Onderstepoort J. vet. Res., 48, 87–104 (1981)

RHIPICEPHALUS ZAMBEZIENSIS SP. NOV., A NEW TICK FROM EASTERN AND SOUTHERN AFRICA, TOGETHER WITH A REDESCRIPTION OF *RHIPICEPHALUS APPENDICULATUS* NEUMANN, 1901 (ACARINA, IXODIDAE)

JANE B. WALKER(1), R. A. I. NORVAL(2) and M. D. CORWIN(3)

ABSTRACT

WALKER, JANE B., NORVAL, R. A. I. & CORWIN, M. D., 1981. *Rhipicephalus zambeziensis* sp. nov., a new tick from eastern and southern Africa, together with a redescription of *Rhipicephalus appendiculatus* Neumann, 1901 (Acarina, Ixodidae). *Onderstepoort Journal of Veterinary Research*, 47, 87–104 (1981).

All stages of *Rhipicephalus zambeziensis* sp. nov. are described from laboratory-reared specimens of a strain originating from cattle near West Nicholson, Gwanda District, Zimbabwe. The redescription of all stages of *Rhipicephalus appendiculatus* is based primarily on laboratory-reared specimens of a strain originating from a mountain reedbuck (*Redunca fulvorufula*), Loskop Dam Nature Reserve, Transvaal, Republic of South Africa. The differences between these 2 species are discussed briefly.

Details of the life cycle of *R. zambeziensis* under laboratory conditions are given, and attempts to cross-breed this species with *R. appendiculatus* are described and discussed.

Résumé

RHIPICEPHALUS ZAMBEZIENSIS *SP. NOV., UNE NOUVELLE TIQUE D'AFRIQUE ORIENTALE ET AUSTRALE, AVEC UNE NOUVELLE DESCRIPTION DE* RHIPICEPHALUS APPENDICULATUS

Tous les stades du Rhipicephalus zambeziensis *sp. nov. sont décrits à partir de spécimens d'une souche provenante de bovidés de West Nicholson, District Gwanda, Zimbabwe et élevés en laboratoire. La nouvelle description de tous les stades du* Rhipicephalus appendiculatus *est primairement basée sur des spécimens d'une souche issue d'une antilope de montagne* (Redunca fulvorufula) *de la réserve naturelle du barrage de Loskop au Transvaal, République d'Afrique du Sud, eux aussi élevés en laboratoire. Les différences entre ces deux espèces sont brièvement discutées.*

Des détails de l'évolution de R. zambeziensis *sous des conditions de laboratoire sont fournis et les tentatives de croisements de cette espèce avec* R. appendiculatus *sont décrites et discutées.*

INTRODUCTION

In their survey of the ixodid ticks of Tanzania, Yeoman & Walker (1967) included a species that came from the Ruaha Valley and its southern slopes. This tick was described briefly as being intermediate in appearance between *Rhipicephalus appendiculatus* Neumann, 1901 and *Rhipicephalus sculptus* Warburton, 1912, but as they were not convinced that it was new, rather than an atypical form of *R. appendiculatus*, they designated it merely as *Rhipicephalus* species II. Since then, however, numerous field collections of this tick have been seen by the writers, and other authors, from the following areas: Zambia, in parts of the Luangwa Valley, on the escarpment slopes of the Zambezi Valley, in the lower Gwembe Valley and in the Kafue National Park (MacLeod, 1970; MacLeod, Colbo, Madbouly & Mwanaumo, 1977; MacLeod & Mwanaumo, 1978); Zimbabwe, especially in the Zambezi Valley and in the western and southern parts of the country; South West Africa (Namibia) at Otjipemba, Ekota and Ondjarakagha in the Kaokoveld and from Grootfontein; Botswana, near Sehitwa, and also in the eastern part of the country (Walker, Mehlitz & Jones, 1978), and the Republic of South Africa, mainly from the northern and western Transvaal.

Some of the collections included live adults; these were fed in the laboratory and complete series of larvae, nymphae and adults of 2 strains, one from Zimbabwe and the other from South West Africa, were reared. Careful examination of all stages of this tick, and comparisons of these with all stages of *R. appendiculatus*, plus cross-breeding experiments with these 2 species, have now shown that *Rhipicephalus* sp. II is a separate and distinct entity. This is formally described below as *Rhipicephalus zambeziensis* sp. nov.

The adults of *R. appendiculatus* were originally described by Neumann (1901), and its immature stages by Howard (1908). One or more of its stages have since been redescribed, sometimes very briefly, by various authors, among them Nuttall (1913); Zumpt (1942); Theiler (1943); Hoogstraal (1956), and Arthur (1975). Nevertheless a detailed redescription of all stages that includes scanning electron microscope (SEM) photographs, and is strictly comparable with the description of *R. zambeziensis*, is included here because it is considered necessary for the proper differentiation of these 2 very similar species.

Details of the life cycle of *R. zambeziensis* under laboratory conditions are given and are compared with observations made by other workers on the life cycle of *R. appendiculatus*. The results of attempts to cross breed these 2 species in the laboratory are also discussed.

Rhipicephalus zambeziensis Walker, Norval & Corwin, sp. nov.

Syn. *Rhipicephalus zambeziensis* Lawrence & Norval, 1979, *Rhodesian Veterinary Journal*, 10, p. 28, *nomen nudum*.

Holotype: ♂, laboratory-reared, from a strain originally collected from cattle, Driehoek Ranch (21°25'S., 29°46'E.), near West Nicholson, Gwanda District, Zimbabwe in 1976 by R. A. I. Norval.

Allotype: ♀, data as above.

Paratypes: ♂♂, ♀♀, nymphae and larvae, data as above.

(1) Veterinary Research Institute, P.O. Onderstepoort, Republic of South Africa, 0110
(2) Veterinary Research Laboratory, P.O. Box 8101, Causeway, Salisbury, Zimbabwe
(3) United States Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratory, Hamilton, Montana 59840, U.S.A.

Received 9 March 1981—Editor

The holotype, allotype and some paratypes are deposited in the collection of the Veterinary Research Institute, Onderstepoort (Ref. No. 3240). Additional paratypes are in the collections of the Veterinary Research Laboratory, Salisbury, Zimbabwe; the British Museum (Natural History), London, and the Rocky Mountain Laboratory, Hamilton, U.S.A. (RML 105751).

DESCRIPTIONS

All measurements given below are in millimetres. The dimensions given for the adults are those of the largest and the smallest specimens in the type series. For the nymphae and larvae the dimensions given are those of the largest of 5 slide-mounted specimens that were measured.

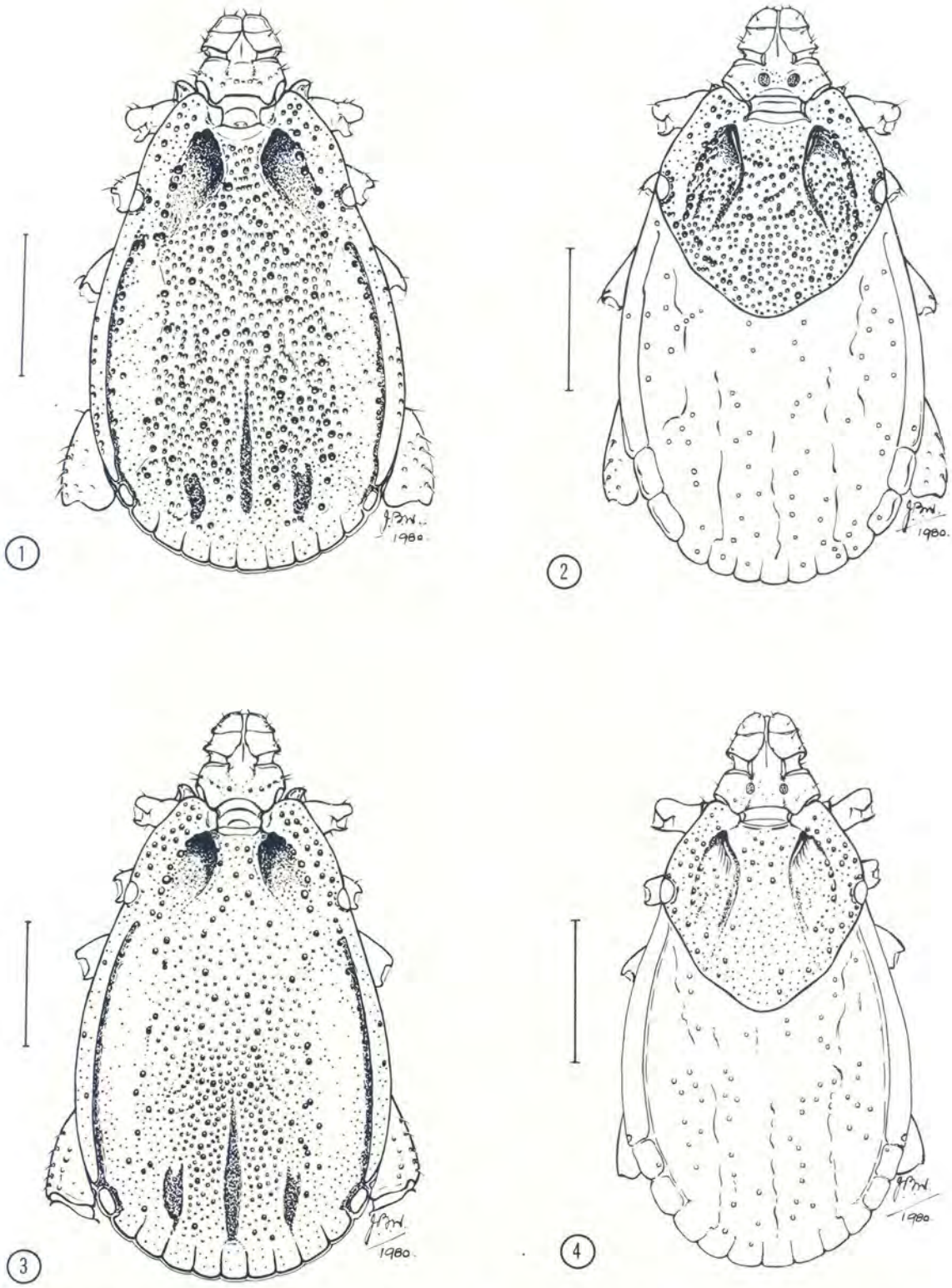


FIG. 1–4 *Rhipicephalus zambeziensis* sp. nov., (1) male, dorsal view; (2) female, dorsal view; *Rhipicephalus appendiculatus* Neumann, (3) male, dorsal view; (4) female, dorsal view. Scale next to each figure represents 1 mm

Male (Fig. 1, 5–10). A moderate-sized, inornate, dark brown tick that closely resembles *R. appendiculatus* in general appearance but is more heavily punctate.

