BULLETIN OF THE CALIFORNIA INSECT SURVEY
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(Acari: Ixodida)

by Deane P. Furman and Edmond C. Loomis

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THE TICKS OF CALIFORNIA (Acari: Ixodida)

INTRODUCTION

Ticks are obligatory, blood-sucking parasites of mammals, birds, and reptiles. There are about 850 species described for the world, most of them in two families: the hard ticks, or Ixodidae, and the soft ticks, Argasidae. A third family, the Nuttalliellidae, is known only from a single species in Africa. In California 7 genera containing 49 species of ticks are known to be established. Two additional species, Amblyomma americanum and Boophilus annulatus, have been introduced repeatedly into the State and are included here in keys and text. Other occasional introductions of exotic ticks are reported by state and federal agencies, but none of these have become established in California.

This publication provides a guide to the identification of adult and immature instars of ticks occurring in California and information on the geographic and seasonal distribution of ticks in the State and on their host associations and their importance to the health and welfare of man and domestic and wild animals. Host association and other collection records are summarized in tabular form for all species encountered frequently. Numbers of specimens per collection are not indicated in the tables. Distribution maps include only precise collection sites.

MEDICAL AND VETERINARY IMPORTANCE

Ticks are among the most important ectoparasites affecting the health of man and domestic and wild animals. They serve as reservoirs and vectors of many organisms pathogenic for humans and other animals, and cause direct harm by their bites, including irritation, anemia, toxemia, allergic sensitization, and paralysis. Rickettsia rickettsii, the classical agent of Rocky Mountain spotted fever in man, has never been isolated from ticks, man, or other animals in California, but 5 serologically distinct strains of spotted-fever-group rickettsiae have been isolated from 5 species of ticks in the State (R.S. Lane, personal communication, 1980). Other tick-associated pathogens occurring in California include Coxiella burneti, causing Q fever; Anaplasma marginale, causing anaplasmosis in cattle; Colorado tick fever virus (CTV); Powassan fever virus; the bacterium Francisella tularensis, causing tularemia; the spirochetes Borrelia hermsi and B. parkeri, causing tick-borne relapsing fever in humans; and the protozoan Babesia canis, a cause of canine jaundice. B. microti, which has been associated in the eastern United States with tick-borne babesiosis of man, a malaria-like disease, has been recorded from rodents and a lagomorph in southern California (Van Peenen and Duncan, 1968). Lyme disease, often resulting in polyarthritis in man, has been associated on circumstantial grounds with the bite of Ixodes pacificus in California (Naversen and Gardner, 1978). Epizootic bovine abortion (foothill abortion) has been associated circumstantially with the feeding of the argasid, Ornithodoros coriaceus, in California. Tick paralysis, a potentially fatal disease of many animals including man, is associated with the feeding of certain female ixodids and has been documented in California on a variety of livestock and wildlife (Brunetti, 1965; Loomis and Bushnell, 1968).

One characteristic of ticks which greatly enhances their importance as vectors and reservoirs of pathogens is the ability to transmit microorganisms transovarially from one generation of ticks to the next one, as in Dermacentor andersoni and Rocky Mountain spotted fever, or Ornithodoros hermsi and relapsing fever. Many ticks can also transmit infections from one developmental instar to the next, as in both the above examples. Transmissibility is more limited in some cases, however, as in Colorado tick fever,

where the virus is known to be transmissible from stage to stage in D. andersoni, but transovarial transmission has not been demonstrated. A third intrinsic characteristic of major importance in determining the role of ticks in the dissemination and maintenance of pathogens is the long life-span of these Acari, commonly a year and frequently two or more years, often exceeding that of their hosts. This provides a much enhanced potential in time and space for the transmission of pathogens to uninfected, susceptible hosts. As noted by Balashov (1968), many tick species feed on small mammals and birds with a high rate of population renewal, which decreases the potential for a subsidence of infection due to the acquisition of immunity by susceptible vertebrates. In such situations, ticks often become the true reservoirs of infection.

BIOLOGY

The basic life cycle of ticks consists of egg, hexapod larva, octopod nymph, and adult male or female. Ixodid ticks typically have a single nymphal instar, while argasids may have from 3 to 7. A decided host preference is shown by some species, such as Boophilus annulatus, whereas others appear to be equally content with almost any terrestrial vertebrate that comes their way. In many tick species the hosts or parts of hosts selected by adults are not the same as those selected by immature forms (e.g., Ixodes pacificus), and the majority of species do not molt on the host. Those which remain on a host for their entire parasitic life are known as one-host ticks, e.g., Dermacentor albipictus and Otobius megnini.

Most ixodid ticks in California are three-host ticks: larva, nymph, and adult must each seek a host in order to obtain a blood meal, after which each form drops from the host. This means that an individual tick may be found in nature in any part of its previous host's range - or, in the case of a larva, of its parental host's range. The chances of an individual tick finding a suitable host on three separate occasions under such circumstances are not good, but the tremendous reproductive capacity of the typical ixodid tick compensates for the loss of developing instars. A gravid female American dog tick may lay 6-7 thousand eggs in a single batch before dying. In general, the various instars of ixodid ticks in the unfed state will either seek a favorable microhabitat such as under logs, in crevices, or in loose soil, to await a propitious time for seeking a host, or will climb onto grasses or shrubs to await the passage of an animal to which they may attach. Thus we use terms such as wood ticks and field ticks for many ixodids. Characteristically, ixodid ticks remain attached by their mouthparts to a suitable host for several days to weeks, feeding slowly on lysed tissue fluids and blood at first, and engorging rapidly on blood before detaching. There is evidence of actual intrastadial growth (neosomy) in some species, as well as stretching of soft cuticular membranes as the ixodid tick engorges.

Argasid tick biology differs in fundamental ways from that of the Ixodidae. Most argasid ticks are rapid feeders, feeding to repletion in a few minutes. Notable exceptions are the larvae of species such as the poultry tick, Argas sanchezi, and the pajahuello, Ornithodoros coriaceus, which feed on a suitable host for 5-10 days. Argasid ticks do not become as engorged as ixodids, and may attach and feed more than once during a single life-stage. Adult females of most argasids typically lay fewer eggs than ixodids and usually lay them in more than one batch, with one or more blood meals intervening. An individual argasid has more chance of surviving successfully from egg to adult than an ixodid because most argasids are lair or nest inhabitants, feeding rapidly on the host at its central homesite and then remaining at that site, where they can feed repeatedly on the same or a related host. The remarkable ability of some argasids to survive long periods of starvation, up to several years, increases their success as lair inhabitants as well as the hazard they pose to hosts as dormant reservoirs of disease agents.

METHODS

PREPARATION AND EXAMINATION

Essential equipment for definitive tick identification includes a stereoscopic microscope capable of 150-200 X magnification. Strong illumination is necessary, preferably from a cool light source such as fiber optics.

Ticks are best preserved in 70% ethyl alcohol. Nymphs and adults may be examined in alcohol under the stereoscopic microscope

or blotted until only moist, with care to avoid excessive drying. A small cake of plastic typewriter cleaner mounted on a microscope slide facilitates manipulation of moist specimens; such a cake, available in most office supply stores, maintains its flexibility for months .

Larvae are usually examined as permanent whole mounts with the compound microscope. Preliminary clearing of the larvae may be necessary in preparing mounts; one to three minutes' submersion in steaming lactic acid is usually sufficient to clear most specimens. After being washed in two or more changes of water, each specimen can be mounted on a slide in a drop of Hoyer's mounting medium and covered with a coverslip. Mounted specimens continue to clear if placed in a warming oven at 40°C for 24-48 hours. After drying, permanent slide mounts should be ringed with a commercial slide-ringing compound or clear fingernail polish.

SIMPLIFIED IDENTIFICATION

Identification of the many kinds of ticks occurring in California may appear a formidable chore. Fortunately, most of those encountered by the general public belong to only 6 species, whose habits bring them into contact with man or his domestic pets.

Of these 6 common ticks 4 are usually acquired by man or his pets through contacting infested brush or grass. One of these, Ixodes pacificus, is a small, dark-legged form which need only be identified to genus for reasonable reliability. The other 3 species in this group are the Pacific Coast tick, Dermacentor occidentalis, the American dog tick, D. variabilis, and the Rocky Mountain wood tick, D. andersoni. In most cases the adults of these 3 species are easily identified by the characters given in the key. Identification of D. andersoni is simplified by its restricted range in California, but there are limited areas of overlapping geographic distribution with D. occidentalis in northeastern California, where intergradation of morphology appears to occur.

Its habit of breeding in and around dog kennels or in homes containing dogs makes the brown dog tick, Rhipicephalus sanguineus, a common pest in both urban and rural situations. Adults of this species, characterized by a short capitulum, hexagonal basis capituli, inornate scutum with eyes, and festoons at the posterior end of the body, need only be identified to genus. And as the pajahuello, Ornithodoros coriaceus, a soft tick of the family Argasidae, is the only one of the 6 common species which lacks a dorsal scutum and has mouthparts not visible from above, it should be relatively simple to make a tentative identification. This species typically occurs in the brushy or tree-shaded environment favored as resting sites by deer and cattle. When man also frequents such sites, he is subject to attack by the resident ticks.

Most of the ticks in California are normally associated with mammalian or avian hosts other than man or his domestic pets, and are encountered by man only when he works with those hosts or invades their ecological niche - e.g., the winter tick, Dermacentor albipictus, on horses and deer, or Ornithodoros hermsi, on chipmunks invading cabins in the high mountains.

It is essential in using a key to determine if the specimen is a larva, nymph, or adult. Larvae are distinguished by three pairs of legs, in contrast to the four pairs seen in nymphs and adults. Nymphs lack the genital aperture, which occurs in the adult in the ventral median area between the second to fourth pairs of coxae. Nymphs of the family Ixodidae have a scutum of the female type, but the basis capituli lacks the porose areas seen only in adult females.

TAXONOMIC CHARACTERS

Familiarity with tick morphology and with the terminology used in taxonomic diagnosis is necessary for proper tick identification. Specialized terms used in characterizing ticks are defined in the following list; see also the labeled illustrations of key characters on Plates 1-4.

Accessory shields: Paired shields outside adanal shields in males of Rhipicephalus.

Adanal plates: Paired plates lateral to anal plate in males of Ixodes.

Adanal shields: Paired shields near the anus in males of Rhipicephalus.

Aeropyles: See Goblets.

Ambulacrum (pretarsus): The terminal segment of the leg, composed of a basal stalk, paired claws, and membranous pulvillus.

Anal groove: A groove of the cuticle partially circumscribing the anus.

Anal plate: a sclerite surrounding the anus of males of Ixodes.

Auriculae: Ventrolateral paired extensions of the basis capituli.

Basis capituli: The basal part of the capitulum which bears the hypostome, chelicerae, and palpi.

Camerostome: In Argasidae, the anteroventral cavity in which the capitulum lies.

Capitulum (gnathosoma): The anterior part of a tick including hypostome, chelicerae, palpi, and basis capituli.

Cervical grooves: Paired grooves in the scutum.

Cheeks: Paired flaps at the sides of the camerostome of some Argasidae.

Chelicerae: Paired mouthparts armed with laterally directed denticles.

Cornua: Dorsal, posterior projections of the posterolateral corners of the basis capituli of ixodids.

Corona: Distal portion of the hypostome, typically armed with minute denticles.

Coxa: Basal segment of leg.

Denticles: The "teeth" on the ventral side of the hypostome, usually arranged in parallel, longitudinal files.

Dentition: The pattern in which the denticles of the hypostome are arranged; e.g., 3/3 indicates 3 files of denticles on each side of the midline.

Dorsal humps: Elevations of the dorsal surface of segments of the legs of some argasids, but exclusive of the dorsal protuberance.

Dorsal plate: Sclerotized area of dorsum, usually centrally situated, on the larva of argasids (not to be confused with the scutum of ixodids).

Dorsal protuberances: Dorsal subapical elevations on the legs of some argasids.

Festoons: Uniform, cell-like divisions on the posterior edge of the body of certain ixodids.

Foveae: Small, paired, subcircular structures in the cuticula of the dorsal surface posterior to the scutum in the female and nymph and to the pseudoscutum in males of certain ixodids.

Frame: The sclerotized periphery of the spiracular plate.

Genital aperture: The sexual opening of adult ticks situated on the median line, ventrally between coxae 2-4.

Genital grooves: Paired, ventral, longitudinal grooves extending from the genital aperture posteriorly, in some cases to the margin of the body.

Goblets (Aeropyles): Larger cell-like pores of the spiracular plate. Smaller aeropyles are also often present near frame or in dorsal prolongations of spiracular plate.

Haller's organ: A sensory structure on the subapical dorsal surface of the tarsi of the anterior pair of legs.

Hypostome: The ventral, anteromedian projection of the basis capituli, typically with ventral longitudinal files of recurved denticles.

Idiosoma: All of the body exclusive of the capitulum.

Lateral carinae: Anterolateral longitudinal ridges of the scutum.

Lateral grooves: Dorsal grooves at sides of scutum of male ixodids.

Marginal grooves: Dorsal grooves at sides of body behind the scutum in female ixodids.

Median ventral plate: A sclerite, or plate, on the ventral surface of male Ixodes, situated between the genital and anal apertures.

Porose areas: Paired, depressed, finely pitted areas on the dorsal surface of the basis capituli of female ixodids.

Pseudoscutum: The anterior portion of the male scutum homologous with the scutum in the female.

Scapulae: The anterior angles, or shoulders, of the scutum of ixodids.

Scutum: The dorsal sclerotized plate covering all or most of the idiosoma of males, and the anterior portion in females, nymphs, and larvae of ixodids.

Sensilla sagittiformia: Four paired dermal sensory structures; one pair located ventrally behind each pair of coxae and one pair dorsally on the posterolateral idiosoma of some ixodid larvae.

Spiracles (spiracular plates): Paired sclerotic areas usually situated posterior or lateral to coxae IV and containing goblet cells (aeropyles).

Spur: Typically broad, subtriangular projections on the coxae and trochanters of the legs or on the palpi, often reduced to mild saliences.

Sutural line: A definite peripheral line of cleavage in Argas spp., dividing the dorsal and ventral surfaces.

KEY TO TICK FAMILIES (ALL STAGES) AND GENERA OF ADULTS OCCURRING IN CALIFORNIA[1]

1 Dorsal scutum absent; capitulum

[1] Genera of adults of ixodids, and nymphs and adults of argasids, are included in this key; for ixodid nymphs, see key under Family Ixodidae.

ventral in nymphs and adults, partially or completely concealed from above; sexual dimorphism of adults slight (Figs. 33-36). Larvae with segment 4 of palpi not greatly reduced, and with palpal segments all of essentially the same shape. . . . .Argasidae - 7

Dorsal scutum present; capitulum at anterior margin, not concealed from above; sexual dimorphism of adults well marked (Figs. 123-128). Larvae with segment 4 of palpi greatly reduced and not similar in shape to other segments . . . . . Ixodidae - 2

2(1) Anal groove distinct, surrounding the anus anteriorly (Fig. 8); festoons absent . . . . . Ixodes

Anal groove distinct or indistinct but never surrounding the anus anteriorly; festoons often present (Fig. 3). 3

3(2) Eyes absent; second palpal segment acutely produced laterally, extending beyond the basis capituli (Fig. 181). . Haemaphysalis

Eyes present; second palpal segment not acutely produced laterally (Fig. 1) 4

4(3) Capitulum long in relation to width; second palpal segment 3 X longer than wide (Fig. 103) . . . . . Amblyomma[1]

Capitulum short in relation to width; second palpal segment not appreciably longer than wide (Fig. 5) 5

5(4) Basis capituli rectangular dorsally (Fig. 5); usually ornate; male without adanal and accessory shields. . . . . .Dermacentor

Basis capituli hexagonal dorsally (Fig. 353); inornate; male with adanal and accessory shields (Fig. 352). 6

6(5) Palpi short, 1/3 longer than broad, and with acute transverse ridges dorsally and laterally (Fig. 110); festoons absent; coxae I shallowly cleft; spiracular plate oval . . . . . .Boophilus[2]

Palpi short, 3/4 longer than broad, without transverse ridges dorsally and laterally (Fig. 353); festoons present; coxae I deeply cleft; spiracular plate comma-shaped . . . . . Rhipicephalus[3]

7(1) Margin of body with a sutural line separating dorsal and ventral surfaces (Figs. 14, 38); unengorged nymphs and adults with body margin thin and acute . . . . . .Argas

Margin of body without a sutural line separating dorsal and ventral surfaces (Fig. 57); margin variably rounded. 8

8(7) Adults with integument granular (Fig. 95) and hypostome vestigial (Fig. 99); nymphs with integument spinose and hypostome well developed (Figs. 98, 100) . . . . . Otobius

Adults and nymphs with integument alike, mammillated or tuberculated, and lacking spines; hypostome well developed in both adult and nymph. . . . . Ornithodoros

FAMILY ARGASIDAE CANESTRINI

Dorsal scutum absent; little sexual dimorphism. Adults and nymphs with capitulum partially or completely invisible from above; integument leathery; spiracles usually situated anterior to coxae IV; palpi of all instars free. Of the over 150 described species from the world, 20 are known to be established in California. As larvae cannot be keyed with the same characters as adults and nymphs, a separate key is given here.

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[1] One species, A. americanum, is occasionally encountered on cattle shipped to California from states where the tick is established.

[2] A common New and Old World cattle parasite, B. annulatus, not currently established in California.

[3] Only one species reported from North America: R. sanguineus.

KEY TO LARVAE OF SPECIES OF ARGASIDAE IN CALIFORNIA[1]

1 Tarsus I with internal, elongate, trumpet-shaped sensillum extending posteriorly from capsule of Haller's organ. Parasites of birds. . .Argas (Argas) - 2

Tarsus I lacking internal trumpet-shaped sensillum extending posteriorly from capsule of Haller's organ. 3

2(1) Dorsal setae: 2 pairs bordering dorsal plate; typically 15 pairs laterally and 7 pairs on posterior quadrant .A. (A.) brevipes

Dorsal setae: 1 pair bordering dorsal plate; typically 22 pairs laterally; 9 pairs on posterior quadrant. .A. (A.) cooleyi

3(1) With 3-4 central setae anterior to the midlength of the dorsal plate. Parasites of birds. . . . . .Argas (Persicargas) - 4

With less than 3-4 central setae anterior to the midlength of the dorsal plate. 6

4(3) Engorged larvae large, about 4 X 2.5 mm. . . . . .A. (P.) giganteus

Engorged larvae small, not over 1 X 0.75 mm 5

5(4) Dorsal posterolateral setae only slightly longer than dorsal anterolateral setae. Tarsus I with 1 pair of lateral setae and 2 pairs of ventral setae. . . . . A. (P.) persicus

Dorsal posterolateral setae about 2 X length of dorsal anterolaterals. Tarsus I with 2 pairs of lateral setae and 3 pairs of ventral setae. . . . . A. (P.) sanchezi

6(3) Venter of body with 5 pairs of setae; dorsum of body with 7-10 pairs of setae. . . . . .Otobius - 7

Venter of body with 6-9 pairs of setae; dorsum of body with more than 10 pairs of setae (except in O. sparnus, which has 10 pairs). . . . . Ornithodoros - 8

7(6) 2 pairs of eyes; tarsus I with 4 paracapsular setae. . . . O. megnini

Eyes absent; tarsus I with 3 paracapsular setae . . O. lagophilus

8(6) Dorsum of body with 2 pairs of eyes; palpal segment IV about 2 X length of any other segment. In deer and cattle bedding areas. . . . . .O. (Ornamentum) coriaceus

Dorsum of body without eyes; palpal segment IV subequal or shorter than any other segment . . 9

9(8) Dorsum of body with 12-13 pairs of setae (11 dorsolateral, 2 central); dorsal plate may be absent, never pyriform, elongated, or pointed if present; hypostome bluntly rounded anteriorly, with denticles 2/2 only on distal portion (Fig. 58) . . . . . .O. (Pavlovskyella) - 10

Dorsum of body with 14-30 pairs of setae (10-25 dorsolateral, 3-4 central); dorsal plate present, elongated or pyriform; hypostome usually pointed anteriorly, with denticles 3/3 to 5/5 throughout the length . . . . . O. (Alectorobius) - 12

Without either of the above combinations of characters (from woodrats and nests). . . . . O. sparnus

10(9) Dorsal plate present (Fig. 59); hypostome short, 0.062-0.076 mm (on rodents and their nests) . . . . . O. (P.) hermsi

Dorsal plate absent; hypostome long, over 0.086 mm (on many hosts). 11

11(10) Hypostome 0.086-0.101 mm long (on rodents and their nests). . . . . .O. (P.) parkeri

Hypostome 0.138-0.150 mm long (on many hosts, including desert tortoises, burrow-inhabiting birds, and rodents). . . . . O. (P.) turicata

12(9) Capsule of Haller's organ with reticulations (from bats and bat retreats) 13

Capsule of Haller's organ without reticulations 15

[1] Modified from Jones and Clifford, 1972.

13(12)Venter of body with 8 pairs of setae plus a posteromedian seta. . . . . .0. (A.) yumatensis

Venter of body with 9 pairs of setae plus a posteromedian seta. 14

14(13)Hypostome arises from a relatively short, subtriangular median extension of the basis capituli . . . . . .0. (A.) dyeri

Hypostome arises from a very long, subtriangular median extension of the basis capituli . . . . . .0. (A.) rossi

15(12)Hypostome dentition 5/5 distally (from marine birds) . . . . . .0. (A.) capensis[1]

Hypostome dentition fewer than 5/5 distally. 16

16(15)Hypostome dentition 4/4 distally (from bats and bat retreats). . . . . .0. (A.) stageri

Hypostome dentition 3/3 distally. . 17

17(16)Posteromedian seta absent (from marine birds) . . .0. (A.) denmarki[1]

Posteromedian seta present (not from marine birds). 18

18(17)Junction of subtriangular median extension of basis capituli with hypostome abrupt, dorsal plate over 0.3 mm long (from bats and bat retreats). . . . . .0. (A.) kelleyi

Junction of subtriangular median extension of basis capituli with hypostome not abrupt, dorsal plate usually less than 0.3 mm long 19

19(18)Subtriangular median extension of basis capituli absent or merely suggested (from rodents) . . . . . 0. (A.) talaje

Subtriangular median extension of basis capituli present, but may be substantially reduced (on bats and birds) . . . . . .0. (A.) concanensis

[1] A species close to both capensis and denmarki occurs on marine birds on the Farallon Islands of California.

Genus Argas Latreille

Argas Latreille, 1796, Precis des caractères génériques des insectes disposés dans un ordre naturel 5:18; Nuttall et al., 1908, Ticks: monograph of the Ixodoidea, part I. Argasidae: 4-5 (synonymy).

Type of genus: Argas reflexus (Fabricius, 1794).

Adults and nymphs of all California Argas species with body flattened dorsoventrally and peripheral margin distinctly flattened; sutural line present, separating dorsal and ventral surfaces. Capitulum anteroventral, invisible from above. Integument leathery, minutely wrinkled. Discs present on dorsal and ventral surfaces. Eyes absent.

Of the 56 described species of Argas in the world (Hoogstraal et al, 1979), 8 are known from the United States, including 5 from California.

KEY TO ARGAS ADULTS AND LATE-STAGE NYMPHS IN CALIFORNIA[2]

1 Dorsal marginal integument composed of striae with scattered setae arising from pits or from linear interstices between ridges (Fig. 24). Postpalpal setae absent (Fig. 23). . . . . subgenus Argas - 2

Dorsal marginal integument composed of "cells" (Fig. 38). Postpalpal setae present (Fig. 37) . . . . subgenus Persicargas - 3

2(1) Legs short; tarsus I less than 3 X longer than broad; tarsus IV less than 4 X longer than broad. Hypostome with teeth bluntly pointed and short, 2/2 anteriorly and 3/3-4/4 posteriorly (Fig. 23). Recorded from owls, woodpeckers, and kestrel . . . . . brevipes

Legs moderately long; tarsus I more than 3 X longer than

[2] Argas (P.) giganteus is known only from the larvae.

broad; tarsus IV more than 4 X longer than broad. Hypostome with definite corona of 2-3 rows of small hooklets, and shaft with 3-4 rows of narrow pointed denticles and 5-7 rows of small hooklets, 2/2 anteriorly and 3/3-5/5 posteriorly (Fig. 28). From Cliff Swallows, California Condor, California Gull. . . . . .cooleyi

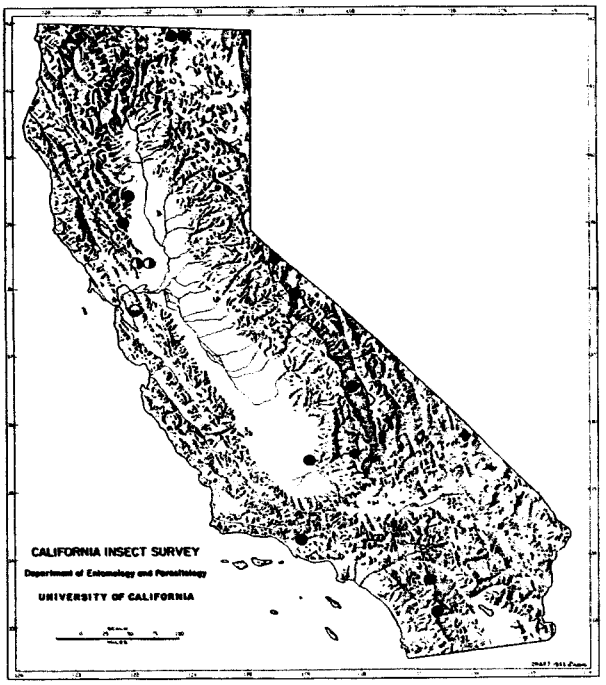
3(1) About 90 dorsal marginal cells, mostly rectangular to subrectangular, each with single large setiferous pit occupying much of surface area (Fig. 32). Mammillae of dorsal integument elevated above ridges (Fig. 32). Female palpi sparsely setose dorsally. Poultry parasite; common in Old World; in the United States rare west of the Mississippi River. . persicus

Over 150 dorsal marginal cells, comparatively small, irregular, with 1-2 setiferous pits in about $\frac{3}{5}$ of the cells occupying no more than half of surface area (Fig. 38). Mammillae and ridges of dorsal integument of equal elevation. Female palpi densely setose dorsally. Common poultry parasite in California, also on wild birds such as quail, Mourning Dove . . sanchezi

Argas (Argas) brevipes Banks
(Figs. 21-24; Map 1)

Argas (A.) brevipes Banks, 1908, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15: 15-16; Kohls, Hoogstraal, and Clifford, 1961, Ann. Entomol. Soc. Amer. 54: 869-877 (all instars).

DIAGNOSIS. Adult. Pattern of discs and ridges of dorsal integument as in Argas cooleyi. Closely resembles A. cooleyi, but smaller: females 3.7-5.6 mm long by 2.5-3.6 mm wide, compared to females of A. cooleyi, 4.3-8.2 mm long by 3.1-5.7 mm wide. Hypostome (Fig. 23) with only a slight suggestion of coronal hooklets, 3-4 rows of bluntly pointed denticles in 2/2 arrangement, and several more proximal bluntly rounded denticles. All legs short. Tarsus I about 2.8 X longer than broad; tarsus IV about 3.5 X longer than broad.



MAP 1. Distribution in California of: Argas brevipes Banks, half-circles; A. cooleyi Kohls and Hoogstraal, solid circles; A. giganteus Kohls and Clifford, rectangles.

Nymph. Similar to adult; large nymphs may equal females in size and have depression in place of genital aperture.

Larva. Two pairs of setae around dorsal plate; 15 pairs laterally; 7 pairs on posterior quadrant. Tarsus I with internal, elongate, trumpet-shaped sensillum extending posteriorly from capsule of Haller's organ.

The short-legged North American bird argasid A. brevipes is known from Arizona, California, Baja California, and Sonora, Mexico, where it lives in close association with birds that build nests in hollow trees or in holes made in trees or Saguaro cactus. Recorded hosts include Screech and Pygmy Owls, Mearns' Gilded Flicker, Sparrow Hawk, Violet-Green Swallow, and the Cactus Wren.

The life cycle from egg to ovipositing female takes 42-82 days (avg. 56), and adults may live for one year at room temperatures without feeding (Clifford and Kohls, 1963).

CALIFORNIA RECORDS. The few California collections of this tick have been from the central part of the state. ALAMEDA CO.: Berkeley (Skyline Blvd. and Redwood Rd.),

many larvae from Sparrow Hawk, Falco sparverius, III-30-1960 (P. Covel). NAPA CO.: Monticello Dam, 6 nymphs from owl, VI-4-1970 (E.E. Grissell). YOLO CO.: Winters, 2 collections on XI-30-1965, 1 from the California Woodpecker, Melanerpes formicivora, and 1 from the Plain Titmouse, Parus inornatus.

Argas (Argas) cooleyi Kohls and Hoogstraal (Figs. 25-28, Map 1)

Argas (A.) cooleyi Kohls and Hoogstraal, 1960, Ann. Entomol. Soc. Amer. 53:625-631, Figs. 1-15 (all instars).

DIAGNOSIS. Adult. Body bluntly rounded anteriorly and posteriorly (Fig. 25). Lateral marginal integument (Fig. 28) similar to that of A. brevipes, with distinct suture encircling entire body and striated margin bearing scattered setae. Dorsal integument with mammillae irregularly patterned; ridges smooth, forming a convergent pattern among discs anteriorly; discs large and arranged in radiating rows. Hood absent. Basis capituli (Fig. 26) broadly rectangular centrally, 2.5 X wider than long. Hypostome (Fig. 26) short and stout, about 2 X as long as wide, apex bluntly rounded, with corona of 2-3 rows of small hooklets; sharp-pointed denticles, 2/2 apically, smaller and from 3/3 to 5/5 basally. Genital aperture a transverse slit at level of bases of coxae I. Anus elliptical at level of apex of trochanter IV. Legs moderately long and stout, with tarsi II-IV each with a slightly elevated subapical protuberance. Tarsus I (Fig. 27) about 3.3 X longer than wide; tarsus IV about 4 X longer than wide.

Nymph. Similar to adult, except that basis capituli is more elongate and hypostome is slightly narrower and more elongate.

Larva. One pair setae around dorsal plate; 22 pairs laterally; 9 pairs on posterior quadrant. Tarsus I with internal, elongate, trumpet-shaped sensillum extending posteriorly from Haller's organ, as in A. brevipes.

A. cooleyi, the Western North American bird argasid, is recorded from California, Colorado, Montana, Nevada, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming, where its chief host is the Cliff Swallow (Petrochelidon pyrrhonota). Single collections have been made from the Barred Owl (Strix varia helveola) in Texas and from near or in the nests of a California Condor, Barn Owl, gull, mud dauber, and sparrow in California. Most collections have been made from swallow nests from May through October, although records include March and December. According to Kohls and Hoogstraal (1960), A. cooleyi should be found in permanently established colonies of Cliff Swallows primarily located on cliff sides as well as from man-made structures over water sources. Since Cliff Swallows breed during spring and early summer the nests remain vacant thereafter, and ticks may retreat into earth, rock, wood, or concrete crevices, thereby making them difficult to find.

Johnson and Casals (1972) isolated the Mono Lake virus (Kemerovo group) from a pool of adult A. cooleyi collected from nests of Larus californicus on an island in Mono Lake, California.

CALIFORNIA RECORDS. COLUSA CO.: 18 mi. W Williams, 1 ♀ from Cliff Swallow nest under bridge over irrigation ditch, VI-5-1956; 17 mi. W Williams, 12 nymphs, 1 ♀ from Cliff Swallow nest on Cache Creek bridge on Hwy 20, VI-10-1958 (both H.N. Johnson); Salt Canyon, males and females from mud dauber nest (Sphecidae), XI-7-1963. GLENN CO.: 4 mi. W Willows, 1 female, XII-5-1965. INYO CO.: 10 mi. S Independence, 1 nymph from nesting hole of Otus asio, XI-20-1940 (K.E. Stager). KERN CO.: Coffee Canyon, 1 nymph from Passer domesticus nest, V-30-1946 (D.P. Furman, H.E. McClure). MODOC CO.: Newell, from swallow nests, larvae on V-17-1959 and adults and larvae on V-26-1961. MONO CO.: Mono Lake, 10 adults from nest of Larus californicus, V-18-1966 (H.N. Johnson). RIVERSIDE CO.: San Jacinto (Soboba Indian Reservation), adults and larvae from Tyto alba nest site, X-15-1961. SAN DIEGO CO.: Warner Hot Springs, 35 males, 31 females, 27 nymphs, VIII-?-1954. (F.N. Gallup). SISKIYOU CO.: Tule Lake Wildlife Refuge, 2 nymphs from Petrochelidon pyrrhonota nest, IV-?-1963 (E. Hansen). VENTURA CO.: Santa Paula Canyon, 7 males, 9 females, 13 nymphs near nest of condor (Gymnogyps californianus) in cave, IX-18-1939 and V-24-1940 (T.F. Kelley), and 58 adults near condor nest, III-25-1946 (C. Koford).

Argas (Persicargas) giganteus Kohls and Clifford (Map 1)

Argas (P.) giganteus Kohls and Clifford, 1968, Ann. Entomol. Soc. Amer. 61:1113-1116 (larva).

DIAGNOSIS. Adult and Nymph unknown.

Larva. Engorged larvae very large, up to 4 mm long by 2.57 mm wide. Dorsal plate rounded. Dorsum with 14 dorsolateral setae and 9-10 central pairs. Venter with 7 pairs setae. Distance between 2nd pair of posthypostomal setae about 2 X that between first pair. Hypostome blunt; dentition 4/4 and 3/3 in distal third; 2/2 proximally.

Engorged larvae of A. giganteus are about twice as large as those of other Persicargas species.

This tick was described from larvae collected from several species of wild birds in Arizona, Utah, New Mexico, California, and Sonora, Mexico.

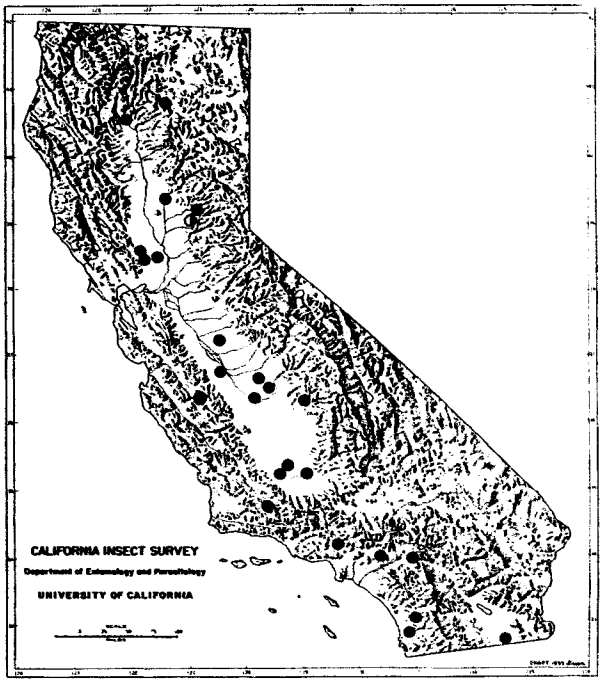
CALIFORNIA RECORDS. KERN CO.: 2.5 mi. E Onyx, 75 larvae from the Brown Towhee, Pipilo fuscus, XII-19-1948. MONO CO.: White Mountains, 13,100' elev., 2 larvae from the Rock Wren, Salpinctes obsoletus, VI-30-1974.

Argas (Persicargus) persicus (Oken) (Figs. 29-32; Map 2)

Rhynchoprion persicum Oken, 1818, Isis: 1567-1570 pl. 19, figs. 1-4.

Argas persicus, Fischer de Waldheim, 1823, Mem. Soc. Imp. Nat. Moscou 6:269-283, pl. 23, figs. 1-11; Cooley and Kohls, 1944, Amer. Midland Naturalist, monogr. 1:17-20 (synonymy, redescription, figs.); Kohls et al., 1970, Ann. Entomol. Soc. Amer. 63:591-595 (all instars).

DIAGNOSIS. Adult. Body usually oval, narrowly rounded anteriorly and broadly rounded posteriorly (Figs. 29 and 30). Mammillae posterior of midlength regular and elevated; anterior of midlength fewer, smaller, and less elevated. Ridges posteriorly narrow, short, irregular but numerous; centrally becoming longer and more conspicuous; anteriorly more numerous, straight or curving and in irregular rows. Discs large and conspicuous in radiating rows, with those anterior slightly smaller than those posterior. Dorsal peripheral row of about 90 large rectangular or subrectangular cells bordering body; each cell with large, setiferous pit (Fig. 32). Hood absent. Basis capituli (Fig. 31) broadly rectangular; 1 pair postpalpal setae present; 8 (rarely 10) pairs posterolateral setae. Hypostome (Fig. 31) with broad base; lateral margins parallel and apex bluntly rounded; sharply pointed denticles 2/2 in files of 3-4 on anterior half. Genital aperture located as transverse slit between coxae I. Anus elliptical, situated medially and posterior to coxae IV. Legs long and narrow; tarsi moderately stout, with no dorsal subapical humps.



MAP 2. Distribution in California of: Argas persicus (Oken), half-circles; A. sanchezi Dugès, solid circles.

Nymph. Similar in late instar to adults, but with fewer setae and lacking genital aperture.

Larva. Body length unengorged less than 1 mm. Dorsal plate rounded, subquadrangular, slightly longer than broad. Dorsum with 26-29 pairs setae; 1 or 2 pairs bordering dorsal plate; dorsal posterolateral setae short, subequal to, or slightly longer than, anterolaterals. Capitulum with 2 pairs posthypostomal setae; 2nd pair about 2 X as widely spaced as first pair. Tarsus I with 1 pair lateral setae and 2 pairs ventrals.

A. persicus, the Persian poultry Argas, is more common in the eastern United States, with collections listed from Georgia, Maryland, and Pennsylvania. Only one collection is known for California - NEVADA CO.: Grass Valley, 1 male, 2 females, 12 nymphs from chicken house, VI-21-1951 (E.C. Loomis). Repeated attempts in 1966 and 1977 to collect this species from the Grass Valley area were negative, although specimens of A. sanchezi were taken from one of the few remaining backyard chicken coops found in this area. All A. persicus collections in the eastern states are from chickens or chicken houses, from June through August. Routine inspections of such habitats would undoubtedly show the presence of this species in other months.

Argas (Persicargas) sanchezi Dugès (Figs. 33-38; Map 2)

Argas sanchezi Dugès, 1887, La Naturaleza (Mexico), ser. 2, 1:18-21, pl. 3, fig. 2; Kohls et al., 1970, Ann. Entomol. Soc. Amer. 63:598-602, figs. 32-48 (all instars).

DIAGNOSIS. Adult. Body as in A. persicus, with similar pattern and formation of mammillae, ridges, and discs (Figs. 33-36). Peripheral cells in a row of about 150 or more, small, irregular outlines and each with 1-2 small setiferous pits occupying no more than half of surface area (Fig. 38). Basis capituli, hypostome (Fig. 37), genital aperture, anus, tarsi, and short, stout legs as in A. persicus.

Nymph. Similar to adult.

Larva. Similar to A. persicus, but tarsus I with 2 pairs lateral setae and 3 pairs ventral setae. Differs from all other American species of the subgenus Persicargas in having posterolateral body setae about 2 X as long as the anterolaterals.

Prior to the extensive study by Kohls et al. (1970) of representative specimens of the subgenus Persicargas from many countries, identification of species in this subgenus was most difficult. These workers redescribed A. (P.) radiatus Railliet, sanchezi, and A. (P.) miniatus Koch and considered these to be valid species and not synonyms of the Old World fowl tick, A. (P.) persicus (Oken), as formerly believed.

A. sanchezi is the common poultry tick in California, often called the "blue bug" by farmers. It is also known in Arizona, Nevada, New Mexico, Texas, and Utah, and in Mexico it has been recorded in Baja California, Durango, and Guanajuato. Hosts are chiefly chickens (chicken houses and roosts) and turkeys (turkey houses), but a variety of wild birds have been found infested. It has been incriminated in the natural transmission of avian spirochetosis (Borrelia anserina) in California (da Massa and Adler, 1979).

In California A. sanchezi has been collected during every month, but mostly from May through September, the months of rapid tick multiplication. The poultry tick is usually a problem only to small farm flocks of poultry where harborage for the ticks is provided by loosely constructed wooden roosts and housing or under the bark of trees used as roosts (see Table 1). Eggs are laid in cracks or crevices, and in warm weather hatch in about 2 weeks. Larvae attach to poultry and suck blood for about 7 days, then drop off at night and hide in available crevices. The 2 nymphal instars and the adults attach and feed only a few minutes at a time, usually at night, and spend the rest of the time in hiding near the roosts or nests of their hosts. There may be 2-3 generations a year under favorable conditions, but developmental time is retarded by cold weather and lack of hosts. Infestations may survive in empty poultry housing for up to 2 years.

The majority of collection records are in drier areas of the state, particularly around the central valley from Shasta County on the north to Kern County on the south, although A. sanchezi occurs also in the dry coastal and inland areas of southern California.

Genus Ornithodoros Koch

Ornithodoros Koch, 1844, Arch. Naturgesch. (Berlin) 10:219; Nuttall et al., 1908, Ticks: a monograph of the Ixodoidea 1:39-41 (redescribed; synonymy).

Type of genus: Ornithodoros savignyi (Audouin, 1826).

Adult and nymph similar, with peripheral margins thick, not clearly defined (except in O. dyeri), and similar to rest of integument; sutural line separating dorsal and ventral surfaces absent; body of unfed specimens flattened, engorged forms usually very convex. Capitulum ventral and sub-

TABLE 1. California Records of Argas sanchezi Dugès

Host or Source	Tick Collections		
	Adults	Nymphs	Larvae
Chicken	10	5	2
Chicken house	14	8	4
Turkey house	1	1	-
Aphelocoma californica	-	-	2
Passer domesticus, nest	1	1	-
Homo sapiens	1	1	-
Bark of tree	1	-	-
Unrecorded	7	3	5
Shed	1	-	-

terminal, with anterior parts often visible dorsally. Integument with discs and mammillae. Eyes present or absent.

KEY TO ORNITHODOROS ADULTS AND LATE-STAGE NYMPHS IN CALIFORNIA[1]

1 2 pairs of eyes along anterolateral margins (Fig. 44) .coriaceus

Without eyes along anterolateral margins 2

2(1) Cheeks present (Fig. 42) (except in nymphs and males of O. stageri); dorsal humps on legs absent (Fig. 87). 3

Cheeks absent (Fig. 67); dorsal humps on legs present or absent . 10

3(2) From bats and bat retreats. 4

From birds or non-chiropteran mammals, from their nests, burrows, or ground surface) 8

4(3) 2 pairs of dorsal parallel longitudinal submarginal ridges (Fig. 47); body narrowly elongate (Fig. 47) (about 2.3X longer than wide) . . . . . .dyeri

Without 2 pairs of dorsal longitudinal ridges; body not narrowly elongate (not more than 2X longer than wide). 5

5(4) Legs unusually long (Fig. 86); tarsus I of female over 1 mm long, of male over 0.8 mm long . . . . . .yumatensis

Legs not unusually long; tarsus I of nymphs and adults less than 0.7 mm long. 6

6(5) Body slightly wider posteriorly than anteriorly; tarsus I without subapical dorsal protuberance (Fig. 77) . . . . .stageri

Body width subequal posteriorly and anteriorly; tarsus I with small subapical dorsal protuberance (Fig. 40) 7

7(6) Hypostome appreciably wider distal to midlength (Fig. 41); palpi hypertrichous, with accessory ventral setae on segments 1-3. . . . . .concanensis

Hypostome with sides subparallel and not appreciably wider distal to mid-length; palpi not hypertrichous and without accessory ventral setae on segments 1-3. . . . . .kelleyi

8(3) From marine birds and their nests . . . . . O. sp. near denmarki

Associated with rodents and terrestrial birds. 9

9(8) Hypostome appreciably wider distal to midlength (Fig. 41). . . . . .concanensis

[1] Modified from Cooley and Kohls, 1944b.

Hypostome not appreciably wider distal to midlength . . . . . talaje

10(2) Dorsal humps on tarsi I present (Fig. 68) 11

Dorsal humps on tarsi I absent. . . 12

11(10) Mammillae large, relatively few, and not crowded (Fig. 82) . turicata

Mammillae small, numerous, and crowded (Fig. 69) . . . . . .parkeri

12(10) Corona of hypostome with 6-8 fine denticles; dorsoventral groove absent; a smaller tick, with females typically less than 4 mm long. From Neotoma and Peromyscus. . . . . .sparnus

Corona of hypostome with numerous fine denticles (Fig. 53); dorsoventral groove present but faint (Fig. 52); females about 5 mm long. From Eutamias . . hermsi

Ornithodoros (Alectorobius) concanensis Cooley and Kohls
(Figs. 39-42; Map 4)

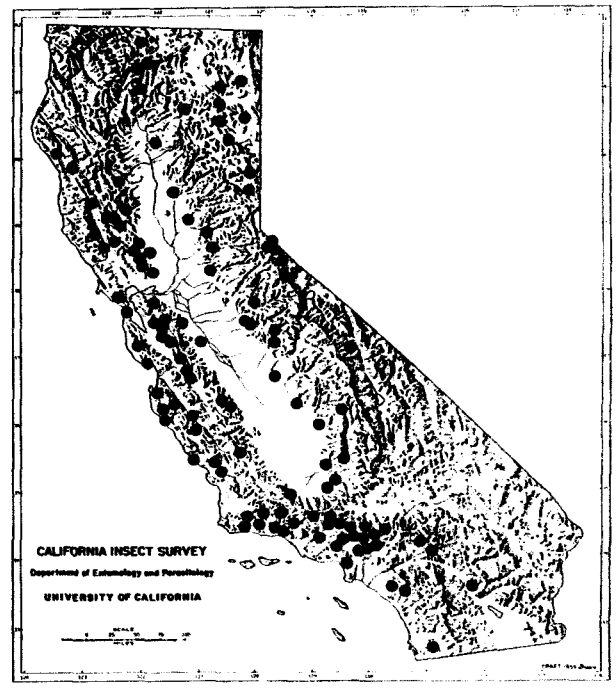
Ornithodoros concanensis Cooley and Kohls, 1941, U.S. Pub. Health Serv. Rept. 56:910, figs. 1 and 2 (adult, nymph); Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58:340, figs. 16-18 (larva).

Ornithodoros aquilae Cooley, 1944b, J. Parasitol. 30:287.

DIAGNOSIS. Adult. Body (Fig. 39) suboval; sides nearly parallel; anterior margin bluntly pointed and posterior rounded. Mammillae large, close but not crowded; usually with 1-2 circular or crescentic pits on top; some pits with minute seta. Discs depressed on dorsum with elevated edges, on venter lineally arranged in preanal and median postanal grooves. Hood short, elevated apically. Cheeks (Fig. 42) oval; anterior ends wider and free. Hypostome appreciably wider beyond middle, moderately large, notched apically, and with denticles 2/2, with about 4 per file but limited to distal third. Palpi hypertrichous (Fig. 41) with accessory ventral setae on segments 1-3. Eyes absent. Tarsus of leg I (Fig. 40) with mild subapical protuberance; dorsal humps absent on all tarsi.

Nymph. Similar to adult.

Larva. Dorsal plate large, pyriform. 12-14 pairs dorsolateral setae; 4-5 dorsal



MAP 3. Distribution in California of Ornithodoros coriaceus Koch, solid circles.

central pairs. Venter with posteromedian seta (= postanal) plus 8 pairs setae; 2 pairs posthypostomal setae. Hypostome arising from small subtriangular extension of basis capituli and tapering to point; dentition 3/3 in distal half and 2/2 to base.

O. concanensis closely resembles O. kelleyi Cooley and Kohls and O. talaje (Guérin-Méneville), from which it is separable as indicated in the keys. It is known from bat retreats in Arizona and Texas, but Kohls, Sonenshine, and Clifford (1965) recorded it from a variety of avian hosts from Colorado, Wyoming, and Montana.

CALIFORNIA RECORDS. MODOC COUNTY: Newell: 3 males and 6 nymphs from swallow nest, V-17-1959; 1 female, V-26-1961 (both J. Schuh). SAN LUIS OBISPO COUNTY: Cholame, 26 larvae from Tyto alba pratincola, IV-14-1946 (M.S. Ray).

Ornithodoros (Ornamentum) coriaceus Koch
Pajahuello Tick
(Figs. 43-46; Map 3)

Ornithodorus coriaceus Koch, 1844, Arch.

Naturgesch. 10:217-219; Koch, 1847, Nürnberg 4, 136 pp. (redescription with figures); Cooley and Kohls, 1944, Amer. Midland Naturalist, monogr. 1:42-45.

Argas coriaceus; Berlese, 1888, Boll. della Soc. Entomol. Italiana 20:193.

DIAGNOSIS. Adult. Body pointed anteriorly, with sides nearly parallel (Fig. 43). Mammillae numerous, irregular in shape and variable in size. Discs large, depressed, and less definite or absent on ventral surface. Hood separated from anterior dorsal projection of body wall. Cheeks absent (Fig. 45). Basis capituli broader than long, surface irregular with coarse transverse wrinkles. Hypostome with sides nearly parallel, denticles 2/2 with 4 large equal-sized ones in each file. Anterior pair eyes (Fig. 44) larger than posterior pair. Anus elliptical. Legs moderate in size, with femur, tibia, and metatarsus flared distally (Fig. 43). Subapical dorsal protuberances evident on all tarsi, with dorsal humps on tarsi I (Fig. 46) to III and one at base of tarsus IV.

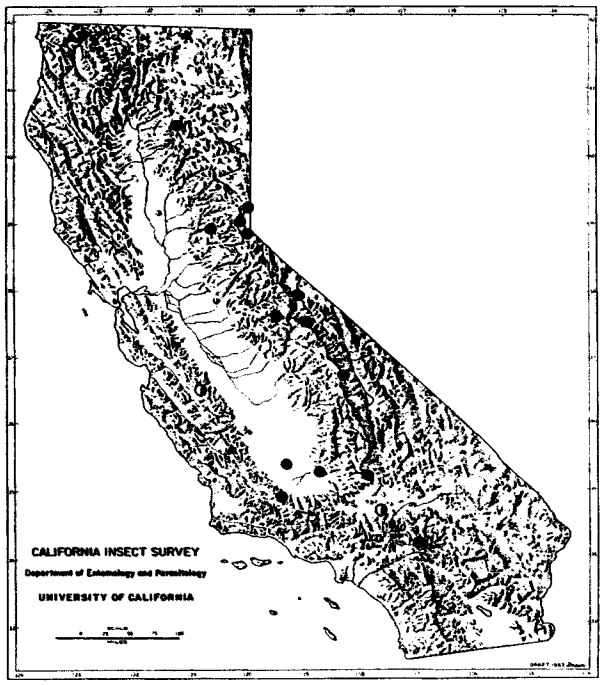
Nymph. Similar to adult.

Larva. Detailed description given by Kohls, Sonenshine, and Clifford (1965). O. coriaceus larva differs from all other argasid larvae in California except that of Otobius megnini (Dugès) in possessing 2 pairs of eyes on dorsum, and differs from megnini in having segment 4 of palpi about 2X as long as any other segment and venter of body with 7 pairs of setae plus a postanal median seta (PMS).

O. coriaceus is the only species of the genus in the Western Hemisphere with two pairs of eyes located as in O. savignyi (Audouin), the type of the genus in Africa. O. coriaceus was originally collected in Sonora, Mexico, and is distributed in the other western states of Mexico southward to the Isthmus of Tehuantepec, where the natives call this tick "talajas" (tala = destruction, havoc). Berlese (1888) states that he saw a specimen taken from cattle hides at Rio Apa, Paraguay. From 1904 through 1941 numerous collections of this species were made in the coastal regions of California (Cooley and Kohls, 1944b), and intensive surveys in subsequent years have shown that this tick is widespread in California and occurs in Nevada and southern Oregon (Loomis and Furman, 1977).

Originally called "pajaronela" by the inhabitants of the Santa Lucia mountain range in coastal California, the tick was designated "pajahuello" by Banks (1904) and subsequently "pajaroello" by Herms (1916) and "pajahuello" by Herms and Wheeler (1935). We cannot find any interpretative meaning for the spelling of either "pajaronela" or "pajaroello," and prefer to use the term "pajahuello" (paja = straw-colored, huello = treading, as on lower parts of animals' hoof), as originally used by Banks (1904) and subsequently by Herms and Wheeler (1935).

O. coriaceus is commonly found in the bedding grounds of deer and cattle underneath foothill chaparral, scrub oak, cottonwood, manzanita, or mahogany brush areas at 185-1850 m elevations along the coast from San Diego County north to Humboldt County. This tick can also be found at elevations up to 2450 m under juniper, yellow and piñon pine, and bitterbrush on the western slope of the Sierra Nevada and in valley areas northeast of the Cascade Range and east of the Sierra Nevada (Map 3). It is recorded from 50 of the 58 California counties. Ticks may be collected the year round in



MAP 4. Distribution in California of: Ornithodoros concanensis Cooley and Kohls, triangles; O. hermsi Wheeler, Herms, and Meyer, solid circles; O. sparnus Kohls and Clifford, half-circles.

CO_2-pan traps (Hokama and Howarth, 1977) placed in the soil or tree-litter of animal bedding grounds below snow level; at higher elevations, ticks are more commonly trapped from late spring to fall. The life cycle from egg to adult normally takes more than one year, with larvae feeding on hosts for 9 days and nymphs passing through 7 instars, each requiring a blood meal that lasts from 8 to 100 minutes; adults feed in 5-50 minutes (Loomis, 1961).

Fence lizards, Sceloporus occidentalis, are reported to eat adult O. coriaceus (Garcia, 1963), and unidentified "red ants" have been reported to carry off small nymphs. Ault and Elliott (1979) observed the jumping spider, Phidippus rimator, attacking nymphs of O. coriaceus.

Cattle and deer are common hosts for this tick, but blood meals may be taken from almost any warm-blooded animal, including domestic poultry. Man is an accidental host, and most tick bites on humans are associated with outdoor, rural, and forest activities. California collection records are given in Table 2.

The pajahuello is best known because of the severe reaction in humans following exposure to its bite. Initial bites usually result in a localized inflammatory reaction accompanied by a burning sensation and a small nodule that forms around the wound. These symptoms usually disappear within 48 hours, leaving a small, purplish nodule that disappears in 1-2 weeks. In other cases, an umbilicated pustule surrounded by an inflamed, painful, edematous area develops. More severe allergic reactions appear in persons previously bitten and thus sensitized to a substance injected during the tick's blood-feeding process.

O. coriaceus is not known to transmit any disease of man, but on the basis of circumstantial evidence it is capable of transmitting the agent of a cattle disease called epizootic bovine abortion ("foothill abortion") (Schmidtmann et al., 1976), and has been shown experimentally to transmit African Swine Fever virus to healthy pigs (Groocock et al., 1980).

Ornithodoros (Alectorobius) dyeri Cooley and Kohls (Figs. 47-50)

Ornithodoros dyeri Cooley and Kohls, 1940, U.S. Pub. Health Serv. Rept. 55:925-928 (nymph); Cooley and Kohls, 1944b, Amer. Midland Naturalist, monogr. 1:95-98 (adults); Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58:342-343 (larva).

TABLE 2. California Records of Ornithodoros coriaceus Koch

Host or Source	Tick Collections		
	Adults and/or Nymphs	Larvae	Unrecorded Instars
Falco mexicanus	-	1	-
Nest of Petrochelidon albifrons	1	-	-
Homo sapiens	29	1	16
Equus caballus	2	-	-
Odocoileus hemionus columbianus	2	-	14
"Deer"	2	4	-
Bos taurus	1	1	2
Deer bed	19	1	1
Cattle bedding area	9	-	-
Soil and litter	59	-	5
Vegetation	3	-	-
Not recorded	30	1	2

DIAGNOSIS. Adult and Nymph. Body yellow-brown, elongated, sides parallel, anterior end pointed, posterior end rounded, flattened on top with distinct, parallel, marginal ridges (Fig. 47). Mammillae indefinite or absent, although small, irregular elevations present on body surface. Hood absent but with median ridge present from mouth parts to the anterior region. Cheeks (Fig. 49) present, broader anteriorly. Basis capituli broader than long, with micromammillae and transverse wrinkles. Hypostome (Fig. 50) short and broad, denticles 5/5, blunt and U-shaped; anterior posthypostomal setae long, faintly barbed, reaching to tip of hypostome, and posterior second pair shorter in length. Coxal and supracoxal folds present, plus a fold or ridge above the supracoxal fold opposite legs III and IV (Fig. 48). Spiracle located posterior to coxa IV. Genital opening of female located in a V-shaped depression (also present in nymphs but absent in males). Eyes absent. Anus small, ovoid, distant from transverse postanal groove. Legs small, micromammillated; tarsi without subapical dorsal protuberances or dorsal humps.

Larva. Differentiated from those of most other bat-infesting Ornithodoros species by reticulations on the capsule of Haller's organ. Distinguished from larvae of O. yumatensis by 9 pairs of ventral setae and smaller dorsal plate, compared to 8 pairs with large dorsal plate on O. yumatensis. The hypostome of O. dyeri arises from subtriangular median extension and tapers to a point; large denticles 3/3 on distal three-fourths and 2/2 posteriorly to base. The hypostome of O. rossi arises from a very long extension of the basis capituli, with distance from base of palpi to basal denticle of hypostome subequal to length of hypostome, as opposed to about half length of hypostome in O. dyeri.

O. dyeri is known from bats and their retreats in Arizona, California, Mexico, and El Salvador.

CALIFORNIA RECORDS. IMPERIAL CO.: 15 mi. NE Yuma, 4 nymphs, and 1 adult from rock crevices in mine tunnel, V-20-1940. RIVERSIDE CO.: Alice Mine (Riverside Mts.) 1 female from spider web in mine shaft, V-16-1954 (W. MacDonald). SAN BERNARDINO CO.: 16 mi. N Needles, several nymphal cast skins from rock crevices in bat caves, VI-14-1940.

Ornithodoros (Pavlovskyella) hermsi Wheeler, Herms, and Meyer (Figs. 51-60; Map 4)

Ornithodoros hermsi Wheeler, Herms, and Meyer, 1935, Proc. Soc. Expmtl. Biol. and Med. 32:1290-1292 (larva, nymph, adult); Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58:352-353 (larva).

Ornithodoros hermsi; Wheeler, 1935, Amer. J. Trop. Med. 15:435-438 (male, female).

DIAGNOSIS. Adult and nymph. Body oval, wider behind, pointed anteriorly (Fig. 51); mammillae numerous, moderate in size, elongated, not conical, with sinuous radiating ridges on sides (Fig. 57); equal in size throughout dorsal surface but smaller in median areas than along sides of ventral surface. Discs present but shallow (Fig. 51). Hood well developed. Cheeks absent. Basis capituli as long as wide, surface irregular with interrupted transverse wrinkles. Hypostome (Fig. 53) apically notched, corona with numerous fine denticles, denticles 2/2 limited to distal third with 5 files of about equal size. Eyes absent. Anus in a long oval pattern. Dorsoventral groove faint (Fig. 52). Preanal and transverse postanal grooves distinct. Legs smooth, not micromammillated, with few hairs and all tarsi without dorsal humps but with mild subapical dorsal protuberances (Fig. 55).

Larva. Dorsum (Fig. 59) with dorsal plate, 11 pairs dorsolateral setae and 2 pairs central setae. Venter with 7 pairs setae but lacking posteromedian (postanal) seta (Fig. 60). Palpi with 5 setae on segment 3. Hypostome (Fig. 58) not arising from median extension of basis capituli, short, truncate or notched apically; dentition only on apical half, 2/2. First pair posthypostomal setae about 2X length of 2nd pair.

The absence of cheeks and dorsal humps on all tarsi distinguish adults and nymphs of this species from all other Ornithodoros species with the exception of O. sparnus, which is usually smaller than O. hermsi and lacks the dorsoventral groove; the corona of its hypostome has 6-8 fine denticles, and larva has smaller dorsal plate than that of O. hermsi. Larvae of O. hermsi are much simpler to distinguish from O. sparnus than are nymphs or adults.

O. hermsi is commonly associated with chipmunk nests, Eutamias spp., in snags and

decayed stumps of trees and in cabins at elevations above 1500 m in California; it occurs also in northern Arizona, Colorado, Idaho, Nevada, Oregon, and Washington. Unusual records are from the toad, Bufo boreus halophilus, and from the nest of an English sparrow in the southern Central Valley of California.

This species vectors the spirochete of relapsing fever, Borrelia hermsi, and Philip and Davis (1940) have records of this tick biting humans. Human cases of tick-borne relapsing fever in California are recorded mainly from inhabitants of mountain cabins in which ticks were collected from nests of chipmunks, rats, and squirrels. Porter et al. (1932) identified spirochetes from the blood and organs of chipmunks and squirrels collected in the immediate vicinity of these cabins.

Adults and nymphs of O. hermsi have been collected in California from February through October. The majority of these records (77%), however, represent collections made from May through September, during the period in which mountain cabins are usually occupied.

CALIFORNIA RECORDS. EL DORADO CO.: Lake Tahoe: 1 male and 1 female from unknown host, X-18-1947; 2 females from drags (=tick flags), VI-8-1953. INYO CO.: Independence, 6 mi. W Gray's Meadow campground, 1 nymph from Peromyscus maniculatus, IX-10-1965 (R.B. Loomis). KERN CO.: Shafter, 4 nymphs and 5 adults from English sparrow nest, IV-2-1947 (W. Doetschman); Hart Park, 1 nymph from ground squirrel burrow, VIII-24-1956 (H. Johnson); Iron Canyon near Garlock, 4 nymphs from unknown host, IV-12-1960 (C.A. Toschi); Maricopa, 1 female from Bufo boreus halophilus, III-2-1968 (J.M. Sheppard). MARIPOSA CO.: Yosemite National Park, 1 female, IX-10-1948 (Park Service staff). MODOC CO: Unrecorded locality, 3 nymphs from Spermophilus beldingi, V-13-1949 (Welsh). MONO CO.: Mammoth Lake, 2380 m elev., 3 males, 1 female, 5 nymphs from cabin, VIII-23-1980; island on Mono Lake, 2 females from nest of California gull, Larus californicus, 1980 (D. Winkler). PLACER CO.: Unrecorded locality, 10 specimens from Douglas fir log, IX-13-1941 (R.M.L.); Lake Tahoe, 1 nymph and 2 adults from animal burrow, tree, and cabin, IV-?-1947; Lake Tahoe (Kings Beach), 2 females, II-1-1949 (W. Graef); Forest Hill, 4 nymphs from bedding in mineshaft, X-10-1973 (K.H. Hansgen). SAN BERNARDINO CO.: Big Bear Lake: 1 female, VIII-14-1933; 1 male, VIII-17-1934; 1 male, IX-23-1934; 1 female, VIII-17-1934 (all C. Wheeler).

Ornithodoros (Alectorobius) kelleyi Cooley and Kohls
(Figs. 61-63)

Ornithodoros kelleyi Cooley and Kohls, 1941, U.S. Pub. Health Serv. Rept. 56:912-914; Cooley and Kohls, 1944, Amer. Midland Naturalist, monog. 1:117 (distrib.); Sonenshine, 1962, J. Parasitol. 48:470-485 (all instars described); Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58:344-346 (distrib.).

DIAGNOSIS. Adult and nymph. Closely resemble those of O. talaje and O. concanensis except for the following: body proportionally longer (Fig. 61), with smaller cheeks (Fig. 63) and a hypostome with sides almost parallel (Fig. 63), compared to adult and nymph of O. concanensis; absence of a distinct notch between the hood and anterior extension of the dorsal body wall when viewed in lateral profile (Fig. 62) separates O. kelleyi from adults and nymphs of O. talaje.

Larva. Much longer (0.95-1.04 mm long unengorged) than larva of O. talaje, with hypostome arising from large, conical median extension, compared to small, subtriangular median extension found on larvae of O. concanensis and O. talaje; denticles 3/3 on distal third of hypostome, compared to 3/3 on distal half of hypostome in concanensis and talaje.

In addition to the 4 California bat records, O. kelleyi is known from a variety of bats and bat retreats, including bat-infested houses in Alabama, Arizona, Arkansas, Colorado, Illinois, Iowa, Maryland, Minnesota, Montana, Nevada, New York, Ohio, Pennsylvania, South Dakota, Texas, West Virginia, Utah, and Wisconsin. It has been recorded also from Alberta, Canada, and Sonora, Mexico.

CALIFORNIA RECORDS. ALAMEDA CO.: SW Livermore, 3 larvae from the bat Antrozous pallidus, IV-5-1945. IMPERIAL CO.: Kane Springs, 8 larvae from A. pallidus, III-29-1945 (D. Constantine). SAN LUIS OBISPO CO.: 4.5 mi. NE Shandon, 91 larvae from A. pallidus, IX-20-1947 (R.T. Orr). SANTA CLARA CO., San Jose, 11 larvae from A. pallidus, V-6-1942 (D. Constantine).

Ornithodoros (Pavlovskyella) parkeri Cooley (Figs. 64-69; Map 5)

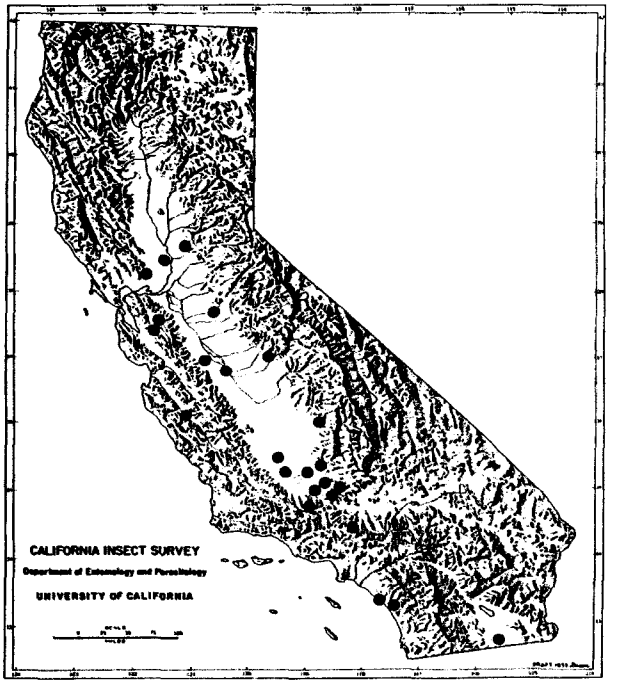
Ornithodoros parkeri Cooley, 1936, U.S. Pub. Health Service Rept. 51:431-433, 1 pl. (adults).
Ornithodoros wheeleri McIvor 1937, J. Parasitol. 23:365-367.

DIAGNOSIS. Adult and nymph. Both ends of body rounded, but broader posteriorly, similar in appearance to O. turicata (Figs. 64, 65). Mammillae (Fig. 69) more numerous and smaller than in O. turicata, larger at sides and largest posteriorly. Hood large and evident from above. Cheeks absent (Fig. 67). Basis capituli (Fig. 66) as wide as long; surface irregular, with transverse wrinkles. Hypostome (Fig. 67) long and rounded apically, with denticles in lateral and median files equal in size 2/2. Genital aperture of adult at interval between coxae I and II (Fig. 66). Eyes absent. Anus in an oval pattern. Legs long, moderate in size but appear heavier than in O. turicata, with segments flared distally; mild subapical dorsal protuberances present on all tarsi except IV; tarsus I with 3-4 dorsal humps (Fig. 68).

Larva. Oval, wider anteriorly, without dorsal plate. Hypostome moderately long, rounded apically, with denticles 2/2. Palp segment 3 extending distal to tip of hypostome. Dorsum with 10-12 dorsolateral pairs setae and 2 central pairs. Venter with 7 pairs setae and single posterior median seta.

O. parkeri lives in close association with various rodents, lagomorphs and the Burrowing Owl (Speotyto cunicularia) in the western and northwestern U.S. Davis (1939) reported this tick feeding on man. Davis (1941) also reported that specimens collected from Idaho and Utah were found to transmit the spirochetes of relapsing fever. Feldman-Muhsam (1973) demonstrated autogeny in O. parkeri.

In California most collections of this species have been made in the Central Valley, with a few from central and southern coastal localities (Map 5). O. parkeri has been collected chiefly from rodents and their burrows or nests (Table 3) from April through October.



MAP 5. Distribution in California of Ornithodoros parkeri Cooley, solid circles.

Ornithodoros (Alectorobius) rossi Kohls, Sonenshine, and Clifford

Ornithodoros rossi Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58:347 (larva).

DIAGNOSIS. Adult and nymph unknown.

Larva. Most structures of the larva similar to those of O. yumatensis. Nine pairs of ventral setae and absence of a pair of anterolateral setae on tarsus I distinguish O. rossi from O. yumatensis. Larvae also resemble closely those of O. dyeri, from which they are distinguished as described under that species.

O. rossi is known only from larvae collected from various species of bats in Arizona, California, Utah, Mexico, Colombia, and Venezuela. In California, Poché and Keirans (1975) reported a collection of larvae from the leaf-nosed bat, Macrotus californicus, in the Turtle Mountains, San Bernardino County. We have not seen any California specimens.

Ornithodoros sparnus Kohls and Clifford (Figs. 70-73; Map 4)

Ornithodoros sparnus Kohls and Clifford, 1963, J. Parasitol. 49:857.

DIAGNOSIS. Adult and nymph. Similar to O. hermsi, except for the following: smaller females to 3.90 X 2.15 mm and males to 3.17 X 1.84 mm, compared to O. hermsi females 5.0 X 3.1 mm and males 3.8 X 2.4 mm; tip of corona of hypostome (Fig. 72) with only 6-8 very fine denticles, whereas corona of O. hermsi has numerous fine denticles; dorsoventral groove absent in O. sparnus (Fig. 70), present in O. hermsi.

