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Central-European Ticks (Ixodoidea)

— Key for determination —

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Dedicated to

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Preface

The world wide distributed ticks, parasites of man and domestic as well as wild animals, also vectors of many diseases, are of great economic and medical importance. Therefore this group of acari is in centre of the research programme in applied acarology all over the world, also in Europe, where, e. g., the tick-borne encephalitis is one of the important medical problems. The preliminary condition of serious investigations about morphology, ecology, ethology and physiology is an exact determination of species. But useful comprehensive literature of determination is rare. This publication, result of team work between Austrian and Czechoslowakian scientists, contains keys which give also the non specialised zoologists and parasitologists the possibility of determining all stages ot tick species living in Central Europe. The enclosed excellent Scanning-photographs exhibit not only many details in microstructure of different organs, they exhibit also the importance of modern morphological methods in taxonomy. A list of hosts and one of basic literature complete this publication, which will help to extend our knowledge about ticks and their life.

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1. Introduction

Ixodid ticks occur throughout the world wherever terrestrial vertebrates are found. They are adapted to parasitic life and many biological features enable ticks to survive especially well. They lay numerous eggs and withstand a comparatively wide temperature and humidity range with greater ease than many other arthropods. They survive for months or years without food and often gain considerable protection from the concealed places in which they feed on the host. Parthenogenesis, possibly a common occurrence, may aid survival. Their integument offers some protection from living enemies, water and chemicals.

During the life history of the ixodid tick there are three phases, the adults of both sexes, nymphs and larvae. The adults male and female mate and latter female produces eggs from which larvae emerge. Eggs are laid only once. Larvae often parasitize small mammals, birds and reptiles, sometimes in their nests or dens. Thickness of the host skin is possibly an important factor restricting the larvae to smaller animals. The larvae, having obtained the necessary nutritional reguirements from their host, moult and produce nymphs. The nymphs do likewise and give rise either to adults males and females. In great part of Central European ticks, three different hosts, either of the same or different species, are usually required to complete the life history. Exception are the single-host boophilid ticks that moult and remain on a single host during their life-time. The degree of host specificity in ixodid ticks varies from genus to genus or within subgroups of various genera.

Argasid ticks deposite eggs at intervals in small batches and totaling only a few hundred. Eggs are laid in niches where females seek shelter. Larvae of Argas feed on birds or bats, or less commonly on other animals, and remain on the host for several days to several weeks. Nymphs and

adults feed for only a few minutes to a few hours at most, in marked contrast to the Ixodidae. There are at least two and more nymphal instars. Argasid adults take several blood meals, each of which is usually followed by a rest for digestion and, in the female for oviposition. Argasid ticks are of considerable economic and medical importance.

Ixodid ticks cause enormous losses to the meat, milk, and leather industries and transmit a remarkable variety of wild and domestic animals pathoergonts to man. It is important to known the ticks that are associated with vertebrate hosts of tick-borne diseases.

The distribution of tick-borne encephalitis in Europe shows a remarkable coincidence with that of *Ixodes ricinus* tick. The other tick species — *Haemaphysalis concinna, H. inermis, H. punctata, Ixodes hexagonus, Dermacentor marginatus, D. reticulatus* were confirmed as vectors of TBE virus, Western subtype, in certain biomes or areas. The virus multiplies in tick and is subsequently transmitted to the vertebrate host by means of infectious saliva during feeding. The virus survives in an active stage in tick instars for long periods and is transmitted interstadially. This persistence of virus in ticks is advantageous for the successful survival of TBE virus in nature during unfavourable conditions, e. g. during the winter period.

The methods by which ticks can affect their host may be summarized as follows: direct effects and transmission of disease agents. Direct effects are: toxicosis, paralysis, sensitization by allergens and „tick host anaemia" (loss of blood, exsanguination, disorder in hematopoetic system). Transmission of disease agent may be mechanical or biological. Mechanical transmission without proliferation: contaminative (e. g. tularaemia and Q fever organism in vector faeces), or direct inoculation (furunculosis from tick-bite, Anaplasma etc.). Biological development in vectors: incidental or essential, by simple proliferation (e. g. tick-borne viruses, rickettsiae and tularaemia).

Systematical part contains the keys for determination of families and genera, subgenera and the species itself. Keys are based on clear body marks, they are simple and make possible a rapid identification. For a detailed study the essential bibliography is given.

Intelligent and effective control of diseases transmitted by ticks can only be achieved on the same premises as the control of other animal-borne infections. This involves the correct diagnosis of the species concerned and the knowledge of the maintenance cycle of pathoergonts in nature (virus — vector — host relationship).

1. 1. Key to the Families and to the Developmental Stages

With scutum . . . . . Family Ixodidae
Without scutum . . . . . Family Argasidae

Family Ixodidae

1 Six legs, spiracles lacking . . . . . Larvae
— Eight legs, spiracles present 2

2 Genital aperture undeveloped, porose areas lacking . . . . Nymphs
— Genital aperture developed, porose areas present in females . Adults

Family Argasidae

1 Six legs . . . . . Larvae
— Eight legs 2
2 Genital aperture undeveloped, in large nymphs may be indicated as small, otherwise undifferentiated depression . . . . . Nymphs
— Genital aperture clearly developed . . . . . Adults

2. Ixodidae: Techniques and Terms

For collecting of ticks the following methods may be used: collecting of active ticks from vegetation by means of white woolen blanket, collecting of ticks from their hosts, and collecting of active and exoactive ticks by Carbon dioxide.

The terms used in description of tick species are: The basis capituli is the basal portion of the capitulum to which the palpi and chelicerare and hypostome are attached (Figs. 4b, 7c). The length of capitulum is measured from the middle of posterior dorsal margin of the basis capituli to the apex of the hypostome and unless, does not include the cornua, arising from the postero-lateral angles of the dorsal ridge. Auriculae arise laterally from the ventral surface of the basis capituli posterior of the insertion of the basal palpal segment.

The palps are movable, sensory organs arising antero-laterally on the basis and each is composed of four segments. Third palpal segment bears in some species, e. g. *Haemaphysalis* more or less developed spur (Fig. 17e). Ventral ridges of palpal segments 2 and 3 are equipped in some species of *Haemaphysalis* and *Rhipicephalus* with a row of pointed or broadened setae (infrainternal setae) (Fig. 16f). The palpal segment 4 bears at the apex a field of sensillae.

Hypostome, a forward extension from the anterior portion of the basis capituli represents an important morphological feature in its shape (pointed-, rounded-, spatulate-, flattened- or incised) and with denticles or crenulations. Both the denticles and crenulations are best seen under microscope after cleaning and mounting or in stereoscaine after overgolding (Figs. 17e, f). Sexual dimorphism of hypostome come into consideration.

Porose areas (areae porosae) (Fig. 2b), paired depression of the dorsum of the basis capituli in females, may be superficial, depressed in varying degree, and variable in shape and size, absent in males, nymphs and larvae.

Dorsal shield is sclerotized plate posterior the capitulum. Dorsal shield in males, dorsum occupies most of the dorsal surface except for the marginal body folds. Dorsal shield in females, nymphs and larvae, scutum (Fig. 2c) ist restricted to the anterior part oft the dorsal surface. Alloscutum (Fig. 2d) is the remainder of dorsal surface. Scutum may be circular, hexagonal, heart-shaped or oval. In some genera eyes (Fig. 2g) are present laterally or orbitally on the scutum or dorsum, in genera *Ixodes* and *Haemaphysalis* lacking. The anterior projections of the dorsal shield, the scapulae, may be rounded, pointed or reduced to small lobes. Cervial grooves (Fig. 2f) may be present as linear paired depressions or

as deep grooves extending posteriorly from the inner angles of the scapulae, and are usually continuous but in some instances interrupted. Lateral carinae are linear elevations close to the margins of the scutum anteriorly; these may be absent or present as slight eminences, gentle elevations or sharp ridges.

Spiracles: Spiracular plate (Fig. 1h) are present in the nymphs and adults. This plate may be rounded, comma-shaped and sub-oval and is located just posterior coxa IV. A more heavily sclerotized median region of the plate is called macula.

Coxa, the basal segment of the leg represents one of the most constant characters. The coxal surface may be flat or convex and the posterior margins of coxae may be either rounded or salient. Postero-external and postero-internal spurs (Figs. 1d, e) are often associated with the coxae. Spurs, if present, occur in different shape, size, position, and combinations in different species. When the inner spur is replaced by a lobe, it is still spoken of a spur. In *Haemaphysalis,* there may be a single spur near the middle of the posterior margin, and it is denoted a middle spur. The posterior margins of the coxae in some species are covered partly by an alloscutal cuticle, the syncoxae. The second proximal leg segment trochanter may bear a spur of variable pattern and size on the ventral side. The tarsus bears a sensory organ (Haller's organ) which consists of few guard setae and a sensory rod and dubble-groove with porose sensory hairs (Figs. 13f, 14c).

The anal grooves embrace the anus anteriorly and usually unite in a point or an arch, or contouring the anus behind. Postanal median groove: ventral, longitudinal groove posterior to the anus.

Ventral shields readily distinguish Ixodes males from Ixodes females and from most other male ticks. These are: a pair of posterior adanal shields bordering the median anal plate; a median shield medianly placed behind the genital opening; an anal shield posterior to the median shield and carrying the anus; pregenital shield in front of the genital aperture; paired epimeral shields, the margins of which are often indefinite, situated postero-laterally (Figs. 1f, l, o, r, s).

Festoons: *Dermacentor, Haemaphysalis, Rhipicephalus* have the postero-dorsal and postero-ventral margins divided into uniform regions by grooves, in both sexes so called festoons (Fig. 2e).

Colour: Living Ixodidae have definable colours, particularly on the basis capituli, scuta, legs and coxae, so that is possible to distinguish the species on their colour, e. g. the legs in *Ixodes ricinus* are brown-black while in *Ixodes trianguliceps* yellow-brown, etc. Ornate ticks, e. g. *Dermacentor* species have the pattern colour superimposed on the fundamental colour.

3. Classification

Integument of body hardened into a scutum which either covers the whole dorsal surface in male, or the anterior part behind the capitulum in female, nymph and larva. Coxae often with one or more spurs. Ixodidae.

Integument of body flexible, leathery and roughened, lacking differentiation into a shield. Coxal spurs always absent . . . . . Argasidae

3. 1. Key to Central European Genera of the Family Ixodidae

Males:

2 Dorsal surface covered with dorsum, porose areas usually absent.
1 Anal grooves embracing the anus anteriorly and usually uniting in a point or arch, no eyes, no festoons, venter covered by seven hardened non-salient plates . . . . . *Ixodes*
— Anal grooves embracing the anus behind uniting with postanal median groove in a calyx, festoons present 2
2 Eyes absent, dorsum inornate, palpi conical, short, venter without plates . . . . . *Haemaphysalis*
— Eyes present, dorsum variably ornate 3
3 No ventral plates or shields. Usually ornamented . . . *Dermacentor*
— Adanal shields with or without accessory adanal shields 4
4 Hypostome relatively short, spatulate, basis capituli triangular, coxa I deeply divided . . . . . *Rhipicephalus*
— Hypostome relatively long 5
5 Ornamentation absent or present, at times confined to the legs *Hyalomma*
— Anal grooves and festoons absent, basis capituli triangular dorsally *Boophilus*

Females:

Dorsal surface of idiosoma covered anteriorly with a scutum, the remainder of idiosoma softer and extensible, capitulum with two porose areas or with a single transverse porose area.

1 Anal grooves embracing the anus anteriorly and usually uniting in a point or arch, no eyes and festoons, capitulum and palps long *Ixodes*
— Anal grooves embracing the anus behind uniting with postanal median groove in a calyx, festoons present 2
— Eyes absent, scutum inornate, palpi conical, short . *Haemaphysalis*
— Eyes present, scutum ornate or inornate, palpi as wide as or wider than long 3
3 Scutum usually ornate, palpi short, broad and moderate, basis capituli rectangular dorsally . . . . . *Dermacentor*
— Scutum inornate 4
4 Hypostome relatively short, spatulate, basis capituli triangular dorsally, coxa I bifid, deeply divided . . . . . *Rhipicephalus*
— Hypostome relatively long 5
5 Ornamentation absent or present, at times confined to the legs, basis capituli subtriangular dorsally, palpi long . . . . . *Hyalomma*
— Anal groove and festoons absent, basis capituli triangular dorsally . . . *Boophilus*

4. Genus Ixodes: Generic Characters

Anal grooves embracing the anus anteriorly and usually uniting in an arch or a point. Always lacking eyes and festoons. Spiracles round or oval. Male dorsum margined by distinct body fold and the male venter with seven non salient plates: a pregenital, a median, an anal, two adanal and two epimeral. Sexual dimorphism pronounced, especially in the hypostome (rarely the hypostomes are similar).