Capitulum (Fig. 5, 6). Not quite as broad as long, the length (including the cornua) × breadth ranging from 0,85×0,76 to 0,62×0,60. Large oval subcollare present. Ventral surface as illustrated.

Basis capituli ranging from about a third broader than long to nearly twice as broad as long; length (including the cornua)×breadth varying from 0,50×0,76 to 0,32×0,60. Antero-lateral margins short, sometimes slightly sinuous, divergent, forming sharp angles at their junctions with the long, concave, convergent postero-lateral margins; posterior margin slightly concave; cornua well-developed. An arc of large, sometimes confluent, punctations, each containing a long, strong seta, present across the middle of the basis capituli.

Palps. Article I easily visible dorsally; article II about a quarter longer than article III; tip of article III sometimes slightly rounded.

Conscutum (Fig. 1, 7–8). Length×breadth ranging from 3,60×2,40 to 2,65×1,70. Inornate, dark brown, well chitinized; narrower anteriorly and widening behind the eyes; in engorged specimens body wall expanded posterolaterally and a tail-like caudal appendage present. Anterior process of coxa I large, sharp, heavily chitinized and easily visible from dorsal surface. Emargination narrow and deep. Eyes less than a third of the way back, marginal, almost flat, delimited by a shallow groove with a few large punctations dorsally. Cervical fields well-marked, depressed, with finely reticulate surfaces. Marginal grooves well-developed, anteriorly reaching nearly to eye level, posteriorly embracing 1 festoon. Postero-median and postero-lateral grooves well developed, the former long and narrow, the latter short and broad, with finely reticulate surfaces. Festoons well-marked. In general, punctation pattern heavy, made up of elements of 3 different sizes. Individual punctations usually discrete, but sometimes so dense that they coalesce in places, making the tick look somewhat rugose. The largest punctations, which are setaceous, particularly evident on the scapulae, along the outer edges of the cervical fields, and in the marginal grooves. On the central part of the conscutum, from the cervical fields to the festoons, they are scattered amongst the far more numerous medium-sized punctations. The short, rather stout, shiny white setae in the large punctations (Fig. 8) show up when the specimen is tilted back and illuminated obliquely from the front. Minute pin-point punctations scattered all along the sides of the conscutum, both in front of and behind the eyes, adjacent to the inner edges of the marginal grooves and round the posterior end of the conscutum.

Legs (Fig. 7). Show a marked increase in size from I–IV.

Ventral surface. Bears scattered, fairly numerous white setae. *Spiracle* (Fig. 9). Elongate, tapering towards the dorsal surface.

Anal plates (Fig. 10). Relatively long, tapering, narrowly rounded at the posterior end.

Accessory anal plates. Represented merely by very small chitinized points adjacent to the anal plates.

Female (Fig. 2, 11–16). A moderate-sized, inornate, dark brown tick that strongly resembles *R. appendiculatus* in general appearance but is more heavily punctate.

Capitulum (Fig. 11, 12). Slightly broader than long, the length (including the cornua)×breadth ranging from 0,83×0,95 to 0,60×0,70. Ventral surface as illustrated.

Basis capituli over twice as broad as long, the length (including the cornua)×breadth ranging from 0,38×0,95 to 0,30×0,70. Antero-lateral margins short, nearly straight, strongly divergent; postero-lateral margins long, concave, convergent; posterior margin straight; cornua well-developed. A row of setae present each side, more or less parallel to the postero-lateral borders. Porose areas sometimes slightly irregular in shape, approximately twice their own diameter apart.

Palps. Article I easily visible from the dorsal surface; article II only slightly longer than article III; tip of article III blunt.

Body. Length×breadth in unfed specimens ranging from 3,70×2,30 to 2,50×1,60. Alloscutum not deeply folded, even in unfed specimens, and bearing scattered, short, rather inconspicuous white setae.

Scutum. (Fig. 13–14). Usually about as broad as long but sometimes either slightly longer than broad or slightly broader than long, in the specimens measured ranging from 1,71×1,71 to 1,25×1,25. Inornate, dark brown, well chitinized; broadest about half-way back, at eye level; posterior border sinuous. Emargination wide. Eyes marginal, almost flat, delimited dorsally by quite a deep groove picked out with a few large punctations. Cervical fields well-marked, depressed; outer margins delimited by large punctations; surfaces slightly reticulate in places, especially along the inner margins. Punctation pattern basically heavy. Largest punctations particularly evident on the scapulae and along the outer margins of the cervical fields, where they sometimes coalesce, and scattered over the central part of the scutum. They contain short, shiny, white setae, but these are rather difficult to see under the stereomicroscope unless the specimen is tilted back and illuminated obliquely from the front. Numerous medium-sized punctations, which may coalesce in places, present on the central part of the scutum. Finest punctations scattered amongst the large punctations on the lateral borders in front of the eyes.

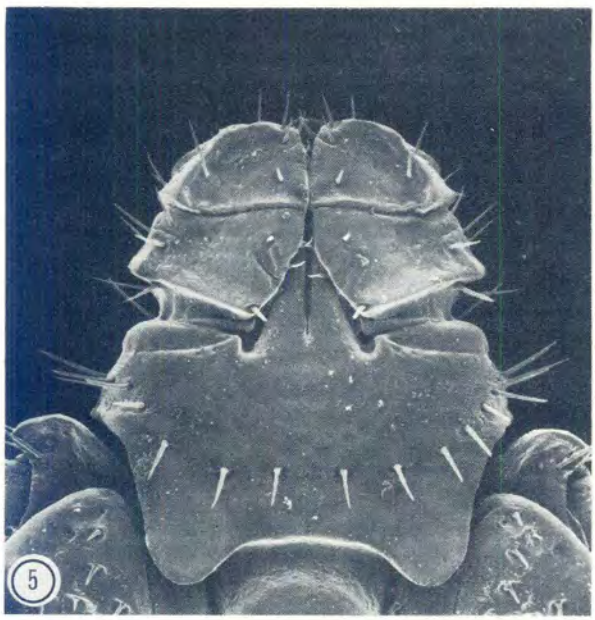
Ventral surface. Bears scattered white setae which are longest and most conspicuous in front of the genital aperture; elsewhere they are small, short and much less obvious than those on the male.

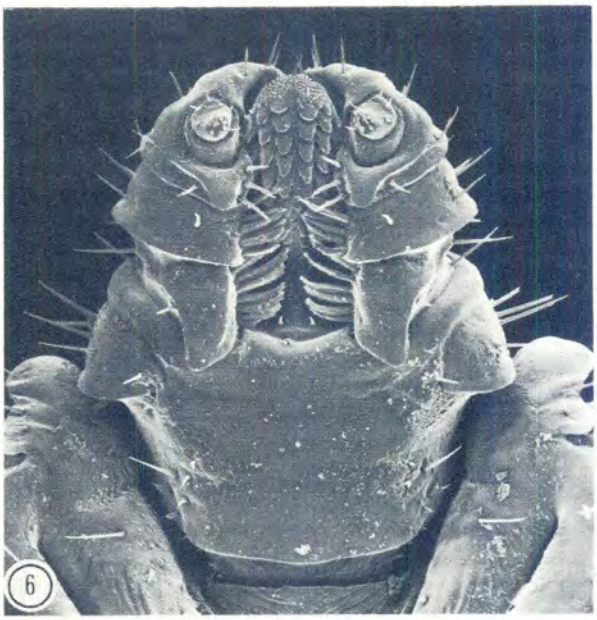
Genital aperture (Fig. 15). A wide opening, straight posteriorly, only curving forwards at the sides. The genital apron is thus almost rectangular in shape.

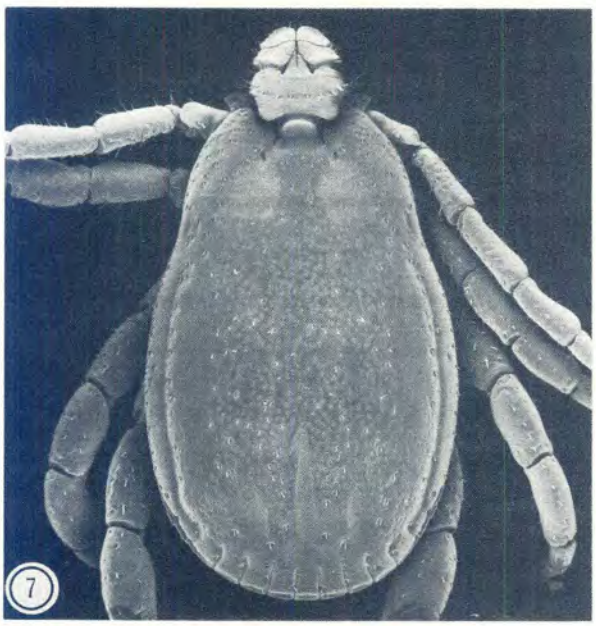
Spiracle (Fig. 16). Broad and rounded, with only a very short extension towards the dorsal surface.

FIG. 5–10 *Rhipicephalus zambeziensis* sp. nov., male, (5) capitulum, dorsal; (6) capitulum, ventral; (7) dorsal view; (8) scapular area, dorsal; (9) spiracle; (10) anal plates →

FIG. 11–16 *Rhipicephalus zambeziensis* sp. nov., female, (11) capitulum, dorsal; (12) capitulum, ventral; (13) scutum, dorsal; (14) scapular area, dorsal; (15) genital aperture; (16) spiracle →


