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# THE *IXODES* TICKS OF CHIROPTERA (IXODOIDEA, IXODIDAE)

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# THE *IXODES* TICKS OF CHIROPTERA (IXODOIDEA, IXODIDAE)<sup>1</sup>

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and  
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During an investigation into *Ixodes* ticks parasitizing mammals it became apparent that existing descriptions of those species which parasitize bats were inadequate in many respects. I therefore obtained for this study specimens from Dr. V. Aellen, Museum d'Histoire Naturelle, Geneva (V.A.), Dr. Gertrud Theiler of the Onderstepoort Research Station (O.R.S.), Mr. Harry Hoogstraal, U. S. Naval Medical Research Unit Number 3, Cairo (H.H.) and Mr. Glen M. Kohls, Rocky Mountain Laboratory, Montana, U.S.A. (R.M.L.) Professor O. Theodor, Hebrew University, Jerusalem (O.T.) allowed me to examine his material, on which he will report in due course. Dr. G. Owen Evans and Mr. E. Browning permitted me to examine specimens in the British Museum (Natural History) (BMNH) collections and were most helpful. The work was carried out when the writer held a Leverhulme Research Award, and is in part a collaborative project between the author and NAMRU-3. For their comments and criticisms of this manuscript I am grateful to Dr. C. B. Philip, Mr. H. Hoogstraal and Mr. Glen M. Kohls.

All measurements in the text are given in millimeters.

## *Ixodes vespertilionis* Koch 1844

*Ixodes vespertilionis* Koch 1844 has a wide distribution, being known from Europe, the Near and Middle East, and Africa. *I. vespertilionis* was re-described by Neumann (1899), by Nuttall, Warburton, Cooper and Robinson (1911) and by Pomerantzev (1950). Nuttall *et al* (Fig. 279) repeated Neumann's figure of the female capitulum which is drawn from a mounted specimen. In this figure the palps are distorted and the significance of the "salient lateral points" is not clear. Furthermore, certain aspects of the female morphology require elucidation. The description of the male as given by these authors is good; the immature stages have been inadequately described by the earlier authors and Pomerantzev (1950) does not deal with them.

### Diagnosis of male

Legs thin, of inordinate length. Coxae unarmed. Capitulum comparatively small, base about as broad as long. Palps clavate, convex dorsally, with numerous long hairs. Hypostome ill defined, practically smooth, indications of few small scalelike teeth distally. Scutum very long and narrow, emargination slight, scapulae rounded and short; cervical grooves faint, diverging. Genital orifice facing second intercoxal spaces. Adanal plates longer than anal plates. Median plate pentagonal, fairly broad, especially posteriorly.

### Redescription of female (Figures 1-4)

*Body*: Unengorged or slightly engorged females 4 long by 2 broad. Legs inordinately long and thin, with tapering tarsi. Hairs of varying lengths numerous on alloscutum.

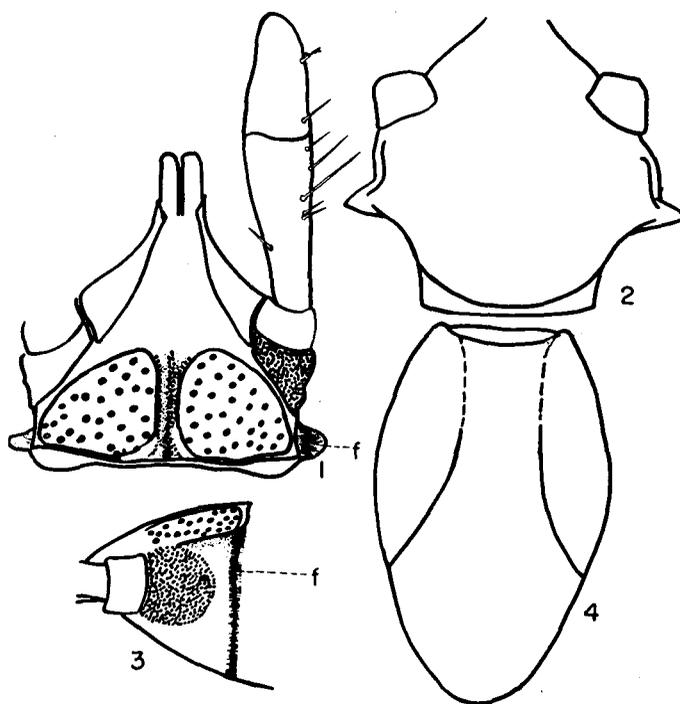
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<sup>1</sup> The opinions and assertions contained herein are the private ones of the author and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

*Capitulum* (Figs. 1, 2 and 3): Basis capituli broad dorsally, triangular, without cornua as such, but posterolateral margins drawn out into salient, broad, "cornua-like" flaps. Basis with lateral margins posterior of insertion of palps either straight or slightly concave; more or less parallel, then converging mesially to base of palps. Posterior to article I an expanse of almost circular membranous tissue, more or less in line with dorsolateral margin of basis. Dorsal ridge and its posterolateral flaps continued around side of basis as sclerotized, vertical, outwardly directed flange (f, in Figs. 1, 3) lying posterior of membranous area at base of palp. Flanges presumably representing "salient lateral points" of earlier authors. Porose areas large, subcircular or subtriangular, somewhat depressed; separated by narrow interval with corrugations, hence a median ridge. Rostrum drawn out to greater extent than figured by Neumann (1899) and repeated by Nuttall *et al* (1911). Palps long and narrow (narrower than figured by Neumann, drawn from mounted preparations). Article II:III::1.0:0.56; article II, 0.39 mm., article III, 0.22 mm.; long hairs present on outer margin. Basis broad ventrally, convex, convexity terminating along posterior, transverse, curved ridge; posterior margin straight; auriculae absent.



FIGS. 1-4. *Ixodes vespertilionis*, female. 1, capitulum, dorsal; 2, capitulum, ventral; 3, basis capituli, lateral; 4, scutum.

*Scutum* (Fig. 4): Longer than broad, as 1.0:0.6; length 1.76 mm., breadth 1.08 mm.; sides gently curved, broadest about midlength (cf. Pomerantzev, 1950, Fig. 210); posterior border less broad than indicated by Neumann and by Nuttall *et al*. Cervical grooves deeper posteriorly and less distinct anteriorly; extending to posterolateral margins in posterior third of scutum. Hairs sparse, located mainly anterolaterally. Punctations small and shallow, numerous. Scapulae particularly short, rounded, emargination very slight.

*Hypostome*: Long and pointed, sides converging from base to apex. About 15+ rows with denticles arranged in 3/3 to 4/4 files and approximating to Fig. 33 of Neumann (1899).

*Legs*: Long and thin, producing "spidery" effect. Surface smooth, with reticulate markings. Tarsus I long; Haller's organ about one-third distance from its tip. Tarsus I, 1.6, metatarsus I, 1.39. Tarsus IV, 1.5, metatarsus IV, 1.36. Length of individual components of leg, however, somewhat variable.

*Coxae*: Large with surface gently convex; spurs completely absent.

*Spiracular plate*: Oval, macula anteriorly placed.

*Vulva*: Between coxae III.

## Redescription of nymph (Figures 5-10)

*Capitulum*: Basis 0.38 long; dorsally triangular, posterior margin straight as in female, flanged posterolaterally and continued laterally to form dorsoventral ridge. Extensive area of membranous tissue posterior of palp. Surface smooth and shining. Palpi with lateral margins straight, inner margins convex, particularly in distal third; becoming narrower towards base of article II. Article II to article III as 1.0:0.9. Combined lengths of articles II and III, 0.29; breadth at junction of articles II and III, 0.1. Ventrally a pronounced 'waisting' effect of basis (Fig. 6), but no evidence of auricular projections.