4. 1. Key of Subgenera and Species

1 Legs inordinately long and thin. Associated with bats and their habitats . . . . . *Eschatocephalus*
— Legs of moderate length and strength 2
2 Coxae without internal spurs, coxae I—IV in male and I—II in female with posterior margins covered over with membraneous fold of cuticle (syncoxae). Large basal palpal segment inserted diagonally on the basis capituli with which is fused. This segment is strongly salient laterally. Associated with small mammals . . . . . *Exopalpiger*
— Coxae with spurs 3
3 Palpi in female long, moderately broad, rounded apically, palpi in male short, very broad, rounded apically, coxal spurs well-developed . . . *Ixodes* s. str.
— Palpi short, club-like in both sexes, coxal spurs slightly developed or absent . . . . . *Pholeoixodes*
4 Legs of normal length, although the last pair is longer than usual; associated with bats and their habitats . . . . *Pomerantzevella*

4. 1. 1. Subgenus Ixodes s. str.

Males:

1 All coxae bear one postero-external and one postero-internal spurs, auriculare slightly developed . . . . . *redikorzevi*
— Coxae II—IV without postero-internal spur 2
2 Hypostome armed, auriculae well developed (Fig. 5a) . . . *ricinus*
— Syncoxae I—II more or less developed 3
3 Coxae I—III with postero-inernal spur, syncoxae I—II slightly developed, scutum with about 100 setae . . . . . *laguri slovacicus*
— Coxae II—IV without postero-internal spur, syncoxae I—II well developed . . . . . *apronophorus*

Females:

1 Internal spur on coxa I distinct, sharp and long, tarsi tapering gradually to their apices. Hypostomal dentition from apex to base 4/4 to 3/3 and 2/2, scutum rounded, auriculae as slight ridges (Fig. 5b) *ricinus*
— Internal spur on coxa I short 2
2 Strong, tooth-like auriculae, ventral cornua as large, backwardly directed projecting which are rounded apically, trochanters lacking spurs . . . . . *apronophorus*
— Trochanters with spur 3
3 Ventral cornua vague and wide, directed postero-laterally. Auriculae are chisel-like projections directed laterally . . . . . *frontalis*
— Ventral cornua lacking, tooth-like auriculae, postero-internal spur of coxa I well-developed 4
4 Spiracular plate disc-shaped, porose areas not lying on the border of basis capituli, dorsal cornua, genital region of oval-deltoid shape *laguri slovacicus*
— Spiracular plate oval, porose areas lying on the border of basis capituli, well-developed dorsal cornua (Fig. 4c—d) . . . . *redikorzevi*

4. 1. 2. Subgenus Pholeoixodes

Males:

1 Coxae I—IV with external spurs distinctly delineated, with strong well-defined postero-internal spur on coxa I, median ventral plate about as broad as long (Fig. 6h) . . . . . *hexagonus*
— Postero-internal angle of coxa I with saliences 2
2 Median plate relatively narrow, basis capituli subrectangular dorsally . . . . . *canisuga*
— Median plate relatively broad 3
3 Basis capituli subtriangular dorsally . . . . . *lividus*
— Median ventral plate much longer than broad 4
4 Postero-internal angle of coxa I lacking salience, hypostome longer and narrower with few large crenulations, anal grooves divergent, reaching posterior margin. Cornua generally absent, or indicated by point postero-lateral extensions. Coxa I not triangular (Fig. 9a) . . . *arboricola*
— All coxae bear short postero-external spur, trochanter with spur . . . *caledonicus*

Females:

1 External spur on coxa I rudimentary. Auriculae represented at best by slight elevations. Hypostomal dentition from apex to base 3/3 to 2/2, tip of hypostome rounded. Scutum hexagonal, tarsi humped apically, associated prevalently with Carnivora (Figs. 6a, b, c, g) *hexagonus*
— Postero-internal angle of coxa I bluntly angled 2
2 Tip of hypostome flattened or weakly concave 3
— Tip of hypostome rounded. Associated with Carnivora (Figs. 7a, b, c) . . . *canisuga*
3 Field lateral to cervical grooves of scutum characterized by strong longitudinal undulations which at or just behind mid-length become irregularly arranged. Associated with sand martins and their nests . . . *lividus*
— Postero-internal angle of coxa I broadly angled 4
4 Tip of hypostome rounded. Associated with birds other than sand martins and their nests in tree-cavities (Fig. 9b) . . . . . *arboricola*
— Palpi strongly concave on outer margins. Hypostomal dentition 2/2 for almost the entire length. Coxae II—III with posterior-internal edges as marginal saliences at best . . . . . *caledonicus*

4. 1. 3. Subgenus Exopalpiger

1 Coxae I—IV with posterior margins covered over with folds of cuticle (Fig. 10a) . . . . . ♂ *trianguliceps*
— Coxae I—II with posterior margins covered over with folds of cuticle . . . ♀ *trianguliceps*

4. 1. 4. Subgenus Eschatocephalus

Both sexes are unique in the extreme elongation of the legs. The long anal grooves of both sexes are open.

1 Anal grooves slightly converge posteriorly, scutum has a few large punctations in three rows and numerous fine, scattered punctations. Coxa IV without a group of spiniform setae . . . . ♂ *vespertilionis*
— Anal grooves are parallel, scutum has numerous small, shallow punctations (Fig. 11a—e) . . . . . ♀ *vespertilionis*

4.1.5. Subgenus Pomerantzevella

1 Coxa IV bears postero-laterally a group of 13—14 long spiniform setae . . . . . ♂ *simplex*
— Anal grooves are short and divergent. Scutum has widely scattered, subequal punctations, basis capituli is triangular, without cornua and auriculae, coxae are flat and without spurs . . . . . ♀ *simplex*

5. Genus Dermacentor: Generic Characters

Usually ornate; anal grooves contouring the anus behind. Basis capituli broader than long, rectangular dorsally. Palpi short, thick, of moderate width, with an elevated postero-dorsal eminence on the proximal part of segment 2; segment 1 immovably attached with segment 2. Hypostome spatulate or subparallel, usually with three rows of denticles or either side of the median line. Eyes usually present. Spiracles suboval or comma-shaped. Ventral plates lacking in males. Festoons eleven in number on postero-dorsal margin. All coxae with external spur. Coxa I bidentate in both sexes and these spurs are much larger and stronger than those on coxa II—IV. Characteristic generic marks are strongly developed coxae IV in male.

5.1. Key of Subgenera and Species

Subgenera

1 Fissure on coxa I not reaching to the middle of coxa . . *Dermacentor*
— Fissure on coxa I by-passing the middle of coxa . . *Dermacentorites*

Species

Males:

1 Palpal segment 2 strongly protuberant, almost angular; slightly broader than long with strong dorso-lateral retrograde spur. Spur on coxa I long and not very dissimilar, external spur shorter than internal spur, separated by a narrow parallel fissure (Figs. 12a, e) *reticulatus*
— Palpal segment 2 with weakly developed dorso-lateral spur (Figs. 13a, e, f) . . . . . *marginatus*

Females:

1 Genital opening lacks wing-like outgrowths (genital alae) (Figs. 12b, e) . . . *reticulatus*
— Genital opening with wing-like outgrowths (Fig. 13b) . *marginatus*

6. Genus Rhipicephalus: Generic Characters

Anal grooves embracing the anus posteriorly. Usually inornate, with eyes and festoons. Males with adanal shields and usually a pair of accessoric shields. Basis capituli triangular, palpi short articulation between 1 and 2 movable, between 2 and 3 slightly movable. Coxa I bifid, deeply divided. Spiracular plate in female oval, in male commashaped.

6. 1. Key of Subgenera and Species

1 Infrainternal setae of 1 and 2 palpal segments thin and well-spaced . . . *Rhipicephalus (Digineus) bursa* ♂♀
— Infrainternal setae of 1 and 2 palpal segments strong with apex serrated and arranged closely each other 2
2 Internal tooth of adanal shield absent in male, spiracular plate in female with narrow dorsal growth (Figs. 14a, b, c, d) . . . . . *Rhipicephalus (Rhipicephalus) sanguineus*
— Internal tooth of adanal shield present in male, spiracular plate in female with slightly developed growth . . . . . *Rhipicephalus (Rhipicephalus) turanicus*

7. Genus Boophilus: Generic Characters

Anal grooves absent. Inornate, with eyes but without festoons. Basis capituli triangular, palpi short, all palpal articulations movable. Adanal and accessoric shields present. Spiracular plate oval or subcircular. Coxae with spurs.

1 Basis capituli triangular with cornua. Coxae I—III with rudimentary tooth, coxae IV without tooth ♂ *Boophilus (Boophilus) calcaratus*
— Basis capituli triangular without cornua. Coxae I—IV with rudimentary teeth . . . . . ♀ *Boophilus (Boophilus) calcaratus*

8. Genus Haemaphysalis: Generic Characters

Anal grooves embrace the anus posteriorly forming with postanal median groove a calyx. Scutum inornate, lacking eyes and in the females lacking lateral grooves. On the posterior body margin there are festoons, usually eleven in number. Coxa I never bifid. Basis capituli subrectangular. Palpi are, with few exceptions, short, conical and wide, projecting laterally beyond the basis, and frequently equipped with varied projections and spurs. Sexual dimorphism slight.

8. 1. Key of Subgenera and Species

1 Laterally projecting basis capituli, elongate palpi without palpal spur in all stages . . . . . *Alloceraea*
— Basis capituli rectangular, palpi basolaterally salient, palpal spur present 2
2 Palpal segments 2 and 3 with a row of broadened infrainternal setae . . . . . *Aboimisalis*
— Palpal segments 2 and 3 with a few pointed setae . . *Haemaphysalis*

8. 1. 1. Subgenus Alloceraea

1 Dorsal cornua lacking, dorsum oval, spiracular plate comma-shaped (Figs. 15a, h) . . . . . ♂ *inermis*
— Scutum broder than long with maximal width in the middle of its length, spiracular plate irregularly rounded (Figs. 15b, e, f, g) ♀ *inermis*

8. 1. 2. Subgenus Haemaphysalis

1 Dorsal cornua relatively long and sharp. Apex of third palpal segment elongate and curved, overlaping of apexes, spiracular plate elongate (Fig. 17a) . . . . . ♂ *coninna*
— Dorsal cornua well-developed, blunt; scutum circular slightly broader than long, spiracular plate irregularly rounded (Figs. 17b, e, f, g, h) . . . ♀ *concinna*

8. 1. 3. Subgenus Aboimisalis

Males:

1 Dorsal cornua blunt, coxae I—III with small blunt teeth, coxa IV with long and sharp tooth of equal length as coxa and directed medially (Figs. 16a, f) . . . . . *punctata*
— Dorsal cornua long and sharp, coxa IV with long and sharp tooth which is shorter than coxa and directed laterally . . . . *sulcata*
2 Dorsal cornua short and broad. Coxae I—IV with small blunt teeth . . . *otophila*

Females:

1 Dorsal cornua absent, scutum heart-shaped. Coxal spur IVa little stronger than spurs oft the coxae I—III (Figs. 16b, e, g) . . *punctata*
— Dorsal cornua absent, scutum circular. Coxae I—IV with slightly developed teeth . . . . . *sulcata*
2 Dorsal cornua short and broad, scutum heart-shaped, as long as broad. Coxae I—IV with small blunt teeth . . . . . *otophila*

9. Genus Hyalomma: Generic Characters

Email pigmentation is fould in many representatives and, where it occurs, it may be found in circular or longitudinal stripes on the leg segments. Eyes either spherical or orbital, distinctive or vaguely defined. Festoons eleven in number present or lacking or may be partially coalesced. Coxa I bifid, dorsal spur on trochanter I small. Spiracles comma-shaped. Palpi generally long, segment 2 less than twice as long as segment 3, the basal segment ventrally in form of a hexagonal plate. Males have 2—4 pairs of anal shields, 1 pair of adanals, 1 pair of accessory and 1—2 pairs of subanals (subanal shields may be absent). Only one species makes its appearance sometimes in Central Europe and this is introduced on tortois.