5

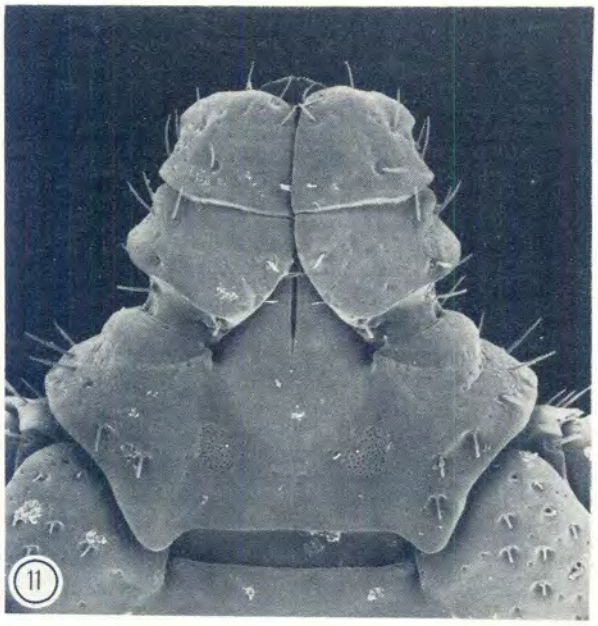

6

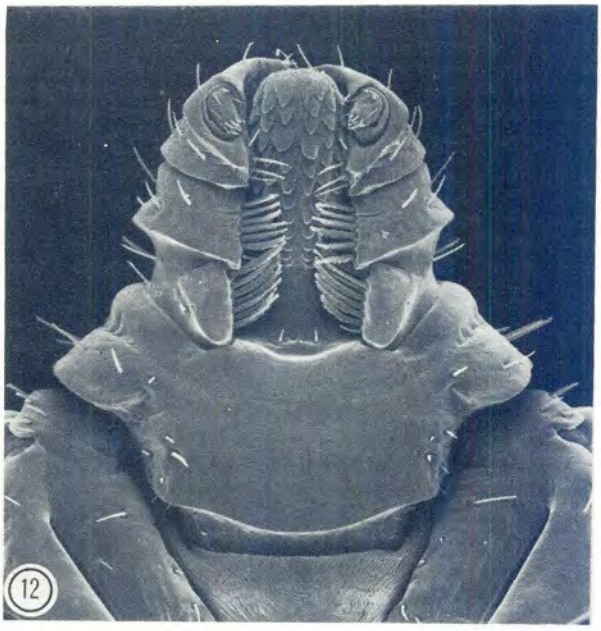

7


8


9

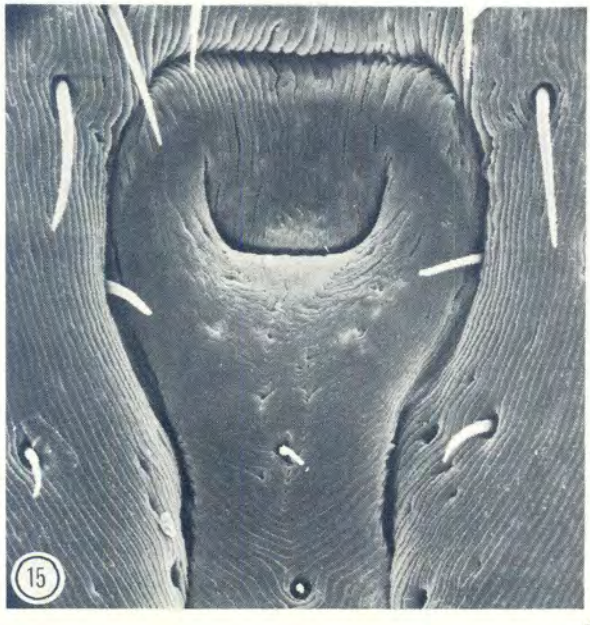

10


11


12


13


14


15


16

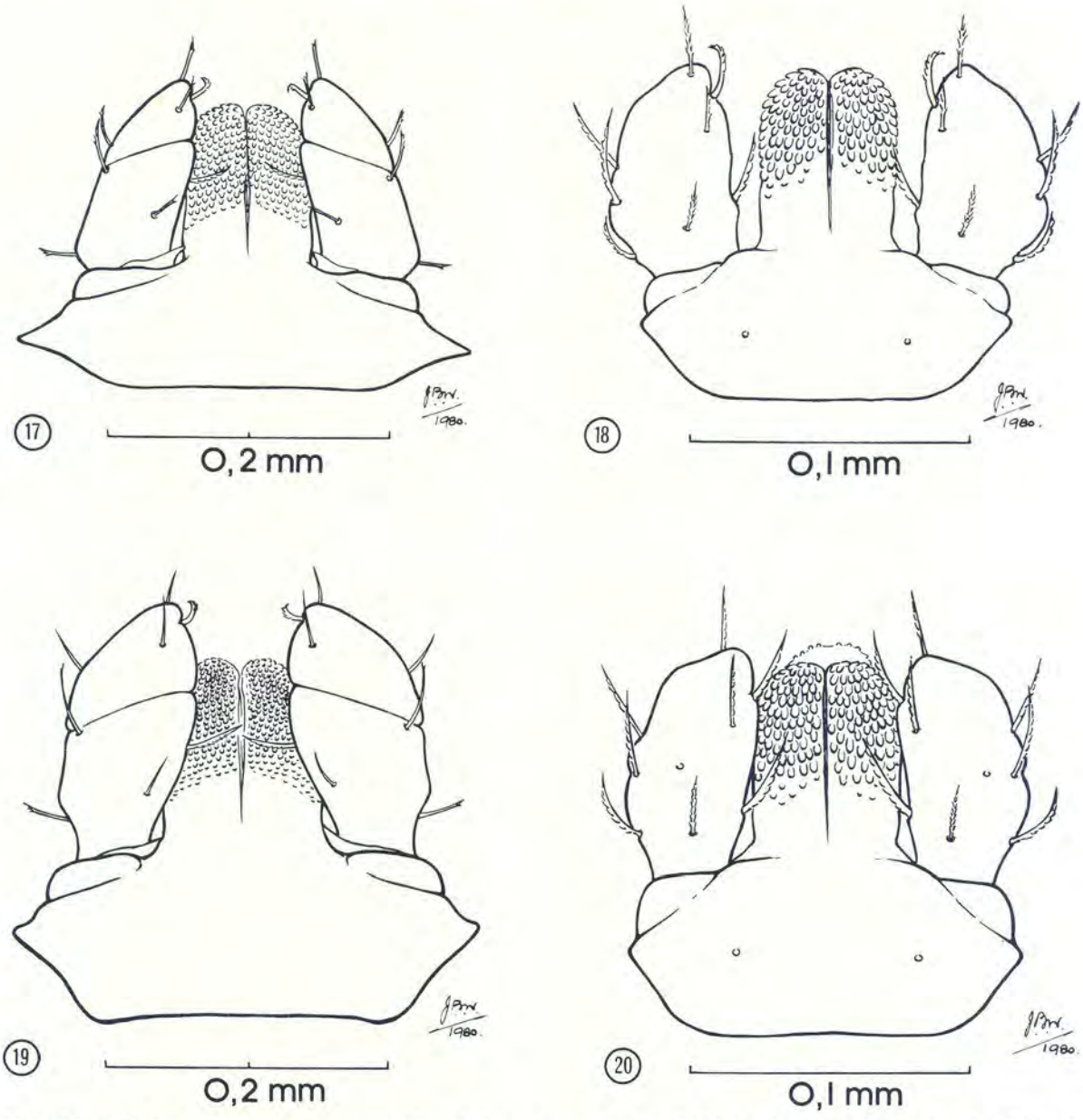


FIG. 17–20 *Rhipicephalus zambeziensis* sp. nov., (17) capitulum of nymph, dorsal; (18) capitulum of larva, dorsal; *Rhipicephalus appendiculatus* Neumann (19) capitulum of nymph, dorsal; (20) capitulum of larva, dorsal

Nymph (Fig. 17, 21–26).

Capitulum (Fig. 17, 21–22). Length (measured from tip of hypostome to posterior border of basis capituli) × breadth 0,20 × 0,33; much broader than long. Ventral surface as illustrated.

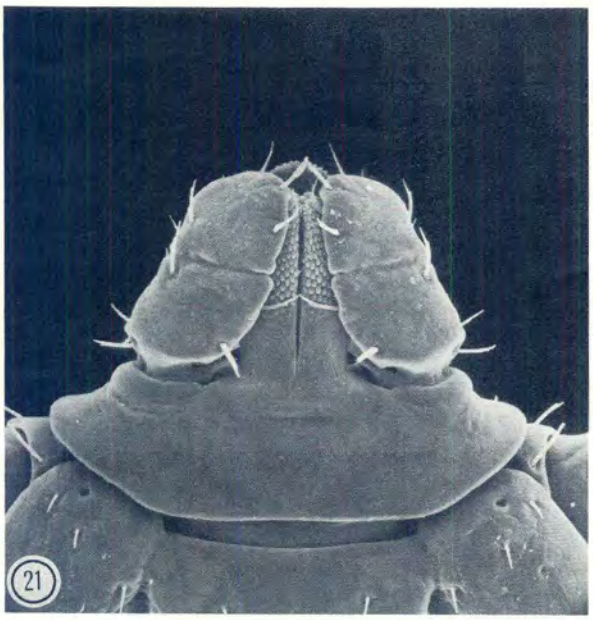
Basis capituli. Length × breadth 0,09 × 0,33; over 3 times as broad as long. Antero-lateral margins comparatively short, mildly concave, divergent; postero-lateral margins longer, strongly convergent and joining the straight posterior margin in a long smooth curve; no cornua. The precise appearance of the basis capituli depends on the tilt of the capitulum, as can be seen by comparing Fig. 17, 21 and 23. In slide-mounted specimens the capitulum is usually inclined slightly downwards, as in Fig. 23, consequently the lateral angles look sharp, not rounded as in Fig. 21, and they project sideways rather than looking somewhat retroussé.

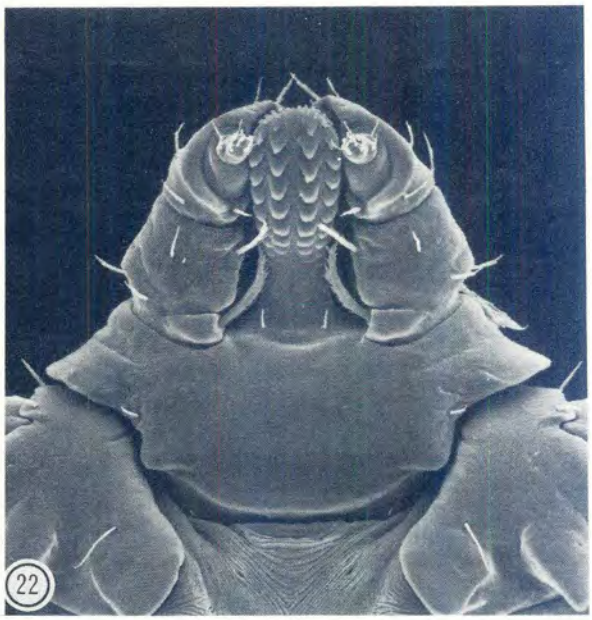
Palps. Article I easily visible from dorsal surface; articles II and III almost the same length. Narrower at the base and apex, otherwise virtually even in width throughout their length.

Body (Fig. 23). Length × breadth of unfed specimen 1,28 × 1,03. Alloscutum bears scattered setae.