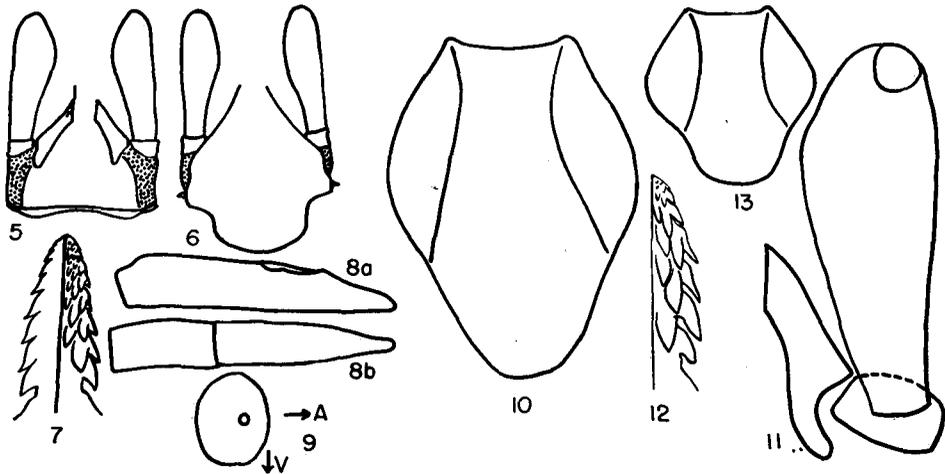
*Hypostome* (Fig. 7): Relatively shorter and broader when compared with female, pointed apically. Teeth arranged as one basal row of 3/3, succeeded by seven or eight rows of 4/4; length 0.17.

*Scutum* (Fig. 10): Longer than broad: 0.8 by 0.55. No lateral carinae, cervical grooves distinct but deeper posteriorly, long, first convergent and then divergent, extending to posterolateral margins. Scapulae and emargination as for female. Hairs sparse.

*Coxae*: Spurs absent, more or less flat. Tarsus I, 0.66, metatarsus I, 0.50. Tarsus IV, 0.69, metatarsus IV, 0.50 (Figs. 8a and b).

*Spiracles*: Elongate-oval, longest axis transverse, 0.21 by 0.17 (Fig. 9).

*Anal grooves*: Long and parallel as in female, gently rounded anterior of anus.



FIGS. 5-10. *Ixodes vespertilionis*, nymph. 5, capitulum, dorsal; 6, capitulum, ventral; 7, hypostome, ventral; 8a, tarsus I; 8b, tarsus IV; 9, spiracle; 10, scutum.

FIGS. 11-13. *Ixodes vespertilionis*, larva. 11, left palp; 12, left side of hypostome; 13, scutum.

## Redescription of larva (Figures 11-13)

*Capitulum*: Length, 0.27, triangular, similar to that of nymph and female. Palps attaining greatest breadth nearer to distal than to proximal end (Fig. 11); long with scattered hairs laterally; no sutural line evident between articles II and III; combined length of articles II and III, 0.17.

*Hypostome* (Fig. 12): Short, relatively broad, length 0.09; outer teeth strong, arranged in one row of 2/2 and five or six rows of 3/3 to tip, median and lateral teeth of about equal strength.

*Scutum* (Fig. 13): Length, 0.43, breadth 0.41, slightly longer than broad; greatest breadth about midlength; anteriorly with rapidly converging margins; posteriorly from midline margins curved in rather strongly and then more gradually to form broad posterior margin. Cervical grooves long, convergent anteriorly, thence divergent, reaching the posterolateral margins where the latter are concave.

*Coxae*: As for nymphs; tarsus I, 0.37, metatarsus I, 0.23. Mean relative lengths of individual segments of legs of all stages shown in Fig. 14.

## Distribution and hosts

The following records are additional to those given by Neumann (1916):

EUROPE. Gibraltar (Neumann, 1916); Spain (Neumann, 1916; Schulze, 1927; Collado, 1936, 1938, 1948); France (Neumann, 1916; Schulze, 1927); Austria (Neumann, 1916; Nuttall,

1916); England, Ireland, Wales (Neumann, 1916; Nuttall, 1916; Hirst, 1916; MacLeod, 1939; Arthur, 1948, 1953); Hungary (Neumann, 1916; Kotlan, 1921a, b); Germany (Schulze, 1923, 1944; Schulze and Schlotke, 1930); Roumania (Leruth, 1939a); Czechoslovakia (Kolenati, 1856 and 1860 as *Sarconyssus excavatus* from Moravia, but see Neumann, 1910); Bulgaria (Schulze, 1927); Yugoslavia (Nuttall, 1916, cf. Oswald, 1939); Belgium (Bequaert, 1913; Schmitz and Bequaert, 1914; Leruth, 1931, 1939b; Cooreman, 1951); Italy (Neumann, 1916; Tonelli-Rondelli, 1930); Greece (Schulze, 1936; Pandazis, 1947); Sardinia (G. M. Kohls in correspondence with H. Hoogstraal); Netherlands (van Eyndhoven, 1950).

The following are new records from Europe (V.A. collection): from grotte de Ver, Neuchâtel, Switzerland and all collected from *Rhinolophus hipposideros*, 1 unfed nymph, 10.12.1944; 1 unfed female, 18.2.1945; 1 larva, 27.10.1950; 3 fully fed nymph, 1948; 1 fed nymph and larva, 27.10.1950; 1 fed female, 23.10.1949. From grotte de Cotencher, Neuchâtel, Switzerland.

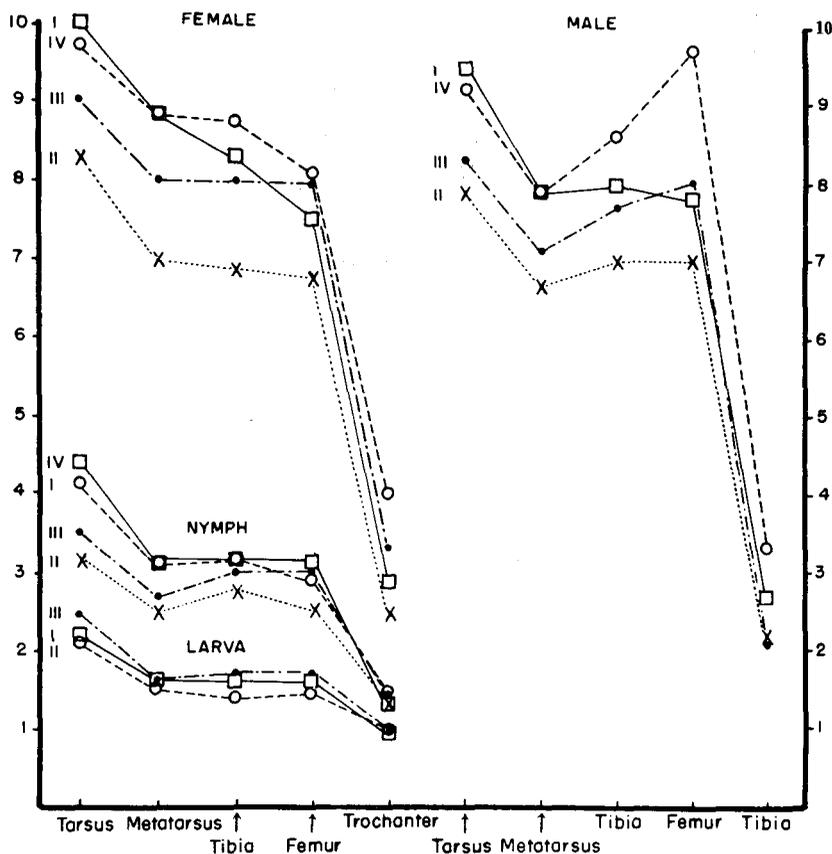


FIG. 14. Relative leg lengths of different stages of *Ixodes vespertilionis*.

1 partly fed nymph, from *Rhinolophus hipposideros*, 18.12.1947; 3 fed and 2 unfed larvae, 1 unfed nymph, from *Plecotus auritus*, 28.1.1951. 1 fed larva from *Myotis daubentoni*, grotte de Pertuis, Neuchâtel, Switzerland, 2.4.1945. 1 partly fed nymph from *Rhinolophus hipposideros*, Soleure, Switzerland, 29.11.1952. 1 gorged female from *Rhinolophus hipposideros*, Ormalingen, Bâle Campagne, Switzerland, 28.7.1949. 1 unfed female from *Rhinolophus hipposideros*, Kristallhöhle, Kobewald, St. Gall, Switzerland, 28.11.1953. 1 gorged female from *Rhinolophus ferrumequinum*, Chatillon Maiche, Doubs, France, -5.1948. 1 unfed nymph from *Myotis myotis* "galeries souterraines artificielles de Kimmeria, près de Xanthi," Greece, 16.5.1954. 1 unfed female, free-living, grotte de Chrysopighi, Serrès, Greece, 7.5.1954. 1 unfed nymph, "grotte anonyme II près de Mylosavrakhi, près de Sidero-castro," Greece, 11.5.1954. 1 unfed nymph, grotte Katapigui, Areopolis, Greece, 29.11.1952. 1 gorged nymph, "grotte près de St. Jean le Prodrome, Serrès," Greece, 6.5.1954. Within this cave the bats *Miniopterus schreibersi* and *Myotis myotis* are found. 2 males, grotte de Narlidja, Turkey, 19.6.53.