Hyalomma (Hyalommasta) aegyptium

1 Coxae I small, bifid, external spur of coxa I short, slightly curved to the outside. Spiracle plate comma-shaped, dorsum strongly convex, blackish-brown colour . . . . . ♂ *aegyptium*

— Coxae I small, bifid with a short spur that is concave towards the outside. Scutum ovalo-rhomboid in outline. Porose areas small, and separated from one another by their diameter. Spiracle plate comma-shaped. Reddish to blackish-brown in colour. Base colour of leg segments a blackish, tan with pale bands distally on most segments and around the middle of the tarsus . . . . . ♀ *aegyptium*

10. Keys for Determination of Nymphs and Larvae

Genera Ixodes, Haemaphysalis and Dermacentor

Key to the Nymphs:

1 Anal grooves embracing the anus anteriorly . . . . . *Ixodes* (2)
— Anal grooves embracing the anus posteriorly 13
2 Coxae I and II with posterior margins covered with folds of cuticle, scutum without cervical grooves (Fig. 10b) . . . . . *triangulicep*s
— Coxae I and II with posterior margins not covered with folds of cuticle . . . 3
3 With legs of moderate length 4
— With legs inordinately long and thin 12
4 External spurs on coxae present 5
— External spurs vestigial or absent on all coxae 10
5 Scutum nearly circular with cervical and lateral grooves 6
— Scutum not circular without lateral grooves 9
6 Basis capituli about as long as broad, cornua distinctive, auriculae rectangular, alloscutal setae 2.5—3 times longer than scutal setae, hypostomal dentition 3/3 (Fig. 5c) . . . . . *ricinus*
— Basis capituli much broader than long, cornua as vague lateral extensions of the basis . . . . . *frontalis*
7 Coxae I—III with internal spurs, alloscutal setae distinctive longer than scutal one (Fig. 4a) . . . . . *redikorzevi*
— Coxae I—III with internal spurs, alloscutal setae distinctive longer than scutal one, hypostomal dentition 2/2, auriculae blunt . . . . . *laguri slovacicus*
8 Scutum widest in front of the middle, alloscutal setae of the same length as scutal setae or a little longer, auriculae acut-angled, coxae I—III with postero-internal spur, hypostomal dentition 3/3 . . . . . *apronophorus*
— Scutum widest at or near mid-length 9
9 Auriculae lacking, cornua if present as a short points, coxa I with postero-internal short spur, coxae I—IV with small and broad postero-external spur (Fig. 6d) . . . . . *hexagonus*
— Auriculae as broad lateral spurs; dorsal cornua long and sharp . . . . . *caledonicus*
10 Hypostomal apex flattened or slightly indented. All coxae without spurs, associated with sand martins and their nests (Fig. 8b) *lividus*
— Hypostomal apex rounded, coxae without spurs 11
11 Anal grooves discontinous in front . . . . . *canisuga*
— Anal grooves in the front of a gothic arch, associated with birds other than sand martins (Fig. 9d) . . . . . *arboricola*

12 Extreme elongation of legs, coxae without spurs . . . *vespertilionis*
— Coxae postero-internally salient, legs of moderate length . . *simplex*
13 Eyes absent . . . . . *Haemaphysalis* (14)
— Eyes present . . . . . *Dermacentor* (17)
14 Palpi oval rounded at apex (Fig. 15c) . . . . . *inermis*
— Palpi conical, basosalient, coxae with spurs, dorsal cornua present (Fig. 17c) . . . . . *concinna*
15 Palpi conical, dorsal cornua absent, but ventral cornua present, coxae with spurs (Fig. 16c) . . . . . *punctata*
— Palpi conical or strongly basosalient, ventral cornua absent . . . 16
16 Coxae without spurs, palpal segment 2 without caudal spur . *sulcata*
— All coxae with spurs, palpal segment 2 with caudal spur . . *otophila*
17 The second palpal segment about half as long again as that of third when viewed ventrally. On the scutum less than 40 short setae (Fig. 13c) . . . *marginatus*
— The second palpal segment only a little longer than third. Scutum with more than 40 long setae (Fig. 12c) . . . . . *reticulatus*

Key to the Larvae:

1 Anal grooves embracing the anus posteriorly 2
— Anal grooves embracing the anus anteriorly . . . . . *Ixodes* (7)
2 Eyes present . . . . . *Dermacentor* (3)
— Eyes lacking . . . . . *Haemaphysalis* (4)
3 Palpi with dermal sensilla dorsally (Fig. 13d) . . . . *marginatus*
— Palpi without dermal sensilla (Fig. 12d) . . . . . *reticulatus*
4 Body circular, palpi oval, scutum broder than long, festoons distinct (Fig. 15d) . . . . . *inermis*
— Body oval, palpi conical, basosalient, scutum broader than long, coxae with spurs, festoons distinct (Fig. 17d) . . . . . *concinna*
5 Body triangular, palpi conical, scutum broad as long or slightly broader, coxae with spurs (Fig. 16d) . . . . . *punctata*
— Scutum broader than long, coxae with spurs . . . . . (6)
6 Body oval, palpi conical, palpal segment 2 without caudal spur . . . . . *sulcata*
— Body oval, palpi conical, palpal segment 2 with caudal spur . . . . . *otophila*
7 Scutum without cervical grooves, lacking postero-internal and external spurs, palpal segment 1 drawn out strongly antero-mesially (Fig. 10c) . . . . . *trianguliceps*
— Palpal segment 1 not drawn out antero-mesially, legs very long, coxae without spurs . . . . . *vespertilionis*
8 Coxa I postero-internally salient . . . . . *simplex*
— Legs of moderate length . . . . . (9)
9 Scutum ovate or with greatest width at or about mid-length . . 10
— Scutum with greatest width distinctly in front of mid-length . . 13
10 Coxa I with postero-external and internal spurs, coxae I—III with distinct external spur, dorsal ridges extended postero-laterally into broad tapered cornua, in front of constriction strong subtriagular and spur-like auriculae, alloscutal setae twice longer than scutal setae, hypostomal dentition 3/3 (Figs. 5d) . . . . . *ricinus*

— Distinct well defined auricular lobes with rounded apices . . . . . *frontalis*

11 Coxa I with postero-external and internal spurs, auriculae acutor rectangular, alloscutal setae 2—2.5 times longer than scutal setae, hypostomal dentition 2/2 (Fig. 4 b) . . . . . *redikorzevi*

— Alloscutal setae of the same length as scutal setae or a little longer, auriculae acut-angled, hypostomal dentition 3/3 . . *apronophorus*

12 Hypostomal dentition 2/2, alloscutal setae 1.5 times longer than scutal one . . . . . *laguri slovacicus*

— Lacking external and internal spurs on all coxae 14

13 Lacking external spur on all coxae but with internal spur (or tuberosity) on coxa I (Fig. 6e) . . . . . *hexagonus*

— Apex of hypostome rounded, palpi club-like, all spurs lacking . . . . . *canisuga*

14 Palpi with lateral margins straight, mesial borders convex, apex of hypostome rounded (associated with birds other than sand martins) (Fig. 9c) . . . . . *arboricola*

— Apex of hypostome indented (associated with sand martins and their nests) (Fig. 8a) . . . . . *lividus*

11. Argasidae: Techniques and Terms

Argasid ticks in general are xerophilic animals and can tolerate the most extreme arid niches. Examination of bird nests, interstices in the walls of bat infested caves and building, bat roots, animal lairs, burrows, rodent nests, or examination of rock interstices and searching under stones and under dry bark of trees near fowl and pigeon houses, and in fowl and pigeon habitations are important for collecting of argasid ticks. Sifting of soil or sand in animal burrows, caves or dens is often most fruitful.

The terms used in description of argasid ticks are: The discs are defined spots or areas of the integument which mark the insertion of dorso-ventral somatic muscles. They are arranged symetrically on the dorsal surface but may be lacking from the ventral surface. The discs may be superficial, depressed, faint or distinct. The integument may also bear irregular elevations or wrinkles in Argas or mammillae in Ornithodorus (Fig. 21a). The longitudinal depressions or furrows mainly on the ventral surface of body are called grooves, while the constant ridges of ventral surface are the folds. The sutural line separates the dorsal from ventral surfaces.

Capitulum is situated in a depression — camerostome. The paired flaps at the sides of the camerostome constitute the cheeks which may either fixed or movable, whilst the hood is the anterior projection of the integument in part the walls of the camerostome, if present (Fig. 3).

Two palpal hairs on the basis capituli are of significance: Posthypostomal hairs and postpalpal hairs. Postpalpal hairs, however, may be small or absent and serve to differntiation the sexes. Spiracular plates are small, situated lateral to coxa IV.

Legs. Humps, other than the subapical dorsal protuberances are

referred as dorsal humps. Bottle-shaped sensilla is the external sensilla of Haller's organ (Fig. 21c). Dorsal plate is a circular or oval squamous area present on dorsal integument in larvae of Argas.

12. Genus Argas: Generic Characters

Definite sutural line separating dorsal and ventral surfaces. Periphery of body flattened and structurally different from dorsum. Spiracular plate small, anterior of coxa IV.

12. 1. Key of Subgenera and Species

1 Outline of body circular or subcircular, tarsal protuberances lacking, mouthparts near anterior body margin . . . . . *Carios*
— Outline of body elongate, dorsal protuberances present 2
2 Peripheral integument closely striated, Haller's organ with bottle-shaped sensilla . . . . . *Argas*
— Peripheral integument of rectangular cells, Haller's organ without bottle shaped sensilla . . . . . *Persicargas*

Key to Adults and Nymphs of Late Stage:

12. 1. 1. Subgenus Persicargas

Dorsal and ventral periphery of distinct quadrangular cells, equal in size, each with a large seta-bearing pit. Postpalpal hairs present. Associated with fowl (Fig. 18a—b) . . . . . *persicus*

12. 1. 2. Subgenus Argas

Dorsal and ventral periphery finely wrinked, peripheral cells unequal in size. Palpi extending beyond hypostome by length of segment 4; postpalpal hairs very small in female, absent in male. Associated with pigeons (Fig. 19a—c) . . . . . *reflexus*

12. 1. 3. Subgenus Carios

Peripheral integument striated, peripheral cells about equal in size. Body outline generally subcircular or circular. Palpi extending beyond hypostome by length of segments 3 and 4. Postpalpal hairs of moderate length in both sexes. Associated with bats (Fig. 20) . . . *vespertilionis*

Key to the Larvae:

1 Palpal segment 1 and 4 short, 2 and 3 longer and subequal . . . . . *vespertilionis*
— Palpal segments 1—3 subequal in length, 4 longer than the others . . . 2
2 Haller's organ with bottle-shaped sensilla, dorsal body setae long, dorsal plate elongate . . . . . *reflexus*
— Haller's organ without bottle-shaped sensilla, dorsal body setae short, dorsal plate rounded . . . . . *persicus*

13. List of hosts

Tick Species / *Host Species* (L = Larva, N = Nymph, I = Imago)	*Ixodes ricinus*	*Ixodes apronophorus*	*Ixodes redikorzevi*	*Ixodes laguri slovacicus*	*Ixodes frontalis*	*Ixodes hexagonus*	*Ixodes canisuga*	*Ixodes arboricola*	*Ixodes lividus*	*Ixodes trianguliceps*	*Ixodes vespertilionis*	*Haemaphysalis inermis*	*Haemaphysalis punctata*	*Haemaphysalis concinna*	*Dermacentor marginatus*	*Dermacentor reticulatus*
Lacerta agilis	*LN*											*LN*	*LN*	*LN*		
Lacerta muralis	*LN*															
Lacerta viridis	*LN*											*LN*	*LN*	*LN*		
Lacerta vivipara	*LN*															
Coronella austriaca	*L*															
Anser anser	*N*															
Anas platyrhynchos														*N*		
Accipiter nisus	*LN*															
Buteo buteo	*N*															
Falco tinnunculus	*N*															
Tetrao urogallus	*LN*															
Lyrurus tetrix	*LN*															
Perdix perdix	*N*											*L*	*LN*			

Coturnix coturnix	*LN*																
Phasianus colchicus	*LNI*													*LNI*	*LN*		
Gallus domesticus	*NI*																
Crex crex														*LN*			
Fulica atra	*N*																
Vanellus vanellus	*N*														*N*		
Scolopax rusticola	*LN*																
Capella gallinago	*N*																
Streptopelia decaocto	*LN*																
Asio otus	*N*																
Upupa epops	*N*														*L*		
Picus viridis	*N*																
Dendrocopus major	*LN*							*LNI*									
Dendrocopus medius	*LN*																
Jynx torquilla	*LN*																
Muscicapa striata	*N*				*LI*			*L*				*L*	*LN*				
Ficedula albicollis	*LN*							*LNI*									
Ficedula hypoleuca	*LN*							*I*									
Sylvia nisoria	*LN*														*LN*		
Sylvia borin	*LN*																
Sylvia atricapilla	*LN*																
Sylvia communis	*LN*				*LN*									*N*			

Tick Species / Host Species (L = Larva, N = Nymph, I = Imago)	Ixodes ricinus	Ixodes apronophorus	Ixodes redikorzevi	Ixodes laguri slovacicus	Ixodes frontalis	Ixodes hexagonus	Ixodes canisuga	Ixodes arboricola	Ixodes lividus	Ixodes trianguliceps	Ixodes vespertilionis	Haemaphysalis inermis	Haemaphysalis punctata	Haemaphysalis concinna	Dermacentor marginatus	Dermacentor reticulatus
Sylvia curruca	N				LN											
Hippolais icterina	LN															
Phylloscopus collybita	N															
Phylloscopus trochilus	LN				LN							L	LN			
Phylloscopus sibilatrix	LN															
Locustella fluviatilis	LN													LN		
Acrocephalus arundinaceus	N															
Acrocephalus scirpaceus	LN															
Acrocephalus schoenobaenus	N															
Lusciniola melanopogon														N		
Turdus pilaris	N															
Turdus viscivorus	N												N	L		
Turdus philomelos	LN													LN		
Turdus iliacus	N															