Larva. Markedly different from O. hermsi: dorsal plate very large, dorsal body surface with 10 pairs setae and venter with 6 pairs; hypostome and palpi much longer than in O. hermsi, with 2/2 dentition along entire length.

O. sparnus has been found only on woodrats (Neotoma) and deer mice (Peromyscus) in Arizona, California, Nevada, and Utah. Laboratory studies by Davis and Mavros (1956) on specimens collected from woodrat nests in 1954 and 1955 showed that these ticks were biologically distinct from O. hermsi: Utah ticks failed to transmit Borrelia hermsi from California, a strain which was readily transmitted by O. hermsi from Oregon and other states. Larvae were not only morphologically distinct from those of O. hermsi but required from 9 to 15 days to engorge on the guinea pig, whereas larval O. hermsi commonly feed in less than 1 hour on adult mice, rabbits, guinea pigs, or man.

CALIFORNIA RECORDS. SAN BENITO CO.: 2.7 mi. S Panoche, 1 female, 3 nymphs from nest and juniper litter in tree, VII-31-1965 (K. Hom and V.F. Lee). SAN BERNARDINO CO.: Kramer Hills, 5 mi. S Kramer Junction, 5 females, 8 males from nest of Neotoma lepida, IV-15-1962 (D.P. Furman and F.J. Radovsky).

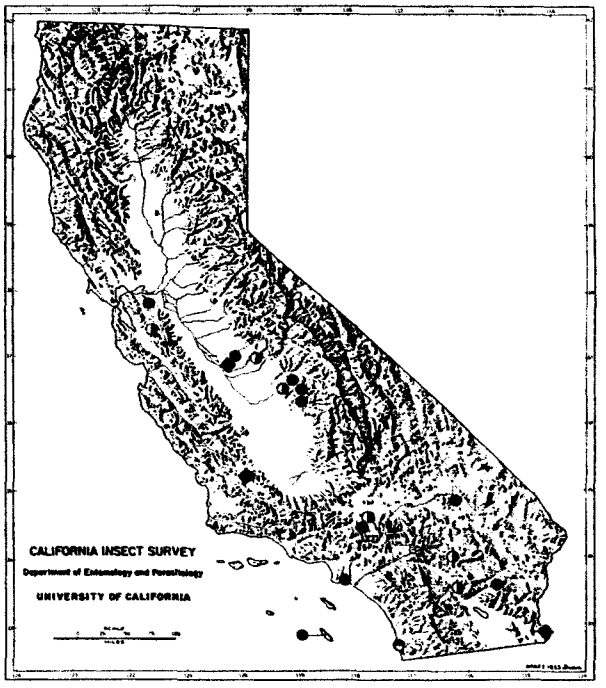
Ornithodoros (Alectorobius) stageri Cooley and Kohls (Figs. 74-77; Map 6)

Ornithodoros stageri Cooley and Kohls, 1941, U.S. Pub. Health Serv. Rept. 56:589, figs. 1-2 (male, female, and larva).

DIAGNOSIS. Adult. Body oval, wider posteriorly (Figs. 74, 75), differentiating this species from adults and nymphs of O. concanensis, O. kelleyi, and O. yumatensis, which have sides parallel. Mammillae large, few, not crowded (Fig. 74). Discs depressed, large and circular. Hood indistinct to absent. Cheeks small, variable in shape (absent in male). Basis capituli (Fig. 76) as wide as long, surface irregular

TABLE 3. *California Records of Ornithodoros parkeri Cooley*

Host or Source	Tick Collections		
	Adults and Nymphs	Larvae	Unrecorded Instars
Gopherus agassizi	1	-	-
Homo sapiens	1	-	-
Spermophilus beecheyi	1	-	-
Spermophilus beecheyi burrow	13	-	-
Spermophilus burrow	6	1	-
Dipodomys sp.	-	1	-
Deer	1	1	-
Animal burrow	6	-	1
Barnyard	1	-	-
Unknown source	4	1	-
Under rocks	2	1	-



MAP 6. Distribution in California of: Ornithodoros stageri Cooley and Kohls, rectangles; O. talaje (Guérin-Méneville), solid circles; O. turicata (Dugès), half-circles.

and wrinkled. Hypostome notched in both sexes; principal denticles 2/2 and large in female; 2 short files of small denticles on each side of median line in males. Genital aperture at interval between coxae I and II. Eyes absent. Anus elliptical. Legs moderate in size and length, surface smooth and shining, neither subapical dorsal protuberances nor dorsal humps present (Fig. 77).

Nymph. Cheeks lacking in early stages; in later stages, cheeks smaller than in adult females.

Larva. Short, oval, with dorsal plate large, pyriform, wider posteriorly. Hypostome lacks long conical base, bluntly pointed apically with denticles 4/4 apically, 3/3 medially, 2/2 at base; lateral files large, median files small. Larvae of this species are distinguished from those of O. dyeri and O. yumatensis by absence of reticulations on capsule of Haller's organ.

O. stageri is found on bats and in bat retreats in Arizona, California, Oklahoma, and Texas. It is also reported from Mexico, Nicaragua, Bolivia, Brazil, and Venezuela. Adults of O. stageri were taken from bats, Myotis velifer and Tadarida mexicana, in Arizona and Texas respectively. Cooley and Kohls (1944b) and Eads et al. (1956) report this species to feed readily on man.

CALIFORNIA RECORDS. IMPERIAL CO.: Senator mine, 21 mi. NE Yuma, adults and nymphs on bat guano, V-21-1940 (G.M. Kohls). MADERA CO.: San Joaquin Experimental Range, 54 larvae from Antrozous pallidus (103 bats), VII and VIII-1951 (Augustson and Wood). SAN LUIS OBISPO CO.: Simmler, 6 adults and 8 nymphs from A. pallidus, IV-14-1951 (R.T. Orr).

Ornithodoros (Alectorobius) talaje (Guérin-Méneville) (Figs. 78-81; Map 6)

Argas talaje Guérin-Méneville, 1849, Rev. Mag. Zool. 1:342-344, pl. 9.
Ornithodoros talaje Neumann, 1896, Mém. Soc. Zool. France 9:34-37; Cooley and Kohls, 1944, Amer. Midland Naturalist monog. 1:82-88, figs. 38-39, pl. 8 (adults, larva); Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58:349-350, figs. 34, 35 (larva).
Alectorobius talaje, Pocock, 1907, in A System of Medicine 2:187-189.
Ornithodoros dugesi Mazzotti, 1943, Rev. Inst. Salub. Enferm. Trop. 4:371-374.

DIAGNOSIS. Adult and nymph. Body pointed anteriorly, with curve of posterior border slightly flattened, sides nearly parallel (Figs. 78, 79). Mammillae larger at sides, largest on posterior border; small on venter. Discs large, distinct, in large depressed areas over median area of dorsum; linearly arranged on venter. Intersection of hood and dorsal body wall forming a notch (Fig. 81). Hood small, bent ventrally in contact with cheeks. Cheeks (Fig. 80) oval, largest of any California species. Basis capituli (Fig. 80) wider than long, with irregular transverse wrinkles and micromammillae. Hypostome short and small, notched apically; denticles 2/2 with 4 large ones in each file. Genital aperture of adult between coxae I. Eyes absent. Anus in an oval frame. Legs small and surfaces micromammillated; Tarsus I with mild subapical dorsal protuberance, absent on other tarsi; dorsal humps on tarsi absent.

Larva. Similar to O. kelleyi, a bat-infesting species. Larvae of talaje have a short-based but broad hypostome with rounded

sides and pointed apically, while in kelleyi the hypostome is long and narrow, pointed apically, with sides nearly straight distal to abrupt constriction marking junction of median extension of basis capituli with hypostome.

O. talaje is found on rodents and in close association with their burrows or nests in Arizona, California, Florida, Kansas, Nevada, and Texas. It is also known from Mexico and Central and South America and found in close association with wild rodents. In Panama, however, Dunn (1933) collected larvae chiefly from rats, monkeys, dogs, cats, chickens, a snake (Epicrates cenchris), and man. But as noted by Fairchild et al. (1966), Dunn's specimens may have been O. puertoricensis Fox.

The spirochetes of relapsing fever were recovered from specimens of O. talaje collected in Arizona and Texas (Davis, 1940; Mackie et al., 1946).

CALIFORNIA RECORDS. CONTRA COSTA CO.: W slope Mt. Diablo, 1 nymph by a rodent burrow, VIII-6-1938 (T. Aitken). FRESNO CO.: 7 mi. E Minkler, 1 nymph under granite chip, XI-27-1965 (A. Jung). LOS ANGELES CO.: San Clemente Island, 1908 (Banks); Palmdale, 2 adults from rotted base of Joshua tree, IV-14-1938 (T. Aitken); Long Beach, female from unspecified host, IV-20-1957 (O. Roberts); Lovejoy Buttes, adults and nymphs from woodrat nest, X-31-1965 (S.F. Wood). MADERA CO.: O'Neals (U.C. San Joaquin Experimental Range), 1 nymph from Spermophilus beecheyi, IX-7-1939 (T. Kelley). RIVERSIDE CO.: Desert Center, 15 adults and 2 nymphs from burrow of Spermophilus sp., IX-26-1939 (C.B. Philip). SAN BERNARDINO CO.: 13.9 mi. S Baker, 3 nymphs, 1 larva under rocks, VII-2-1978 (S. Werman). TULARE CO.: near Terminus Reservoir on State Hwy 198, 1 female under rock, XI-26-1965 (V. Lee); 13.7 mi. S Badger, 2 females under granite chip, XII-27-1965 (D.O. Yong).

Ornithodoros (Pavlovskyella) turicata (Dugès)
(Figs. 82-85; Map 6)

Argas turicata Dugès, 1876, El Repertorio de Guanajuato, Mexico (newspaper), April 25.

Ornithodoros americanus Marx, 1895, Proc. Entomol. Soc. Wash. 3:195-201, 1 pl.

Ornithodoros turicata; Neumann, 1896, Mem. Soc. Zool. France 9:31-34; Cooley and Kohls, 1944, Amer. Midland Naturalist monog. 1:56-61, figs. (adults, larva); Kohls, Sonenshine, and Clifford, 1965, Ann. Ent. Soc. Amer. 58:356-357 (larva).

DIAGNOSIS. Adult and nymph. Body with both ends evenly rounded (Figs. 82, 83). Mammillae (Fig. 82) numerous and large, smaller in the midventral area, larger at posterior margin; mammillae larger and less crowded than in O. parkeri. Hood large, evident from above. Cheeks absent. Basis capituli (Fig. 84) as wide as long, surface irregular with few transverse wrinkles. Hypostome long, rounded apically, with denticles 2/2 and large teeth limited to distal $\frac{2}{5}$ths of length. Sex pore at interval between coxae I and II. Eyes absent. Anus in an oval pattern. Legs moderate in size and length, with segments slightly flared distally; mild subapical dorsal protuberances present on all tarsi except IV; tarsus I (Fig. 85) with 3-4 dorsal humps.

Larva. Oval, slightly wider posteriorly, without dorsal plate. Hypostome long, rounded apically with denticles 2/2; extends to or beyond apex of palpal segment III. Dorsum with 10-11 pairs thick, dorsolateral setae and 2 central pairs. Venter with 7 pairs setae and a posteromedian seta.

O. turicata is found in Arizona, California, Colorado, Kansas, New Mexico, Oklahoma, Texas, and Utah, on various rodents and lagomorphs and in their burrows or habitats, and on man and livestock. In Florida and Mexico, this species has been found in close association with pigs. O. turicata is rarely collected in California. O. turicata can transmit the spirochetes of relapsing fever, particularly in the hot, dry regions of the southwestern states. It is quite similar in appearance to O. parkeri.

CALIFORNIA RECORDS. ALAMEDA CO.: Calaveras Dam: 1 adult and 9 nymphs from unknown host, V-31-1940 (R. Holdenried); 1 male from Spermophilus beecheyi, VIII-28-1942. LOS ANGELES CO.: Hi Vista, 65 nymphs from desert tortoise (Gopherus agassizi), VIII-27-1961. MADERA CO.: 20 mi. NE Madera, 1 nymph from S. beecheyi, VIII-30-1939 (T. Kelley). RIVERSIDE CO.: Thermal, 80 specimens from G. agassizi, X-15-1935 (Harbison). SAN BERNARDINO CO.: Joshua Tree, 1 nymph from G. agassizi, IV-26-1959 (R.E. Ryckman). TULARE CO.: 8 mi. N Orange Cove on Drake ranch, 1 female and 2 nymphs from S. beecheyi, V-14-1942 (R.V. Wings).

Ornithodoros (Alectorobius) yumatensis Cooley and Kohls (Figs. 86-88)

Ornithodoros yumatensis Cooley and Kohls, 1941, U.S. Pub. Health Serv. Rept. 56: 592-594, figs. (larva, nymph, male, and female); Cooley and Kohls, 1944, Amer. Midland Naturalist, monog. 1:74-79; figs. (adults, larva); Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58:350-351 (larva).

DIAGNOSIS. Adult and nymph. Body oval, sides almost parallel, bluntly pointed anteriorly (Fig. 86). Mammillae irregular in shape, moderate in size and number, but equal in size in median and peripheral areas on all surfaces, close together but not crowded. Discs moderate in size, mildly depressed; lineal arrangement on venter in preanal, transverse postanal, and median postanal grooves. Hood indefinite. Cheeks (Fig. 88) large, twice as long as wide, attached along one side, with few short hairs. Capitulum (Fig. 88), when extended, reaching beyond anterior end of body; basis capituli with surface granulated and faintly wrinkled. Hypostome (Fig. 88) with sides subparallel, apex mildly notched. Denticles small or faint, lateral files large but smaller toward median line. Genital aperture of adult at interval between coxae I and II. Eyes absent. Anus large and elliptical. Legs long and slender, with surfaces made irregular by numerous granulations; tarsi (Fig. 87) without subapical dorsal protuberances or dorsal humps. Hypostome smaller, with smaller denticles, in male.

Larva. Body sub-oval. Dorsal plate pyriform, widest posteriorly. Capitulum large, as long as half length of body. Hypostome long and slender, arising from a conical base nearly as long as hypostome, pointed apically; dentition 3/3 in apical $\frac{3}{4}$ths, 2/2 near base of toothed portion. Legs long and slender. 14-16 pairs of dorsal setae; 8 pairs of ventral setae, plus posteromedian seta.

O. yumatensis is known from Arizona, California, Georgia, New Mexico, and Texas, where infrequent collections have been made from bats and bat retreats. It is also reported from Mexico, Nicaragua, Colombia, and Venezuela.

CALIFORNIA RECORDS. IMPERIAL CO.: 15 mi. NE Yuma, 2 nymphs, 1 male from rock crevices in mine tunnel, V-20-1940; Senator mine, 21 mi. NE Yuma, 1 larva from bat guano, V-21-1940 (G.M. Kohls). RIVERSIDE CO.: Alice Mine (Riverside Mts.), nymphal skin from spider web in mine shaft, V-16-1954 (W. MacDonald).

Genus Otobius N. Banks

Otobius Banks, 1912, Proc. Entomol. Soc. Wash. 14:99.

Type of genus: Argas megnini Dugès, 1884.

Adult and nymph dissimilar, sexes similar. Adult with integument granulated, no mammillae, discs indefinite; nymph striated, set with spines. No change in pattern of integument at sides. Capitulum distant from anterior margin. Hood absent. Hypostome of nymph well developed; vestigial in adult. Eyes absent in nymph and adult, present or absent in larva.

KEY TO OTOBIUS IN CALIFORNIA ADULTS AND LATE-STAGE NYMPHS

Nymphal integument with heavy spines anteriorly and lighter spines posteriorly (Fig. 98); adult integument with dorsal pits separated by distance 2X pit diameter (Fig. 97). . . . . megnini

Nymphal integument with spines all one size (Fig. 93); adult integument with dorsal pits separated by distance diameter of 1 pit . . . . . lagophilus

Otobius lagophilus Cooley and Kohls (Figs. 89-94, Map 7)

Otobius lagophilus Cooley and Kohls, 1940, U.S. Pub. Health Serv. Rept. 55:928, figs. 3-5 (male, female, nymph); Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58:361-362 (larva fig.).

DIAGNOSIS. Adult. Body rounded on both ends (Figs. 89-90), but less constricted at the sides behind legs IV than in O. megnini. Integument granular, with dorsal pits separated by 1 pit diameter (Fig. 92). Hood and camerostome not apparent. Basis capituli (Fig. 91) broad, short as in O. megnini.

Hypostome vestigial. Spiracle ovate, convex; eyes absent; anus subcircular. Legs short, heavy, with moderate subapical protuberances definite on all tarsi, more pronounced on IV.

Nymph. Body shape and size as in adult, generally smaller than nymph of O. megnini. Slender spines over entire body surface, more abundant and longer anteriorly (Fig. 93), shorter posteriorly, in contrast to spines on nymphs of O. megnini. Hypostome (Fig. 94) well developed with 3/3 dentition. Spiracle slightly convex instead of conical in shape as in megnini. Legs short and heavy, with subapical protuberances absent or very small on first 3 tarsi but distinct on IV.

Larva. Similar in most aspects to larva of O. megnini but with 7-9 pairs of dorsal body setae, 5 ventral pairs, and without eyes.

O. lagophilus is the spinose tick associated typically with Lepus species (jackrabbits), on which the nymphs are usually attached to the face. Specimens collected from burrows in Mexico were found to be naturally infected with rickettsiae of Rocky Mountain spotted fever (Silva-Goytia and Elizondo, 1952). Philip et al. (1955) and Eklund et al. (1955) reported that O. lagophilus collected in Nevada and Utah were infested with spotted fever rickettsiae and Colorado tick fever virus respectively. Laboratory experiments have demonstrated that larvae and nymphs of O. lagophilus retained tularemia organisms up to 676 days, but transovarian transmission did not occur.

Bacha (1957) reared this tick on Lepus californicus in the laboratory. The life cycle from egg hatch to ovipositing females required from 55 to 134 days. Other experimental hosts such as cottontail and domestic white rabbits, guinea pigs, an adult kangaroo rat (Dipodomys), suckling deer mice (Peromyscus), and harvest mice (Reithrodontomys) were unsatisfactory.

O. lagophilus is known from Alberta, Canada, to Chihuahua and Coahuila, Mexico. In the United States it is recorded from California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, and Wyoming.

Of 16 collections of O. lagophilus in California 5 are from jackrabbits, 4 from pikas, and 7 from dirt at entrances to ground squirrel and other burrows. These collections were made from March through June and in August.

CALIFORNIA RECORDS. KERN CO.: 17 mi. W Bakersfield, 3 collections of 7 males and 4 females from burrows of Spermophilus beecheyi, VIII-15-1956 (D. Roberts and E. Smith); Cantil, 4 nymphs from Lepus californicus, V-9-1954 (B. Prunty); Hart Park, Kern River, 1 nymph from ground squirrel burrow, VIII-24-1956 (D. Roberts); 3 mi. W Wasco, 29 males, 2 females from ground squirrel burrow, VIII-17-1956 (H. Johnson); Lerdo airport, 1 nymph from L. californicus, III-13-1942; Bakersfield, 1 nymph from L. californicus, V-1962. LOS ANGELES CO.: Sierra Pelona Valley, 2 nymphs from jackrabbit, IV-22-1950. MONO CO.: Bodie, 4 collections from Ochotona princeps: 1 nymph, VIII-4-1949, and nymphs and larvae, 1948, IV-28-1949, and V-13-1949 (J.H. Severaid). SAN BERNARDINO CO.: Barstow, 17 nymphs from L. californicus deserticola, VI-20-1924. SAN JOAQUIN CO.: Lonetree Canyon, near Tracy, from rodent burrows: 5 females and over 200 larvae, VIII-18-1951; 13 males, 11 females, and 2 nymphal skins, VI-1952 (both E.C. Loomis).

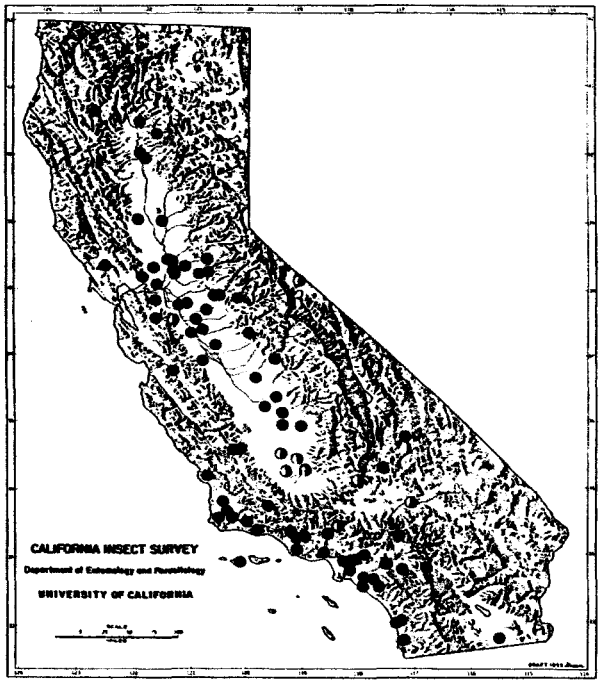
Otobius megnini (Dugès)
Spinose Ear Tick
(Figs. 95-100, Map 7)

Argas megnini Dugès, 1884, La Naturaleza 6:197, figs.

Otobius megnini; Banks, 1912, Proc. Entomol. Soc. Wash. 14:99; Cooley and Kohls, 1944b, Amer. Midland Naturalist monog. 1:21 (synonymy, redescription adults, nymphs, larva); Kohls, Sonenshine, and Clifford, 1965, Ann. Entomol. Soc. Amer. 58(3):362-363 (larva).

DIAGNOSIS. Adult. Body rounded behind, slightly attenuated anteriorly; broadest at legs II and III, constricted behind leg IV (Figs. 95-96). Integument granular; dorsum with numerous small, slightly depressed pits, each separated by 2X pit diameter (Fig. 97); not distinct on ventral side. Hood short and broad. Camerostome lined with numerous fine, long hairs. Basis of capitulum (Fig. 99) very broad and short, curved to approach reniform shape. Hypostome (Fig. 99) vestigial, short, broad, concave dorsally and without denticles. Genital aperture at level of posterior ends of coxae I (Fig. 96). Spiracle circular, mildly convex. Eyes absent. Anus very small and circular. Legs short and heavy; except for tarsi I, all tarsi with subapical dorsal protuberance moderate.

Nymph. Second instar nymphs, easily distinguished from other ticks, are the



MAP 7. Distribution in California of: Otobius lagophilus Cooley and Kohls, half-circles; O. megnini (Dugès), solid circles.

forms commonly seen in ears of domestic animals. Body shape of fed tick similar to adult, but lateral constriction often less pronounced. Unfed nymph much narrowed posteriorly (Fig. 98). Integument with shiny surface and fine striae continuous over depressed areas, which are counterpart of discs. Spines over entire body surface except around capitulum (Fig. 98); heavy, v-shape spines on dorsum extending in front of spiracles anteriorly, those on ventral surface extending from anus anteriorly; slender spines on posterior dorsal and lateral areas and on those ventral areas not described above. Hood and camerostome absent. Capitulum subrectangular, as broad as long, with few setae at sides in front and with short, heavy spines on each side behind. Hypostome (Fig. 100) large, tapering, denticles 4/4 with about 8 per file. Spiracle conical. Eyes absent. Legs short and heavy, tarsi with subapical dorsal protuberance absent or very small. First nymphal stage similar to second, but smaller, more slender, legs and hypostome half as large.

Larva. Body oval, striated with 9-10 pairs of setae on dorsum, 5 pairs on ventral surface. 2 pairs of ocellus-like eyes on dorsum over legs I and II. Moderately large elongated dorsal plate with 2 pairs of lateral sensilla. Hypostome dentition 2/2.

O. megnini, the spinose ear tick, is an important pest of livestock and horses in the western United States. It is also known as far north as British Columbia and south through Mexico, with reports of specimens from Argentina, Brazil, and Chile. Introductions of this species have been found in South Africa, India, and Australia, as a result of long-term feeding in host's ears and the rapid, long-distance travel by livestock transport. O. megnini is known to transmit the Q-Fever agent, Coxiella burnetti, in sheep and dairy stock. Dense ear infestations on livestock will cause intense head-rubbing and loss of hair similar to that caused by lice. Tick-bite areas are subject to secondary infection, and serious auditory and ear problems may result.

In California, this species is more common in the warm, arid, livestock ranching areas of the Central Valley and the cismontane southern region. It has been collected in 38 counties, but recorded distribution within counties is spotty because of failure to report most infestations. There are 228 collections recorded from 11 hosts in California (Table 4). Most common hosts are cattle and horses and, in descending order, dogs, man, sheep, cat, elk, and deer. The pronghorn antelope, Antilocapra americana, should not be overlooked as a host, since Shad (1958) found this tick in the ears of antelopes in New Mexico. Non-host collections are recorded from the environs frequented by livestock. These include barns, salt troughs, and dirt in cattle pens. One collection by the junior author included adults, nymphs, and larvae taken from underneath eucalyptus bark as high as 12 feet above ground. An unusual collection of 1 nymph was recorded from a swallow nest in Aliso Canyon, Orange County, by J. Belkin (UCLA).

Collection data for O. megnini shows that this species may be collected as nymphs throughout the year. Adults are not commonly found unless inspections are made underneath wooden salt troughs, between cracks in board sidings of barns or in wooden corral posts, and under bark of trees. Collections from these sites suggest negative geotropism, positive thigmotropism, and possible avoidance of light. Larvae are usually not found unless an inspector

TABLE 4. California Records of Otobius megnini (Dugès)

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
"Swallow nest"	-	1	-	-
Homo sapiens	-	8	1	-
"Rabbit"	-	-	-	1
Marmota monax	1	-	-	-
Canis familiaris	-	14	1	1
Felis domestica	-	4	-	-
Equus caballus	-	21	1	-
Cervus canadensis	-	2	-	-
Cervus nannodes	-	-	1	-
Odocoileus sp.	-	2	-	-
Bos taurus	4	127	22	12
Ovis aries	-	4	1	-
Wooden feed or salt troughs	4	2	3	-
Dairy barn	1	1	-	-
Soil and vegetation	4	1	-	-
Tree bark	1	1	1	-
Miscellaneous or unknown	7	8	-	-

makes a thorough skin scraping deep within the ears of hosts.

This species was successfully reared in the laboratory on the closely shaved stomach area of rabbits, and required from 62 to 118 days for the complete life cycle from egg hatch to ovipositing females (Loomis, 1961).

FAMILY IXODIDAE MURRAY

Dorsal scutum present; marked sexual dimorphism; male scutum almost covering body; female scutum small, covering about half or less of body. Capitulum conspicuous, terminal; fourth palpal segment reduced and typically inserted subterminally in segment III; porose areas present only on basis capituli of female. Spiracles posterolateral to coxae IV. Of some 650 described species (Hoogstraal, 1973), 29 species in 4 genera are established in California.

KEY TO NYMPHS OF IXODIDAE GENERA OF CALIFORNIA[1]

1 Anal groove distinct, surrounding anus anteriorly and extending to posterior body margin (Fig. 265); no foveae, eyes, or festoons. . . . . Ixodes

Anal groove, if present, never surrounding anus anteriorly; foveae present, with or without eyes or festoons. 2

2(1) Anal groove absent; legs poorly developed, short; no marginal festoons. . . . . .Boophilus

Anal groove distinct or indistinct, surrounding anus posteriorly; legs normal, marginal

[1]Adapted from Serdyukova (1955).

festoons[1] present (Fig. 165) 3

3(2) Eyes absent; coxa I with internal spur, no external spur (Fig. 183). . . . . .Haemaphysalis

Eyes present; coxa I with internal and external spurs (Fig. 165). 4

4(3) Palpi with segment I not visible dorsally (Fig. 354), small and angular ventrally; apices of palpi sharply triangular in dorsal view (Fig. 354); postanal groove distinct (Fig. 355) . . . . . .Rhipicephalus

Palpi with segment I visible dorsally (Fig. 149), well developed and of varied shape ventrally; palpi bluntly tipped in dorsal view (Fig. 149); postanal groove may be indistinct. 5

5(4) Postanal groove distinct; basis capituli in dorsal view short, rectangular, with posterior margin nearly straight . .Amblyomma[2]

Postanal groove indistinct; basis capituli in dorsal view subtriangular or, if subrectangular, posterior margin concave. . . . . .Dermacentor

KEY TO LARVAE OF IXODIDAE GENERA OF CALIFORNIA[3]

1 Anal groove present, interrupted anterior to anus but extending posteriorly beside anus; eyes absent; 4-5 pairs of setae on scutum; 2 pairs of posthypostomal setae spaced well posterior to hypostome[4]; sensilla sagittiformia absent . . . . . Ixodes

Anal groove absent; eyes present or absent; 3 pairs of setae on scutum (Fig. 16); 1 pair of posthypostomal setae bordering hyopostome (Fig. 17); sensilla sagittiformia present (Fig. 16) 2

2(1) Marginal festoons absent; palpi short and thick. . . . . Boophilus

Marginal festoons present; palpi variable. 3

3(2) Eyes absent . . . . . .Haemaphysalis

Eyes present. 4

4(3) Two pairs marginal dorsal setae anterior to sensilla sagittiformia; 11 festoons present . . . . . .Amblyomma

3-4 pairs of marginal dorsal setae anterior to sensilla sagittiformia; 9 festoons present 5

5(4) Auriculae absent; palpi appear 2-segmented, triangular, with a sharp tip; 4 pairs of marginal dorsal setae anterior to sensilla sagittiformia. . Rhipicephalus

Auriculae present, palpi appear 3-segmented, with blunt tips; 3 pairs of marginal dorsal setae anterior to sensilla sagittiformia (Fig. 16) .Dermacentor

Genus Amblyomma Koch

Amblyomma Koch, 1844, Arch. Naturgesch. (Berlin) 10:223; Robinson, 1926, Ticks: a monograph of the Ixodoidea 4:9; Cooley and Kohls, 1944, J. Parasitol. 30:82.

Type of genus. Amblyomma cajennense (Fabricius, 1787).

Amblyomma species have very long mouthparts with segment 2 of the palpi notably elongate. Usually ornate. Eyes and festoons present. Postanal groove present. Males without adanal plates. Of the approximately 100 described species none is established in California, but A. americanum, is occasionally found on cattle imported from other states.

[1] Marginal festoons may not be apparent on fully engorged nymphs.

[2] A. americanum occasionally introduced on imported cattle.

[3] Adapted from Serdyukova (1955).

[4] 1 pair of posthypostomal setae in Ixodes uriae.

Amblyomma americanum (Linnaeus)
Lone Star Tick
(Figs. 101-104)

Acarus americanus Linnaeus, 1758, Regnum animale, ed. 10:615.
Amblyomma americanum; Koch, 1844, Arch. Naturgesch. (Berlin) 10:229; Cooley and Kohls, 1944, J. Parasitol. 30:87 (synonymy listed).

DIAGNOSIS. Female (Fig. 102). Palpi slim, elongate; segment 2 about 2X length of segment 3. Scutum typically with white spot near posterior end (Fig. 102) on otherwise inornate surface. Coxa I (Fig. 104) with external spur much longer than internal spur.

Male (Fig. 101). Palpi (Fig. 103) as in female. Scutum typically with 2 pairs of semicircular white lines in anterolateral and posterolateral areas; represented in some only by interrupted pale lines (Fig. 101). Coxa I similar to that of female.

Nymph. Palpi similar to those of adults. Inornate. Coxae with external spurs. Basis capituli with lateral margins parallel.

Larva. Separable from other ixodid genera by presence of eyes in combination with 2 pairs of marginal dorsal setae in front of sensilla sagittiformia, and presence of 11 festoons.

The lone star tick, which is not known to be established in California, is an important pest of man, domestic stock, and deer in other areas. It can transmit the causal agents of Rocky Mountain spotted fever, tularemia, and Q fever, and can cause tick paralysis in man and dogs.

A. americanum is a 3-host tick, all instars of which will attack man and livestock as well as a variety of other mammals. Immature instars also occur commonly on birds. In the United States the tick is established from Missouri to Texas and eastward to the Atlantic coast. The northern limit of its breeding range in the eastern United States is Pennsylvania and southern New Jersey (Bequaert, 1946). In California, adults of A. americanum have been collected mainly from cattle shipped to feed lots in Imperial County from Texas.

Genus Boophilus Curtice

Boophilus Curtice, 1891, J. Comp. Med. Vet. Arch. 12: 317.
Margaropus Neumann 1907 (nec Karsch 1879), Arch. Parasitologie 11:223
Boophilus Salmon and Stiles, 1901, 17th Rept. U.S. Bur. Anim. Ind., Washington: 419 (description, synonymy); Cooley, 1946, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 187:9; Arthur, 1960, Ticks: a monograph of the Ixodoidea 5:205 (description, synonymy).

Type of genus: Boophilus annulatus (Say, 1821).

Boophilus species are inornate, without festoons but with eyes. Palpi short, compressed; segments II and III with transverse ridges on dorsal and lateral surfaces. Hypostome dentition 4/4 in California species. Female scutum small, but in male extending length of body. Coxa I (Fig. 111) with 1-2 spurs, and in male with long anterior process. All tarsi with terminal ventral spurs.

Boophilus annulatus (Say)
Cattle Tick
(Figs. 105-114)

Ixodes annulatus Say, 1821, J. Acad. Nat. Sci. Phila. 2:75.
Ixodes bovis Riley, 1869, Reports on the diseases of cattle in the U.S., p. 168.
Boophilus bovis, Curtice, 1891, J. Comp. Med. Vet. Arch. 12: 313.
Boophilus annulatus; Salmon and Stiles, 1901, 17th Rept. Bur. Anim. Ind., Washington, p. 421; Cooley, 1946, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 187:11 (synonymy, literature, descriptions female, male, nymph, larva); Arthur, 1960, Ticks: a monograph of the Ixodoidea 5:219 (synonymy, literature, descriptions, biology).

DIAGNOSIS. Female. Unfed specimens small, 2.75 mm long from tips of palpi to posterior margin, 1.4 mm wide; engorged specimens up to 12 X 8 mm (Cooley, 1946a). Basis capituli (Fig. 110) much broader than long, with lateral margins forming short points; cornua essentially absent. Scutum wider anteriorly (Fig. 107); anterolateral margins almost parallel and straight. Coxae without spurs except short rounded external spur on coxa I. Tarsi II-IV each with subapical ventral spur (Fig. 112).

Male. Length 2.16-2.28 mm from tips of palpi to posterior margin; width 1.26-1.32 mm (Cooley, 1946a). Body without caudal

appendages. Basis capituli (Fig. 109) much broader than long, with definite cornua and straight posterior margin. Scutum with slightly constricted, sinuous margins in posterolateral areas. Adanal and accessory shields (Fig. 106) each with blunt caudal point. Coxa I (Fig. 111) with long anterior process, free terminally. Coxa I with external and internal spurs of subequal length and variable width. Coxae II to IV without spurs. Tarsal spurs as in female.

Nymph. Basis capituli much wider than long, with short lateral points as in adult (Fig. 114). Cornua absent. Palpi similar to those of adults. Hypostome with denticles 3/3. Scutum subpentagonal (Fig. 113), length subequal width. Short rounded spur on each of Coxae I-III; coxa IV without spur.

Larva. Capitular length from tips of palpi equal to width of basis capituli; without cornua. Palpi short, broad. Hypostome short, with denticles 2/2. Scutum subpentagonal, covering about half length of body of unfed specimen. Eyes indistinct. Coxae without spurs.

At one time B. annulatus was widely distributed in the southern part of the United States, including California. Eradication programs during the early part of the twentieth century eliminated the tick from the United States, but it continues to exist in Mexico and occasionally may be introduced. Of the 5 recognized Boophilus species in the world, B. annulatus is the only one known to have been established in the United States. In California cattle ticks are easily recognized by the characters given for the genus, most of which are shared by the nymphs.

In common with other Boophilus species, the life cycle from larvae to engorged and mated adults is completed on a single host. Hooker et al. (1912) reported that at Dallas, Texas, the minimum period from attachment of the larvae to dropping of the first engorged female was 20 days and the maximum period 59 days. The fertilized female drops from the host and deposits about 2,000 to more than 4,000 eggs which hatch in 19 to over 200 days, depending on the prevailing temperature. Larvae climb to the tips of vegetation and attach to passing hosts. The usual hosts are cattle, but records of other hosts include deer, equines, sheep, goats, and buffalo. The biology of the cattle tick was described in detail by Hunter and Hooker (1907) and by Hooker, et al. (1912), who included other pertinent references to the literature.

B. annulatus is of great veterinary importance as a biological vector of Babesia bigemina, the protozoan parasite causing redwater, or Texas cattle fever.

Genus Dermacentor Koch

Dermacentor Koch, 1844, Arch. Naturgesch. (Berlin) 10:217-239.

Dermacentor; Nuttall and Warburton, 1911, Ticks: a monograph of the Ixodoidea 2:120.

Dermacentor; Cooley, 1938, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 171: 15-19.

Type of genus: Ixodes reticulatus (Fabricius, 1794).

Dermacentor species possess eyes and festoons, typically ornate. Basis capituli of adults rectangular, of nymphs triangular or rectangular. Palpi short and relatively broad. Anal groove indistinct, situated posterior to anus. Coxa I bifid. Coxae I-IV increasing in size progressively. In engorged females and nymphs, neither festoons nor anal groove may be apparent.

There are 6 species of Dermacentor which occur in California. Intraspecific variation in morphology is common, but specimens may be identified in most cases with the aid of a key and illustrations supplemented by text diagnoses.

KEY TO ADULTS OF DERMACENTOR IN CALIFORNIA

1 Spurs on coxa I with facing edges widely divergent (Fig. 155). Scutum with large, deep punctations bearing setae; with long rugo-punctate cervical grooves in female . . . . . parumapertus

Spurs on coxa I with facing edges parallel or nearly so (Fig. 147). Scutum with shallow punctations bearing setae, without elongate or rugo-punctate cervical grooves in female. 2

2(1) Spiracular plate lacking dorsal prolongation (Fig. 118) or with broad truncate prolongation; goblet cells very large, of uniform size (75-85) . albipictus

Spiracular plate oval with distinct dorsal prolongation (Fig.

130), with goblet cells minute to large, 50 or fewer to more than 100. (Goblet cells large in D. hunteri, but spiracular plate with narrow dorsal prolongation containing smaller punctations.) (Fig. 137). 3

3(2) Spiracular plate with numerous goblet cells, minute, granular in appearance (Fig. 163). . . . . variabilis

Spiracular plate with medium to large goblet cells (Fig. 148) . . .4

4(3) Male with attenuated dorsal prolongation of spiracular plate; goblet cells fewer than 50, larger than in andersoni or occidentalis; smaller punctations lacking or sparse toward frame but present in dorsal prolongation; female spiracular plate similar to male's but with broader dorsal prolongation (Fig. 137). . . . . .hunteri

Spiracular plate with moderately broad to slender dorsal prolongation and goblet cells distinct but moderate in size, 50 to more than 100, tending to be smaller toward frame and dorsal prolongation (Fig. 148) 5

5(4) Scutal punctations relatively uniform in size; gray pattern color of scutum, legs, and palpi dorsally, with prominent, reddish-brown, uniformly "measled" appearance from base color around punctations (Fig. 141): cornua of male about as long as broad basally, of female broader than long (Figs. 143, 144) . . . . . occidentalis

Scutal punctations of markedly different sizes, larger ones deeper and up to 4X larger than the more numerous small ones; gray pattern color of scutum, legs, and palpi dorsally, with only a faintly "measled" appearance due to minute size of the majority of punctations (Fig. 123). Cornua of both sexes broader than long (Figs. 127, 128) . . . . . .andersoni

KEY TO NYMPHS OF DERMACENTOR IN CALIFORNIA[1]

1 Lateral points of basis capituli indistinct, short (Fig. 121); idiosoma slender (Fig. 119), with lateral margins weakly curved. . . . . albipictus

Lateral points of basis capituli distinct, extending beyond apices of scapulae (Fig. 139); idiosoma broad posteriorly, with lateral margins strongly curved (Fig. 140) 2

2(1) Internal spur of coxa I reduced, not apparent (Fig. 157); ventral basal spurs of basis capituli absent or not apparent (Fig. 158). 3

Internal spur of coxa I small but apparent (Fig. 152) ventral basal spurs of basis capituli distinct (Fig. 151) 4

3(2) Anterolateral edges of basis capituli straight in dorsal view; posterior border even. Spiracular plates subcircular (Fig. 159) with ring of about 7 relatively large goblet cells around eccentric macula . . . . . parumapertus

Anterolateral edges of basis capituli slightly convex over anterior margins of palpal segment I (Fig. 139); posterior border irregular. Spiracular plates broader mesally, with ring of relatively small goblet cells around macula in broad end of plate (Fig. 138). . . hunteri

4(2) Spiracular plate small, with anteroposterior diameter usually about 90-111 μm, typically irregularly ovoid (Fig. 150), with broader end toward ventral side, but some subcircular; ring of 6-7 larger goblet cells around eccentric macula. External spur of coxa I about as long as broad; internal spur not deflected outward (Fig. 152) . . . . . .occidentalis

Spiracular plate large, with anteroposterior diameter usually over 125 μm, typically ovoid

[1] Modified from Brinton et al. (1965).

to subcircular (Fig. 167); group of 6-20 or more larger goblet cells around eccentric macula. External spur of coxa I longer than broad; internal spur deflected outward (Fig. 166). 5

5(4) Anterolateral edges of basis capituli slightly convex in dorsal view (Fig. 133). Spiracular plate with about 6-10 moderately large goblet cells around macula and 1 or more rows of small punctatations bordering frame (Fig. 134). . . . . .andersoni

Anterolateral edges of basis capituli slightly concave (Fig. 164). Spiracular plate as viewed with SEM with about 20 relatively small goblet cells around macula and several rows of minute punctations bordering frame (Fig. 167). . . . . variabilis

KEY TO LARVAE OF DERMACENTOR IN CALIFORNIA[1]

1 Dermal sensilla present (Fig. 16) . .2

Dermal sensilla absent. 4

2(1) Spur on coxa I broadly tapered and sub-acute . . . . . parumapertus

Spur on coxa I moderately tapered or acute (Fig. 17). 3

3(2) Posterodorsal margin of basis capituli straight to slightly concave in unmounted specimens. . . . . occidentalis

Posterodorsal margin of basis capituli appears slightly convex on unmounted specimens. . . . . .andersoni

4(1) Basis capituli with lateral points much reduced, not extending beyond the scapulae; spurs on coxae II and III inconspicuous. . . . . .albipictus

Basis capituli with lateral points extending beyond scapulae (Fig. 16); spurs on coxae II and III distinct (Fig. 17) . . .5

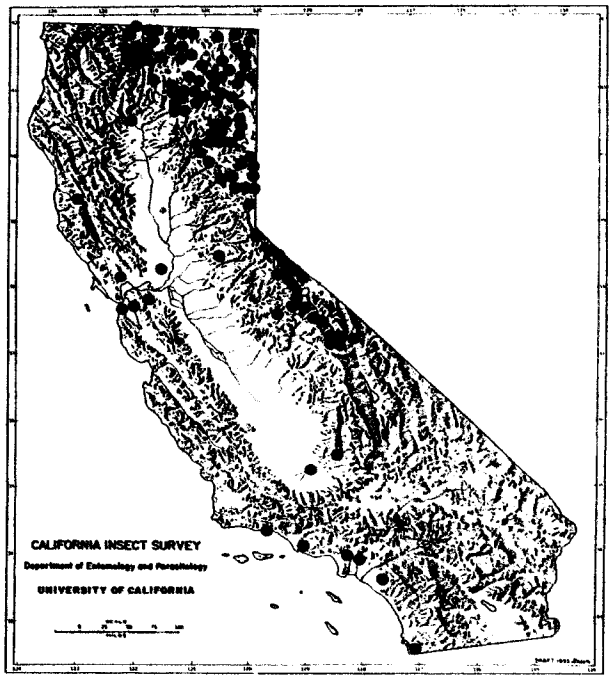
5(4) Spur on coxa I acute; spurs on coxae II and III not extending beyond posterior margin of plate; margins of cervical grooves parallel . . . . .variabilis

Spur on coxa I sub-acute; spurs on coxae II and III extending beyond posterior margin of plate; margins of cervical grooves divergent. . . . . .hunteri

[1]Adapted from Brinton, et al. (1965).

Dermacentor albipictus (Packard)
Winter Tick
(Figs. 115-122; Map 9)

Ixodes albipictus Packard, 1869, Ann. Rept. Peabody Acad. Sci. 1:65-66 (female).
Ixodes nigrolineatus Packard, 1869, Ann. Rept. Peabody Acad. Sci. 1:66.
Dermacentor variegatus Marx, in Neumann, 1897, Mem. Soc. Zool. Fr. 10:367-370.
Dermacentor albipictus; Banks, 1908, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:44-45; Cooley, 1938, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 171: 59-64 (male, female, nymph, larva); Gregson, 1956, Canada Dept. Agric. Sci. Serv., Entomol. Publ. 930:31-33.



MAP 8. Distribution in California of Dermacentor andersoni Stiles, solid circles.

Dermacentor nigrolineatus; Banks 1908, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:48-49.

Dermacentor salmoni Stiles, 1910, U.S. Pub. Health Mar. Hosp. Serv., Hyg. Lab. Bull. 62:55-60.

DIAGNOSIS. Female (Fig. 116). A medium to large Dermacentor, 2.8-5.5 mm long from tip of scapula to caudal end, 1.6-3.5 mm wide; engorged specimens up to 17 X 12 mm, with olive green body. Silvery-gray pattern color of dorsal capitulum, scutum, and legs predominant or absent. Scutum with reddish-brown base color in some populations limited to spots around eyes, cervical grooves and their posteriorly diverging extensions, and pair of lines parallel and lateral to these extensions. Scutum (Fig. 116) longer than wide, with section posterior to eyes narrower than in other California species; subangulate laterally. Punctations not markedly different in size. Coxa I with spurs of variable length, but proximal edges parallel to slightly divergent. Coxae II and III with internal spur small, broad; external spurs large, acute (Fig. 117). Coxa IV lacking internal spur, but external spur large, acute. Spiracular plates (see Fig. 118) typically rounded, subcircular to ovate, only occasionally with rudimentary broad, truncate, dorsal projection; with goblet cells much larger than in other Dermacentor species and without smaller perforations near frame such as seen in D. occidentalis.

Male (Fig. 115). A medium-sized Dermacentor, 2.8-6.1 X 1.7-3.9 mm. Silvery-gray pattern color variable as in female. In well-ornamented males, pseudoscutum evident. Punctations of scutum of moderate difference in size, but not obvious. Coxal spurs and spiracular plates as in female.

Nymph. Slender, elongate, with sides almost parallel (Fig. 119). Basis capituli (Fig. 121) roughly rectangular dorsally, with at most rudimentary lateral points. Scutum length and width subequal, with posterior tip narrowly rounded. Spiracular plates (Fig. 122) large, subcircular, with 15-20 large, distinct goblet cells. Coxa I with external spur of moderate size, internal spur small. Coxae II and III with only small external spurs. Coxa IV with external spur small or absent (Fig. 120).

Larva. Subcircular body shape. Basis capituli with reduced lateral points not extending laterally beyond apices of scapulae. Dermal sensillae absent. Sensillae porosa and sagittiformia present. Coxa I with broad internal spur. Coxae II and III with indistinct marginal spurs, or lacking spurs.

D. albipictus adults differ from other species in California in the shape of the spiracular plate and the larger goblet cells of the plate. Nymphs differ from other Dermacentor species in lacking sharp lateral points on the basis capituli, which is thus roughly rectangular rather than triangular. Larvae differ from other species by reduced lateral points on the basis capituli and lack of dermal sensillae on the dorsal aspect of palpal segment II. In California, larvae and nymphs of Dermacentor occurring on large herbivores in the winter are almost always D. albipictus. Adult Dermacentor species commonly seen on large herbivores in the winter season include both albipictus and occidentalis.

Variation in ornamentation and degree of sclerotization is pronounced in different populations of D. albipictus. Cooley (1938) noted the predominance of the unornamented form ("nigrolineatus") in the south and east and the ornamented form in the western United States. Both types occur in California. Similarly, there is considerable variation in size and shape of the spiracular plate.

The winter tick is a widely distributed species in North America. It is a one-host tick which occurs primarily on large herbivorous mammals during the fall, winter, and early spring months. In parts of California the tick is a severe pest of horses during the winter. Heavily infested horses may become emaciated and anemic and develop an abdominal swelling known as "water belly." This tick can transmit anaplasmosis of bovines, but is not considered as important a vector as other Dermacentor species.

The larvae of the winter tick become active in September or later and typically attach to large herbivores such as horses or deer. They feed and molt on the same host, and the resultant nymphs remain on the host to feed and molt to the adult males and females. Nymphs and larvae typically may be found on their hosts from September to April, although they may each engorge and molt in as few as 9 days. Female ticks drop from their hosts after engorging for 8-30 days to oviposit on the ground. Adult ticks are found most frequently on their hosts during the winter but occur in lesser numbers as late as June and as early as September.

Eggs hatch in spring and typically pro-

duce larvae which diapause until fall. Wright (1969) indicated that activation of the diapausing larvae may be a function of photoperiodicity. The unfed larvae may survive for up to 346 days, according to Bishopp and Wood (1913).

California collections of D. albipictus are most concentrated around the coastal range in the north-central part of the State and on the western foothills of the Sierra Nevada, but this tick has been found in widely scattered areas from the extreme north to the southeast.

As seen in Table 5, California collections of D. albipictus are most numerous from horses and deer. The relatively few collections from cattle indicate that cattle are not common hosts of the winter tick in California. The single collection of 2 males from a jackrabbit reported by Lane et al. (1981) represents the only record of this tick from a lagomorph. One would not expect to collect adults of D. albipictus by dragging, or flagging, vegetation. This is reflected by a total of only 3 collections of adults in California through this method.

Dermacentor andersoni Stiles
Rocky Mountain Wood Tick
(Figs. 123-134; Map 8)

Dermacentor venustus Marx, in Neumann, 1897, Mem. Soc. Zool. Fr. 10:365; Intl. Com. Zool. Nomencl. 1978, Bull. Zool. Nomencl. 35:88 (Opinion 1107, Suppression of Dermacentor venustus Marx).

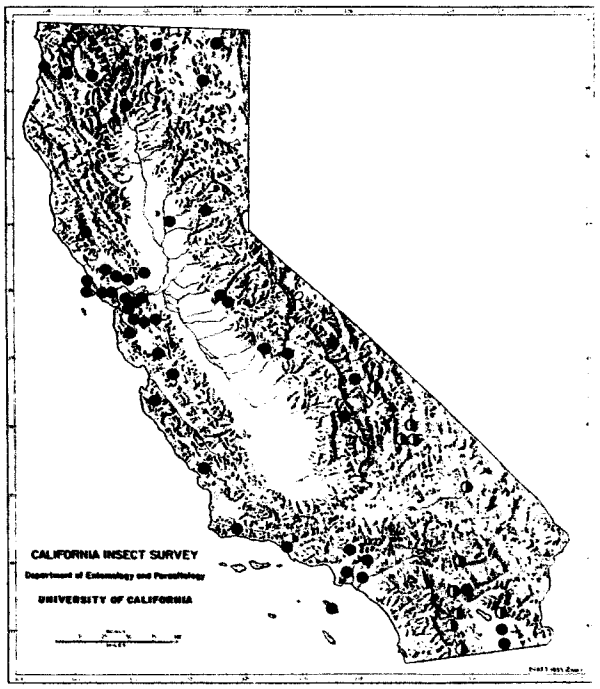
Dermacentor andersoni Stiles, 1908, U.S. Pub. Health Mar. Hosp. Serv. Rept. 23:949.

Dermacentor modestus Banks, 1909, Proc. Entomol. Soc. Wash. 10:170-171.

Dermacentor andersoni; Cooley, 1938, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 171:31 (male, female, nymph, larva); Gregson, 1956, Canada Dept. Agric. Sci. Serv., Ent. Publ. 930:28; Intl. Com. Zool. Nomencl. 1978, Bull. Zool. Nomencl. 35:88 (Opinion 1107, Conservation of Dermacentor andersoni Stiles, 1908).

TABLE 5. California Records of Dermacentor albipictus (Packard)

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Circus cyaneus	1	-	-	-
Lepus californicus	1	-	-	-
Spermophilus sp.	-	1	-	-
Felis concolor	1	-	-	-
Equus caballus	41	14	2	3
Odocoileus hemionus columbianus	14	18	10	-
Odocoileus hemionus	6	4	1	1
Odocoileus sp.	15	3	1	1
Cervus nannodes	1	-	-	-
Cervus roosevelti	1	-	-	-
Bos taurus	9	3	-	1
Antilocapra americana	1	-	-	-
Ovis canadensis	1	-	-	-
Vegetation (tick drag)	3	-	3	-
Under rock	1	-	-	-
Unrecorded host	5	-	-	2



MAP 9. Distribution in California of: Dermacentor albipictus (Packard), solid circles; D. hunteri Bishopp, half-circles.

DIAGNOSIS. Female (Figs. 125, 126). A medium to large Dermacentor measuring about 2.8-5.4 X 1.9-3.7 mm; engorged specimens up to 16 X 10 mm. Silvery-gray ornamentation pattern superimposed on a reddish-brown base color typically on scutum, dorsal aspects of legs, and to lesser extent on basis capituli. Degree of ornamentation variable. Cornua (Fig. 128) typically much broader than long, rounded apically. Scutum with cervical grooves 3-4 X longer than wide; punctations of 2 distinctly different sizes: relatively few large deep ones, and often bearing a seta, and more numerous small punctations without setae; small punctations inconspicuous and usually seen only on ornamented parts of scutum as minute reddish dots. Spiracular plates (Fig. 130) oval with moderately broad to slender dorsal prolongation; typically over 100 goblet cells of moderate size subtended by numerous smaller punctations toward frame and dorsal prolongation. Coxa I (Fig. 131) bifid with inner spur broader than external spur, with facing margins subparallel, apices rounded. External spurs on coxae II-IV about as broad at base as long; internal spur on coxae II and III, short, broad, rounded; no internal spur on coxa IV.

Male (Figs. 123, 124). 2.5-6.1 X 1.6-4.1 mm, broadly ovoid. Ornamentation variable as described for female. Cornua (Fig. 127) as in female but slightly longer and with apices subacute. Scutum with cervical grooves deep and up to 3X longer than wide; punctations as in female. Spiracular plates as described for female, with fewer goblet cells (Fig. 129). Coxae as in female, usually progressively enlarged from anterior to posterior (Fig. 124).

Nymph. Basis capituli dorsally subtriangular, with lateral sharp points extending at almost right angle to longitudinal axis of body past apices of scapulae and with anterolateral margins slightly convex (Fig. 133); distance between apices of lateral points 340-360 μm; ventrally with short basal spurs (Fig. 132), in some reduced to small rounded projections. Scutum slightly longer than wide to wider than long, strongly convex posteriorly, covering less than half of idiosoma. Spiracular plate (Fig. 134) subcircular, relatively large (representative diameter 129 μm); macula eccentric; goblet cells numerous, small, with ring of larger goblet cells around macula. Coxa I (Fig. 132) with external spur large and much longer than wide (representative measurement: 73 X 54 μm); internal spur distinct, small, with broadly pointed apex deflected outward. Coxae II and III with small external spurs (Fig. 132). Coxa IV with external spur very small or absent (Fig. 134).

Larva. Ovoid, tapering anteriorly. Basis capituli with subacute, broadly tapered lateral points extending laterally beyond apices of scapulae; distance between apices of lateral points 188-193 μm; anterolateral margins irregularly curved and posterodorsal margin slightly convex as seen in unmounted specimens. Palpal apex subacute. Dermal sensillae on dorsal surface of palpal segment II. Internal spur on coxa I subacute. Coxae II and III each with small broad spur.

Adults of D. andersoni resemble D. occidentalis, from which they may be distinguished by the larger size of the small scutal punctations on occidentalis, which in well-ornamented males give the latter a distinctly measled appearance. In both sexes the cornua of occidentalis are longer, and in the female more pointed, than in andersoni. Adults of the similar-appearing D. variabilis differ in having spiracular plates with much smaller and more numerous goblet cells. Nymphs of D. andersoni may

be difficult to separate from those of occidentalis or variabilis by any one character, but the combination of characters described above will usually serve to identify them. Larvae of occidentalis usually have the posterodorsal margin of the basis capituli straight to slightly concave as seen in unmounted specimens, rather than slightly convex as in andersoni. In the generally larger larvae of andersoni, compared to occidentalis, there is a greater distance between lateral points of the basis capituli. Larvae of D. parumapertus have a much broader and more rounded internal spur on coxa I than do andersoni.

D. andersoni is notorious as a vector of Rocky Mountain spotted fever in the northwestern United States and western Canada. It is also the only proven vector to man of Colorado tick fever virus, and a vector of the tularemia agent Francisella tularensis, and the Q fever agent Coxiella burneti. The virus of Powassan fever has been isolated from this tick and it has been incriminated as a vector of anaplasmosis in cattle. It is the most important cause of tick paralysis in North America in humans, livestock, and wild mammals.

D. andersoni occurs in western North America from British Columbia to Saskatchewan southward through North Dakota to New Mexico, Arizona, and California. It is a 3-host tick, in which larvae and nymphs typically feed on small mammals such as ground squirrels, and adults usually feed on large mammals such as deer, sheep, horses, cattle, coyotes, and bear; man is attacked readily by adult ticks. The life cycle is completed in 1-3 years.

D. andersoni is encountered most frequently in the spring in California, beginning in March and reaching a peak abundance of adults in May. Adults as well as nymphs may be encountered in lesser numbers, however, throughout the summer until October.

In California D. andersoni is largely restricted to the northeastern and central eastern portions of the State, in the southeastern Cascade Mountains, the Modoc Plateau, and the eastern slopes of the Sierra Nevada. Some collections are recorded also from western slopes of the Sierra Nevada, where the tick appears to be established, but the isolated collections recorded from southern California and the San Francisco Bay area seem to represent only specimens introduced from other areas. The southernmost established populations of the tick in California seem to be in northern Inyo County in the Bishop, Big Pine Creek, and Round Valley areas, a popular recreational region.

While 25 hosts of the Rocky Mountain wood tick are recorded from California (Table 6), the majority of collections have been made by flagging vegetation. Adults of this tick were identified by us from 5 of 167 bears (Ursus americanus) examined by D. Graeber from 1974 to 1978 for ectoparasites in Yosemite National Park. Infested bears were found at Tuolumne Meadows at an elevation of 2,630 m and on the floor of Yosemite Valley at 1,225 m elevation. In a similar study made in Sequoia National Park, no D. andersoni were found on 73 bears examined from May to December 1980.

Dermacentor hunteri Bishopp
(Figs. 135-140; Map 9)

Dermacentor hunteri Bishopp, 1912, Proc. Biol. Soc. Wash., 25:33 (male, female); Cooley, 1938, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 171:45 (all instars).

DIAGNOSIS. Female (Fig. 136). Large ticks, 3.5-4.3 X 1.8-2.5 mm. Idiosoma broadest posteriorly at level of spiracular plates. Silvery-gray ornamentation similar to that of D. andersoni. Basis capituli with cornua broader than long, with ends rounded to subacute. Scutum tapered posteriorly, almost subangulate; cervical grooves 2X as long as broad; large punctations relatively sparse; small punctations more numerous but inconspicuous even on ornamented areas of scutum. Typically scutum of both sexes with 2 pairs of diagonal marks of base color located posteromedian to eyes (Figs. 135, 136). Spiracular plates diagnostic: oval with slender dorsal prolongation slightly broader than in male (Fig. 137); goblet cells large, fewer than 50; lacking smaller punctations toward frame but with 10-20 small punctations in dorsal prolongation. Coxae I of both sexes with opposing margins of internal and external spurs parallel; coxae II, III, and IV with external spurs distinct, semi-acute; internal spurs of coxae II and III reduced, rounded; coxa IV lacking internal spur.

Male (Fig. 135). Large ticks, 3.9-4.6 X 2.6-3.1 mm. Silvery-gray ornamentation similar to that of D. andersoni, but more boldly marked. Basis capituli with cornua about as long as width at base and with subacute tips. Scutum with cervical grooves

TABLE 6. California Records of *Dermacentor andersoni* Stiles

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Homo sapiens	40	-	-	8
Ochotona princeps	2	6	-	-
Sylvilagus sp.	1	2	-	1
Lepus townsendii	1	-	-	-
Lepus sp.	1	1	-	1
Eutamias amoenus	-	1	-	1
Eutamias minimus	-	2	-	-
Eutamias quadrimaculatus	-	1	-	-
Eutamias speciosus	-	2	-	-
Eutamias townsendi	-	1	-	-
Eutamias sp.	-	2	1	-
Marmota flaviventris	2	2	-	1
Spermophilus beecheyi	-	2	-	-
Spermophilus beldingi	-	9	-	-
Spermophilus lateralis	-	10	3	-
Spermophilus sp.	-	2	-	1
Tamiasciurus douglasii	2	1	-	1
Glaucomys sabrinus	-	-	1	-
Peromyscus boylii	-	8	2	-
Peromyscus maniculatus	-	4	2	-
Neotoma fuscipes	-	2	-	-
Erethizon dorsatum	3	-	-	-
Canis familiaris	3	-	-	-
Ursus americanus	5	-	-	-
Equus caballus	12	-	-	3
Odocoileus sp.	1	-	-	-
Bos taurus	2	-	-	1
Ovis aries	5	-	-	-
Vegetation (tick drag)	192	3	-	10
CO_2 trap	1	-	-	-
House	2	-	-	-
Unrecorded	58	1	-	5

2X as long as broad; punctations disparate in size: relatively few large punctations, less conspicuous than in D. andersoni; small punctations inconspicuous, even on ornamented areas of scutum. Spiracular plates and coxal spurs as described for female, except for narrower dorsal prolongation of male plates.

Nymph. Basis capituli (Fig. 139) subtriangular dorsally with lateral points prominent, extending beyond apices of scapulae; ventral basal spurs absent or merely rounded saliences (Fig. 140). Scutum (Fig. 139) short and weakly curved posteriorly, about $\frac{1}{3}$ idiosomal length in unfed specimen. Idiosoma 1.35-1.47 mm long. Spiracular plates (Fig. 138) ovate with broader end anteromedial; with eccentric macula in broader end; 110-116 X 85-98 µm wide; goblet cells smaller than in adult; ring of larger cells around macula. Coxa I (Fig. 140) with external spur as broad basally as long; internal spur rounded, indistinct. External spurs on coxae II and III small, marginal, broad, rounded; coxa IV with spur absent or rudimentary.

Larva. Basis capituli with lateral points extending beyond apices of scapulae; dermal sensilla and sensilla porosa absent; anterolateral margins irregularly curved. Scutum about $\frac{1}{3}$ length of idiosoma, with posterior margin slightly curved convexly; cervical grooves each with posteriorly diverging margins, but paired grooves converging posteriorly. Coxa I with broadly subacute internal spur; coxae II and III with small, broad, postmarginal spurs.

The above diagnoses of D. hunteri nymph and larva are modified from those of Brinton et al. (1965), based on specimens reared in our laboratory. Adults feed readily on the laboratory rabbit. During an initial attachment period of several days there is little feeding, but females undergo a rapid engorgement period in the last 2-3 days of attachment, when they reach a body length of 12-15 mm.

Adults of this rather large and well-ornamented tick typically parasitize bighorn sheep in Arizona, California, Nevada, Utah, New Mexico, and Mexico, including Baja California. Little is known of this tick's biology nor has it been implicated as a vector of disease agents.

In California, D. hunteri has been collected only in the southeastern arid regions of the State within the range of Desert Bighorn Sheep. With one exception, only adult ticks have been collected (Table 7). Of the 31 recorded collections from California, 27 have been identified by us; 17 of these were taken from 1963 to 1980 at Deep Canyon, 3.5 miles south of Palm Desert, Riverside County. Several of these collections were made by entomologists beating vegetation to collect insects. The majority of California collections were made in March and April, but adults have been taken in all seasons.

The single California record of a wild-caught nymph of D. hunteri is for a specimen taken from Neotoma lepida, V-30-80, in the Kelso Mountains, San Bernardino County (S.

TABLE 7. California Records of Dermacentor hunteri Bishopp

Host or Source	Tick Collections	
	Adults	Nymphs
Homo sapiens	5	-
Neotoma lepida	-	1
Ovis canadensis	3	-
Vegetation (including tick drag)	10	-
Malaise trap baited with CO_2	1	-
Unrecorded	11	-

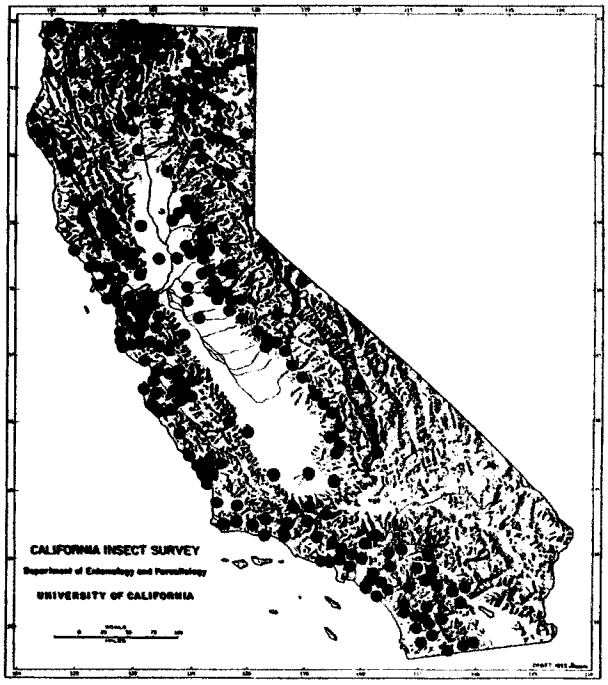
Dike). Identification of the nymph was confirmed by comparison with nymphs reared in our laboratory from wild-caught females of D. hunteri. Records from outside of California indicate that deer and more rarely rabbits may serve as at least occasional hosts of D. hunteri adults.

Dermacentor occidentalis Marx
Pacific Coast Tick
(Figs. 141-152; Map 10)

Dermacentor occidentalis Marx, in Curtice, 1892, J. Comp. Med. Vet. Arch. 13:226; Cooley, 1938, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 171:39 (all instars).

DIAGNOSIS. Female (Fig. 142). A medium-sized tick measuring about 2.9-3.8 X 1.8-2.5 mm. Typical specimens with silvery-gray pattern color prominent on scutum and dorsal surface of legs, with less on basis capituli and dorsal side of palpi. Extent of ornamentation highly variable. Basis capituli much wider than long. Cornua (Fig. 144) variable, typically slightly broader than long, terminating in subacute to rounded point. Scutum about half length of idiosoma; punctations in both sexes (Fig. 146) numerous, with smaller punctations (Fig. 141) more conspicuous and larger than in D. andersoni and each surrounded by wide areola of base color producing red "measled" appearance on ornamented areas of scutum (not visible on SEM photos). Cervical grooves (Fig. 145) short, broad, with posterolateral margins undefined. Spiracular plate broadly oval with short, broad posterolateral prolongation; goblet cells moderate sized, typically fewer than 100, with smaller punctations bordering frame and extending into posterolateral prolongation. Coxa I (Fig. 147) bifid, with inner spur broader than external spur and inner margins subparallel; apices rounded. External spurs on coxae II-IV subacute to acute. Internal spurs on coxae II and III marginal, rounded.

Male (Fig. 141). Length from tips of scapulae to posterior margin 2.6-3.9 mm; width 1.6-2.6 mm. Ornamentation as described for female. Basis capituli width slightly greater than length. Cornua (Fig. 143) large, prominent; length variable, up to as long as wide, terminating in round to pointed apex. Scutum with cervical grooves deep, rounded, pit-like; punctations as in female, but more prominent. Spiracular plate (Fig. 148) as in female, but with more pronounced posterolateral projection. Coxal spurs as in female.



MAP 10. Distribution in California of Dermacentor occidentalis Marx, solid circles.

Nymph. Idiosoma maximum length to tips of scapulae 1.21 mm (maximum length of D. andersoni 1.45 mm) (Brinton et al., 1965); distance between lateral points of basis capituli about 306-317 µm; ventral spurs of basis capituli distinct, postmarginal (Figs. 151, 152); external spur of coxa I moderate-sized, 48 X 40 µm wide (73 X 54 µm in andersoni); internal spur small, distinct (Fig. 152), not deflected outward; spiracular plate subcircular to oval (Fig. 150), with longest axis at right angle to long axis of tick body; anteroposterior length about 94-113 µm (about 127 µm in andersoni) and with moderate-sized goblet cells (up to 17 µm diameter).

Larva. Broadly ovoid, tapering anteriorly. As described for D. andersoni, but palpi rounded apically, posterodorsal margin of basis capituli straight to slightly concave, distance between lateral points of basis capituli 167-182 µm, and internal spur on coxa I more acutely pointed.

Immature instars of D. occidentalis are particularly difficult to distinguish from

D. andersoni in areas where both species occur. Adults are usually distinguishable as described under D. andersoni. Although hybridization between male occidentalis and female andersoni has been described (Oliver et al., 1972), the authors concluded that this very rarely happens in nature.

