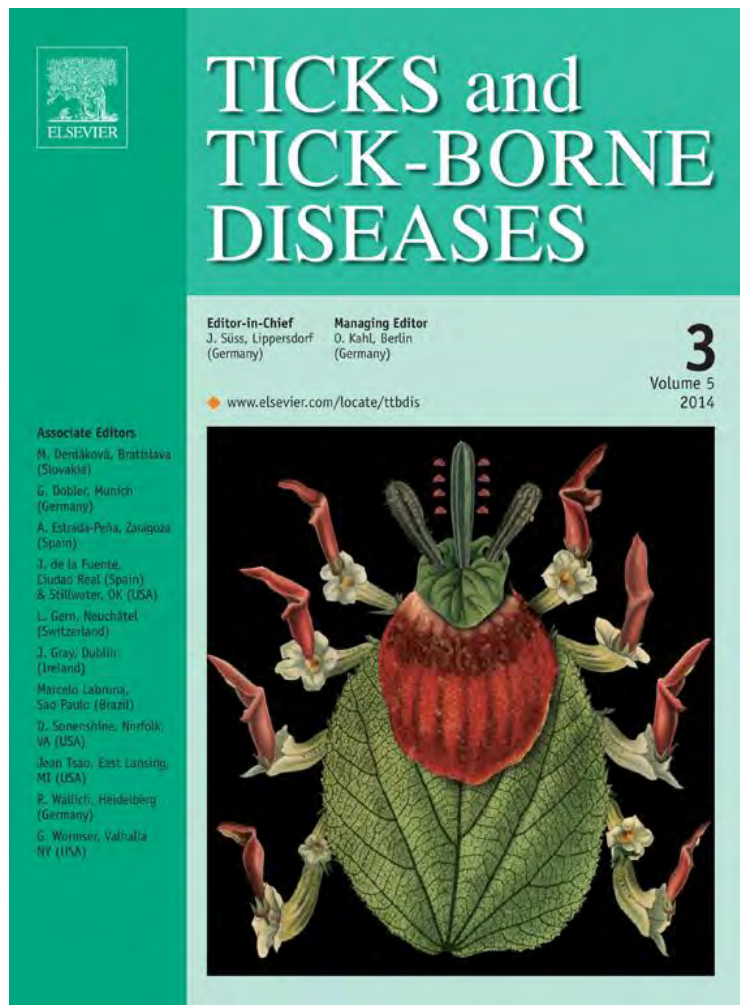


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# Ticks and Tick-borne Diseases

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Original article

## Reassessment of the taxonomic status of *Amblyomma cajennense* (Fabricius, 1787) with the description of three new species, *Amblyomma tonelliae* n. sp., *Amblyomma interandinum* n. sp. and *Amblyomma patinoi* n. sp., and reinstatement of *Amblyomma mixtum* Koch, 1844, and *Amblyomma sculptum* Berlese, 1888 (Ixodida: Ixodidae)



Santiago Nava<sup>a,\*</sup>, Lorenza Beati<sup>b</sup>, Marcelo B. Labruna<sup>c</sup>, Abraham G. Cáceres<sup>d</sup>, Atilio J. Mangold<sup>a</sup>, Alberto A. Guglielmone<sup>a</sup>

<sup>a</sup> Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Rafaela and Consejo Nacional de Investigaciones Científicas y Técnicas, CC 22, CP 2300 Rafaela, Santa Fe, Argentina

<sup>b</sup> United States National Tick Collection, Institute for Coastal Plain Science, Georgia Southern University, Statesboro, GA 30460, USA

<sup>c</sup> Universidade de São Paulo, Faculdade de Medicina Veterinária e Zootecnia, Av. Prof. Orlando M. de Paiva 87, 05508-900 São Paulo, Brazil

<sup>d</sup> Departamento Académico de Microbiología Médica, Facultad de Medicina, Universidad Nacional Mayor de San Marcos, Lima, Perú and Laboratorio de Entomología, Instituto Nacional de Salud, Lima, Peru