Merula merula	LN				LNI								LN	LN		
Saxicola rubetra	N				L											
Oenanthe oenanthe	N															
Erithaceus rubecula	LN													L		
Luscinia luscinia	LN				L								LN			
Luscinia megarhynchos	LN				L									LN		
Phoenicurus phoenicurus	LN				LN			LNI					N			
Phoenicurus ochruros								LNI								
Prunella modularis	LN															
Troglodytes troglodytes	LN															
Monticola solitarius	·												L			
Lanius collurio	LN													LN		
Parus major	LN				LNI			LN						LN		
Parus coeruleus	LN							LNI						L		
Parus ater	L							LNI								
Parus cristatus	N							LNI								
Parus palustris	LN							LNI								
Parus montanus	N							LNI								
Sitta europaea	LN							LNI						LN		
Certhia familiaris	LN							LN								
Riparia riparia									LNI							
Coccothraustes coccothraustes	LN													LN		
Chloris chloris	N															

Tick Species: L = Larva, N = Nymph, I = Imago

Host Species \ Tick Species	*Ixodes ricinus*	*Ixodes apronophorus*	*Ixodes redikorzevi*	*Ixodes laguri slovacicus*	*Ixodes frontalis*	*Ixodes hexagonus*	*Ixodes canisuga*	*Ixodes arboricola*	*Ixodes lividus*	*Ixodes trianguliceps*	*Ixodes vespertilionis*	*Haemaphysalis inermis*	*Haemaphysalis punctata*	*Haemaphysalis concinna*	*Dermacentor marginatus*	*Dermacentor reticulatus*
Carduelis carduelis	LN															
Spinus spinus	N															
Linaria cannabina	N															
Serinus canaria	N															
Fringilla coelebs	LN													LN		
Fringilla montifringilla	N															
Pyrrhula pyrrhula	N															
Emberiza calandra	N												LN			
Emberiza citrinella	LN												L	LN		
Emberiza hortulana	N															
Passer domesticus	LN				I			LNI								
Passer montanus	LN							LNI					LN			
Aegithalos caudatus	L															
Galerida cristata													LN			

Alauda arvensis	*LN*													*LN*			
Anthus trivialis	*LN*													*LN*	*LN*		
Anthus pratensis	*N*																
Motacilla flava	*LN*																
Motacilla alba	*LN*																
Sturnus vulgaris	*LN*							*LI*						*LN*	*LN*		
Oriolus oriolus															*LN*		
Corone cornix	*LN*																
Corvus frugilegus	*N*																
Coloeus monedula	*LN*																
Pica pica	*LN*													*L*			
Garrulus glandarius	*LN*														*LN*		*N*
Rhinolophus ferrum equinum											*LNI*						
Rhinolophus euryale											*LNI*						
Rhinolophus hipposideros											*LNI*						
Myotis myotis											*LNI*						
Myotis oxygnathus											*LNI*						
Myotis daubentoni											*LNI*						
Miniopterus schreibersii											*LNI*						
Plecotus auritus											*LNI*						
Erinaceus europaeus	*LNI*					*LNI*									*LNI*		
Erinaceus roumanicus	*LNI*					*LNI*							*NI*	*LNI*	*LNI*	*LNI*	*LNI*
Talpa europaea	*LN*									*LN*		*LN*	*L*		*LN*	*L*	*LN*

Tick Species / Host Species (L = Larva, N = Nymph, I = Imago)	*Ixodes ricinus*	*Ixodes apronophorus*	*Ixodes redikorzevi*	*Ixodes laguri slovacicus*	*Ixodes frontalis*	*Ixodes hexagonus*	*Ixodes canisuga*	*Ixodes arboricola*	*Ixodes lividus*	*Ixodes trianguliceps*	*Ixodes vespertilionis*	*Haemaphysalis inermis*	*Haemaphysalis punctata*	*Haemaphysalis concinna*	*Dermacentor marginatus*	*Dermacentor reticulatus*
Sorex araneus	LN									LN		LN		LN	LN	LN
Sorex minutus	LN									LN				N		L
Sorex alpinus	LN									LN						
Neomys fodiens	LN									LN						L
Neomys anomalus	LN	L								L						
Crocidura leucodon	LN														LN	
Crocidura suaveolens	LN									LN					LN	
Lepus europaeus	LNI											NI	LNI	LNI	LN	LNI
Oryctolagus cuniculus	LNI												LNI	LNI	LN	LNI
Sciurus vulgaris	LNI												LN	LN		
Citellus citellus	LN		LNI	LNI									N	L	LN	
Glis glis	LNI											N				
Eliomys quercinus	LN												L		LN	
Dryomys nitedula	LN												N		LN	

Muscardinus avellanarius	*LN*											*LN*			*LN*	
Mus musculus	*LN*															
Micromys minutus	*LN*													*L*		
Apodemus agrarius	*LN*									*LNI*					*LN*	*LN*
Apodemus flavicollis	*LN*	*L*								*LNI*		*LN*	*LN*	*LN*	*LN*	*LN*
Apodemus sylvaticus	*LN*									*LNI*		*LN*	*LN*	*LN*	*LN*	*LN*
Apodemus microps	*LN*														*LN*	
Rattus norvegicus	*L*															
Cricetus cricetus	*LNI*		*LNI*													
Clethrionomys glareoulus	*LN*	*L*								*LNI*		*LN*	*LN*	*LN*	*LN*	*LN*
Arvicola terrestris	*LN*	*LNI*								*LNI*				*LN*		*N*
Microtus arvalis	*LN*	*LNI*								*LNI*		*LN*	*LN*	*LN*	*LN*	*LN*
Microtus agrestis	*LN*	*I*								*LNI*						
Chionomys nivalis	*LN*									*LN*						
Microtus oeconomus														*LN*		*LN*
Pitymys subterraneus	*LN*									*LN*		*LN*				
Pitymys tatricus	*LN*									*LN*						
Felis silvestris silvestris	*LNI*					*I*						*N*			*L*	
Felis silvestris f. catus	*LNI*					*I*										
Canis familiaris	*LNI*					*I*						*NI*	*NI*	*I*	*LNI*	*NI*
Vulpes vulpes	*LNI*					*LNI*	*LNI*					*NI*	*NI*	*NI*	*I*	*I*
Martes martes	*LNI*													*LN*		
Mustela erminea	*LNI*					*LNI*								*N*	*N*	*N*

Tick Species / Host Species (L = Larva, N = Nymph, I = Imago)	*Ixodes ricinus*	*Ixodes apronophorus*	*Ixodes redikorzevi*	*Ixodes laguri slovacicus*	*Ixodes frontalis*	*Ixodes hexagonus*	*Ixodes canisuga*	*Ixodes arboricola*	*Ixodes lividus*	*Ixodes trianguliceps*	*Ixodes vespertilionis*	*Haemaphysalis inermis*	*Haemaphysalis punctata*	*Haemaphysalis concinna*	*Dermacentor marginatus*	*Dermacentor reticulatus*
Mustela nivalis	*LNI*					*LNI*										*N*
Putorius putorius	*LNI*					*LNI*							*N*			
Putorius eversmannii	*LNI*					*LNI*							*N*		*LN*	
Meles meles	*LNI*					*LNI*	*I*						*N*	*I*		
Equus caballus	*NI*											*I*	*NI*		*I*	*I*
Sus scrofa	*LNI*											*LNI*	*I*		*I*	*I*
Cervus elaphus	*LNI*											*NI*	*NI*	*NI*	*NI*	*NI*
Dama dama	*LNI*											*I*	*I*		*I*	*I*
Capreolus capreolus	*LNI*											*I*	*I*	*NI*	*NI*	*NI*
Bos taurus	*LNI*											*NI*	*NI*	*I*	*I*	*I*
Rupicapra rupicapra	*LNI*															
Capra hircus	*LNI*											*NI*	*NI*	*I*	*NI*	*NI*
Ovis musimon	*LNI*													*I*	*I*	
Ovis aries	*LNI*											*NI*	*NI*	*I*	*I*	*I*

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15. Explanation to the figures

Fig. 1: *Ixodes ricinus* ventral view of male: a, segment 4 of palp; b, hypostome; c, ventral surface of basis; d, external spur of coxa; e, internal spur of coxa; f, pregenital plate; g, macula of spiracle; h, spiracul plate; i, coxa; j, trochanter; k, femur; l, genital aperture; m, tibia; n, metatarsus; o, adanal plate; p, tarsus; q, anus; r, anal plate; s, median plate; t, anal groove; u, chelicerae; v, crenulation of hypostome; y, Haller's organ.

Fig. 2: *Dermacentor reticulatus* dorsal view of female: a, palp; b, porose areas; c, scutum; d, alloscutum; e, festoons; f, cervical groove of scutum; g, eye.

Fig. 3: *Argas reflexus* ventral view: a, capitulum; b, genital region of female; c, marginal integument; d, camerostome; e, tarsus.

Fig. 4: *Ixodes redikorzevi:* a, nymph; b, larva; c, female; d, capitulum ventrally, ♀ (100 ×).

Fig. 5: *Ixodes ricinus:* a, male and b female dorsally; c, nymph; d, larva ventrally.

Fig. 6: *Ixodes hexagonus:* a, female dorsally and b ventrally; c, engorged female; d, nymph; e, larva; f, male; g, Haller's organ, ♀ (450 ×); h, Haller's organ, ♀ (950 ×).

Fig. 7: *Ixodes canisuga:* a, female ventrally; b, Haller's organ, ♀ (1050 ×); c, capitulum dorsally, ♀ (120 ×).

Fig. 8: *Ixodes lividus:* a, larva; b, nymph.

Fig. 9: *Ixodes arboricola:* a, male; b, female; c, larva; d, nymph.

Fig. 10: *Ixodes trianguliceps:* a, male; b, nymph; c, larva.

Fig. 11: *Ixodes vespertilionis:* a, engorged female on bat; b, female dorsally; c, scutum; d, coxa; e, capitulum, palps and hypostome.

Fig. 12: *Dermacentor reticulatus:* a, male and b, female dorsally; c, nymph; d, larva; e, male and female on leaf of *Carex hirta.*

Fig. 13: *Dermacentor marginatus:* a, male and b, female dorsally; c, nymph; d, larva; e, palps and hypostome ventrally, ♂ (112 ×); f, Haller's organ, ♂ (270 ×).

Fig. 14: *Rhipicephalus sanguineus:* a, palps and hypostome ventrally, ♀ (180 ×); b, Haller's organ, ♂ (1350 ×); c, Sensory cone of Haller's organ, ♂ (4700 ×); d, Haller's organ, ♂ (475 ×).

Fig. 15: *Haemaphysalis inermis:* a, male and b, female dorsally; c, nymph; d, larva; e, palps and hypostome, ♀ (520 ×); f, hypostomal dentition, ♀ (460 ×); g, sensory rods of palpal segment 4, ♀ (1050 ×); h, Haller's organ, ♀ (920 ×).

Fig. 16: *Haemaphysalis punctata:* a, male and b, female dorsally; c, nymph; d, larva; e, palps and hypostome ventrally, ♀ (175 ×); f, palps and hypostome ventrally, ♂ (165 ×); g, Haller's organ, ♂ (1050 ×).

Fig. 17: *Haemaphysalis concinna:* a, male and b, female dorsally; c, nymph; d, larva; e, palps and hypostome, ♀ (175 ×); f, hypostomal dentition, ♀ (850 ×); g, sensory rods of palpal segment 4, ♀ (1400 ×); h, Haller's organ, ♀ (850 ×).

Fig. 18: *Argas persicus:* a, adults in wood crevice; b, adult stage.

Fig. 19: *Argas reflexus:* a, Haller's organ, ♀ (1650 ×); b, nymph; c, adult stage.

Fig. 20: *Argas vespertilionis:* male.

Fig. 21: *Ornithodorus papillipes, female:* a, surface of integument on the ventral side near hypostome, ♀ (1100 ×); b, capsule of Haller's organ, ♀ (1750 ×); c, sensillae of Haller's organ, ♀ (1900 ×).