The Pacific Coast tick is known only from California, Oregon, and northern Baja California, Mexico. Adult ticks occur commonly on cattle, horses, deer, and man. Both sexes of D. occidentalis remain attached to their hosts for extended periods. Oliver and Brinton (1972) determined that the male usually requires 5 days attachment before becoming sexually potent. Larvae and nymphs normally feed on various rodents and other small mammals. It is our impression that nymphs of D. occidentalis attack humans more frequently than indicated by the record; the irritation produced by their feeding is easily mistaken for that produced by other arthropods such as spiders. The total impact of this tick on the health of man and livestock is incompletely known, but it is associated with a formidable list of diseases. D. occidentalis causes tick paralysis in cattle, horses, and deer in several different areas of California and is associated with the transmission and spread of bovine anaplasmosis. It has been found naturally infected with Colorado tick fever virus, the rickettsia of Q fever, and the causal agent of tularemia. Lane et al. (1981) isolated spotted fever group rickettsiae from D. occidentalis collected in Mendocino County.

The Pacific Coast tick occurs throughout most of California, except for the southeastern desert region and parts of the San Joaquin and Sacramento valleys. Collections, primarily of adults, are recorded from 54 of 58 counties. As indicated in Table 8, man and deer are the most frequently recorded hosts of the adult ticks. In part this reflects the results of a systematic survey of the ectoparasites of deer conducted by Westrom (1975). Over a two-year period 59 of 72 (82%) black-tailed deer examined at the Hopland Field Station in Mendocino County were found to be infested with this tick. It was the most frequently encountered tick on the deer of that area. Of 2,112 D. occidentalis collected from deer, all but 2 nymphs and 2 larvae were adults. California records of adult ticks from man, horses, and cattle are common, but verified collections from dogs are infrequent. This is surprising, because adults of this tick are so commonly collected from vegetation in areas frequented by dogs. Adults of D. occidentalis were identified by us from 2 of 167 bears examined for ectoparasites by D. Graeber from 1974 to 1978 in Yosemite National Park,

TABLE 8. California Records of Dermacentor occidentalis Marx

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Homo sapiens	108	7	2	4
Ochotona princeps	-	1	-	-
Sylvilagus audubonii	3	1	-	-
Sylvilagus bachmani	-	1	1	1
Sylvilagus sp.	-	5	1	-
Lepus californicus	-	4	-	-
Lepus sp.	-	1	-	1
Eutamias merriami	4	3	-	-
Eutamias speciosus	-	1	-	-
Eutamias townsendi	-	1	-	-
Eutamias sp.	1	1	1	5
Spermophilus beecheyi	8	55	12	18
Spermophilus beldingi	-	1	-	-

TABLE 8 continued

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
"Ground squirrel"	1	-	-	-
Tamiasciurus douglasi	1	14	5	1
Perognathus californicus	8	3	-	-
Perognathus sp.	-	3	1	-
Dipodomys venustus	2	2	1	-
Reithrodontomys megalotis	-	-	1	-
Reithrodontomys sp.	1	-	-	-
Peromyscus maniculatus	4	8	3	-
Peromyscus truei	-	2	1	-
Peromyscus californicus	-	-	1	-
"Deer mouse"	-	-	-	1
Neotoma fuscipes	1	5	4	1
Neotoma lepida	-	4	-	-
Neotoma sp.	2	12	5	4
Microtus californicus	3	3	1	1
Microtus sp.	-	-	1	-
"House mouse"	1	1	-	-
Canis familiaris	7	-	-	-
Urocyon cineroargenteus	1	-	-	-
Ursus americanus	2	-	-	-
Mustela frenata	-	1	-	-
Taxidea taxus	1	-	-	-
Mephitis mephitis	-	1	-	-
Equus caballus	82	2	-	9
Shetland pony	-	-	-	1
"Mule"	5	-	1	1
Sus scrofa	1	-	-	-
Odocoileus hemionus columbianus	59	2	2	-
"Deer"	23	-	-	1
"Fallow deer"	2	-	-	-
Bos taurus	63	2	1	7
Ovis aries	1	-	-	-
Vegetation (tick drag)	418	4	2	42
CO_2 trap	6	1	-	-
Miscellaneous	3	1	-	-
House	4	1	-	-
Unrecorded	245	2		12

but none were found on 73 bears examined from May to December 1980 at Sequoia National Park.

Incidence of adult D. occidentalis in California is greatest during April and May, although adult ticks are recorded for every month. Nymphs and larvae are most common during spring and summer.

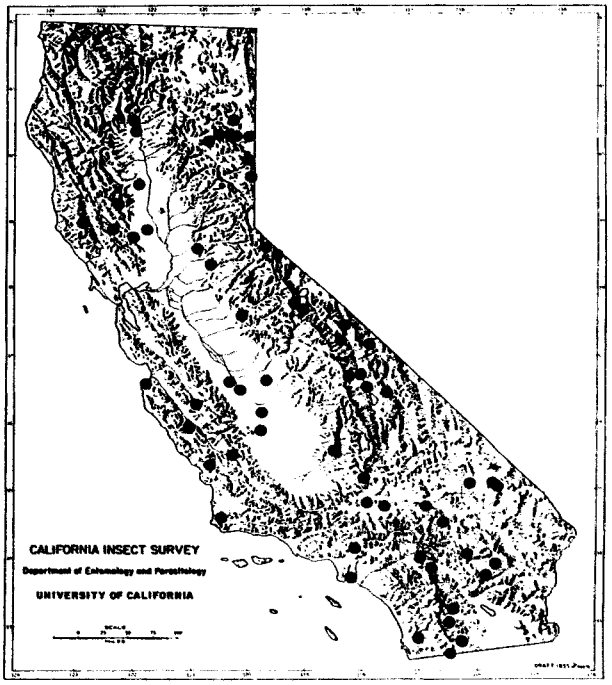
Dermacentor parumapertus Neumann (Figs. 153-159; Map 11)

Dermacentor parumapertus Neumann, 1901, Mém. Soc. Zool. Fr. 14:267-268 (female); Banks, 1908, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:45-46 (male, female); Cooley, 1938, U.S. Publ. Health Serv., Natl. Inst. Health Bull. 171:52 (nymph, larva).

Dermacentor parumapertus marginatus Banks, 1908, U.S. Dept. Agric., Bur. Ent. Tech. Ser. 15:46.

DIAGNOSIS. Female (Fig. 154). A relatively small Dermacentor, 2.2-3.4 mm long from tips of scapulae to posterior margin. Typically brown with gray pattern restricted to spot on posterior margin of scutum, but variable to extensive pattern. Basis capituli about 2X as broad as long. Cornua short, rounded. Scutum about half length of idiosoma in unfed specimen; posterior scutal margins irregularly subangulate; cervical grooves deep, elongate, diverging posteriorly, with posterolateral margins merging imperceptibly with adjacent surface (Fig. 156); median anterior area and areas anterolateral to cervical grooves elevated; punctations large, most numerous along posterior cervical grooves; small punctations so minute as to be easily overlooked. Spiracular plate broadly oval with distinct, broad posterolateral prolongation; goblet cells larger in ring around macula, with fine punctations in remainder of plate including posterolateral prolongation. Coxa I bifid, with opposing margins of internal and external spurs divergent (Fig. 155). Coxae II and III with external and internal spurs; coxa IV with external spur.

Male (Fig. 153). Length 2.4-3.1 mm from tips of scapulae to posterior margin. Typically dark reddish-brown with gray pattern restricted to posterolateral marginal spots of scutum, but variable to extensive pattern. Basis capituli wider than long. Cornua wider than long, rounded. Scutum with cervical grooves parallel, long, deep anteriorly, open posteriorly; punctations large, prominent in lateral grooves. Small punctations minute, inconspicuous. Spiracular plate similar to that of female, but posterolateral prolongation typically narrower. Coxal spurs (Fig. 155) as described for female.



MAP 11. Distribution in California of Dermacentor parumapertus Neumann, solid circles.

Nymph. Basis capituli (Fig. 158) subtriangular, with lateral points extending past apices of scapulae; ventral spurs indistinct. Scutum over $\frac{1}{3}$ length of idiosoma; cervical grooves elongate, deep anteriorly with parallel sides; shallow posteriorly. Spiracular plate (Fig. 159) subcircular to slightly ovoid, with narrower end laterodorsal; macula eccentric, surrounded by ring of 6-7 larger goblet cells and 1 to several rings of irregular perforations. Coxa I (Fig. 157) with moderate-sized external spur but internal spur an indistinct swelling. Coxae II, III, IV (Fig. 157) with small external spurs, sometimes reduced on IV.

Larva. Basis capituli subtriangular, moderately pointed laterally. Palpi rounded apically; dermal sensillae present. Cervical grooves distinct, deep anteriorly. Coxa I with internal spur small, broadly tapered, rounded to subacute apically; coxae II and III with only small, broad, external spurs.

Adults of D. parumapertus differ from all other California species of Dermacentor in that the opposing margins of the internal and external spurs of coxa I obviously diverge. Nymphs resemble those of D. andersoni and D. occidentalis, but andersoni has a much larger external spur on coxa I, and both andersoni and occidentalis have a well-defined internal spur on Coxa I. From the very similar nymphs of D. hunteri, parumapertus differs in having less acutely pointed lateral points on the basis capituli, more rounded spiracular plates, and a smaller external spur on coxa I. Larvae differ from other species of the genus by a combination of dermal sensilla and a broadly tapered, rounded to subacute spur on coxa I.

D. parumapertus does not normally feed on man, but it is considered of great potential significance in the maintenance of zoonoses. It has been found naturally infected with Colorado tick fever virus, with Francisella tularensis, and with a rickettsia of the spotted fever group. Experimentally it has been shown to transmit the rickettsia of Rocky Mountain spotted fever and the bacillus of tularemia.

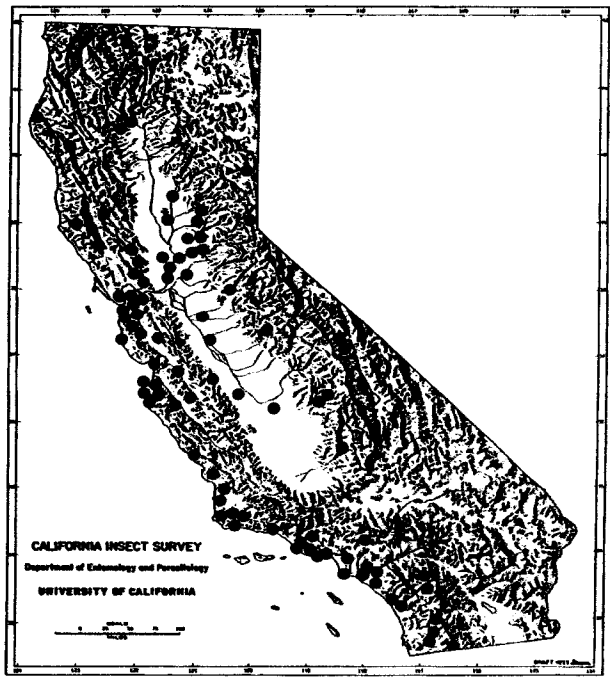
D. parumapertus is widely distributed in the southwestern United States and adjacent regions of Mexico. The adults occur most abundantly on the Black-tailed Jackrabbit. Nymphs occur in lesser numbers on jackrabbits, and both nymphs and larvae commonly infest a variety of small rodents (Gastfriend, 1955; Allred and Roscoe, 1956).

In California, D. parumapertus is widely distributed, particularly in lowland areas of the Central Valley, the mountains, and Great Basin region in the east, the southeast corner of Lassen County, and the southeastern arid part of the State. It is also known along the coast from Mendocino County south to the Mexican border. California records of the tick reflect the recorded host distribution of Lepus californicus, to which adult ticks primarily are restricted. Immatures occur on a variety of rodents as well as on Sylvilagus and Lepus (Table 9). California collections of adult D. parumapertus have been limited to March through August. Nymphs and larvae have been taken in every season except late fall.

Dermacentor variabilis (Say)
American Dog Tick
(Figs. 160–167; Map 12)

Ixodes variabilis Say, 1821, J. Acad. Nat. Sci. Phila. 2:77 (male; female, described as Ixodes punctulatus; synonymy). Dermacentor variabilis; Banks, 1908, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:49; Cooley, 1938, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 171:23 (all instars described); Arthur, 1960, Ticks: a monograph of the Ixodoidea 5:40 (synonymy).

DIAGNOSIS. Female (Fig. 161). Medium to large Dermacentor; unfed specimens 2.7–5.2 X 2.2–3.0 mm (Cooley, 1938); engorged female up to 15 X 10 mm. Basis capituli wider than long, with cornua broad, short, and apices narrowly to bluntly rounded. Scutum with silvery-gray pattern of variable extent, typically more extensive than red-brown base color. Cervical grooves (Fig. 161) shallow and constricted anteriorly; deep, prominent, long in midsection, shallow posteriorly; combined appearance of apposed cervical grooves hourglass-shaped. Large scutal punctations prominent; small punctations more numerous, but obvious only in patterned areas. Diameter large punctations up to 4X small punctations. Scutum less than half length of idiosoma; posterior margin angulate. Spiracular plate shape



MAP 12. Distribution in California of Dermacentor variabilis (Say), solid circles.

variable, typically broad with blunt posterodorsal prolongation; goblet cells very small and numerous, with smaller punctations near frame and in posterodorsal prolongation (Fig. 163). Coxa I with large inner spur, roughly triangular; external spur of subequal length, but slimmer; opposing margins of spurs subparallel. Coxae II and III with external spurs and smaller, rounded internal spurs. Coxa IV with small external spur; internal spur absent or at most represented by small marginal swelling.

Male (Fig. 160). Medium to large, 2.3-4.4 X 1.6-2.4 mm (Cooley, 1938). Silvery-gray pattern of variable extent but frequently less extensive than red-brown on scutum. Basis capituli as described for female. Scutum with cervical grooves deep, short. Punctations and spiracular plate (Fig. 162) as in female. Coxal spurs as in female, but no vestige of internal spur on Coxa IV.

Nymph. Basis capituli (Fig. 164) subtriangular with anterolateral margins

TABLE 9. California Records of Dermacentor parumapertus Neumann

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Homo sapiens	1	-	-	-
Sylvilagus audubonii	2	-	-	-
Sylvilagus bachmani	1	1	-	-
Sylvilagus sp.	7	5	3	-
"Rabbit"	2	1	-	1
Lepus californicus	37	9	3	3
Lepus deserticola	1	-	-	-
Lepus sp.	43	37	6	10
Eutamias minimus	-	1	-	-
Eutamias sp.	-	-	-	1
Spermophilus beldingi	-	1	-	-
Spermophilus lateralis	-	1	-	-
Spermophilus sp.	-	-	-	1
Perognathus longimembris	-	3	1	-
Perognathus parvus	-	2	-	-
Dipodomys agilis	-	1	-	-
Dipodomys heermanni	-	1	1	-
Dipodomys merriami	-	12	1	-
Dipodomys ordii	-	2	-	-
Dipodomys panamintinus	-	9	2	-
Dipodomys sp.	-	1	1	-
Peromyscus californicus	-	1	-	-
Canis familiaris	-	-	-	1
Canis latrans	-	-	-	1
Vegetation (tick drag)	1	-	-	-
Unrecorded host	2	-	1	2

straight or slightly concave; lateral points long, slender; posterodorsal margin almost straight; ventral basal spurs (Fig. 166) variable but distinct. Palpi long, slender. Scutum (Fig. 164) with posterior margin arcuate, extending over one-third to half of idiosoma. Spiracular plate (Fig. 167) large, 134 X 162 µm, suboval, with longer apex parallel to that of body. Approximately 20 small goblet cells, 6-9 µm diameter, surrounding eccentric macula; frame bordered by band of many minute punctations. Coxa I (Fig. 165) with external spur large, semiacute; internal spur small, acute to subacute, distinct. Coxae II and III with small external spurs, those on IV indistinct to absent (Fig. 165).

Larva. Palpi relatively slender. Dermal sensillae absent. Basis capituli with lateral points prominent; anterolateral margins irregularly curved; posterodorsal margin straight. Scutum extending one-third to half length of idiosoma; posterior margin shallowly arcuate, irregular. Coxa I with subacute internal spur; II and III each with broad, indistinct, external spur.

Adults of D. variabilis differ from all other species of Dermacentor in the finely granular appearance of the spiracular plate. Nymphs closely resemble D. andersoni, but the spiracular plate has smaller goblet cells, the palpi are slenderer, and the anterolateral margins of the basis capituli are not elevated nor is the posterior margin composed of 3 distinct arcs as in andersoni. Larvae lack the dermal sensilla seen in andersoni; they are distinguished from the very similar larvae of D. hunteri by a more acute spur on coxa I and by a more arcuate posterior margin of the scutum.

D. variabilis is the most important vector of Rickettsia rickettsii, the causal organism of Rocky Mountain spotted fever, in the eastern United States. It is also capable of transmitting to man Francisella tularensis. It causes tick paralysis in the eastern United States as well as in California (Robinow and Carroll, 1938; Jessup, 1979).

The American dog tick is widespread in the eastern and central United States as well as in California, Oregon, eastern Washington, and northern Idaho. In Canada it occurs in southeastern and south-central regions, and Bishopp and Trembley (1945) record it from Mexico.

The dog is a preferred host of the adult ticks, but man and many wild and domesticated large mammals are attacked. Immature instars feed on a variety of rodents and lagomorphs, particularly meadow mice (Microtus spp.). Adult ticks mate on the host while females feed. Following an engorgement period of up to 13 days the female drops to the ground, where she may lay up to 6,500 eggs. The life cycle of this 3-host tick may be completed in less than a year, but in the absence of a suitable host all stages are able to withstand relatively long periods of starvation; in such cases completion of the life cycle may take 2 or more years. The remarkable ability of the American dog tick to survive adverse environmental conditions is exemplified by our collection of 2 female ticks from an area recently flooded for more than 6 weeks to a depth of approximately 12 feet. The ticks were caked with fine sediment, indicating prolonged immersion, but it is possible that they had crawled out of the water on the emergent trunks of trees in the vicinity during the course of the flood.

In California, adults of the American dog tick have been recorded for every month, with the majority from March through July. Few records of immature instars have been made for the State, but larvae and nymphs appear to be active from late winter until summer. Collection records indicate that the American dog tick is a long-time resident of California: numerous collections are recorded from a variety of locations early in the twentieth century.

Recorded hosts of D. variabilis in California are given in Table 10. Dogs and humans are commonly attacked by the adult tick, with a variety of carnivores also serving as hosts. D. variabilis occurs most abundantly in the coastal ranges from northern to southern California; it also appears to be well established on the floor of the interior valleys, particularly in the Sacramento Valley. Several collections have been recorded from mountainous areas of east-central California, including 4 females collected from a black bear at an elevation of 6,400 ft at Sequoia National Park, Tulare County, VI-27-1980 (D. Graber).

Genus Haemaphysalis Koch

Haemaphysalis Koch, 1844, Arch. Naturgesch. (Berlin) 10:237; Nuttall and Warburton, 1915, Ticks: a monograph of the Ixodoidea 3:349 (synonymy, literature, diagnosis); Cooley, 1946, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 187: 30-51.

TABLE 10. California Records of Dermacentor variabilis (Say)

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Gerrhonotus sp.	-	1	1	-
Sturnus vulgaris	-	1	-	-
Didelphis marsupialis virginiana	1	-	-	-
Homo sapiens	16	-	-	1
Sylvilagus audubonii	1	-	-	-
Lepus californicus	1	-	-	-
Peromyscus sp.	-	1	-	-
Microtus californicus	1	35	1	-
Canis familiaris	91	-	1	1
Canis latrans	12	-	-	1
Urocyon cinereoargenteus	7	1	-	-
"Fox"	2	-	-	-
Ursus americanus	1	-	-	-
Procyon lotor	8	-	-	-
Mustela frenata	1	-	-	-
Taxidea taxus	7	-	-	-
"Skunk"	1	-	-	-
Felis domestica	2	-	-	-
Felis rufus	10	-	-	-
"Wild cat"	1	-	-	-
Equus caballus	1	-	-	-
"Deer"	1	-	-	-
Bos taurus	5	1	-	1
Vegetation (tick drag)	16	-	1	-
Unrecorded source	59	-	-	2

Type of genus: Haemaphysalis concinna Koch.

DIAGNOSIS. Small, inconspicuous ticks. All instars with lateral expansions of palpal segment II extending beyond margins of basis capituli (Fig. 181), characteristic of no other genus found in California. All instars inornate; eyes absent; festoons present. Anal groove posterior to anus in adults and nymphs. Male without shields or plates ventrally. Larvae with 2 marginal dorsal pairs of setae anterior to sensillae sagittiformia and 1 pair of posthypostomal setae.

KEY TO HAEMAPHYSALIS SPECIES IN CALIFORNIA

Ventral cornua present (Fig. 179); hypostome dentition 3/3 in adults (Fig. 179); male with short internal spur on coxa IV (Fig. 180); nymph with basis capituli quadrangular dorsally (Fig. 182); larva with lateral margins of basis rounded. . . . . leporispalustris

Ventral cornua absent (Fig. 170); hypostome dentition 5/5 in

adults (Fig. 171); male with long internal spur on coxa IV (Fig. 174); nymph with basis capituli hexagonal dorsally (Fig. 175); larva with lateral margins of basis acute. . chordeilis

Haemaphysalis chordeilis (Packard) (Figs. 168-175; Map 13)

Ixodes chordeilis Packard, 1869, Ann. Rept. Peabody Acad. Sci. 1:67 (female).

Haemaphysalis punctata var. cinnabarina, Neumann, 1905, Arch. Parasitologie 9:237 (nec Koch, 1844).

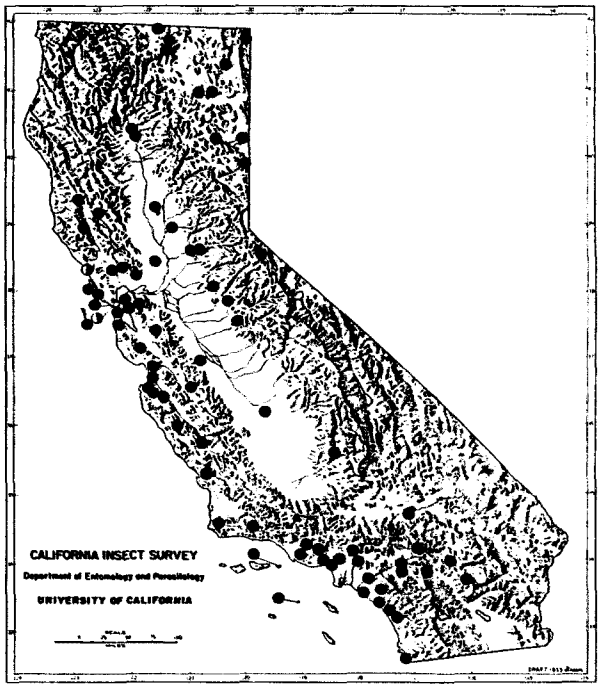
Haemaphyslis chordeilis; Banks, 1908, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:34, pl. iv, fig. 11.

Haemaphysalis cinnabarina; Nuttall and Warburton, 1915, Ticks: a monograph of the Ixodoidea 3:372, figs. 316-320 (nec Koch) (all instars).

DIAGNOSIS. Female. Size and shape similar to H. leporispalustris. Unfed female 2.8-2.9 X 1.4-1.8 mm (Hooker et al., 1912). Basis capituli (Fig. 173) with porose areas large, oval, depressed, well separated; dorsal cornua rudimentary to absent; basal spurs (ventral cornua) absent (Fig. 170). Palpal segment II with lateral angle short, truncated; segment III with short, retrograde ventral spur (Fig. 171). Hypostome (Fig. 171) clavate, with small corona; dentition 5/5. Scutum (Fig. 172) oval, widest anteriorly, with large, rather blunt scapulae. Cervical grooves conspicuous. Legs lacking ventral trochanteral spurs; trochanter I with large, pointed dorsal spur; all tarsi with terminal ventral spurs. Coxa I with moderately long subacute internal spur. Coxa IV with spur as large or larger than spur of Coxa II or III.

Male. Essentially same size as unfed female. Shape (Fig. 168) elongate ovoid; widest behind middle. Basis capituli shape similar to female, but dorsal cornua distinct and longer. Palpi and hypostome as in female (Fig. 170). Scutum (Fig. 168) ovoid, convex, widest behind middle. Legs and coxae similar to those of female, except that coxa IV with very long acuminate spur (Fig. 174).

Nymph. Basis capituli (Fig. 175) hexagonal dorsally; cornua absent both dorsally and ventrally. Palpi as in adults. Hypostome clavate; dentition 2/2. Scutum subcircular; cervical grooves distinct. Legs with only trochanter I bearing dorsal spur. Trochanters without ventral spurs. Coxae essentially as in female.



MAP 13. Distribution in California of Haemaphysalis chordeilis (Packard), half-circles; H. leporispalustris (Packard), solid circles.

Larva. Basis capituli hexagonal dorsally; lacking either dorsal or ventral cornua. Hypostome rounded apically; dentition 2/2. Scutum broader than long. Coxae with distinct spur only on II.

H. chordeilis adults are easily distinguished from those of H. leporispalustris by the lack of a ventral cornua on the basis capituli and a denticular hypostomal formula of 5/5 rather than 3/3. A long, prominent internal spur on coxa IV of chordeilis males separates them from leporispalustris. Nymphs and larvae of chordeilis are separable by the hexagonal shape of the basis capituli in dorsal view as well as by the absence of a ventral cornua.

H. chordeilis is primarily a bird tick, although it has been recorded from a variety of mammals, including man. It is generally considered to be widespread in the eastern United States and throughout Canada except for the Pacific coast wet belt (Gregson,

1956). It has been implicated in the death of turkeys in the United States.

CALIFORNIA RECORDS. H. chordeilis has been recorded rarely in California, and from only two locations, both near the coast in northern California. MARIN CO.: Fort Barry: 1 male and 1 female, I-3-1952, and 1 male, I-9-1952, both collections taken from vegetation by a tick drag (Rocky Mountain Laboratory collection); 1 nymph, II-4-1952, no other information, but identified by G.M. Kohls. SONOMA CO.: Bodega Bay Head, 1 male, I-27-1980, collected from vegetation by tick drag (A. McGowan).

Haemaphysalis leporispalustris (Packard)
Rabbit Tick
(Figs. 176-183, Map 13)

Ixodes leporis-palustris Packard, 1869, Ann. Rept. Peabody Acad. Sci. 1:67 (female).
Haemaphysalis leporis-palustris; Nuttall and Warburton, 1915, Ticks: a monograph of the Ixodoidea 3:387 (synonymy; description of all instars).

DIAGNOSIS. Female. Small, broadly ovoid tick, widest posteriorly (Fig. 177). Length of unfed female, tips of palpi to posterior margin, 1.71-2.5 mm; engorged female up to 10 X 7 mm (Cooley, 1946a). Basis capituli quadrate, with porose areas mildly depressed, oval, well separated (Fig. 181); dorsal cornua present or absent; basal spurs (ventral cornua) present on posterior ventral margin as in male (Fig. 179). Palpal segment II with lateral angle more reflexed and longer than in H. chordeilis (Fig. 181); segment III with short retrograde ventral spur as in male (Fig. 179). Hypostome clavate, with small corona; dentition 3/3. Scutum oval, widest anteriorly (Fig. 177); scapulae rounded, large; cervical grooves elongate, conspicuous. Legs with small ventral spurs on trochanters; trochanter I with large, acute, dorsal spur (Fig. 181); tarsi lacking spurs. Coxa I with large, rounded internal spur and small external spur; coxae II-IV each with short spur.

Male. Body shape and size similar to unfed female or slightly smaller (Fig. 176). Basis capituli (Fig. 178) shape similar to female, dorsal cornua always distinct and longer than in female. Ventral cornua, palpi (Fig. 179) as in female. Hypostome as in female except for larger corona (Fig. 179). Scutum (Fig. 176) ovoid, widest behind midlevel. Cervical grooves conspicuous. Legs and coxal spurs as in female, with spur of coxa IV short, acute (Fig. 180).

Nymph. Basis capituli and palpi (Fig. 182) similar to male, segment 2 of palpi with 4-8, only slightly barbed hairs on inner margin. Hypostome rounded distally; dentition 2/2 to base. Scutum subcircular; cervical grooves distinct. Trochanter of leg I with spurs as in adults. Coxae (Fig. 183) as in adults.

Larva. Basis capituli rectangular dorsally, similar to nymph, including ventral cornua. Hypostome similar to nymph, fewer teeth per file. Coxa I with raised lobe on inner side; coxae II and III each with definite spur.

All instars of H. leporispalustris are separable from H. chordeilis as described under the latter.

The rabbit tick is widely distributed throughout the Western Hemisphere. It is a 3-host tick that commonly parasitizes lagomorphs during all stages of its life history. Larvae and nymphs frequently parasitize a variety of rodents and ground-frequenting birds, but adults occur almost exclusively on rabbits. Sonenshine and Stout (1970) reported 40 species of birds as hosts for immature instars of the rabbit tick. As demonstrated by George (1971), the drop-off rhythm of engorged rabbit ticks is adapted to the resting habits of the rabbit host. Camin and Drenner (1978) found host specificity of larval ticks linked to strato-orientation of the larvae on vegetation during the host-finding stage.

The rabbit tick is involved in the transmission of the causal rickettsia of Rocky Mountain spotted fever and the bacillus of tularemia. It is important in maintaining reservoirs of these infections in nature, but it is not responsible for direct transmission of these agents to man, since it does not bite humans. Lane (personal communication, 1980) reports that 2.75% of H. leporispalustris pools taken in Mendocino County produced antibodies to spotted-fever-group rickettsiae when inoculated into mice. Tully et al. (1977) reported that a spiroplasma from H. leporispalustris experimentally is associated with ocular and other disease symptoms in laboratory mice and rats.

In California, adult and nymphal rabbit ticks are found on hosts throughout the year but have been collected most abundantly in

the spring. Larvae have been recorded during every season except winter. The tick has been collected in 35 counties of the State, throughout the coastal range from Mendocino County in the north to San Diego County in the south. It occurs in inland areas around and within the Central Valley, the northeastern Modoc plateau, and in relatively arid parts of southern counties. As seen in Table 11, almost all collections of adult H. leporispalustris in California have been from jackrabbits or brush rabbits. Although the majority of collections of immature instars are also from lagomorphs, a variety of rodents and birds have been found infested with larvae and/or nymphs of the rabbit tick. The 2 collections recorded from man and the single collections each from the dog, wildcat, deer, and cow may not represent specimens feeding on these hosts.

Genus Ixodes Latreille

Ixodes Latreille, 1795, Mag. Encycl. J. Sci. Lett. Arts, 4:18.
Ixodes Salmon and Stiles, 1901, 17th Rept. U.S. Bur. Anim. Ind., p. 459.
Ixodes Nuttall and Warburton, 1911, Ticks: a monograph of the Ixodoidea, 2:116.
Ixodes Cooley and Kohls, 1945, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 184:7.
Ixodes Keirans and Clifford, 1978, J. Med. Entomol. Suppl. 2:3.

Type of genus: Acarus ricinus Linnaeus, 1758.

Ixodes species lack ornamentation, eyes, and festoons. Anal groove surrounding anus anteriorly. Palpi variable. Coxae of subequal size, with or without spurs. Males with 7 nonsalient ventral plates.

Of 36 species of Ixodes recorded from the United States, 20 are known from California.

KEY TO FEMALES OF IXODES IN CALIFORNIA[1]

1 Porose areas large but not contiguous. Cornua absent. Palpal article IV visible dorsally (Fig. 336). Auriculae absent (Fig. 337). Coxae lacking internal and external spurs (Fig. 333) . . . . . subgenus Ceratixodes - uriae

Without this combination of characters. 2

2(1) Porose areas large, occupying most of dorsal surface of basis capituli, almost contiguous or fused (Fig. 306). Cornua absent. Coxae I-IV with external spurs, lacking internal spurs (Fig. 225). Trochanters I and II with small spurs (Fig. 225) . . . .subgenus Scaphixodes - 3

Without this combination of characters. 4

3(2) Hypostome arising from a small median extension of basis capituli; auriculae as bulbous lateral extensions (Fig. 224). . . . . .howelli

Hypostome not arising from a median extension of basis capituli; auriculae as evenly curved, shelf-like lateral extensions (Fig. 307) . . . signatus

4(2) Cornua present (Fig. 194). Auriculae large, posteriorly directed spurs or bulbous projections. Palpal article I with large, anteriorly directed spur (Fig. 195). Trochanters with spurs. Hypostome dentition 5/5 anteriorly. . . . . subgenus Multidentatus - auritulus

Without this combination of characters. 5

5(4) Palpi either thick, club-like, length:width ratio 3:1 or less (Fig. 282), or if greater than 3:1 (angustus, holdenriedi, ochotonae, woodi), hypostome pointed to very narrowly rounded apically (Figs. 189, 347). Auriculae absent or faint (except for small, definite triangular saliences in some hearlei) . . . . . .subgenus Pholeoixodes - 6

Palpi much longer than wide, length:width ratio greater than 3:1 (Fig. 248). Auriculae either prominent as angular shelf-like extensions or posteriorly directed spurs or

[1]Adapted from Keirans and Clifford (1978).

TABLE 11. California Records of Haemaphysalis leporispalustris (Packard)

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Lophortyx californica	-	4	-	-
Melanerpes formicivorus	-	-	1	-
Chamaea fasciata	-	-	1	-
Thryomanes bewicki	-	1	2	-
Toxostoma bendirei	-	-	1	-
Toxostoma redivivum	1	1	-	-
Oreoscoptes montanus	-	-	1	-
Pipilo erythrophthalmus	-	2	5	-
Pipilo fuscus	1	1	-	-
Zonotrichia atricapilla	-	1	-	-
Zonotrichia leucophrys	-	1	1	-
Melospiza melodia	-	1	2	-
Homo sapiens	-	2	-	-
Sylvilagus audubonii	9	13	5	9
Sylvilagus bachmani	18	23	14	2
Sylvilagus cinerescens	1	-	-	-
Sylvilagus nuttallii	1	-	-	-
Sylvilagus sp.	18	17	10	3
"Rabbit"	10	10	4	5
Oryctolagus cuniculus	1	-	-	-
Lepus californicus	24	17	19	3
Lepus sp.	31	17	10	3
Eutamias maculatus	-	1	-	-
Eutamias sp.	-	-	-	1
Spermophilus beecheyi	-	1	-	5
Spermophilus beldingi	-	-	1	-
Spermophilus lateralis	-	1	-	-
Spermophilus sp.	-	-	-	1
Neotoma sp.	1	-	-	-
Canis familiaris	1	-	-	-
Felis rufus	-	-	-	1
Odocoileus hemionus	-	-	-	1
Bos taurus	1	-	-	-
Ground litter	1	-	-	-
Unrecorded	5	4	1	1

curved horns (Fig. 249), or if weakly developed as lateral saliences (jellisoni, pacificus), hypostome rounded apically . . . . . subgenus Ixodes - 15

6(5) Basis capituli ventrally with angular hump on each side of hypostome (Fig. 327). Scutum about as long as wide, with rugose lateral areas (Fig. 324) . . . . . .texanus

Basis capituli without angular hump on each side of hypostome (Fig. 347) (rounded shoulders on each side of hypostome in I. kingi). Scutum as long or longer than wide; lateral areas smooth, punctate, and/or rugose . .7

7(6) Space between small porose areas 1.5-2 X greater than width of one porose area (Fig. 210). Auriculae, if apparent, lateral bluntly triangular protuberances (Fig. 211). Hypostome rounded. Coxa I with short, weak internal spur . . . . . hearlei

Space between medium sized to large porose areas half to subequal width of one porose area (porose areas weak in I. soricis and small with deep pores in I. kingi). Auriculae absent or small and weakly defined (Fig. 347). Hypostome pointed, or if rounded, coxa I with strong internal spur 8

8(7) Ventral surface of basis capituli very elongate, smooth, impunctate, not constricted laterally (Fig. 347). Hypostome dental formula 2/2 throughout length. Cornua absent. Prominent lateral ridges bordering porose areas (Fig. 346). Scutum (Fig. 345) much longer than wide, with definite lateral carinae and large anteriorly projecting scapulae. . . . . .woodi

Without this combination of characters. 9

9(8) Coxa I with internal and external spurs subequal (Fig. 311) 10

Coxa I with internal spur definitely longer than external (Fig. 297). 13

10(9) Very small tick (ca. 1.5 mm long), with furrows on posterior margin of scutum (Fig. 310). Barbed setae on all coxae (Fig. 311). . . . . .soricis

Without this combination of characters. 11

11(10) Hypostome 3/3 throughout length; lateral denticles flaring (Fig. 189). . . . . angustus

Hypostome 3/3 only at apical end; 2/2 at base (Fig. 215); lateral denticles not flaring 12

12(11) Scutum narrowly elongate (Fig. 250), over 1.2 mm long; lateral carinae near lateral margin . . . . . .ochotonae

Scutum broadly elongate (Fig. 216), about 1.05 mm long; lateral carinae not close to lateral margin. . . . . holdenriedi

13(9) Scutum usually distinctly rugose, especially in anterolateral area (Fig. 287). Cornua absent . . . . . .rugosus

Scutum punctate but not distinctly wrinkled (Fig. 235). Cornua present, distinct 14

14(13) Posterior margin of basis capituli sinuous between cornua (Fig. 298). . . . . sculptus

Posterior margin of basis capituli straight or evenly curved (Fig. 238) . . . . . kingi

15(5) Auriculae laterally extended, sharp-edged protuberances (Fig. 203). Porose areas diffuse (Fig. 202). Trochanters with spurs (Fig. 201). . . . . brunneus

Without this combination of characters. 16

16(15) Auriculae reduced or not apparent (Fig. 263). 17

Auriculae as definite curved horns (Fig. 317) or posteriorly directed protuberances (Fig. 273). 18

17(16) Genital aperture between coxae IV. Transverse sutural line on venter of basis capituli usually visible (Fig. 263). Apex of hypostome bluntly

rounded (Fig. 263). Hypostome denticle formula 4/4 apically. File 3 of hypostome denticles extends over half of length. Tarsus I approximately 0.84 mm long exclusive of ambulacrum. . . . . .pacificus

Genital aperture at level of coxae III. Transverse sutural line not visible. Apex of hypostome very narrowly rounded but not acuminate. Hypostome dental formula 3/3 apically. File 3 of hypostome denticles extends not more than half of length (Fig. 231). Tarsus I approximately 0.54 mm long exclusive of ambulacrum . .jellisoni

18(16) Auriculae as posteriorly directed spurs (Fig. 273). . . . . .peromysci

Auriculae as curved, retrograde horns (Fig. 249). 19

19(18) Genital pore at level of posterior margins of coxae IV. Hypostome arises from smoothly acuminate medial projection of basis capituli (Fig. 317). Spur on palpal article I usually broadly pointed, hook-like, with sides not equilateral (Fig. 317). . . . . spinipalpis

Genital pore at level of coxae III or III-IV. Hypostome arises from round-shouldered medial projection of basis capituli (Fig. 249). Spur on palpal article I sharp, forming an isosceles triangle with palpal margin (Fig. 249) . .neotomae

KEY TO MALES OF IXODES SPECIES IN CALIFORNIA[1]

1 Fourth palpal segment not terminal, protruding from ventral surface of 3rd segment (Fig. 335). Hypostome deeply indented apically, denticles obsolete (Fig. 335). Coxae without spurs (Fig. 331). Ventral plates terminally with a fringe of long setae (Fig. 334). . subgenus Ceratixodes - uriae

Without this combination of characters. 2

2(1) Scutum smooth, with 2 pit-like depressions dorsolaterally (Fig. 196). . . . . .auritulus

Scutum smooth or rough, but lacking 2 pit-like depressions dorsolaterally. 3

3(2) Palpal articles 1-3 fused, cornua absent (Fig. 304). Hypostome rudimentary, denticles weakly developed (Fig. 305). Genital aperture situated between coxae II. Coxa I-IV with short external spurs; internal spurs absent (Fig. 222) 4

Without this combination of characters. 5

4(3) Hypostome rounded apically (Fig. 305). Terminal end of palpal segment 3 rounded (Fig. 305). . . . . signatus

Hypostome pointed apically. Terminal end of palpal segment 3 pointed (Fig. 223). . . . . .howelli

5(3) Hypostome with lateral denticles different in shape and size from median denticles (Fig. 261). 6

Hypostome with lateral and median denticles of subequal shape and size (Fig. 205) 9

6(5) Without definite cornua (Fig. 261). . . . . .pacificus

With definite cornua (Fig. 246) . . .7

7(6) Median ventral plate about $2\frac{1}{2}$ X as long as anal plate. Coxae I with moderately long, penciliform, bluntly pointed internal spur (Fig. 274). Body (idiosoma) not over 1.1 mm long . . . . . .peromysci

Median ventral plate about 3X as long as anal plate. Coxa I with long, tapering, pointed internal spur (Fig. 243). Body (idiosoma) 1-1.5 mm long . . .8

8(7) Pseudoscutum demarked by zone of punctations (Fig. 314). Basal

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[1] Adapted from Keirans and Clifford (1978). Key excludes the male of I. holdenriedi, which is unknown, and of jellisoni and ochotonae, which are poorly known.

teeth of hypostome as large as largest lateral teeth (Fig. 316). Body 1.38-1.5 mm long. . . . . spinipalpis

Pseudoscutum not demarked by zone of punctations. Basal teeth of hypostome not as large as largest lateral teeth (Fig. 249). Body 1.02 mm long. . neotomae

9(5) Trochanters with spurs (Fig. 207) . . . . . .brunneus

Trochanters without spurs 10

10(9) Cornua distinct (Fig. 236). Lateral carinae present on scutum . . . . . kingi

Cornua indistinct or absent. Scutum without lateral carinae. . 11

11(10)Small projection ventrally on palpal segment I. Coxa I with very short, blunt internal spur. Hypostome with mild transverse crenulations. Lacking well-defined shoulders at base of hypostome . . . . . .hearlei

Without this combination of characters. 12

12(11)Palpi very rugose dorsally. Posterior margin of basis capituli sinuous (Fig. 322). Ventrally, basis capituli with angular hump on each side of hypostome (Fig. 323). . . . . .texanus

Without this combination of characters. 13

13(12)Internal spur of coxa I relatively long, thin, acuminate (Fig. 293). Hypostome with definite teeth, not crenulations (Figs. 283, 295). 14

Internal spur of coxa I relatively short, not acuminate (Fig. 341). Hypostome with denticles as crenulations (Fig. 343). . . . 15

14(13)Hypostome with numerous rows of long, pointed, overlapping teeth (Fig. 283). . . . . .rugosus

Hypostome with fewer rows of short, rounded, widely spaced teeth (Fig. 295). . . . . sculptus

15(13)Extremely small tick (idiosoma ca. 1.0 mm long). Palpi bulbous. Hypostome reduced, with irregular crenulations. . . .soricis

Larger tick (idiosoma over 1.3 mm long). Palpi elongate (Fig. 343). Hypostome not reduced, with regular crenulations (Fig. 343). 16

16(15)Hypostome with large, regular crenulations overlapping base of preceding row (Fig. 187) . . . . . angustus

Hypostome with smaller crenulations not overlapping base of preceding row (Fig. 343). . . .woodi

KEY TO NYMPHS OF IXODES SPECIES IN CALIFORNIA[1]

1 External spurs vestigial or absent on all coxae 2

External spur present on coxa I (Fig. 349). 4

2(1) With only 1 pair of posthypostomal setae. Hosts are marine birds . . . . . .uriae

With 2 pairs of posthypostomal setae (Fig. 309). Varied hosts 3

3(2) Scutum widest anteriorly. Shoulders of hypostome humped or at right angle to hypostome ventrally (Fig. 329). Distinct rugose areas laterally on scutum and dorsally on palpi. Hosts primarily mustelids . .texanus

Scutum widest near middle. Shoulders of hypostome not humped, but gradually tapered. Palpi and scutum lacking distinct rugose areas. Hosts primarily squirrels . . . .hearlei

4(1) Internal spur of coxa I absent (Fig. 309). Hosts usually marine birds . . . . . .signatus

Internal spur of coxa I present (Fig. 349). Various hosts. 5

5(4) Hypostome dentition 4/4 with 4 or more denticles in the innermost file. Segment 1 of palpi

[1] Modified from Gregson (1956). Nymphs of I. holdenriedi, jellisoni, and neotomae are unknown.

with anterior spur but without posterior spur (Fig. 199). Hosts marine birds . . . . auritulus

Without this combination of characters. 6

6(5) Palpi long and slender (Fig. 266); length:width ratio usually exceeds 3.5:1. Hypostome apex pointed or narrowly rounded (Fig. 267) (rarely blunt). Auriculae present. 7

Palpi (Fig. 190) short to moderately long, thickset, length: width ratio usually less than 3.5:1. Hypostome apex blunt (Fig. 190). Auriculae present or absent 10

7(6) Basis capituli with 2 auriculae on each side (Fig. 209). Hypostome pointed apically. Hosts birds . . . . . brunneus

Basis capituli with single auricula on each side (Fig. 319). Hypostome narrowly rounded apically (Fig. 319). Hosts various 8

8(7) Basis capituli appears subtriangular in dorsal view (Fig. 264). Internal spur of coxa I about 2X as long as external spur (Fig. 267). Scutum slightly wider than long and with scapulae short and rounded (Fig. 264). Unfed body length 1.0-1.2 mm. Hosts lizards, small and large mammals, and birds . . . . . .pacificus

Without this combination of characters. 9

9(8) A very small tick; body ca. 0.65 mm long in unfed state; capitulum length 0.25 mm; width 0.16 mm. Scutum (Fig. 278) length subequal to width. Scapulae short and rounded. Spiracular plate oval, 0.11 X 0.07 mm. Hypostome length ca. 0.14 mm. Hosts Peromyscus maniculatus, Rattus rattus, Gerrhonotus multicarinatus; Channel Islands, California. . . . . .peromysci

A small tick; body ca. 0.77 mm long in unfed state; capitulum length 0.39 mm; width 0.23 mm. Scutum longer than wide, ca. 0.60 X 0.51 mm. Scapulae short, triangular. Spiracular plate nearly circular: 0.11 X 0.10 mm. Hypostome length ca. 0.2 mm. Hosts rodents, lagomorphs, birds . . . . . .spinipalpis

10(6) Palpal segment I (Fig. 190) with anterior and posterior spurs or with only a posterior spur. 11

Palpal segment I without spurs; projections, if any, of segment I rounded and lobe-like (Fig. 290). 16

11(10) Palpal segment I with posterior spur but without anterior spur (Fig. 257) (ochotonae may have a rudimentary anterior spur). . . 12

Palpal segment I with both anterior (usually, but see kingi) and posterior spurs (Fig. 190). . 13

12(11) Auriculae faint lateral protuberances (Fig. 257). Internal spur of coxa I short, barely larger than external spur. Hosts pikas, woodrats . . .ochotonae

Auriculae short rounded teeth (Fig. 348). Internal spur of coxa I much larger than external spur (Fig. 349). Hosts woodrats. . . . . .woodi

13(11) Scutum longer than wide. Very small tick; scutum 0.40-0.50 X 0.36 mm; hypostome 0.07-0.08 mm long. Hosts shrews, moles. .soricis

Scutum as wide or wider than long. Medium-size ticks; scutum 0.45-0.54 X 0.48-0.54 mm; hypostome 0.15-0.18 mm long . 14

14(13) Coxa I with internal and external spurs subequal (Fig. 191). Hosts rodents. . . . . .angustus

Coxa I with internal spur appreciably larger than external spur (Fig. 241). Hosts primarily rodents. 15

15(14) Posterior margin of basis capituli sinuous in dorsal view (Fig. 300). Internal spur on coxa I large (Fig. 297). Spiracular plate with numerous goblet cells. Hosts burrowing mammals . . . . . sculptus

Posterior margin of basis capituli straight in dorsal view

(Fig. 240). Internal spur on coxa I of moderate size (Fig. 241). Spiracular plate with few small goblet cells (anterior spur of palpal segment I may be present or absent). Hosts rodents . . . . . .kingi

16(10) Scutum (Fig. 289) with lateral carinae, length subequal to width; scapulae short, angular. Auriculae (Fig. 290) curved saliences. Hosts skunk, fox, dog, weasel . . . . . .rugosus

Scutum without lateral carinae, broader than long; scapulae lacking. Auriculae (Fig. 226) triangular lateral projections. Hosts birds. . . . . howelli

Ixodes (Pholeoixodes) angustus Neumann (Figs. 184-191; Map 14)

Ixodes angustus Neumann, 1899, Mém. Soc. Zool. Fr. 12:136 (female); Nuttall and Warburton, 1911, Ticks: a monograph of the Ixodoidea 2:195, 197, figs. 187, 189, 190 (male, nymph, larva).

DIAGNOSIS. Female. Unfed female about 1.74 mm long, slightly smaller than Ixodes pacificus. Capitulum (Fig. 188) lacks cornua. Porose areas rather large, subtriangular or suboval. Palpi slightly more than 3X longer than wide. Auriculae absent (Fig. 189). Hypostome acuminate, pointed, and with strong sharp denticles 3/3 to base (Fig. 189). Scutum (Fig. 185) slightly longer than wide, widest at midlevel, broadly rounded behind. Coxa I with internal and external spurs subequal, short to moderate in length as in nymph (Fig. 191). Coxae II-IV lacking internal spur but with external spur. Females of similar I. ochotonae distinguishable by denticles 3/3 only apically. Superficially similar to I. pacificus, which has hypostome rounded apically and inner spur of coxa I much longer than external spur.

Male. Capitulum (Fig. 186) narrower behind, with sides and posterior border straight, salient; cornua absent; auriculae (Fig. 187) represented by short lateral ridges. Hypostome (Fig. 187) rounded apically, with bluntly rounded median and lateral tooth-like denticles of subequal size and shape. Coxa I with a relatively short internal spur. All coxae with external spurs. Scutum (Fig. 186) with large punctations on lateral margins.

MAP 14. Distribution in California of Ixodes angustus Neumann, solid circles.

Nymph and larva. Characterized by presence of both anterior and posterior spur on first palpal segment, giving the ventral aspect a diamond-shaped appearance (Fig. 190) typically larger and more conspicuous than in I. soricis, I. kingi, or I. sculptus. Cooley and Kohls (1945) note, however, that these projections are variable in angustus nymphs, and that the anterior horn may be moderately long, short, or absent. Coxa I (Fig. 191) with spurs subequal as in adults.

I. angustus in all instars is a common parasite of rodents. It is of no proven economic or public health significance, although reported occasionally biting man or dogs. It is widely distributed in North America, occurring from Alaska to California on the Pacific Coast, throughout Canada, and from the Pacific to Atlantic coasts of the United States.

Easton and Goulding (1974) note that I. angustus is probably a nest-specific tick. Males typically are found in rodent or insectivore nests, but only rarely on hosts. Apparently the tick does not quest for hosts on vegetation, hence it is rarely recovered by flagging.

In California I. angustus has been collected in every month, with immature stages recorded in each of the four major seasons. Distribution is primarily in the northern to central parts of the State, with no records south of the Greenhorn mountains.

In California, 67 collections of 1 to numerous specimens are recorded from 16 identified and 4 unidentified species of hosts. I. angustus has been taken most commonly from meadow mice, Microtus species, but it also readily infests deer mice, Peromyscus species, and other rodents (Table 12). Only two nonrodent hosts have been recorded as infested with I. angustus: Scapanus latimanus, the California mole, and Bassariscus astutus, the ringtailed cat.

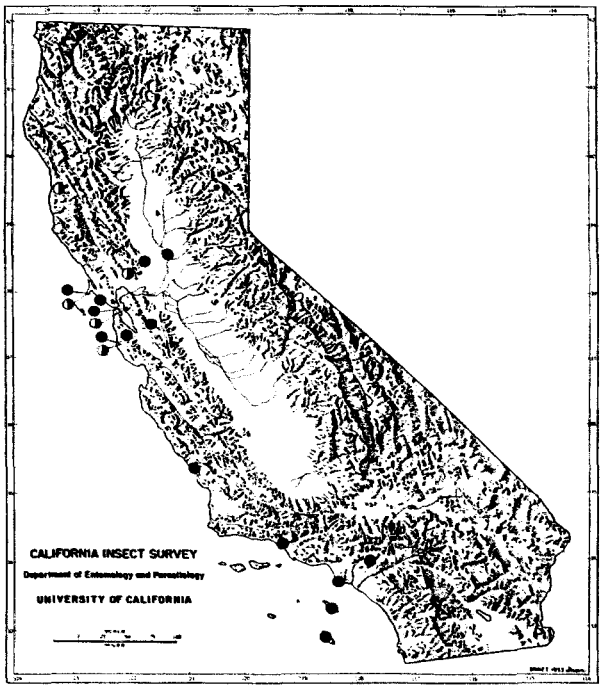
Ixodes (Multidentatus) auritulus Neumann
(Figs. 192-199, Map 15)

Ixodes thoracicus Neumann, 1899 (nec Koch, 1844), Mém. Soc. Zool. Fr. 12:149, figs. 22, 23 (female) (homonym).

Ixodes auritulus Neumann, 1904, Arch. Parasitologie 8:450 (nomen novem for I. thoracicus Neumann, 1899); Nuttall, 1916, Parasitology 8:314, figs. 15, 16 (nymph, larva). Cooley and Kohls, 1945, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 184:195. Kohls and Clifford, 1966, J. Parasitol. 52:815, figs. 20-24 (male).

TABLE 12. California Records of Ixodes angustus Neumann

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Scapanus latimanus	-	2	2	1
Aplodontia rufa	2	1	-	-
Eutamias speciosus	1	-	-	-
Spermophilus beecheyi	-	1	-	-
Sciurus griseus	1	-	-	-
Sciurus species	1	-	-	1
Peromyscus californicus	2	2	1	-
Peromyscus boylii	4	-	1	-
Peromyscus maniculatus	8	2	-	-
Peromyscus truei	2	-	-	-
Peromyscus sp.	2	1	1	-
Neotoma fuscipes	2	1	-	-
Microtus californicus	9	1	-	-
Microtus longicaudus	1	1	-	-
Microtus montanus	3	2	-	-
"Mouse"	1	-	-	-
Rattus norvegicus	1	1	-	-
Rattus rattus	1	-	-	-
"Rodent"	1	-	-	2
Bassariscus astutus	-	1	-	-
Vegetation (tick drag)	1	-	-	-
Unrecorded	2	2	-	-



MAP 15. Distribution in California of: Ixodes auritulus Neumann, half-circles; Ixodes brunneus Koch, solid circles.

DIAGNOSIS. Female. Readily recognized by characteristic combination of features. Dorsally basis capituli with strong cornua (Fig. 194), and ventrally with even stronger horn-like to bulbous auriculae directed posteriorly (Fig. 195). First palpal segment with a prominent anterior spur-like projection visible both dorsally and ventrally, but no corresponding posterior projection (Fig. 195). Hypostome broadly rounded apically, with denticles 5/5 distally, subtended by 4/4 and 3/3 consecutively to base (Fig. 195). Scutum (Fig. 193) widest at middle, broadly rounded behind; anterolateral margins flattened; scapulae reduced or absent; surface smooth; cervical grooves shallow, forming hourglass pattern. Coxae all with external spurs. Distinct internal spur of coxa I shorter than external spur. Internal spur absent on coxa IV, and reduced or not apparent on coxae II and III.

Male. Known from a single specimen collected in Chile and described by Kohls and Clifford (1966). Scutum smooth, with two pit-like depressions dorsolaterally (Fig. 196). No cornua nor auriculae on basis capituli. Coxae (Fig. 197) lacking well-defined internal spurs, but posterointernal margins salient; each coxa with a small, pointed external spur.

Nymph. Yellowish brown. Strong anterior projection on first palpal segment (Fig. 199), as in female. Cornua present and ventrally basis capituli with large, triangular auriculae (Fig. 199). Coxal spurs essentially as in female (Fig. 198).

Larva. Palpal article 1 with a large, acute, tooth-like anterior projection. Auriculae well developed.

I. auritulus is of no known economic importance. It is primarily parasitic on birds, particularly ground-frequenting passerine and galliform hosts. Its recorded distribution extends from Alaska to the most southerly tip of South America.

The 13 collections of I. auritulus from California were taken from birds collected from February to November, indicating year-round activity. The recorded distribution probably reflects areas of ornithological activity rather than the actual distribution of the tick.

CALIFORNIA RECORDS. ALAMEDA CO.: Berkeley, 1 nymph from Zonotrichia atricapilla, XI-26-1954. MARIN CO.: Fort Barry, 1 female from Circus hudsonicus, XI-11-1944; Point Reyes Bird Observatory: 3 females from Z. atricapilla, X-27-1976 (B. Sorrie); 1 nymph each from Hylocychla ustulata swainsoni, VIII-24-1976 and IX-8-1976 (B. Sorrie); 1 female and 2 nymphs from H. u. swainsoni, VII-9-1979; 1 female from H. u. swainsoni, VIII-1-1979; 4 larvae from Passerella ileaca, XI-9-1978 (P. Paton). MENDOCINO CO.: Ten Mile River, 1 nymph from Zonotrichia leucophrys nuttalli, V-10-1959 (R.C. Banks). NAPA CO.: Napa Mead Ranch, 1 nymph from Pheucticus melanocephalus, VIII-25-1970. SAN MATEO CO.: Pescadero, 6 females from a "blackbird," II-28-1964 (W. Plummer). SAN FRANCISCO CO.: Farallon Islands, 2 larvae from Z. atricapilla, X-27-82, and 2 nymphs from Z. atricapilla, X-30-82 (R. P. Henderson).

Ixodes (Ixodes) brunneus Koch
(Figs. 200-209; Map 15)

Ixodes brunneus Koch, 1844, Arch. Naturgesch. (Berlin) 10:232 (female). Anastos and Smith, 1957, J. Parasitol. 43:535-537, pls. I, III, IV (male, nymph, larva).

Ixodes californicus Banks, 1904, Proc. Calif. Acad. Sci. 3:369, pl. 41, fig. 57.

Ixodes kelloggi Nuttall and Warburton, 1908, Proc. Camb. Phil. Soc. 14:396, figs. 6-8.

DIAGNOSIS. Female. Mouthparts relatively long, slim (Fig. 202), with palpi 4X or more longer than wide and segment 2 much longer than 3. Hypostome (Fig. 203) narrow and pointed, with dentition 4/4 becoming 3/3 and 2/2 near the base. Cornua short and bluntly rounded. Auriculae, distinctive for this species, large, laterally extended, sharp-edged protuberances of somewhat variable shape (Fig. 203). Porose areas diffuse, large (Fig. 202). Coxa I with 2 subequal spurs (Fig. 201). Coxae II-IV with only external spur obvious, but II and III with suggestion of internal spur (Fig. 201).

Male. Palpi (Fig. 204) short and wide; article 2 slightly wider than 3. Hypostome (Fig. 205) 3/3 with lateral and median denticles small, blunt, subequal. Basis capituli (Fig. 205) without cornua, and auriculae inapparent. Scutum with prominent marginal grooves, deep and continuous posteriorly. Coxa I with 2 short, blunt, subequal spurs. Coxae II and III with external spur larger than internal spur; coxa IV with external spur only. Trochanters with spurs (Fig. 207).

Nymph. Outer palpal margin straight to convex; first segment narrowed in basal third (Fig. 208). Hypostome narrow, pointed; denticles 3/3, then 2/2 to base; lateral denticles large, pointed. Cornua large, directed laterally. Auriculae (Fig. 209) appearing double on each side, each triangular and bluntly pointed laterally. Marginal groove of dorsum distinct. Coxa I with internal spur slightly longer than external spur; coxae II-IV with external spur only.

Larva. Basis capituli, including hypostome, similar to that of nymph, palpi relatively shorter and wider. Two pairs of posthypostomal setae; 3 pairs of marginal ventral setae; 5 pairs of central dorsal setae; 5 pairs of scutal setae. Coxal spurs similar to those of nymph.

The disputed validity of I. brunneus and I. frontalis Panzer, 1795 was clarified by Homsher and Sonenshine (1975), who described discontinuous morphological distinctions in the structure of Haller's organ in females of the two forms. I. frontalis is an avian parasite of birds in Europe, but occurs on migrating birds in Asia and Africa.

I. brunneus is a common parasite of ground-frequenting birds. It is widespread in the United States and may be expected to occur in Canada and Mexico. Males are rarely collected from birds, but they as well as nymphs and larvae were described and illustrated from colony-reared specimens by Anastos and Smith (1957).

I. brunneus has been reported to affect its avian hosts adversely (Bishopp and Trembley, 1945). Rickettsia rickettsii, has been recorded from the ticks in nature by Clifford et al. (1969). This raises the issue of possible transfer of pathogens for long distances by ticks attached to migrating birds.

In California, the recorded collection sites represent in part locations where ornithological activities are most intensively pursued.

Hosts from which the tick has been recorded in California are given in Table 13.

Ixodes (Pholeoixodes) hearlei Gregson (Figs. 210-213; Map 16)

Ixodes hearlei Gregson, 1941, Canad. Entomol. 73:220, pl. XV, figs. 1-11 (male, female, nymph).

DIAGNOSIS. Female. Unfed specimens oval, wider behind midbody; 2.5 X 1.6 mm. Yellowish brown. Hypostome with almost parallel sides and a rounded apex; dentition 2/2 except for coronal area. Hypostome arising from anterior projection of basis capituli which originates at inner bases of palpi, tapering anteriorly, with mildly rounded shoulders (Fig. 211). Basis capituli with small, widely separated porose areas (Fig. 210). Cornua weakly developed. Auriculae absent or small, bluntly triangular protuberances (Fig. 211). Palpi thick and club-like, almost straight on lateral margins but rounded medially; segment 1 with small, ventral, pointed plate (Fig. 211). Scutum (Fig. 212) about as wide as long, widest anterior to midlevel; mildly rugose anterolaterally; punctations moderate; cervical grooves distinct. Coxae appearing superficially devoid of spurs; coxa I with a very short, rounded internal spur. Genital opening between coxae III.

Male. Oval, broader behind midlevel, about 2.5 X 1.7 mm. Capitulum lacking cornua, auriculae represented by mildly triangular lateral projections. Palpi short, oval dorsally, lacking a suture

TABLE 13. California Records of Ixodes brunneus Koch

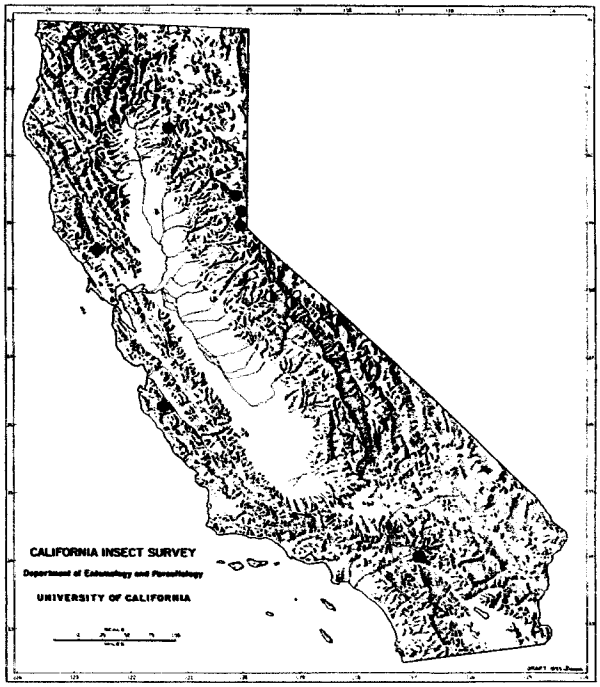
Host or Source	Tick Collections		
	Adults	Nymphs	Larvae
Lophortyx californica	-	1	-
Tyto alba pratincola	1	1	-
Stellula calliope	1	-	-
Cyanocitta stelleri	1	-	-
Thryomanes bewicki	1	-	-
Parus inornatus	-	-	1
Toxostoma redivivum	-	1	-
Turdus migratorius	1	-	-
"Thrush"	1	-	-
Lanius ludovicianus anthonyi	1	-	-
Dendroica townsendii	1	-	-
Agelaius phaeniceus	1	-	-
Piranga ludoviciana	1	-	-
Pheucticus melanocephalus	1	-	-
Pipilo erythrophthalmus	-	-	3
Carpodacus pupurius	2	-	-
Zonotrichia leucophrys	2	1	-
Zonotrichia atricapilla	1	-	1
Vegetation (Rhus)	1	-	-
Unrecorded	2	-	-

between segments 2 and 3; segment 1 with a small, pointed, ventral plate. Hypostome broad at base, tapering anteriorly, mildly bilobed apically, denticles weak and appearing as mild, transverse crenulations. Scutum with conspicuous, large, shallow punctations and a lesser number of small punctations. Scapulae short, rounded. Lateral carinae absent. Coxa I with a short, rounded internal spur; external spurs very short on all coxae. Trochanters without spurs.

Nymph. Cornua lacking; dorsal posterior margin of basis capituli straight, salient. Hypostome rounded apically and dentition 2/2 (Fig. 213). Two pairs of posthypostomal setae (Fig. 213). Auriculae as rounded protuberances anteriorly positioned, almost adjoining palpi. Palpi (Fig. 213) short and broad; segment 1 with a transverse, pointed ventral plate easily confused with larger posterior spur of other Ixodes such as I. sculptus and I. ochotonae. Scutum widest near middle. Coxae lacking external spurs, but coxa I (Fig. 213) with a short, rounded internal spur, as in female.

The larva of I. hearlei is undescribed. I. hearlei is known as a squirrel tick, and it closely resembles I. marxi, a species found on squirrels in eastern North America. I. hearlei has been recorded from British Columbia, Oklahoma, Washington, Montana, Texas, and Oregon, in addition to California.

CALIFORNIA RECORDS. MONTEREY CO.: Hastings Reservation, 3 females from Sciurus griseus, VIII-14-1948 (J.M. Linsdale). PLACER CO.: near Brockway, 3 males and 4



MAP 16. Distribution in California of: Ixodes hearlei Gregson, solid circles; I. holdenriedi Cooley, rectangles; I. howelli Cooley and Kohls, half-circles.

females from nest in decayed tree, X-1946 (D. Longanecker); Sawtooth Springs Rd. S Truckee, 4 females from Spermophilus lateralis, VII-11-1978 (Hansgen and Clover). PLUMAS CO.: 1 female from Tamiasciurus douglasi, V-13-1949 (E.W. Jameson, Jr.). SAN BERNARDINO CO.: Seven Oaks, 1 female from "gray squirrel," V-9-1936. SHASTA CO.: Manzanita Lake, Lassen National Park, 1 male and 2 females from nest of S. lateralis, IX-20-1940 (T. Aitken). SIERRA CO.: 3.7 mi. N, 2.2 mi. W Hobart Mills, 3 nymphs from Eutamias amoenus, date? (A.M. Barnes).

Ixodes (Pholeoixodes) holdenriedi Cooley
(Figs. 214-217; Map 16)

Ixodes holdenriedi Cooley, 1946, Pan-Pac. Entomol. 22:103, fig. 1. (female).

DIAGNOSIS. Female. Capitulum (Fig. 214) with very short, bluntly pointed cornua. Porose areas large and bordering posterolateral margins of basis capituli. Palpi long with a length-width ratio of about 3.6:1; outer margins straight; segment 1 with a small convex ventral plate (Fig. 215). Transverse sutural line distinct on ventral side of basis capituli. Auriculae absent. Hypostome (Fig. 215) tapering in distal half to a point; dentition 3/3 in apical $\frac{2}{5}$ths, then 2/2 to base. Scutum (Fig. 216) oval, widest anterior to middle. Coxa I with internal and external spurs subequal in length, but internal spur narrower (Fig. 217). External spurs present on coxae II and III, but absent on IV. Genital aperture at level of interval between coxae II and III.

Morphologically, I. holdenriedi is very similar to I. ochotonae, but the sides of the hypostome taper in the distal half instead of remaining essentially parallel until reaching the distal fifth, as in ochotonae.

The only recorded California collection is of 2 females from Thomomys bottae, the Valley Pocket Gopher, at Fitch Mountain, 3 mi. E Healdsburg, Sonoma County, III-25-1945 (M. Hobmaier). A gopher collected from the type locality in June 1981 by Furman and Lane harbored only larvae of I. pacificus.

Ixodes (Scaphixodes) howelli Cooley and Kohls
(Figs. 218-227; Map 16)

Ixodes howelli Cooley and Kohls, 1938, U.S. Pub. Health Serv. Rept. 53:1616, fig. 1 (female); Kohls, 1947, J. Parasitol. 33:57, figs. 1, 2 (male, nymph, larva).

DIAGNOSIS. Female. A long-legged tick (Figs. 220, 221), separable from the closely related marine bird tick, I. signatus, by hypostome arising from a short median extension of basis capituli (Fig. 224); extension originating at inner bases of palpi, tapering anteriorly, with mildly rounded shoulders before reaching base of hypostome. Unfed female 2.7-2.8 mm long, with a broad, almost straight posterior margin. Capitulum lacking defined cornua. Porose areas large, almost confluent. Auriculae (Fig. 224) lateral, bulbous protuberances continuous with narrow, dorsoventral ridge on each side. Palpi broad, short; segments 2 and 3 fused. Hypostome (Fig. 224) short, spatulate, with denticular formula 4/4 at corona, 3/3 in distal third, 2/2 in basal two-thirds. Scutum (Fig. 220) slightly longer than wide; widest at midlevel; scapulae rudimentary; cervical grooves well defined, shallow, broad, extending to posterolateral

margins. Coxa I (Fig. 225) with ill-defined, rounded, internal spur (Fig. 225). All coxae with external spurs (Fig. 225). Trochanters I-III with small, acute spurs. Engorged specimens bilobed posteriorly.

Male. Legs as in female. Posterior margin of body more strikingly squared than in female (Figs. 218, 219). Differs from closely related I. signatus in having segment 4 of palpi arising subterminally on the ventral aspect of segment 3, and in an untoothed, plate-like hypostome, pointed apically rather than bluntly tipped (Fig. 223). Capitulum lacking cornua and auriculae. Palpi with segments 1-3 fused (Fig. 223). Coxae as in female, but coxa I and II with short internal spurs. Ventrally, a fringe of heavy spines bordering posterior margins of adanal plates and anal plate, extending anterolaterally to spiracular plates (Fig. 222).