AFRICA. *I. vespertilionis* has been reported from the following localities in Algeria: Rhar el Djema, Ain Amara (Constantine); Beni Add, Ain Fezza (Oran) (Neumann, 1916); Rivet, Guelt es Stel, both records quoted by Senevet (1937); a living female taken from a bat in the Institut Pasteur by Nuttall (Nuttall *et al.*, 1911) and a general statement of its occurrence in Algeria (Leruth, 1939b). From Morocco we have the following new records: 2 gorged larvae, 1 gorged nymph from grotte de Sidi bou Knadel, 15 km. north of Rabat, 2.6.1953; 2 gorged females, grotte de Sidi bou Knadel, 15 km. north of Rabat, 9.6.1953 J. B. Panouse *leg.*

Hoogstraal (1954) reported a nymph from an unidentified bat in the Sudan and also (unpublished) from the crater of Mt. Menengai, Kenya. Dr. Theiler (unpublished) recorded it from Uganda and I have identified a male from *Hipposideros caffer*, Lootsberg caves, Cape Province (O.R.S. no. 2621).

RUSSIA. Olenov (1927, 1931) and Pomerantzev (1950) reported its occurrence in Russia and in Northern Iran, and Karpov & Popov (1945) have reported it in western Siberia.

JAPAN. Kohls (in personal communication to Hoogstraal) records it from *Rhinolophus ferrum-equinum*, Sawada, Myiagi, Honshu.

AUSTRALIA. Nuttall *et al.* (1911) and Leruth (1939b) referred to the occurrence of *I. vespertilionis* in Australia, and Fielding (1926) has reported it from North Queensland bats.\*

There is a lack of detail concerning these records and Hoogstraal (Ticks of the Sudan, in press) has already drawn attention to the improbability of Nuttall & Warburton's specimens being from Australia; he has little hesitation in considering it to be actually a South African record.

Neumann (1916) gave the following genera of European bats as hosts of this tick: *Rhinolophus*, *Plecotus*, *Pipistrellus* and *Myotis*. *Rh. ferrum-equinum* and *Rh. hipposideros* are most frequently parasitized, according to Leruth (1939b). The hosts from which ticks were collected in Switzerland were *Rh. hipposideros*, *Myotis daubentoni* and *Plecotus auritus*. From Greece, the hosts were *Miniopterus schreibersi* and *Myotis myotis*. In Africa, the hosts thus far recorded are *Pipistrellus kuhlii*, *Miniopterus schreibersi arenarius*, *Myotis tricolor*?, and *Hipposideros caffer*.

#### BIOLOGY

Biologically, *I. vespertilionis* is interesting. No males have been found on bats, but they wander over the walls of the caves, particularly where the rocks are creviced. Unfertilized females and unfed immature forms occupy similar niches. It seems likely that the fully fed stages secrete themselves between the stones of the caves to digest the blood meal.

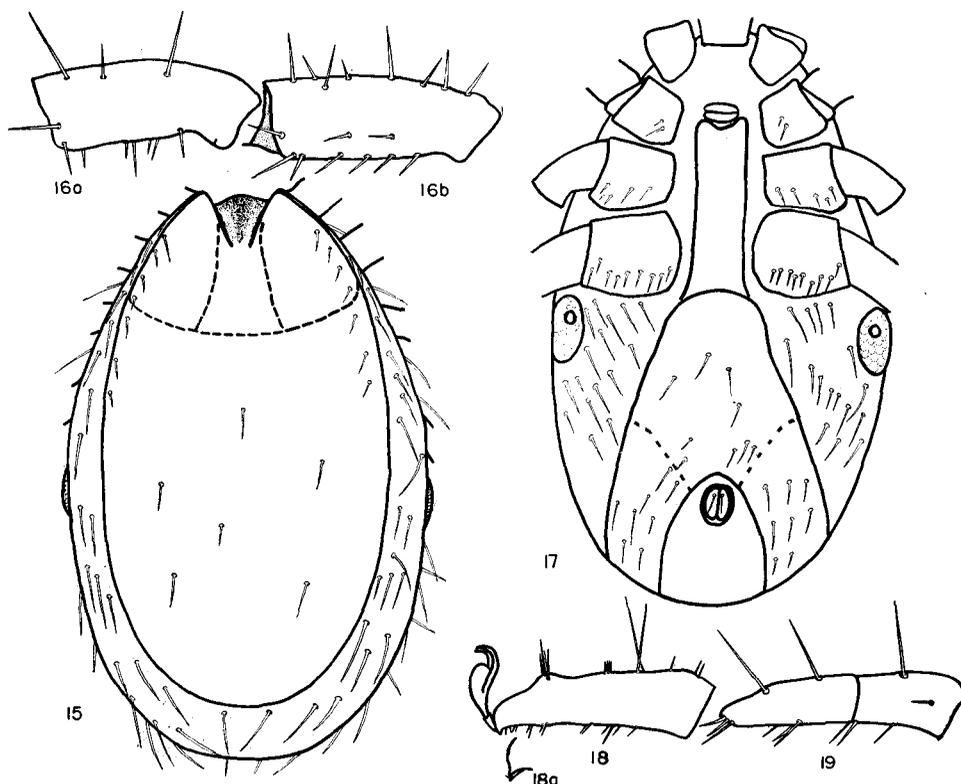
A comparison of the data for Switzerland and Macedonia shows that between October and January there is a reasonably high catch of partially and fully gorged ticks, substantiated by the data in the Monograph of Nuttall, *et al.* (1911), while in Macedonia there were a number of unfed nymphs and females in the middle months of the year. The limited material of Leruth (1939b) gives a similar picture and the presence of eight males wandering on the walls in July suggests that possibly feeding takes place mainly during the winter months. It is obvious however that further collections over a continuous period of time are necessary before the seasonal activity of this species can be satisfactorily explained.

This description is based on a single male from South Africa. There is no further information concerning its host or its precise source. The structure of Haller's organ on tarsus I most strongly suggests that it is a species associated with bats (Arthur, in press). It is very probable that this male will prove to be that of an already described female, but it is unsafe at present to attribute it to any known species.

\* Ferguson (1925) quotes Nuttall *et al.* (1911) that *I. vespertilionis* occurs in Australia.

*Ixodes spiculae* n. sp.

(Figures 15–23)



FIGS. 15–19. *Ixodes spiculae* n. sp., male. 15, dorsal view; 16a, metatarsus I; 16b, metatarsus IV; 17, ventral view; 18 tarsus I; 18a, apex of tarsus I; 19, tarsus IV.

## Description of male

**Body** (Figs. 15 and 17): Oval, brown, legs stout and long; some of the bristles, notably on the legs and palps, are long and particularly strong. Body length 4.2, greatest width slightly anterior of the spiracles, 2.0. Upper margin of spiracle visible from above.

**Capitulum** (Figs. 20 and 21): The basis attains its greatest width across the convex dorsal ridge; cornua absent; lateral margins gently curved, converging to the base of the palps and presenting a truncated triangular appearance. Length, including hypostome, 0.35, breadth 0.30. Surface pale yellow and markedly rugose. Palps borne on a broad membranous "palpiger," article I broader than long. Articles II and III without evident suture line between them; combined length of articles II and III 0.29, very broad and globular for the distal three-quarters of their length (greatest width, 0.15) armed with very long stout, straight, and curved spines (Fig. 23). Article IV small, directed downwards. Ventral surface of basis long, lateral margins diverging to the base of the palps, very slightly concave, posterior margin slightly curved. Palps bend downwards; median surface strongly concave basally as seen in ventral view (Fig. 20).