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### ABSTRACT

A reassessment of the taxonomic status of *Amblyomma cajennense* based on the morphological analyses of ticks from the whole distribution area of the species resulted in the redescription of *A. cajennense*, the validation of 2 species which had been reduced to synonymy in the past, *Amblyomma mixtum* and *Amblyomma sculptum*, and the description and definition of 3 new species, *Amblyomma tonelliae* n. sp., *Amblyomma interandinum* n. sp., and *Amblyomma patinoi* n. sp. This study provides descriptions and redescriptions, scanning electron microscopic and stereomicroscopic images, updated synonymies, information on geographical distributions, and host associations for each of the 6 species. *Amblyomma cajennense* s.s. is found in the Amazonian region of South America, *A. interandinum* is reported from the northern part of the Inter-Andean valley of Peru, *A. mixtum* is present from Texas (U.S.A.) to western Ecuador, *A. patinoi* occurs in the Eastern Cordillera of Colombia, *A. tonelliae* is associated with the dry areas of the Chaco region which spans from central-northern Argentina to Bolivia and Paraguay, whereas *A. sculptum* is distributed from the humid areas of northern Argentina, to the contiguous regions of Bolivia and Paraguay and the coastal and central-western states of Brazil.

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### Introduction

*Amblyomma cajennense* (Fabricius, 1787) is a widely distributed tick taxon, which feeds on a variety of vertebrate hosts, mostly mammals. Its distribution spans from southern Texas (U.S.A.) to northern Argentina (Estrada-Peña et al., 2004). This tick is an important pest of domestic animals and humans in the Neotropical region (Guglielmone et al., 2003, 2006). It is also one of the main vectors of *Rickettsia rickettsii*, the agent of Rocky Mountain spotted fever, in some areas of Central and South America (Labruna, 2009). In addition, different arboviruses have been isolated from, or associated

with, *A. cajennense* (Belle et al., 1980; Linthicum et al., 1991). In the past, the taxonomic status of this tick was the object of much debate. Aragão and Fonseca (1953), and later Kohls (1958), concluded that a number of species described or revalidated by Koch (1844) and Tonelli-Rondelli (1937) should be returned to synonymy. The proposals of Aragão and Fonseca (1953) and Kohls (1958) were never challenged. The conclusions of these authors were further corroborated by an analysis of the cuticular hydrocarbons of *A. cajennense* from distinct geographical origins, which did not reveal any significant difference (Estrada-Peña et al., 1993).

Nevertheless, the tick is found in environments as diverse as the dry grasslands of the Chaco region of Argentina and Paraguay, the highlands of the Peruvian Andes, and the tropical forest of Guiana (Estrada-Peña et al., 2004). Despite its nearly ubiquitous geographic distribution in the Neotropical region, *A. cajennense*

\* Corresponding author. Tel.: +54 03492440121; fax: +54 03492440114.

E-mail address: [nava.santiago@inta.gob.ar](mailto:nava.santiago@inta.gob.ar) (S. Nava).

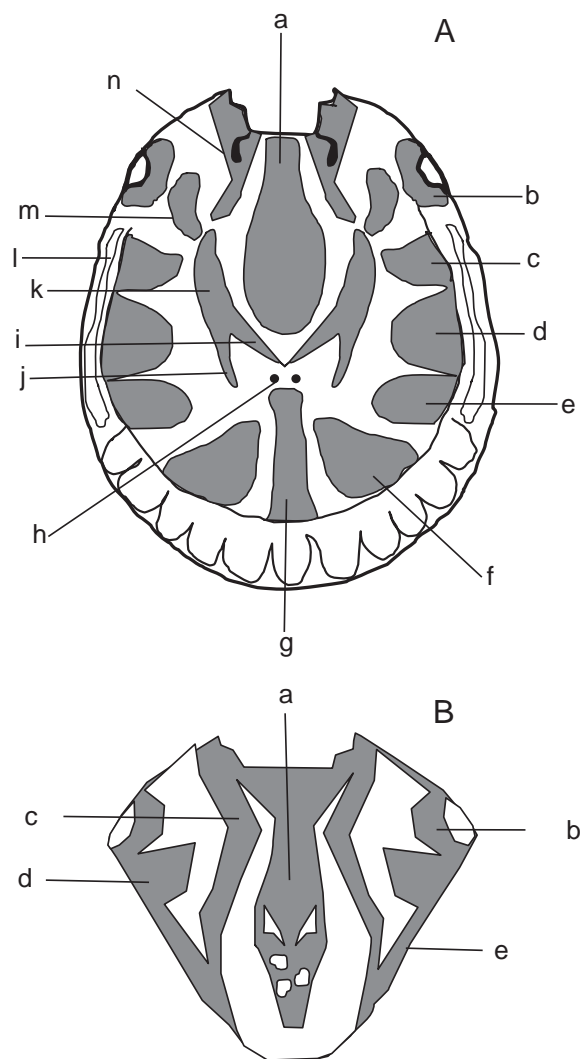
ticks from different areas are found infected with different rickettsial genospecies. *A. cajennense* infected with *R. rickettsii* have been collected in localized foci in Mexico, Panama, Colombia, Brazil, and Argentina (Patiño-Camargo, 1941; Bustamante and Varela, 1946; Rodaniche, 1953; Guedes et al., 2005; Paddock et al., 2008). *Rickettsia amblyommii* is very prevalent in some *A. cajennense* populations from Panama, northern Brazil (Labruna et al., 2004; Bermúdez et al., 2009), and Ecuador (Beati, unpublished data), but has not been detected in any of the thousands of specimens examined from southern Brazil (Sangioni et al., 2005; Pacheco et al., 2009).