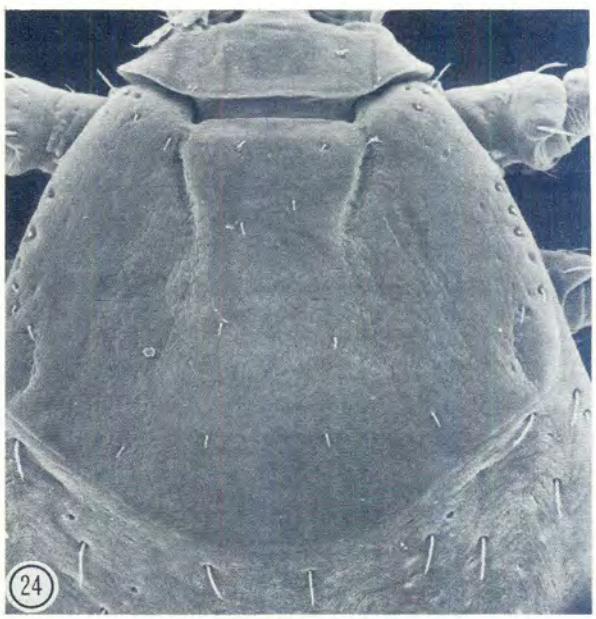
FIG. 21–26 *Rhipicephalus zambeziensis* sp. nov., nymph, (21) capitulum, dorsal; (22) capitulum, ventral; (23) dorsal surface; (24) scutum, dorsal; (25) coxae; (26) spiracle →

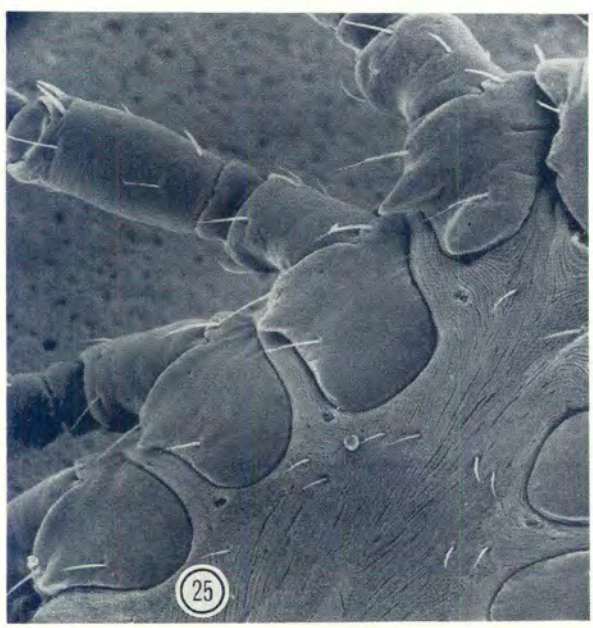
FIG. 27–31 *Rhipicephalus zambeziensis* sp. nov., larva, (27) capitulum, dorsal; (28) capitulum, ventral; (29) dorsal surface; (30) scutum, dorsal; (31) coxae →

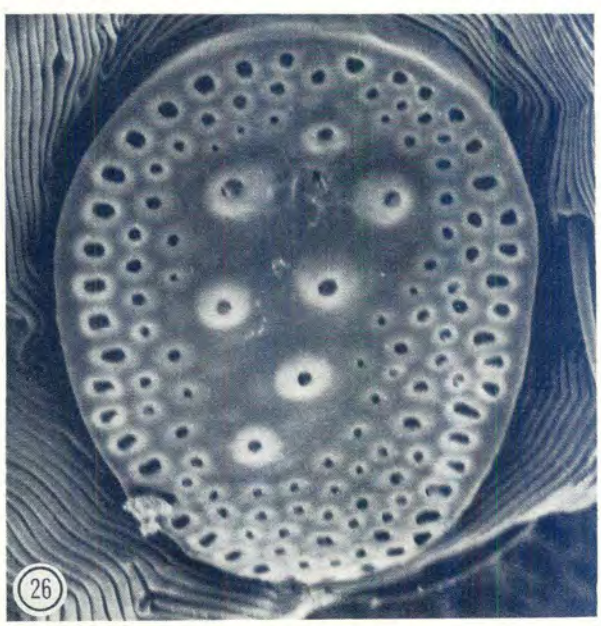

21

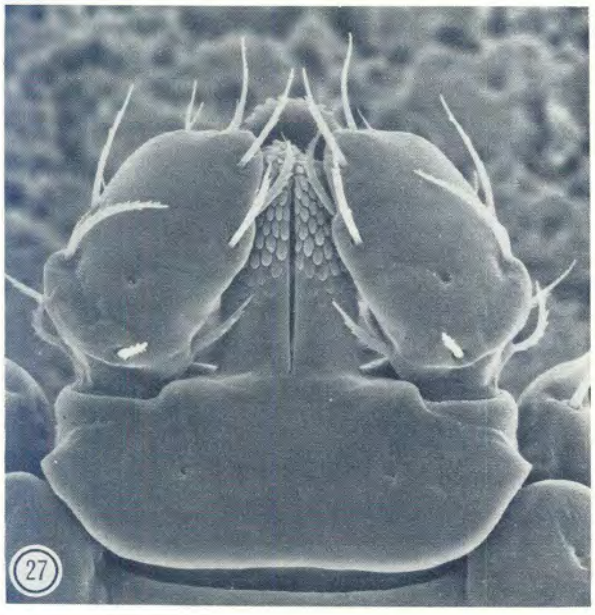

22

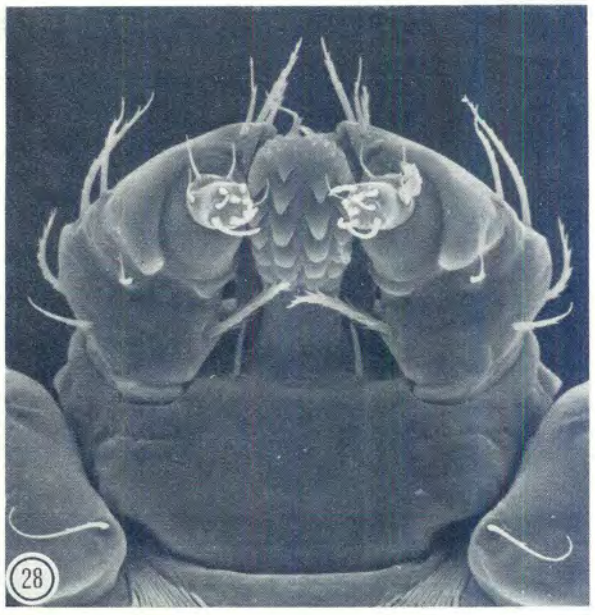

23


24


25


26


27


28


29


30


31

Scutum (Fig. 24). Length × breadth 0,52 × 0,64; much broader than long. Emargination wide and fairly shallow. Antero-lateral borders only very slightly convex; postero-lateral borders usually straight, sometimes very slightly sinuous, meeting mid-dorsally in a broad, smooth curve. Eyes at the widest part of the scutum, slightly bulging, each edged dorsally by a shallow groove. Cervical fields depressed, relatively narrow; their outer margins almost straight, their inner margins fairly deep and convergent initially, becoming shallower and divergent and running back almost parallel to the outer margins. Scutal setae sparse and much shorter and finer than those on the alloscutum.

Ventral surface. Coxae (Fig. 25). Coxa I with a relatively long, sharp external spur and a relatively short, broad, rounded internal spur. Coxae II, III and IV with short, sharp, external spurs.

Spiracle (Fig. 26). Almost egg-shaped, with a few scattered pores in the centre surrounded by a peripheral belt of numerous closely-set pores.

Larva (Fig. 18, 27–31).

Capitulum (Fig. 18, 27–28). Length (measured from tip of hypostome to posterior border of basis capituli) × breadth 0,12 × 0,145, broader than long. Ventral surface as illustrated.

Basis capituli. Length × breadth 0,055 × 0,145; over twice as broad as long. Antero-lateral margins short, divergent; postero-lateral margins long, convergent, slightly sinuous; lateral angles short and sharp. Posterior margin straight to very slightly concave.

Palps. Constricted at the base, then widening markedly; tips truncated.

Body (Fig. 29). Length × breadth of unfed specimen 0,54 × 0,47.

Scutum (Fig. 30). Length × breadth 0,25 × 0,41. Emargination wide and shallow. Antero-lateral borders slightly convex; postero-lateral borders straight, meeting mid-dorsally in a broad, shallow curve. Eyes at the widest part of the scutum, delimited dorsally by shallow grooves. Cervical grooves short, slightly convergent.

Ventral surface. Coxae (Fig. 31). A single spur present on each coxa, that on coxa I being much the largest and sharpest while those on coxae II and III are smaller, broader and blunter. On some specimens the spurs on coxae II and III are very reduced.

Rhipicephalus appendiculatus Neumann, 1901

This redescription is based primarily on an F_1 series of this species reared by Dr W. O. Neitz (Ref. No. 3305, RML No. 105752) from a ♀ taken off a mountain reedbuck [*Redunca fulvorufula* (Afzelius, 1815)], Loskop Dam Nature Reserve (25°24′S, 29°21′E), Transvaal, 8th August 1970, by L. R. Irby.

Redescription

All measurements given below are in millimetres. Series 3305 does not include specimens showing the great range of sizes recorded for this species by Nuttall (1913). The dimensions given are those of the largest ♂ and ♀ in this series, and of the largest of 5 slide-mounted nymphae and larvae, plus the range of body measurements recorded by Nuttall (1913) for adults and nymphae [in brackets].

Male (Fig. 3, 32–37). A moderate-sized, inornate, reddish-brown tick.

Capitulum (Fig. 32–33). Not quite as broad as long, the length (including the cornua) × breadth of the largest ♂ 0,96 × 0,80. Large oval subcollare present. Ventral surface as illustrated.

Basis capituli. About a quarter broader than long in large specimens, the length (including the cornua) × breadth in the largest ♂ 0,54 × 0,80; in small males much broader than long. Antero-lateral margins short, only slightly divergent, forming obtuse angles at their junctions with the much longer, concave, convergent postero-lateral margins; posterior margin concave, cornua large. In smaller specimens the lateral angles tend to be more acute (Nuttall, 1913, Fig. 3). An arc of large, discrete punctations, each containing a long strong seta, present across the middle of the basis capituli.

Palps. Article I easily visible from dorsal surface; article II slightly longer than article III; tip of article III rather flattened.

Conscutum (Fig. 3, 34–35). Length × breadth of largest ♂ 4,15 × 2,75 [range 4,4 × 2,8 to 1,8 × 1 (Nuttall, 1913)]. Inornate, reddish-brown and well chitinized; narrower anteriorly and widening behind the eyes; in engorged specimens body wall expanded postero-laterally and a tail-like caudal appendage present. Anterior process of coxa I large, sharp, heavily chitinized and easily visible from the dorsal surface. Emargination narrow and deep. Eyes less than a third of the way back, marginal, almost flat, delimited dorsally by a very shallow groove, and sometimes 1 or 2 large punctations. Cervical fields well-marked, depressed, with finely reticulate surfaces. Marginal grooves well-developed, anteriorly reaching nearly to eye level, posteriorly embracing 1 festoon. Postero-median and postero-lateral grooves well-developed, the former long and narrow, the latter short and broad, with finely reticulate surfaces. Festoons well-marked. In general punctation pattern medium to light, made up of elements of 3 different sizes. The largest punctations, which are setaceous, particularly evident on the scapulae, along the outer edges of the cervical fields and along the marginal grooves. On the central part of the conscutum, from the cervical fields to the festoons, they are widely scattered among the much more numerous medium-sized punctations. The small, inconspicuous, shiny white setae in the large punctations (Fig. 35) are difficult to see under the stereomicroscope unless the specimen is tilted back and illuminated obliquely from the front. Minute pinpoint punctations are scattered all along the sides of the conscutum, both in front of and behind the eyes, adjacent to the marginal grooves and round the posterior end of the conscutum.