**Hypostome** (Fig. 22): Short and broad; indented apically with slight lobe arising from each anterior protuberance. Two rows of 2/2 teeth and one row of 1/1 teeth, occupying a third of the distance distally; apical and subapical lateral teeth pointed but thereafter crenulated, proximally no evidence of either lateral or median teeth. Length 0.14.

**Scutum** (Fig. 15): Twice as long as broad,  $3.3 \times 1.6$ ; elongate oval, tapering more anteriorly than posteriorly. Color pale brown, translucent in holotype, with gut diverticula showing through. Scapulae rounded, emargination moderately deep but narrow. Cervical grooves deeper anteriorly but fading out towards the posterior limit of the faintly indicated pseudoscutum; greater convexity between the scapulae than elsewhere, where cervical grooves form pronounced valleys. No lateral ridges. Sparsely covered with short white hairs. Surface finely reticulate,

no punctations. Body fold very prominent, wide for the most part; narrowing appreciably at the level of the intercoxal spaces between third and fourth pairs of legs; bearing long, strong, curved bristles.

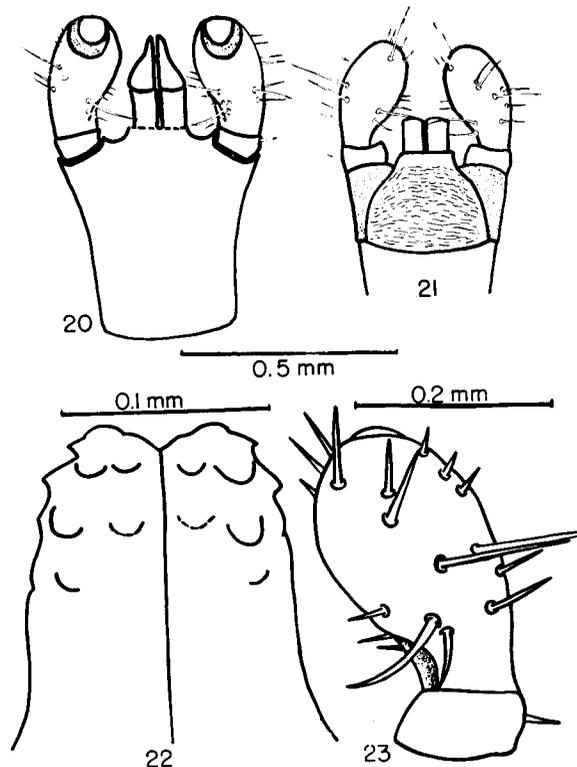
*Ventral plates* (Fig. 17): Postgenital plate (as distinct from median plate) extends from level of second pair of legs to just posterior of fourth pair, long; rectangular, not heavily sclerotized but marked off by grooves. Median, anal, and adanal plates sharply demarcated from rest of opisthosoma by pronounced grooves. Median plate not strongly sclerotized and no clear distinction between it and adanal plates, latter pigmented. Anal plate more heavily pigmented than other ventral plates. Anal groove rounded anteriorly, (approaching ogival condition), diverging. Long scattered spines on the ventral plates but the epimeral plate behind the fourth coxae more densely covered with similar strong spines.

*Genital orifice* (Fig. 17): Between anterior margins of second coxae.

*Spiracle*: Large, egg-shaped; long axis corresponds with long axis of body, macula antero-ventral. Length 0.4 (Fig. 17).

*Legs*: Large, long and strong, well supplied with spinose bristles which become stronger from leg I to leg IV. Paired spines on ventral surface of leg strong and broad. Tarsal segment appreciably narrower than more proximal segments. Tarsi narrow to claw, with more oblique bend near distal fifth. Length of tarsus I, 0.65; breadth, 0.17; metatarsus I, length 0.67, breadth, 0.23. Tarsus IV, length 0.73, breadth 0.25; metatarsus IV, length 0.72, breadth 0.18. Coxae lacking spurs, generally flat except for coxa I, which is quite strongly convex. Increase in length and breadth of coxae I to IV and in density of bristle cover (Fig. 17). Coxae approach quite close to the midline.

*Holotype*: deposited in Onderstepoort Research Station, South Africa. No data regarding host or source. O.R.S. No. 2621 (i).

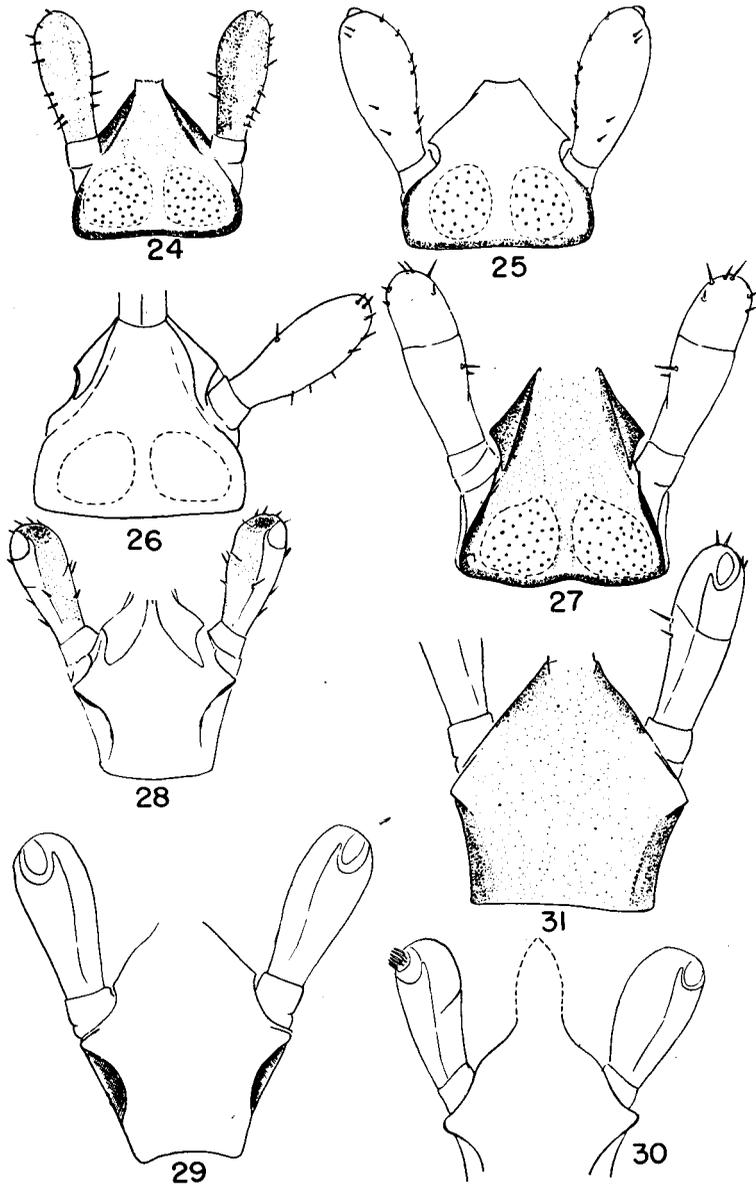


FIGS. 20-23. *Ixodes spiculae* n.sp., male. 20, capitulum, ventral; 21, capitulum, dorsal; 22, hypostome; 23, palp.