Fig. 5b: *Ixodes ricinus* ♀

Fig. 6a: *Ixodes hexagonus* ♀

Fig. 6b: *Ixodes hexagonus* ♀

Fig. 5a: *Ixodes ricinus* ♂

Fig. 6c: *Ixodes hexagonus* ♀

Fig. 6f: *Ixodes hexagonus* ♂

Fig. 12a: *Dermacentor reticulatus* ♂

Fig. 12b: *Dermacentor reticulatus* ♀

Fig. 12e: *Dermacentor reticulatus* ♀ & ♂

Fig. 13b: *Dermacentor marginatus* ♀

Fig. 13a: *Dermacentor marginatus* ♂

Fig. 19c: *Argas reflexus*, adult stage

Fig. 17b: *Haemaphysalis concinna* ♀

Fig. 15b: *Haemaphysalis inermis* ♀

Fig. 16b: *Haemaphysalis punctata* ♀

Fig. 17a: *Haemaphysalis concinna* ♂

Fig. 15a: *Haemaphysalis inermis* ♂

Fig. 16a: *Haemaphysalis punctata* ♂

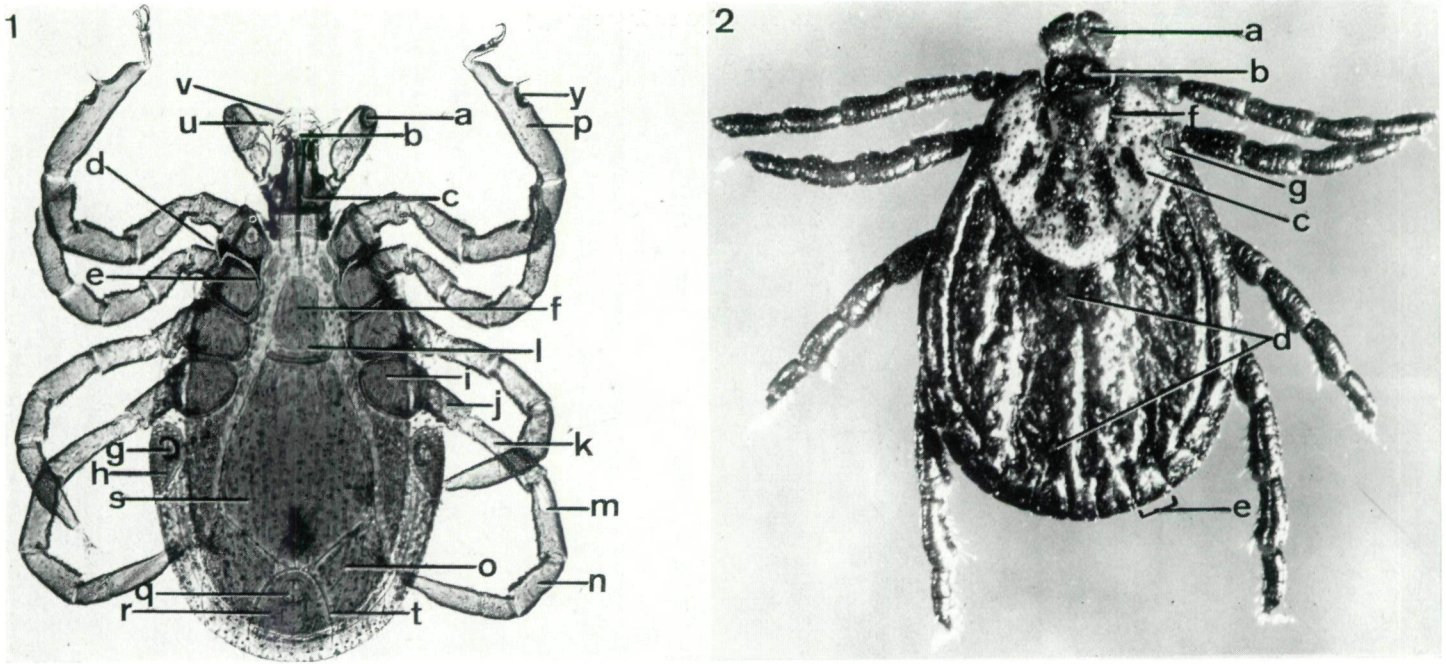


Plate III

Fig. 1: *Ixodes ricinus* ♂

Fig. 2: *Dermacentor reticulatus* ♀

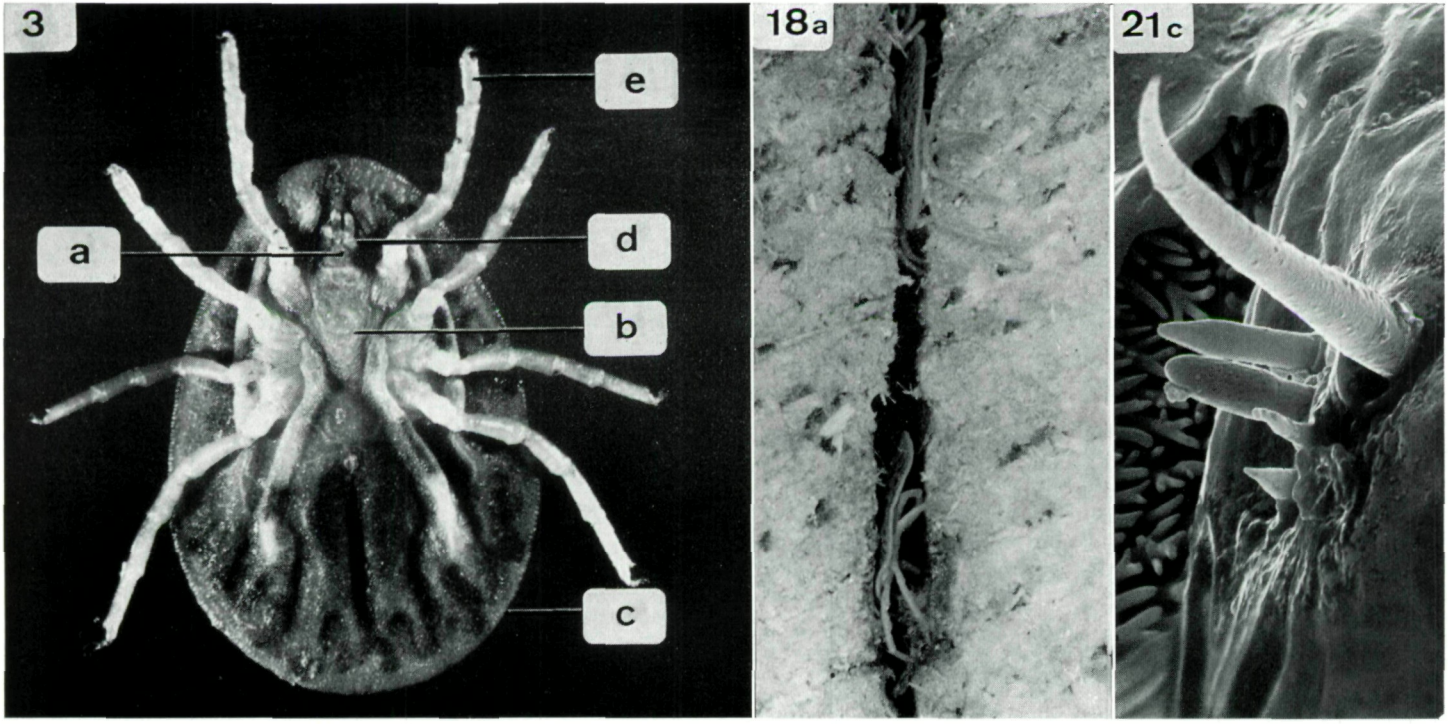


Plate IV

Fig. 3: *Argas reflexus*, adult stage

Fig. 18a: *Argas persicus*

Fig. 21c: *Ornithodorus papillipes*, Haller's organ of ♀

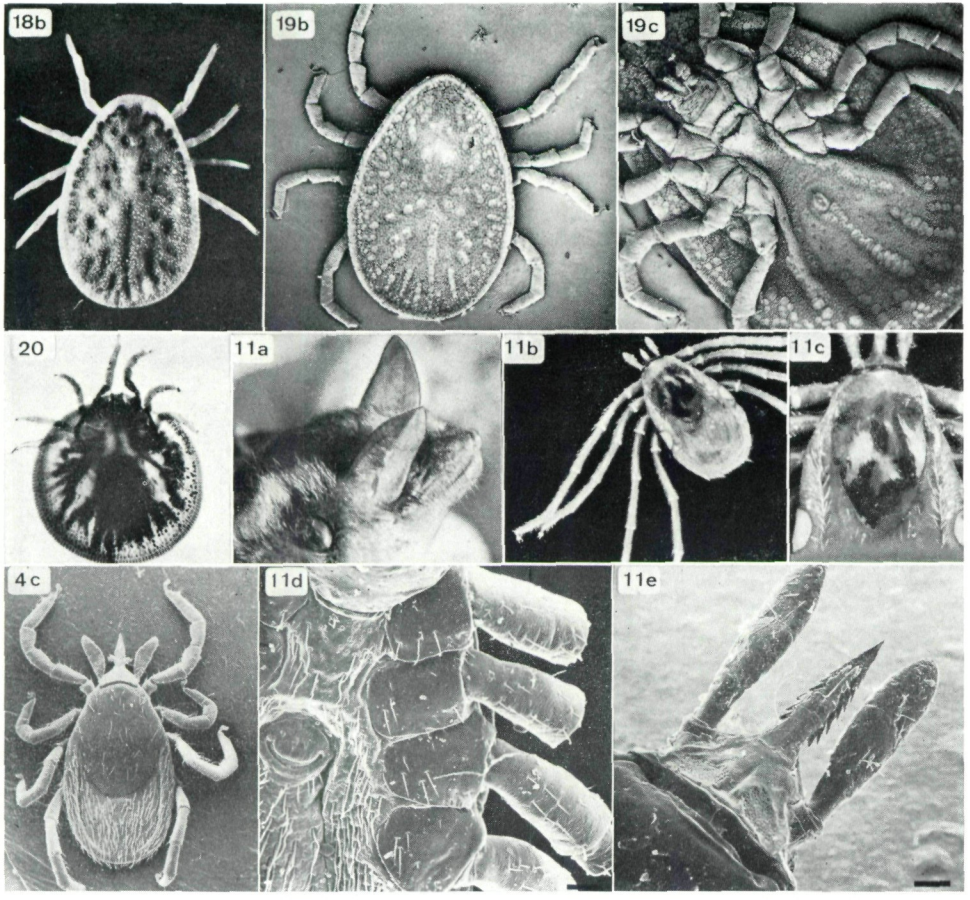


Plate V

Fig. 18b: *Argas persicus*, adult stage

Fig. 19b: *Argas reflexus*, nymph

Fig. 19c: *Argas reflexus*, adult stage

Fig. 20: *Argas vespertilionis* ♂