In small specimens the scutum is often much less strongly chitinized and the pattern of grooves and punctations is usually much reduced (Nuttall, 1913, Fig. 3).

Legs (Fig. 34). Show a marked increase in size from I–IV.

Ventral surface. Bears fairly numerous, scattered fine white setae. *Spiracle* (Fig. 36). Quite broad at the ventral end, tapering gently towards the dorsal end.

Anal plates (Fig. 37). Relatively short and broad, tapering abruptly and broadly rounded at the posterior end. In small specimens often more smoothly curved in outline (Nuttall, 1913, Fig. 3).

Accessory anal plates. Represented by relatively small, short, pointed projections adjacent to the anal plates.

Female (Fig. 4, 38–43). A moderate-sized inornate, reddish-brown tick.

Capitulum (Fig. 38–39). Slightly broader than long, the length (including the cornua) × breadth of the largest ♀ 0,84 × 0,92. Ventral surface as illustrated.

Basis capituli over twice as broad as long, the length (including the cornua) × breadth of the largest ♀ 0,40 × 0,92. Antero-lateral margins short, straight, strongly divergent; postero-lateral margins long, concave, convergent; posterior margin straight, cornua large and broadly rounded. A row of setae present each side, more or less parallel to the postero-lateral borders. Porose areas rounded, well over twice their own diameter apart.

Palps. Article I easily visible from the dorsal surface, article II longer than article III; tip of article III blunt.

Body. Length × breadth of largest ♀, unfed, in series 3305 3,40 × 2,30 [range 4,3 × 2,8 to 1,8 × 1 (Nuttall, 1913)]. Alloscutum not deeply folded, even in unfed specimens, and bearing scattered short, rather inconspicuous, white setae.

Scutum (Fig. 40–41). A little broader than long, in the largest ♀ length × breadth 1,56 × 1,60. Inornate, reddish-brown, well chitinized; broadest at eye level, not quite half-way back, posterior margin sinuous. Emargination wide. Eyes marginal, almost flat, delimited dorsally by a faint groove picked out with a few punctations. Cervical fields depressed, with outer margins delimited by large punctations and sometimes a slight ridge; surfaces slightly reticulate in places. In general punctation pattern light. Largest punctations present on the scapulae, along the outer margins of the cervical fields and scattered over the central part of the scutum. They contain very short, shiny white setae but these are virtually impossible to see under the stereomicroscope unless the specimen is tilted back and illuminated obliquely from the front. Numerous small punctations, and in places minute pin-point punctations, scattered over the scutum.

Ventral surface. Bears scattered fine white setae which are longest and most conspicuous in front of the genital aperture. Elsewhere they are very small and short.

Genital aperture (Fig. 42). Smoothly curved, rather like the tip of a tongue in shape.

Spiracle (Fig. 43). Broadly comma-shaped.

Nymph (Fig. 19, 44–49).

Capitulum (Fig. 19, 44–45). Length (measured from tip of hypostome to posterior border of basis capituli) × breadth 0,27 × 0,34; broader than long. Ventral surface as illustrated.

Basis capituli. Length × breadth 0,13 × 0,34. Antero-lateral margins short, divergent; postero-lateral margins much longer, slightly concave and convergent, joining the slightly concave posterior margin fairly abruptly. As always, it is important to remember that the precise shape of the basis capituli depends on the angle from which it is viewed (compare Fig. 19, 44 and 46).

Palps. Article I easily visible from the dorsal surface; article II longer than article III; widest at the junction between articles II and III.

Body (Fig. 46). Length × breadth of unfed specimen 1,42 × 0,96. Alloscutum bears short, scattered setae.

Scutum (Fig. 47). Length × breadth 0,62 × 0,70; much broader than long. Emargination wide and fairly shallow. Antero-lateral borders convex; postero-lateral borders straight, meeting mid-dorsally in a broad smooth curve. Eyes at the widest part of the scutum, slightly bulging, each edged dorsally by a shallow depression. Cervical fields depressed, relatively broad; their outer margins slightly convex, their inner margins fairly deep and convergent initially, becoming divergent and very shallow. Scutal setae sparse; shorter and finer than those on the alloscutum.

Ventral surface. Coxae (Fig. 48). Coxa I with a relatively long narrow external spur and a shorter, much broader, internal spur. Coxae II, III and IV with much smaller external spurs.

Spiracle (Fig. 49). More or less oval, with scattered pores in the centre surrounded by a peripheral belt of numerous closely-set pores.

Larva (Fig. 20, 50–54).

Capitulum (Fig. 20, 50–51). Length (measured from tip of hypostome to posterior border of basis capituli) × breadth 0,16 × 0,16. As broad as long, or nearly so. Ventral surface as illustrated.

Basis capituli. Length × breadth 0,07 × 0,16; a little over twice as broad as long. Antero-lateral margins short, divergent; postero-lateral margins long, convergent, very slightly concave; lateral angles very short and blunt. Posterior margin very slightly concave.

Palps. Constricted at the base, then widening markedly; tips truncated.

Body (Fig. 52). Length × breadth of unfed specimen 0,55 × 0,50.

Scutum (Fig. 53). Length × breadth 0,28 × 0,45. Emargination wide and medium in depth. Antero-lateral borders convex; postero-lateral borders straight, meeting mid-dorsally in a broad smooth curve. Eyes at the widest part of the scutum, delimited dorsally by a faint groove. Cervical grooves short, slightly convergent.

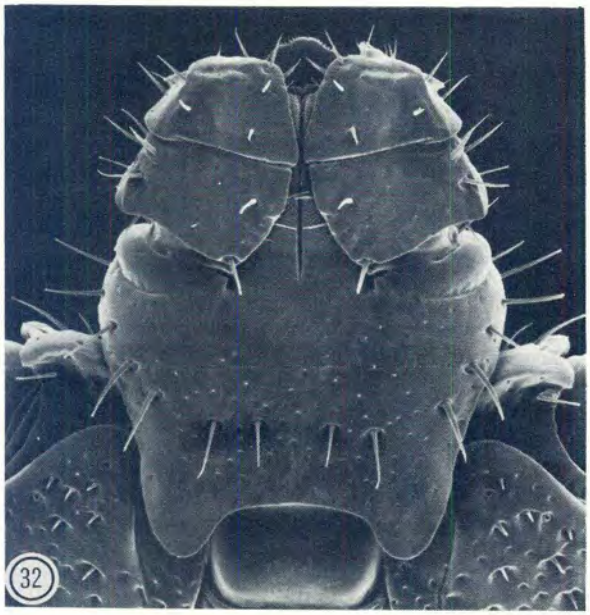
Ventral surface. Coxae (Fig. 54). A single spur present on each coxa, that on coxa I broad and rather blunt, those on coxae II and III ridgelike.

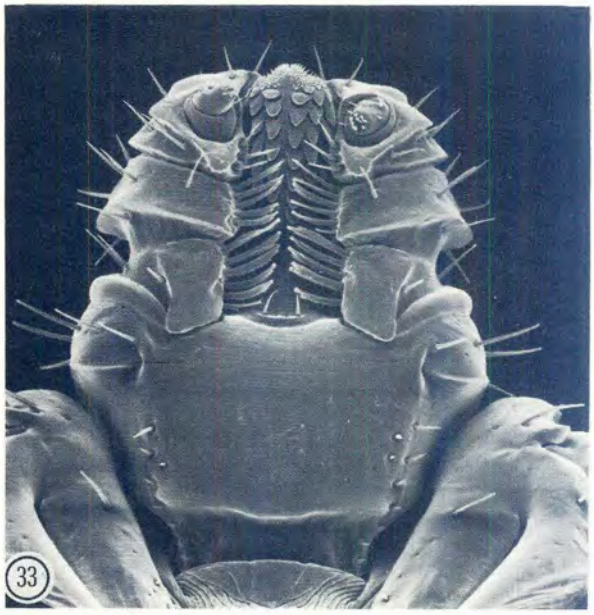
FIG. 32–37 *Rhipicephalus appendiculatus* Neumann, male, (32) capitulum, dorsal; (33) capitulum, ventral; (34) dorsal view; (35) scapular area, dorsal; (36) spiracle; (37) anal plates →

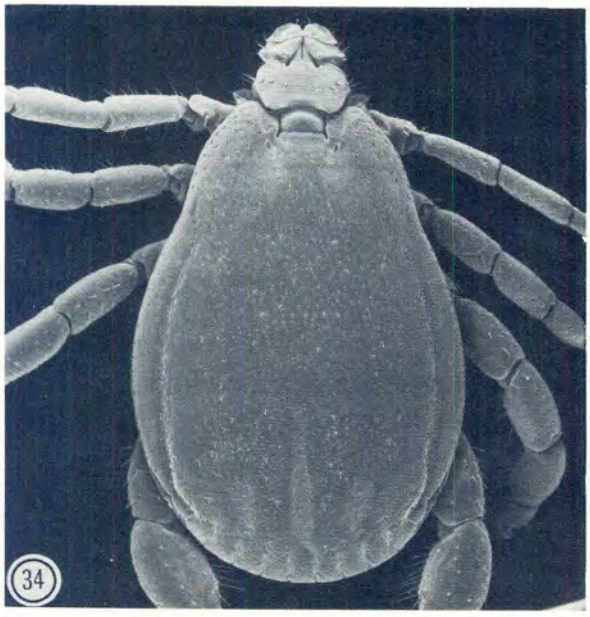
FIG. 38–43 *Rhipicephalus appendiculatus* Neumann, female, (38) capitulum, dorsal; (39) capitulum, ventral; (40) scutum, dorsal; (41) scapular area, dorsal; (42) genital aperture; (43) spiracle →

FIG. 44–49 *Rhipicephalus appendiculatus* Neumann, nymph, (44) capitulum, dorsal; (45) capitulum, ventral; (46) dorsal surface; (47) scutum, dorsal; (48) coxae; (49) spiracle →

FIG. 50–54 *Rhipicephalus appendiculatus* Neumann, larva, (50) capitulum, dorsal; (51) capitulum, ventral; (52) dorsal view; (53) scutum, dorsal; (54) coxae →