*Ixodes simplex simplex* Neumann, 1906

(Figs. 24-26, 28-30, 33-43)

*Ixodes simplex simplex* has, apparently, a wide geographical range, but its diag-



FIGS. 24-31. Capitula of females of *Ixodes simplex simplex* (24-26, 28-30) and of *I. simplex africanus* n. subsp. (27, 31). 24, dorsal view, specimen from Banyuls, France (R.M.L. Coll. 31988); 25, dorsal view, specimen from near Kameaka, Honshu Japan (R.M.L. coll. 30943); 26, dorsal view, type specimen from Kashmir (BMNH); 27, dorsal view, specimen from Mt. Menengai, Rift Valley (HH 3957); 28, ventral view, specimen from Banyuls, France (R.M.L. coll. 31988); 29, ventral view, type specimen from Kashmir (BMNH); 30, ventral view, specimen from Kameaka, Honshu, Japan (R.M.L. 30943), the posterior region of the basis is obscured due to the distension of the opisthosoma; 31, ventral view, specimen from Mt. Menengai (HH 3957).

nosis in all cases is far from clear. The collection in the BMNH consists of three specimens, each of which is labelled as "type" by Neumann in 1905. All were mounted on cards, and prior to study Dr. G. Owen Evans very kindly resuscitated the specimens with 0.5% tribasic sodium phosphate. Nuttall *et al.* (1911) imply

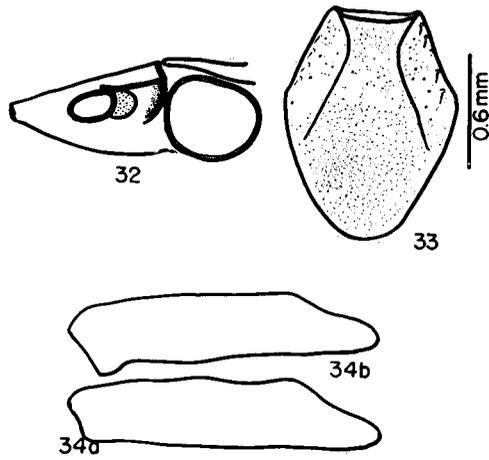
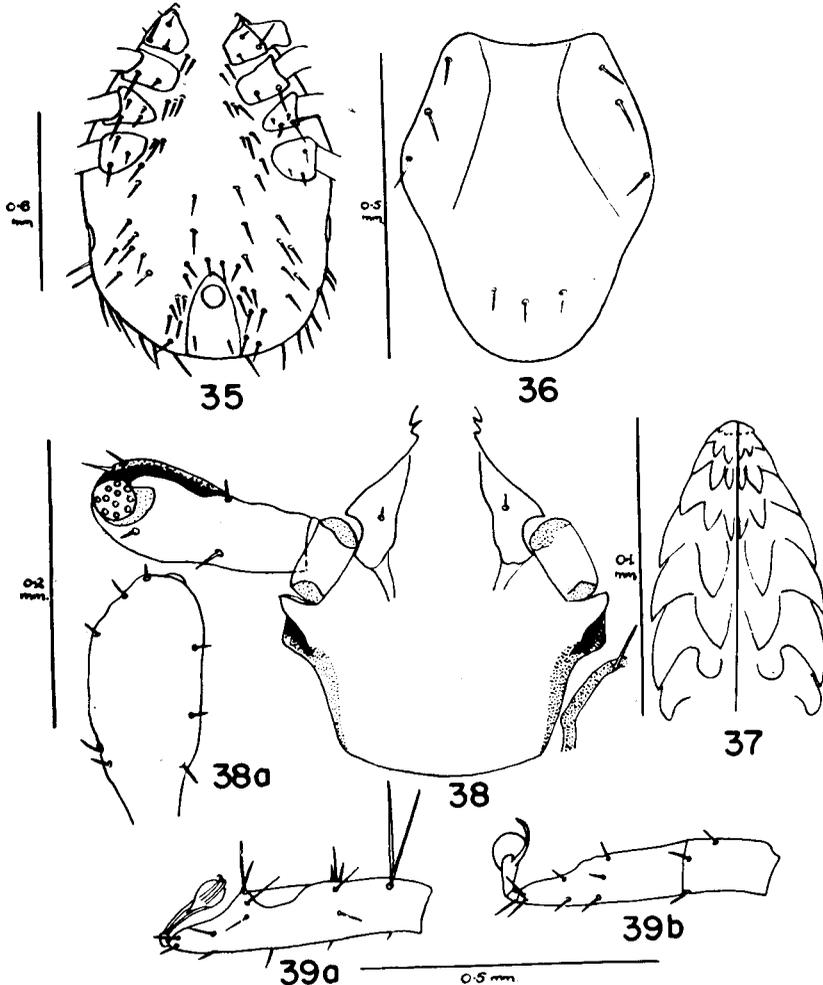


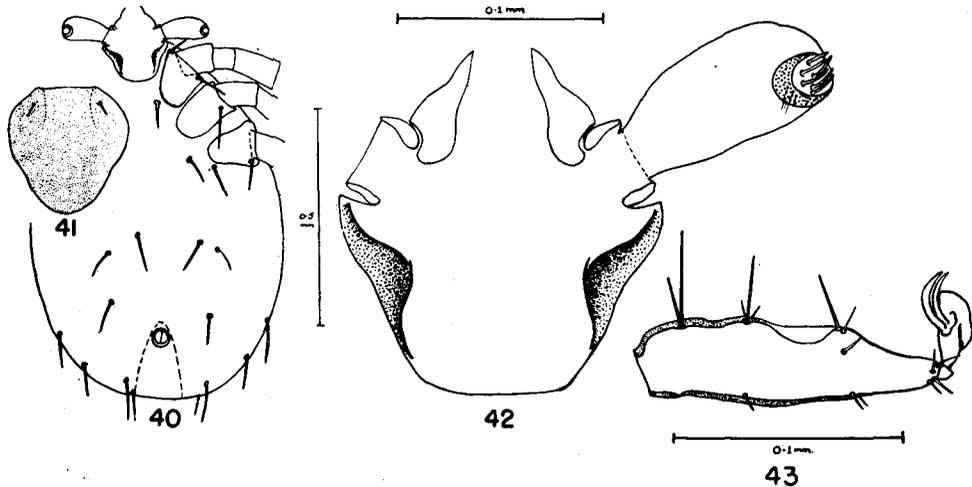
FIG. 32. *I. simplex africanus*, side view, palp removed. Stippling represents the membranous area at the base of the palp.

FIGS. 33-34. *I. simplex simplex*, female. 33, scutum; 34a, tarsus I; 34b, tarsus IV.



FIGS. 35-38. *I. simplex simplex*, nymph. 35, ventral view; 36, scutum; 37, hypostome; 38, basis capituli, ventral view; 38a, palp, dorsal; 39a, tarsus I; 39b, tarsus, IV.

that no hypostome or chelicerae are present on these specimens, but they are in fact present on both the female and the nymph from Shanghai (collection data—"found on bat—*Rhinolophus ferrum-equinum*, Shanghai, R. Swisshoe leg."). One of these type specimens (female) bears no host or locality data and the other is labelled as "? Gaboon, French Congo". Investigation has shown that the latter specimen was removed from *Myotis* (= sp. *Vespertilio*) from Kashmir or a neighboring country and was purchased from E. Gerard in 1873.



Figs. 40-43. *I. simplex simplex*, larva. 40, ventral view; 41, scutum; 42, basis capituli, ventral; 43, tarsus I.

**Material examined:** Female and nymph from Shanghai, "found on bat, *Rhinolophus ferrum-equinum*, Shanghai, R. Swisshoe leg."; female from an unknown source; female from Kashmir or a neighboring country: Two females from *Miniopterus s. schreibersi*, Banyuls, France, April, 1937 (R.M.L., no. 31988); one female and three larvae from *Myotis macrodactylus*, Honshu, near Kameaka, Japan, 30.9.1952 (R.M.L., no. 30943); one nymph, from *Miniopterus schreibersi*, Kamakura, Japan, 24.12.1945 (R.M.L., no. 22366); two nymphs, *Miniopterus schreibersi*, *Myotis myotis*, "grotte près de St. Jean le Prodrome, Serrès, Greece, 6.5.1954" (V.A., no. 27); one nymph "libre grotte de Chrysopighi, Serrès, Greece" (V.A., no. 35); 6 larvae, 4 nymphs, *Miniopterus schreibersi*, "grotte Apano Scola près de Naoussa, Greece, 25.5.1954" (V.A., no. 28); 1 nymph, "libre, grotte Katapigui, Areopolis, Greece, 29.11.1952" (V.A., no. 40); 1 nymph, "origine?, probablement N. Africa, Musée Zool. Strasbourg" (V.A. no. p. 879); 1 nymph, *Miniopterus schreibersi arenarius*, Ngong, S.E. Mt. Elgon (6000 ft.), Kenya, 11.9.1950 (H. Hoogstraal collection from Chicago Natural History Museum = CNHM); 1 female, 2 nymphs from "bats", Kapretwa, Kitali, Kenya, 7.1939 (O.R.S., no. 2622 ii); 1 nymph, "bats", Kapretwa, Kitali, Kenya, 7.1939 (O.R.S., no. 2622 ii); 1 nymph from *Rhinolophus*, CNHM no. 78471, Anglo-Egyptian Sudan, Equatoria (Katire, 35 miles S.E. Torit), 3.5.1951, host collected by J. S. Owen (ex alc. by H.S.D.); 2 nymphs, *Miniopterus schreibersi*, caves, Sterkstroom, Cape, 6.1944 (O.R.S., no. 2621).