Fig. 11a: *Ixodes vespertilionis* ♀ on bat

Fig. 11b: *Ixodes vespertilionis*, ♀

Fig. 11c: *Ixodes vespertilionis*, scutum of ♀

Fig. 4c: *Ixodes redikorzevi* ♀

Fig. 11d: *Ixodes vespertilionis*, coxa of ♀

Fig. 11e: *Ixodes vespertilionis*, capitulum of ♀

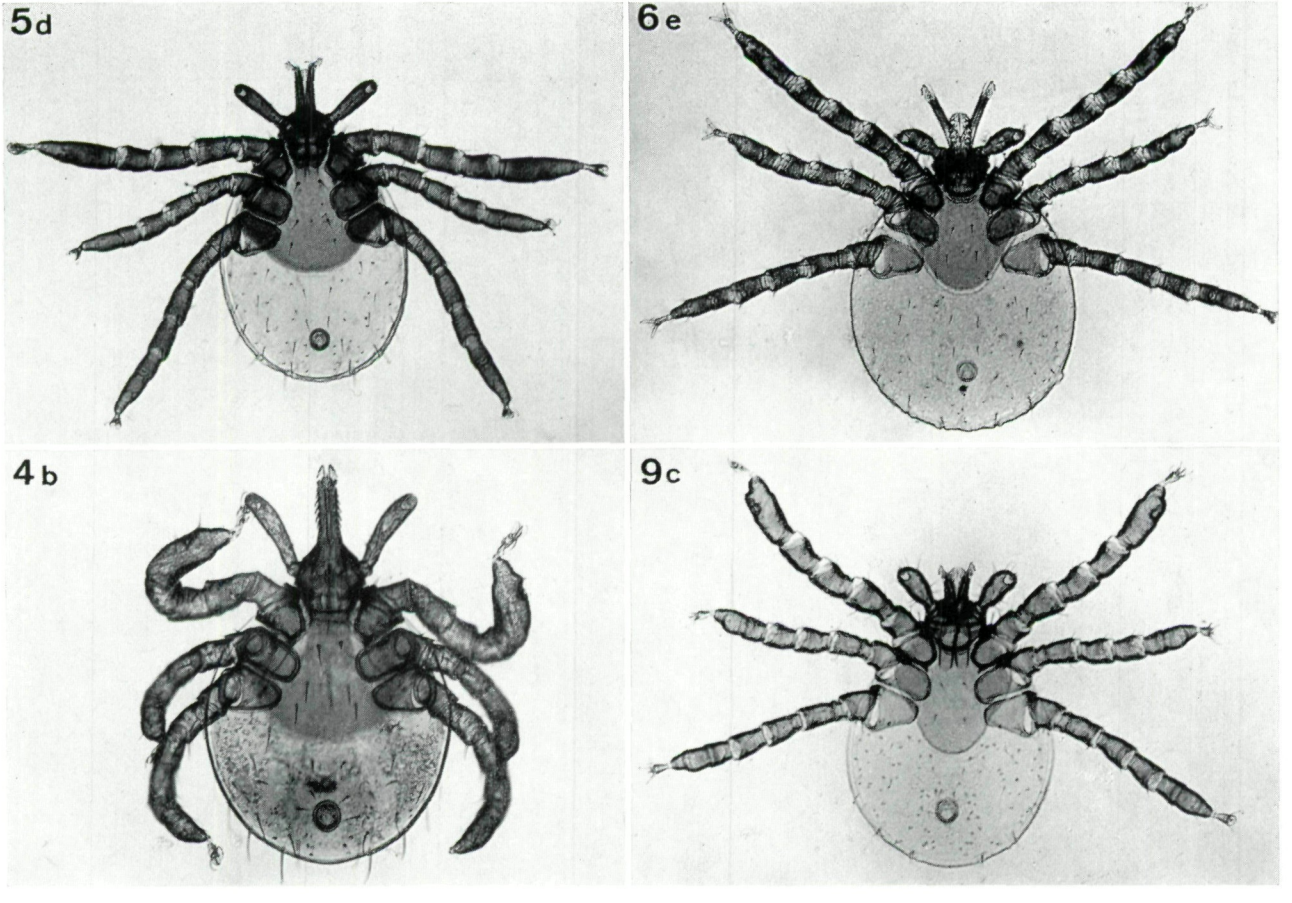
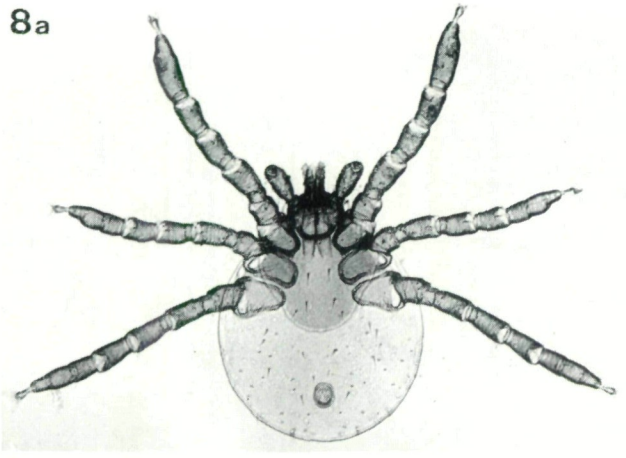
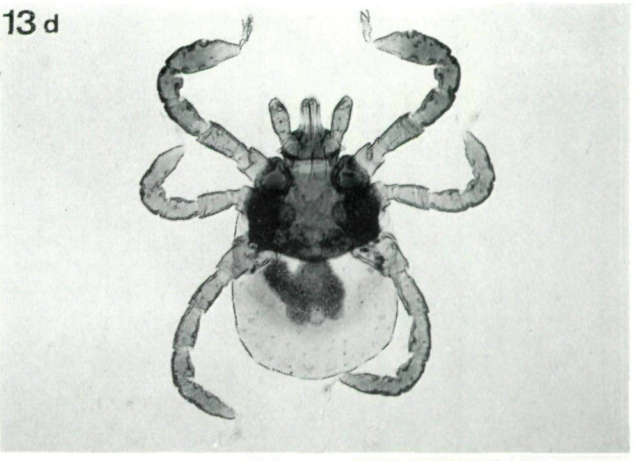
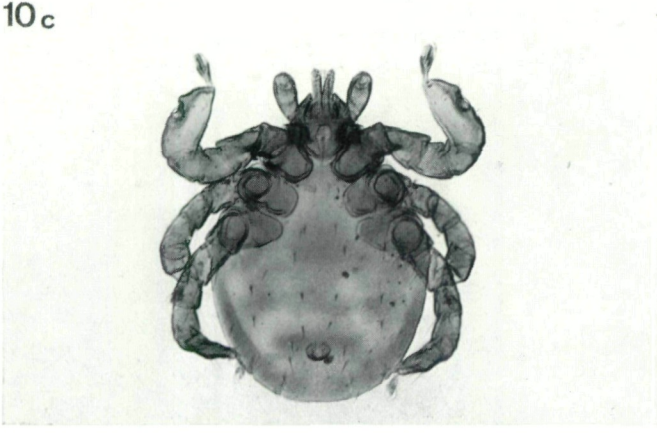


Plate VI Fig. 5d: *Ixodes ricinus*, larva
Fig. 4b: *Ixodes redikorzevi*, larva
Fig. 6e: *Ixodes hexagonus*, larva
Fig. 9c: *Ixodes arboricola*, larva







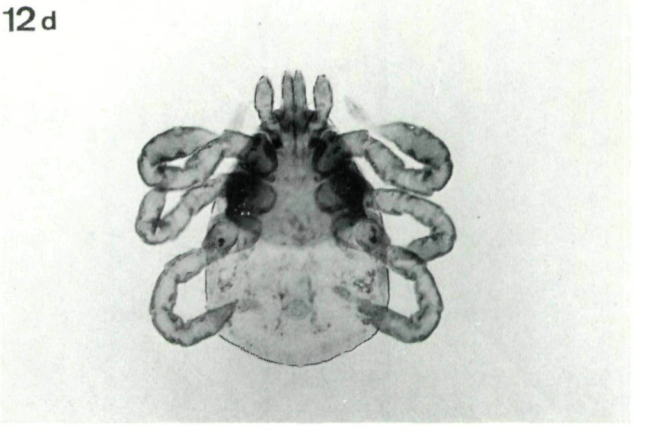
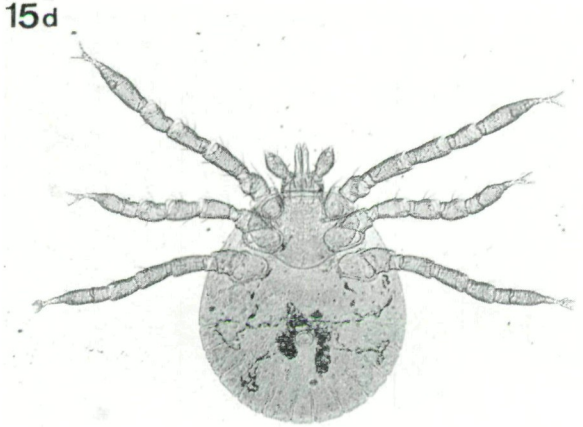
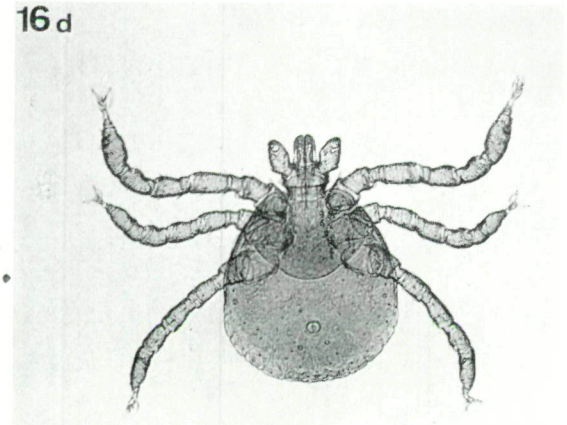


Plate VII Fig. 8a: *Ixodes lividus*, larva
Fig. 10c: *Ixodes trianguliceps*, larva
Fig. 13d: *Dermacentor marginatus*, larva
Fig. 12d: *Dermacentor reticulatus*, larva





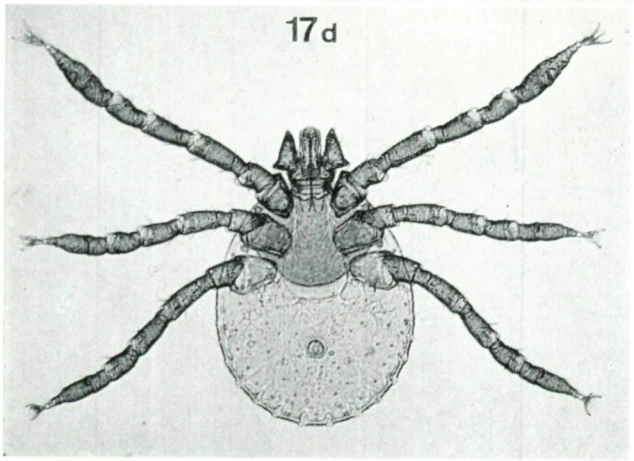
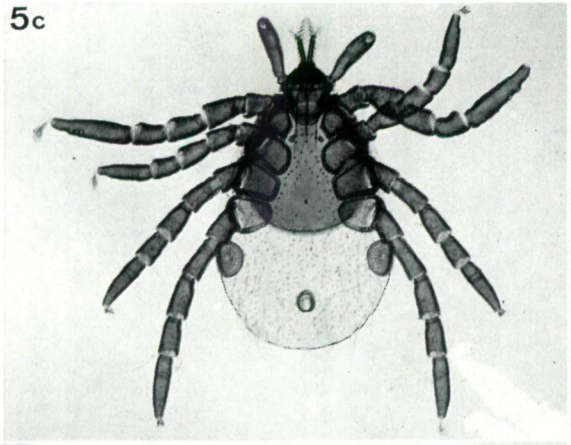
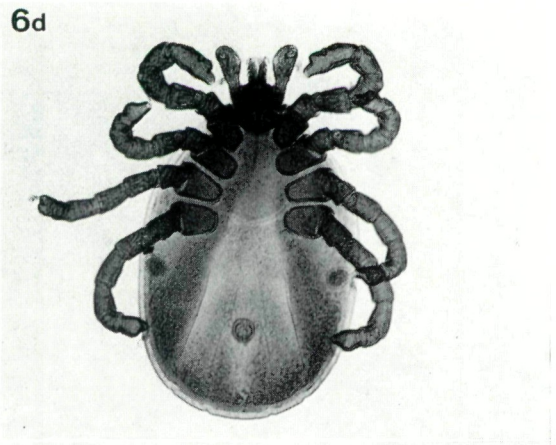


Plate VIII

Fig. 15d: *Haemaphysalis inermis*, larva
Fig. 16d: *Haemaphysalis punctata*, larva
Fig. 17d: *Haemaphysalis concinna*, larva