Nymph. Cornua distinct. Auriculae (Fig. 226) lateral, triangular. Palpi (Fig. 226) short, broad, with segments 2 and 3 fused; segment 1 lacking anterior and posterior spurs. Hypostome (Fig. 226) with denticles 2/2; shape as in female. Scutum lacking scapulae and lateral carinae. Coxae with external spurs, but only coxa I with distinct, smaller, inner spur (Fig. 227).

Larva. Capitulum and hypostome similar to those of nymph. Scutum lacking scapulae and lateral carinae. Coxae with external spurs, but internal spur present only on coxa I.

This yellowish-brown bird tick is recorded by Keirans and Clifford (1978) only from the Gray-crowned Rosy Finch, Leucosticte tephrocotis, the type host; the Cliff Swallow, Petrochelidon pyrrhonota; and the Prairie Falcon, Falco mexicanus. Kohls (1947) found numerous specimens, including larvae, nymphs, and adult females, infesting nestling Cliff Swallows, but obtained males only from crevices near nests. He speculated that the males may be nonfeeding, as is the case with males of some other Ixodes species.

In addition to the high montane records from California, I. howelli is known from Colorado, Montana, and Texas.

CALIFORNIA RECORDS. MONO CO.: 1.2 mi. E, 0.7 mi. S White Mountain Peak, 1 nymph from Leucosticte tephrocotis, VII-13-1973 (R. Johnson); 0.1 mi. E, 0.2 mi. N White Mountain Peak, 1 female from L. tephrocotis, VI-27-1974; Ellery Lake, Tioga Pass Hwy, 1 female from L. tephrocotis, VII-14-1974. TUOLUMNE CO.: N Yosemite National Park, 1 female from L. tephrocotis, VII-1937 (Herms).

Ixodes (Ixodes) jellisoni Cooley and Kohls (Figs. 228-231; Map 17)

Ixodes jellisoni Cooley and Kohls, 1938, U.S. Pub. Health Serv. Rept. 53:1619, fig. 2 (female); Cooley and Kohls, 1945, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 184:41, fig. 15 (male).

DIAGNOSIS. Female. Differs from closely related I. pacificus in having hypostome narrowly rounded apically rather than bluntly rounded and file 3 of denticles extending not more than half length of hypostome (Fig. 231). Denticle formula 3/3 apically and 2/2 to base, instead of 4/4 distally, then 3/3 and 2/2 to base, as in pacificus. Cornua short (Fig. 230) or absent, as opposed to absent in pacificus. Auriculae appearing only as faint lateral swellings (Fig. 231). Scutum usually longer than broad, less often subcircular (Fig. 228). Genital aperture at level of coxae III, as opposed to between coxae IV in pacificus. Coxa I (Fig. 229) with internal spur long, slim, pointed; external spur almost rudimentary. Coxae II, III, and IV with external spur small.

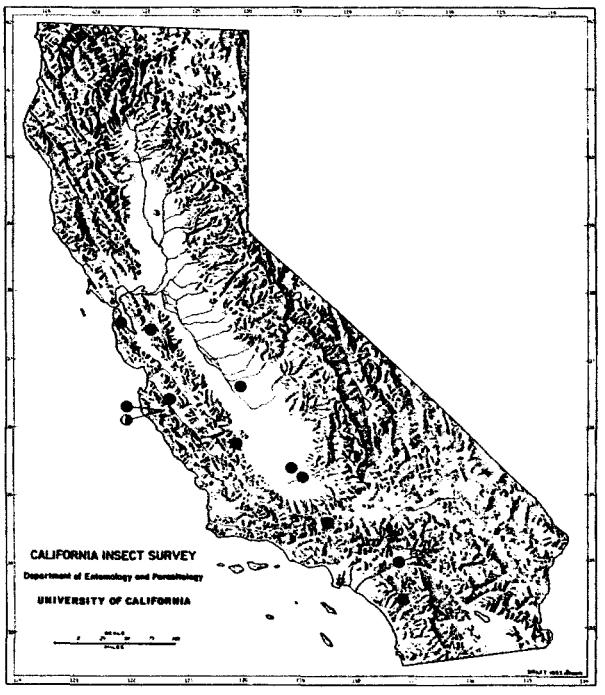
Male. Very poorly known, but separable from I. pacificus by presence of a posterior spur on segment 1 of palpi.

Nymph and larva undescribed.

I. jellisoni is a rather rarely encountered tick occurring on a variety of rodents in California. It is also recorded from Utah by Johnson (1966).

The 20 recorded California collections of I. jellisoni were made in the central to southern parts of the State, and most were taken from October to January. Pocket mice and kangaroo rats are the usual hosts.

CALIFORNIA RECORDS. ALAMEDA CO.: Calaveras Dam, from Perognathus californicus: 1 female, X-24-1932; 1 male, 1 female, X-11-1940, 2 females, XI-14-1940; 2 females, XI-12-1944 (all R. Holdenried); 1 female, X-24-1942 (Longanecker); 2 females, XII-6-1940, 2 females, XII-7-1940 (F.C. Evans). FRESNO CO.: Junction of Hwys. 180 and 145, ?adults from Dipodomys nitratoides, XII-26-1952 (R.A. Bodostian and G.F. Augustson). KERN CO.: Bakersfield, 2 females from D. nitratoides, XII-3-1963 (D. Roberts); Lerdo



MAP 17. Distribution in California of: Ixodes jellisoni Cooley and Kohls, solid circles; I. kingi Bishopp, half-circles.

Grid, 2 females from D. nitratoides, I-15-1965 (W. Mulback). KINGS CO.: NW Antelope, 1 female from Ground Squirrel, IV-2-1932 (RML #8037, type). LOS ANGELES CO.: Lake Hughes, 1 female from unrecorded host, II-24-1947. MONTEREY CO.: Henry Sands Canyon, 3 females from Dipodomys elephantinus, III-15-1956 (K. Murray); Hastings Reservation: 1 female from P. californicus, IV-12-1940 (J.M. Linsdale); 1 female from Thomomys bottae, XI-26-1941; 1 female each from Perognathus sp., XI-22-1950 and XI-28-1950. RIVERSIDE CO.: Temecula, 1 female from Dipodomys agilis, XI-11-1966 (R.M. Davis). SAN BERNARDINO CO.: Loma Linda, 1 female from D. agilis agilis, XII-19-1955 (R.D. Lee). SAN MATEO CO.: San Mateo, 1 female from cat, XI-29-1949 (R. Maynard).

Ixodes (Pholeoixodes) kingi Bishopp
(Figs. 232-241; Map 17)

Ixodes pratti Banks, 1908, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:27, pl. IV, figs. 1, 4, 5 (pro parte, misid.).

Ixodes kingi Bishopp, 1911, Proc. Biol. Soc. Wash. 24:201, pl. II, figs. 7-12 (female, male); Hooker, Bishopp, and Wood, 1912, U.S. Dept. Agric., Bur. Entomol. Bull. 106:82, pl. VI, figs. 1-3 (nymph, larva).

DIAGNOSIS. Female. Unfed (Fig. 233), approximately size of I. pacificus, about 2 X 1.32 mm. Engorged, nearly circular, reaching 16 mm (Cooley and Kohls, 1945). Capitulum (Fig. 238) with distinct, rounded cornua; posterior margin of basis capituli almost straight; porose areas with deep pores; auriculae (Fig. 239) weakly defined, not apparent. Palpi (Fig. 238) short, broad, not more than 2.5 X longer than broad; segment 1 with flattened ventral plate (Fig. 239). Hypostome (Fig. 239) rounded apically, with nearly parallel sides, subtended basally by short rounded shoulders; denticles coarse, 2/2. Scutum (Fig. 235) longer than broad; surface punctate, with punctations most obvious mesad of lateral carinae; cervical grooves not apparent. Coxae all with short external spurs; coxa I (Fig. 239) with moderately long, slim, internal spur, blunt apically.

Male (Fig. 232). Body size approximately 2.5 X 1.7 mm. Capitulum (Fig. 236) with short, distinct cornua and almost straight posterior edge dorsally; auriculae (Fig. 237) mild, lateroventral saliences. Hypostome (Fig. 237) rounded, or bilobed apically; denticles coarse, 3/3 apically, then 2/2 to base; median and lateral denticles discrete, similar in size and shape. Ventrally with shoulders subtending base of hypostome (Fig. 237). Palpi short, broad; segment 1 with flattened ventral plate as in female. Scutum (Fig. 234) with lateral carinae evident and punctations most prominent along inner aspects of carinae. Coxae as in female. Genital aperture between coxae II.

Nymph. Basis capituli and scutal shape (Fig. 240) similar to female, except that auriculae present as ventrolateral saliences (Fig. 241) and segment 1 of palpus with a ventral spur or horn, extending posterolaterally. Hypostome (Fig. 241) rounded apically; denticular formula 2/2. Coxae as in female, but inner spur of coxa I relatively short (Fig. 241).

Larva. Hypostome rounded; denticular formula 2/2. Palpi short, broad; segment 1 with posteroventral horn, or spur but no anterior horn.

The female of I. kingi resembles I. sculptus but is more massive and has a much

stouter hypostome. I. texanus females share many characteristics with I. kingi, but the former lack an internal spur on coxa I, a cornua, and heavy scutal punctations, as well as differing in other features.

I. kingi is widespread in the United States, occurring from coast to coast and from Canada to Mexico. West of the Rocky Mountains, collections are mainly recorded from pocket gophers, kangaroo rats, and mice (Gregson 1971).

CALIFORNIA RECORDS. INYO CO.-SAN BERNARDINO CO.: Death Valley, 1 female in Nuttall tick collection, identified by J.E. Keirans (see fig. 168 in Nuttall and Warburton (1911), p. 174). KERN CO.: Walker Pass, Thomomys, I-1-1891, 1 female (A.K. Fisher). MONTEREY CO.: Hastings Reservation: 5 larvae from Neotoma fuscipes, II-14-1946; 1 larva from N. fuscipes, IV-4-1946.

Ixodes (Ixodes) neotomae Cooley (Figs. 242-249; Map 18)

Ixodes neotomae Cooley, 1944, Pan-Pacif. Entomol. 20:7, fig. 1, 2 (male, female).

DIAGNOSIS. Female (Figs. 244, 245). Unfed, relatively small, about 1.5 X 1.02 mm. Capitulum (Fig. 248) with distinct, short cornua and relatively small, well separated porose areas. Auriculae (Fig. 249) long, retrograde, acutely pointed horns directed posteromedially. Palpi over 3.5 X longer than wide, with lateral profile lines straight; segment 1 (Fig. 249) ventrally with posterolaterally directed sharp spur. Hypostome (Fig. 249) subtended basally by a round-shouldered anterior projection of basis capituli; narrowly rounded apically; denticles 4/4, 3/3, then 2/2 at base. Scutum (Fig. 244) length about $\frac{4}{5}$ths total length of body in unfed female, very broadly rounded behind. Coxa I with short external spur, much longer internal spur. Other coxae lacking internal spurs, with progressively shorter external spurs on II, III, and IV. Genital aperture at level of posterior margins of coxae III.

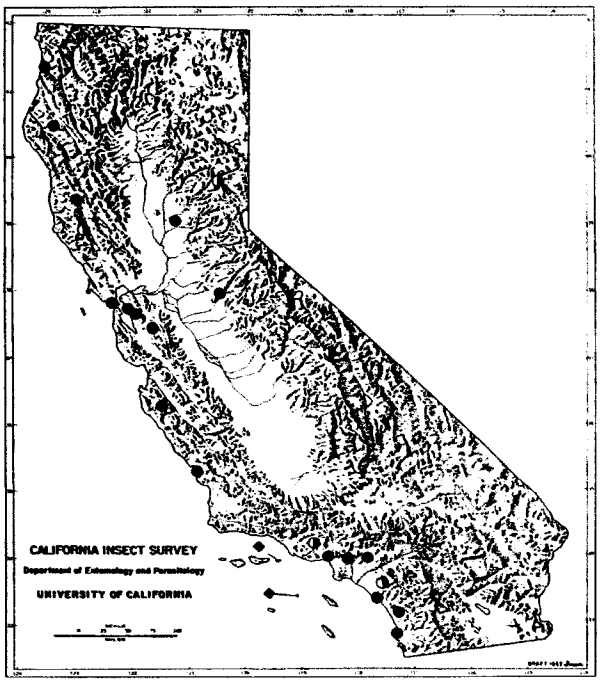
Male (Figs. 242, 243). Small, about 1.0 X 0.7 mm. Capitulum (Fig. 246) with short, distinct cornua joined by straight posterior margin of basis capituli. Auriculae (Fig. 247) short, pointed, or rounded lateral protuberances at same level as ventral surface of basis capituli. Palpi short, broad, with segments 1-3 distinctly separate. Hypostome (Fig. 247) large, mildly notched apically, with moderate-sized basal denticles; lateral denticles large, pointed; median denticles small, blunt crenulations. Scutum oval, convex; pseudoscutum discernible primarily by darker color rather than by surface structure. Ventral median plate 3X as long as anal plate. Coxae essentially as in female.

Nymph. Keirans and Clifford (personal communication) consider the nymph of this species undescribed. In their judgment, the nymph described as I. neotomae by Cooley and Kohls (1945, p. 36) "is not neotomae but is apparently based on a slide-mounted very small female of some Ixodes sp."

Larva undescribed.

I. neotomae closely resembles I. spinipalpis and to a somewhat lesser degree I. peromysci.

I. neotomae has been collected most frequently from woodrats and rabbits (Table 14). Since the closely related I. spinipalpis also occurs commonly on rabbits as well as rodents, the differentiation of these two species may be unusually difficult.



MAP 18. Distribution in California of: Ixodes neotomae Cooley, solid circles; I. ochotonae Gregson, half-circles; I. peromysci Augustson, rectangles.

With the exception of a collection reported from New Mexico by Keirans and Clifford (1978), the recorded distribution of I. neotomae is restricted to California, primarily from coastal counties from northern to southern ends of the State. Collections are recorded for every month except May. We have not examined the specimens recorded here as nymphs of I. neotomae, and we consider such records of dubious validity.

Ixodes (Pholeoixodes) ochotonae Gregson (Figs. 250-257; Map 18)

Ixodes ochotonae Gregson, 1941, Canad. Entomol. 73:224, pl. XVI, figs. 1-11 (male, female, nymph, larva).

DIAGNOSIS. Female. Unfed, approximately 2.2 X 1.4 mm, approximately same size as I. pacificus. Capitulum (Fig. 252) without cornua; porose areas large, well separated; auriculae (Fig. 253) essentially absent; palpi long, over 3.5 X longer than wide; distal fifth of hypostome tapered; pointed apically, denticles 3/3 or 3/2 apically, then 2/2 to base (Fig. 254). Scutum (Fig. 250) length-width ratio variable, but always longer than broad. All coxae with small external spurs; coxa I (Fig. 251) with internal spur subequal to external spur. Superficially, some specimens appear to lack coxal spurs.

Male. Body approximately 2.2 X 1.5 mm. Basis capituli lacking cornua and auriculae. Palpi short, broad. Hypostome short, broad, rounded distally; denticles irregular, transverse, small crenulations. Coxae as in female. Genital aperture between coxae III.

Nymph. Anterior spur absent on segment 1 of palpi, posterior spur present, tapering to point, directed posterolaterally (Fig. 257). Palpi short, thick. Cornua small. Posterior margin basis capituli slightly sinuous (Fig. 256). Auriculae faint. Hypostome rounded apically, dentition 2/2 (Fig. 257). Scutum about as long as wide, but posterolateral margins converging sharply before terminating in rounded posterior extremity; lateral carinae distinct (Fig. 255); coxae similar to those of female.

Larva. Palpal article 1 with anterior spur sharp, equiangular; posterior projection rounded. Cornua projecting laterally. Auriculae absent. Hypostome denticles 2/2. Internal spur of coxa I broadly angulate.

The female of I. ochotonae resembles closely I. angustus and I. holdenriedi. I. angustus differs in having a hypostome with denticles 3/3 to the base. In I. holdenriedi, the hypostome tapers in its apical half, terminating in a point. The male of

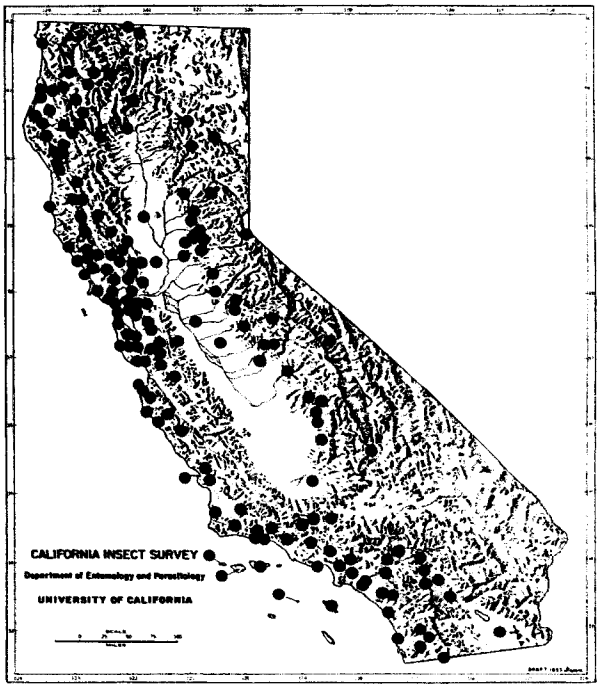
TABLE 14. California host records of Ixodes neotomae Cooley

Host or Source	Tick Collections		
	Adults	Nymphs	Larvae
Sylvilagus audubonii	1	-	-
Sylvilagus bachmani	3	-	-
Sylvilagus sp.	2	-	-
Lepus californicus	2	-	-
"Jack rabbit"	2	-	-
"Rabbit"	7	1	1
"Deer mouse"	1	-	-
Neotoma fuscipes	10	4	-
Neotoma lepida	3	-	-
Neotoma sp.	2	1	-
Urocyon cinereoargenteus	1	-	-
Unrecorded	3	1	-

ochotonae resembles angustus, but the latter has stronger blunt denticles on the hypostome arranged in 5 transverse rows. The nymph is separable from angustus, which has both anterior and posterior spurs on segment 1 of the palpi.

I. ochotonae is known primarily from pikas and woodrats. Its distribution includes most of the western United States and British Columbia, Canada.

CALIFORNIA RECORDS. INYO CO.: 3 mi. S and 5 mi. W Big Pine Creek, 1 female from Ochotona princeps, VI-7-1942 (D. F. Hoffmeister). MENDOCINO CO.: Hopland Field Station, near Hopland, 2 nymphs from Urocyon cinereoargenteus, IV-21-1975 (R.S. Lane). ORANGE CO.: 5.8 mi. E Trabucco, 1 nymph from Neotoma fuscipes, XII-20-1965 (J.S. Fowler). PLUMAS CO.: Plumas Eureka State Park, 1 female from Eutamias townsendii, V-6-1981 (T. Schwan); specific localities not recorded: 2 larvae, 2 nymphs from N. fuscipes, III-24-1949 (E.W. Jameson, Jr.); 16 nymphs from Neotoma sp. III-7-1949; 1 nymph from Neotoma sp., III-6-1949.



MAP 19. Distribution in California of Ixodes pacificus Cooley and Kohls, solid circles.

Ixodes (Ixodes) pacificus Cooley and Kohls
Western Black-legged Tick
(Figs. 258-267; Map 19)

Ixodes californicus Banks, 1908 (nec Banks, 1904), U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:24, pl. 2, fig. 12.

Ixodes pacificus Cooley and Kohls, 1943, Pan-Pacif. Entomol., 19:140 (female, male, nymph); Allred, Beck, and White, 1960, Brigham Young Univ. Sci. Bull., Biol. Ser. 1:16 (larva).

DIAGNOSIS. Female. Unfed, small, red-brown with black legs (Figs. 258 to 259). Body length about 2.6 mm. Hypostome arising from a smoothly tapered, median projection of basis capituli; hypostome broadly rounded apically; denticles typically 4/4 apically, 3/3 to level proximal to midlength of hypostome, then 2/2 to base (Fig. 263). Cornua absent (Fig. 262) and auriculae not apparent, or present as small ridges (Fig. 263). Palpal length-width ratio about 3.5:1. Palpi and trochanters of legs lacking spurs. Coxae each with a small external spur. Coxa I with a strong, acuminate inner spur extending over coxa II (Fig. 263). Genital opening near level of coxae IV (Fig. 258).

Male (Fig. 258). Small, about 2.2 mm long; dark brownish black. Cornua absent (Fig. 260), but auriculae present as lateral ridges (Fig. 261); ventrally, basis capituli with salient posterior point at midline. Palpi short, broad; segment 1 with small ventral tooth. Hypostome (Fig. 261) prominent, large, with large, laterally projecting lateral denticles, particularly near base; small median denticles as crenulated diagonal lines. Coxae essentially as in female.

Nymph. With definite cornua (Fig. 266). Auriculae (Fig. 267) small, lateral, shelf-like projections or bluntly triangular, not greatly different from more acutely triangular auriculae of I. spinipalpis. Dorsal scutum (Fig. 264) shape variable, from subcircular to bluntly angulate at posterolateral fourth with almost straight converging margins before curving again to form rounded posterior margin. Hypostome (Fig. 267) narrowly rounded apically; denticles 3/3, then 2/2 to base. Palpi long; segment 2 longer than 3. Palpi and trochanters of legs lacking spurs, segment 1 of palpi with a faint ventral plate. Coxae basically as in adult female, but internal spur of coxa I weaker (Fig. 267).

Larva. Spurs absent on palpi article 1. Hypostome widest at midlevel, and narrowly tapered, rounded apically; denticles

2/2 to base except for short distal 3/3, with third file composed of 3-4 denticles. Basis capituli with angular auriculae forming ventrolateral margins of basis. Five pairs of scutal setae; 4 pairs of central dorsal setae; central dorsal seta 1 50-65 µm long. Seven pairs coarse marginal dorsal setae, bluntly tipped and minutely fimbriated, 1.5-2 X as long as pair of supplementary setae; 4 pairs of marginal ventral setae. Coxa I with prominent acute inner spur; coxae I and II with small external spurs.

Adults of I. pacificus are very similar to the relatively rare I. jellisoni. Females of the latter differ from pacificus in having the hypostome very narrowly rounded apically; the basis capituli has no visible transverse sutural line, and the tarsi are shorter (tarsi I 0.54 mm long, compared to 0.84 mm in pacificus); and the genital aperture is at the level of coxae III. The male of jellisoni has a distinct posterior spur on segment 1 of the palpi instead of the mild ventral tooth seen in pacificus.

This is the most commonly encountered Ixodes species in California, and the most important economically and to human health. Adult ticks feeding on man may produce painful sores which are slow to heal. Occasionally their bites are followed by sensory disturbances near the affected area. Nymphs probably attack man more frequently in California than indicated by the record. Three collections of nymphs embedded in the skin of man were made in 1981, primarily because of an increased awareness of the problem. Domestic livestock and wild game animals are commonly bitten. Nelson (1973) has reported tick paralysis caused by I. pacificus in a dog in California, and Hughes et al. (1976) isolated a spotted-fever-group rickettsia from the tick in Oregon. Lane et al. (1981) cite evidence that I. pacificus in Mendocino County is associated with a rickettsia of the spotted fever group. Epidemiological evidence points to the implication of I. pacificus in the transmission of Lyme disease of man in northern California and Oregon (Steere and Malawista, 1979; Naversen and Gardner, 1978).

Arthur and Snow (1968) reared I. pacificus in the laboratory using guinea pigs as hosts. They found that a relative humidity of approximately 90% was essential to survival of all stages. Under the culture conditions reported, the life cycle requires less than one year, which reflects the condition occurring naturally, although the poor yield of adults reported by the authors indicates that a vital factor, nutritional, environmental, or immunological, was inimical to normal development.

I. pacificus is known from California, Oregon, Washington, Idaho, Nevada, and Utah, and in British Columbia. In California it is recorded from 50 counties at elevations ranging from sea level to over 2,150 m. As might be expected for a species in which the adults are so vulnerable to desiccation, most collections have been made in coastal areas.

Among 3,000 specimens of adult I. pacificus collected in California, the majority were taken from November through May. Larvae and nymphs were most commonly found from March through June, but they, as well as the adult, have been collected in every season. The immature stages occur commonly on alligator lizards (Gerrhonotus spp.), fence lizards (Sceloporus spp.), and ground-inhabiting birds, and less frequently on a variety of small rodents and lagomorphs. In the most thorough study of its kind ever reported for deer, Westrom (1975) reported collecting larvae and nymphs most abundantly in the spring, but in lesser numbers at all seasons, from 23 of 71 deer examined in Mendocino County, indicating that large mammals may play a more important role as hosts of the immature stages than is generally realized.

Arthur and Snow (1968) implicated 55 species of vertebrates as hosts for I. pacificus, and 52 species are recorded here from California (Table 15), including several not previously listed. Dogs are common hosts of the adult in coastal regions. On deer, Westrom (1975) reported it as second only to Dermacentor occidentalis as an acarine parasite in Mendocino County, finding it on 66% of the 71 deer examined. Man and horses are frequently bitten by adult females. We identified I. pacificus from 11 of 167 bears (Ursus americanus) examined by D. Graeber from 1974 to 1978 for ectoparasites in Yosemite National Park, and from 28 of 73 bears examined by Graeber in Sequoia National Park from May to December 1980.

Ixodes (Ixodes) peromysci Augustson
(Figs. 268-279; Map 18)

Ixodes peromysci Augustson, 1939, Bull. S. Calif. Acad. Sci. 38:142, pl. 30, figs. 1-5; pl. 31, figs. 1-9 (female, male, nymph, larva).

DIAGNOSIS. Female (Fig. 269). One of our smallest ticks, body about 1.3 X 0.8 mm in unfed state. Basis capituli (Fig. 271) with faint, well separated porose areas; cornua distinct, posteriorly directed, pointed projections; posterior dorsal margin straight, salient; auriculae prominent, posteriorly directed stout spurs (Fig. 273); palpi over 3X longer than wide; basal palpal segment with prominent posteroventral spur (Fig. 273); hypostome long, narrow, narrowly rounded terminally, with denticles 3/3 in apical half, then 2/2 to base (Fig. 273). Scutum longer than wide (Fig. 271). Legs of moderate length. Coxae with external spurs short but distinct; internal spur only on coxa I, short. Genital aperture between coxae IV.

Male (Fig. 268). Relatively rarely recorded. Very small, with body, or idiosoma, 0.96-1.1 mm long. Capitulum (Fig. 270) with well developed cornua, pointed and directed posteriorly. Auriculae mild saliences (Fig. 272). Palpi short and broad. Hypostome (Fig. 272) broadly and deeply indented apically, with lateral large, sharp denticles, in contrast to more median diagonal rows of crenulations; basal denticles large, relatively blunt, and directed posteriorly. Scutum (Fig. 270) with distinct punctations, more prominent in area bordering and posterior to pseudoscutum. Ventral plates (Fig. 275) with distinct punctations. Median ventral plate about 2.5 X longer than anal plate. All coxae with distinct, short external spurs; coxa I with longer, bluntly pointed internal spur (Fig. 274).

Nymph (Fig. 279). Body length from tip of scapulae 0.65-0.70 mm. Capitulum not subtriangular dorsally (Fig. 276). Cornua and posterior margin of capitulum as in female. Auriculae bluntly triangular lateral extensions (Fig. 277). Capitulum 0.25 X 0.16 mm. Hypostome similar to female, but 0.144 mm long and denticles 3/3 only near apex, then 2/2 to base. Palpi long, slim, with slightly concave outer margins; segment 1 with small ventral posterior projection (Fig. 277). Scutum subcircular, about 0.42 mm long (Fig. 278). Coxal spurs similar to those of female. Spiracular plate oval, 0.11 X 0.07 mm.

Larva. Subcircular, about 0.5 X 0.45 mm in the unfed state. Scutum as broad as long, with acute lateral angles. Cornua, auriculae, and coxae I-III similar to those of nymph.

Females of I. neotomae and I. spinipalpis, which resemble I. peromysci, are separable by their somewhat larger size, hypostome dentition greater than 3/3, and horn-like retrograde auriculae. Males of peromysci resemble closely neotomae and spinipalpis, but the internal spur of coxa I is not acuminate, and the ventral median plate is less than 3X longer than the anal plate. The nymph of peromysci is distinguished from species of similar appearance such as I. pacificus and I. spinipalpis by its small size.

I. peromysci is known only from California. All the collections confirmed by us have been from the Channel Islands, where the primary host appears to be Peromyscus maniculatus.

CALIFORNIA RECORDS. SANTA BARBARA CO.: Santa Barbara Island: 11 males, 16 females, 6 nymphs, 1 larva from Peromyscus maniculatus, V-(28-30)-1939 (Augustson); 3 females from P. maniculatus, VI-12-1978 (Storrer and Trager); 4 females and 1 male from P. maniculatus, III-(8,9)-1979; 1 female from P. maniculatus, III-8-1979 (P.W. Collins); 1 female, 1 male from P. maniculatus III-8-1979 (J. Storrer); 1 nymph from P. maniculatus, III-6-1979 (J. Storrer). VENTURA CO.: Anacapa Island: 1 female from P. maniculatus, X-3-1978 (J.M. Greaves); 3 collections of 1-2 nymphs each from P. maniculatus anacapae, X-(1-3)-1978; 5 collections of 1-13 nymphs each from Rattus rattus, X-(1-3)-1978; 1 nymph from Gerrhonotus multicarinatus, X-1-1978 (D.L. Johnson and S.E. Miller).

In addition to the above records, the Rocky Mountain Laboratory of the National Institute of Allergy and Infectious Diseases lists 1 nymph of I. peromysci from Neotoma fuscipes collected IV-4-1933 at Pasadena, Los Angeles County. J.E. Keirans (personal communication) states that the specimen is misidentified, and he believes it may represent the true nymph of I. neotomae.

Ixodes (Pholeoixodes) rugosus Bishopp (Figs. 280-291; Map 20)

Ixodes cookei var. rugosus Bishopp, 1911, Proc. Biol. Soc. Wash. 24:197, pl. II, figs. 1, 2 (female, male).

Ixodes rugosus; Cooley and Kohls, 1945, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 184:122, fig. 44H-K (nymph).

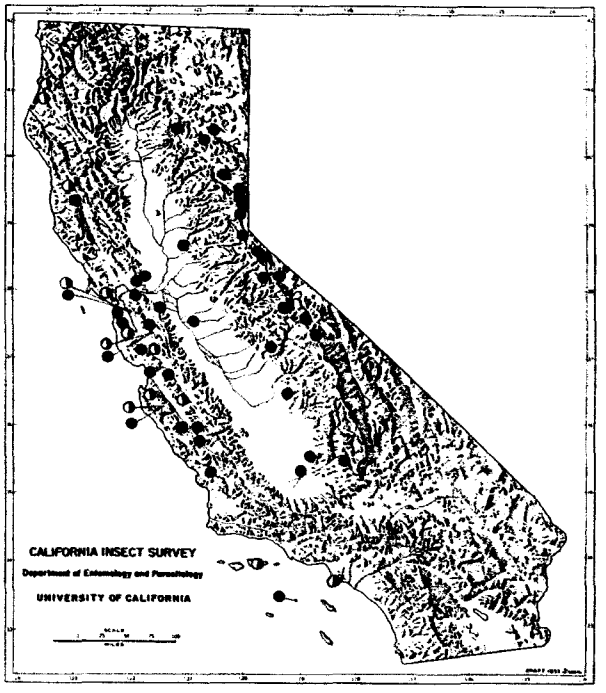
DIAGNOSIS. Female. Unfed, oval-shaped, almost 3 mm long, red-brown. Basis capituli (Fig. 284) with porose areas large,

TABLE 15. California Records of Ixodes pacificus Cooley and Kohls

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Sceloporus o. occidentalis	-	14	15	-
Sceloporus graciosus	-	3	2	-
Sceloporus sp.	-	6	3	-
Cnemidophorus sp.	-	1	-	-
Gerrhonotus coeruleus	-	4	1	-
Gerrhonotus m. multicarinatus	-	8	4	-
Gerrhonotus m. scincicauda	-	2	1	-
Gerrhonotus sp.	-	8	13	-
"Lizard"	-	3	3	1
Lophortyx californica	-	1	-	-
Aphelocoma californica	-	1	-	-
Colaptes cafer	-	1	-	-
Cyanocitta stelleri	-	1	-	-
Troglodytes troglodytes	-	2	-	-
Thryomanes bewickii	1	-	-	-
Hylocichla ustulata	-	3	-	-
Wilsonia pusilla	-	1	-	-
Aimophila ruficeps	-	-	1	-
Aimophila sp.	-	-	1	-
"Sparrow"	-	6	-	-
Junco oreganus	1	4	-	-
Zonotrichia leucophrys nuttalli	-	1	-	-
Zonotrichia atricapilla	-	1	1	-
Passerella ileaca	-	1	-	-
Melospiza melodia	-	1	-	-
Didelphis marsupialis virginiana	-	1	-	-
Scapanus latimanus	-	-	1	-
Sorex sp.	-	-	1	-
Homo sapiens	52	8	1	-
"Jackrabbit"	3	-	-	-
"Cottontail rabbit"	1	-	-	1
Spermophilus beecheyi	3	8	-	1
Spermophilus sp.	1	1	1	-
Sciurus griseus	-	1	-	-
Perognathus californicus	-	2	-	-

TABLE 15 continued

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Dipodomys deserti	1	1	-	-
Dipodomys sp.	1	-	-	-
Reithrodontomys megalotis	-	-	5	-
Peromyscus boylii	-	1	1	-
Peromyscus maniculatus	-	-	9	-
Peromyscus truei	-	-	1	-
Peromyscus sp.	-	-	1	-
Neotoma fuscipes	-	-	2	-
Neotoma lepida	1	-	1	-
Microtus californicus	-	1	1	-
Microtus sp.	-	-	1	-
Canis familiaris	80	1	-	2
Canis latrans	10	-	-	-
Urocyon cinereoargenteus	5	-	-	1
Urocyon littoralis littoralis	1	-	-	-
"Fox"	3	-	-	-
Ursus americanus	40	-	-	-
Procyon lotor	-	1	-	-
Mustela frenata	1	-	-	-
Taxidia taxus	1	-	-	-
Felis catus	5	-	-	-
Felis concolor	7	1	-	-
Felis rufus	20	-	-	-
Equus caballus	42	-	-	-
"Mule"	1	-	-	-
Sus scrofa	1	-	-	-
Odocoileus h. columbianus	45	13	16	1
"Deer"	16	2	-	1
Cervus nannodes	1	-	-	-
Bos taurus	12	-	-	-
Vegetation (tick drag)	88	1	1	4
House	4	-	-	-
Unrecorded	108	8	-	1



MAP 20. Distribution in California of: Ixodes rugosus Bishopp, half-circles; I. sculptus Neumann, solid circles.

depressed, subtending posterior margin of the basis. Cornua and auriculae not apparent or absent. Palpi length-width ratio 2.5:1. Hypostome (Fig. 285) short (0.45 mm), spatulate, rounded apically, arising from a broad-shouldered base; denticles 2/2, except 3/3 on corona. Scutum longer than broad, widest anteriorly, usually with anterolateral rugosities and large, numerous punctations (Fig. 287). External spurs of all coxae small. Internal spur of coxa I moderately long, thin, and pointed apically (Fig. 288). Genital aperture between coxae III.

Male. Subelliptical (Fig. 280), similar in size to unfed female. Basis capituli (Fig. 282) with posterior margin straight to slightly concave. Cornua absent. Auriculae curved lateral saliences. Palpal segment 1 with salient posterolateral margin almost tooth-like in appearance. Hypostome (Fig. 283) with 3-4 irregularly paired rows of bluntly pointed, overlapping denticles; lateral and median denticles of approximately same shape and size. Scutum evenly rounded at both ends; surface with numerous shallow punctations (Fig. 286). Coxae as in female.

Nymph. Basis capituli broad with short, nearly parallel lateral margins (Fig. 289). Cornua short. Auriculae curved lateral saliences. Palpi short, broad; segment 1 ventrally with prominent, rounded posterior projection. Hypostome rounded apically; dentition 2/2 except for additional minute denticles on corona (Fig. 290). Scutum (Fig. 289) length and width subequal; lateral carinae distinct, bowed outward at midlevel. Internal spur of coxa I short, rounded (Fig. 291); external spurs of coxae present, small.

Larva. Larvae have been recorded but are undescribed.

Adults and nymphs of I. rugosus superficially resemble I. pacificus but are more closely related to I. sculptus, as discussed under that species.

I. rugosus is known primarily from skunks, foxes, weasels, and dogs along the Pacific coast of Washington, Oregon, and California. Gregson (1956) lists 6 collection records from British Columbia from coyotes and skunks.

California collections of I. rugosus extend from Humboldt County to Los Angeles County, restricted to or west of the coastal mountain range. All instars have been collected most frequently from the spotted skunk, Spilogale gracilis, although nymphs and adults have been found on various other carnivores (Table 16). The adults and nymphs have been collected in California during every season of the year.

Ixodes (Pholeoixodes) sculptus Neumann
(Figs. 292-301; Map 20)

Ixodes sculptus Neumann, 1904, Arch. Parasitologie 8:462 (female); Hixson, 1932, Iowa State Coll. J. Sci. 7:36, figs. 2, 3 (male, nymph, larva).

Ixodes aequalis Wherry and Wellman, 1909, Entomol. News 20:376 (nomen nudum).

Ixodes aequalis Banks, 1910, Proc. Entomol. Soc. Wash. 12:8.

DIAGNOSIS. Female (Fig. 296). Unfed, about 2.2-2.6 X 1.4-1.8 mm. Engorged female 6.3 X 4.5 mm (Cooley and Kohls, 1945). Capitulum (Fig. 298) with conspicuous cornua tending to converge posteriorly and elevated over salient and sinuous posterior margin. Auriculae essentially absent. Palpi of moderate length; length-width ratio not over 3:1. Palpal segment 1 (Fig. 299) with ventral plate angulate posteriorly. Hypo-

TABLE 16. California Records of Ixodes rugosus Bishopp

Host or Source	Tick Collections		
	Adults	Nymphs	Larvae
Didelphis virginiana	1	-	-
Homo sapiens	1	-	-
Canis familiaris	3	1	-
Urocyon cinereoargenteus	2	-	-
Urocyon littoralis santacruzae	1	-	-
Procyon lotor	1	1	-
Mustela frenata xanthogenys	3	4	-
"Weasel"	1	-	-
Spilogale gracilis	10	9	5
Mephitis mephitis	3	7	-
"Skunk"	1	1	-
Felis rufus	1	1	-
Unrecorded	1	-	-

stome (Fig. 299) bluntly rounded, with sides slightly convex, arising from a tapered medial projection of basis with mere suggestions of shoulders; dentition 3/3 subapically, then 2/2 to base. Scutum suboval, deeply punctate, with cervical grooves and lateral carinae usually distinct. Coxae each with short external spur; coxa I (Fig. 297) with long pencil-shaped internal spur. Genital aperture between coxae III.

Male (Fig. 292). Body oval, 2.5 X 1.7 mm. Basis capituli (Fig. 294) with straight to concave posterodorsal margin and cornua small to absent. Auriculae weak lateral ridges. Palpi short, broad; segment 1 with small ventral plate. Hypostome (Fig. 295) short, with apex rounded or notched; denticles short, rounded, widely spaced teeth (almost crenulations), approximately subequal in size laterally and medially. Scutum with numerous large punctations, particularly laterally. Coxae as in female. Genital aperture (Fig. 293) between coxae II.

Nymph. Capitulum (Fig. 300) with large, pointed cornua diverging posteriorly; posterior margin slightly sinuous; auriculae large, rounded saliences. Palpal segment 1 ventrally with prominent anterior and posterior projections (Fig. 301). Hypostome (Fig. 301) rounded apically; denticles 3/3 apically, then 2/2 to base. Coxae as in female.

Larva. Segment 1 of palpi with both anterior and posterior ventral spurs prominent and of subequal size. Lateral margins of basis capituli subparallel; 2 pairs central dorsal setae.

The female I. sculptus resembles I. rugosus, but it has a much more prominent cornua and lacks anterolateral scutal wrinkles. It also resembles I. kingi, but is less massive and the posterior margin of the basis capituli is sinuous. The male of sculptus is similar to rugosus, but the hypostome of the latter has more pointed denticles which are overlapping rather than rounded and widely spaced. The nymph of I. sculptus is separable from I. angustus and I. soricis in that the internal spur of coxa I is considerably longer than the external spur. Nymphs of rugosus and kingi lack the anterior spur of palpal segment 1 seen on sculptus, but in some specimens of the latter the anterior spur is rounded and similar in appearance to rugosus.

I. sculptus is widely distributed in the central and western United States and Canada, where it occurs commonly on burrowing rodents and in their nests.

In California, I. sculptus is rather generally distributed in the coastal range of the central part of the state, and in the Sierra Nevada from Kern County to Lassen County. Collections are primarily from ground squirrels, Spermophilus spp., and their burrows (Table 17). Adults as well as nymphs may be found throughout the year, but collections of larvae have been recorded only during the summer.

Ixodes (Scaphixodes) signatus Birula (Figs. 302-309, Map 21)

Ixodes signatus Birula, 1895, Izv. Imp. Akad. Nauk, ser. 5, 2:357, table 1, figs. 10-13 (female); Nuttall and Warburton, 1911, Ticks: a monograph of the Ixodoidea 2:263, fig. 263 (nymph, larva); Gregson, 1954, Canad. Entomol. 86:275, fig. 1 (male).

Ixodes arcticus Osborn, 1899, in Jordan et al., Acarina fur seals and fur-seal islands, North Pacific Ocean, pt. 3, 9:553, fig. 2.

Ixodes parvirostris Neumann, 1901, Mém. Soc. Zool. Fr. 14:284.

Ixodes eudyptidis var. signata Neumann, 1904, Arch. Parasitologie 8:451.

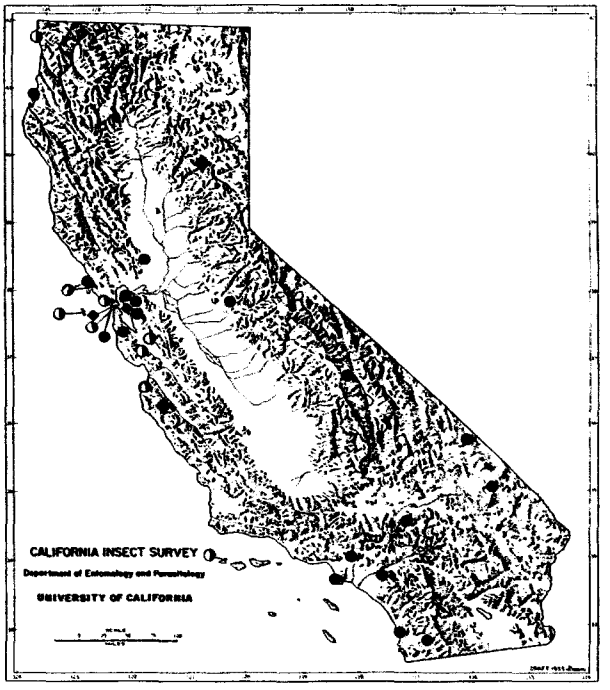
Ceratixodes signatus; Banks, 1908,, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:21.

DIAGNOSIS. Female. Spider-like appearance (Fig. 303), with long, thin legs. Body elongate, engorged size 8 X 3.5 mm. Capitulum (Fig. 306) broad, without cornua, although posterolateral corners salient. Porose areas extensive and almost confluent on median line. Evenly curved lateral extensions of basis capituli form auriculae (Fig. 307). Hypostome (Fig. 307) broadly rounded apically; dentition 3/3 distally, then 2/2 to base; not arising from median extension of the basis capituli. Scutum (Fig. 303) oval but variable. Cervical grooves always distinct. Coxae with external spurs, but lacking internal spurs (Fig. 308). Spiracular plate nearly circular; macula eccentric; goblets numerous and small. Genital aperture at level of coxae II.

Male (Fig. 302). An elongate narrow-bodied tick with elongate, oblong scutum having nearly parallel lateral margins.

TABLE 17. Records of Ixodes sculptus Neumann, 1904

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Lophortyx sp.	1	-	-	-
Homo sapiens	1	-	-	-
"Jackrabbit"	1	1	-	-
Eutamias merriami	1	2	-	-
Marmota sp.	-	2	1	-
Spermophilus beecheyi	102	26	2	6
Spermophilus beecheyi douglasii	2	1	-	-
Spermophilus beldingi	6	6	-	-
Spermophilus lateralis	13	3	-	-
Spermophilus oregonus	2	-	-	-
Neotoma fuscipes	1	-	-	-
Martes americana	1	1	-	-
Mustela frenata	3	2	1	-
Vegetation	4	-	-	1
Unrecorded	10	-	-	1



MAP 21. Distribution in California of: Ixodes signatus Birula, half-circles; I. soricis Gregson, rectangles; I. spinipalpis Hadwen and Nuttall, solid circles.

Capitulum (Fig. 304) lacking cornua and auriculae, palpi with numerous stout spines; segment 3 spatulate and reflexed, with inner distal flange and two stout distal spines; segment 4 in some specimens invisible in dorsal view, due to subapical ventral insertion. Hypostome reduced, truncate and concave mediodistally (Fig. 305); denticles rudimentary. Coxae as in female.

Nymph. Brownish-black nymphs elongated as in female and resembling it closely in other respects, including shape of capitulum (Fig. 309) and coxal armature (Fig. 309).

Larva. Similar to female in shape of capitulum, armature of legs, and shape of anal groove.

I. signatus is a large tick which may be distinguished from the closely related bird tick, I. howelli, as described under the latter species, as well as by the fact that the normal hosts of howelli are terrestrial rather than marine birds.

I. signatus is known from California, Oregon, Washington, Alaska, Canada, Japan, and eastern Russia.

In California, I. signatus is known primarily from cormorants and their nests; the Pigeon Guillemot is the only other host recorded here. All stages of the tick have been collected in every season.

CALIFORNIA RECORDS. DEL NORTE CO.: Castle Rock, Crescent City, 1 nymph and 1 larva from Phalacrocorax pelagicus, date? (H.S. Fullon). HUMBOLDT CO.: Flat Iron Rock, 10 females, 13 nymphs, 45 larvae from rocks, VI-22-1972 (H. Johnson). MARIN CO.: Fort Baker: 2 nymphs from P. pelagicus, IV-24-1957 (M. Tingle); 1 female from "cormorant," IV-15-1957 (Fontaine and M. Tingle); 1 female and 1 nymph from Phalacrocorax penicillatus, date? (Shepard); Stinson Beach, 1 female from "cormorant," IX-27-1939 (Herms); Tomales Bay, 8 females, 23 nymphs, 4 larvae from Phalacrocorax sp., XII-16-1920 (M.E. Davidson); Point Tomales, 10 males, 8 females, 23 nymphs, 1 larva from rocks, II-26-1979 (G. Ulrich). MONTEREY CO.: Pacific Grove: 1 female from P. pelagicus, 1894 (Nuttall and Warburton); 3 females, 1 nymph, 1 larva from P. penicillatus, 1894, Nuttall collection, identification verified by J.E. Keirans; 2 females from P. pelagicus, XII-30-1905; unidentified location, 1 nymph from P. pelagicus, VIII-2-1927, Bishopp collection. SAN FRANCISCO CO.: Farallon Islands: 3 males, 28 females, 8 nymphs, 1 larva from abandoned nests of P. pelagicus, V-6-1949 (D.G. Hanna); 24 females, 3 nymphs, 1 larva, XI-18-1949 (E.S. Ross and D. Kelly); 1 larva from P. penicillatus, VIII-9-1982 (R. Henderson). SANTA BARBARA CO.: Prince Island, 9 females, 3 nymphs, 1 larva from Cepphus columba, VII-23-1977 (Kelley and T. Schwan). SANTA CLARA CO.: Los Gatos, 1 female from "orchard," III-13-1954 (L. Maitozo); San Jose, 1 nymph from "Cormorant," III-12-1954 (Binnewies).

Ixodes (Pholeoixodes) soricis Gregson
(Figs. 310-313; Map 21)

Ixodes soricis Gregson, 1942, Canad. Entomol. 74:137, figs. 1-9 (female, nymph, larva); Gregson and Kohls, 1952, Canad. Entomol. 84:185, fig. 1 (male).

DIAGNOSIS. Female (Fig. 310). Pale yellowish white. Very small: unengorged body to tip of scapula 1.2 X 0.48 mm (Gregson, 1942). Body with numerous appressed setae. Capitulum (Fig. 312) with cornua very small; auriculae not apparent. Palpi convexly curved on both inner and outer margins (Fig. 313); less than 3X longer than

broad. Hypostome (Fig. 313) pointed apically; sides evenly tapered to apex; dentition 3/3; denticles long, sharp. Scutum (Fig. 310) length-width ratio over 4:3; scapulae short; lateral carinae distinct, long, straight; longitudinal furrows on posterior margin visible at magnification of 100X. All coxae (Fig. 311) with external spurs and barbed setae; internal spur on coxa I subequal to external spur. Genital opening (Fig. 311) at level of interface between coxae III and IV.

Male. Extremely small: 0.97 (to tip of scapula) X 0.64 mm (Gregson and Kohls, 1952). Basis capituli without cornua or auriculae; posterior dorsal margin straight to slightly convex. Palpi short, bulbous. Hypostome reduced, slightly notched apically, with 4 transverse rows of irregular crenulations. Scutum convex, narrower anteriorly than posteriorly. Ventrally anal plate about $\frac{2}{3}$rds as long as median plate. Genital opening at level of anterior margins of coxae III. Coxae similar to those of female, but internal spur of coxa I slightly larger than external spur.

Nymph. Basis capituli with very small cornua and no auriculae. Hypostome apex rounded; dentition 2/2 until 1/1 near base. Segment 1 of palpi ventrally with prominent anterior and posterior spur-like projections. Scutal length about 0.4 mm. Coxal spurs similar to those of female.

Larva. Palpal segment 1 with ventral anterior and posterior spurlike projections as in nymph. Scutum 0.257 X 0.28 mm (Gregson, 1942).

I. soricis closely resembles I. angustus, from which the female is distinguished by its smaller size and the presence of furrows on the posterior margin of the scutum; the male is separable from angustus by its smaller size and by its more reduced hypostome with irregular crenulations. Nymphs of soricis are smaller than those of angustus, and the scutum lacks the lateral carinae of the latter. The only other male tick in California as small as I. soricis is I. peromysci, a species easily separable by such features as its strong cornua, heavily toothed hypostome and insular distribution.

I. soricis is primarily a parasite of shrews in the western United States and Canada. In California it has been collected from 3 species of shrews, Sorex trowbridgii, S. vagrans and S. ornatus. The only other host recorded in the state is the broad-footed mole, Scapanus latimanus. The 51 collections of 1 to numerous specimens are recorded from only 6 California counties, although the combined ranges of the recorded hosts cover all but the southeastern region of California.

CALIFORNIA RECORDS. ALAMEDA CO.: Strawberry Canyon, 1 nymph from Scapanus latimanus, V-25-1955 (W.C. Russell). MARIN CO.: Fort Baker: 1 female from Sorex sp., XI-15-1957 (M. Tingle); 7 nymphs from Sorex sp., VI-29-1943 (R. Holdenried); Camp Mendell, 1 female from Sorex trowbridgii, X-10-1942 (R. Holdenried); Fort Baker, 1 female from Sorex vagrans, I-9-1943 (Holdenried and Burroughs). MONTEREY CO.: Hastings Reservation, from Sorex ornatus: 1 female, V-2-39 (R. Holdenried); 2 females, XII-16-39 (J.A. Gray); 5 females and 2 larvae, I-13-40; 2 collections of 1 female each II-11-40; 1 female, XII-17-41; 1 female, I-17-56. PLUMAS CO.: Rock Creek Dam, 2 females, 4 nymphs, 5 larvae from S. trowbridgii, V-30-1950 (E.W. Jameson); E Rock Creek Dam, 2 nymphs from S. trowbridgii, VI-1-1950 (E.W. Jameson); Quincy and unrecorded locations, 33 collections from S. trowbridgii, 35 females, 6 nymphs, 3 larvae, X-31-48 - XI-2-50 (E.W. Jameson). SAN MATEO CO.: no specific locality given, 3 larvae from S. vagrans, II-21-73 (R.B. Eads). SONOMA CO.: no specific locality given, 1-6 specimens each from 3 Scapanus latimanus, 1976-77 (cited by Yates et al., 1979).

Ixodes (Ixodes) spinipalpis
Hadwen and Nuttall
(Figs. 314-319; Map 21)

Ixodes dentatus var. spinipalpis Hadwen and Nuttall, in Nuttall, 1916, Parasitology 8:301, figs. 6, 7, 8 (female, nymph, larva).

Ixodes diversifossus Bishopp, 1912, Proc. Biol. Soc. Wash. 25:30, pl. 1, figs. 7-12 (nec Neumann, 1899) (female, male).

DIAGNOSIS. Female. Closely resembling I. peromysci but larger; unfed female 1.89 X 1.26 mm (Cooley and Kohls 1945). Capitulum (Fig. 315) with distinct cornua. Auriculae (Fig. 317) posteriorly directed, retrograde horns. Segment 1 of palpi with short, broadly pointed ventral spur with unequal sides (Fig. 317). Hypostome arising from acuminate medial projection of basis capituli; narrowly rounded apically, with pointed denticles larger laterally than medially; 4/4, 3/3, then 2/2 to base (Fig.

317). Scutum (Fig. 315) oval, widest behind midlevel, reaching more than half length of body in unfed female. All coxae with short external spurs. Coxa I (Fig. 318) with long, slim internal spur. Genital opening between coxae IV.

Male. Idiosoma 1.4-1.5 mm long. Capitulum (Fig. 314) with distinct cornua, posteriorly converging lateral margins, and straight posterior margin between cornua. Hypostome large, slightly notched apically. Lateral denticles large, sharp, but more median denticles in diagonal rows of pointed to rounded crenulations; basally with pair of large, relatively blunt, posteriorly directed teeth (Fig. 316). Scutum (Fig. 314) with pseudoscutum variably indicated by darker color and smaller punctations than on remainder of shield. Coxae essentially as in female. Ventral median plate 3X longer than anal plate.

Nymph. Capitulum with distinct cornua and short, bluntly triangular auriculae (Fig. 319). Palpi long, slim, with outer margins concave. Hypostome (Fig. 319) narrowly rounded apically, widest at midlevel; denticles long, pointed, 3/3 in apical third, then 2/2 to base. Scutum broadly oval, rounded caudally. Internal spur of coxa I about twice as long as external spur.

Larva. Capitulum with only rudimentary cornua. Auriculae present but reduced. Palpi long, slim. Hypostome narrowly rounded apically, with denticles 3/3, then 2/2 basally. Scutum as broad as long. Coxae I and II with spurs as in nymph, but smaller.

Females of I. peromysci have auriculae which are posteriorly directed spurs rather than retrograde horns as in I. spinipalpis. Females of I. neotomae have the genital atrium at the level of coxae III or III-IV rather than at the level of coxae IV. I. neotomae females also have the spur of palpal segment 1 more acutely pointed and with equal sides. Males of neotomae do not have quite as large basal teeth on the hypostome as in spinipalpis, nor is the pseudoscutum demarked by a zone of punctations. The similar males of peromysci are much smaller than the males of spinipalpis. Nymphs of the very similar peromysci differ from spinipalpis in having the internal and external spurs of coxae II subequal, as well as by the smaller measurements of peromysci.

I. spinipalpis is of no demonstrated economic or public health importance. Its wide host range and distribution would suggest a potential significance in the circulation of a variety of microorganisms among its hosts, and it has been found naturally infected with Powassan virus in South Dakota. It is distributed throughout the western United States and Canada, occurring on lagomorphs and rodents. Immature ticks occur also on birds.

In California the 10 recorded species of hosts include a variety of rodents and lagomorphs as well as terrestrial birds (Table 18). Adults have been taken in fall, winter, and spring, nymphs during all seasons. The geographic distribution in California includes both the southern and northern coastal ranges as well as the central Sierra Nevada and the arid southeastern region.

Ixodes (Pholeoixodes) texanus Banks
(Figs. 320-329; Map 22)

Ixodes pratti Banks, 1908, U.S. Dep. Agric., Bur. Entomol. Tech. Ser. 15:27, pl. IV, figs. 1, 4, 5 (pro parte, misid.).

Ixodes texanus Banks, 1909, Proc. Entomol. Soc. Wash. 10:172, figs. 16, 17 (female); Cooley and Kohls, 1945, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 184:77, figs. 30, 31 (male, nymph); Allred, Beck, and White, 1960, Brigham Young Univ. Sci. Bull. Biol. Ser. 1:22, figs. 28-30 (larva).

DIAGNOSIS. Female. Sclerotized parts yellowish brown. Basis capituli (Fig. 326) with cornua indistinct to moderate and with posterior margin slightly sinuous. Porose areas deep, irregular, well separated. Palpi short, wide, rugose; segment 1 with small ventral plate, somewhat angular posterolaterally. Hypostome flanked basally by angular humps (Fig. 327), rounded apically; dental formula 2/2 except apically, where smaller denticles may be 5/5. Lateral denticles coarse, pointed; median denticles smaller, more rounded. Auriculae absent. Scutum (Fig. 324) length and width subequal; lateral areas wrinkled. Coxae (Fig. 325) with external spurs vestigial to absent; coxa I with short, rounded inner spur. Genital aperture at level of posterior margins of coxae III (Fig. 325).

Male. Basis capituli (Fig. 322) with cornua indistinct to absent; posterior dorsal margin sinuous; auriculae absent. Palpi short, wide, rugose; segment 1 as in female. Hypostome (Fig. 323) flanked

TABLE 18. California Records of Ixodes spinipalpis Hadwen and Nuttall

Host or Source	Tick Collections		
	Adults	Nymphs	Larvae
Pipilo fuscus	-	1	-
Pipilo erythrophthalmus	-	-	2
Zonotrichia atricapilla	-	-	1
Sylvilagus bachmani	3	2	6
Sylvilagus sp.	-	1	1
Lepus californicus	1	-	-
"Rabbit"	2	1	1
Perognathus formosus	-	2	-
Peromyscus maniculatus	-	2	2
Peromyscus sp.	-	2	-
Neotoma fuscipes	1	2	-
Neotoma lepida	1	3	1
Neotoma sp.	3	1	-
Microtus californicus	-	2	1
Unrecorded	1	1	1

basally by angular humps as in female and slightly notched apically; denticles faint, transverse rows of crenulations. Ventral median and anal plates of subequal length. Genital aperture at about level of coxae II. Coxae (Fig. 321) with external spurs as low ridges. Coxa I with internal spur very short, rounded. Trochanters without spurs.

Nymph. Basis capituli of California specimens lacking cornua, with posterior dorsal margin nearly straight (Fig. 328). Palpi short, thick, rugose; segment 1 ventrally with plate protruding posterolaterally as a rounded flange (Fig. 329). Hypostome (Fig. 329) broadly rounded; dental formula 2/2, except apical area with a third file of about 3 teeth. Basally, hypostome flanked by angular humps or shoulders (Fig. 329) best seen on ventral side. Scutum broader than long and broader anterior to midlevel; rugose anterolaterally. Coxal spurs similar to those of female.

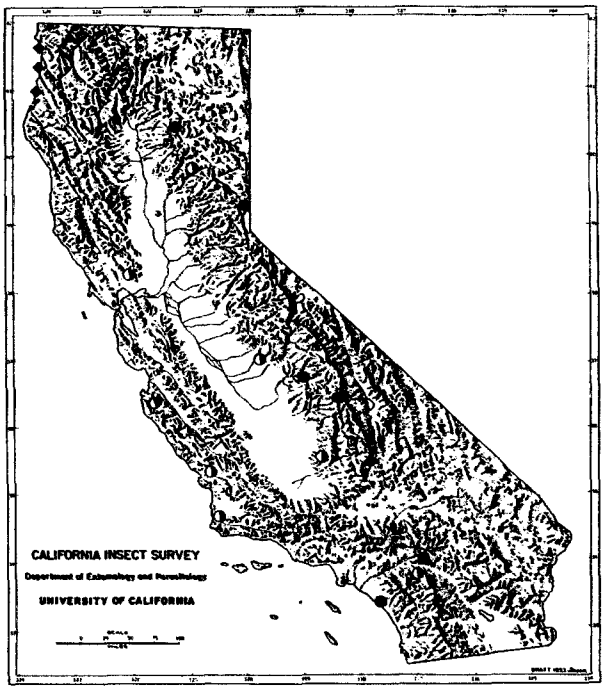
Larva. No spurs on palpal segment 1. Hypostome somewhat oval in outline; denticles 2/2 to base, plus 1-2 apical teeth in file 3. Coxae without external spurs; internal spur of coxa I bluntly pointed.

I. texanus closely resembles I. hearlei, but the female of the latter is smaller, less robust, and lacks the angular humps subtending the base of the hypostome. Similarly, the male and nymphs of hearlei lack humps on either side of the hypostome.

I. texanus is distributed throughout the United States and Mexico. In Canada it is common in British Columbia but less common in the east. In the west it is primarily found on mustelid hosts, but raccoons are frequently infested in the east.

In California, recorded distribution of I. texanus is primarily from interior mountainous areas. Specimens collected from pine martens near Lake Tahoe appear quite typical of I. texanus, but larvae, nymphs and females collected in southern California from skunks and the opposum are atypical and are only provisionally placed in this species.

CALIFORNIA RECORDS. FRESNO CO.: King's River, 1 female from gray squirrel, VII-1896 (V.L. Kellogg), (in Nuttall collection, identification verified by J.E. Keirans).



MAP 22. Distribution in California of: Ixodes texanus Banks, solid circles; I. uriae White, rectangles; I. woodi Bishopp, half-circles.

NEVADA CO.: Sagehen Creek Field Station, from Martes americana: 1 female, VII-18-1979; 1 nymph, VII-22-79; 2 nymphs and 1 female, VII-29-1979; 1 nymph, VIII-4-1979; 1 nymph, VIII-17-1979; 6 females, IX-19-1979, 3 nymphs and 13 females, II-1-1980; 1 female, II-5-1980 (W. Zielinski). ORANGE CO.: Dana Point: 1 female from Didelphis virginiana, X-29-1951; 2 females and 50 larvae from Spilogale gracilis, X-22-1952; San Juan Capistrano: 1 female and 3 nymphs from Mephitis mephitis, X-4-1951; 1 female, 9 nymphs, 40 larvae from S. gracilis, X-18-1951. SAN BERNARDINO CO.: Seven Oaks, 1 female from gray squirrel, V-9-1936. SHASTA CO.: Lassen Natl. Park, 2 females and 1 male from Eutamias s. frater, IX-20-1940 (T. Aitken). TULARE CO.: Mt. Whitney, 2 females from unidentified host, VI-19-1915.

Ixodes (Ceratixodes) uriae White
(Figs. 330-339; Map 22)

Ixodes uriae White, 1852, in Sutherland, Journal of a voyage in Baffin's Bay and Barrow Straite, 1850-1851, 2: appendix, ccx, fig. 10 (female); Neumann, 1899, Mém. Soc. Zool. Fr. 12:126, 127 (male, nymph); Nuttall, 1912, Parasitology 5:60, fig. 9 (larva).

Hyalomma puta Pickard-Cambridge, 1876, Proc. Zool. Soc. London 17:261, pl. XIX, fig. 3.

Ixodes borealis Kramer and Neuman, 1883, in Nordenskiöld, Vega Expeditiones Vetensk 3:527, pl. 43.

Ixodes hirsutus Birula, 1895, Isv. Imp. Akad. Nauk, ser. 5, 2:356, pl. I, figs. 7-9.

Ixodes putus procellariae Schulze, 1930, Sitzungsber. Abh. Naturforsch. Ges. Rostock 2:120-124.

DIAGNOSIS. Female (Figs. 332, 333). A large, long-legged tick. Body length, including capitulum, 3.3 mm, increasing to 11 X 7 mm in engorged state (Nuttall and Warburton, 1911). Dorsal and ventral body prominently clothed with long hairs. Capitulum (Fig. 336, 337) without cornua or auriculae. Porose areas large, distinct, separated by narrow median strip of cuticula. Palpi with segment 4 relatively elongate and visible from above; segment 1 relatively well developed. Hypostome rounded apically; dentition 2/2; subequal size; teeth bluntly pointed. Scutum (Fig. 332) wider anteriorly, broadly rounded caudally. Cervical grooves broad, straight, prominent, diverging posteriorly. Coxae without spurs. Genital aperture (Fig. 333) at level of interval between coxae II and III.

Male (Figs. 330, 331). Large: length, exclusive of caudal spines, 3.16 mm, width 2.49 mm (Cooley and Kohls, 1945). Capitulum (Fig. 335) without cornua or auriculae. Palpi with segment 1 large and visible in dorsal view; segment 4 arising on ventral surface well removed from apical point of segment 3. Hypostome (Fig. 335) reduced, broad, bilobed, with vestigial denticles. Scutum (Fig. 330) punctate; cervical grooves prominent, diverging posteriorly. Anal, adanal, and epimeral plates bearing caudal fringe of prominent spines (Fig. 334). Coxae essentially as in female. Genital aperture at level of posterior margins of coxae I.

Nymph. Capitulum and hypostome (Fig. 338) similar to those of female. Scutum (Fig. 339) widest anteriorly; cervical grooves prominent. Coxae without spurs.

Larva. With only 1 pair of posthypostomal setae; 4 pairs of scutal setae.

I. uriae occurs on marine birds and in their nests in both northern and southern hemispheres in boreal, subpolar, and polar regions. It has been recorded from Europe, Asia, Australia, South America, and Canada, as well as from Alaska, Oregon, and California.

Eley (1977) recorded I. uriae from 10 of 12 species of seabirds nesting on offshore rocks of Del Norte and Humboldt counties. The birds found infested were Oceanodroma furcata, the Fork-tailed Petrel; O. leucorhoa, Leach's Petrel; Phalacrocorax auritus, the Double-crested Cormorant; P. penicillatus, Brandt's Cormorant; P. pelagicus, the Pelagic Cormorant; Larus occidentalis, the Western Gull; Uria aalge, the Common Murre; Cepphus columba, the Pigeon Guillemot; Ptychorhamphus aleuticus, Cassin's Auklet; and Lunda cirrhata, the Tufted Puffin. Eley also collected 2 female I. uriae from Lutra canadensis, the River Otter, on a beach 1.5 km south of Trinidad, Humboldt Co., on V-2-1970. The latter host association is considered accidental. Harald Johnson collected 1 male, 9 females, and 12 engorged nymphs from Flatiron Rock, Trinidad Head, Humboldt Co., on VI-22-1972. We have examined the male of this collection; all others were destroyed during virus isolation attempts.

Ixodes (Pholeoixodes) woodi Bishopp (Figs. 340-349; Map 22)

Ixodes angustus woodi Bishopp, 1911, Proc. Biol. Soc. Wash. 24:205, pl. II, fig. 13 (female); Cooley and Kohls, 1945, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 184:163, fig. 65G-I (nymph); Kohls, 1950, J. Parasitol. 36:65, fig. 1 (male).

DIAGNOSIS. Female (Fig. 344). Capitulum (Figs. 346, 347) without cornua or auriculae. Porose areas moderate in size, well separated. Palpi up to 3.8 X longer than wide; segment 1 with laterally projecting suboval ventral plate. Hypostome borne on tapered median anterior projection of basis capituli; apex narrowly rounded; denticles 2/2, with lateral denticles larger than medians. Ventral basis capituli elongate, smooth, lacking lateral constrictions. Scutum (Fig. 345) distinctly longer than wide, oval, widest caudad to midlevel. Scapulae large, triangular. All coxae with short external spurs; coxa I with slender internal spur as long or longer than external spur. Genital aperture at level of coxae III.

Male. Small: body 2.22 mm long to tip of scapula, width 1.44 mm (Kohls, 1950). Capitulum (Fig. 342) without cornua. Auriculae broad lateral saliences. Palpi short, broad; lacking ventral projections on segment 1. Hypostome (Fig. 343) notched apically; denticles as discrete crenulations; files in 4/4 arrangement with no overlapping of rows. Scutum with well-defined punctations throughout; cervical grooves absent. Coxae (Fig. 341) similar to those of female, but inner spur of coxa I not as slim. Ventral median plate somewhat longer than anal plate. Genital aperture at level of interval between coxae II and III.

Nymph. Capitulum with short cornua; auriculae small, broadly pointed projections (Fig. 348). Palpi short, broad; segment 1 without anterior spur, but with strong posterior spur directed laterally more than posteriorly (Fig. 348). Hypostome short, rounded apically; denticles 2/2 to base (Fig. 348). Scutum slightly wider than long; widest at midlevel; lateral carinae faint. Coxal spurs (Fig. 349) similar to those of female, but internal spur of coxa I wider and longer than external spur.

Larva. Undescribed.

Females of I. woodi resemble I. angustus and I. ochotonae, but differ in having 2/2 dentition throughout the length of the hypostome and prominent ridges on the dorsal side of the basis capituli, which restrict the posterolateral extensions of the porose areas. The hypostome of the male woodi differs from that of angustus, in which the crenulations are indistinct. Nymphs of angustus differ from woodi in having an anterior spur on segment 1 of the palpi. Nymphs of ochotonae differ from woodi in that the posterior spur of palpal segment 1 is directed more posteriorly than laterally, and in having a weaker internal spur on coxa I.

I. woodi is primarily found on woodrats, Neotoma species, and their nests. Keirans and Clifford (1978) list collections from Alabama, Arizona, California, Colorado, Indiana, Kansas, Oklahoma, Texas and Utah. I. woodi is known from skunks as well as woodrats and their nests in foothill and low mountainous regions of central and southern California.