In view of possible confusion I propose that the specimen "from Kashmir or a neighboring country" (BMNH) be elected as the type specimen.

#### Redescription of female

**Body:** Color in alcohol preserved specimens varying from yellow to dark brown; scutum, capitulum and legs pale to dark brown. Body oval with distinctive white hairs on alloscutum.

**Capitulum** (Figs. 24-26, 28-30): Dorsal surface of basis generally flattened in median area, gently curved to base of palps, strongly convex anterolaterally. Lateral margins posterior of palps curved and converging mesad of latter; posterior margins usually straight. No cornua,

posterolateral angles rounded and continuous with dorsoventral flange (Fig. 32). Porose areas consisting of widely scattered pores set in subcircular depression of integument, large separated by narrow interval. Posterior of palps laterally a distinctive crescentic membranous area. Palps short and broad (not as figured by Nuttall *et al.*, 1911), broadest near distal end, narrow proximally; suture line between articles II and III indistinct. In type (from Kashmir) article II 0.17 long; article III 0.15 long. Palps gently curved or straight both laterally, and mesially, more strongly curved towards mesial apex of article III, breadth at junction of articles II and III, 0.14. Hairs few and short. Basis slightly broader than long, length from dorsal ridge to apex of rostrum (excluding hypostome) in Kashmir type 0.37; breadth 0.40. Ventral view, basis pentagonal, posterior border concave in some specimens, slightly convex in others (e.g. Banyuls specimens). Distinct "waist" about one-third distance from posterior margin, profile of "waist" continuous with auricular-like ridges, triangular in form lying behind basal article of palp. Palps flattened on mesial faces except for slight indentation dorsal to article IV. Article I broad, directed antero-laterally.

Hypostome missing in all females except Shanghai specimen (see later) and that from Japan. The latter agrees in essentials with that figured for the nymph (Fig. 37), but, as the specimens belong to the R.M.L., I have not made a preparation of the hypostome.

*Scutum* (Fig. 33): Longer than broad, 1.17 by 0.89; broadest slightly anterior of midlength; posterolateral outlines very slightly curved and narrowing appreciably, terminating in curved posterior margin. Anterior of midlength, margin somewhat indented and sclerotization somewhat irregular where convergence begins. Scapulae very small, short, rounded protuberances; emargination ill-defined. Cervical grooves faintly indicated but not obsolete (cf. Fig. 199 of Nuttall *et al.*, 1911, and their monographic text), extending almost to posterolateral margins. No lateral carinae. Color dark brown in Neumann "types", paler in other specimens; glossy; punctations widely separated for the most part. Few short hairs in lateral and anterior fields.

*Spiracles*: In specimen of unknown source (BMNH), spiracle on right side elongate oval with its long axis transverse to that of body; left spiracle rounded, but somewhat blunter antero-ventrally; major axis still transverse. Spiracles of specimens from Kashmir, France, and Japan agreeing with left spiracle of aforementioned specimen.

*Legs*: Moderately thick and strong.

*Coxae*: Flat, unarmed. Tarsi parallel-sided for the greater part of their length, but tarsus I beyond Haller's organ tapering gradually to tip. Tarsus I, 0.79 (Fig. 34a), metatarsus I, 0.65. Tarsus IV, 0.78 (Fig. 34b), metatarsus IV, 0.67.

*Vulva*: Between coxae III.

*Anal grooves*: Very short; ogival in front, markedly diverging behind.

#### Description of Nymph

Immature specimens are known in collections but I am unaware of any descriptions or illustrations other than that of the larva given by Bedford (1934). The following descriptions are based on nymphs and larvae from bats examined in collections, from Greece, Africa, and Japan.

Sclerotized parts pale brown; length of gorged specimen, 1.2, breadth 0.86 (Fig. 35).

*Capitulum* (Fig. 38): Length, dorsal ridge to tip of hypostome, 0.24; greatest width 0.23. Basis broad, lateral margins short, curved. Cornua absent. Surface slightly convex, smooth, impunctate. Ventrally slightly waisted, sides converging to curved posterior border. Palpi with fairly regular surface, nearly straight laterally, curved mesially; slightly narrowing to base (Fig. 38a). No well-defined auriculae. Hairs few and short. Combined length of palpal articles II and III, 0.16; greatest breadth of 0.07 nearer to the apex than base; sutural lines between articles II and III indistinct.

*Hypostome* (Fig. 37): Broadest nearer base; curved profile lines. Denticles arranged from apex to base as 4 rows of 3/3. 3 rows of 2/2, 1 row 1/1. Length, 0.1.

*Scutum* (Fig. 36): Length 0.54, breadth 0.42. Widest slightly anterior of midlength. Surface shining, punctations fine and uniformly distributed. Lateral carinae absent. Cervical grooves present and distinct, at first convergent and then divergent in direction of posterolateral margins, but fading out before reaching margin. Hairs few. Scapulae rounded, very short, emargination very shallow.

*Coxae* (Fig. 35): As in adults. Tarsus I tapering beyond Haller's organ to apex. Length of tarsus I, 0.44 (Fig. 39a); tarsus IV, 0.44 (Fig. 39b).

#### Description of larva

*Body* (Fig. 40): Elongate oval, widest about midlength. Color yellow-brown. As in older stages, opisthosoma bears long hairs. Length of gorged specimen 0.9, breadth 0.62. Basis capituli essentially as in nymph (cf. Figs. 38 and 42). Palps relatively broader than in nymph,

length 0.12, breadth 0.05; straight laterally, curved mesially (Fig. 42). Hypostome missing in all specimens examined.

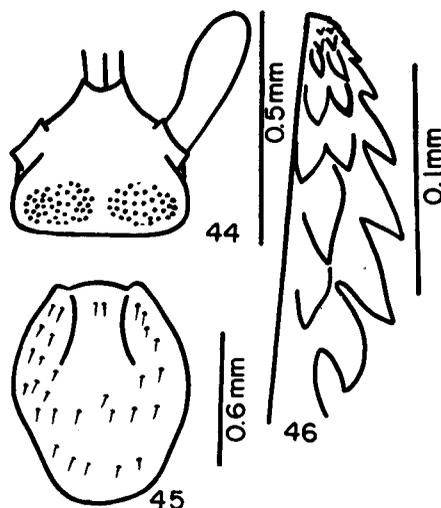
*Scutum* (Fig. 41): Length 0.3, breadth 0.28. Finely punctate with few hairs. Cervical grooves short, more prominent anteriorly and fading out before reaching posterolateral margins.

*Anal groove*: Ogival.

*Coxae*: As in later stages, provided with long hairs (Fig. 40); coxa I subtriangular; coxa II long, rounded on its inner face; coxa III subtriangular. *Tarsi* resembling those of later stages, except for somewhat undulate dorsal surface of tarsus I; length 0.13 (Fig. 43).

The Shanghai "Type" Specimen of *Ixodes simplex simplex*.

(Figures 44, 45, 46)



FIGS. 44-46. *I. simplex simplex* female from Shanghai (BMNH). 44, basis capituli, dorsal; 45 scutum; 46, hypostome.

#### Description of female

The female "type" specimen from Shanghai (BMNH) differs from the other specimens examined in its pale coloring; the scutum is broadly ovate (Fig. 45); the anal groove is rounded anteriorly and has parallel sides. The legs, too, are relatively longer. The porose areas are transversely elongate and depressed (Fig. 44). The question thus arises as to whether these differences are significant or whether we are dealing with a case of intraspecific variation. Because of the small sample, one can not be dogmatic on this point. Within a single species, the scutum is particularly variable and considered alone provides no adequate criterion of subspecies. Likewise, specimens of *I. simplex* from Jerusalem have small subcircular porose areas with a wide interval, but in other respects they agree with the Kashmir specimens.