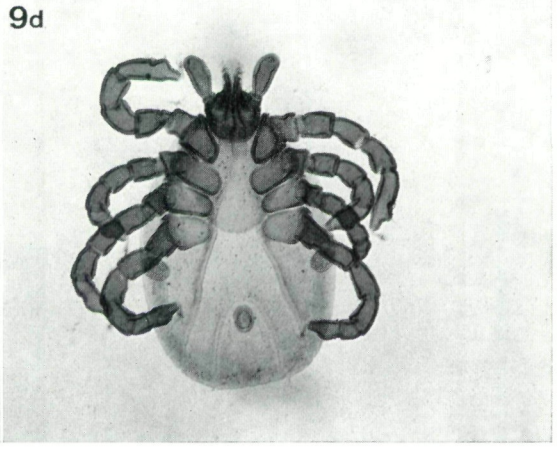


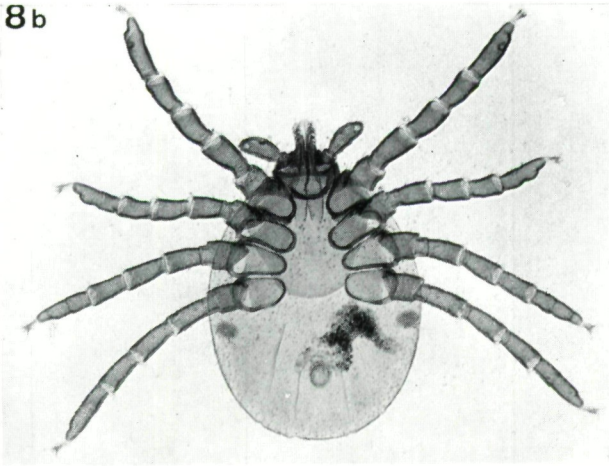
Plate IX

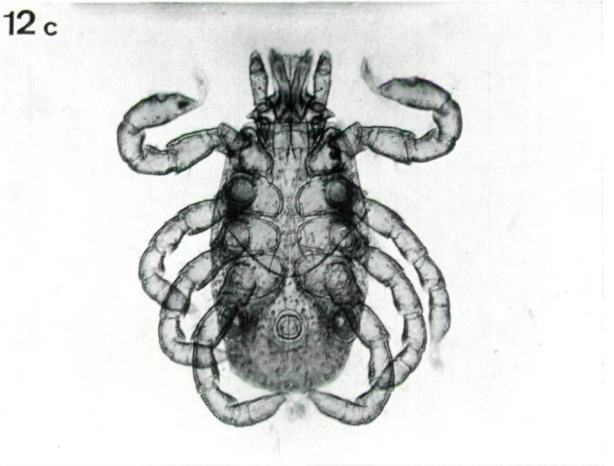
Fig. 5c: *Ixodes ricinus*, nymph

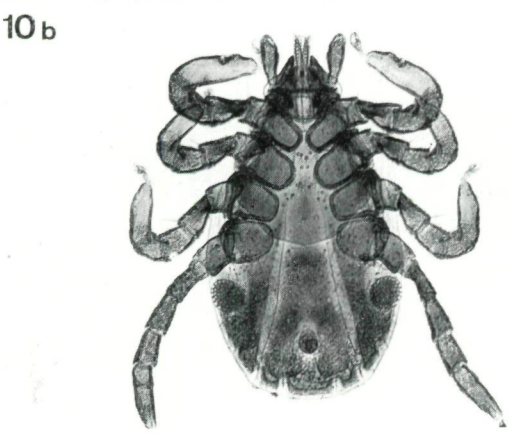
Fig. 6d: *Ixodes hexagonus*, nymph

Fig. 4a: *Ixodes redicorzevi*, nymph

Fig. 9d: *Ixodes arboricola*, nymph







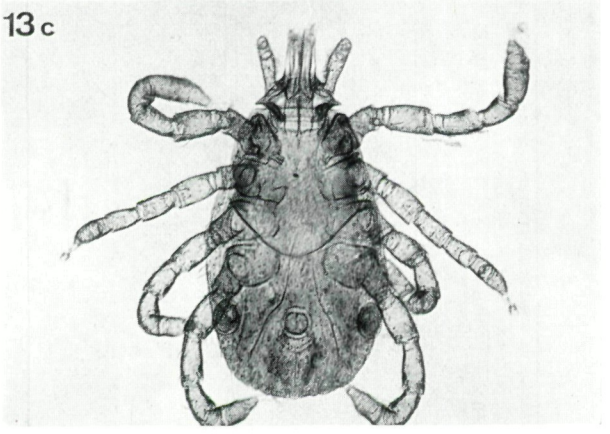
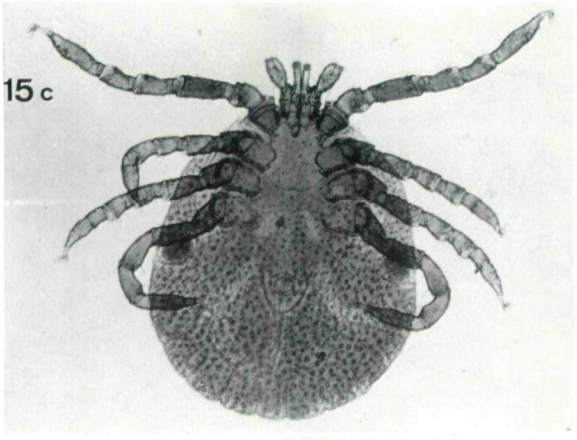
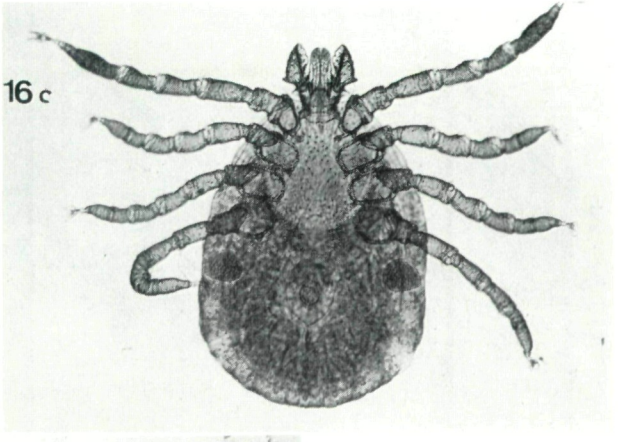


Plate X Fig. 8b: *Ixodes lividus*, nymph
Fig. 10b: *Ixodes trianguliceps*, nymph
Fig. 12c: *Dermacentor reticulatus*, nymph
Fig. 13c: *Dermacentor marginatus*, nymph





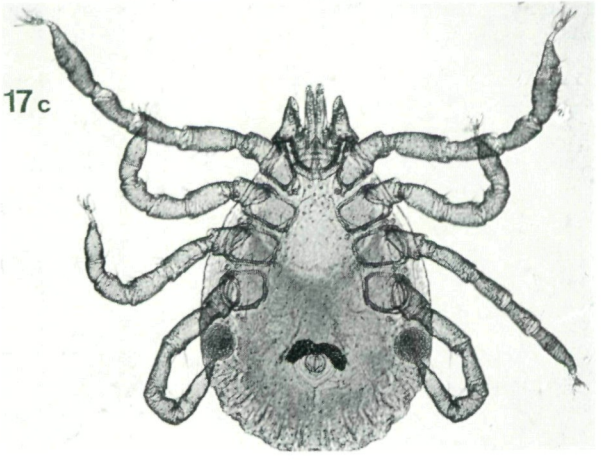


Plate XI

Fig. 15c: *Haemaphysalis inermis,* nymph
Fig. 16c: *Haemaphysalis punctata,* nymph
Fig. 17c: *Haemaphysalis concinna,* nymph

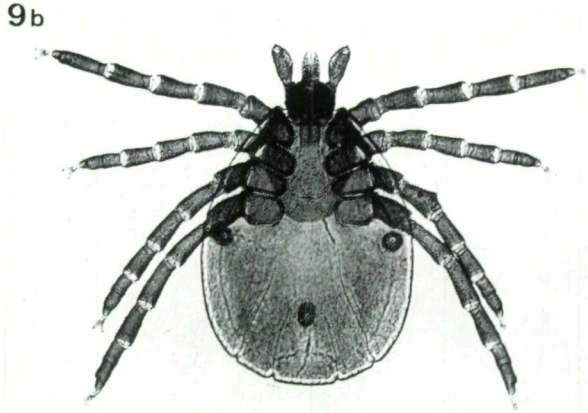


Plate XII

Fig. 9b: *Ixodes arboricola* ♀
Fig. 9a: *Ixodes arboricola* ♂
Fig. 10a: *Ixodes trianguliceps* ♂

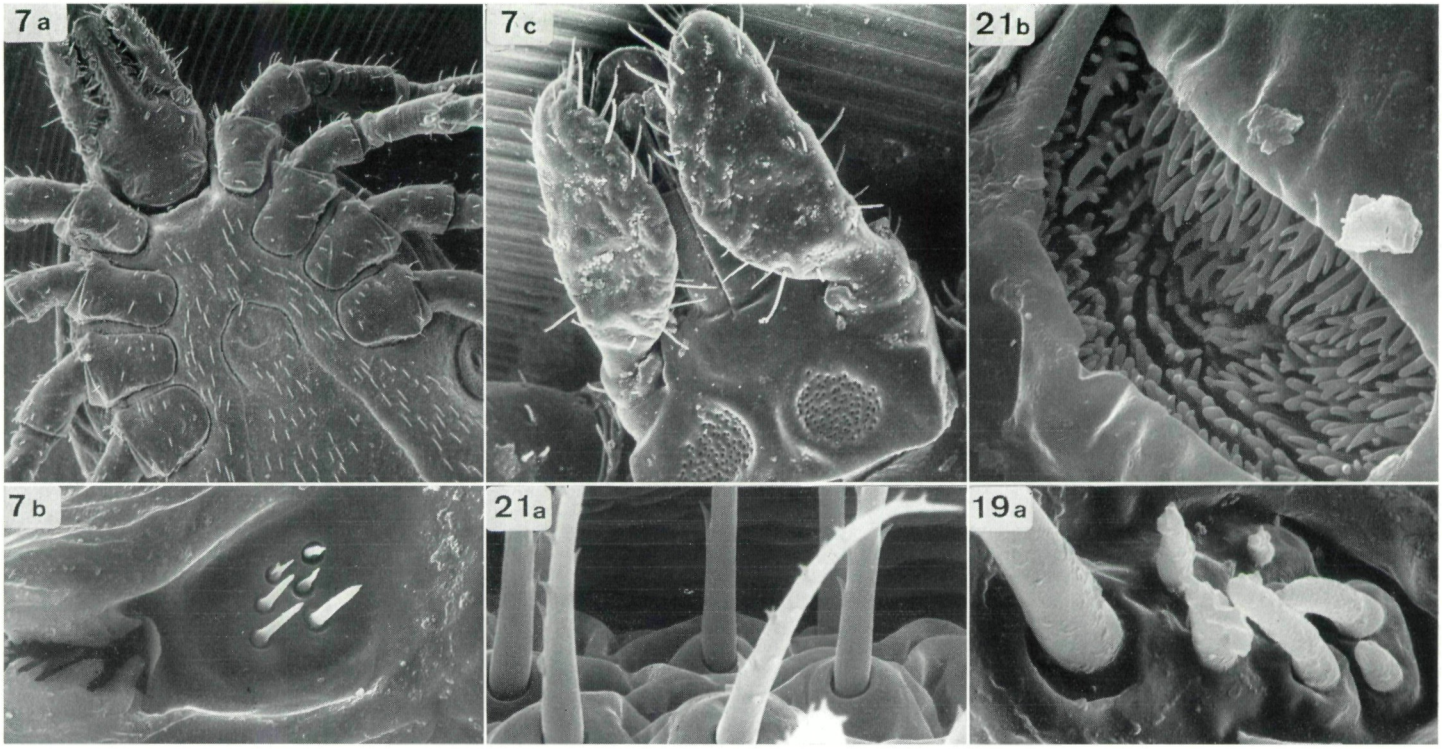


Plate XIII

Fig. 7a: *Ixodes canisuga* ♀
Fig. 7c: *Ixodes canisuga*, capitulum of ♀
Fig. 21b: *Ornithodorus papillipes*, capsule of HALLER's organ of ♀
Fig. 7b: *Ixodes canisuga*, HALLER's organ of ♀
Fig. 21a: *Ornithodorus papillipes*, integument of ♀ near hypostome
Fig. 19a: *Argas reflexus*, HALLER's organ of ♀ (without capsule)