CALIFORNIA RECORDS. KERN CO.: 2-4 miles SW Glenville, 1 nymph from Neotoma fuscipes,

II-(17-18)-1959 (A.M. Barnes). MADERA CO.: San Joaquin Experimental Range, 2 nymphs from N. fuscipes, XI-14-1950 (O'Neal and N. Cohn). MONTEREY CO.: Hastings Reservation: 4 nymphs from Spilogale gracilis, XI-19-38; 4 nymphs from N. fuscipes, I-11-39 (R. Holdenried); 2 nymphs from N. fuscipes, III-28-39 (R. Holdenried); 2 nymphs from Spilogale gracilis, II-26-40; 1 nymph from N. fuscipes, XI-13-40; 1 nymph from Mephitis mephitis, X-26-44; 1 nymph from N. fuscipes, I-10-46; 3 nymphs from N. fuscipes, II-2-46; 11 nymphs from N. fuscipes, III-3-46. NAPA CO.: 10 miles S Monticello, 2 nymphs from N. fuscipes, III-17-1957 (R.O. Schuster). PLUMAS CO.: 2.4 miles E Virgilia, 1 female and 2 nymphs from N. fuscipes, X-25-1961 (A.M. Barnes). RIVERSIDE CO.: 3 collections from San Timoteo Canyon: 2 nymphs from N. fuscipes, I-8-1952; 1 female from nest of N. fuscipes, I-8-1952; 2 nymphs and 1 larva (presumably of same species) from nest of N. fuscipes, I-27-1952 (Ryckman et al.). SAN LUIS OBISPO CO.: 1 mi. N, 4 mi. E Santa Margarita, 3 nymphs from N. fuscipes, X-31-1951 (K. Murray). SANTA BARBARA CO.: Vandenberg Air Force Base, 1 female from N. fuscipes, XI-10-1980 (M. Madon).

Genus Rhipicephalus Koch

Rhipicephalus Koch, 1844, Arch. Naturgesch. (Berlin) 10:238.
Rhipicephalus Nuttall and Warburton, 1911, Ticks: a monograph of the Ixodoidea 2:122.
Rhipicephalus Cooley, 1946, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 187:23.
Rhipicephalus Hoogstraal, 1956, African Ixodoidea 1:583.

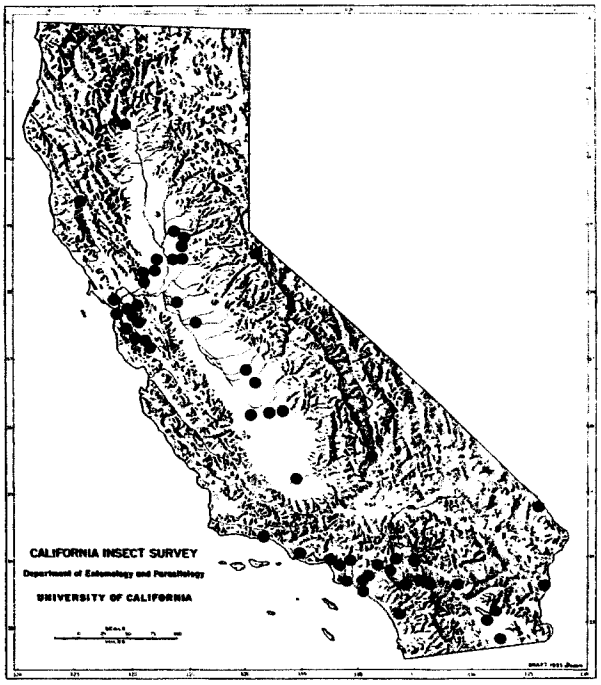
Type of genus: Rhipicephalus sanguineus (Latreille, 1806).

DIAGNOSIS (California species only). All instars inornate, with eyes and 9 festoons. Basis capituli hexagonal, with triangulate lateral projections (Fig. 303). Palpi of adults and nymphs short, with segment 1 barely, or not at all, visible in dorsal view (Fig. 353). Adults with coxa I bifid. Adults and nymphs with distinct anal groove posterior to anus (Fig. 355). Larvae with 1 pair of posthypostomal setae; scutum with 3 pairs of setae; 8 pairs of marginal dorsal setae, of which 4 pairs anterior to sensilla sagittiformia; 2 pairs of central dorsal setae.

Rhipicephalus sanguineus (Latreille)
(Figs. 350-356; Map 23)
Brown Dog Tick

Ixodes sanguineus Latreille, 1806, Genera crustaceorum et insectorum 1:157.
Rhipicephalus sanguineus; Koch, 1844, Arch. Naturgesch. 10:239; Hooker et al., 1912, U.S. Dept. Agric., Bur. Entomol. Bull. 106:102 (all instars described); Cooley, 1946, U.S. Pub. Health Serv., Natl. Inst. Health Bull. 187:24.
Rhipicephalus stigmaticus Gerstäcker, 1873, Gliederthiere, p. 496.
Rhipicephalus texanus Banks, 1908, U.S. Dept. Agric., Bur. Entomol. Tech. Ser. 15:34.

DIAGNOSIS. Female. Body (Fig. 351) oval to elliptical; widest posteriorly. Unfed tick small: 2.4-2.7 mm long from tips of scapulae X 1.44-1.68 mm wide (Cooley, 1946a). Capitulum hexagonal (Fig. 353). Cornua present as salient corners. Porose areas small, with long axis longitudinal. Palpi short, broad; segment 1 with ventral, subtriangular plate and curved, irregularly branched, parallel setae on inner margin;



MAP 23. Distribution in California of Rhipicephalus sanguineus (Latreille), solid circles.

segment 2 with similar setae. Hypostome long, clavate, with distinct corona and 3/3 dentition. Coxa I with external spur thinner and more acutely pointed than internal spur; coxae II-IV with small rounded external spurs. Coxae II and III with internal spurs as small rounded mounds. Spiracular plate short, comma-shaped.

Male. (Fig. 350). Elongate oval, widest behind middle. Size similar to that of unfed female. Capitulum shape similar to that of female. Coxae as in female, but coxa IV with small internal spur (Fig. 352). Genital aperture at level of anterior region of coxae II. Anal, adanal, and accessory plates distinct (Fig. 352). Spiracular plate elongate, comma-shaped.

Nymph. Basis capituli (Fig. 354) hexagonal in dorsal view. Anal groove (Fig. 355) in form of arc bordering posterior of anus. Coxa I (Fig. 356) with external spur widely separated from smaller internal spur; coxae II and III with small external spurs (Fig. 356); coxa IV with external spur rudimentary or absent. Other diagnostic features as given for genus.

Larva. Basis capituli hexagonal in dorsal view. Other diagnostic features as given for genus.

Adults of R. sanguineus may be distinguished from all other ticks occurring normally in California by the hexagonal basis capituli. A cattle tick, Boophilus annulatus, which at one time was introduced occasionally over the southern borders of the state, has a hexagonal basis capituli, but is easily distinguishable by a lack of marginal festoons and presence of prominent transverse ridges on the short palpi. Nymphs of R. sanguineus may be most easily confused with some species of Dermacentor, from which they differ in having the basis capituli hexagonal dorsally, with the anterolateral margins converging abruptly to the base of the hypostome, in contrast to the more gradual convergence of the antero-lateral margins in Dermacentor. Rhipicephalus nymphs also differ from Dermacentor in possessing a much smaller palpal segment 1 which is typically not visible dorsally and forms only a small angular plate ventrally; the palpal apices are more sharply triangular dorsally, and the anal groove is more distinct. The latter character is best observed in unfed, unmounted specimens. Larvae differ from the similar-appearing larvae of Dermacentor in having 4 rather than 3 marginal dorsal setae anterior to the sensillae sagittiformia.

The brown dog tick, also known as the kennel tick, is the only representative of the large genus Rhipicephalus in the United States. Hoogstraal (1956) states that this tick now occupies practically all countries between 50°N and about 35°S. As the name implies, it is a common pest on dogs. Its habits differ from those of other ticks occurring on dogs in California in that typically it is a resident of kennels or homes housing dogs, rather than the exterior environment. It is a 3-host tick in which the larva, nymph, and adult each engorge once, typically on the dog, dropping off after each feeding to seek harborage in the kennel or home. Eggs are laid in cracks in the housing, often in the upper parts of the structure. Other hiding places, such as under the edge of rugs, furniture, etc., may be infested. In subtropical areas or in heated structures, breeding may occur throughout the year. Nuttall (1915) reported that at a 30°C temperature the life cycle of R. sanguineus could be completed in as little as 63 days. He also found that adults may survive without food up to 568 days.

In the United States, the brown dog tick is important primarily as a blood sucking nuisance of dogs, but it has tremendous potential as a carrier of disease agents. It is a vector of the protozoan parasite Babesia canis, causing canine jaundice. This pathogenic protozoan is common in many tropical regions, and although it is uncommon in the United States, it has been reported from California (Levine, 1973). Outside of the United States, R. sanguineus has been associated with a variety of pathogens, including Babesia equi of equines in central Asia; B. gibsoni of canines in India and China; Rickettsia conori, causing boutonneuse fever in man in southern Europe and Africa; and Rickettisa siberica, the causal agent of Siberian tick typhus in man. In Mexico, R. sanguineus has been implicated in the transmission to man of rickettsiae of the spotted fever group, and Burgdorfer et al. (1975, 1978) reported it as a vector in Mississippi of Rickettsia rhipicephali. The causal agent of canine rickettsiosis, Ehrlichia canis, is transmitted by R. sanguineus in the Middle East, Africa, and the Orient.

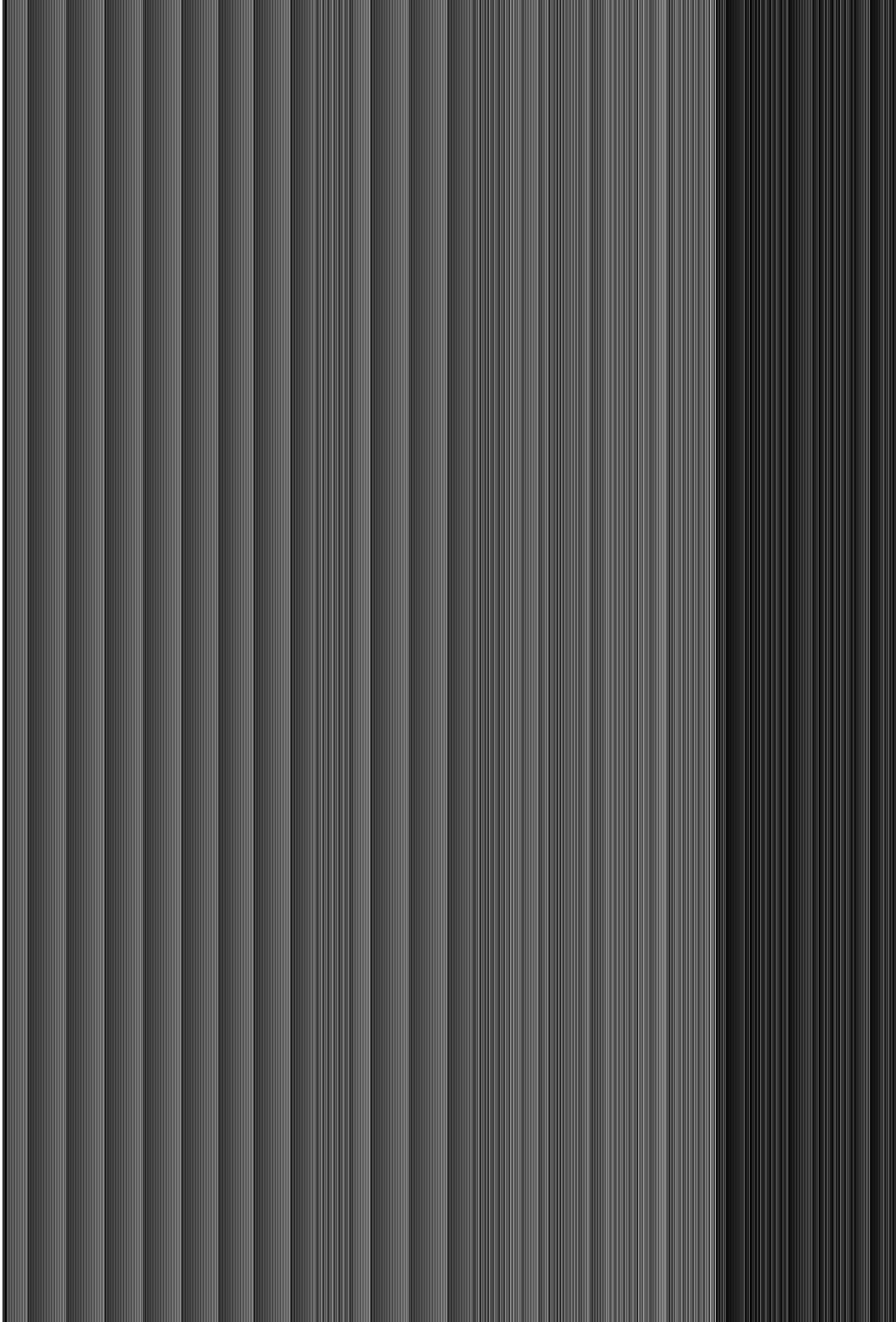
R. sanguineus in the United States is almost exclusively a parasite of dogs; only rarely has it been found attacking man. But in some countries it is found on a variety of domestic and wild mammals as well as on birds, and in certain areas attacks

man readily. It probably represents a species complex.

The majority of California collections are associated with the large population centers, but it appears that infestations may be encountered wherever dogs are maintained. Adult ticks have been collected in every month; nymphs have been collected in every season. Collections of larvae are relatively few, with no records for January through April, but in all probability breeding is continuous throughout the year in San Diego and Imperial counties and in warm housing in which infested dogs live. As seen in Table 19, California records of the brown dog tick have been made almost exclusively from dogs or their housing. A single collection of an adult female tick is recorded from an unidentified bird from Kern County.

TABLE 19. California Records of Rhipicephalus sanguineus (Latreille)

Host or Source	Tick Collections			
	Adults	Nymphs	Larvae	Unrecorded Instars
Bird	1	-	-	-
Homo sapiens	1	1	-	-
Canis familiaris	53	22	5	5
Kennel	4	1	1	-
House	13	5	1	2
Vegetation	1	-	-	-
Miscellaneous	1	-	-	1
Unrecorded	20	5	1	24



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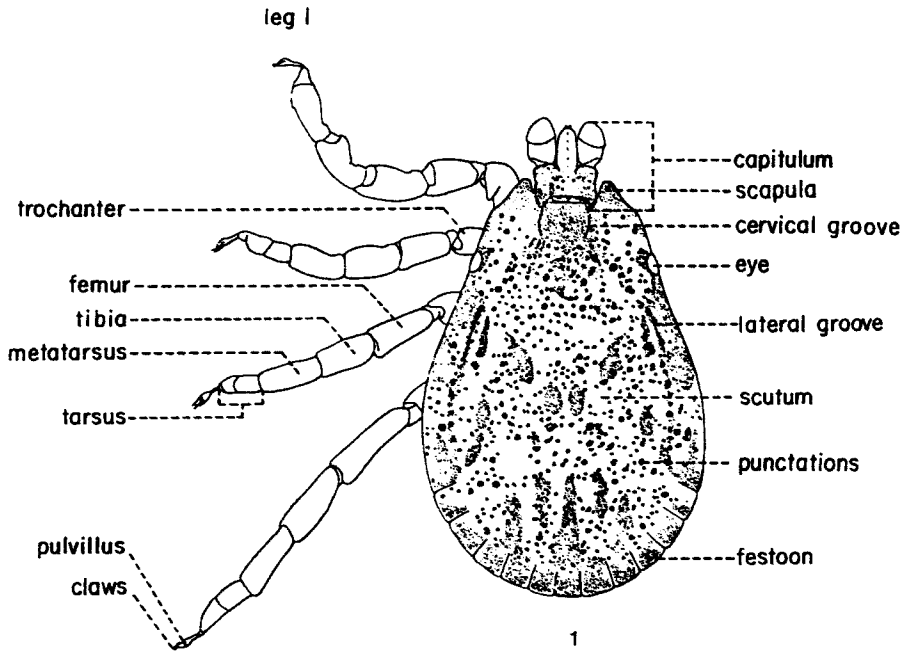
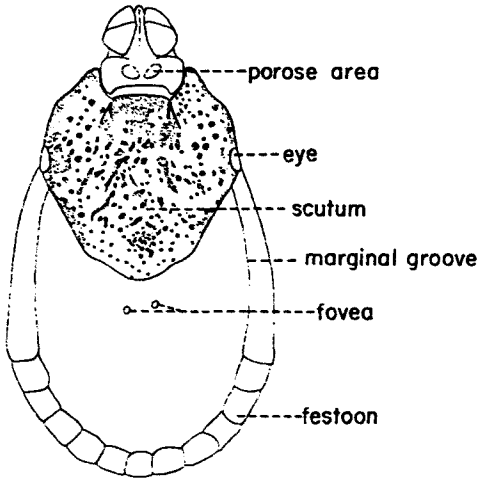
Plates

Plate 1

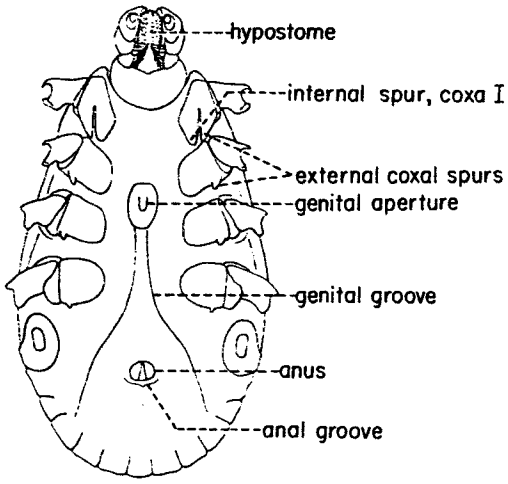
Figs. 1-4. Fig. 1, Dermacentor occidentalis Marx, ♂, dorsal view; Figs. 2-4, D. andersoni Stiles, ♀, dorsal and ventral views and spiracular plate.


leg I
capitulum
scapula
cervical groove
eye
lateral groove
scutum
punctations
festoon
trochanter
femur
tibia
metatarsus
tarsus
pulvillus
claws
leg 4

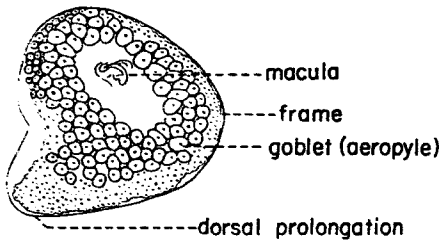
1


porose area
eye
scutum
marginal groove
fovea
festoon

2


hypostome
internal spur, coxa I
external coxal spurs
genital aperture
genital groove
anus
anal groove

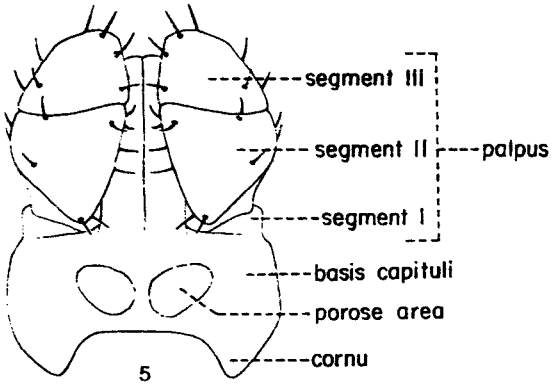
3


macula
frame
goblet (aeropyle)
dorsal prolongation

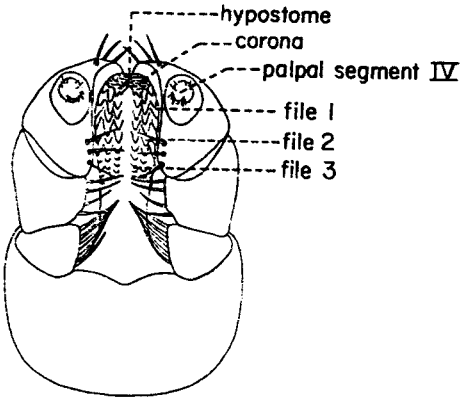
4

Plate 2

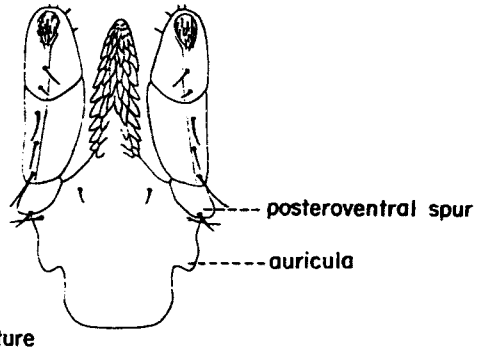
Figs. 5-11. Figs. 5 and 6, Dermacentor, ♀; capitulum, dorsal and ventral views; Fig. 7, Ixodes, tarsus, leg I; Fig. 8, Ixodes, ♂, ventral view; Fig. 9, Ixodes , capitulum, ventral view; Fig. 10, Rhipicephalus sanguineus (Latreille), ♂, posterior idiosoma, ventral view; Fig. 11, I. angustus Neumann, nymph, capitulum, ventral view.


segment III
segment II
palpus
segment I
basis capituli
porose area
cornu

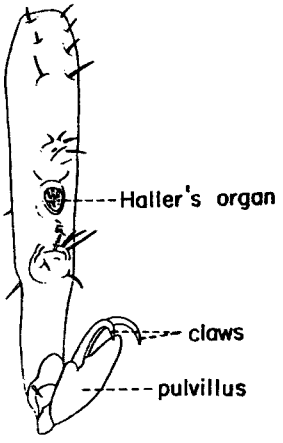
5


hypostome
corona
palpal segment IV
file 1
file 2
file 3

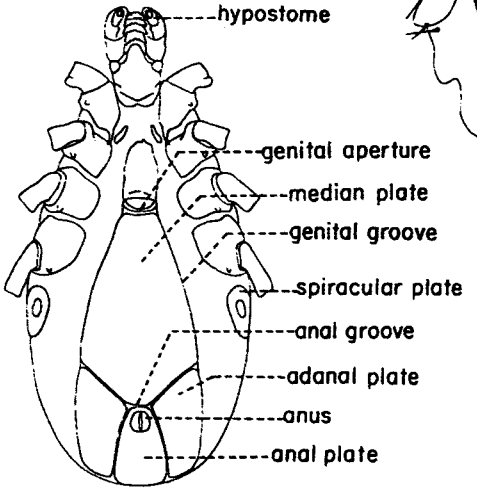
6


posteroventral spur
auricula

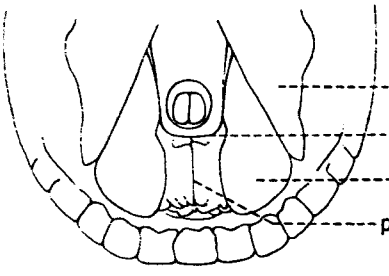
9


Haller's organ
claws
pulvillus

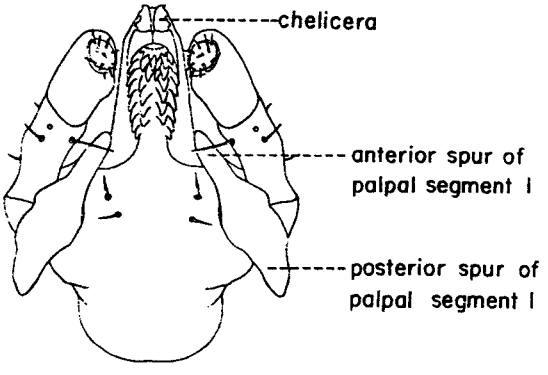
7


hypostome
genital aperture
median plate
genital groove
spiracular plate
anal groove
adanal plate
anus
anal plate

8


accessory shield
anal groove
adanal shield
postanal - median groove

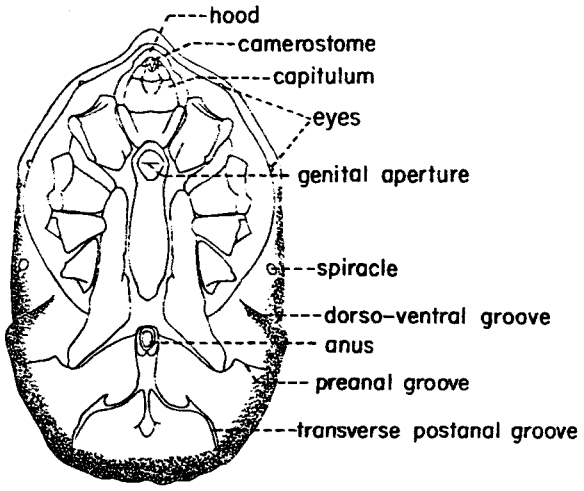
10


chelicera
anterior spur of palpal segment I
posterior spur of palpal segment I

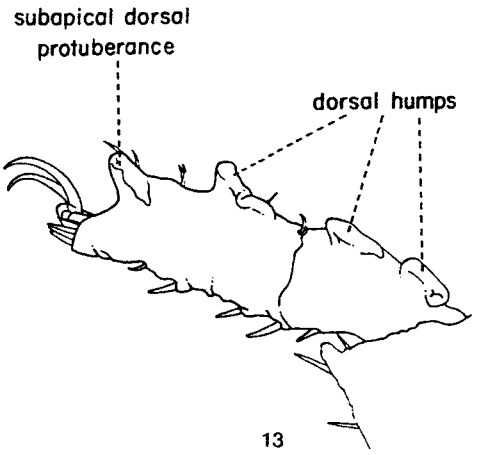
11

Plate 3

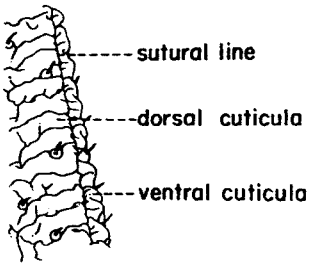
Figs. 12-15. Fig. 12, Ornithodoros coriaceus Koch, ♀, ventral view; Fig. 13, O. coriaceus Koch, tarsus, leg I; Fig. 14, Argas brevipes Banks, lateral sutural line and marginal dorsal integument; Fig. 15, A. persicus (Oken), capitulum, ventral view.


hood
camerostome
capitulum
eyes
genital aperture
spiracle
dorso-ventral groove
anus
preanal groove
transverse postanal groove

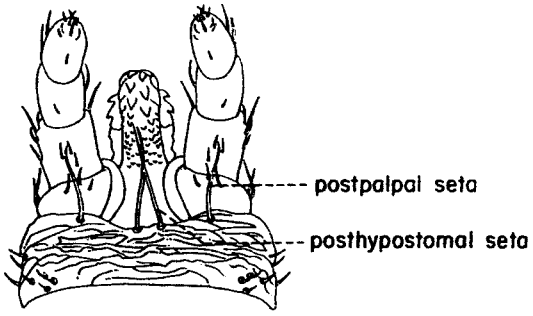
12


subapical dorsal protuberance
dorsal humps

13


sutural line
dorsal cuticula
ventral cuticula

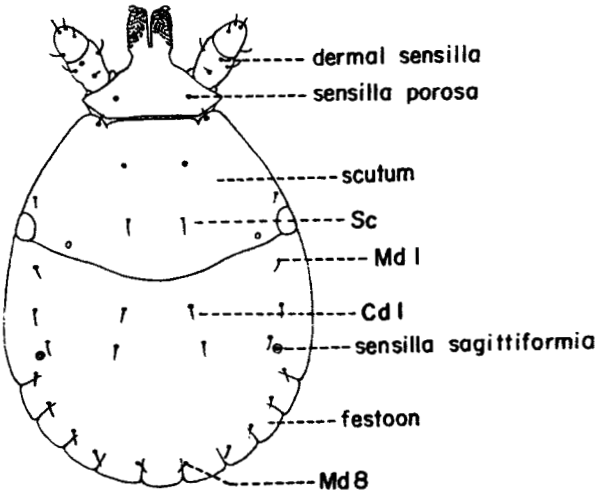
14


postpalpal seta
posthypostomal seta

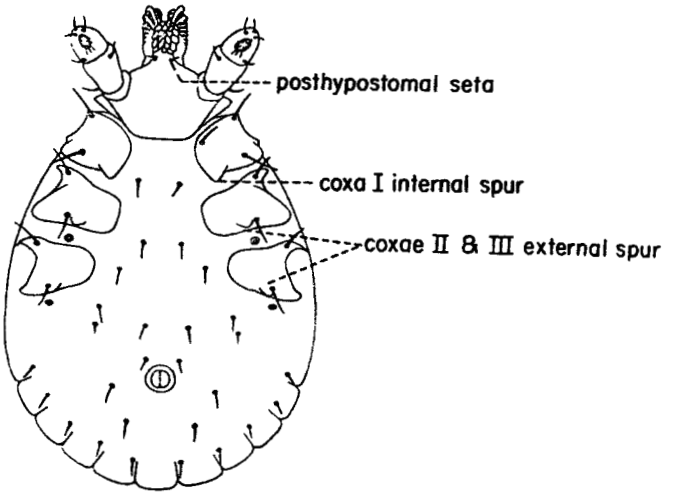
15

Plate 4

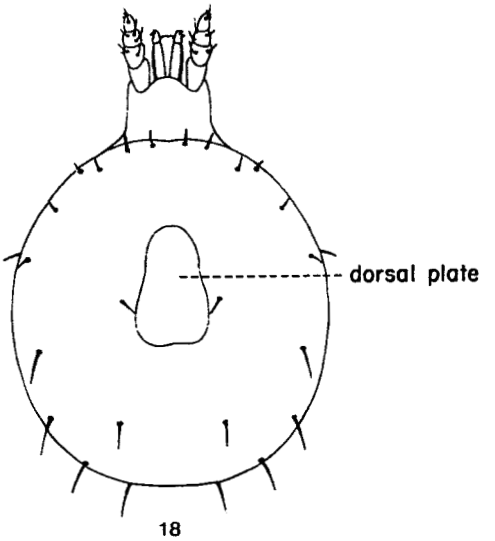
Figs. 16-20. Figs. 16 and 17, Dermacentor andersoni Stiles, larva, dorsal and ventral views; Figs. 18 and 19, Ornithodoros, larva, dorsal and ventral views; Fig. 20, Argasidae, larva, tarsus, leg I. A, apical; AV, apicoventral; B, basal; BV, basoventral; Cd 1, central dorsal seta 1; Md, marginal dorsal seta; MV, midventral; PC, paracapsular; Ph, post-hypostomal seta; PL, posterolateral; Pm, posterior median seta; PM, posteromedian; Sc, scutal seta; St, sternal setae.


dermal sensilla
sensilla porosa
scutum
Sc
Md I
Cd I
sensilla sagittiformia
festoon
Md 8

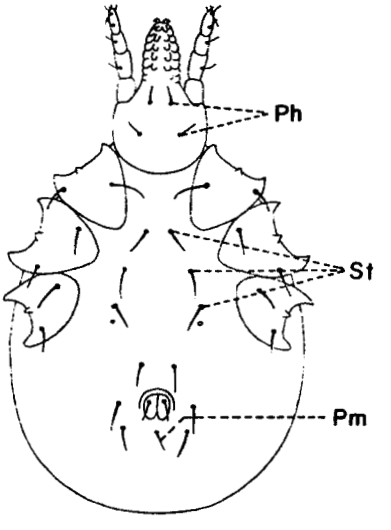
16


posthypostomal seta
coxa I internal spur
coxae II & III external spur

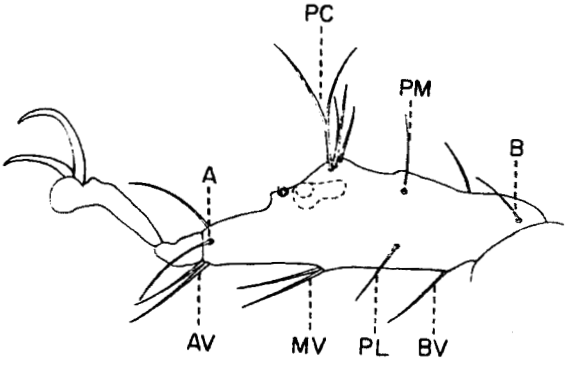
17


dorsal plate

18


Ph
St
Pm

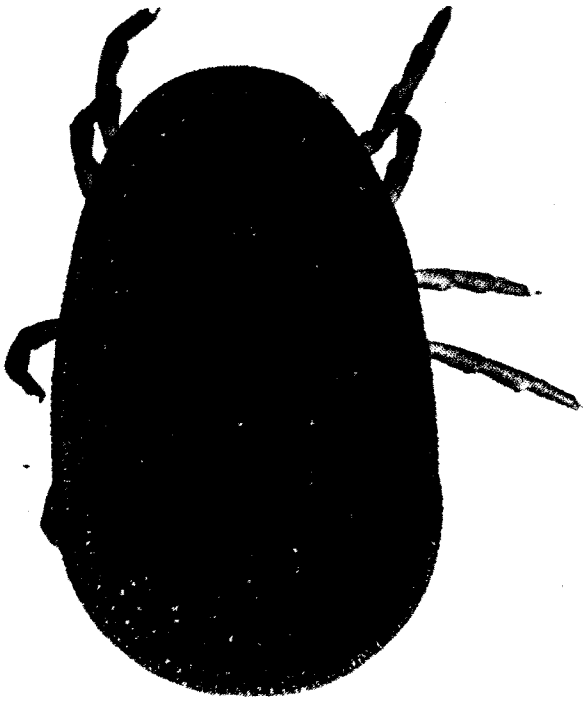
19


PC
PM
B
A
AV
MV
PL
BV

20

Plate 5

Figs. 21-24. Argas brevipes Banks: Fig. 21, Dorsum, ♀; Fig. 22, Venter, ♀; Fig. 23, Capitulum, ♂; Fig. 24, Marginal dorsal integument, ♀.



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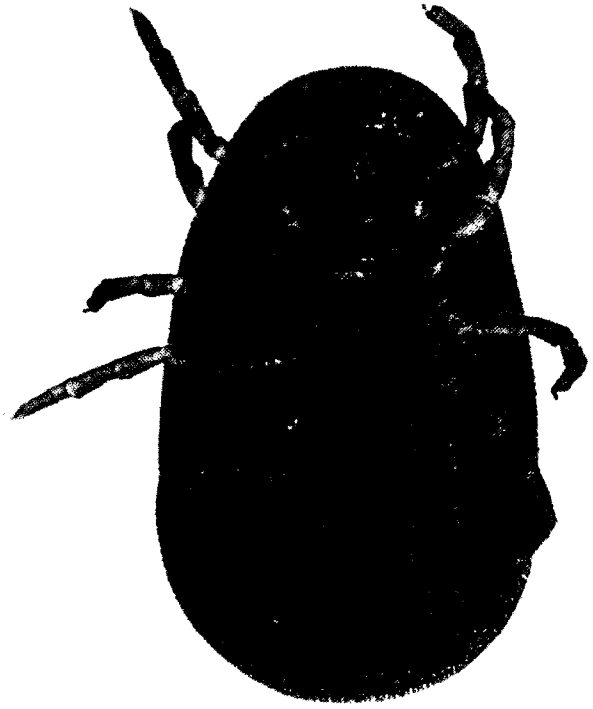
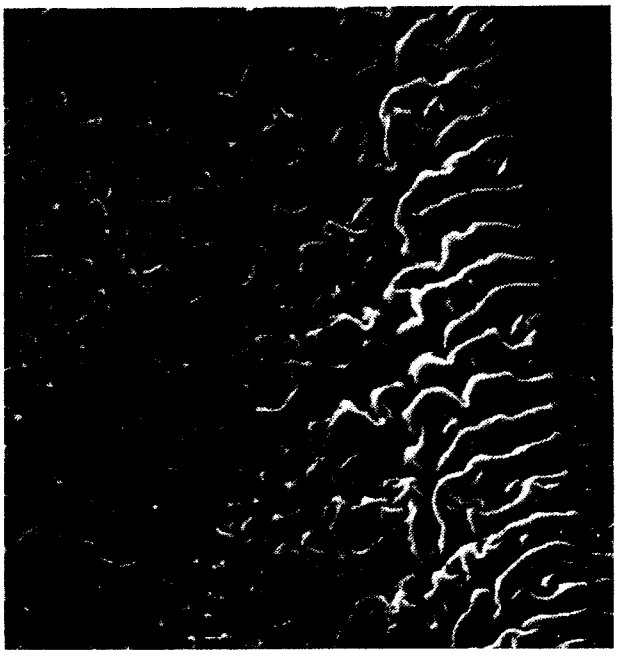


22

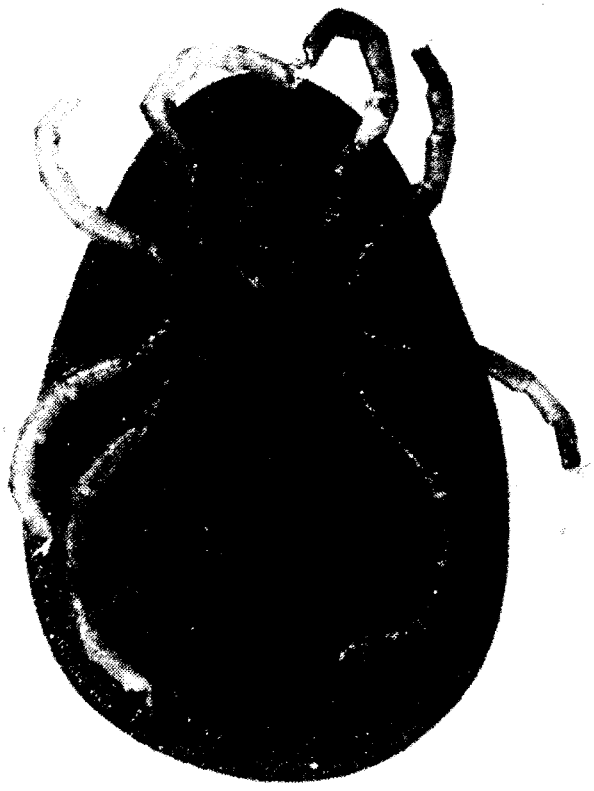
23



24

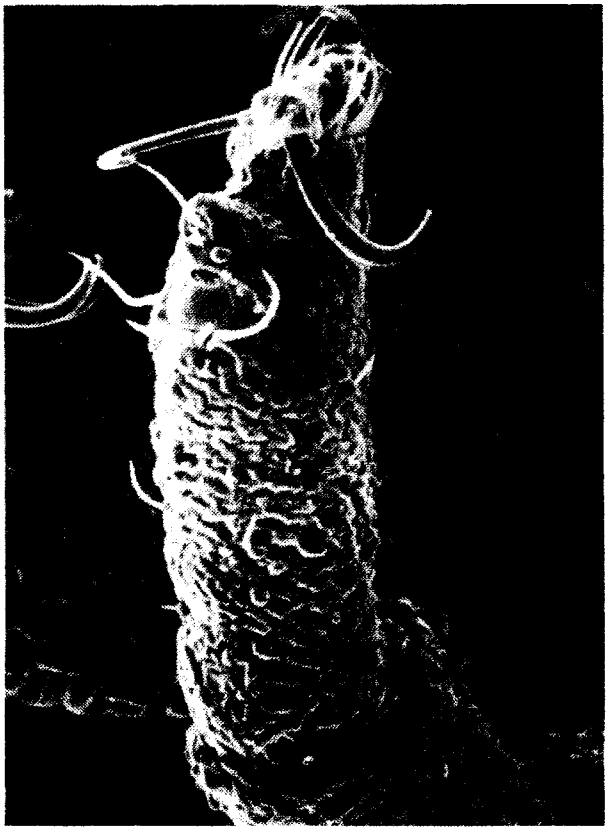
Plate 6

Figs. 25-28. Argas cooleyi Kohls and Hoogstraal: Fig. 25, Venter, ♀; Fig. 26, Capitulum, ♀; Fig. 27, Tarsus, leg I, ♀; Fig. 28, Marginal dorsal integument, ♂.



25

26



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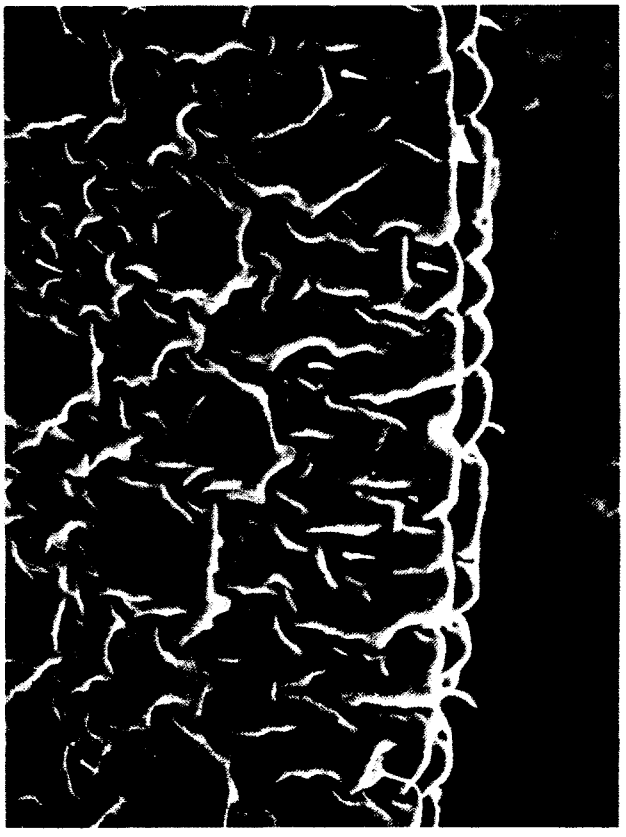

28

Plate 7

Figs. 29-32. Argas persicus (Oken): Fig. 29, Dorsum, ♀; Fig. 30, Venter, ♀; Fig. 31, Capitulum, ♀; Fig. 32, Marginal dorsal integument, ♂.

29

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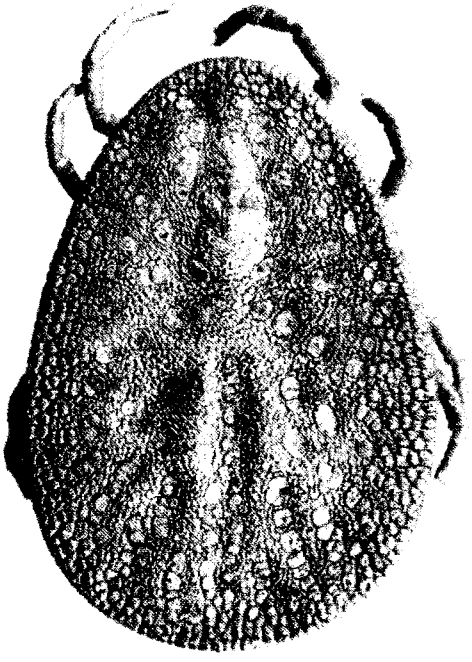
Plate 8

Figs. 33-38. Argas sanchezi Dugès: Fig. 33, Dorsum, ♂; Fig. 34, Venter, ♂; Fig. 35, Dorsum, ♀; Fig. 36, Venter, ♀; Fig. 37, Capitulum, ♀; Fig. 38, Posterolateral marginal integument, ♀.



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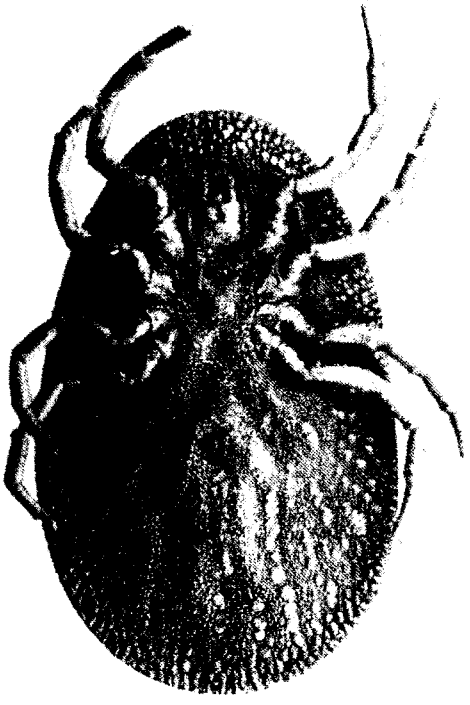

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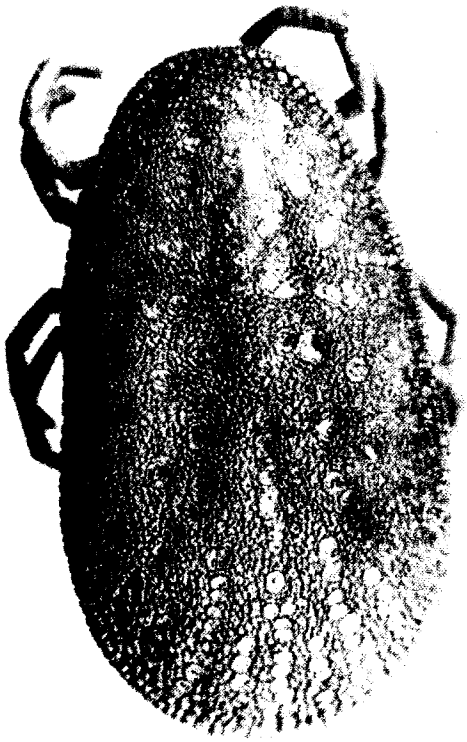

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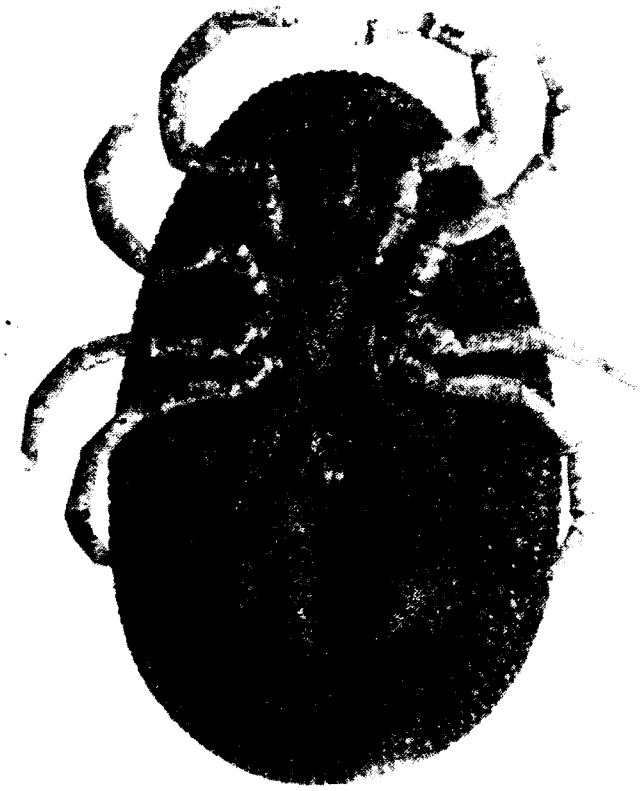
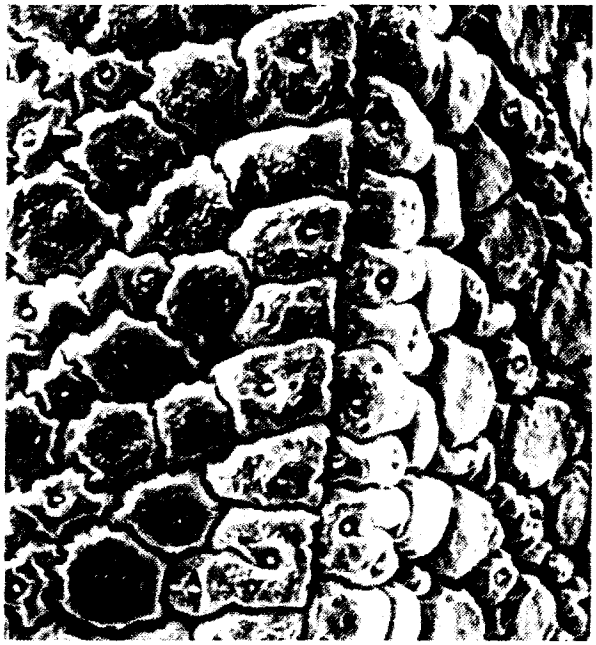


36

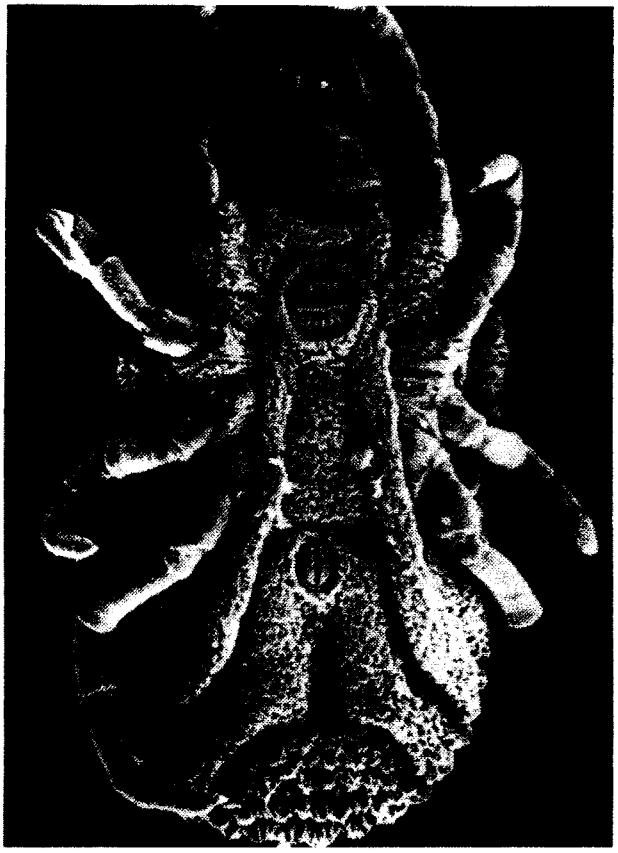
37



38

Plate 9

Figs. 39–42. Ornithodoros concanensis Cooley and Kohls: Fig. 39, Venter, ♀; Fig. 40, Tarsus, leg I, ♀; Fig. 41, Capitulum, ♀; Fig. 42, Capitulum and cheeks, ♀.



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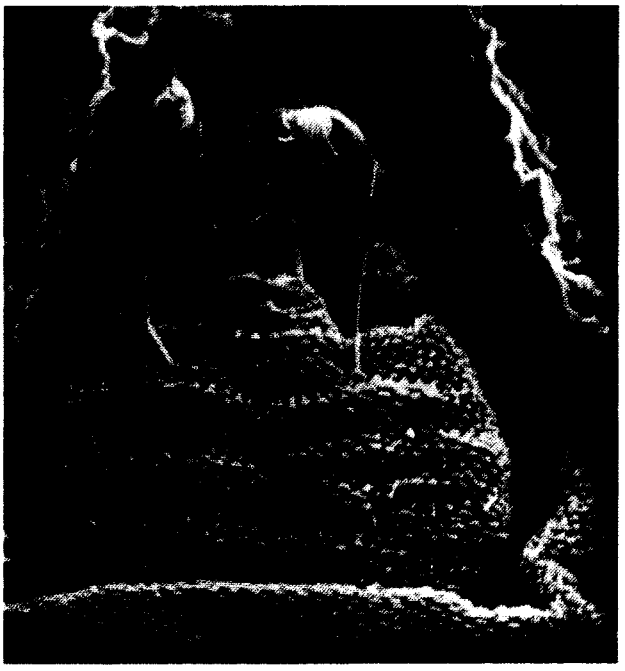
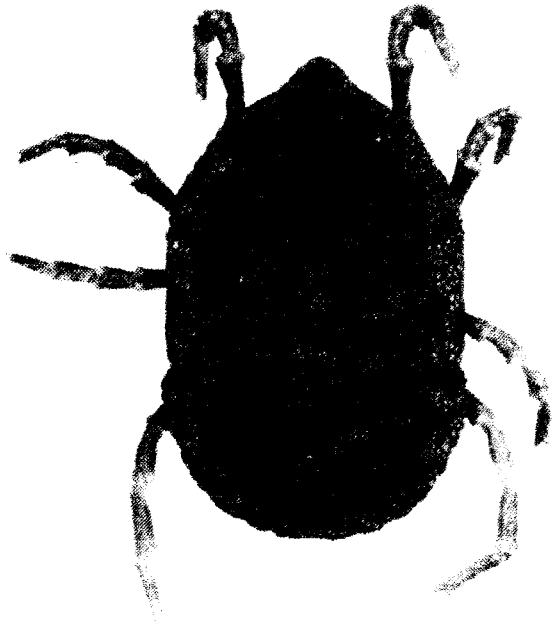


42

Plate 10

Figs. 43-46. Ornithodoros coriaceus Koch: Fig. 43, Dorsum, ♂; Fig. 44, Eyes on anterolateral margin, adult; Fig. 45, Capitulum, adult; Fig. 46, Tarsus, leg I, adult.



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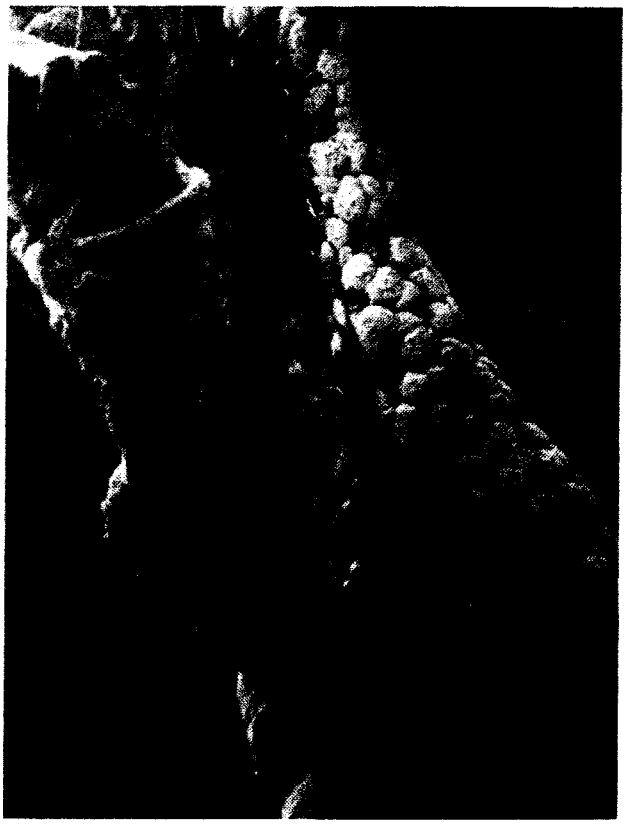

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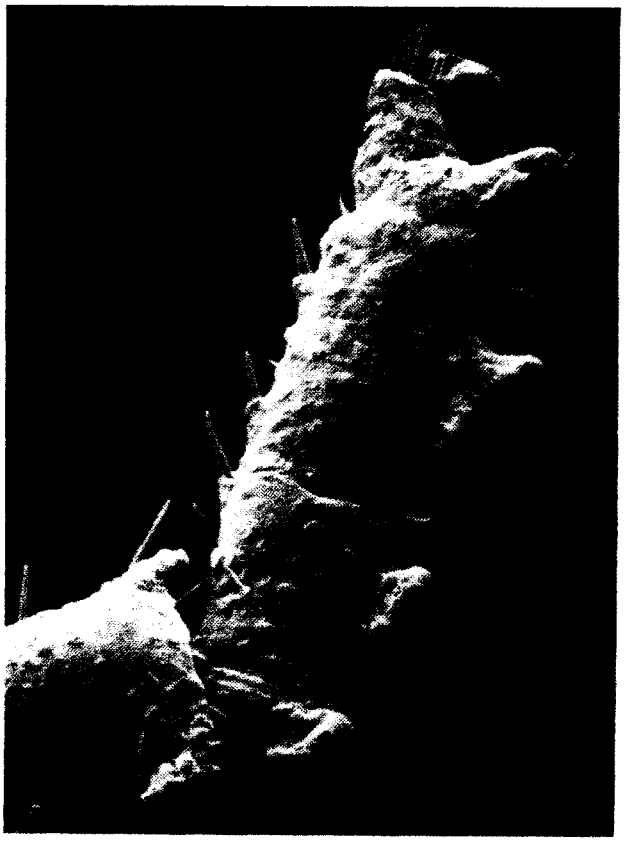
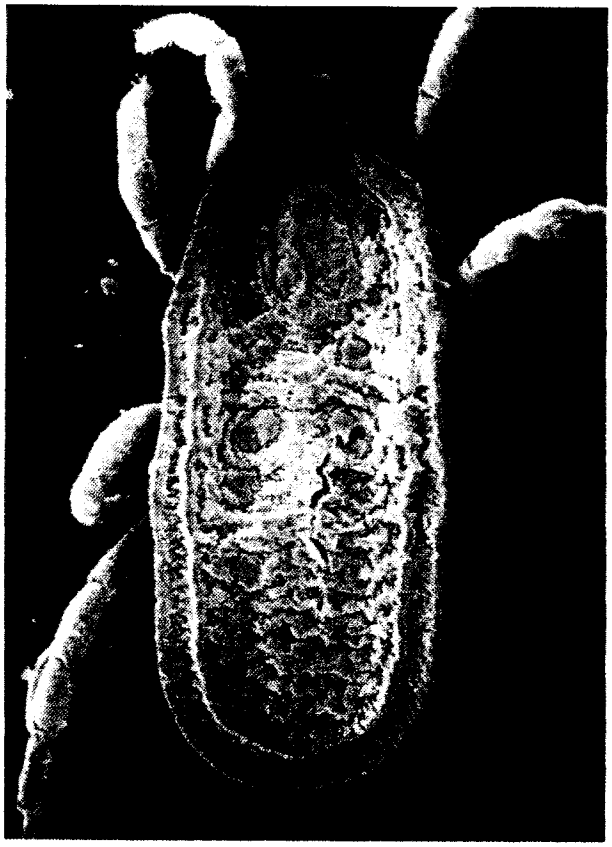


46

Plate 11

Figs. 47-50. Ornithodoros dyeri Cooley and Kohls, ♂: Figs. 47 and 48, Dorsal and ventral views; Fig. 49, Capitulum; Fig. 50, Hypostome detail.



47

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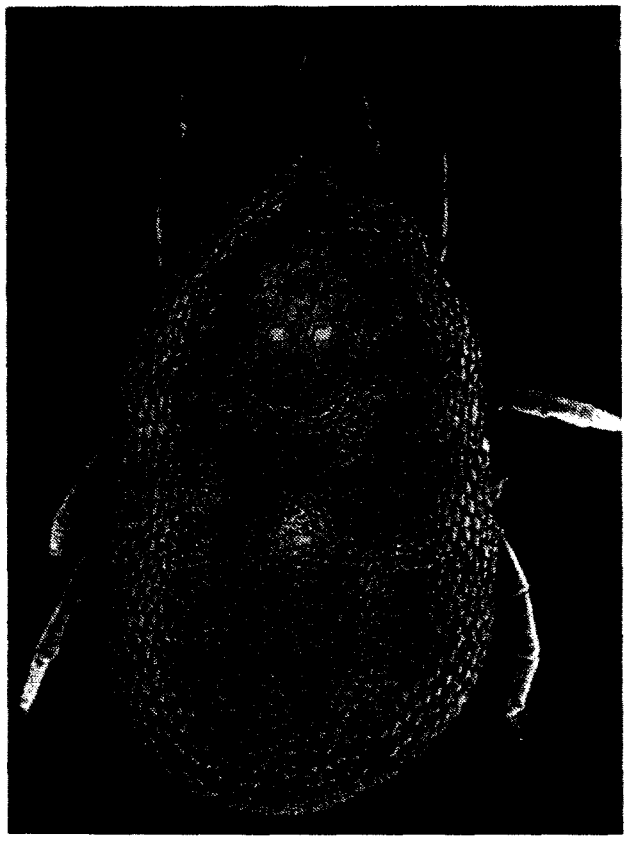
Plate 12

Figs. 51-56. Ornithodoros hermsi Wheeler, Herms and Meyer: Figs. 51 and 52, Dorsal and ventral views, ♀; Fig. 53, Capitulum, adult; Fig. 54, Genital orifice, ♂; Fig. 55, Tarsus, leg I, adult; Fig. 56, Genital orifice, ♀.



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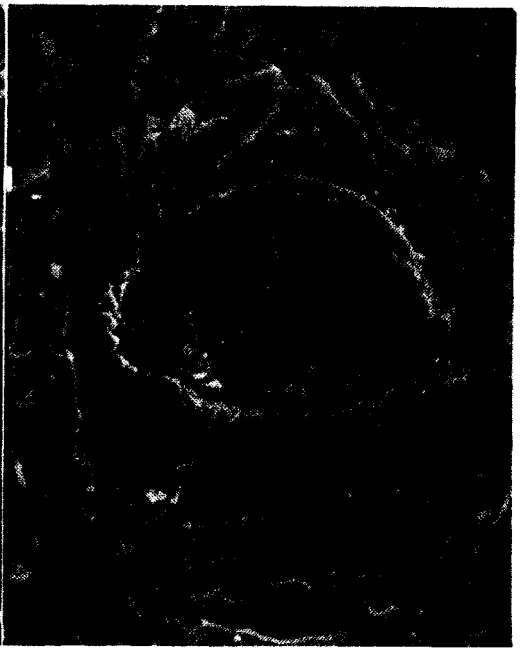

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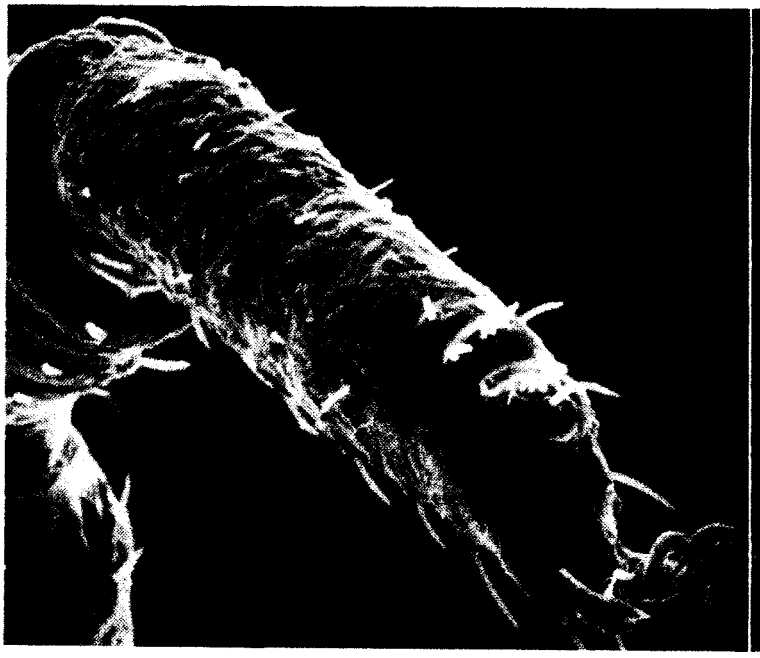


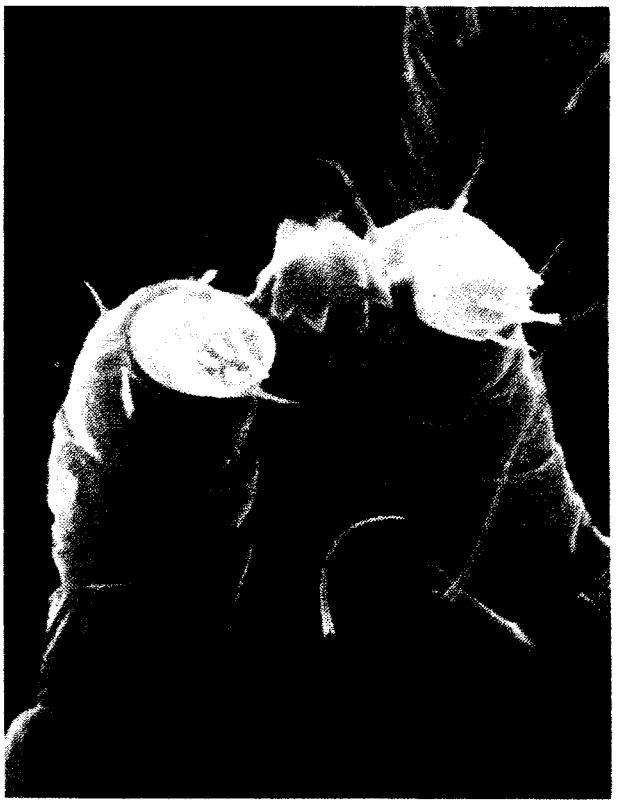
55

56

Plate 13

Figs. 57-60. Ornithodoros hermsi Wheeler, Herms and Meyer: Fig. 57, Dorsolateral integument, adult; Figs. 58-60, Capitulum and dorsal and ventral views, larva.

57



58

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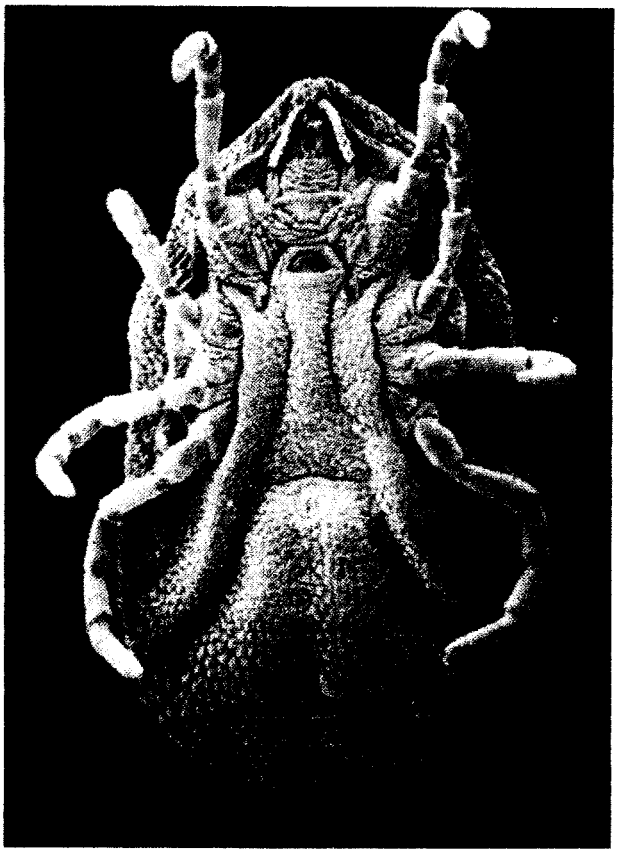
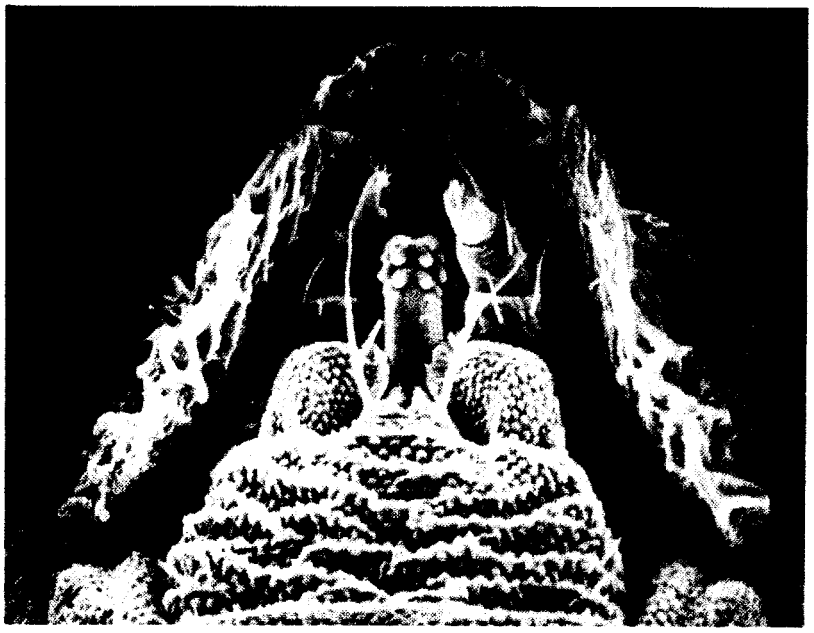
Plate 14

Figs. 61-63. Ornithodoros kelleyi Cooley and Kohls, ♂: Fig. 61, Ventral view; Fig. 62, Anterolateral profile; Fig. 63, Capitulum.



61

62



63

Plate 15

Figs. 64-69. Ornithodoros parkeri Cooley, ♀ : Figs. 64 and 65, Dorsal and ventral views; Fig. 66, Capitulum and genital region; Fig. 67, Capitulum detail; Fig. 68, Tarsus, leg I; Fig. 69, Dorsal integument detail.