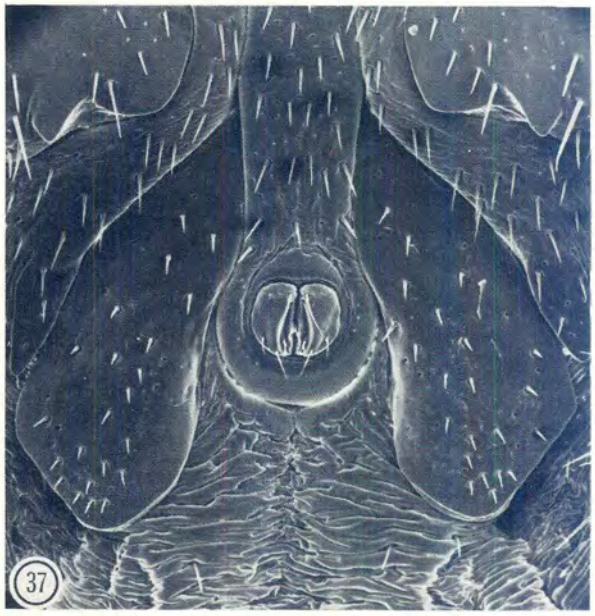

32

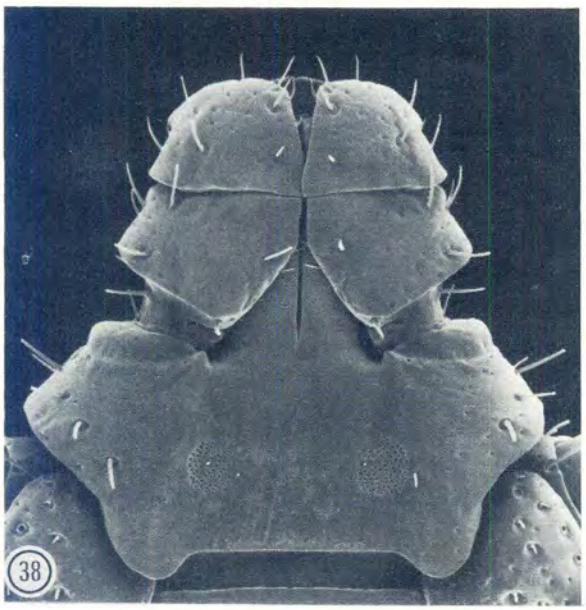

33


34

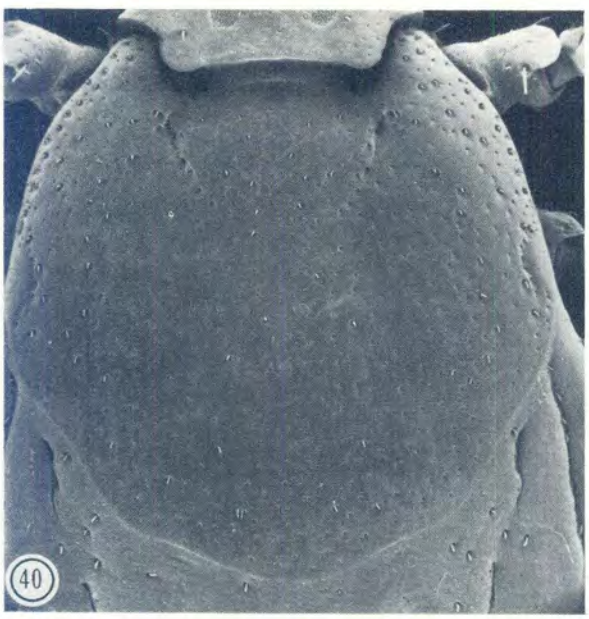

35


36

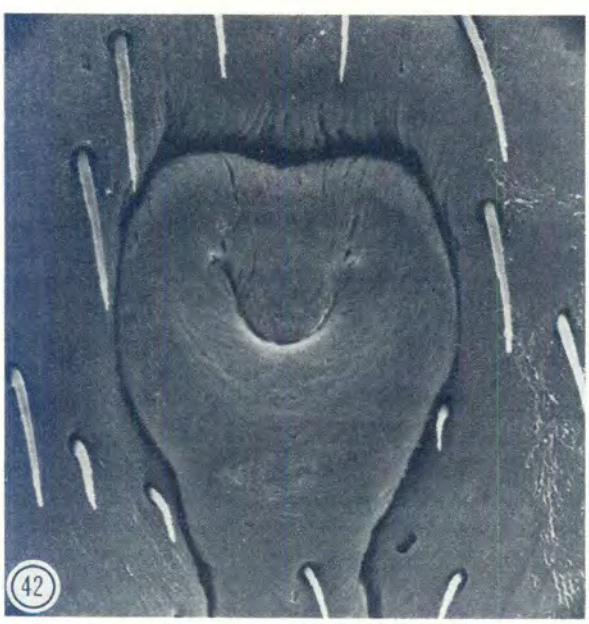

37

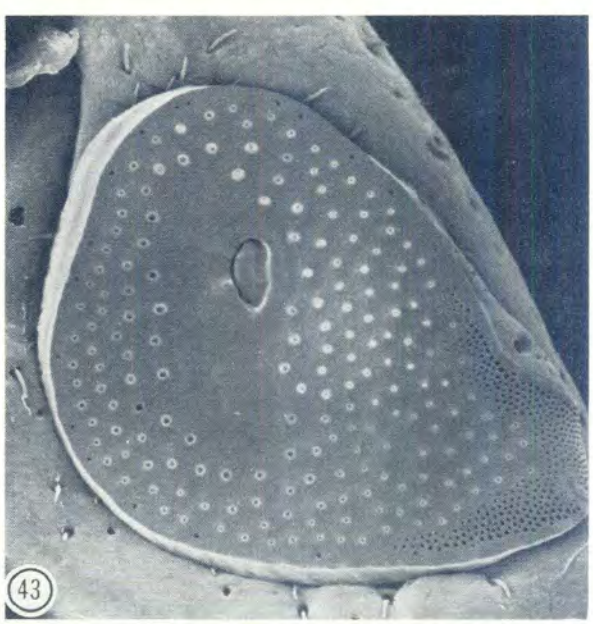

38

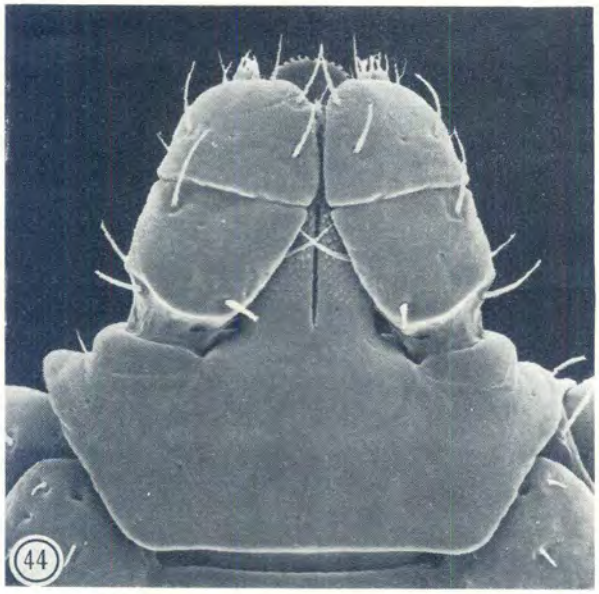

39


40


41


42

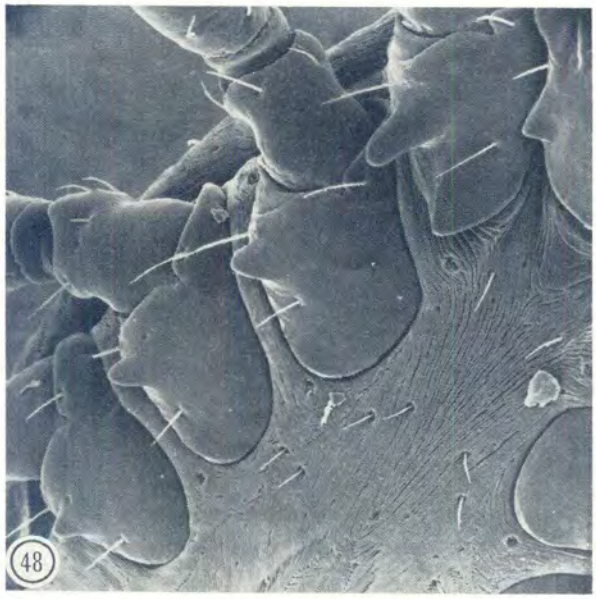

43

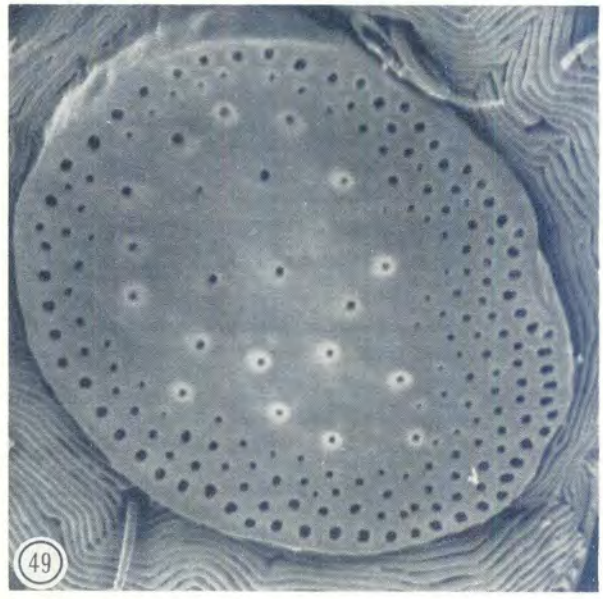

44

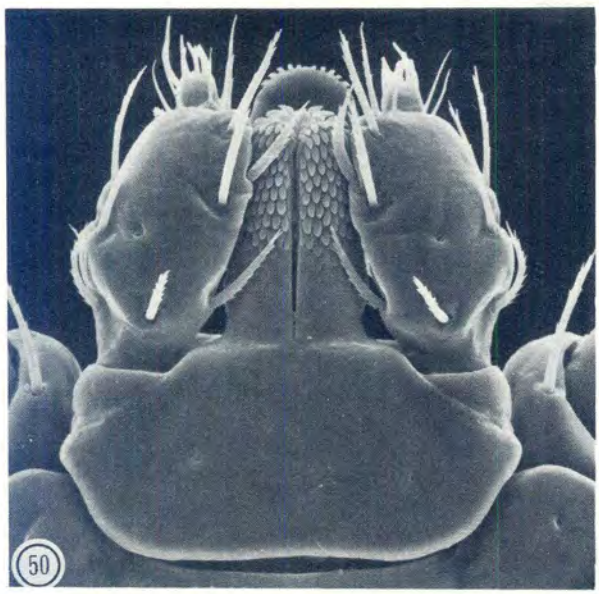

45

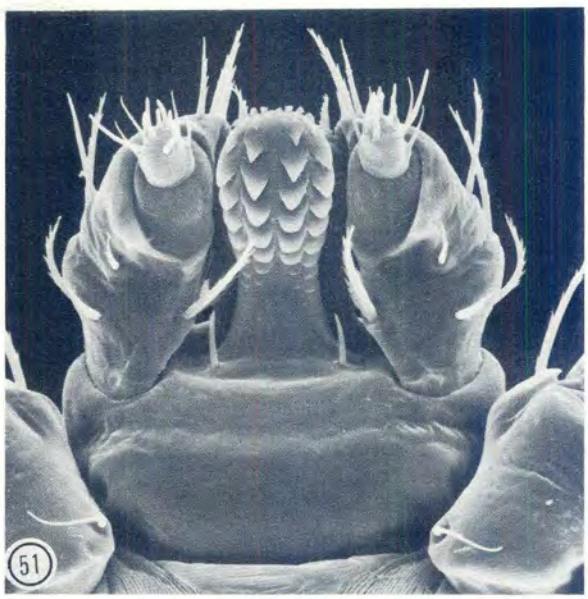

46


47


48

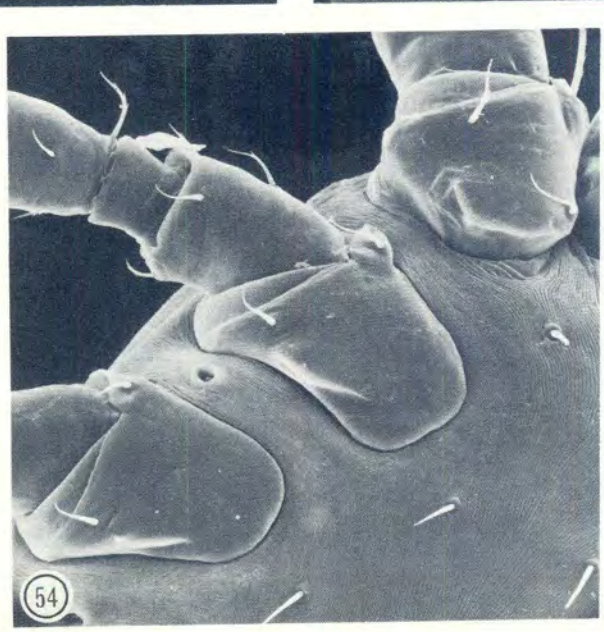

49


50


51


52


53


54

Discussion

The morphological similarity between *R. zambeziensis* and *R. appendiculatus* at all stages of their life cycles, especially the adults, can pose problems when attempts are made to identify field-collected specimens. The most notable features distinguishing these 2 species are, in the adults, the differences in their punctation patterns (Fig. 1–4) and, in the immature stages, the differences in the proportions of their bases capituli and the shape of their palps (Fig. 17–20). Both species do, however, show a wide range of morphological variation and it can be extremely difficult, sometimes even impossible, to identify individual specimens with certainty. Whenever possible, therefore, it is advisable to examine series of specimens rather than single ticks. It is also important to consider the ecological conditions in the areas where the ticks were obtained. Although the distributions of these 2 species do overlap in places, their ecological preferences differ markedly and in general they occur in different regions.

Laboratory Studies

Life cycle of R. zambeziensis

The strain of *R. zambeziensis* used was that originally obtained from cattle on Driehoek Ranch. Larvae and nymphs were fed on the ears of rabbits and adults on the ears of Friesland steers. After detachment, engorged ticks were maintained in an incubator at 25 °C and 85–87 per cent RH and examined daily to monitor development. Egg batches were removed daily from ovipositing females and the eggs were counted.

Preoviposition period

In 44 fully engorged females the preoviposition period lasted 6–10 days (mean 6,73 days).

Oviposition period

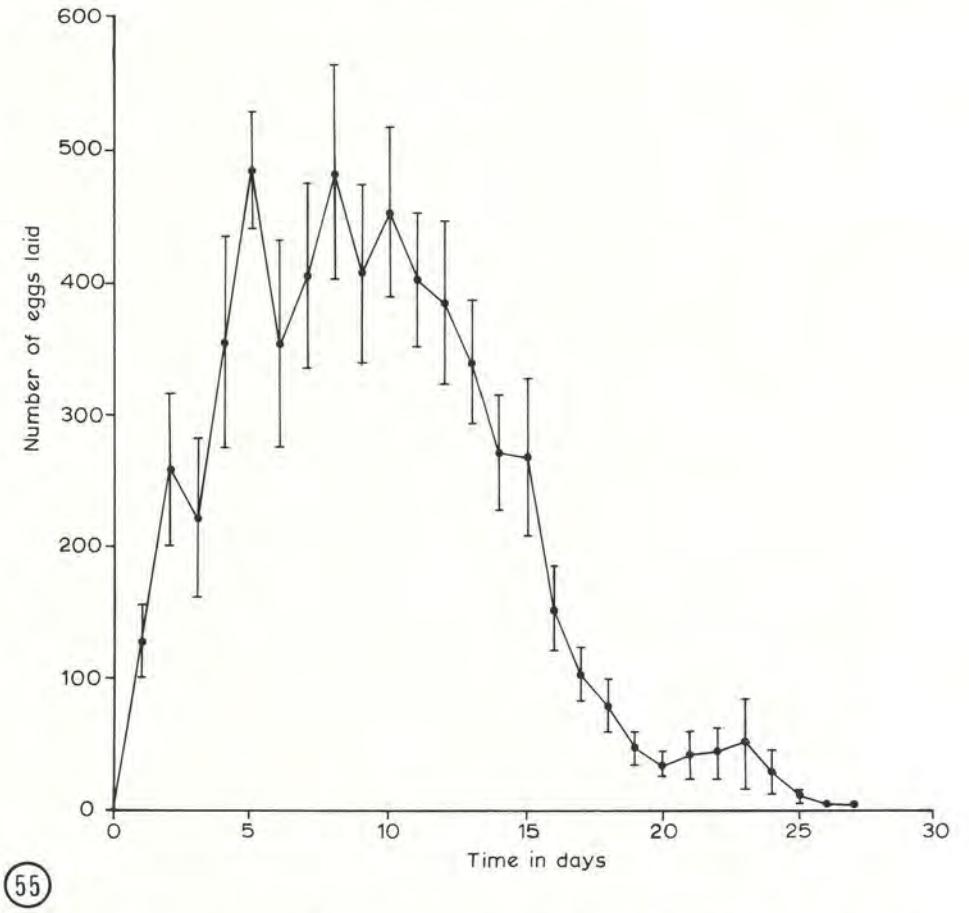