Cross-mating experiments with *A. cajennense* ticks from geographically distant areas of Brazil (Labruna et al., 2011) and Argentina (Mastrolopolo et al., 2011) suggested that this taxon is probably represented by a complex of different species. Afterwards, a molecular analysis of the genetic diversity within *A. cajennense* based on the comparison of multiple gene sequences in ticks collected from the entire distributional range of this tick species (Beati et al., 2013) showed strong genetic structure and delimited 6 geographically mutually exclusive clades compatible with cryptic speciation. In the study of Beati et al. (2013), all clades corresponded to allo- and parapatric localities characterized by different ecological features: One clade occurred in the Interandean valley of Peru, the second clade was associated with the dry part of the Chaco region of Argentina and Paraguay, the third clade with humid forested areas of northern Argentina and coastal southern Brazil, the fourth clade with the Amazonian region, the fifth clade with mountainous area of the Eastern cordillera of Colombia, and the sixth clade spanned the Pacific coast of Ecuador, through Central America, to Texas. Therefore, in this work, the morphology of representative specimens of each clade was examined and compared, in order to verify whether or not the observed genetic subdivision could be associated with distinctive phenotypic features. The taxonomic status of *A. cajennense* and of the synonymized related species was reassessed in light of these new findings, by expanding the morphological comparison to type material and specimens from different museum collections.

## Materials and methods

The morphological comparison included adult specimens from the following tick collections: the Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria in Rafaela, Argentina (INTA), the Coleção Nacional de Carrapatos da Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Brazil (CNC), and the U.S. National Tick Collection, Georgia Southern University, Statesboro, Georgia, U.S.A. (USNTC, RML accession numbers). We obtained type specimens also from the Zoological Museum in Berlin (ZMB), Germany, the Museo di Storia Naturale La Specola (MSNS), Firenze, Italy, and the Arachnida Collection of the Zoological Museum, University of Copenhagen, Denmark (CZMC).

Ticks were cleaned for both light and scanning electron microscopy with ultrasound (20 kHz) using distilled water and commercial detergent in a proportion of 9:1. Ten males and 10 unengorged females representing each clade (see 'Introduction' section) were measured with a stereoscope Nikon® C-PS (all measurements are given in millimetres, with the mean followed by the standard deviation and range in parentheses). Scanning electron photomicrographs were taken at the Servicio de Microscopía Electrónica, Museo de La Plata, Universidad Nacional de La Plata, Argentina, using a JEOL/JSM 6360 LV® Digital Scanning Microscope. Colour photographs were generated by a BK Plus Lab System (Visionary Digital) and stacked with Helicon Focus v. 4.77 in the laboratory of Jonathan Coddington (Smithsonian Institution, Washington, DC). The terminology chosen in this study for



**Fig. 1.** Schematic outline and terminology used to identify elements of the ornamentation in male (A) and female (B) specimens. (A) a, central area; b, ocular spot; c, first lateral spot; d, second lateral spot; e, third lateral spot; f, postero-accessory spot; g, postero-median spot; h, fovea; i, posterior branch of limiting spot; j, anterior branch of limiting spot; k, limiting spot; l, marginal stripe; m, antero-accessory spot; n, cervical spot. (B) a, central area; b, ocular spot; c, cervical spot; d, accessory spot; e, limiting spot.

describing male and female scutal ornamentation, modified from Dönitz (1909), is illustrated in Fig. 1.

In order to prevent confusion in this article, the name *A. cajennense* sensu lato applies to the group of species synonymized with *A. cajennense* by Aragão and Fonseca (1953, see below), whereas *A. cajennense* sensu stricto refers to the species as redefined in this work. Scientific names of mammal hosts reported here have been listed following Wilson and Reeder (2005).