64

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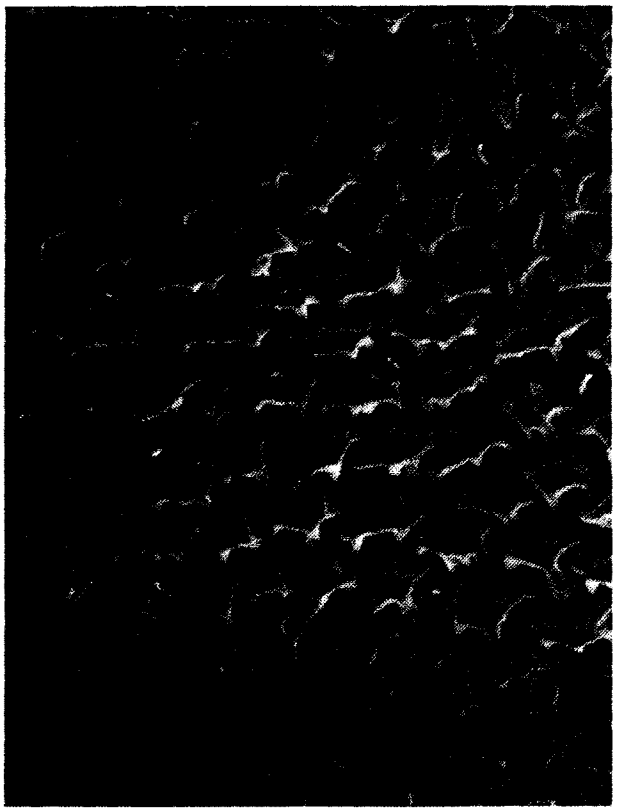
Plate 16

Figs. 70-73. Ornithodoros sparnus Kohls and Clifford: Fig. 70, Ventral view, ♀; Fig. 71, Dorsal integument, ♂; Fig. 72, Capitulum, ♀; Fig. 73, Tarsus, leg I, ♀.

70



71

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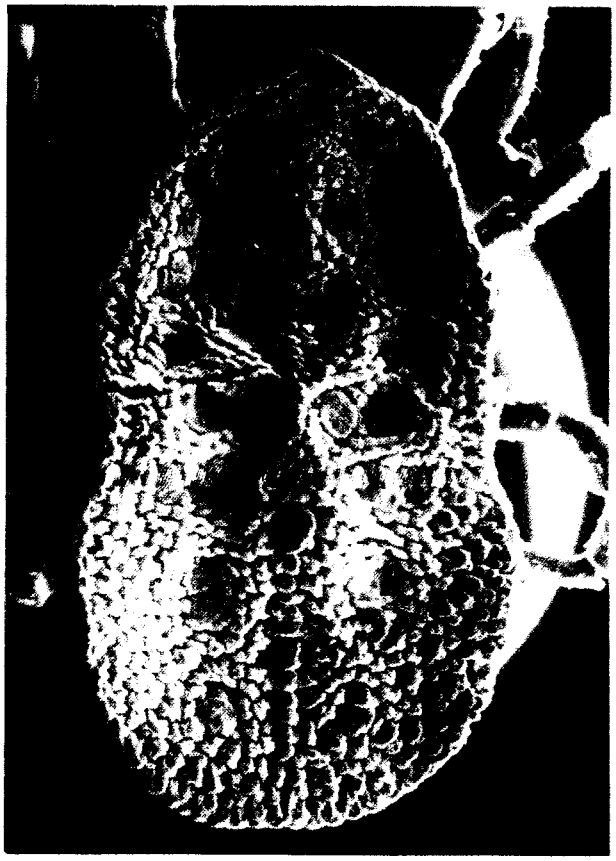
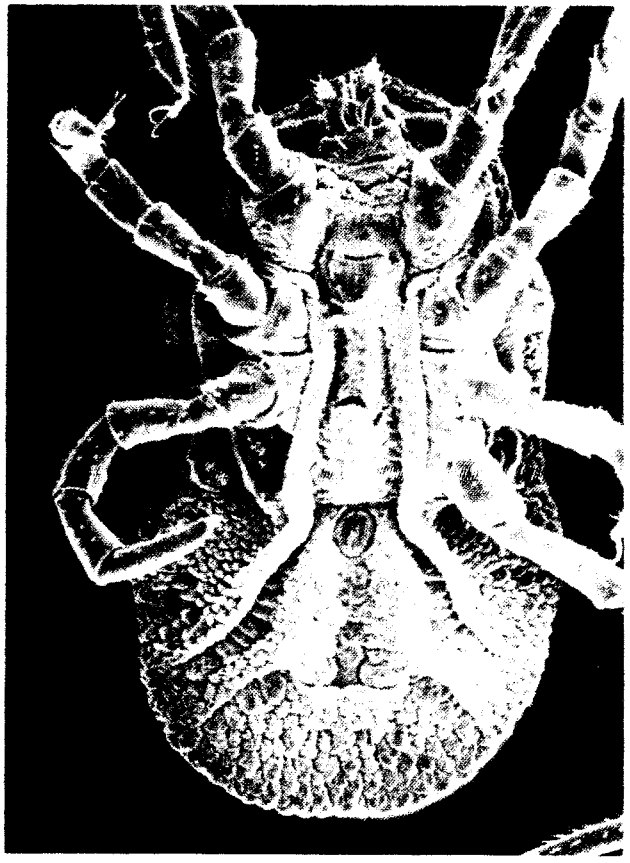
Plate 17

Figs. 74–77. Ornithodoros stageri Cooley and Kohls, ♀: Figs. 74 and 75, Dorsal and ventral views; Fig. 76, Capitulum; Fig. 77, Tarsus, leg I.



74



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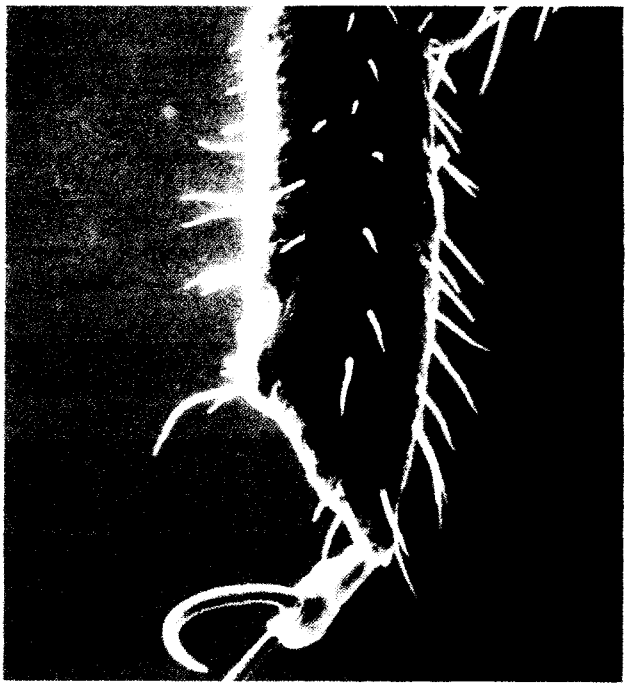

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Plate 18

Figs. 78-81. Ornithodoros talaje (Guérin-Méneville), ♀: Figs. 78 and 79, Dorsal and ventral views; Fig. 80, Capitulum; Fig. 81, Antero-lateral view of body wall and hood.

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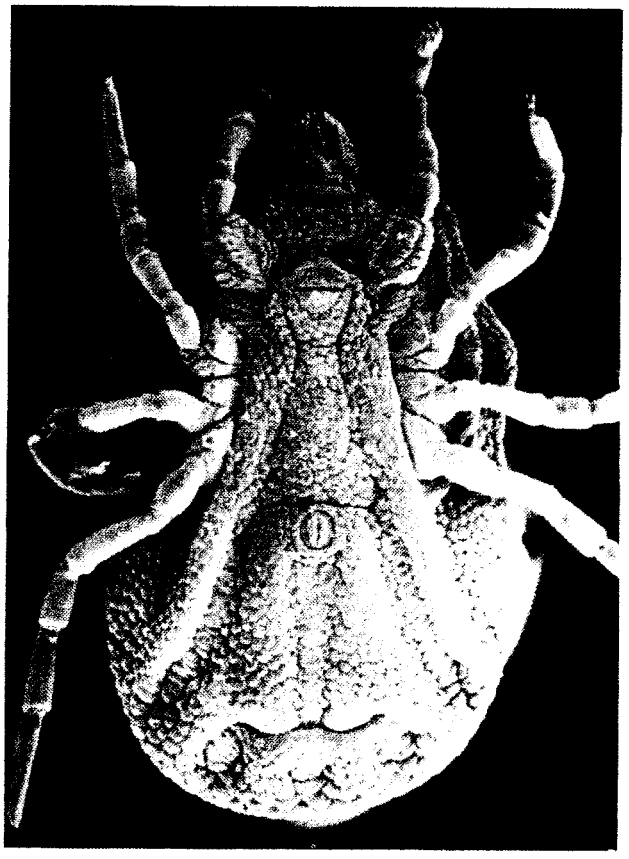

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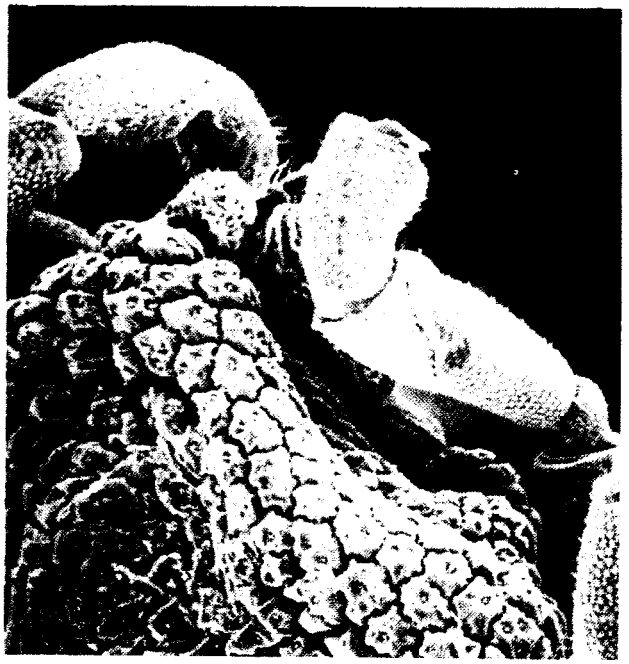

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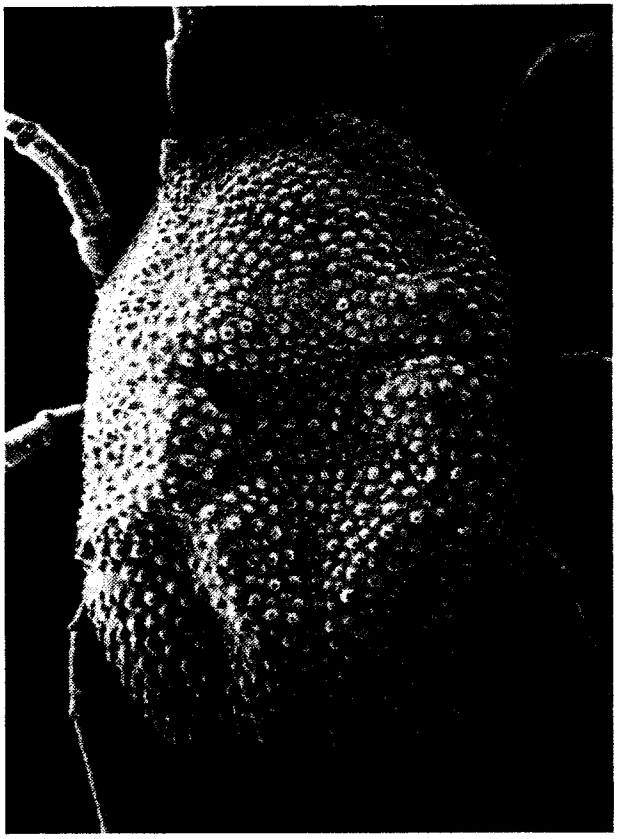
Plate 19

Figs. 82-85. Ornithodoros turicata (Dugès), ♂: Figs. 82 and 83, Dorsal and ventral views; Fig. 84, Capitulum; Fig. 85, Tarsus, leg I.



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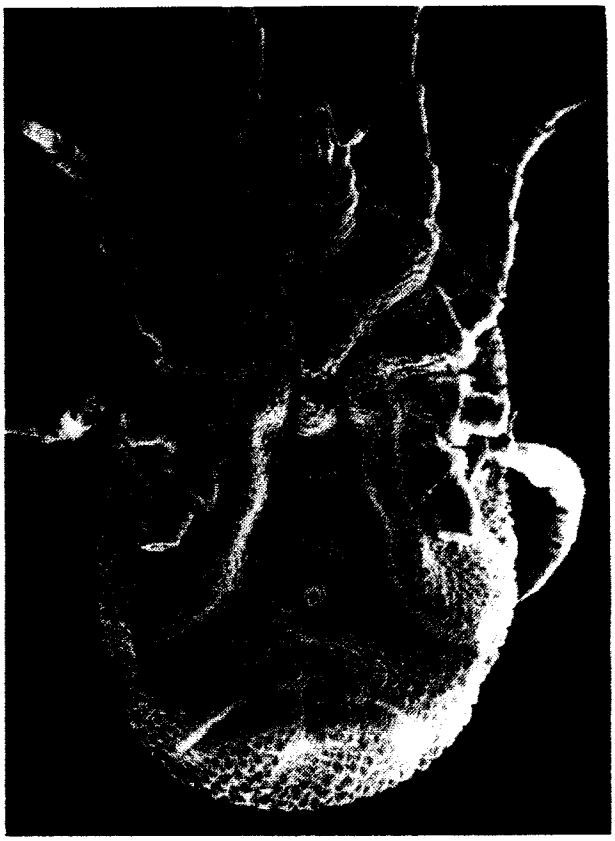

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Plate 20

Figs. 86-88. Ornithodoros yumatensis Cooley and Kohls, ♀: Fig. 86, Ventral view; Fig. 87, Tarsus, leg IV; Fig. 88, Capitulum.

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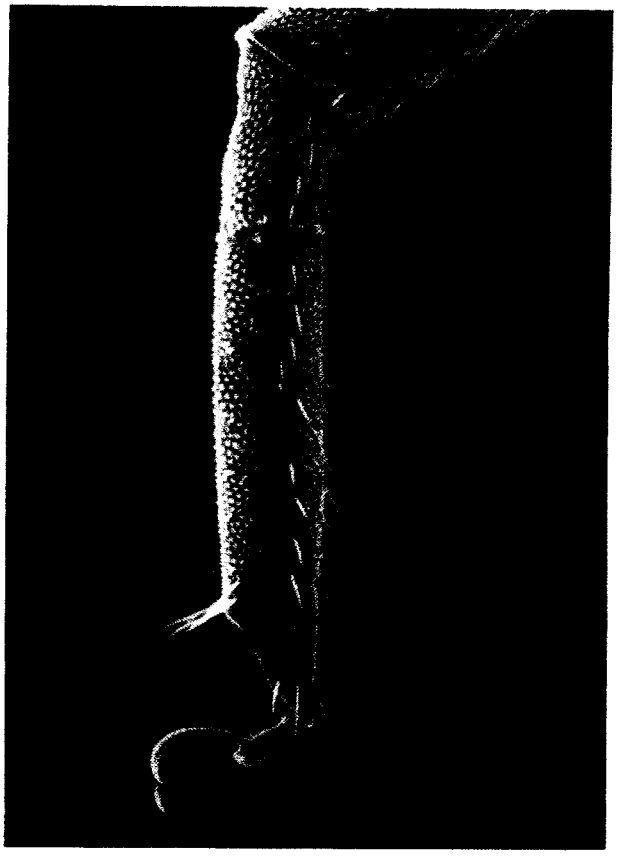

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Plate 21

Figs. 89-94. Otobius lagophilus Cooley and Kohls: Figs. 89 and 90, Dorsal and ventral views, ♀; Fig. 91, Capitulum, ♀; Fig. 92, Dorsal integument detail, ♀; Fig. 93, Dorsal view, nymph; Fig. 94, Capitulum, ventral view, nymph.

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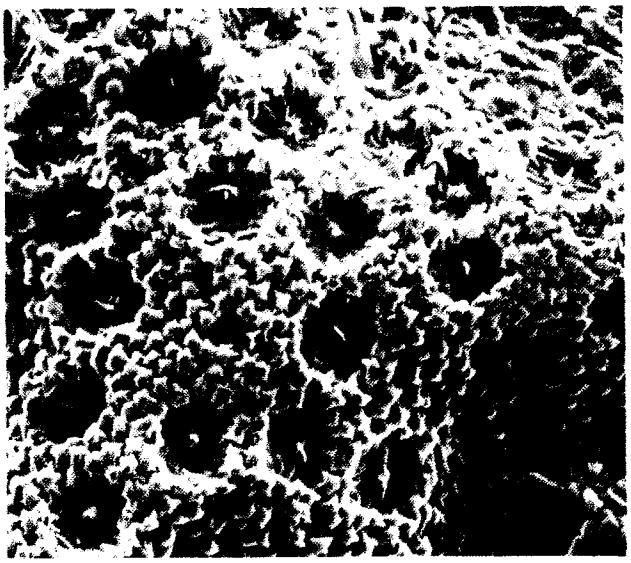

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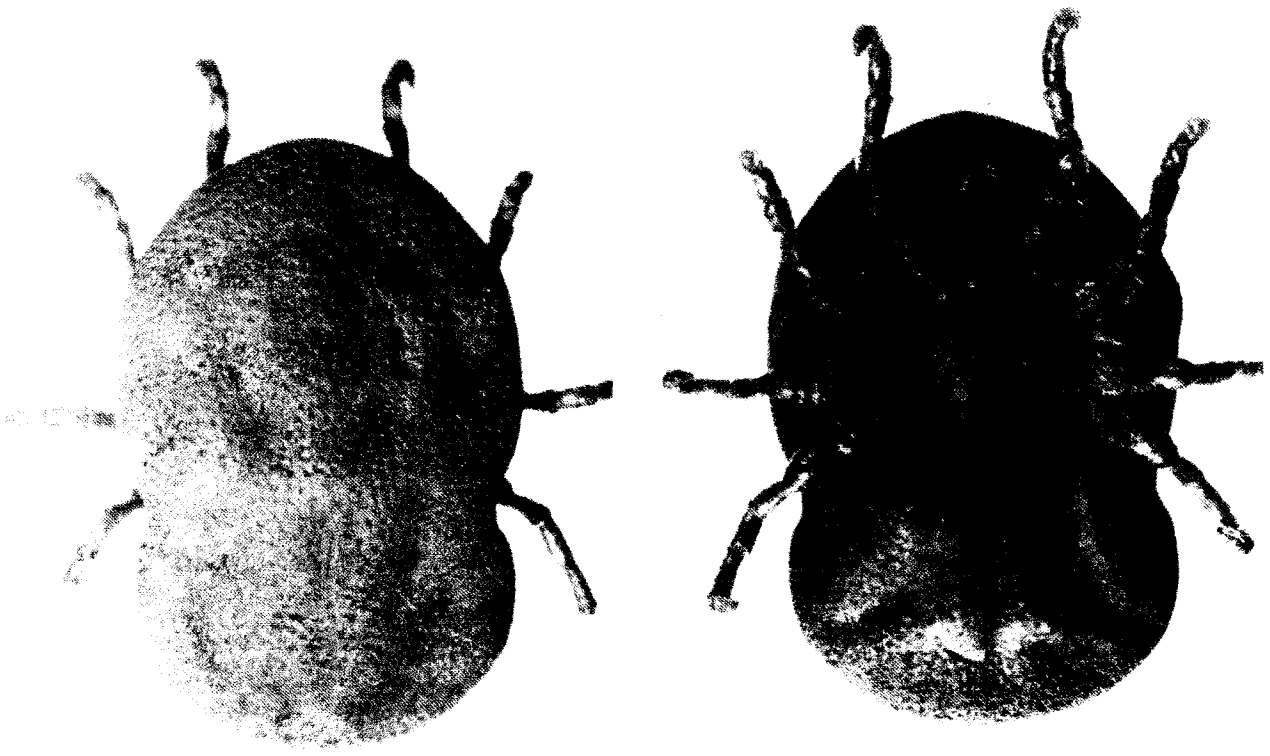
Plate 22

Figs. 95-100. Otobius megnini (Dugès): Figs. 95 and 96, Dorsal and ventral views, ♀; Fig. 97, Dorsal integument detail, ♀; Fig. 98, Ventral view, nymph; Fig. 99, Capitulum, ♀; Fig. 100, Capitulum, nymph.



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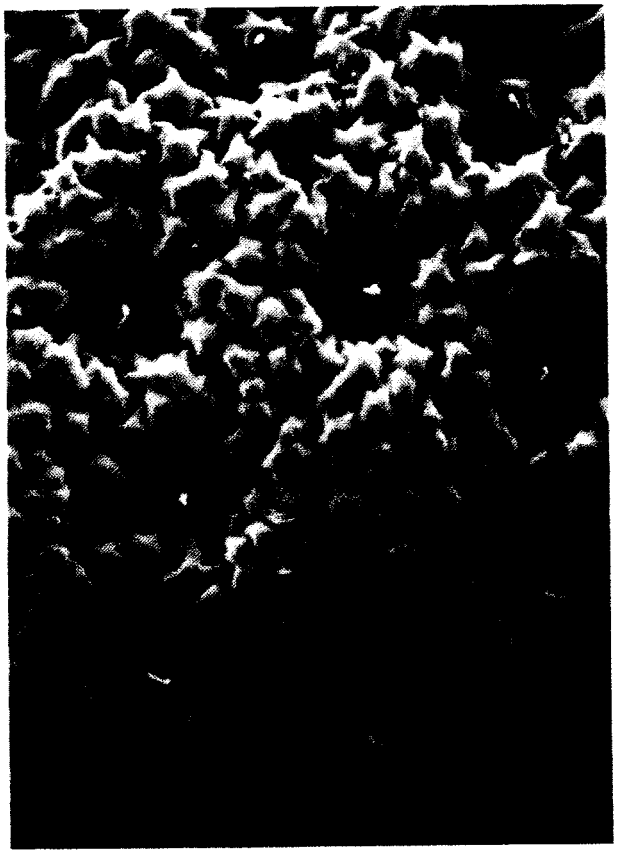

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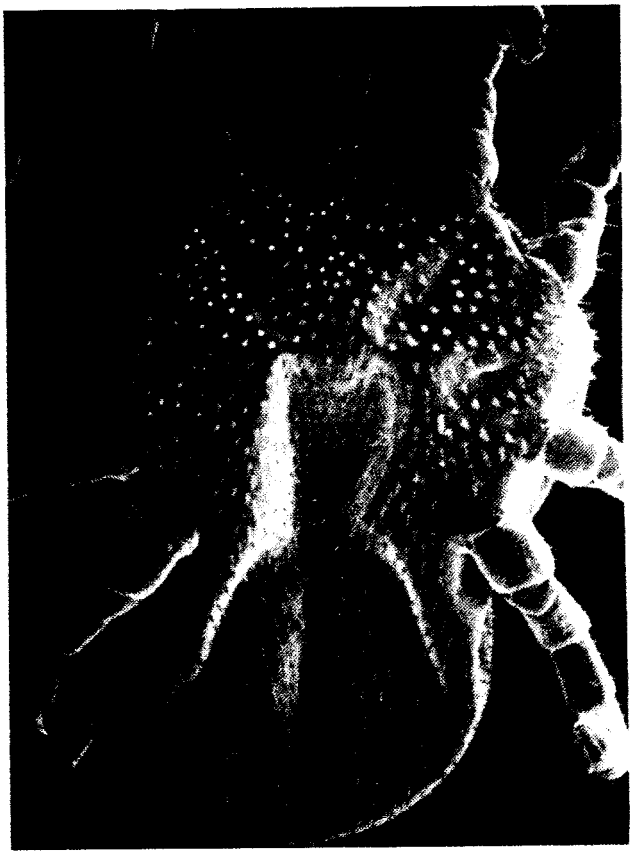

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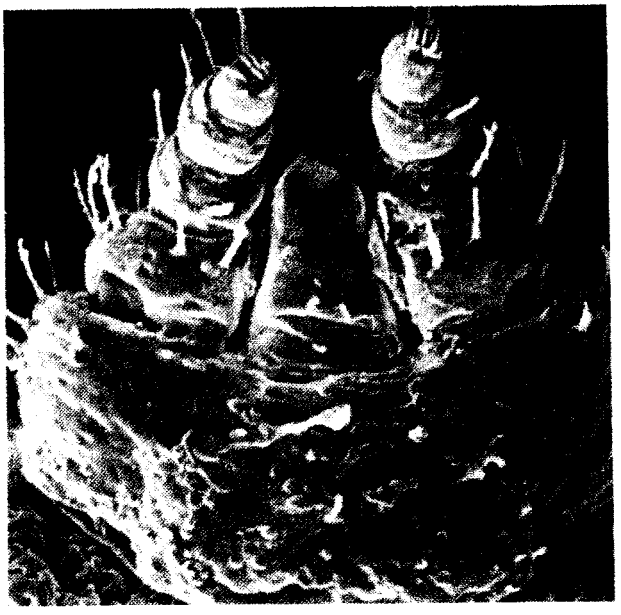

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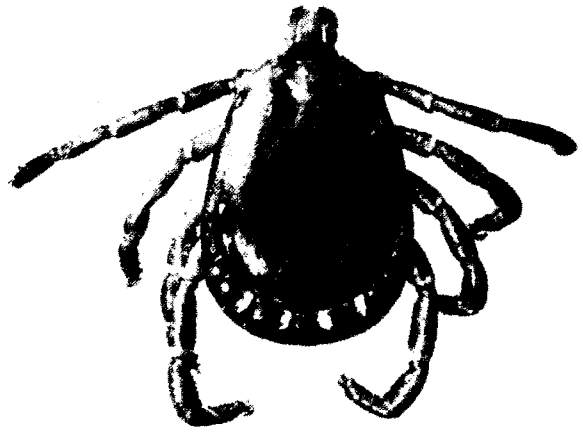
Plate 23

Figs. 101-104. Amblyomma americanum (Linnaeus): Fig. 101, Dorsal view, ♂; Fig. 102, Dorsal view, ♀; Fig. 103, Capitulum, dorsal view, ♂; Fig. 104, Capitulum, ventral view, ♀.



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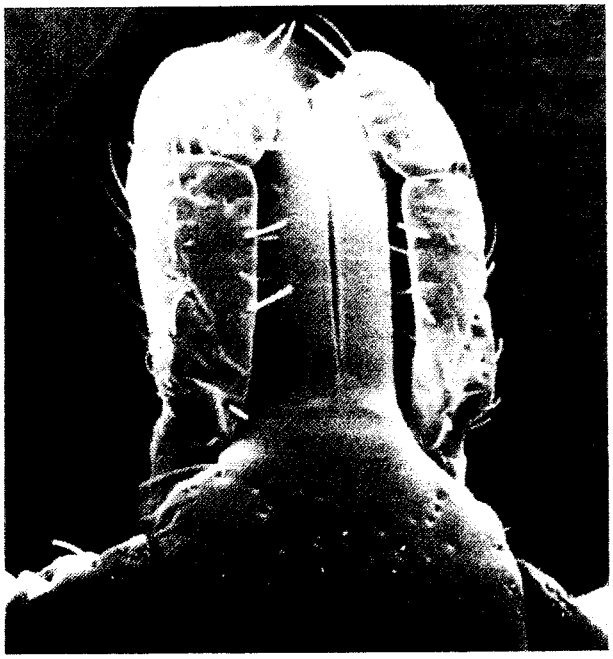

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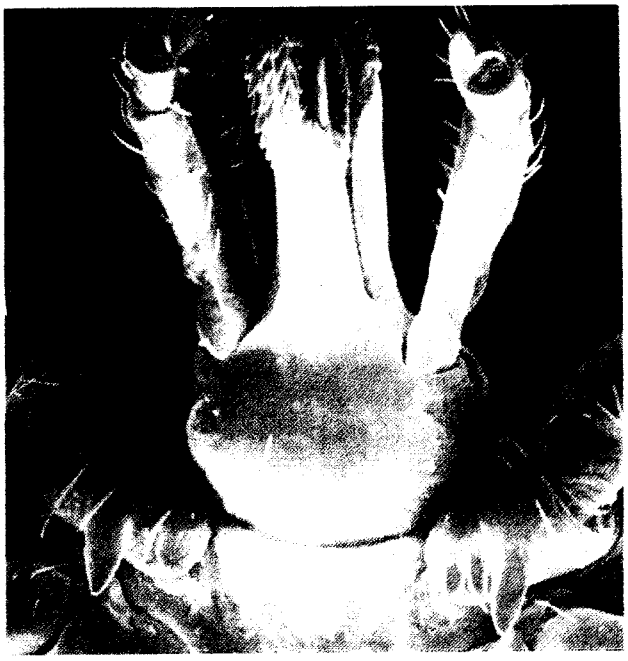

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Plate 24

Figs. 105-108. Boophilus annulatus (Say): Figs. 105 and 106, Dorsal and ventral views, ♂; Figs. 107 and 108, Dorsal and ventral views, ♀.

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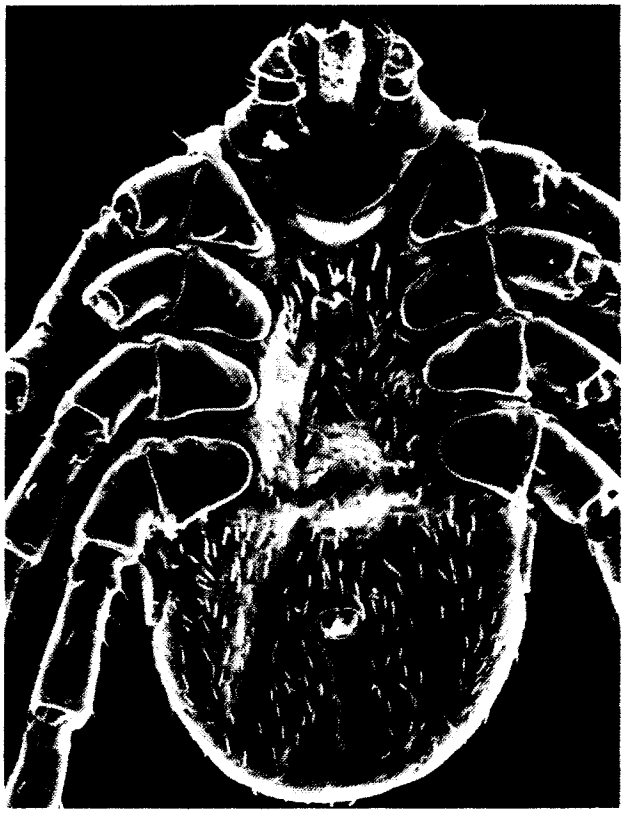

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Plate 25

Figs. 109-114. Boophilus annulatus (Say): Fig. 109, Capitulum, dorsal view, ♂; Fig. 110, Capitulum, dorsal view, ♀; Fig. 111, Coxa and trochanter I, ♂; Fig. 112, Tarsus, leg III, ♀; Fig. 113, Dorsal view, nymph; Fig. 114, Capitulum, dorsal view, nymph.

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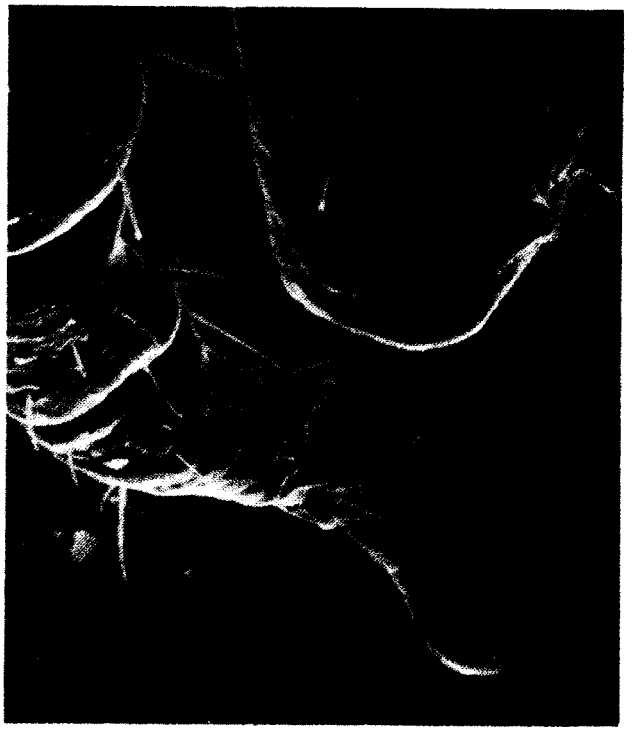

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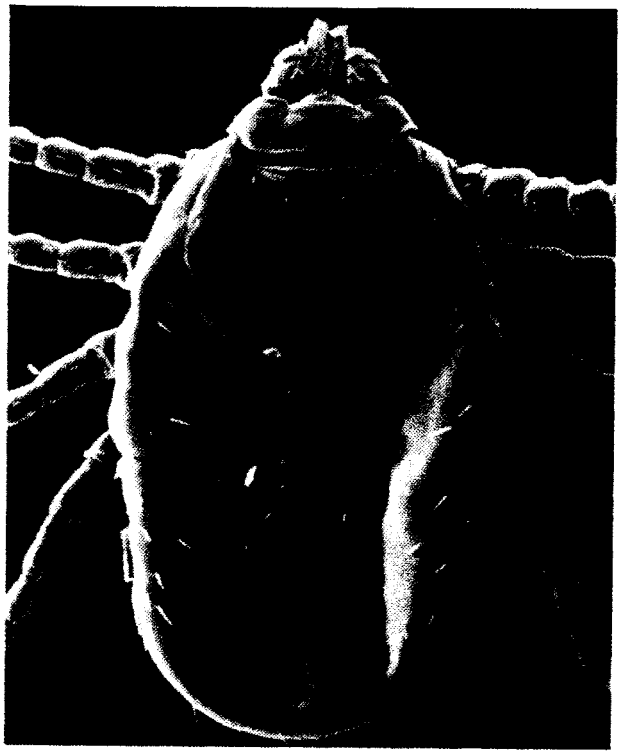

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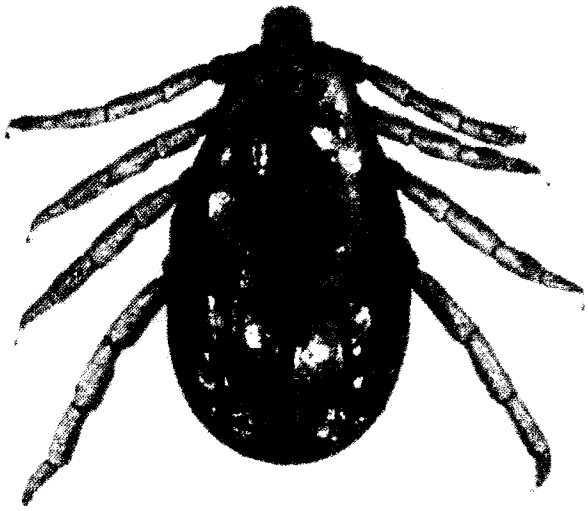
Plate 26

Figs. 115–118. Dermacentor albipictus (Packard): Fig. 115, Dorsal view, ♂; Fig. 116, Dorsal view, ♀; Fig. 117, Coxae I–IV, ♀; Fig. 118, Spiracular plate, ♂.



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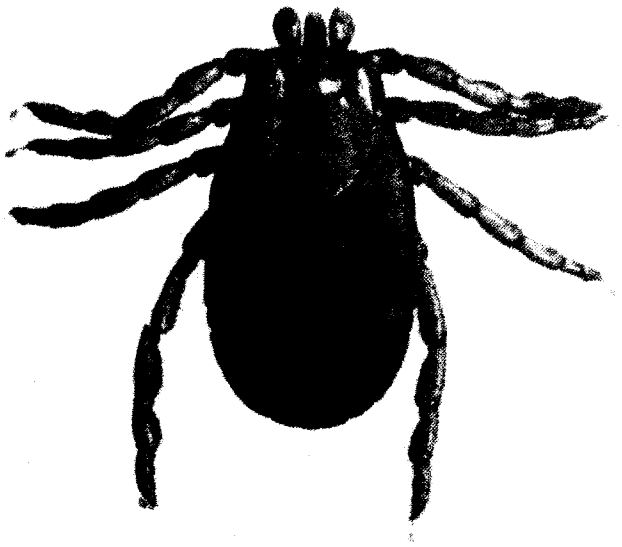

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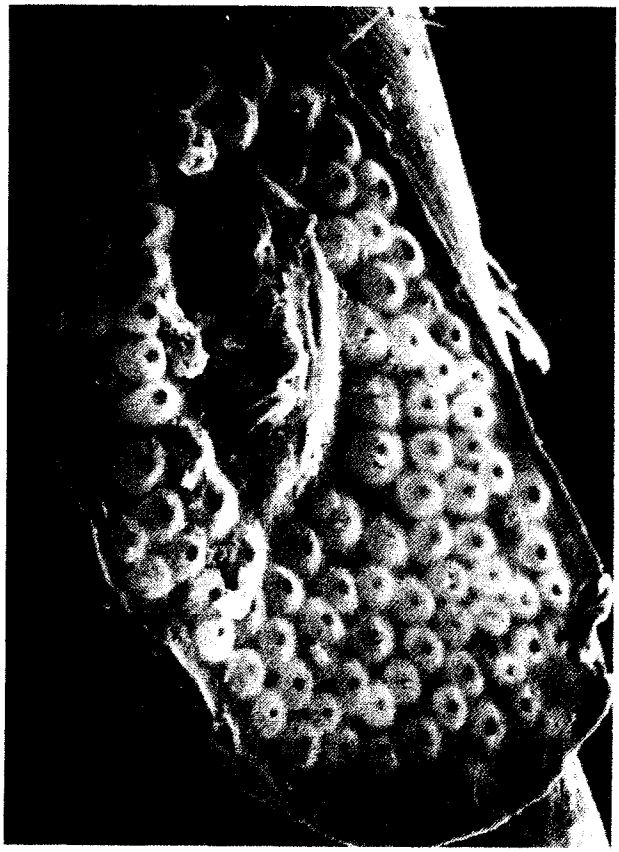

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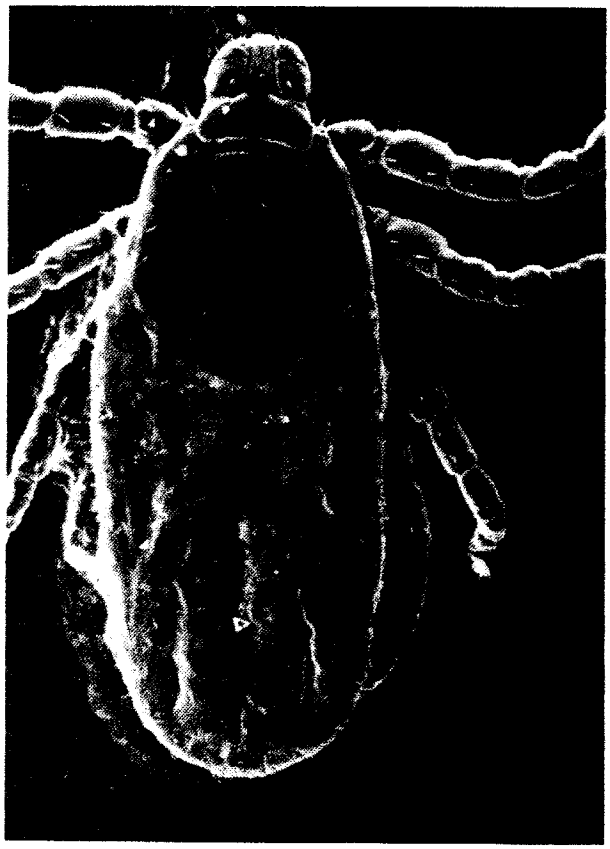
Plate 27

Figs. 119-122. Dermacentor albipictus (Packard), nymph: Fig. 119, Dorsal view; Fig. 120, Coxae I-IV; Fig. 121, Capitulum, dorsal view; Fig. 122, Spiracular plate.



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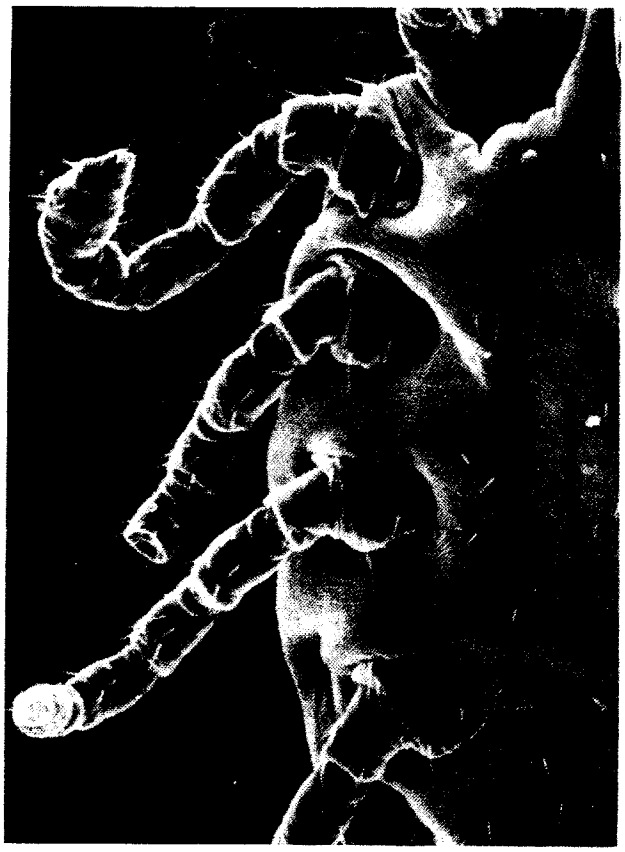

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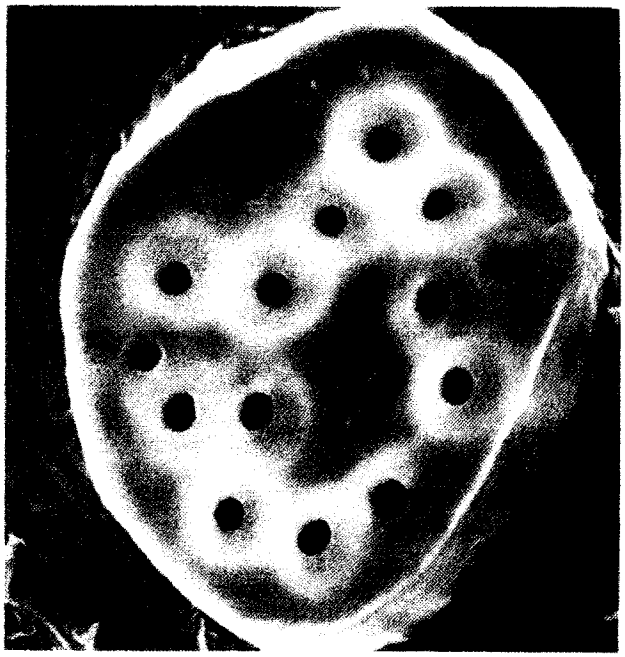

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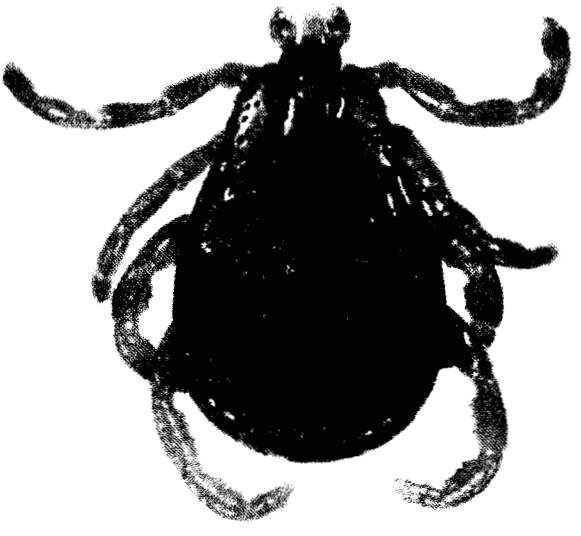
Plate 28

Figs. 123-128. Dermacentor andersoni Stiles: Figs. 123 and 124, Dorsal and ventral views, ♂; Figs. 125 and 126, Dorsal and ventral views, ♀; Fig. 127, Capitulum, dorsal view, ♂; Fig. 128, Capitulum, dorsal view, ♀.



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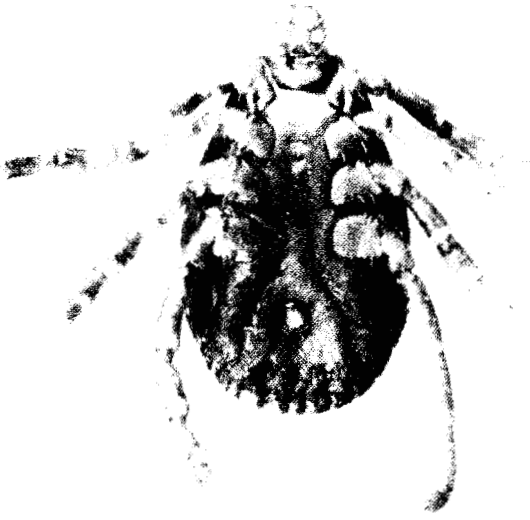

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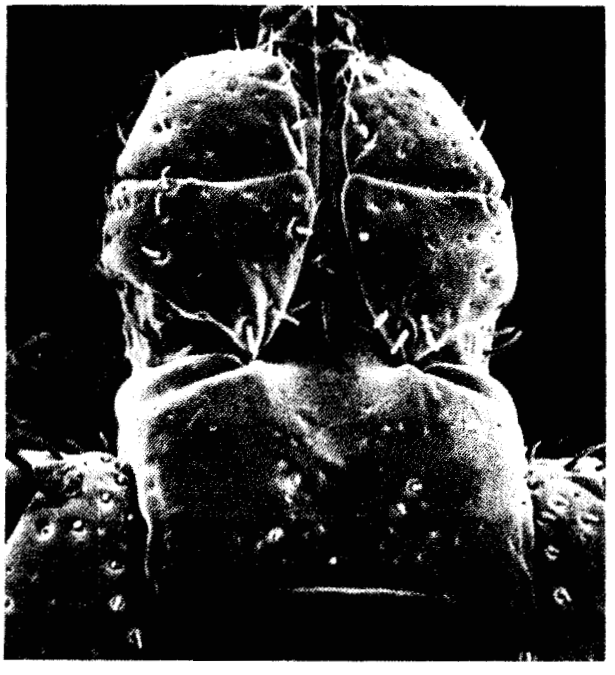

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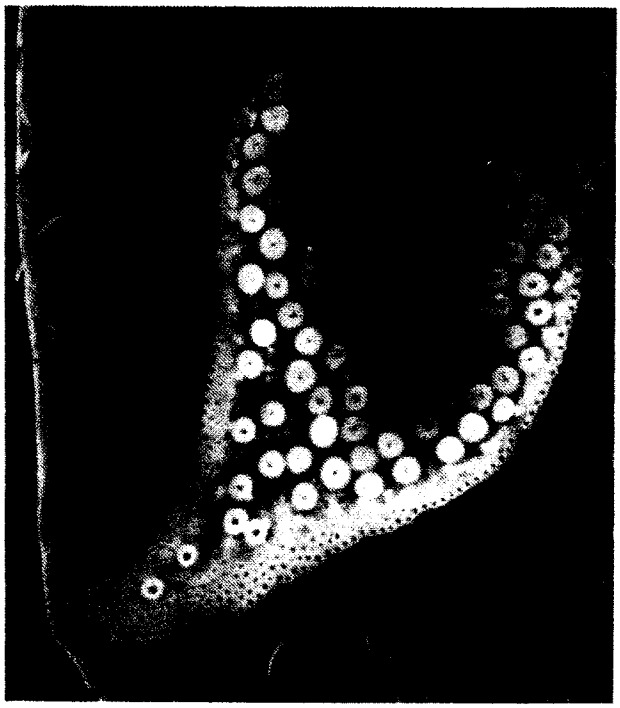
Plate 29

Figs. 129-134. Dermacentor andersoni Stiles: Fig. 129, Spiracular plate, ♂; Fig. 130, Spiracular plate, ♀; Fig. 131, Coxa I and capitulum, ♀; Fig. 132, Ventral aspect with coxae I-III, nymph; Fig. 133, Capitulum, dorsal view, nymph; Fig. 134, Ventral aspect with coxa IV, nymph.



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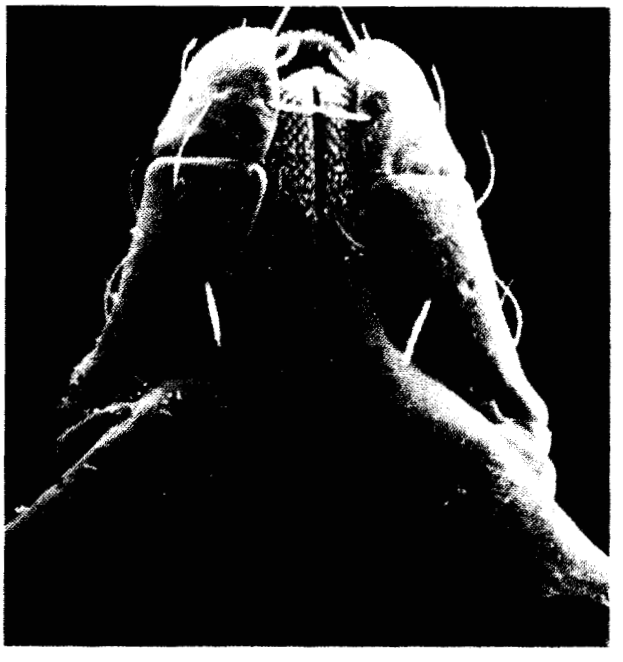

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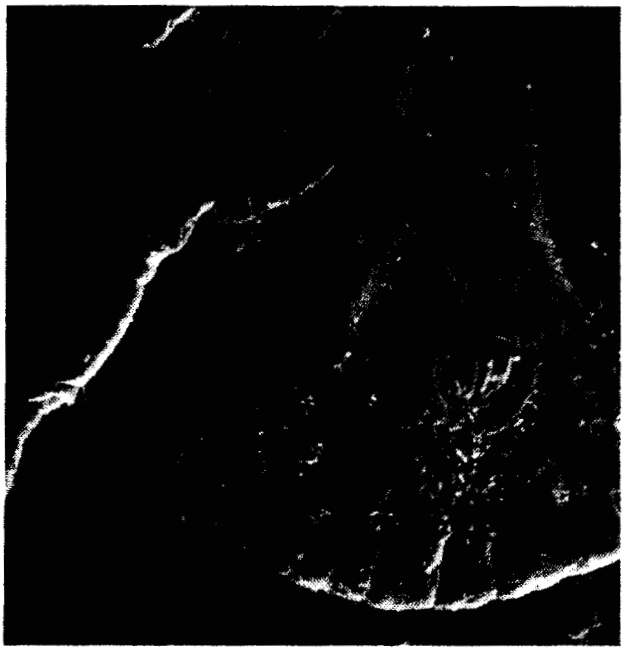

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Plate 30

Figs. 135-140. Dermacentor hunteri Bishopp: Fig. 135, Dorsal view, ♂; Fig. 136, Dorsal view, ♀; Fig. 137, Spiracular plate, ♀; Fig. 138, Spiracular plate, nymph; Fig. 139, Scutum and capitulum, nymph; Fig. 140, Ventral view, nymph.

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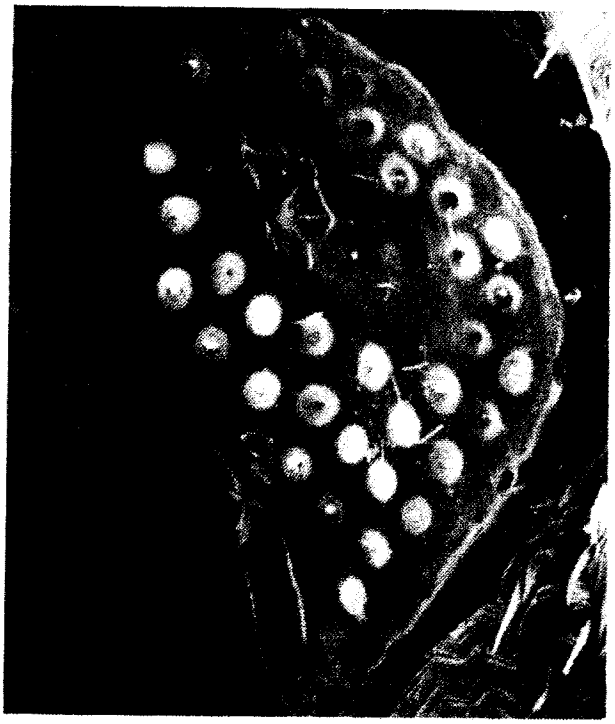

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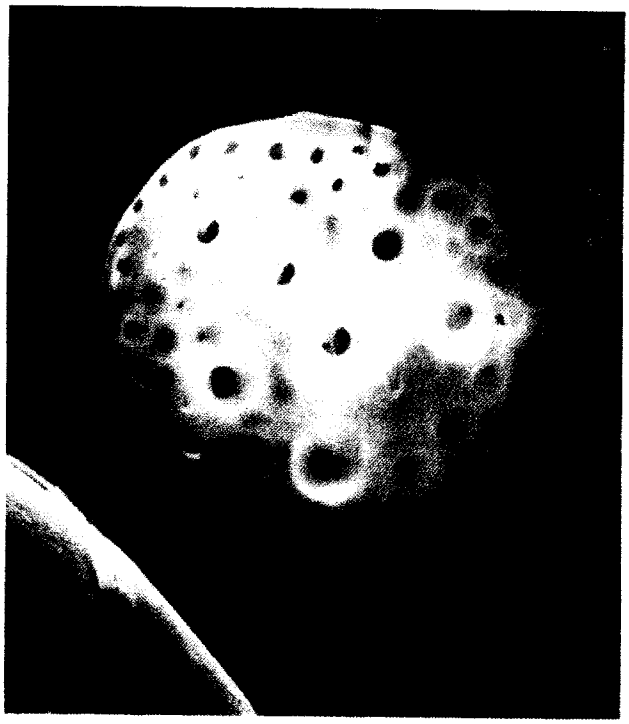

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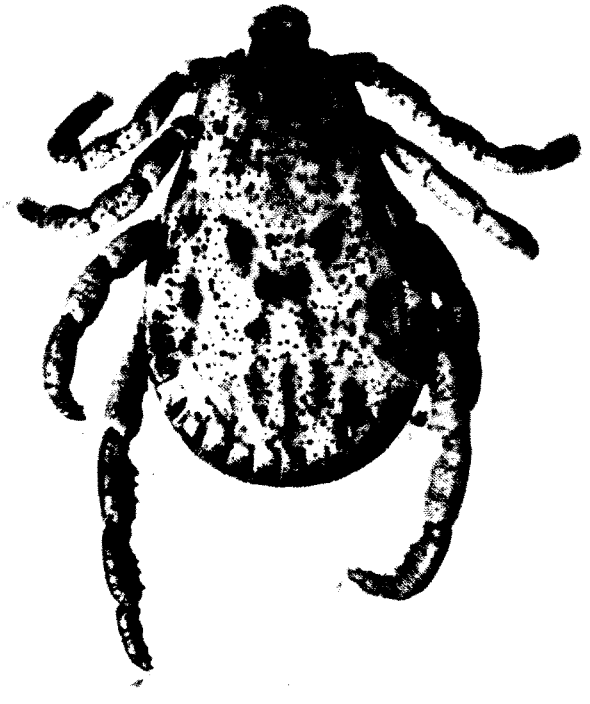
Plate 31

Figs. 141-146. Dermacentor occidentalis Marx: Fig. 141, Dorsal view, ♂; Fig. 142, Dorsal view, ♀; Fig. 143, Capitulum, dorsal view, ♂; Fig. 144, Capitulum, dorsal view, ♀; Fig. 145, Scutum, ♀; Fig. 146, Scutal detail, adult.



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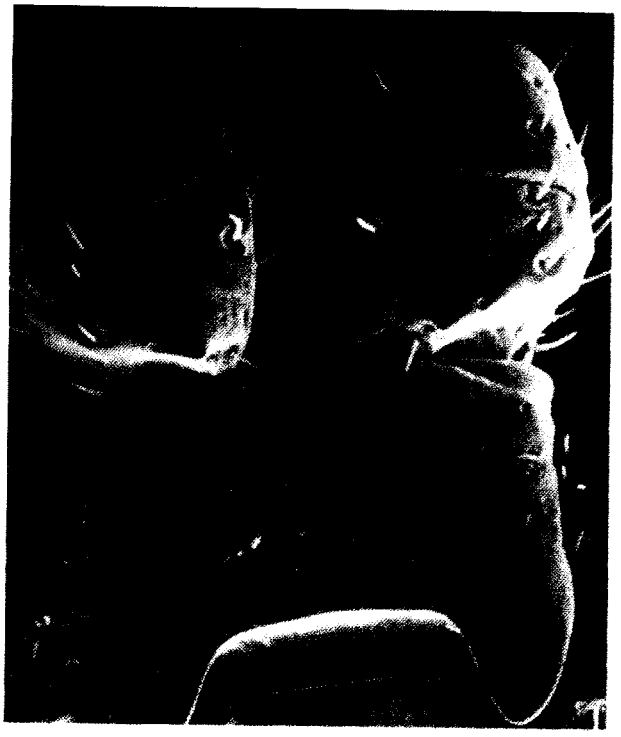

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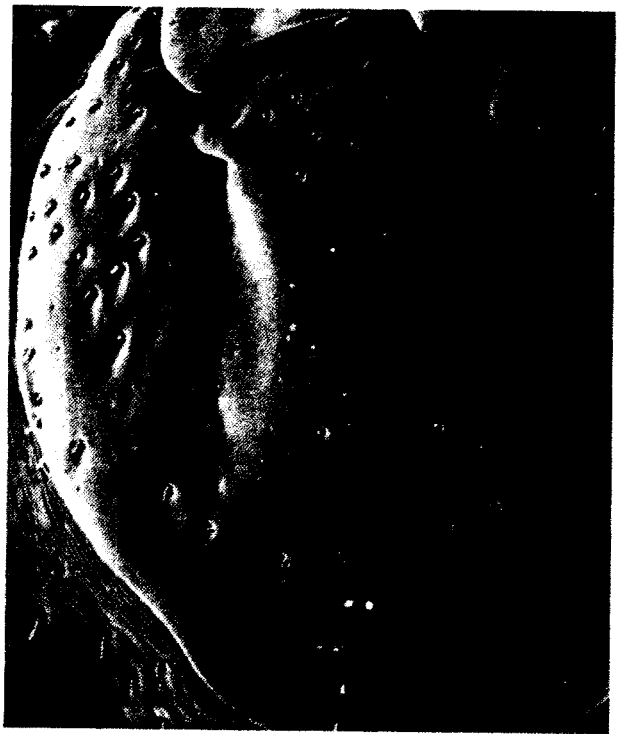

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Plate 32

Figs. 147-152. Dermacentor occidentalis Marx: Fig. 147, Coxa I, ♀; Fig. 148, Spiracular plate, ♂; Fig. 149, Dorsal view, nymph; Fig. 150, Spiracular plate, nymph; Fig. 151, Ventral view, nymph; Fig. 152, Capitulum and coxae I, ventral view, nymph.

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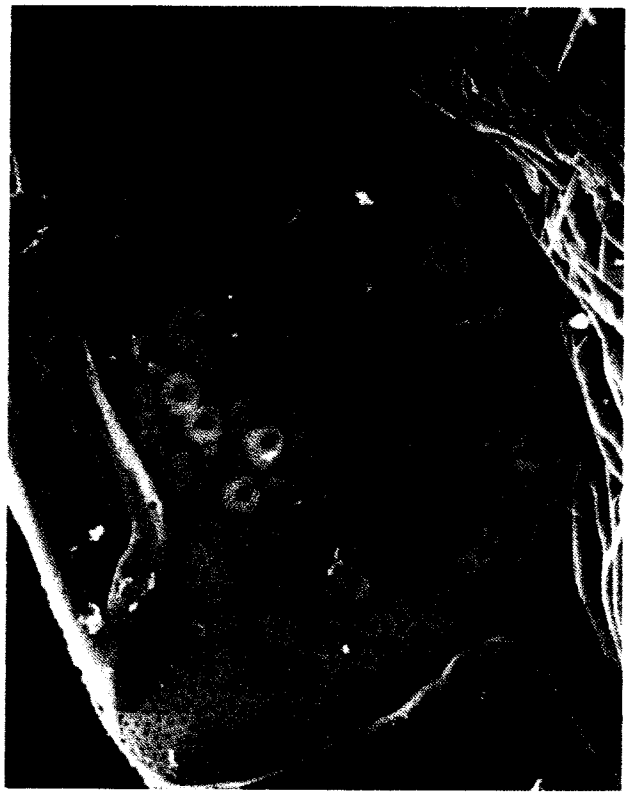

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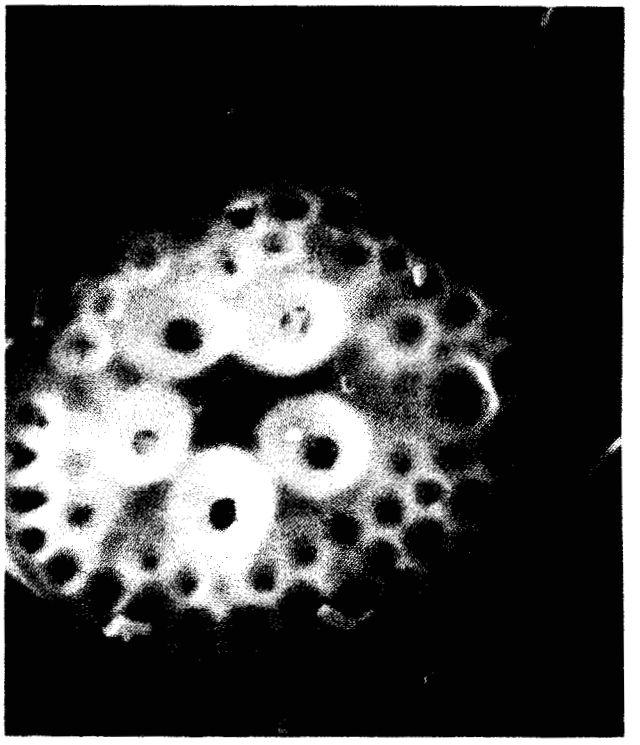

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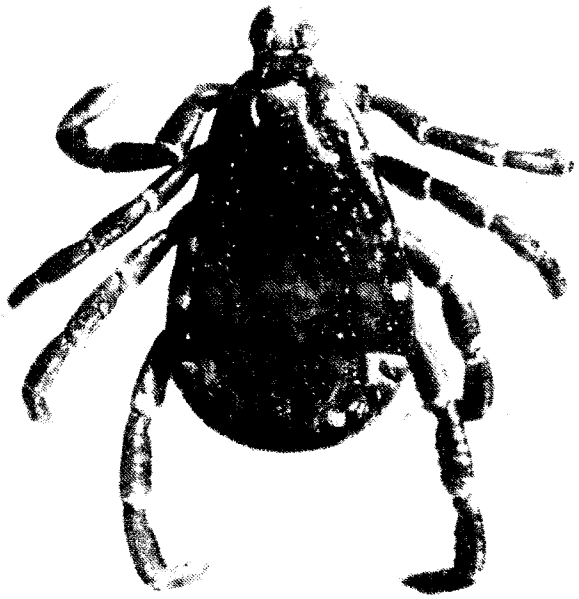
Plate 33

Figs. 153-159. Dermacentor parumapertus Neumann: Fig. 153, Dorsal view, ♂; Fig. 154, Dorsal view, ♀; Fig. 155, Coxa I, ♂; Fig. 156, Scutum, ♀; Fig. 157, Coxae I-IV, nymph; Fig. 158, Capitulum, ventral view, nymph; Fig. 159, Spiracular plate, nymph.



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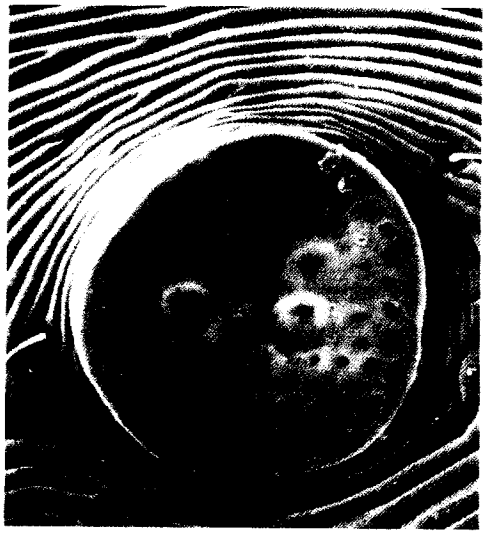

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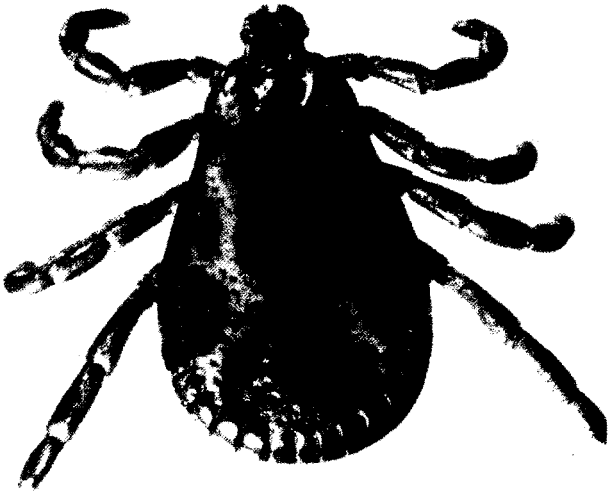
Plate 34

Figs. 160-163. Dermacentor variabilis (Say): Fig. 160, Dorsal view, ♂; Fig. 161, Dorsal view, ♀; Fig. 162, Spiracular plate, ♂; Fig. 163, Spiracular plate, ♀.



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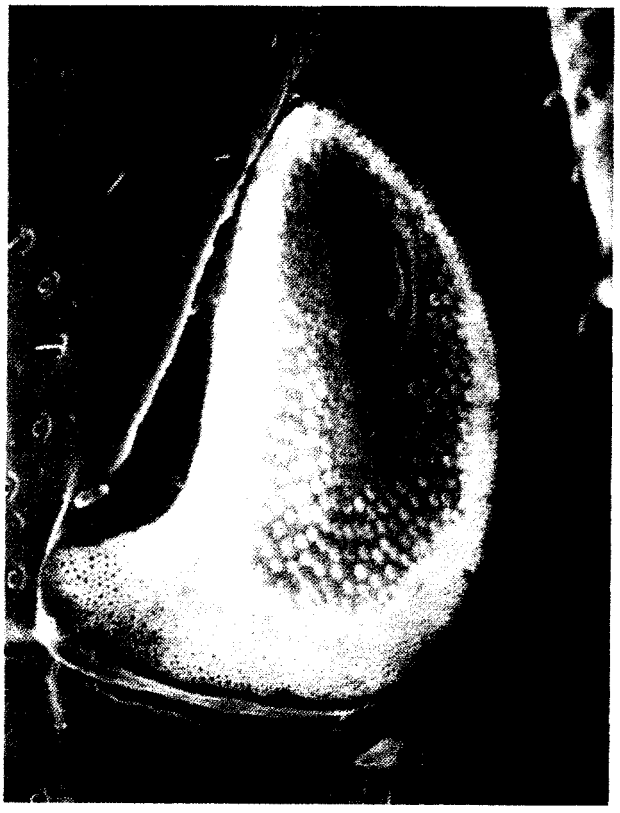

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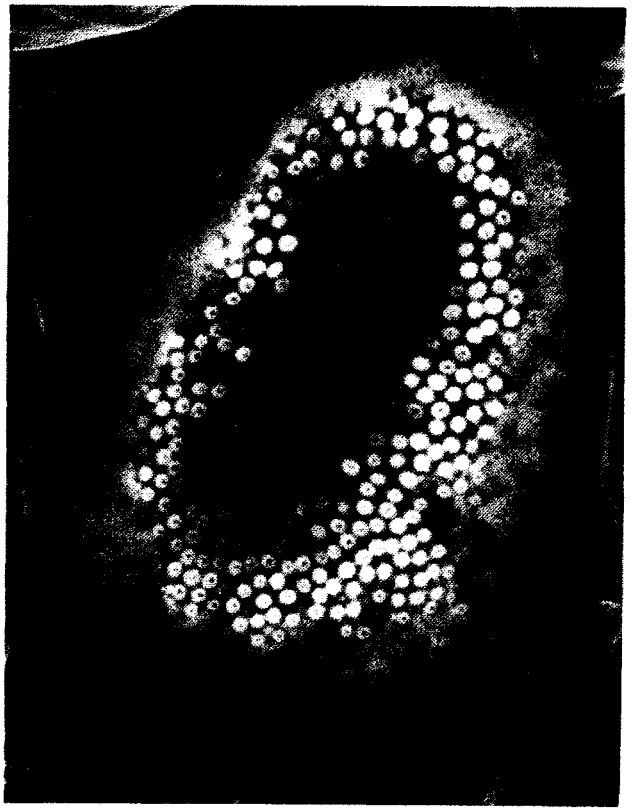

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Plate 35

Figs. 164-167. Dermacentor variabilis (Say), nymph: Figs. 164 and 165, Dorsal and ventral views; Fig. 166, Capitulum, ventral view; Fig. 167, Spiracular plate.