In 10 fully engorged females from which eggs were collected daily, the oviposition period lasted 20–28 days (mean 25,20 days). The number of eggs laid per day (Fig. 55) rose sharply to reach a peak on Day 5 and remained at a high level until Day 10. Egg production then declined steadily until laying ceased. The maximum number of eggs laid in a day by an individual female was 778. Total egg production by individual females ranged from 3 830–7 506 (mean 5 804) and the numbers of eggs produced were significantly correlated with the masses of the engorged ticks ($r=0,959$; $P<0,01$). Fully engorged females ranged in mass from 258–462 mg.

Incubation period

The incubation period of eggs taken from any single day's production ranged from 30–38 days.

Feeding periods

Larvae completed feeding in 3–6 days (mean 4,41 days), nymphs in 4–8 days (mean 5,14 days) and females in 5–11 days (mean 7,16 days) (Fig. 56). Males remained attached to hosts for several weeks after females had completed engorgement.



55

FIG. 55 *Rhipicephalus zambeziensis* sp. nov. The mean number of eggs laid per day by 10 fully engorged females maintained at 25 °C and 85–87% RH. Vertical lines indicate standard error

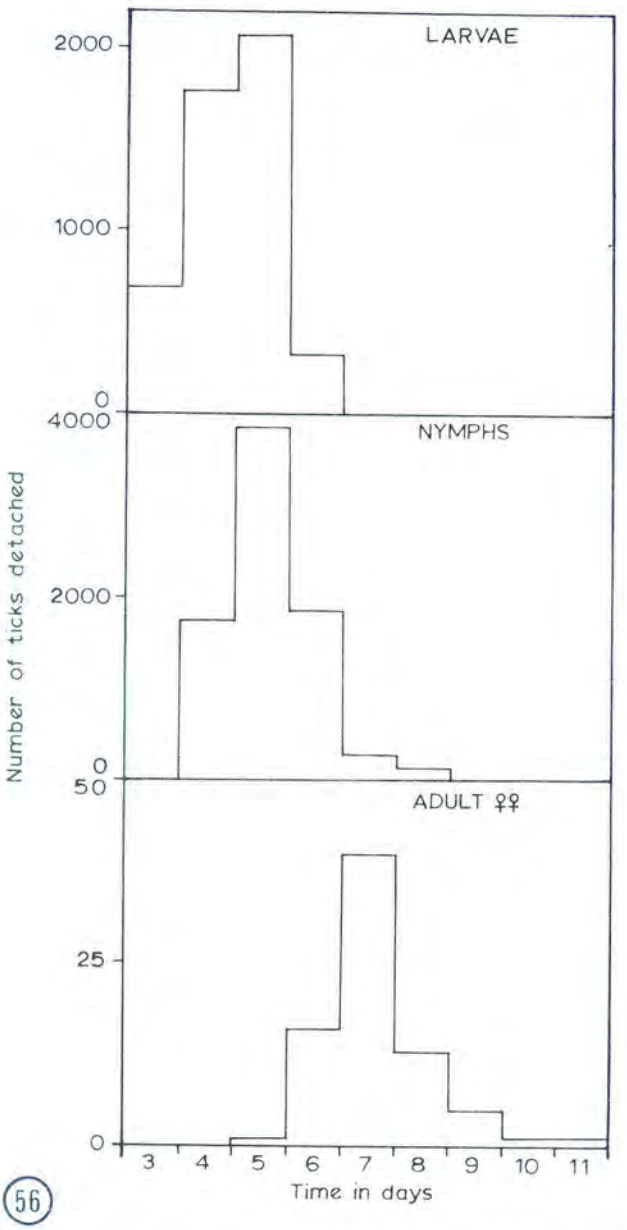


FIG. 56 *Rhipicephalus zambeziensis* sp. nov. The duration of feeding of larvae and nymphs on rabbits and adult females on cattle

Premoult periods

In a sample of 865 ticks the nymphal premoult period lasted 10–16 days (mean 11,30 days).

The adult premoult period in a sample of 489 ticks was 19–26 days (mean 21,65 days). The period was significantly shorter ($P<0,01$) in females (mean 20,77 days) than in males (mean 22,44 days).

Cross-breeding experiments

As *R. zambeziensis* and *R. appendiculatus* do occur sympatrically in certain areas, cross-breeding experiments were undertaken to see if interspecific mating and hybridization between the species can take place. In these experiments, batches of males of 1 species were confined in ear bags on the ears of steers with equal numbers of females of the other species (Table 1). Records were kept of the numbers of males seen to pair with females, and of the numbers of females which detached either partially or fully engorged. In the control experiments males and females of the same species were confined together.

