout, ca. 1 1/2 times as long as wide. Article 1 indistinct; sutures between articles 2 and 3 slightly distinct; article 2 ca. 1/2 as long as article 3, article 3 broadly triangular, bluntly pointed distally with a blunt ventral retrograde spur near latero-posterior margin. Articles 2 and 3 each with 2 ventral and 4 dorsal setae, article 4 with several terminal setae.

Hypostome.—Subclavate, average 0.044 mm long. Dentition 2/2 with 5 or 6 denticles per file. One pair of posthypostomal setae, average 0.022 mm apart and average 0.013 mm long.

Legs.—Coxa I with a broadly rounded spur; 3 setae. Coxa II with a small, rounded spur; 2 setae. Coxa III with a rudimentary to absent spur; 2 setae. Tarsus I tapering distally, ca. 3 times as long as wide; dorsally with 2 prehalleral, 2 halleral, and 6 posthalleral setae, in 3 groups of 2 setae each; ventrally with 3 groups of 4 setae each, the terminal one in tandem of 2 setae.

BIOLOGY.—The biology of R. sanguineus has been well studied in other parts of the world. Hoogstraal (1956) gave a thorough review of the life cycle. This species is definitely known as a three-host tick.

Information concerning the Indonesian species is very limited. Under uncontrolled laboratory condition, females started to oviposit 1 to 3 days after having detached from the host. The eggs hatched in 24 to 30 days. Hoogstraal (1956) cited Nuttall's studies that the incubation period of the eggs was 17 to 19 days at 30°C, and the larvae fed for about 4 days before molting to the nymphal stage.

In other parts of the world R. sanguineus has been incriminated as the vector of canine rickettsiosis and canine piroplasmosis

(Hoogstraal 1956). Also, spirochetosis of sheep, goats, horses, and cattle is transmitted by this species. The actual situation of these diseases and the transmission by this species is not known in Indonesia, but this species should be regarded as a possible vector.

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