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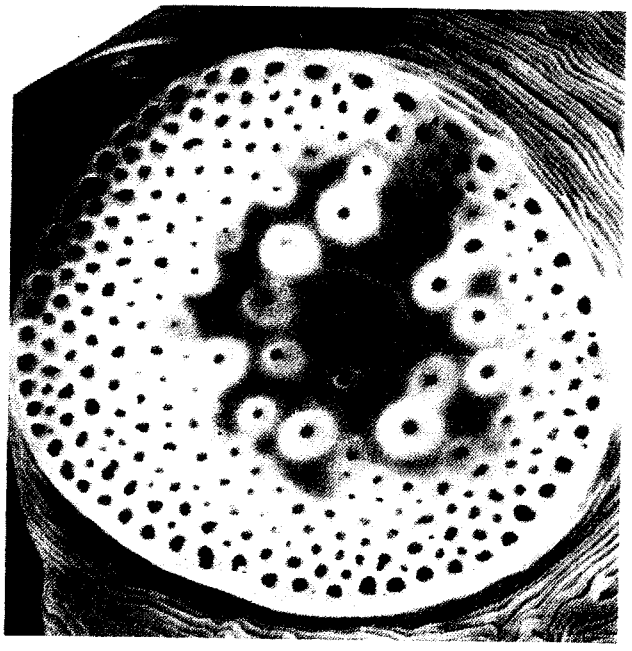

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Plate 36

Figs. 168-171. Haemaphysalis chordeilis (Packard): Fig. 168, Dorsal view, ♂; Fig. 169, Dorsal view, engorged ♀; Fig. 170, Capitulum, ventral view, ♂; Fig. 171, Capitulum, ventral view, ♀.

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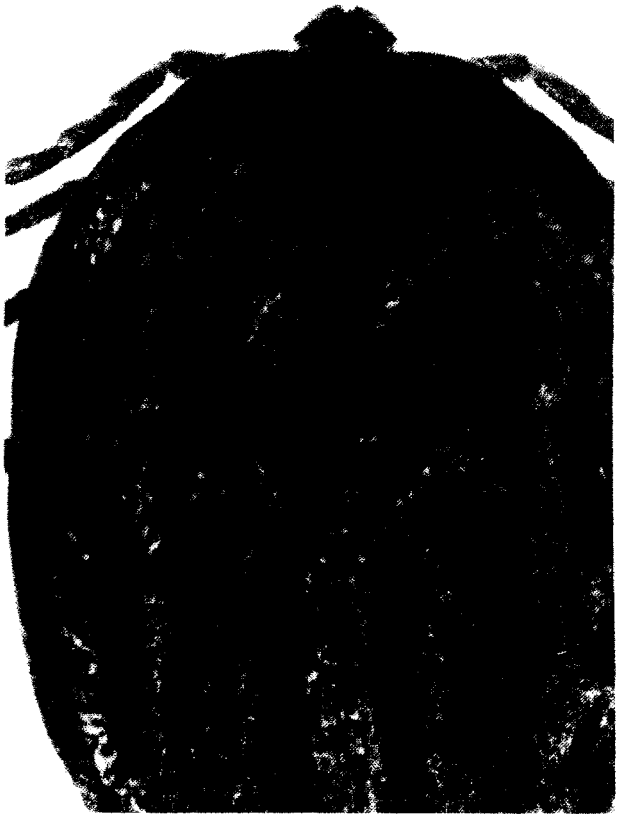

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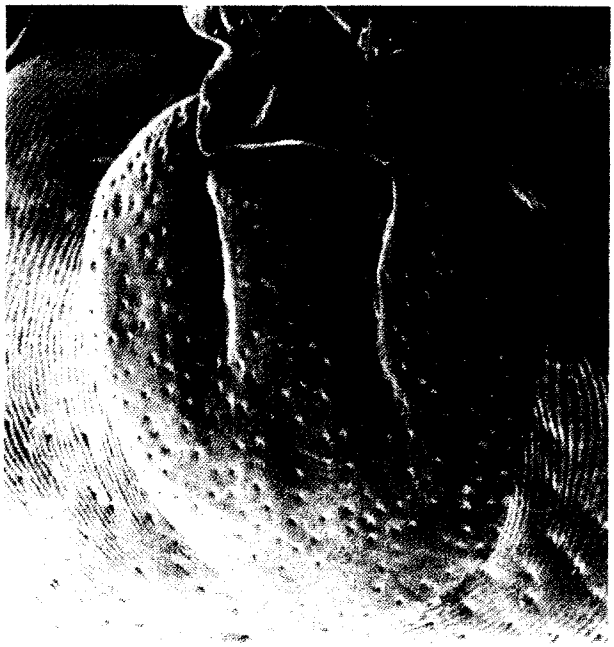
Plate 37

Figs. 172-175. Haemaphysalis chordeilis (Packard): Fig. 172, Scutum, ♀; Fig. 173, Capitulum, dorsal view, ♀; Fig. 174, Coxae I-IV, ♂; Fig. 175, Capitulum, dorsal view, nymph.



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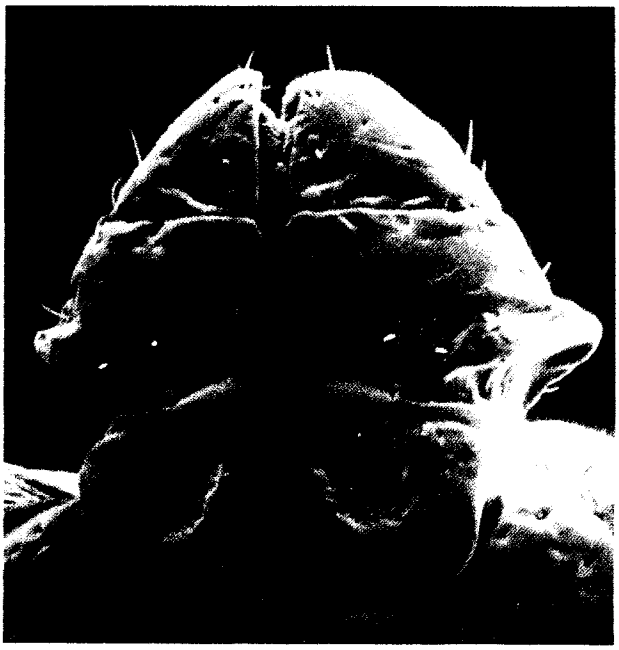

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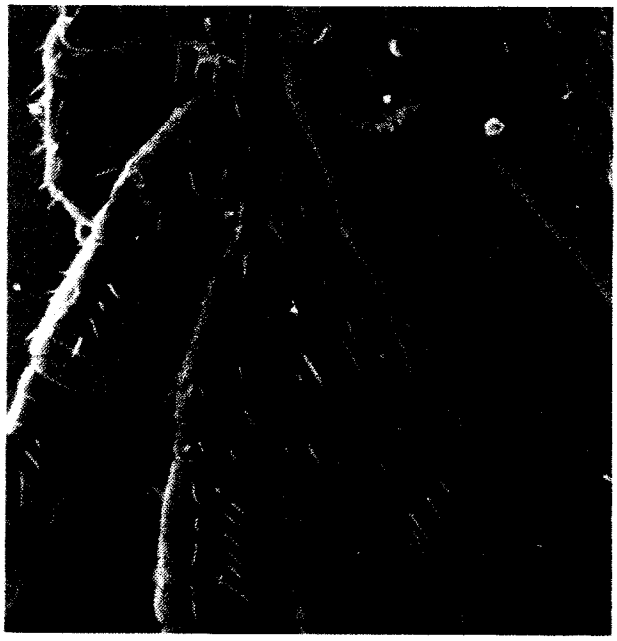

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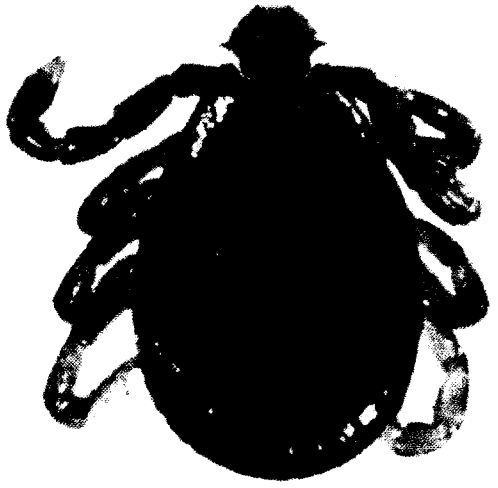
Plate 38

Figs. 176-179. Haemaphysalis leporispalustris (Packard): Fig. 176, Dorsal view, ♂; Fig. 177, Dorsal view, ♀; Figs. 178 and 179, Capitulum, ♂, dorsal and ventral views.



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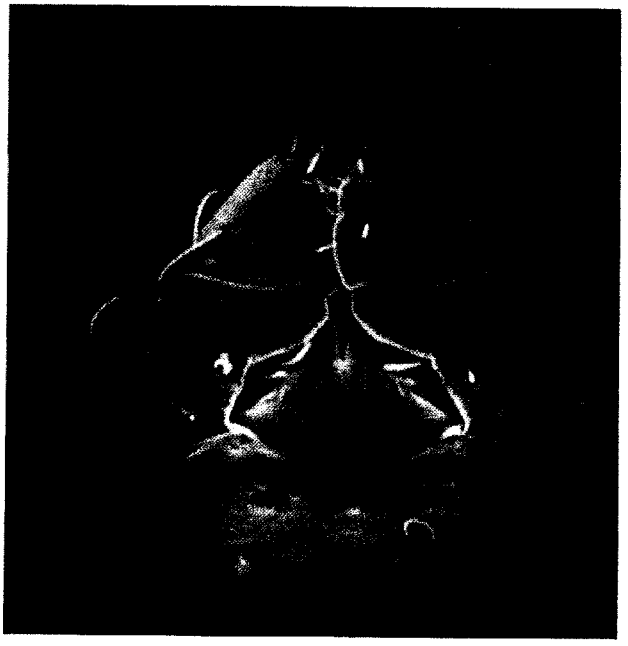

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Plate 39

Figs. 180-183. Haemaphysalis leporispalustris (Packard): Fig. 180, Coxa and trochanter IV, ♂; Fig. 181, Anterior dorsal view, ♀; Fig. 182, Capitulum, dorsal view, nymph; Fig. 183, Coxae and trochanters I and II, nymph.

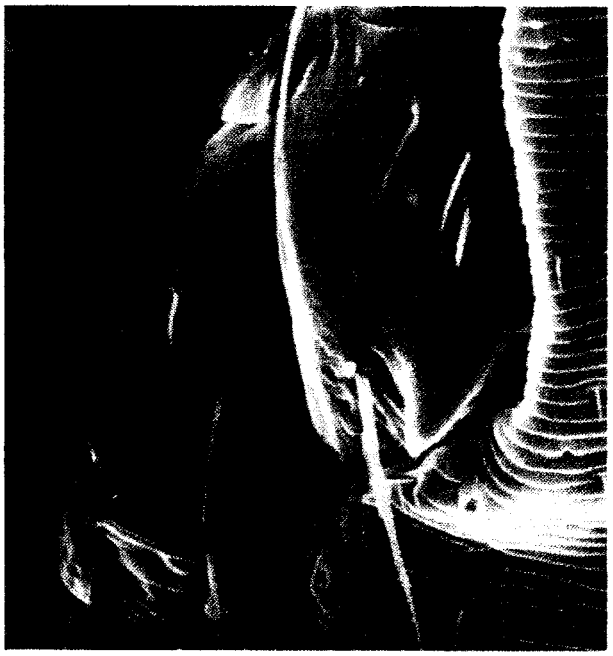

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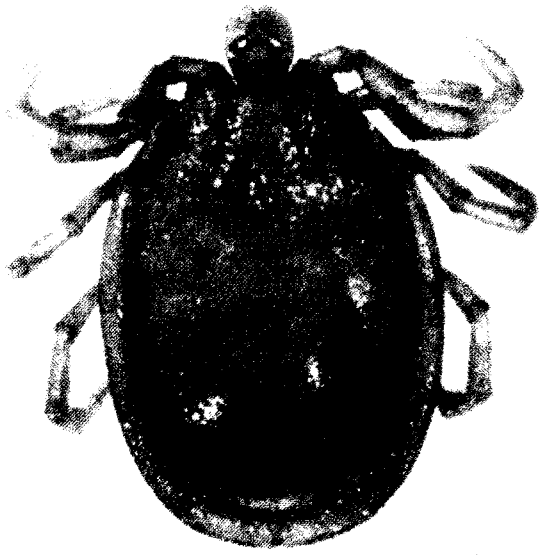
Plate 40

Figs. 184-187. Ixodes angustus Neumann: Fig. 184, Dorsal view, ♂; Fig. 185, Dorsal view, ♀; Fig. 186, Capitulum and scutum, ♂; Fig. 187, Capitulum, ventral view, ♂.



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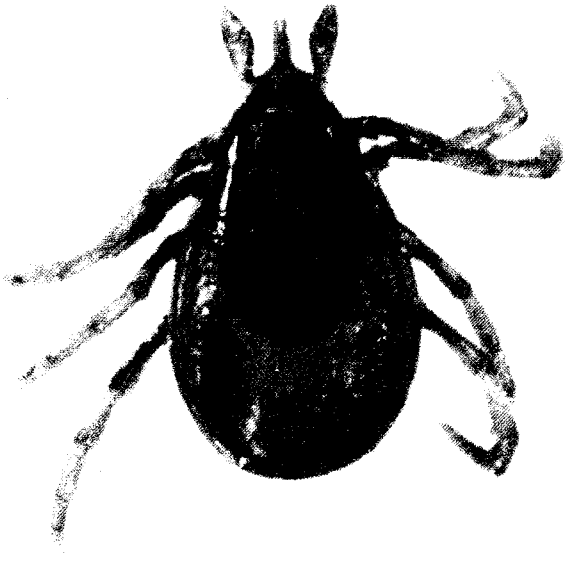

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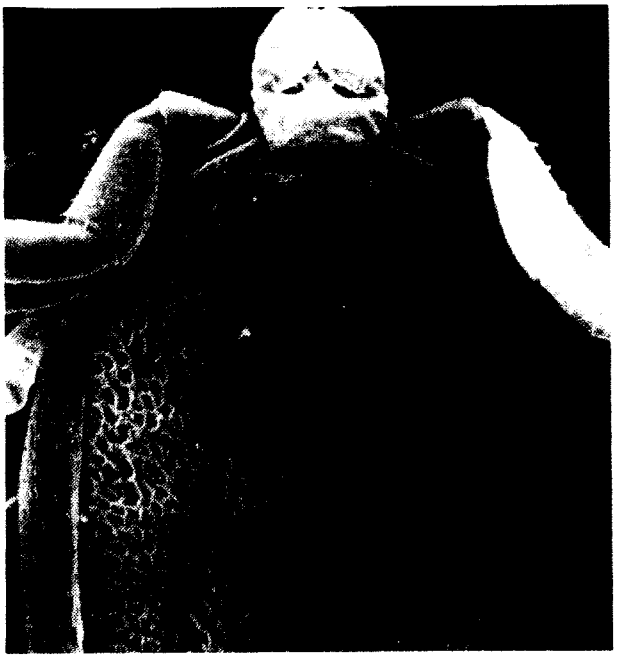

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Plate 41

Figs. 188-191. Ixodes angustus Neumann: Figs. 188 and 189, Capitulum, ♀, dorsal and ventral views; Fig. 190, Capitulum, ventral view, nymph; Fig. 191, Coxa I, nymph.

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Plate 42

Figs. 192-195. Ixodes auritulus Neumann, ♀: Fig. 192, Dorsal view; Fig. 193, Scutum; Figs. 194 and 195, Capitulum, dorsal and ventral views.

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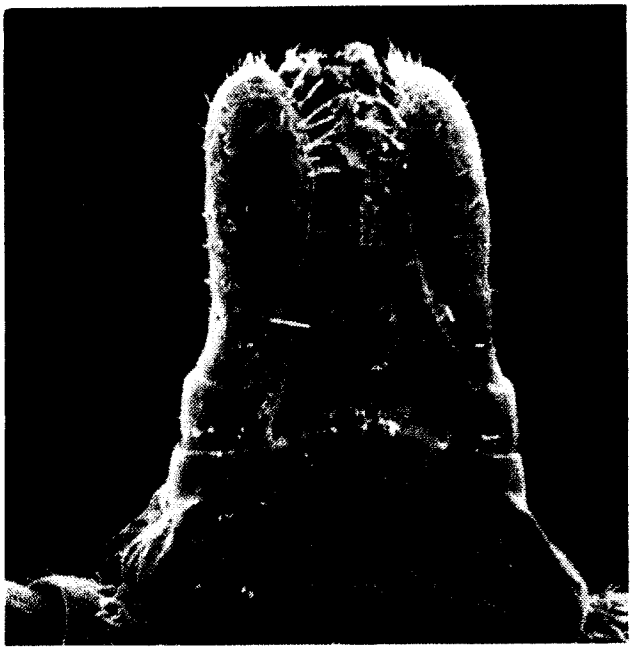

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Plate 43

Figs. 196-199. Ixodes auritulus Neumann: Fig. 196, Scutum, ♂; Fig. 197, Coxae I-IV, ♂; Fig. 198, Coxa I, nymph; Fig. 199, Capitulum, ventral view, nymph. (Figs. 196 and 197 courtesy Keirans and Clifford, 1978.)

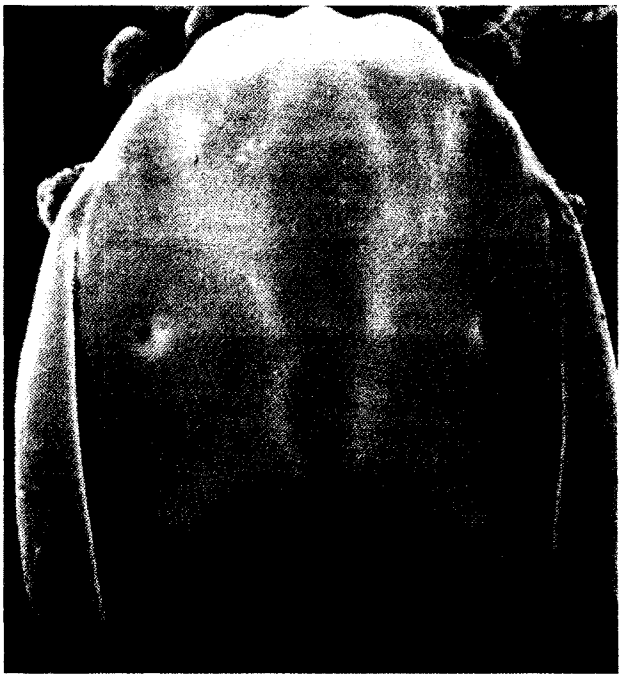

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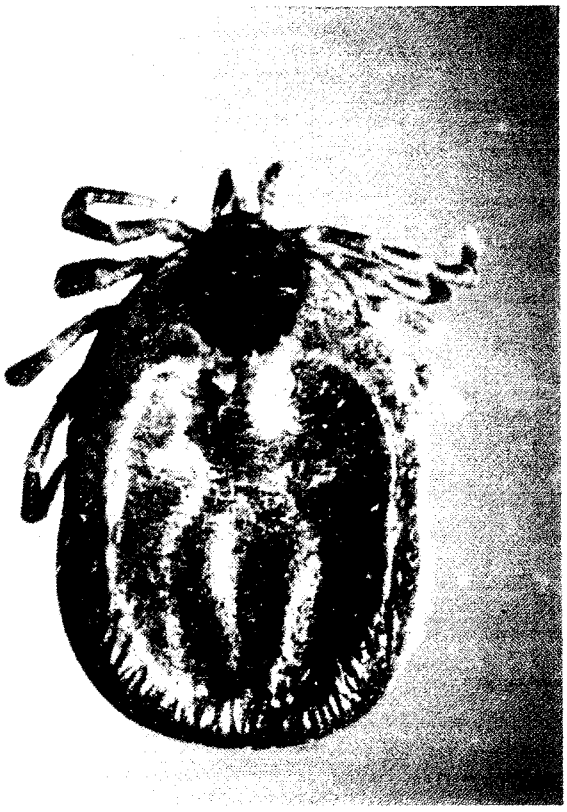
Plate 44

Figs. 200-203. Ixodes brunneus Koch, ♀: Fig. 200, Dorsal view; Fig. 201, Coxae I-IV; Figs. 202 and 203, Capitulum, dorsal and ventral views.



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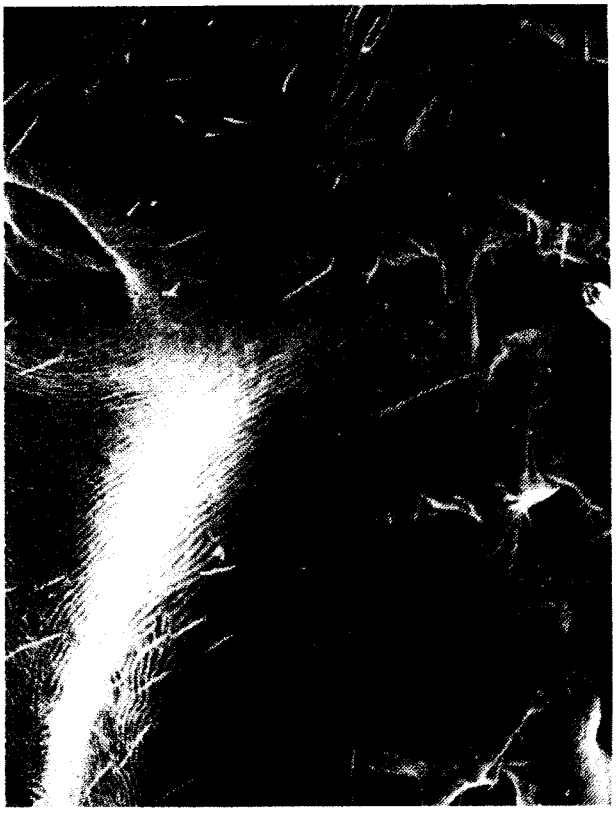

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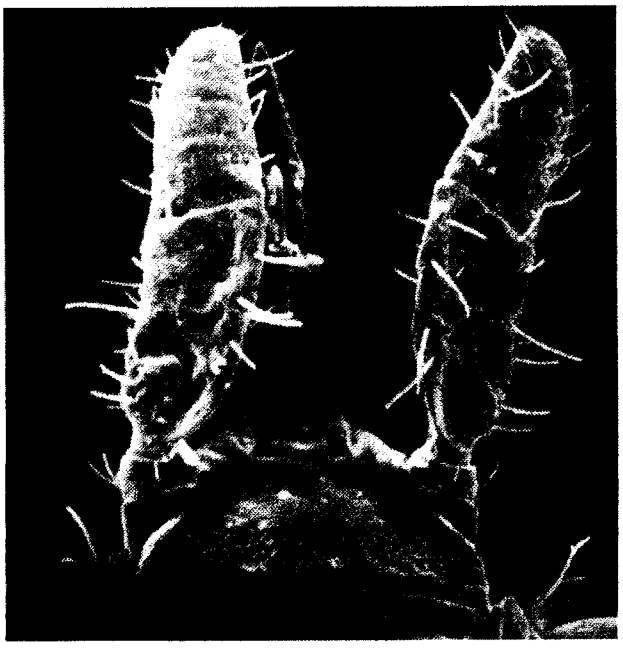

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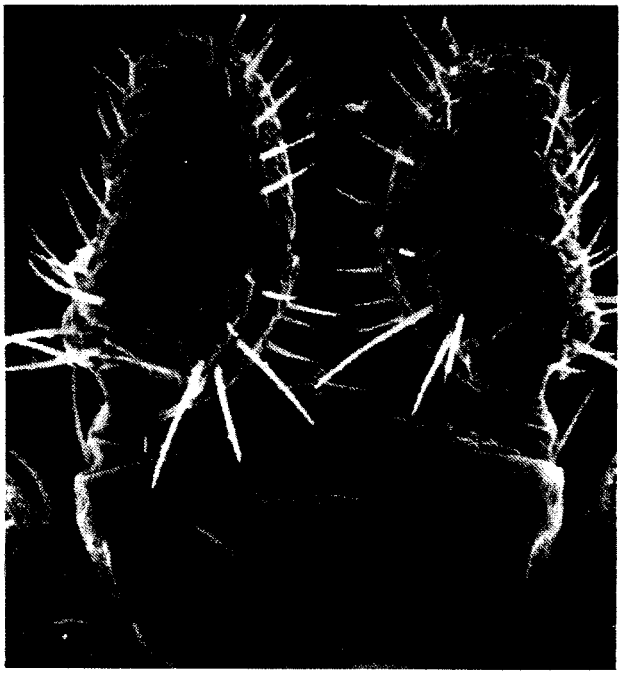
Plate 45

Figs. 204-209. Ixodes brunneus Koch: Fig. 204 and 205, Capitulum, ♂, dorsal and ventral views; Fig. 206, Scutum, ♂; Fig. 207, Coxae I-IV, trochanters II-III, ♂; Fig. 208, Capitulum, dorsal view, nymph; Fig. 209, Basis capituli, ventral view, nymph. (Figs. 204-207 courtesy Keirans and Clifford, 1978.)



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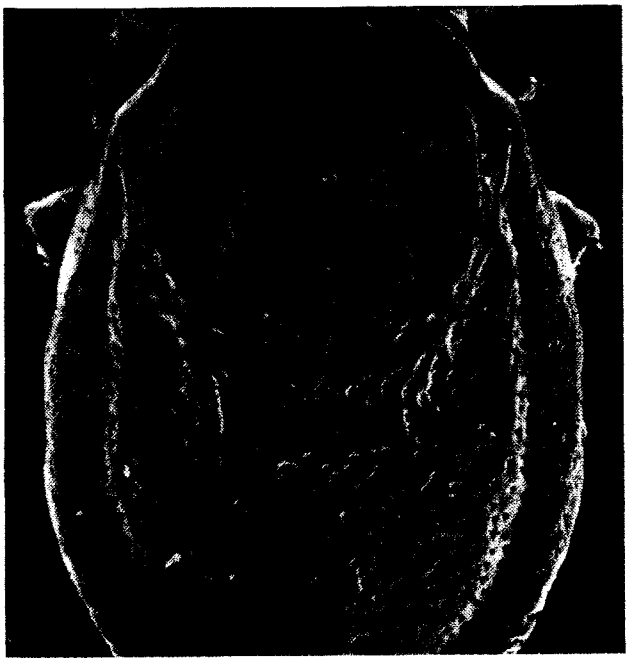

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Plate 46

Figs. 210–213. Ixodes hearlei Gregson: Fig. 210 and 211, Capitulum, ♀, dorsal and ventral views; Fig. 212, Scutum, ♀; Fig. 213, Capitulum, ventral view, nymph.

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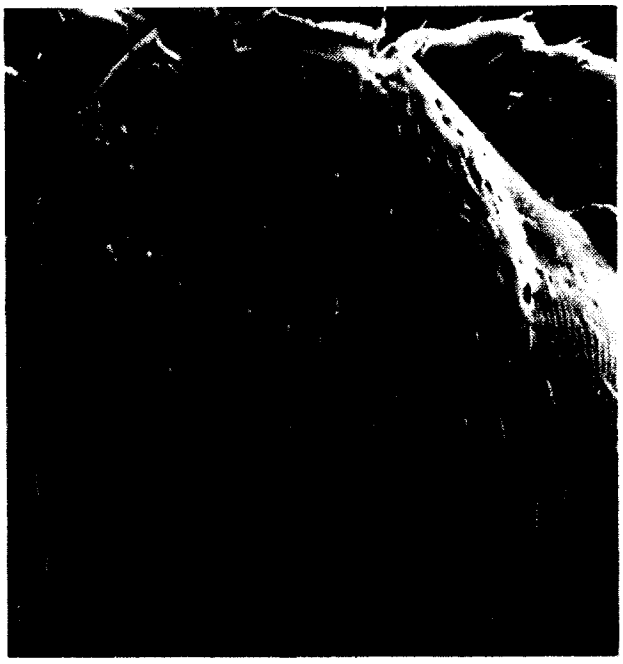

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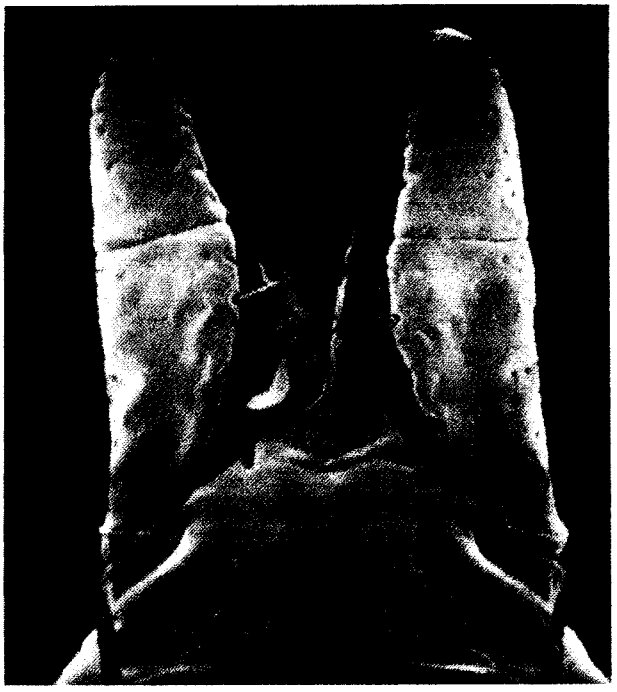
Plate 47

Figs. 214-217. Ixodes holdenriedi Cooley, ♀: Figs. 214 and 215, Capitulum, dorsal and ventral views; Fig. 216, Scutum; Fig. 217, Coxae I-IV. (Figs. 214-217 courtesy Keirans and Clifford, 1978.)



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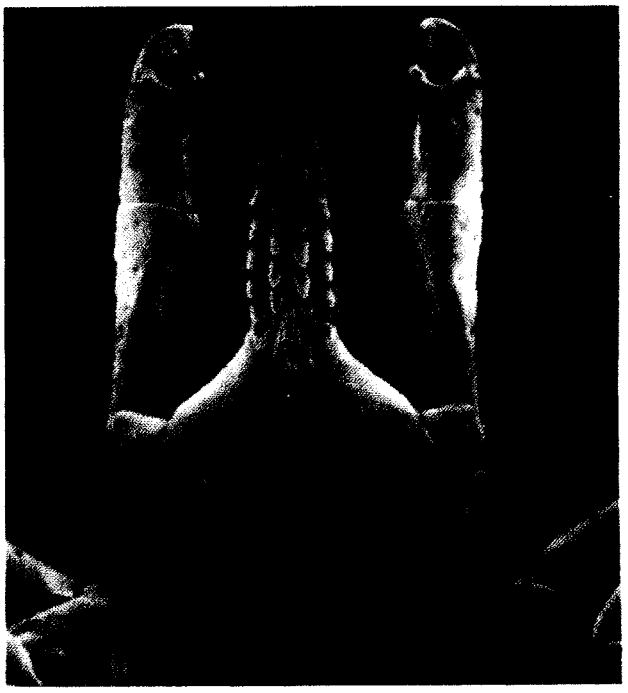

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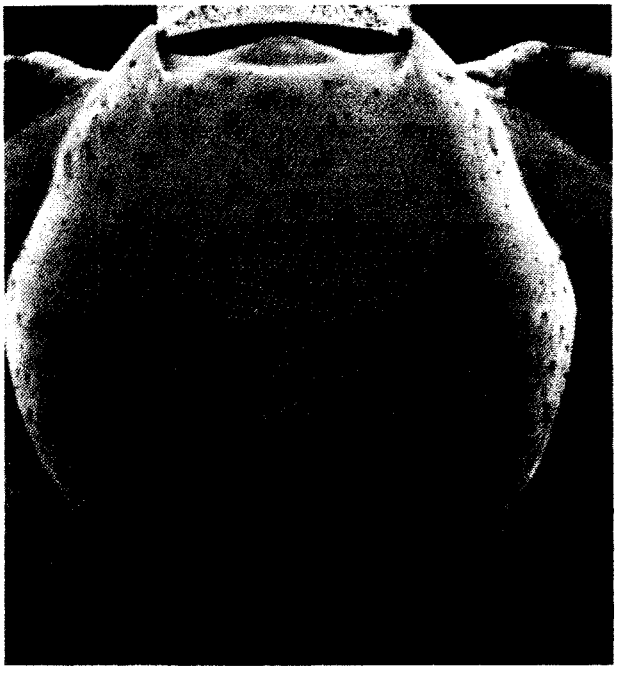

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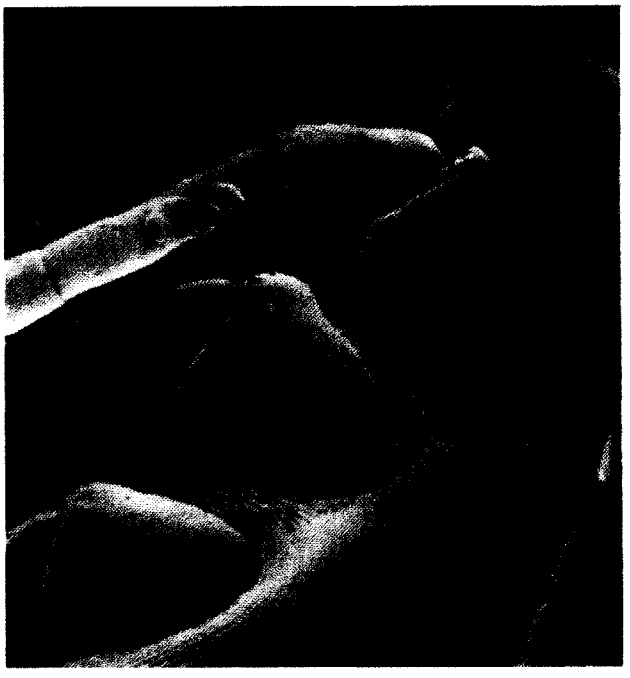

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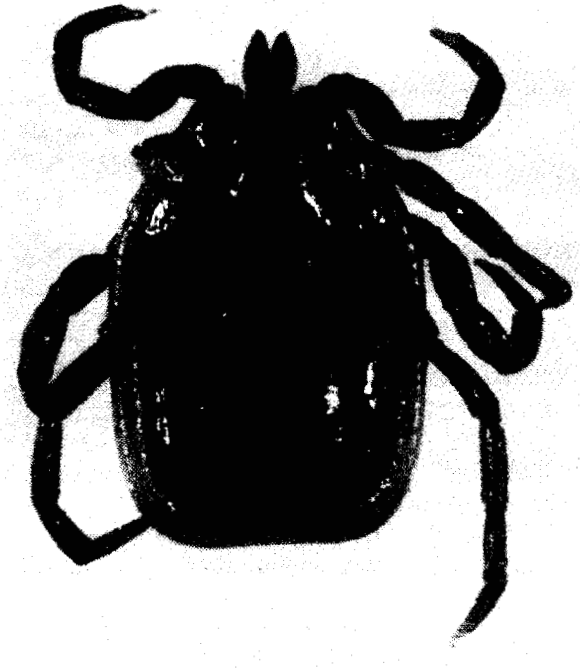
Plate 48

Figs. 218–223. Ixodes howelli Cooley and Kohls: Figs. 218 and 219, Dorsal and ventral views, ♂; Figs. 220 and 221, Dorsal and ventral views, ♀; Fig. 222, Posterior, ventral view, ♂; Fig. 223, Capitulum, ventral view, ♂.



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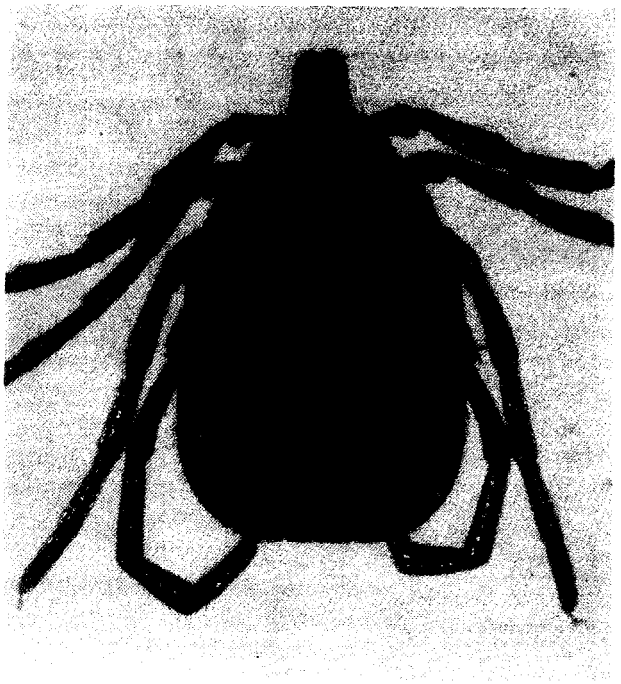

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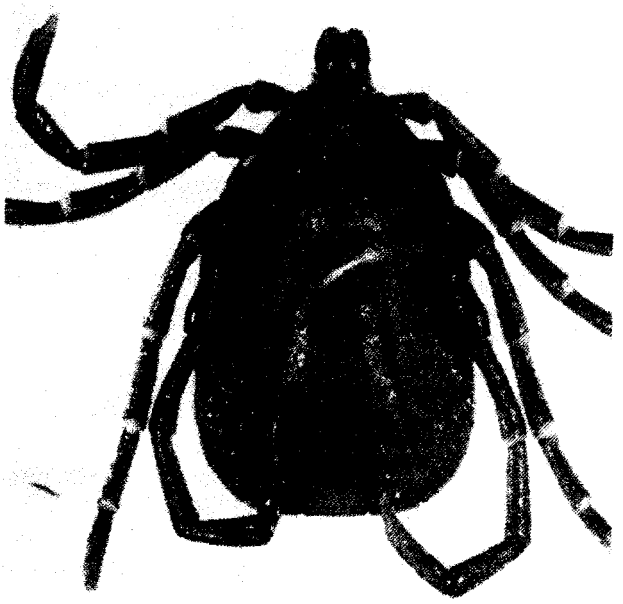

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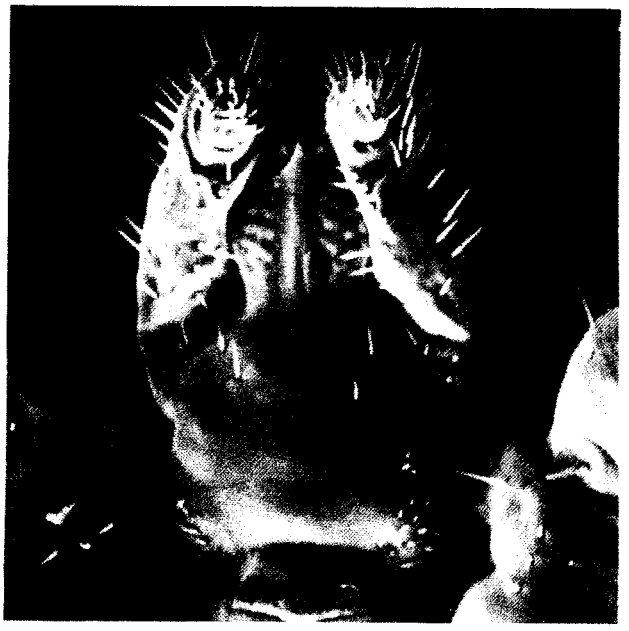

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Plate 49

Figs. 224-227. Ixodes howelli Cooley and Kohls: Fig. 224, Capitulum, ventral view, ♀; Fig. 225, Coxae and trochanters I and II, ♀; Fig. 226, Capitulum, ventral view, nymph; Fig. 227, Coxa I, nymph.

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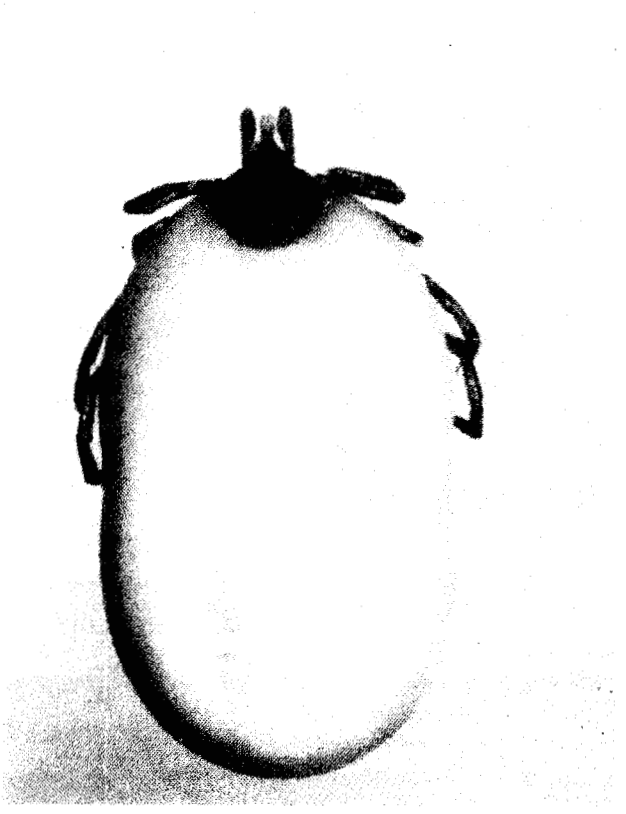
Plate 50

Figs. 228-231. Ixodes jellisoni Cooley and Kohls, ♀: Fig. 228, Dorsal view; Fig. 229, Coxa I; Figs. 230 and 231, Capitulum, dorsal and ventral views (tip of hypostome missing).



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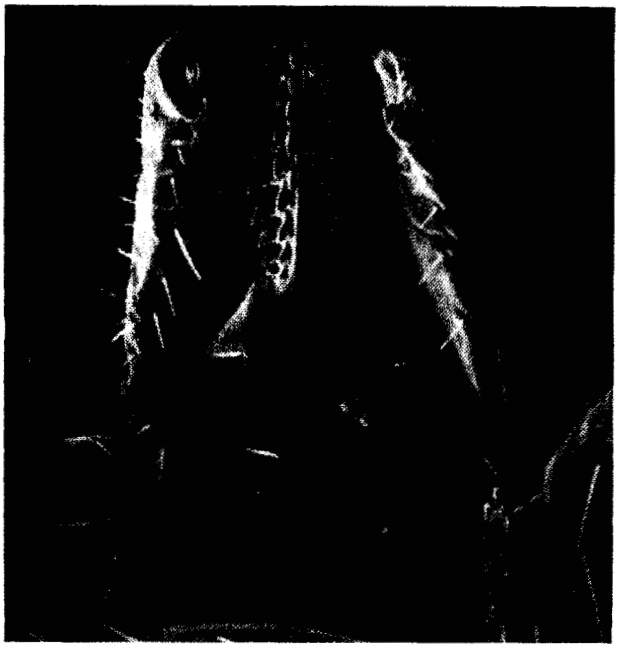

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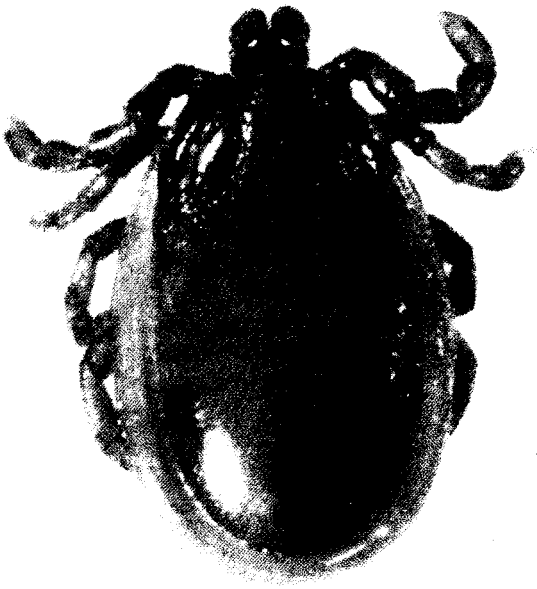
Plate 51

Figs. 232-235. Ixodes kingi Bishopp: Fig. 232, Dorsal view, ♂; Fig. 233, Dorsal view, ♀; Fig. 234, Scutum, ♂; Fig. 235, Scutum, ♀.



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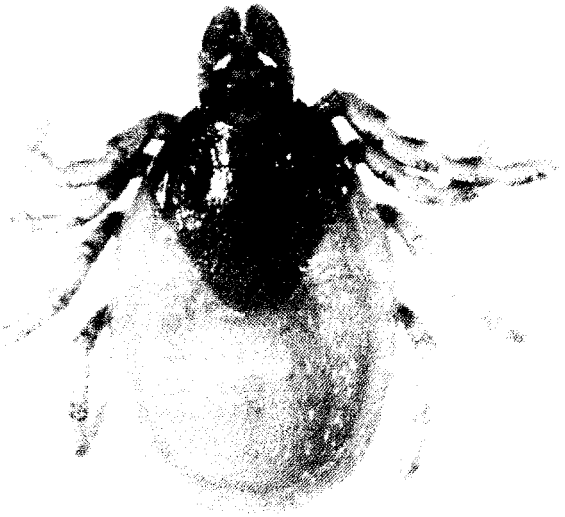

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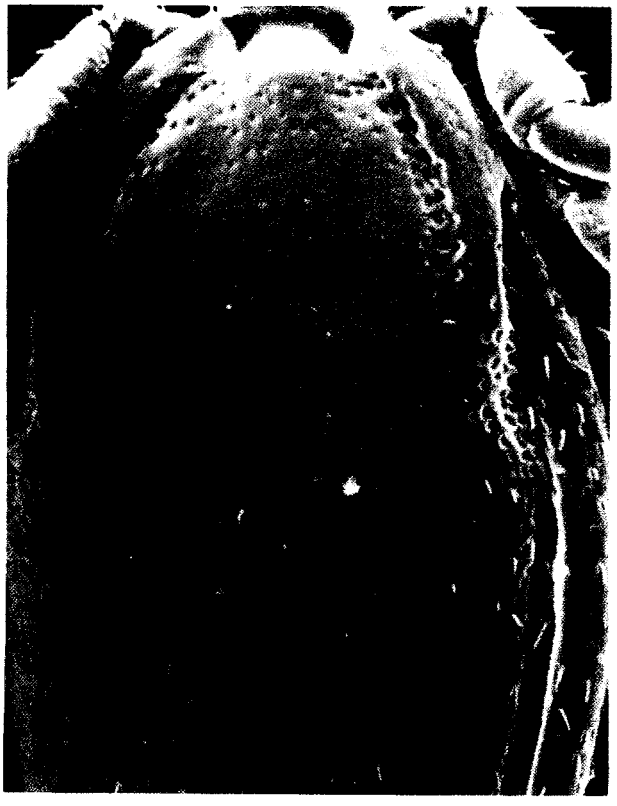

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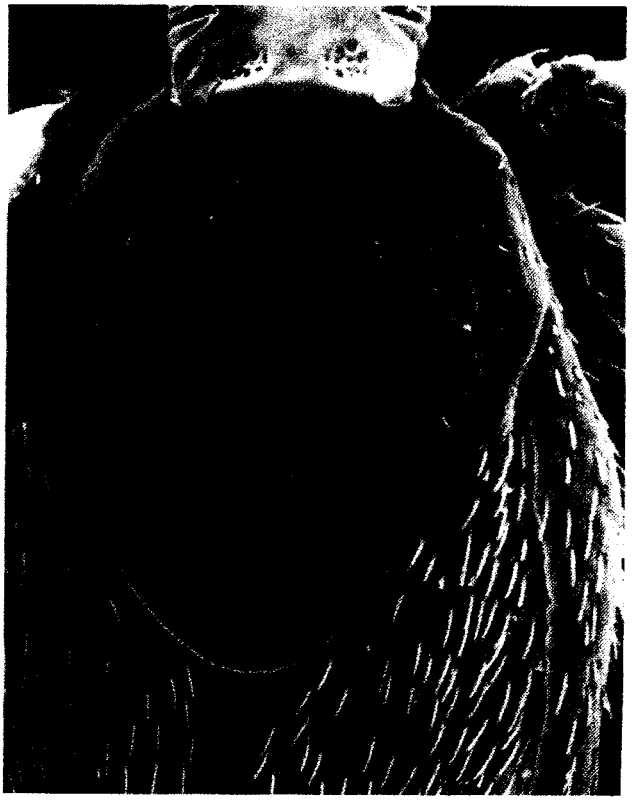

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Plate 52

Figs. 236-241. Ixodes kingi Bishopp: Figs. 236 and 237, Capitulum, ♂, dorsal and ventral views; Figs. 238 and 239, Capitulum, ♀, dorsal and ventral views; Fig. 240, Scutum and capitulum, nymph; Fig. 241, Capitulum, ventral view, nymph.

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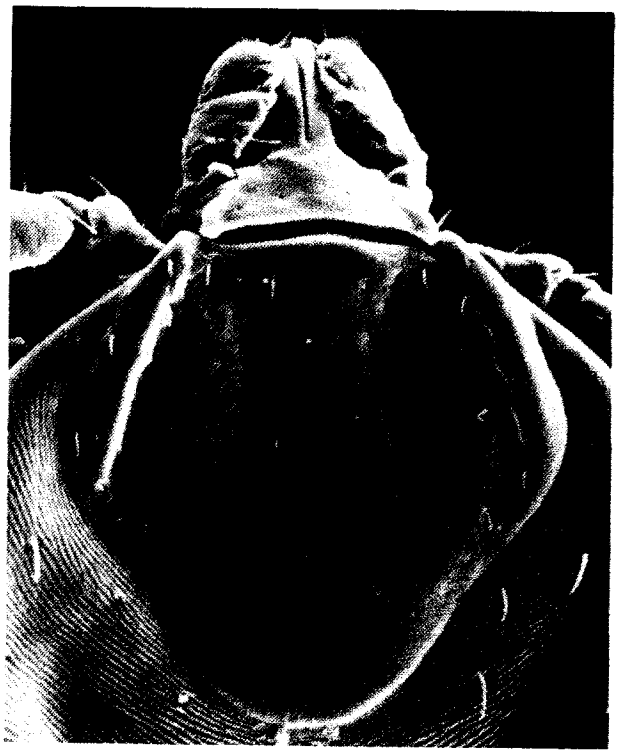

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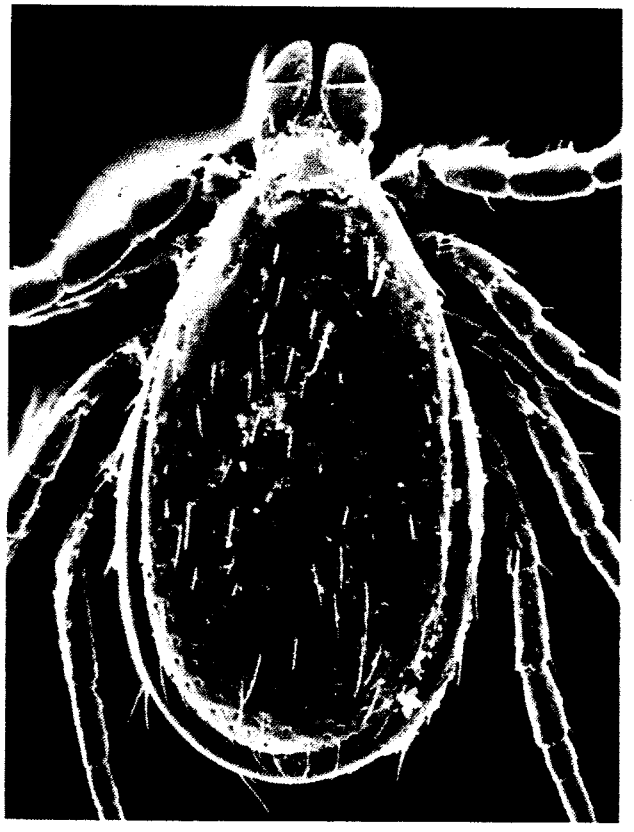
Plate 53

Figs. 242-245. Ixodes neotomae Cooley: Figs. 242 and 243, Dorsal and ventral views, ♂; Figs. 244 and 245, Dorsal and ventral views, ♀.



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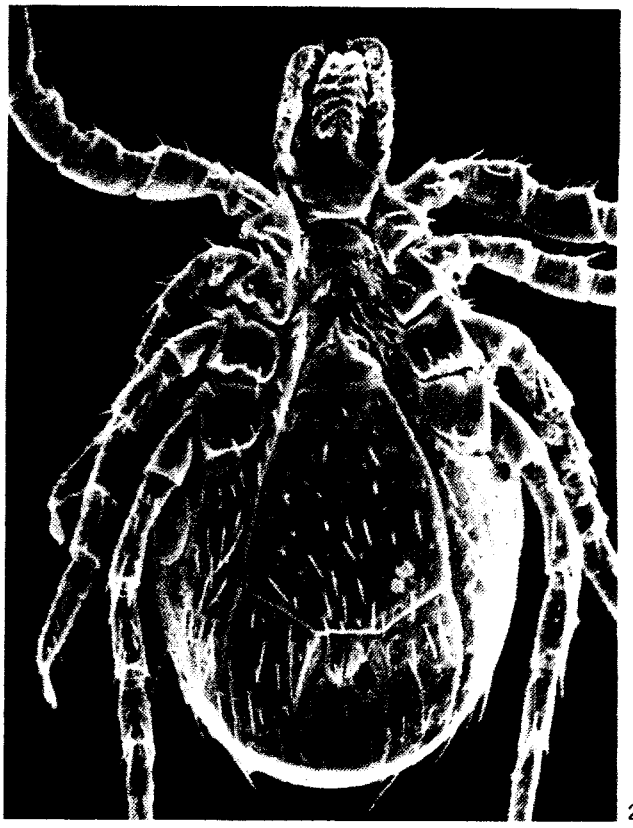

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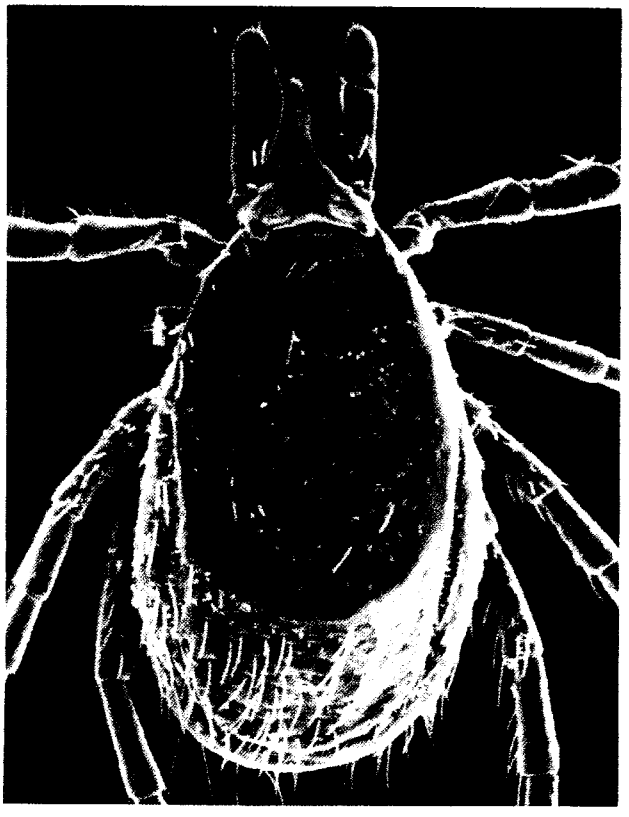

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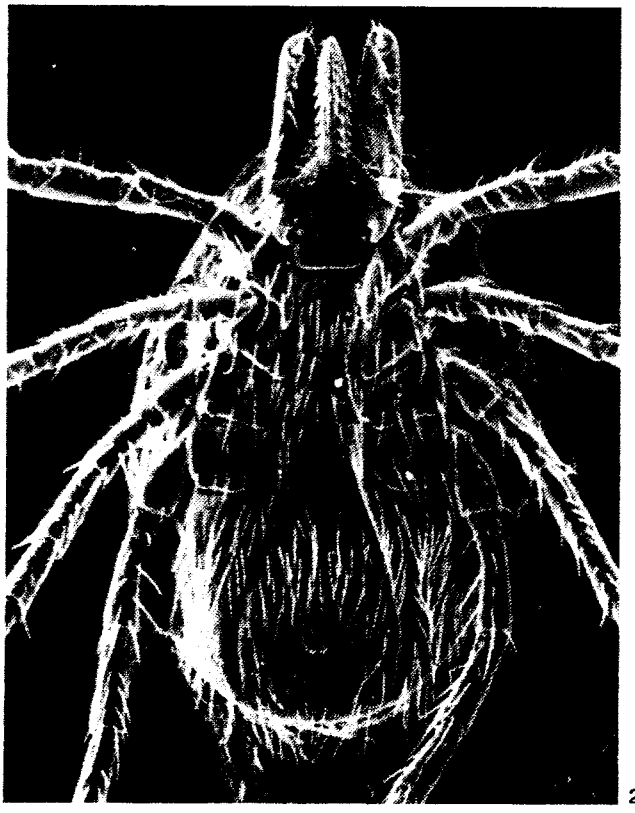

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Plate 54

Figs. 246-249. Ixodes neotomae Cooley: Figs. 246 and 247, Capitulum, ♂, dorsal and ventral views; Figs. 248 and 249, Capitulum, ♀, dorsal and ventral views.

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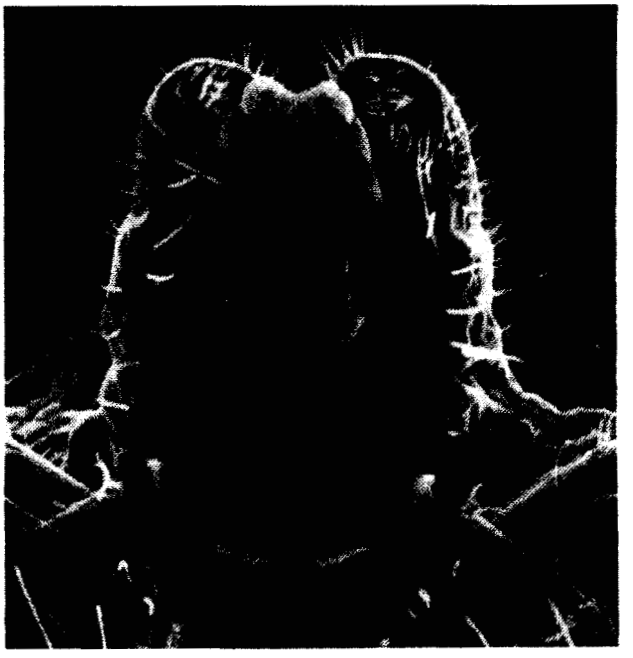

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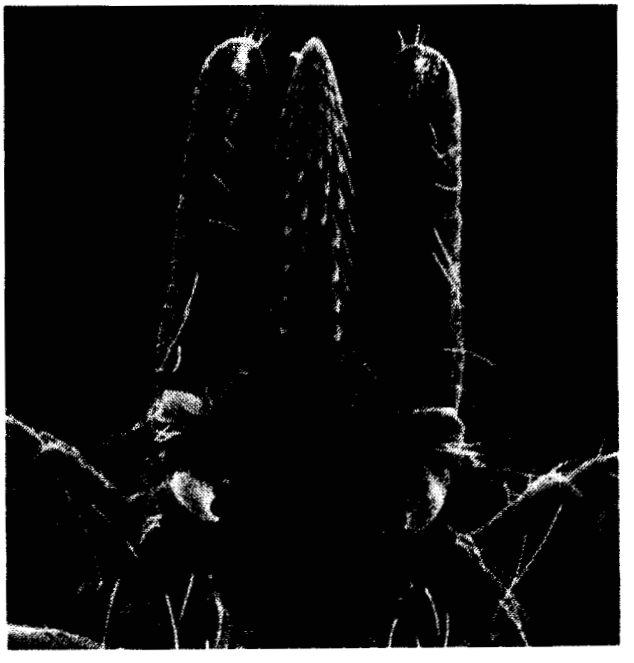

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Plate 55

Figs. 250-253. Ixodes ochotonae Gregson, ♀: Fig. 250, Scutum and basis capituli; Fig. 251, Coxae I and II; Figs. 252 and 253, Capitulum, dorsal and ventral views.

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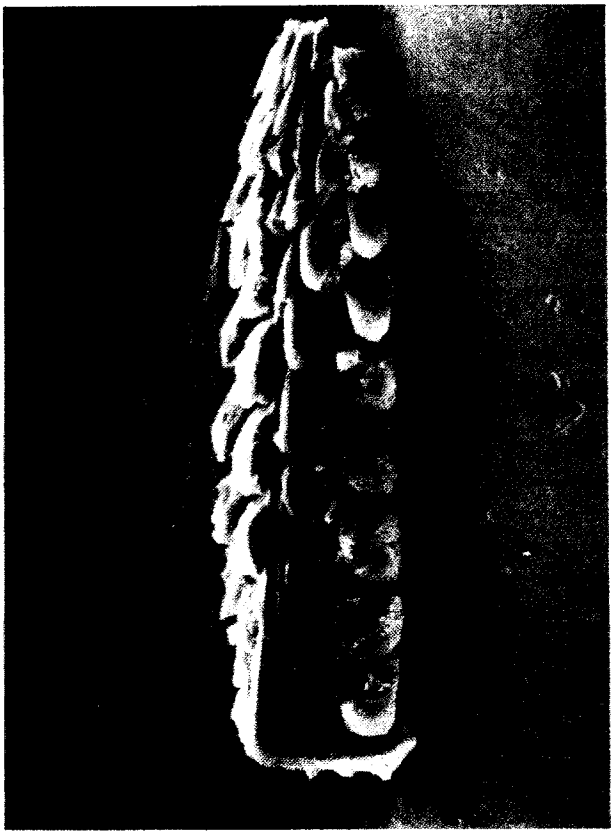
Plate 56

Figs. 254-257. Ixodes ochotonae Gregson: Fig. 254, hypostome, ♀; Fig. 255, Scutum, nymph; Figs. 256 and 257, Capitulum, nymph, dorsal, and ventral views.



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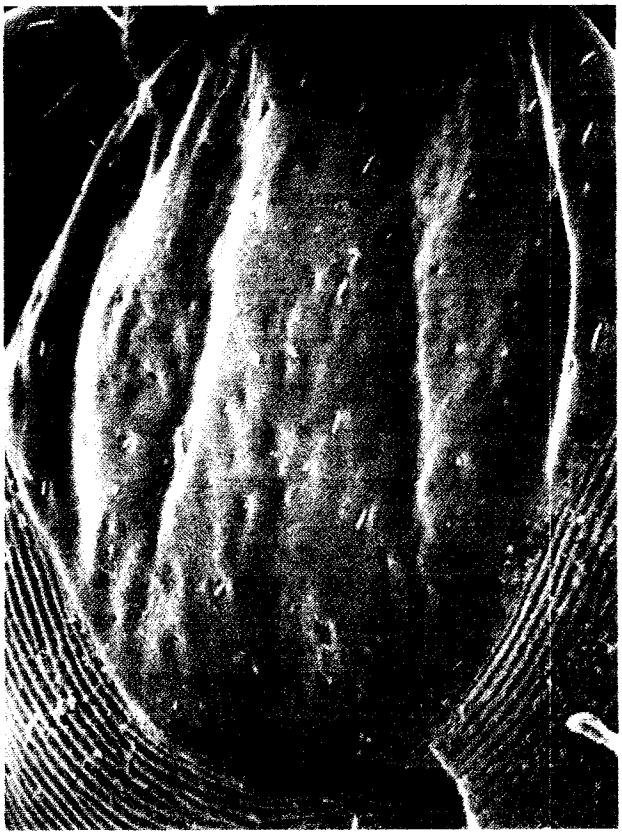

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Plate 57

Figs. 258-263. Ixodes pacificus Cooley and Kohls: Fig. 258, Dorsal view, ♂, mating with ♀, ventral view; Fig. 259, Dorsal view, ♀; Figs. 260 and 261, Capitulum, ♂, dorsal and ventral views; Fig. 262, Capitulum, dorsal view, ♀; Fig. 263, Coxae I and II and capitulum, ♀.

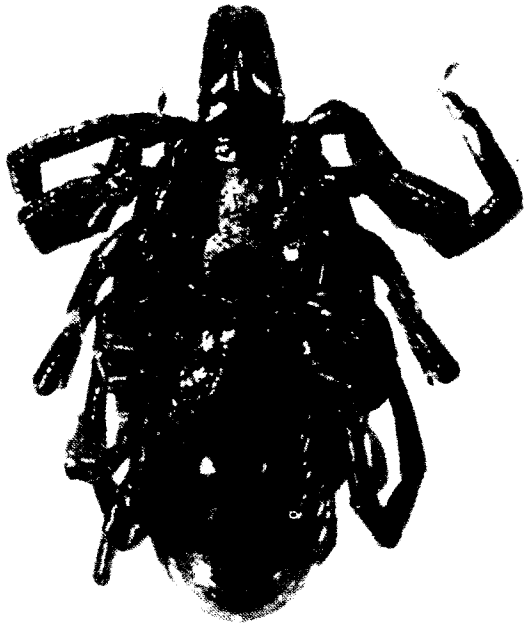

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Plate 58

Figs. 264-267. Ixodes pacificus Cooley and Kohls, nymph: Figs. 264 and 265, Dorsal and ventral views; Fig. 266, Capitulum, dorsal view; Fig. 267, Coxae I and capitulum.

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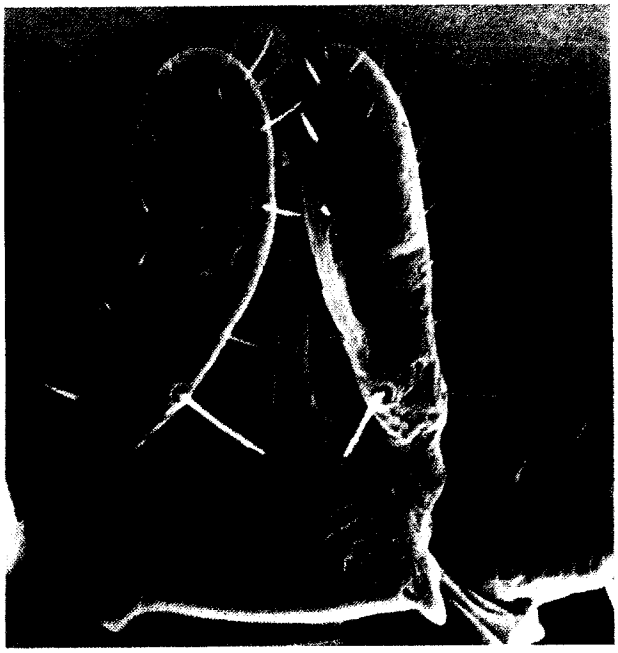

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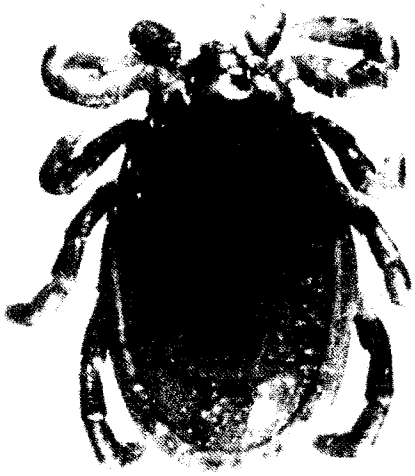
Plate 59

Figs. 268-273. Ixodes peromysci Augustson: Fig. 268, Dorsal view, ♂; Fig. 269, Dorsal view, ♀; Fig. 270, Scutum and basis capituli, ♂; Fig. 271, Scutum and basis capituli, ♀; Fig. 272, Capitulum, ventral view, ♂; Fig. 273, Capitulum, ventral view, ♀.



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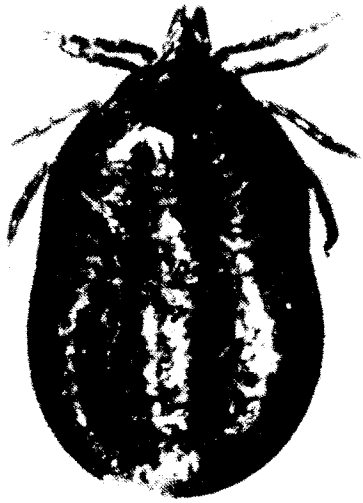

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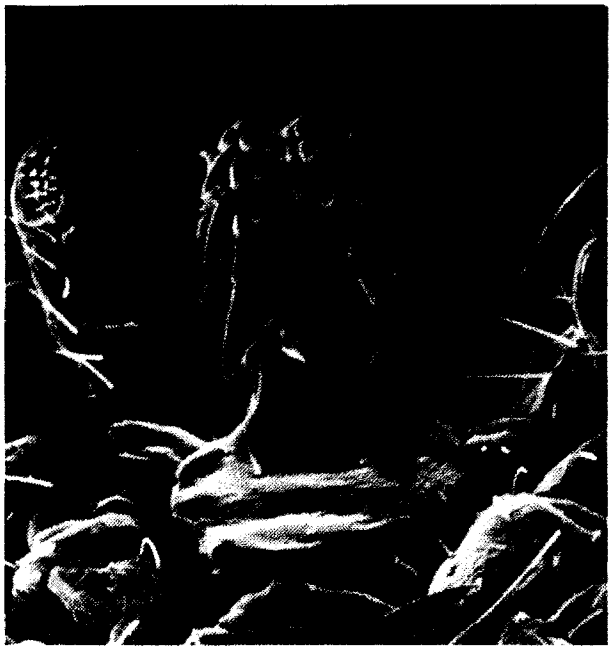

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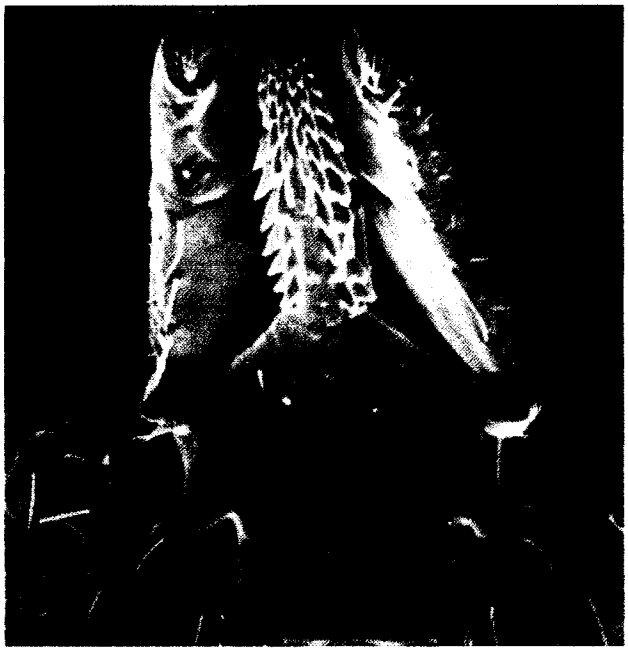

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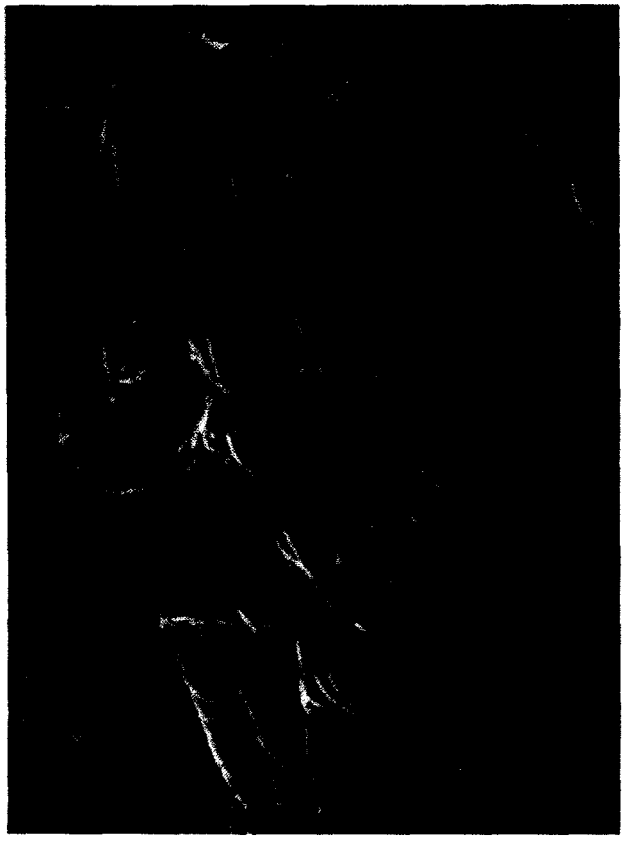
Plate 60

Figs. 274-279. Ixodes peromysci Augustson: Fig. 274, Coxae I-IV, ♂; Fig. 275, Ventral view, ♂; Figs. 276 and 277, Capitulum, nymph, dorsal and ventral views; Fig. 278, Scutum, nymph; Fig. 279, ventral view, nymph.