In all experiments the per cent attachment of both male and female ticks after 24 hours was high but at this stage no pairing of the sexes was observed. In controls (males and females of the same species), pairing was recorded after 3–6 days. No active pairing, however, was observed in the test experiments (males of 1 species and females of the other). No *R. appendiculatus* males were seen paired with *R. zambeziensis* females, while only 3 per cent of the *R. zambeziensis* males were seen paired with *R. appendiculatus* females. In the controls the majority of females detached fully engorged and laid viable eggs. In the test experiments, on the other hand, most females detached when they were only partially engorged and then failed to lay eggs. The only females which engorged were the 3 *R. appendiculatus* females which had been paired with *R. zambeziensis* males. Two of these females laid eggs, but less than 1 per cent of these eggs hatched. The mean per cent hatch in samples of egg batches laid by control females was 89,22 in the case of *R. zambeziensis* and 91,41 in the case of *R. appendiculatus*.

Discussion

Although the durations of the developmental periods of *R. zambeziensis* tend to be slightly longer than those of *R. appendiculatus*, in general the life cycles of the 2 species are very similar (Table 2).

The pattern of oviposition and the relationship between the masses of engorged females and the the numbers of eggs produced in *R. zambeziensis* is similar to that observed in most other ixodid tick species which have been studied (Branagan, 1973; Norval, 1974; Rechav, Knight & Norval, 1977).

As in *R. appendiculatus*, male nymphs of *R. zambeziensis* moult earlier than female nymphs, which is an unusual feature in ixodid ticks (Rechav *et al.*, 1977).

Sonenshine, Silverstein, Layton & Homsher (1974) and Sonenshine, Silverstein, Plummer, West & McCullough (1976) stated that copulation within the Metastriata (Ixodidae) is the culmination of a hierarchy of pheromone-regulated orientation responses, and suggested that interspecific mating is probably the result of 2 species utilizing the same or similar compounds as sex pheromones. In the case of *R. zambeziensis* and *R. appendiculatus* it is clear that reproductive isolation occurs as a result of the lack of attraction of males of 1 species to females of the other, probably because of the production of different sex pheromones. In the few instances where interspecific pairing (and presumably mating) did occur, egg masses with an extremely low viability were produced, possibly indicating cytoplasmic and/or genetic incompatibility (Knipling, Laven, Craig, Pal, Kitzmiller, Smith & Brown, 1968; Oliver, Wilkinson & Kohls, 1972; Gladney & Dawkins, 1973) between the species. The failure of most females to complete feeding when confined with the incorrect males must have resulted from the lack of mating, as the final phase of feeding in females of the Metastriata does not occur until after copulation (Pappas & Oliver, 1972).

The lack of interspecific mating between *R. zambeziensis* and *R. appendiculatus* confirms, biologically, the validity of their taxonomic separation. It also shows that the 2 species can exist sympatrically.

TABLE 1 Cross-breeding experiments between *Rhipicephalus zambeziensis* and *Rhipicephalus appendiculatus* on the ears of steers. In each treatment approximately 100 male ticks were confined with an equal number of female ticks

	R. appendiculatus ♂♂ × *R. zambeziensis* ♀♀	*R. zambeziensis* ♂♂ × *R. appendiculatus* ♀♀	*R. appendiculatus* ♂♂ × *R. appendiculatus* ♀♀	*R. zambeziensis* ♂♂ × *R. zambeziensis* ♀♀
% ♀♀ attachment after 24 hours	91,0	89,5	88,0	90,4
Max. % ♀♀* paired with ♂♂ on a single day	0,0	3,0	70,5	81,7
% ♀♀ detached* partially engorged	100,0	97,0	0,0	2,4
% ♀♀ detached* fully engorged	0,0	3,0	100,0	97,6

* Percentage based on the numbers of ticks attached after 24 hours

TABLE 2 A comparison of the durations of the life cycles of *Rhipicephalus zambeziensis* and *Rhipicephalus appendiculatus*. Data on the durations of the developmental periods were recorded in all instances at 25 °C and 85–87% RH

Period	Duration (days)	
	R. zambeziensis	*R. appendiculatus*
Preoviposition	6–10 ($\bar{x}$=6,73)(1)	5–8 ($\bar{x}$=6,18)(2)
Oviposition	20–28 ($\bar{x}$=25,20)(1)	24(2)
Egg incubation	30–38(1)	28–33 ($\bar{x}$=30,3)(2)
Larval feeding (rabbits)	3– 6 ($\bar{x}$=4,41)(1)	3– 6(4) ($\bar{x}$=4,11–5,44)(3)
Nymphal premoult	10–16 ($\bar{x}$=11,30)(1)	10–15 ($\bar{x}$=11,89)(2)
Nymphal feeding (rabbits)	4– 8 ($\bar{x}$=5,14)(1)	4– 7(4) ($\bar{x}$=4,64–6,51)(3)
Adult premoult (males)	20–26 ($\bar{x}$=22,44)(1)	16–20 ($\bar{x}$=18,16)(2)
Adult premoult (females)	19–25 ($\bar{x}$=20,77)(1)	15–19 ($\bar{x}$=16,52)(2)
Adult female feeding (cattle)	5–11 ($\bar{x}$=7,16)(1)	6–11(4) ($\bar{x}$=8,20)(3)

Key.—(1)=present study; (2)=Branagan (1973); (3)=Branagan (1974) and (4)=Tukahirwa (1976)

Acknowledgement

We should like to thank Mr Justin Muchuwe for his able technical help during this study.

References

ARTHUR, D. R., 1975. The larvae of some ixodid ticks (Acarina) from the eastern Cape Province of South Africa. *Bulletin of Entomological Research*, 65, 405–421+plates xv–xxv.

BRANAGAN, D., 1973. The developmental periods of the ixodid tick *Rhipicephalus appendiculatus* Neum. under laboratory conditions. *Bulletin of Entomological Research*, 63, 155–168.

BRANAGAN, D., 1974. The feeding performance of the ixodid *Rhipicephalus appendiculatus* Neum. on rabbits, cattle and other hosts. *Bulletin of Entomological Research*, 64, 387–400.

GLADNEY, W. J. & DAWKINS, C. C., 1973. Experimental interspecific mating of *Amblyomma maculatum* and *A. americanum*. *Annals of the Entomological Society of America*, 66, 1093–1097.

HOOGSTRAAL, H., 1956. African Ixodoidea. I. Ticks of the Sudan (with special reference to Equatoria Province and with preliminary reviews of the genera *Boophilus, Margaropus* and *Hyalomma*). Research Report NM 005 050.29.07, 1,101 pp. Washington, D.C., Department of the Navy, Bureau of Medicine and Surgery.

HOWARD, C. W., 1908. A list of the ticks of South Africa, with descriptions and keys to all the forms known. *Annals of the Transvaal Museum*, 1, 73–169, plates I–XVI.

KNIPLING, E. F., LAVEN, H., CRAIG, G. B., PAL, R., KITZMILLER, J. B., SMITH, C. N. & BROWN, A. W. A., 1968. Genetic control of insects of public health importance. *Bulletin of the World Health Organization*, 38, 421–438.

LAWRENCE, J. A. & NORVAL, R. A. I., 1979. A history of ticks and tick-borne diseases of cattle in Rhodesia. *Rhodesian Veterinary Journal*, 10, 28–40.

MACLEOD, J., 1970. Tick infestation patterns in the southern province of Zambia. *Bulletin of Entomological Research*, 60, 253–274.

MACLEOD, J. & MWANAUMO, B., 1978. Ecological studies of ixodid ticks (Acari: Ixodidae) in Zambia. IV. Some anomalous infestation patterns in the northern and eastern regions. *Bulletin of Entomological Research*, 68, 409–429.

MACLEOD, J., COLBO, M. H., MADBOULY, M. H. & MWANAUMO, B., 1977. Ecological studies of ixodid ticks (Acari: Ixodidae) in Zambia. III. Seasonal activity and attachment sites on cattle, with notes on other hosts. *Bulletin of Entomological Research*, 67, 161–173.

NEUMANN, L. G., 1901. Revision de la Famille des Ixodidés (4e Mémoire). *Mémoires de la Société zoologique de France*, 14, 249–372.

NORVAL, R. A. I., 1974. The life cycle of *Amblyomma hebraeum* Koch, 1844. *Journal of the Entomological Society of Southern Africa*, 37, 357–367.

NUTTALL, G. H. F., 1913. *Rhipicephalus appendiculatus:* Variation in size and structure due to nutrition. *Parasitology*, 6, 195–203.

OLIVER, J. H., WILKINSON, P. R. & KOHLS, G. M., 1972. Observations on hybridization of three species of North American *Dermacentor* ticks. *Journal of Parasitology*, 58, 380–384.

PAPPAS, P. J. & OLIVER, J. H., 1972. Reproduction in ticks (Acari: Ixodidae). 2. Analysis of the stimulus for rapid and complete feeding of female *Dermacentor variabilis* (Say). *Journal of Medical Entomology*, 9, 47–50.

RECHAV, Y., KNIGHT, M. M. & NORVAL, R. A. I., 1977. Life cycle of the tick *Rhipicephalus evertsi evertsi* Neumann (Acarina: Ixodidae) under laboratory conditions. *Journal of Parasitology*, 63, 575–579.

SONENSHINE, D. E., SILVERSTEIN, R. M., LAYTON, E. C. & HOMSHER, P. J., 1974. Evidence for the existence of a sex pheromone in 2 species of ixodid ticks (Metastigmata: Ixodidae). *Journal of Medical Entomology*, 11, 307–315.

SONENSHINE, D. E., SILVERSTEIN, R. M., PLUMMER, E., WEST, J. R. & McCULLOUGH, T., 1976. 2,6-dichlorophenol, the sex pheromone of the Rocky Mountain wood

tick, *Dermacentor andersoni* Stiles and the American dog tick, *Dermacentor variabilis* (Say). *Journal of Chemical Ecology*, 2, 201–209.

THEILER, GERTRUD, 1943. Notes on the ticks off domestic stock from Portuguese East Africa. 55 pp.+49 figs. Estação Anti-Malárica, Lourenço Marques.

TUKAHIRWA, E. M., 1976. The feeding behaviour of larvae, nymphs and adults of *Rhipicephalus appendiculatus*. *Parasitology*, 72, 65–74.

WALKER, JANE B., MEHLITZ, D. & JONES, G. E., 1978. Notes on the ticks of Botswana. German Agency for Technical Co-operation, Ltd. (GTZ), Eschborn, West Germany.

YEOMAN, G. H. & WALKER, JANE B., 1967. The ixodid ticks of Tanzania. xii+215 pp. Commonwealth Institute of Entomology, London.

ZUMPT, F., 1942. *Rhipicephalus appendiculatus* Neum. und verwandte Arten. VI. Vorstudie zu einer Revision der Gattung *Rhipicephalus* Koch. *Zeitschrift für Parasitenkunde*, 12, 538–551.

Printed by and obtainable from the Government Printer, Private Bag X85, Pretoria 0001