The Shanghai specimen possesses a hypostome which is broad basally and has a rounded apex. In Fig. 46 the hypostome may be slightly foreshortened as it was drawn *in situ*. Nine lateral teeth are evident on it and the dentition from apex to base is 5 rows of 3/3, 2 rows of 2/2, 1 row of 1/1; apically there is a corona. Length from tip to basal tooth, 0.16. Apart from these differences this specimen agrees in all fundamentals with *I. simplex simplex*.

#### Description of nymph

Basis of Shanghai nymph strongly constricted ventrally, wider in front, posterior margin straight, postero-lateral margins curved (Fig. 56).

*Hypostome* (Fig. 49): Broad, rounded apically. Dentition from apex to base, 2 rows of 4/4 teeth, 2 rows of 3/3 teeth, 2 rows of 2/2 teeth, 1 row of 1/1 teeth; the tooth in the basal row rounded apically, remainder pointed. Length 0.11.

*Scutum* (Fig. 57): Slightly larger and broader than that found in Macedonian, Swiss, and Palestinian material, otherwise closely similar.

#### Distribution and hosts

Apart from the data given under "material examined", the following records are known: Greece (Schulze, 1937); Japan (Kishida, 1930); Palestine (Theodor; the specimens which

have been examined will be reported on by Prof. Theodor); Belgian Congo (Bequaert, 1931); Kenya (Bequaert, from private communication with Glen M. Kohls, 1.2.1955); South Africa (Bedford, 1934). Zumpt (1950) reported the possibility that larvae and nymphs of an *Ixodes* sp. from the Sterkfontein caves, Witwatersrand, might be *I. simplex*.

(Figs. 27, 31, 47, 58c, 59, 60)

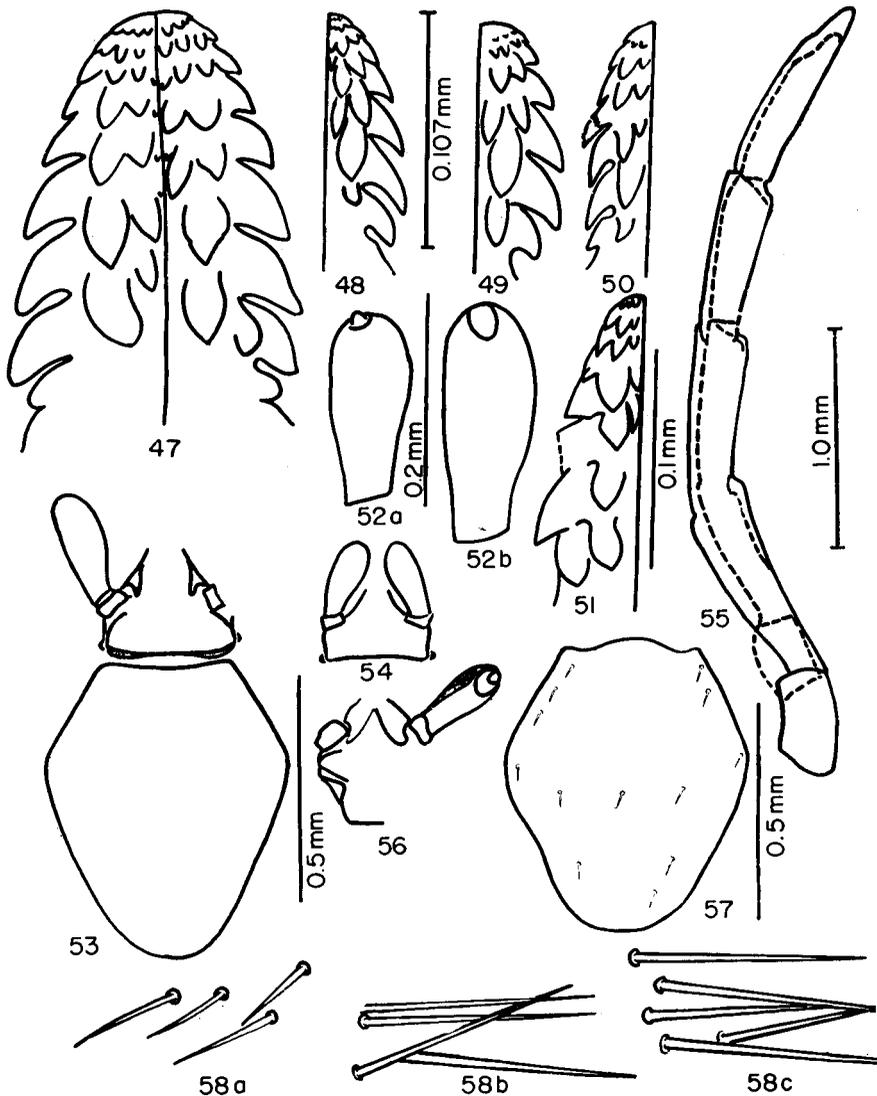


FIG. 47. *I. simplex africanus*, female, hypostome.

FIGS. 48-51. Hypostomes of *I. simplex simplex*. 48, from nymph, Kapretwa, Kitali, Kenya; 49, from nymph, Shanghai; 50, from nymph, Mount Elgon; 51, from female, Palestine.

FIGS. 52a-b. Nymphal palps from *I. simplex simplex* from Kapretwa, Kitali, Kenya (52a); from *Ixodes* sp. *incertae* (ORS coll. 2552) (52b).

FIGS. 53-54. Nymphal capitulum and scutum from *Ixodes* sp. *incertae* (ORS coll. 2552) (53); from *I. simplex simplex* from Kapretwa, Kitali, Kenya (54).

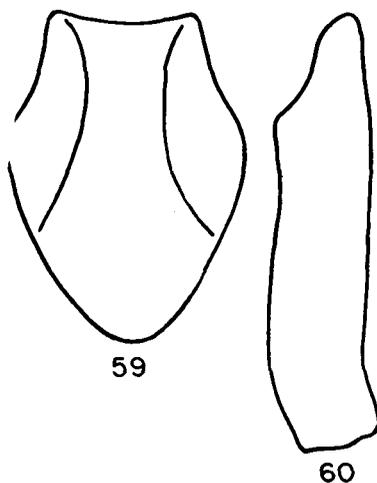
FIG. 55. Leg I of *I. simplex africanus* (thick line) superimposed on leg I of *I. simplex simplex* type from Kashmir (broken line).

FIGS. 56-57. *I. simplex simplex*, nymph. Type specimen from Shanghai (BMNH). 56, capitulum; 57, scutum.

FIG. 58a-c. Alloscutal hairs drawn to the same scale and taken from comparable areas of the body. a, from type specimen from Shanghai (BMNH); b, from *I. sp. incertae* (ORS coll. 2552); c, from *I. simplex africanus*.

*I. simplex africanus* new subspecies

The female specimen, which I refer to as the new subspecies *I. simplex africanus*, was collected in the crater of Mt. Menengai, Rift Valley, Kenya (H. Hoogstraal, no. 3957). The specimen was originally identified as *I. simplex* by Dr. Bequaert and Mr. Hoogstraal, but I consider it to merit subspecific rank.



FIGS. 59-60. *I. simplex africanus* female. 59, scutum; 60, tarsus I.