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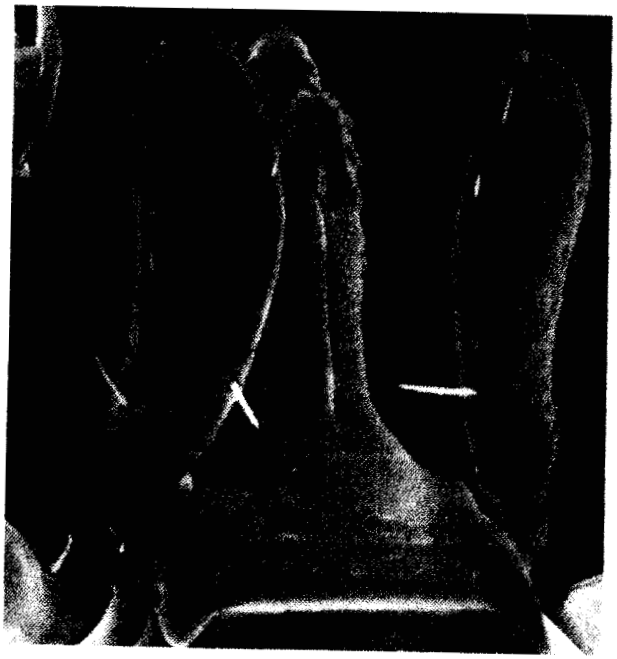

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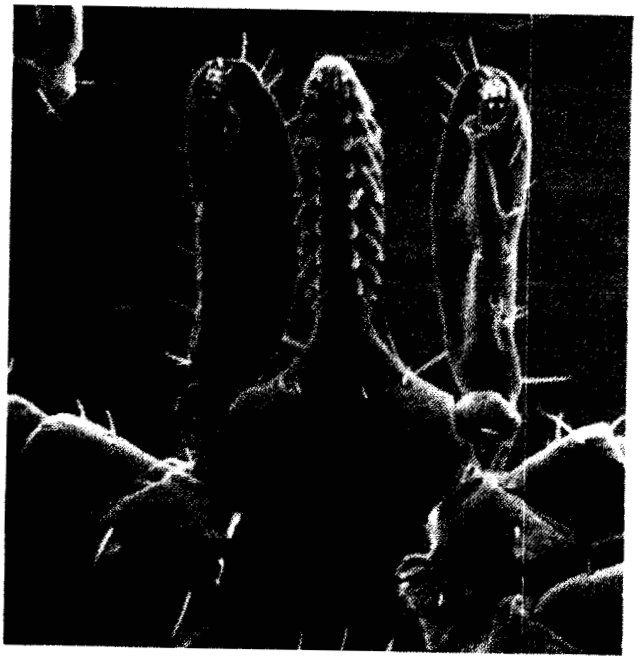

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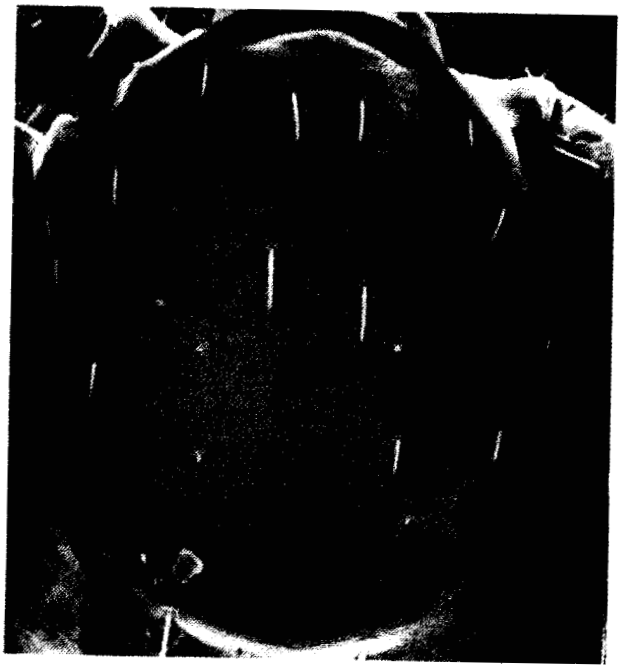

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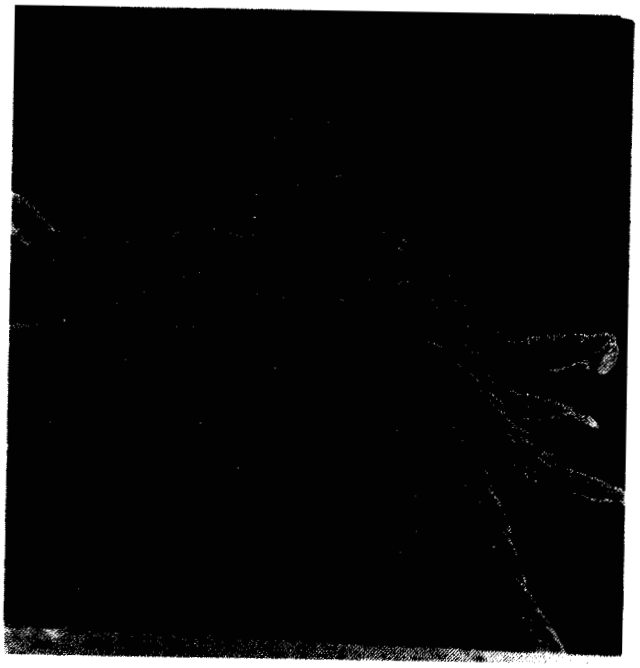

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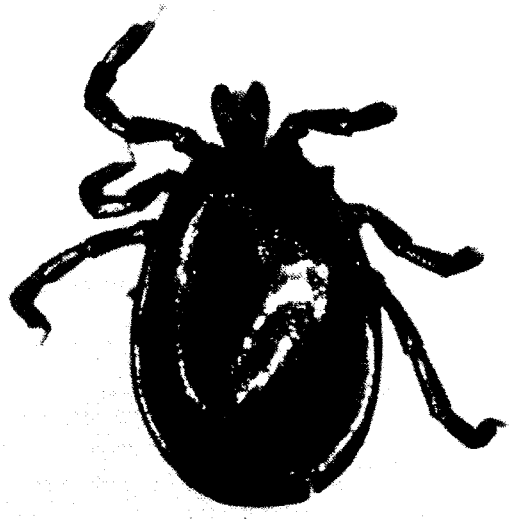
Plate 61

Figs. 280-285. Ixodes rugosus Bishopp: Fig. 280, Dorsal view, ♂; Fig. 281, Dorsal view, engorged ♀; Figs. 282 and 283, Capitulum, ♂, dorsal and ventral views; Figs. 284 and 285, Capitulum, ♀, dorsal and ventral views.



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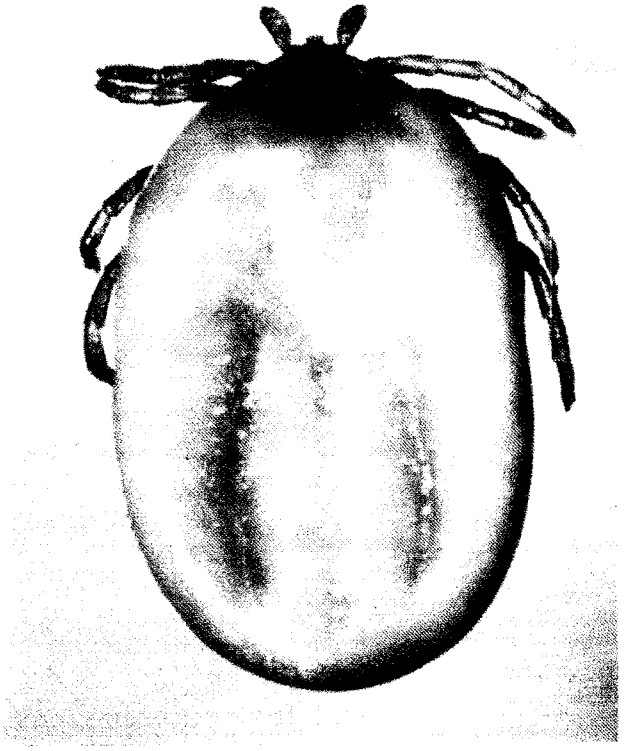

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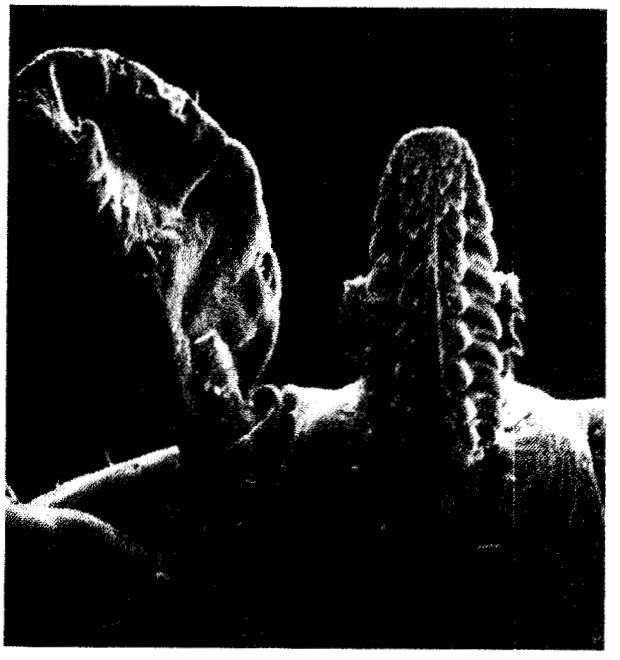

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Plate 62

Fig. 286-291. Ixodes rugosus Bishopp: Fig. 286, Scutum and dorsal integument, ♂; Fig. 287, Scutum, ♀; Fig. 288, Coxae I-IV, ♀; Fig. 289, Scutum and capitulum, nymph; Fig. 290, Capitulum, ventral view, nymph; Fig. 291, Coxae I-IV, nymph.

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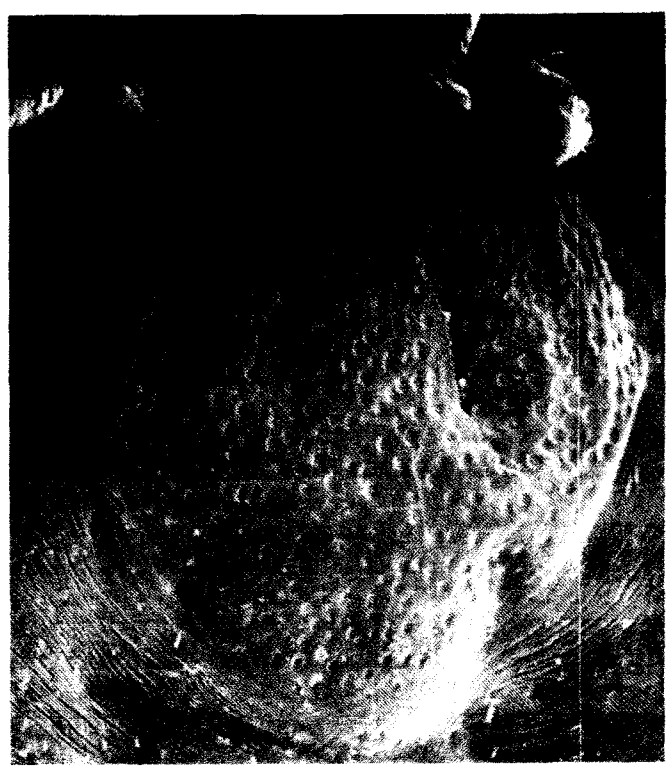

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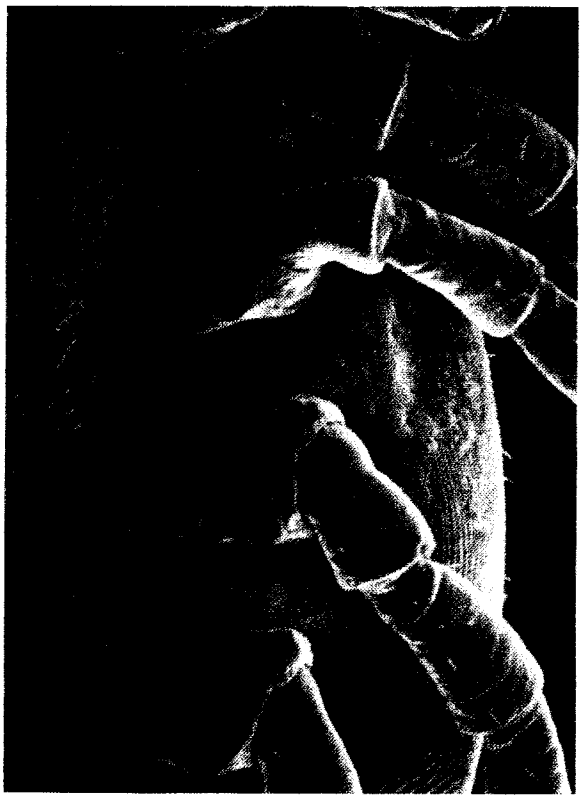

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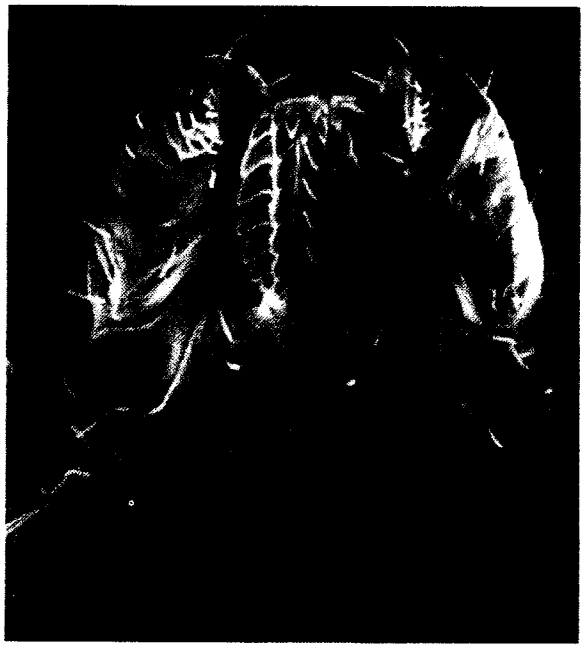

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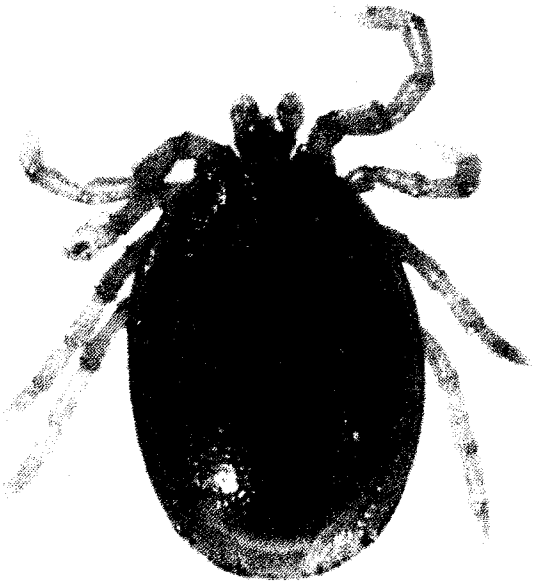
Plate 63

Figs. 292-295. Ixodes sculptus Neumann, ♂: Figs. 292 and 293, Dorsal and ventral views; Figs. 294 and 295, Capitulum, dorsal and ventral views.



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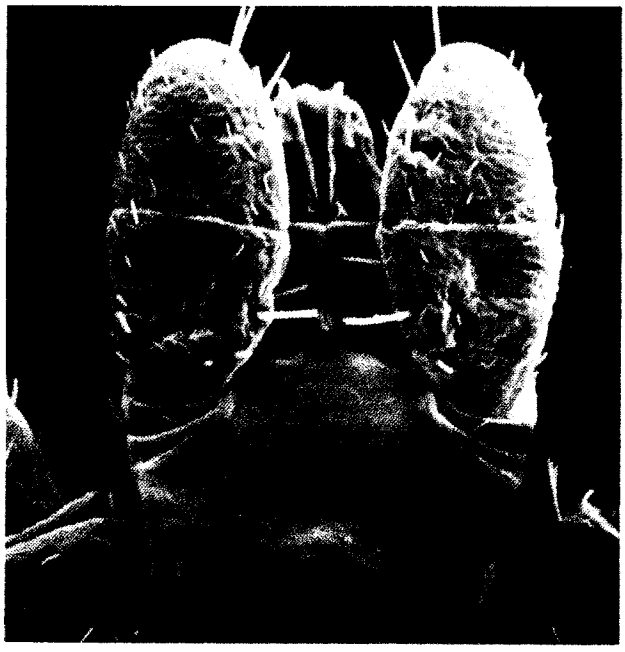

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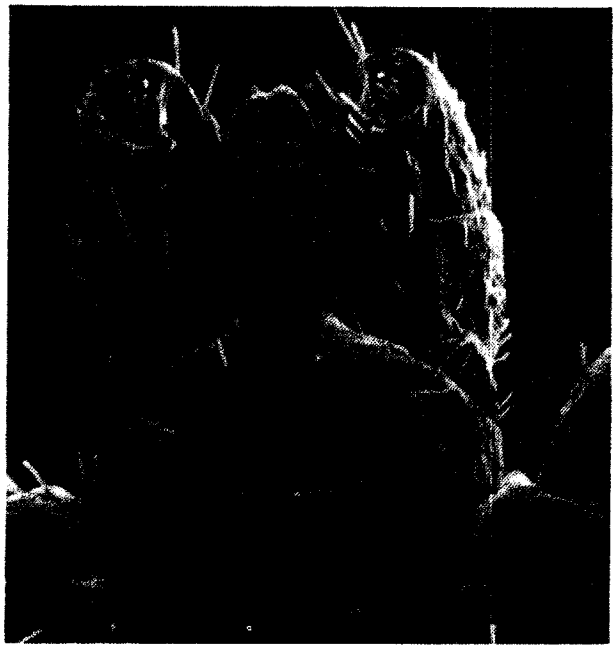

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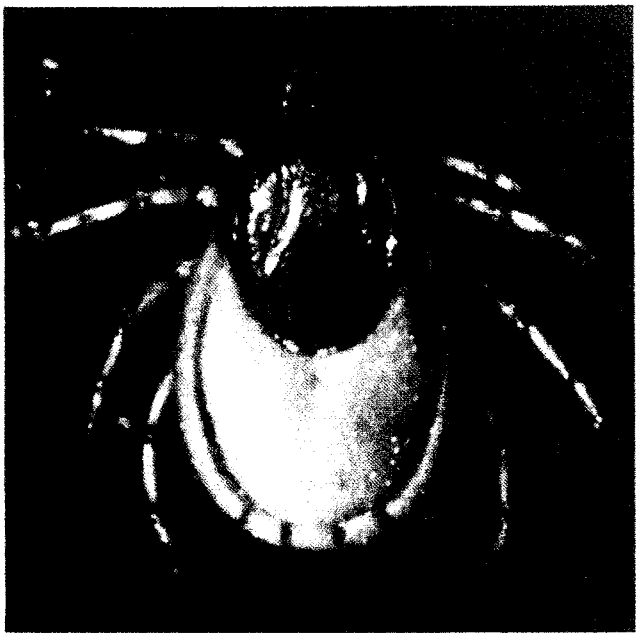
Plate 64

Figs. 296-301. Ixodes sculptus Neumann: Fig. 296, Dorsal view, ♀; Fig. 297, Coxa I, ♀; Figs. 298 and 299, Capitulum, ♀, dorsal and ventral views; Figs. 300 and 301, Capitulum, nymph, dorsal and ventral views.



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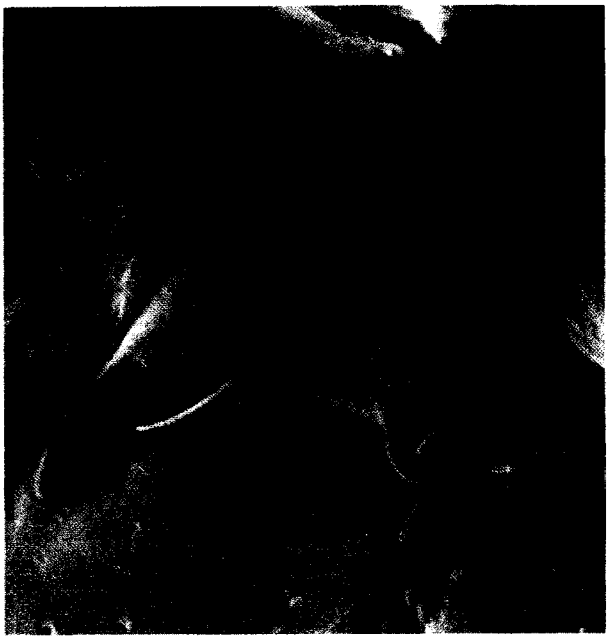

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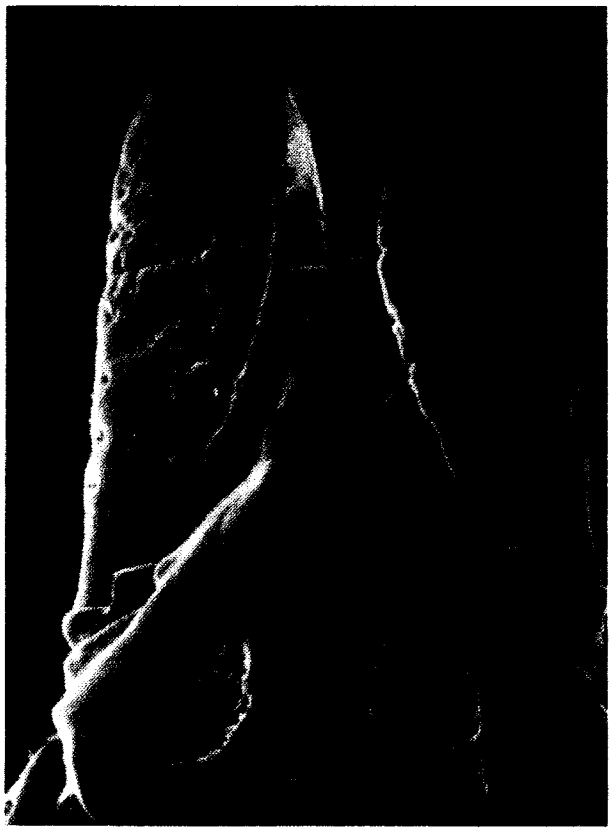

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Plate 65

Figs. 302-305. Ixodes signatus Birula: Fig. 302, Dorsal view, ♂; Fig. 303, Dorsal view, ♀; Figs. 304 and 305, Capitulum, ♂, dorsal and ventral views.

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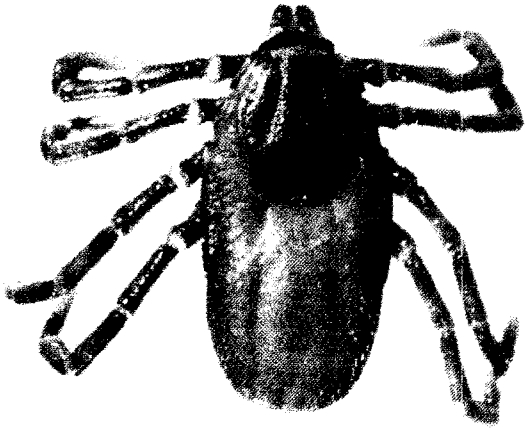

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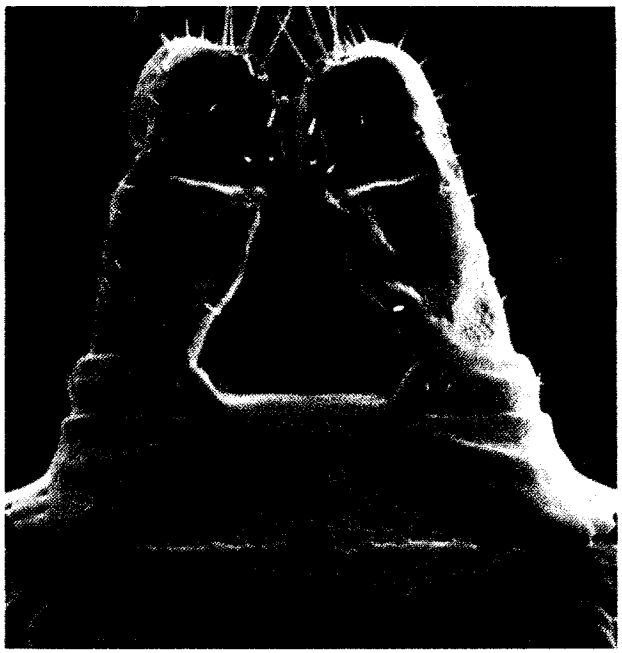
Plate 66

Figs. 306-309. Ixodes signatus Birula: Figs. 306 and 307, Capitulum, ♀, dorsal and ventral views; Fig. 308, Coxa I, ♀; Fig. 309, Capitulum and coxa I, ventral view, nymph.



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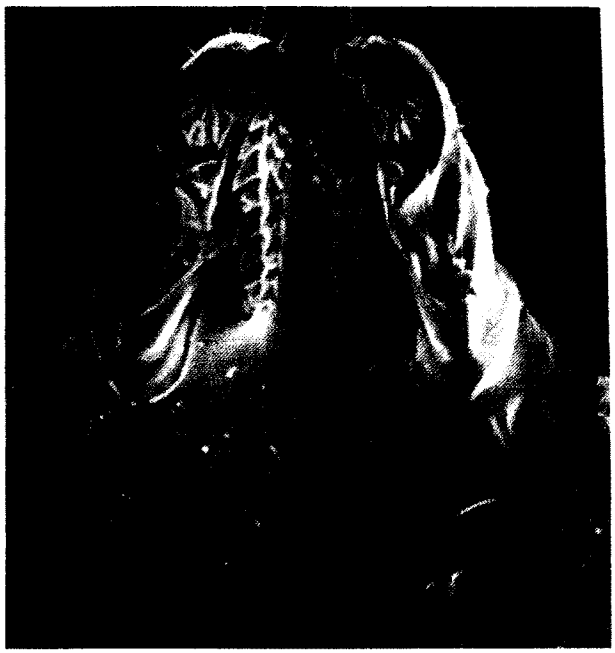

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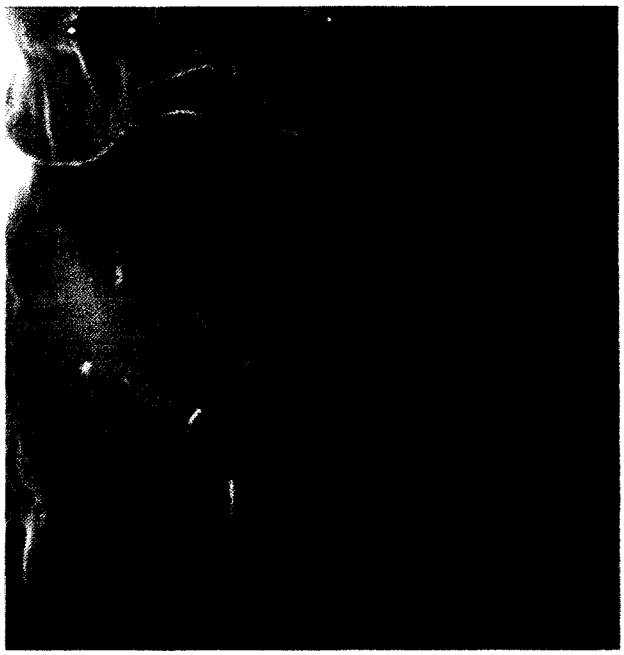

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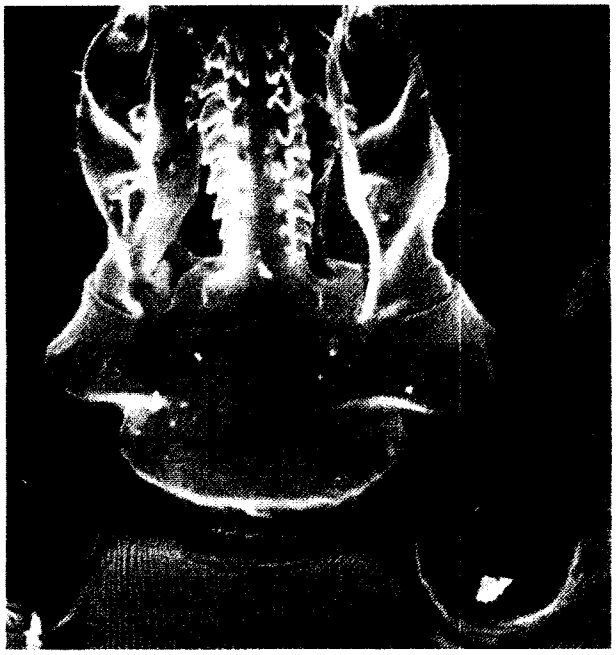

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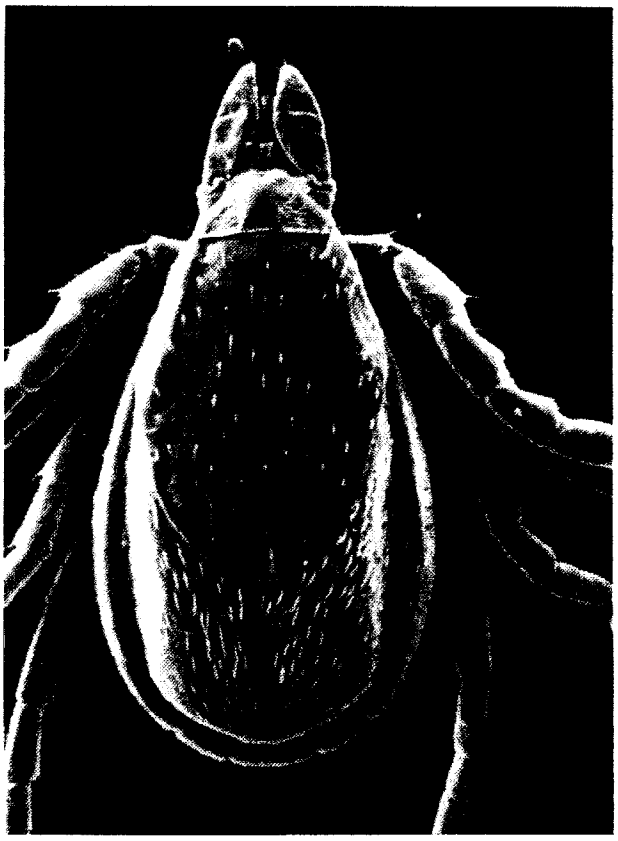
Plate 67

Figs. 310-313. Ixodes soricis Gregson, ♀: Fig. 310, Dorsal view; Fig. 311, Coxae I-IV; Figs. 312 and 313, Capitulum, dorsal and ventral views.



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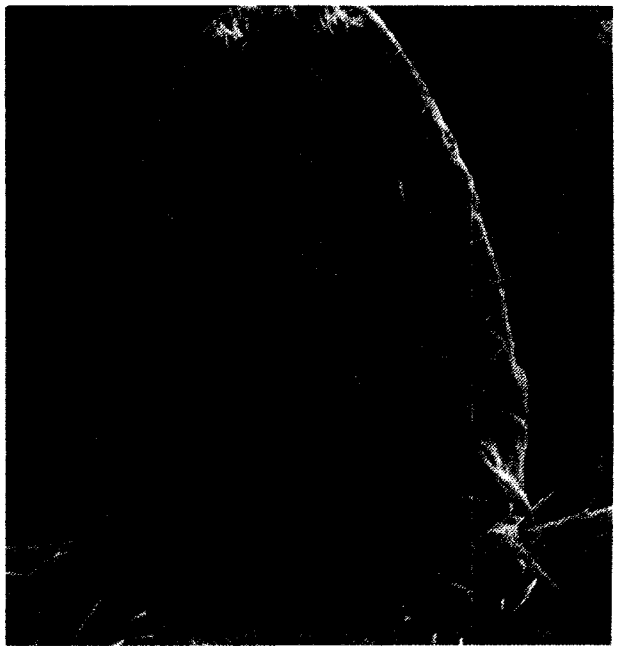

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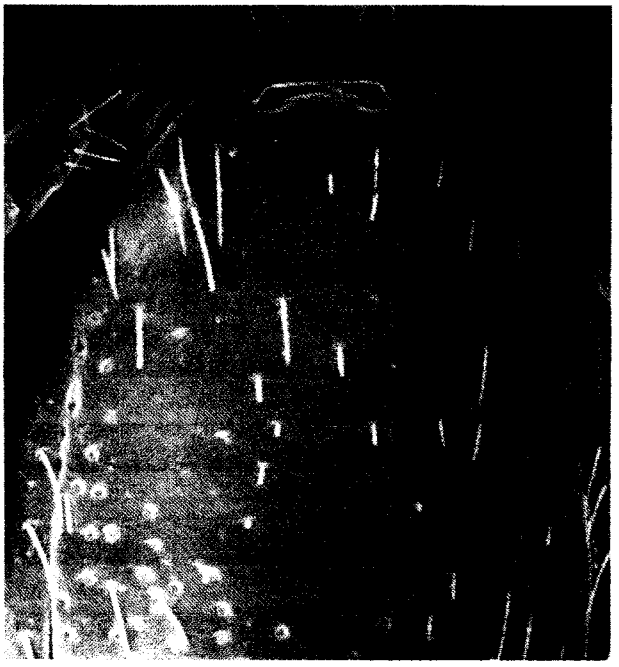
Plate 68

Figs. 314-319. Ixodes spinipalpis Hadwen and Nuttall: Fig. 314, Scutum and basis capituli, ♂; Fig. 315, Scutum, ♀; Fig. 316, Capitulum, ventral view, ♂; Fig. 317, Capitulum, ventral view, ♀; Fig. 318, Coxa I, ♀; Fig. 319, Capitulum, ventral view, nymph.



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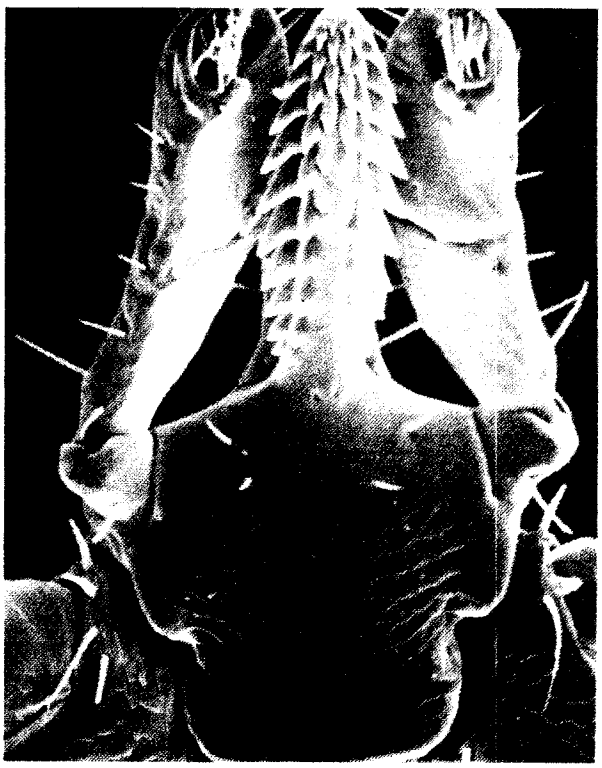
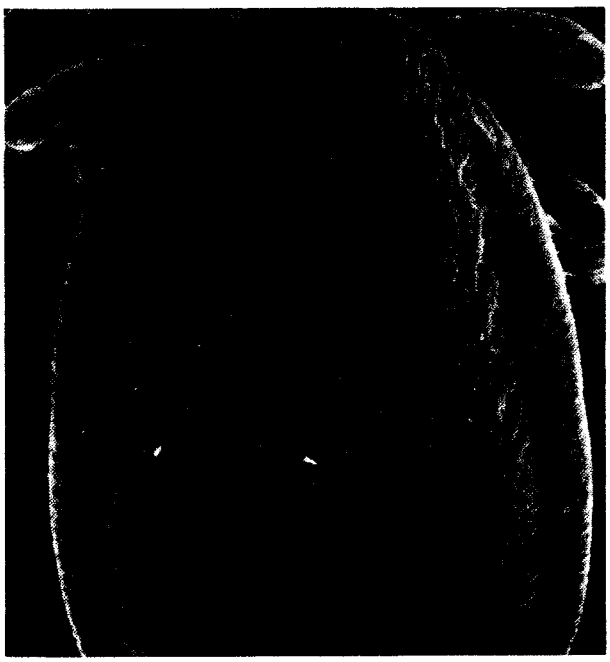


319

Plate 69

Figs. 320–323. Ixodes texanus Banks, ♂: Fig. 320, Scutum; Fig. 321, Coxae I-IV; Figs. 322 and 323, Capitulum, dorsal and ventral views. (Figs. 320–323 courtesy Keirans and Clifford, 1978.)



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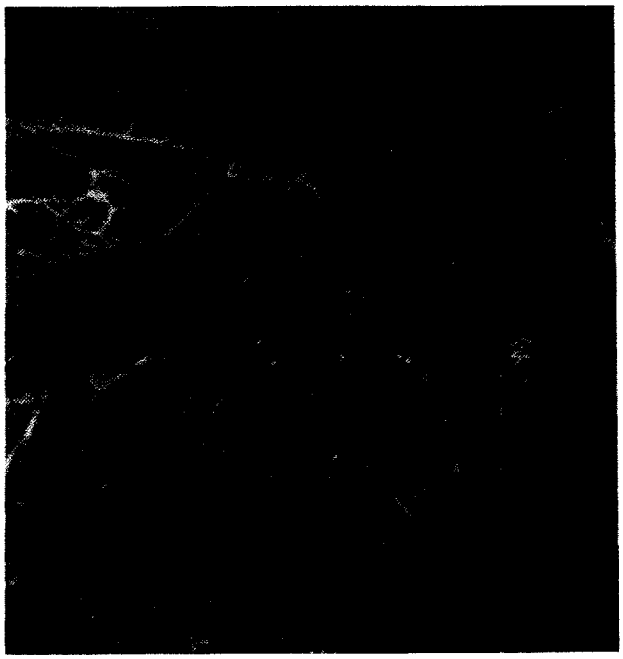

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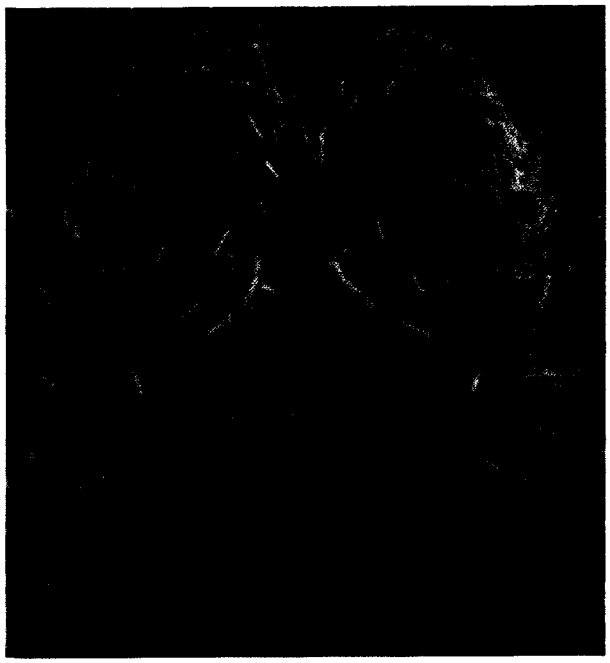

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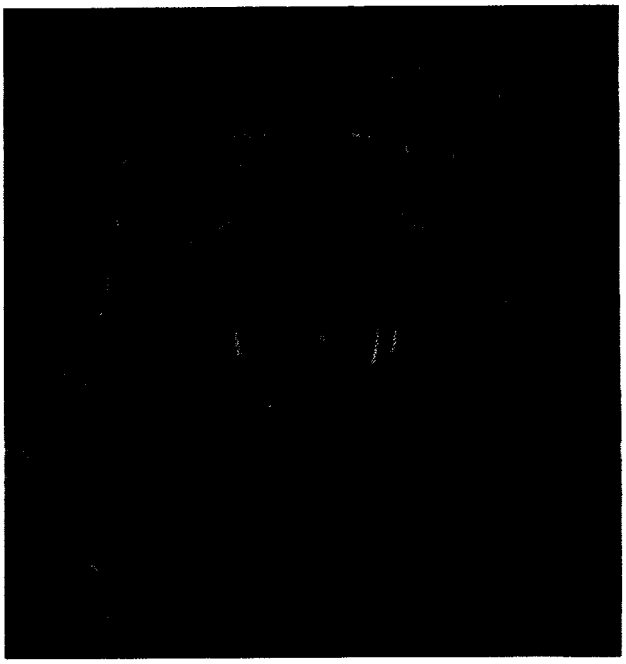

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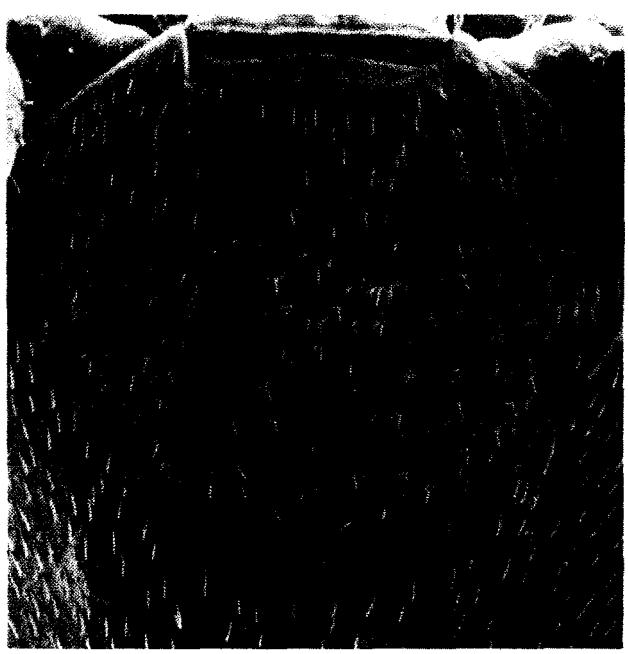
Plate 70

Figs. 324-329. Ixodes texanus Banks: Fig. 324, Scutum, ♀; Fig. 325, Coxae I-IV ♀; Figs. 326 and 327, Capitulum, ♀, dorsal and ventral views; Figs. 328 and 329, Capitulum, nymph, dorsal and ventral views.



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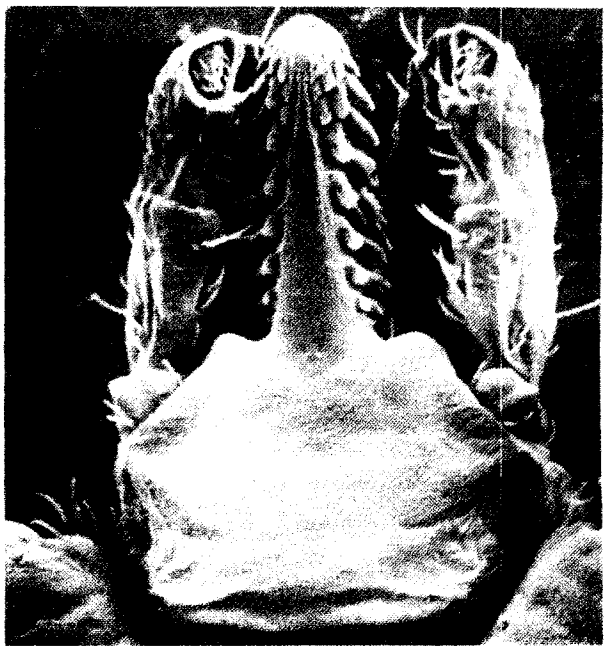

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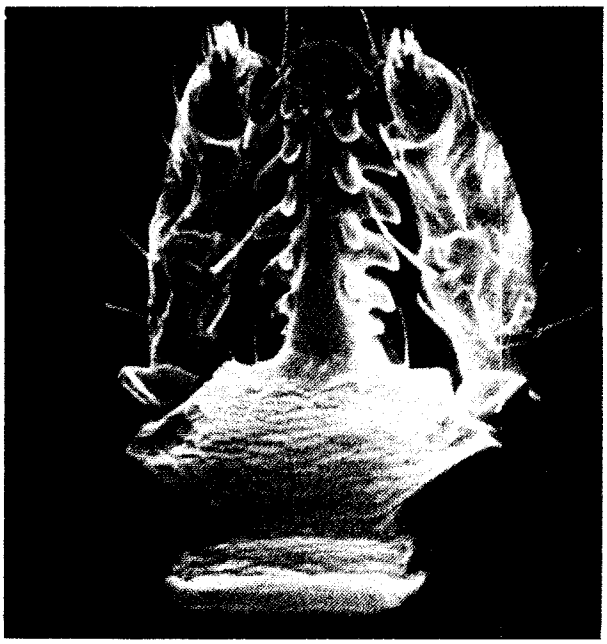

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Plate 71

Figs. 330-333. Ixodes uriae White: Figs. 330 and 331, Dorsal and ventral views, ♂; Figs. 332 and 333, Dorsal and ventral views, ♀.

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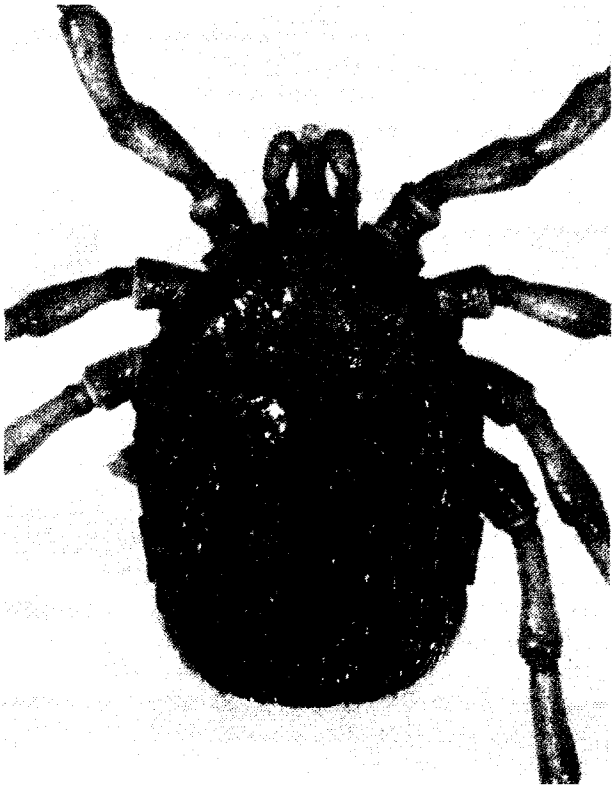

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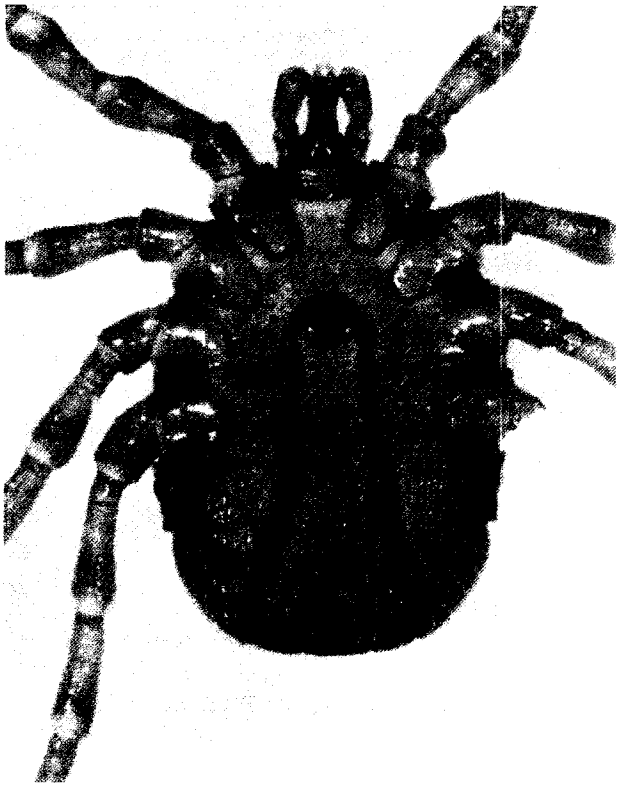

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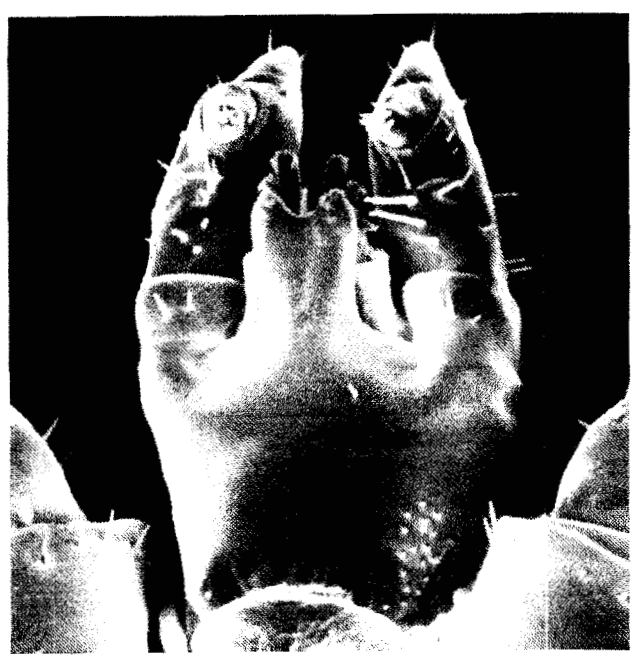
Plate 72

Figs. 334-339. Ixodes uriae White: Fig. 334, Posterior ventral view, ♂; Fig. 335, Capitulum, ventral view, ♂; Fig. 336 and 337, Capitulum, ♀, dorsal and ventral views; Fig. 338, Capitulum, dorsal view, nymph; Fig. 339, Scutum, nymph.

334



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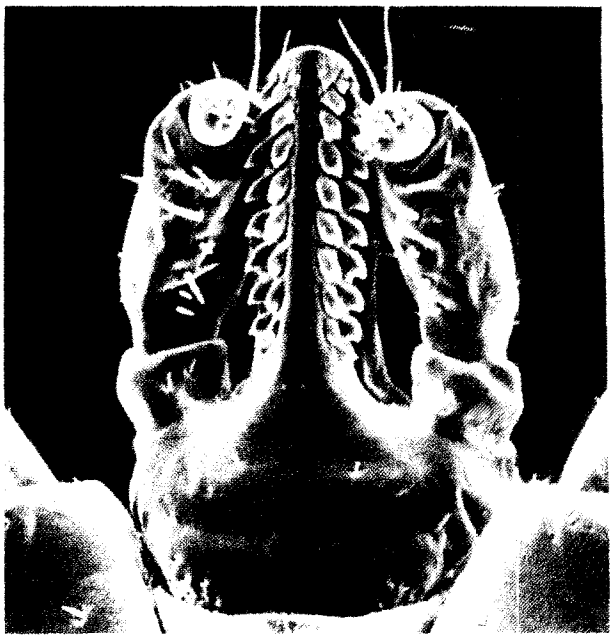

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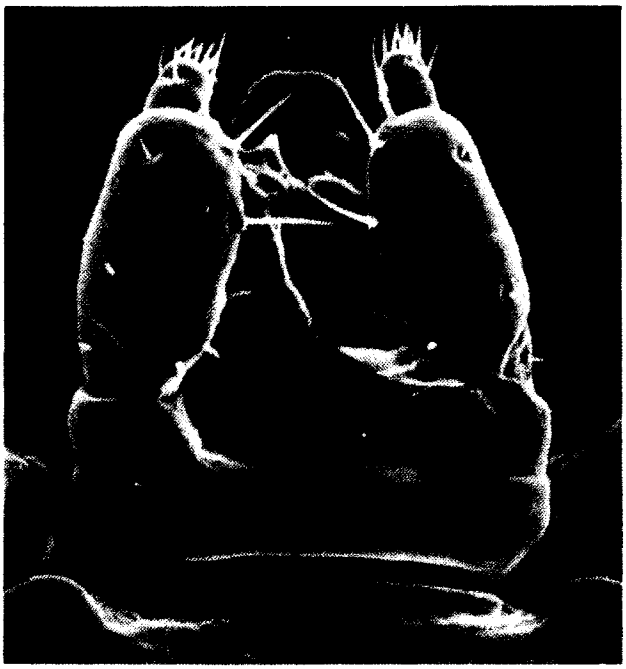

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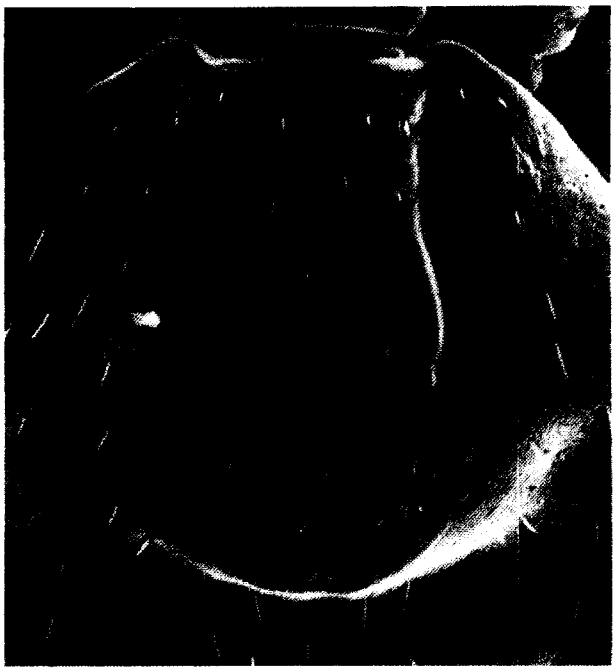

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Plate 73

Figs. 340-343. Ixodes woodi Bishopp, ♂: Fig. 340, Dorsal view; Fig. 341, Coxae I-IV; Fig. 342, Anterior scutum and capitulum; Fig. 343, Capitulum, ventral view.

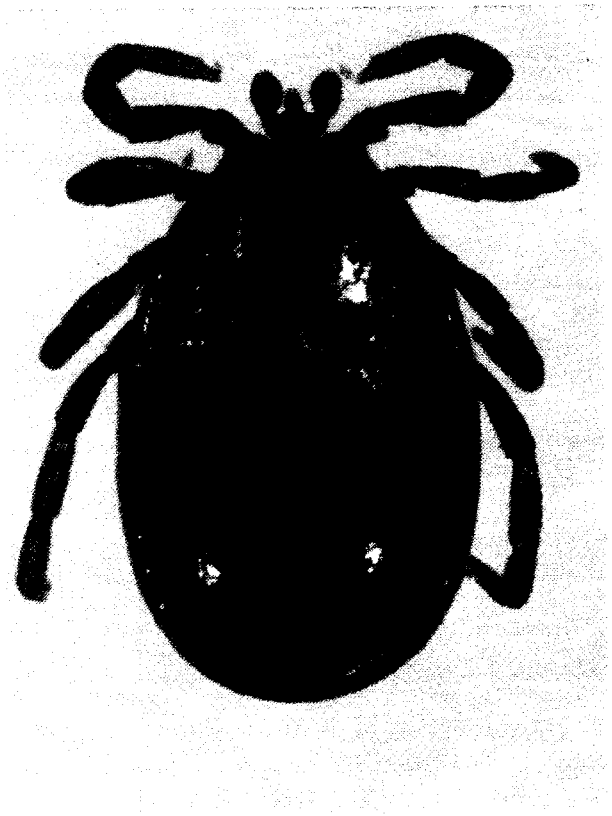

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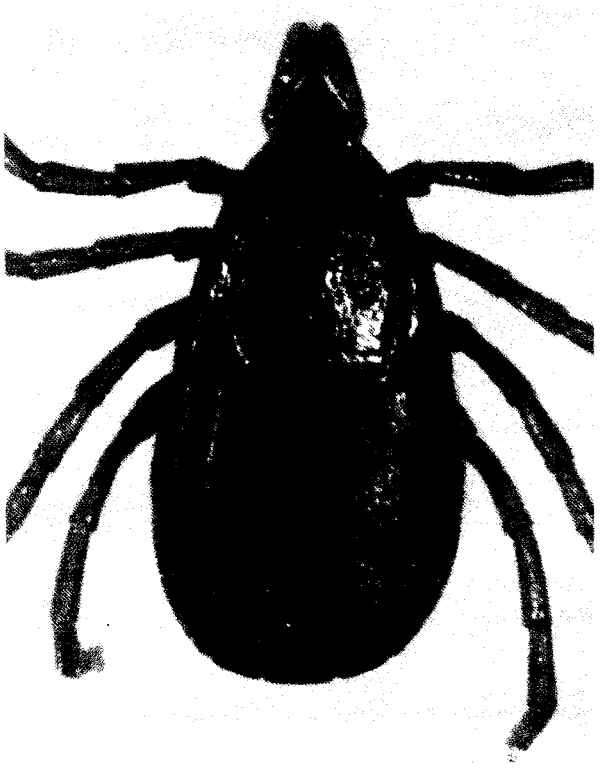
Plate 74

Figs. 344-349. Ixodes woodi Bishopp: Fig. 344, Dorsal view, ♀; Fig. 345, Scutum, ♀; Figs. 346 and 347, Capitulum, ♀, dorsal and ventral views; Fig. 348, Capitulum, ventral view, nymph; Fig. 349, Coxa I, nymph.



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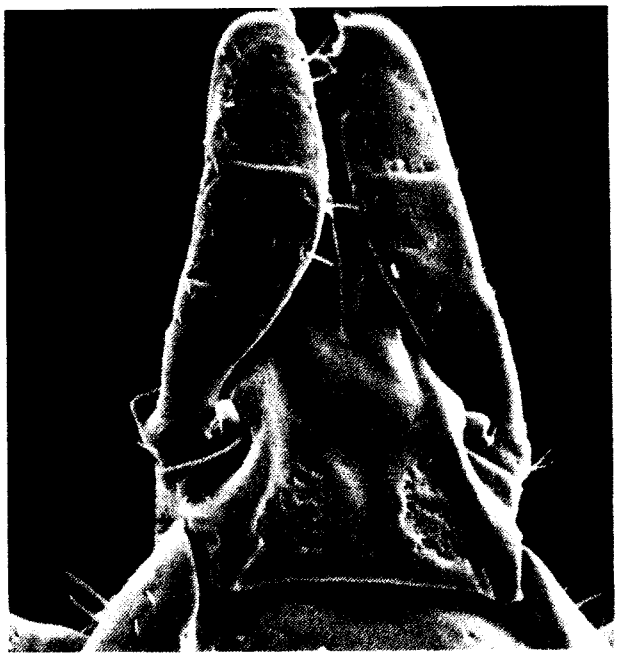

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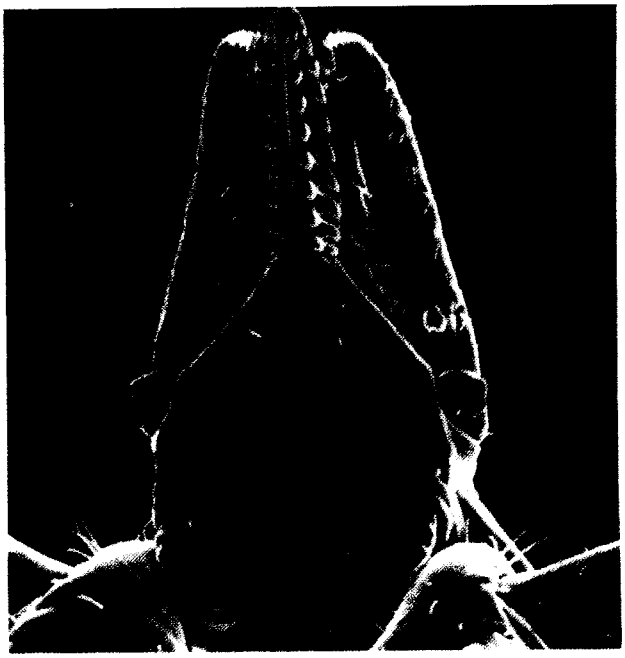

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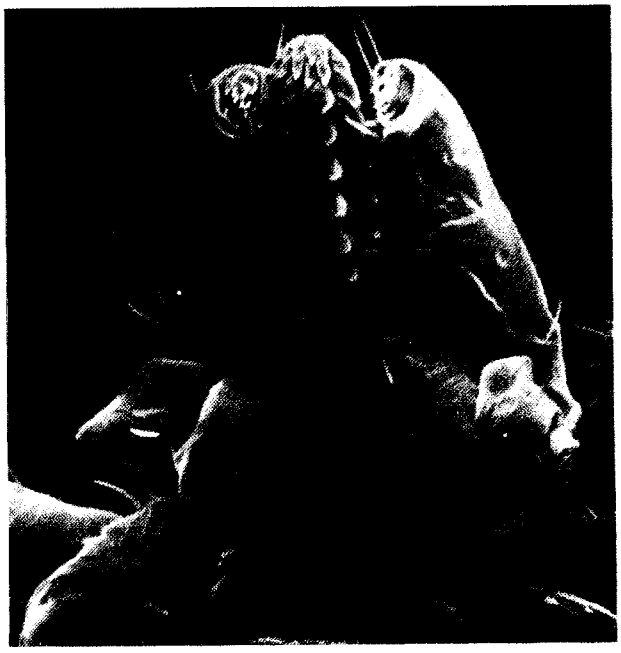

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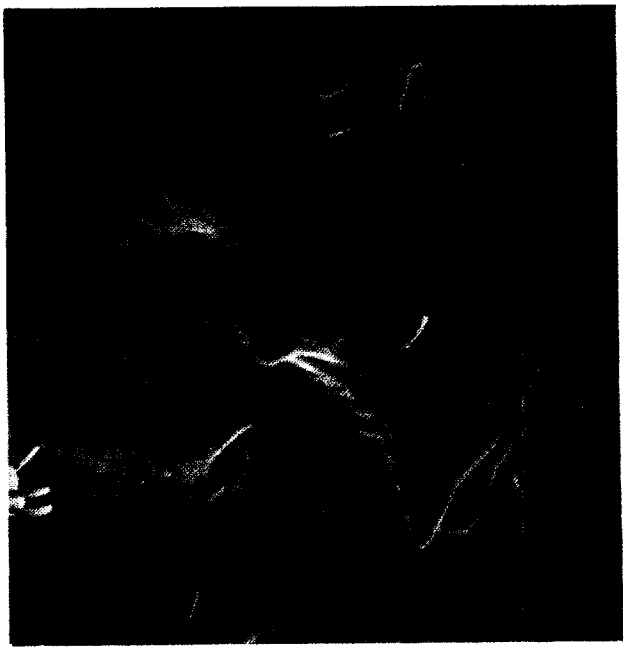

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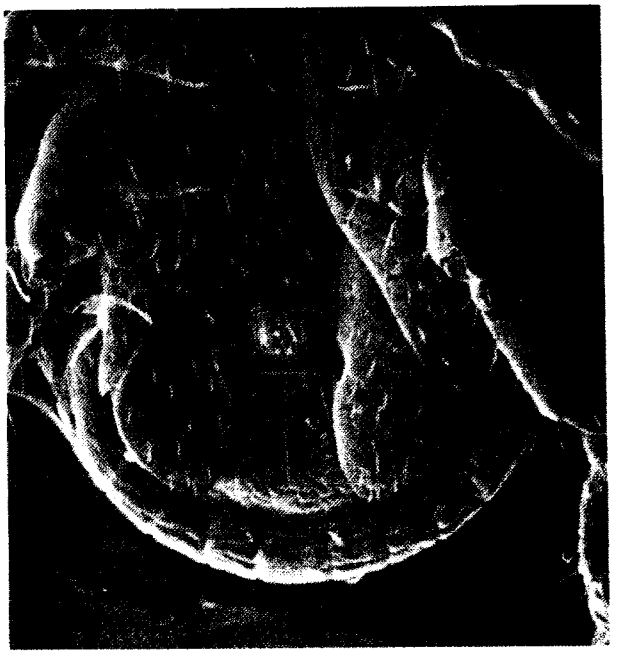
Plate 75

Figs. 350-356. Rhipicephalus sanguineus (Latreille): Fig. 350, Dorsal view, ♂; Fig. 351, Dorsal view, ♀; Fig. 352, Posterior ventral view and coxae III-IV, ♂; Fig. 353, Capitulum, dorsal view, ♀; Fig. 354, Capitulum; dorsal view, nymph; Fig. 355, Anal groove, nymph; Fig. 356, Coxae I-IV, nymph.

350 351



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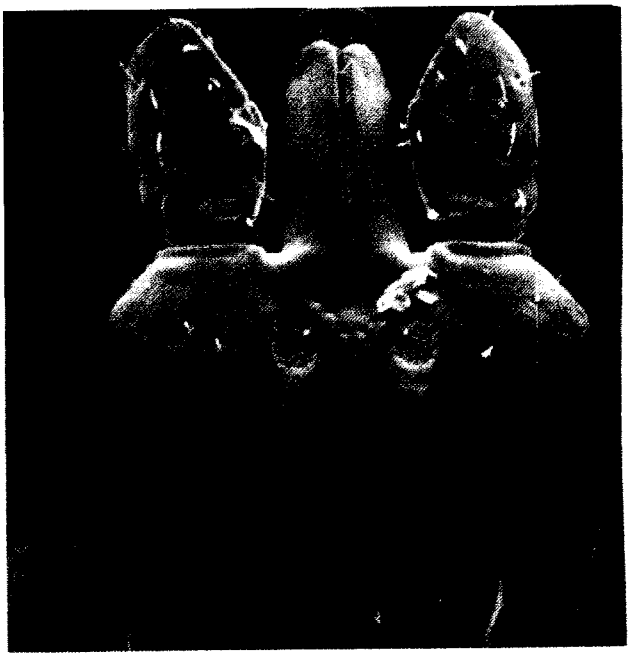

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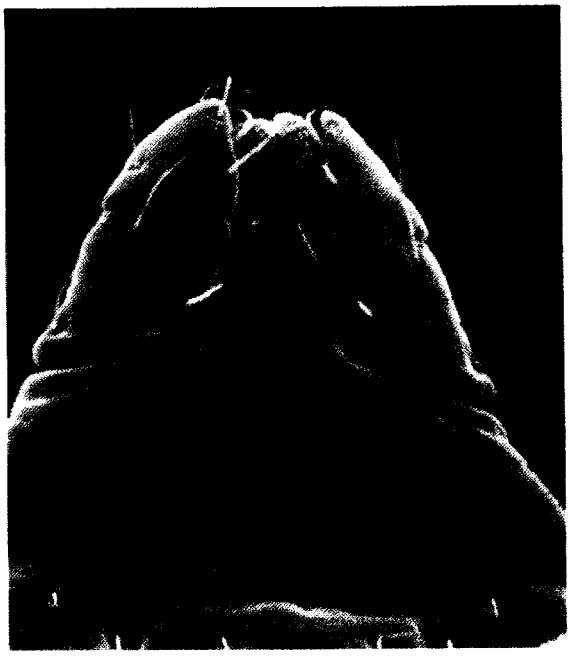

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