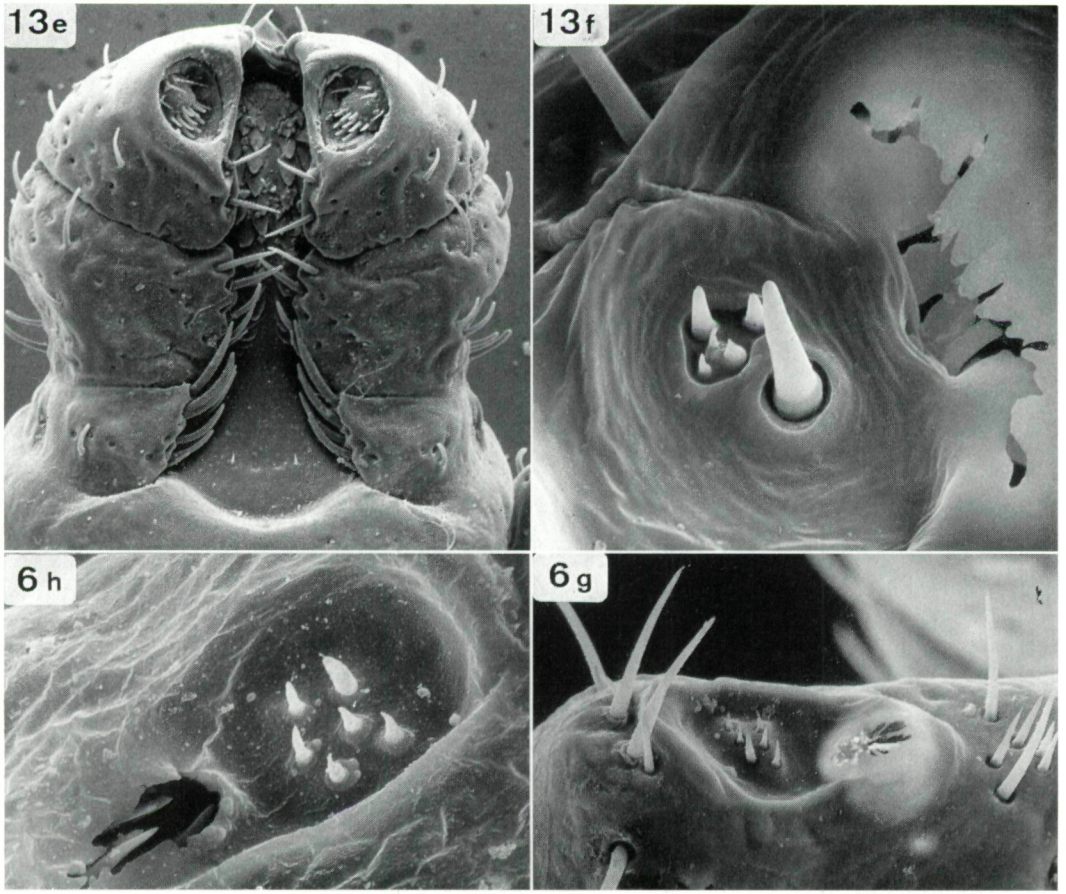


Plate XIV

Fig. 13e: *Dermacentor marginatus,* palps and hypostome of ♀

Fig. 13f: *Dermacentor marginatus,* HALLER's organ of ♂

Fig. 6h: *Ixodes hexagonus,* HALLER's organ of ♀

Fig. 6g: *Ixodes hexagonus,* HALLER's organ of ♀

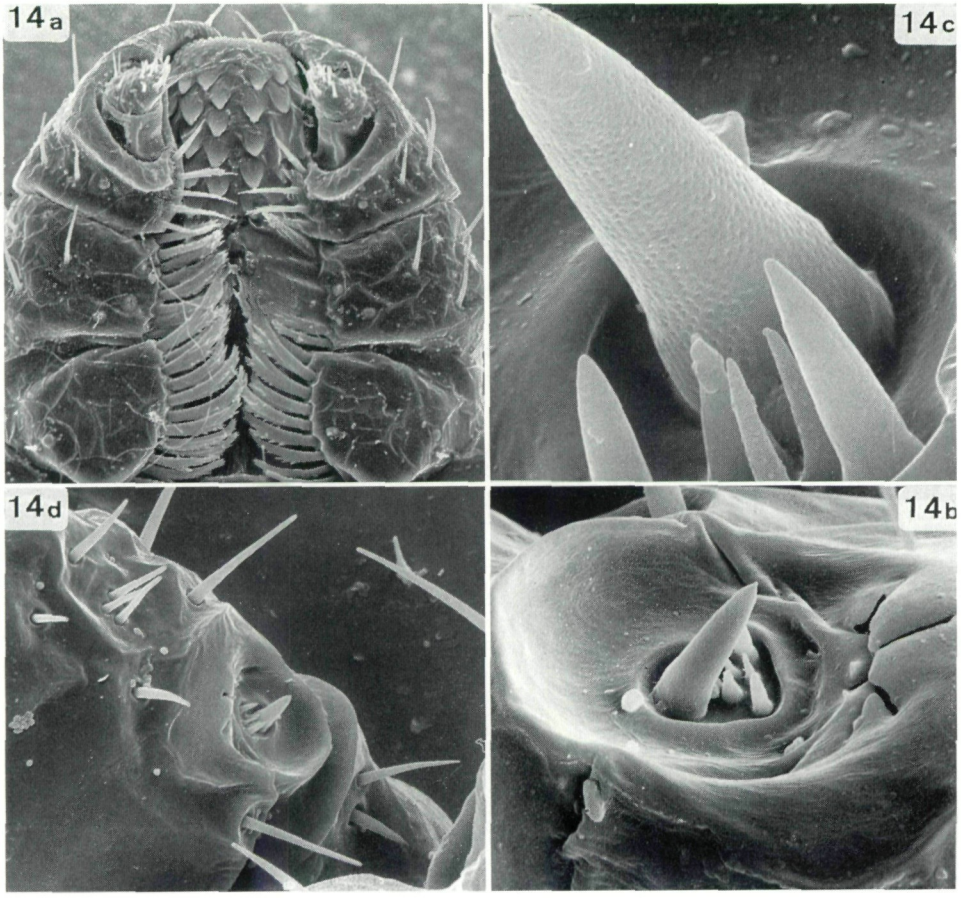


Plate XV

Fig. 14a: *Rhipicephalus sanguineus*, palps and hypostome of ♀

Fig. 14c: *Rhipicephalus sanguineus*, sensory cone of HALLER's organ of ♂

Fig. 14d and 14b: *Rhipicephalus sanguineus*, HALLER's organ of ♂

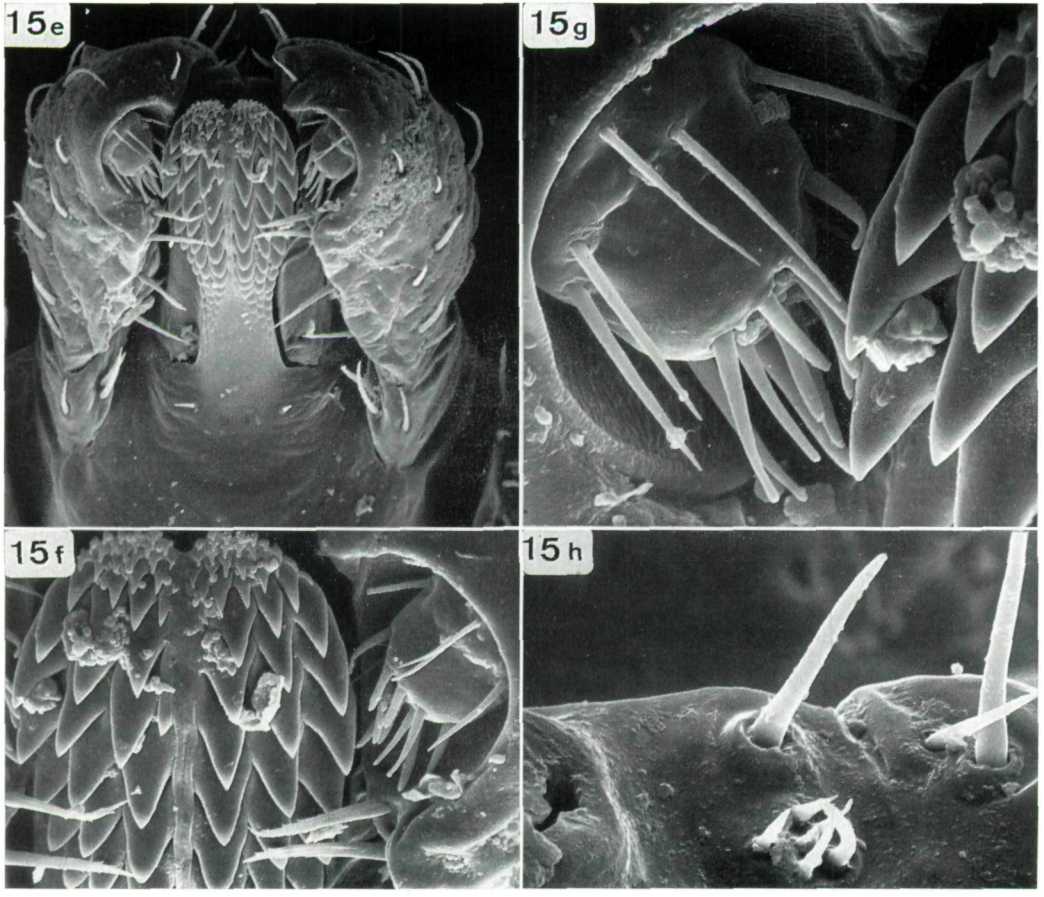


Plate XVI

Fig. 15e: *Haemaphysalis inermis*, palps and hypostome of ♀

Fig. 15g: *Haemaphysalis inermis*, palpal segment 4 of ♀

Fig. 15f: *Haemaphysalis inermis*, hypostomal dentition of ♀

Fig. 15h: *Haemaphysalis inermis*, HALLER'S organ of ♀

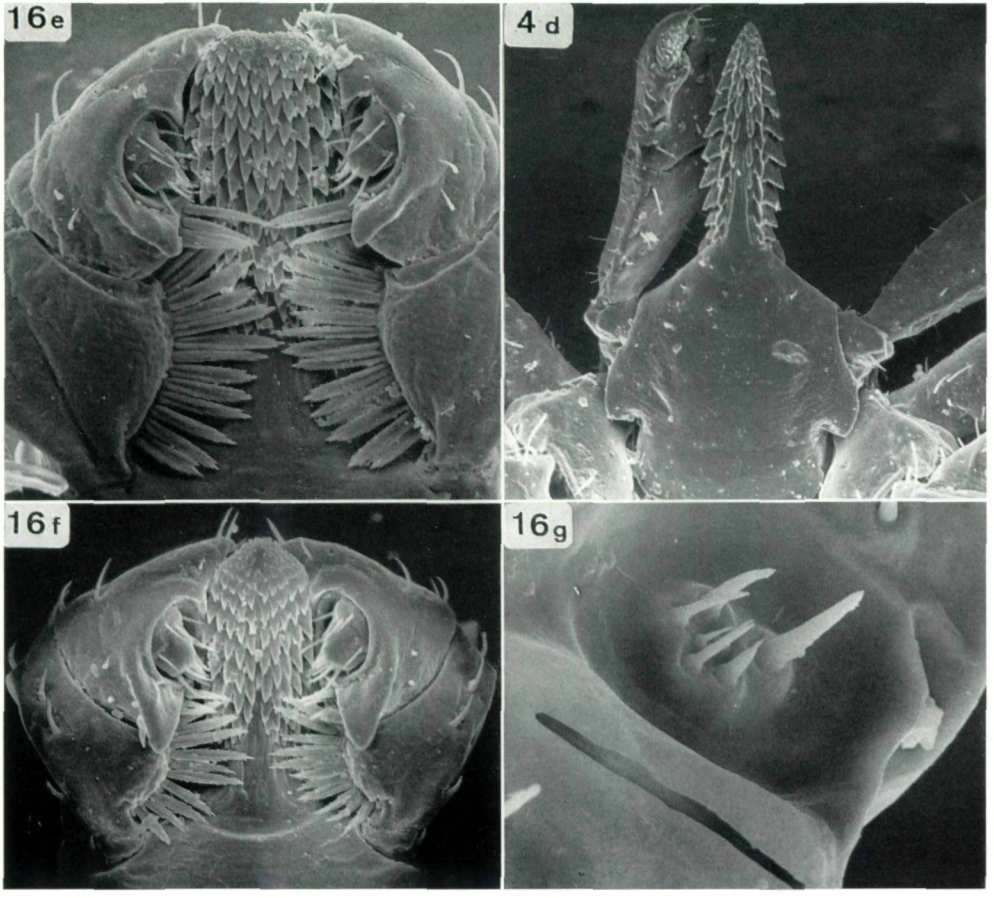


Plate XVII

Fig. 16e: *Haemaphysalis punctata*, palps and hypostome of ♀

Fig. 4d: *Ixodes redikorzevi*, hypostome, palp and capitulum of ♀

Fig. 16f: *Haemaphysalis punctata*, palps and hypostome of ♂

Fig. 16g: *Haemaphysalis punctata*, HALLER's organ of ♂

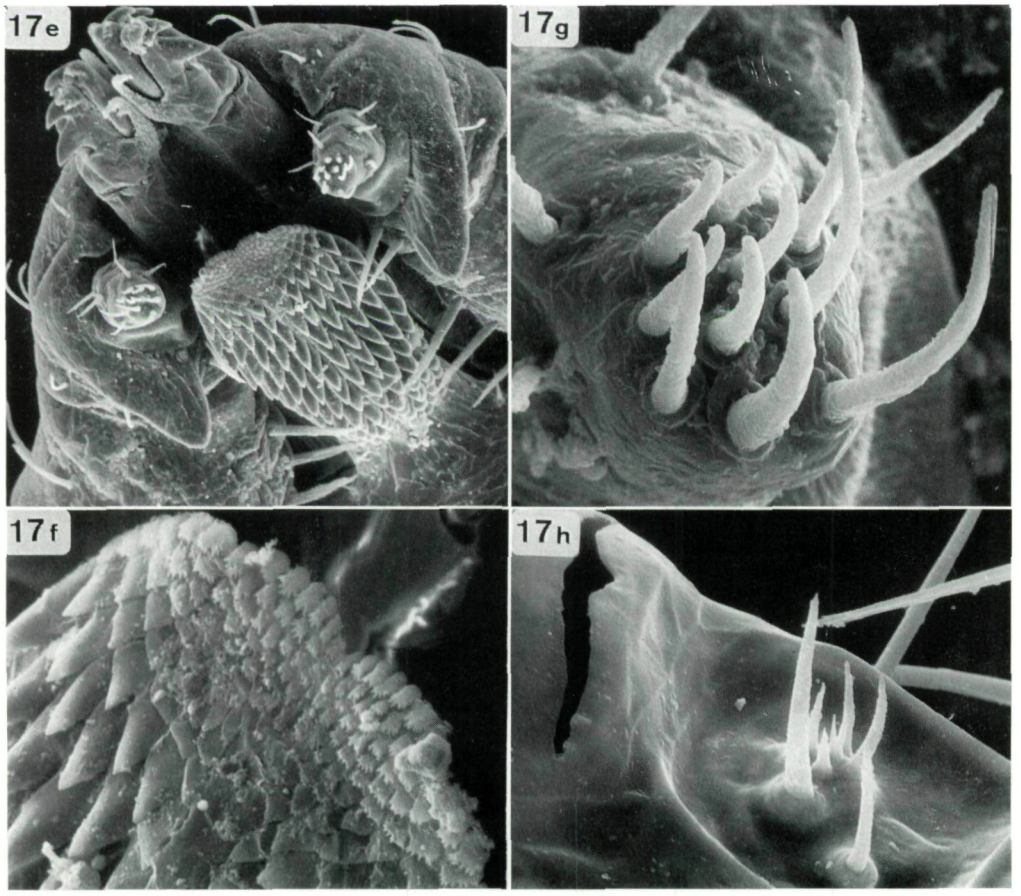


Plate XVIII

Fig. 17e: *Haemaphysalis concinna*, palps and hypostome of ♀

Fig. 17g: *Haemaphysalis concinna*, sensory rods of palpal segment 4 of ♀

Fig. 17f: *Haemaphysalis concinna*, hypostomal dentition of ♀

Fig. 17h: *Haemaphysalis concinna*, HALLER's organ of ♀