Description of female

Large subspecies, legs long and thick, alloscutum in alcohol-preserved specimens straw-colored, bearing strong, long, white hairs (cf. Figs. 58a, 58b, 58c). Scutum, legs and capitulum pale brown. Female, in partially gorged state, elongate oval. *Capitulum* (Figs. 27, 31, 47): Distinctly longer than broad, length 0.45 mm., breadth across dorsal ridge 0.39 mm. Lateral margins converging more strongly from posterior border to base of palps than in *I. simplex simplex* (cf. Figs. 24, 25, 26, 27). Dorsal ridge distinctly sinuous. Palps longer and relatively narrower, lacking bulbous character of *I. simplex simplex*; length of article II, 0.23 mm., length of article III, 0.13 mm.; hairs few and short. Porose areas very large, set in subcircular depression with well separated pores, some extending to dorsal ridge. Basis ventrally broad, auricular-like extensions not as prominent as in *I. simplex simplex* and waist practically negligible (cf. Figs. 28, 29, 30, 31). *Hypostome*: Length, 0.19 mm.; broad (in Fig. 47 the hypostome has been unduly flattened under the cover glass). Dentition asymmetrical in this specimen, arranged on left side as two rows of 1/1, five rows of 3/3, with an additional minute denticle on mesial side of last four rows, two rows 4/4 to tip; on right side, two rows of 1/1, one row 3/3, one row of 2/2, three rows of 3/3 (again with small mesial denticles), and two rows of 4/4. Hypostomal differences between *I. simplex simplex* (Shanghai specimen), *I. simplex simplex* from Palestine, and *I. simplex africanus* demonstrated by comparing Figs. 46, 47 and 51:

*Scutum* (Fig. 59): About equally convex anteriorly and posteriorly. Smooth, finely punctate, with few short hairs. Cervical grooves evident but not extending back to posterolateral border. Agreement in shape between the scufa of the two sub-species substantial, and such differences of detail as do exist may well come within normal range of intraspecific variation. Length, 1.35 mm., breadth, 0.9 mm.

Opisthosomatic hairs of *I. simplex africanus* nearly 2.5 times as long as those of *I. simplex simplex*.

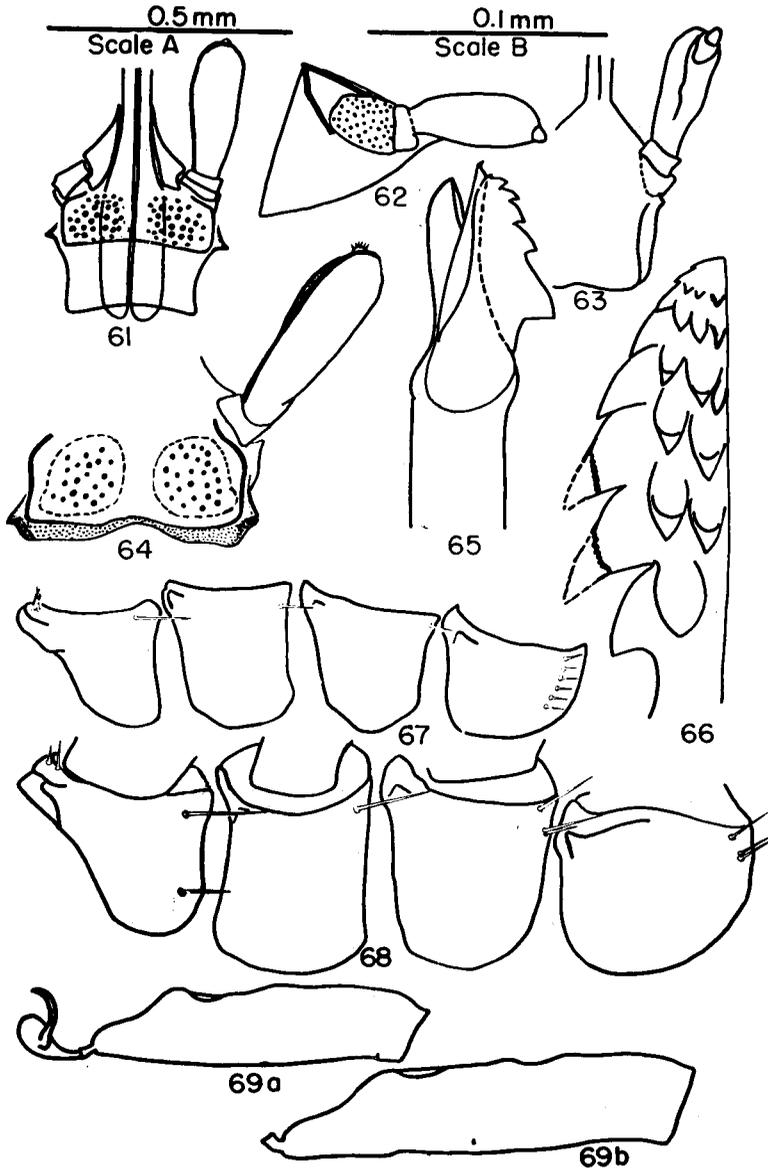
Coxae of African subspecies, as in *I. simplex simplex*, lacking spurs, coxae IV having rounded profile and presenting cupshaped outline; coxae in Shanghai female rectangular. Legs of *I. simplex africanus* longer than any of *I. simplex simplex* examined, and legs of former particularly stout and strong, as depicted in drawing by Hoogstraal (Ticks of the Sudan, in press) and as seen in superimposition of leg I of subspecies *I. simplex africanus* on that of Kashmir

type of *I. simplex simplex* (Fig. 55). Length of tarsus I, 0.89 mm. (Fig. 60), metatarsus I, 0.74 mm. Length of tarsus IV, 0.91 mm., metatarsus IV, 0.78 mm.

*Anal groove*: Ogival.

*Genital orifice*: Level with anterior margins of coxae III.

*Holotype female*: deposited in collection of Chicago Natural History Museum.



Figs. 61-63. *I. simplex simplex*, capitulum of female from Kapretwa, Kitali, Kenya. 61, dorsal view; 62, side view; 63, ventral view.

Figs. 64-66. *I. sp. incertae*, female from Irene, Pretoria (ORS coll. 2552). 64, capitulum, dorsal. The stippling represents the "cornua-like" flaps. 65, digit; 66, hypostome.

Figs. 67-68. Coxae I-IV of females of *I. simplex simplex* from Kapretwa, Kitali, Kenya (67) and from *I. sp. incertae* from Irene, Pretoria (ORS coll. 2552) (68).

Figs. 69 a-b, tarsus I of female of *I. simplex simplex* from Kapretwa, Kitali, Kenya (69a) and of *I. sp. incertae* (ORS coll. 2552) (69b).

Figs. 61-64, 67-69a, b, drawn to scale A; Figs. 65-66, drawn to scale B.

*Ixodes* sp. incertae

In the collection of ticks sent to me by Dr. G. Theiler is a nymph and female from *Myotis tricolor*, 10.1931, collected in a cave at Irene, Pretoria (O.R.S. no. 2552). Both the nymph and the female are consistently larger than *I. simplex simplex*. Although there is obviously a close affinity with the latter, the differences which make me uncertain are (1) the cornua-like flaps stippled in Figs. 53 and 64 which are reminiscent of those occurring in *I. vespertilionis* and are absent in *I. simplex simplex*, and (2) the very long legs of the Pretoria specimens. This is evident by a comparison of the coxae (Figs. 67 and 68) and of tarsus I (Figs. 69a, 69b). The tarsal and metatarsal lengths approach those of *I. simplex africanus*, being as follows: tarsus I, 0.86 mm., metatarsus I, 0.71 mm.; tarsus IV, 0.89 mm., metatarsus IV, 0.74 mm. The legs however are distinctly stouter than those of *I. vespertilionis* and are intermediate in thickness between those of *I. simplex simplex* and *I. simplex africanus*.

The hypostome (Fig. 66) does not conform to that of *I. vespertilionis* nor to those of known *simplex* specimens, the differences being such as to probably not constitute intraspecific variation. The scutum is not unlike that of *I. vespertilionis* and measures 1.19 mm. long by 0.97 mm. broad. The capitulum and scutum of the Pretoria nymph are figured (Fig. 53). I am hesitant about assigning to these specimens specific or varietal rank until further material is available.

## SUMMARY

1. This paper reviews the morphology and distribution of *Ixodes vespertilionis* Koch 1844, with particular reference to the female and the immature stages. New records of its occurrence in Switzerland, Greece, and Morocco are given.

2. A new species, *Ixodes spiculae*, from South Africa is described (host unknown).

3. *Ixodes simplex* Neumann, 1906, is subdivided into two subspecies, *I. simplex simplex*, which has been found in Palestine, Greece, France, Japan, China and Africa and *I. simplex africanus* from the Rift Valley, Kenya. Nymphs and larvae of *I. simplex simplex* are described and figured.

4. A South African form of uncertain status is described and figured but not named. It has affinities with both *I. simplex* and *I. vespertilionis*.

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