## Synonymy

Fabricius (1787) described *Acarus cajennensis* from a male specimen, later transferred to the genus *Ixodes* by Fabricius (1805). Tonelli-Rondelli (1937) and Kohls (1958) stated that the holotype of *Acarus cajennensis* was lost. However, Guglielmone et al. (2003) reported that the type was listed among the holdings of the CZMC. After examining the type received from the CZMC, it became clear that the specimen did not correspond to Fabricius' description of *Acarus cajennensis*, but to that of *Acarus lineatus* (Fabricius, 1775). The type specimen of *Acarus lineatus* was also thought to be lost

and its name was considered to be a rejected nomen dubium (Neumann, 1911; Camicas et al., 1998). Conceivably, an accidental switch between the 2 contiguously pinned type specimens – but not of their corresponding labels – and the loss of the *Acarus cajennensis* type are at the origin of subsequent taxonomic issues. There is now no doubt that the holotype of *A. cajennense* is not available any more. The taxonomic status of *Acarus lineatus* will be further discussed separately. Say (1821) described *Ixodes crenatus* from southern U.S.A. The name is often synonymized under *A. cajennense*, but the description of the species is poor, being equally evocative of species as different as *A. cajennense*, *Amblyomma imitator*, or even *Amblyomma maculatum*. The fact that Say describes the marginal groove as becoming gradually obsolete before the middle of the body is not consistent with the morphology of *A. cajennense*. Although the Say collection was not completely destroyed by dermestid beetles, as was reported by Keirans et al. (1996), the list of the rescued species does not include any tick taxa (Mawdsley, 1993). *Ixodes crenatus* is a nomen dubium and is removed from the synonymy list of *A. cajennense*. Relevant to this question, it is important to mention that *Amblyomma crenatum*, described by Neumann (1899), applies to an oriental species unrelated to the North American *I. crenatus*.

Koch (1844) included *Acarus cajennensis* and *Acarus lineatus* in the newly erected genus *Amblyomma* and described for the first time a female of *A. cajennense*, from samples collected in “Cajenne, Brasilien”, probably meaning that his specimens came from both, Cayenne (in French Guiana) and Brazil. Although we observed a label in the Koch samples with the inscription “Type”, there is no evidence that these samples belonged to the type series used by Fabricius in his description of *Acarus cajennensis*. Therefore, a male neotype, collected by one of the authors (L.B.) on July 6, 2008, from the shrubs along the Montabó hiking trail (4°56'N 52°18'W) in Cayenne (French Guiana) was designated and is deposited in the USNTC (RML 124079).

Koch also describes 2 additional closely related species, *Amblyomma mixtum* (2 males and one female) and *Amblyomma tenellum* (2 males), from Mexico. He designated type series for each species. In 1847, he published a more detailed description of the 3 species with illustrations. Stoll (1894) provided the first recognizable illustrations of *A. mixtum* collected from Mexico, Guatemala, Nicaragua, and Costa Rica in his monograph on the Acari of Central America. His illustrations include good drawings of the spiracular plate and genital aperture of female specimens. Neumann (1899, 1911) reduced these 2 junior species to synonyms of *A. cajennense*. Tonelli-Rondelli (1937) considered them to be valid tick species, distinct from *A. cajennense*, and provided excellent descriptions and illustrations for all Koch's types. Her opinion was, however, overturned by Aragão and Fonseca (1953) and Kohls (1958) who returned *A. mixtum* and *A. tenellum* to synonymy. Koch's descriptions are not very informative, but the types are available and were loaned to us by the curator of the ZMB for morphological comparison. A careful examination of all samples showed that *A. mixtum* is different from *A. cajennense* s.s. and is identical to samples we examined from Texas (USA), Mexico, Central America, and coastal Ecuador. *Amblyomma mixtum* is, therefore, reestablished as a valid species. As Koch had not designated a name-bearing type among the *A. mixtum* series, the only female specimen of the type series is designated as lectotype (ZMB 1061).

*Amblyomma tenellum* males are very small ticks with all the typical characteristics of *Amblyomma imitator*. Neumann (1899) first treated *A. tenellum* as a junior synonym of *A. maculatum*, but after examining Koch's types (ZMB 1043), he transferred it to the synonymy list of *A. cajennense* (Neumann, 1901). When Kohls (1958) described *A. imitator*, he had the opportunity to examine Koch's types. Surprisingly, he failed to acknowledge that similarities in size, shape, and ornamentation between *A. tenellum* and *A.*

*imitator* were far more obvious than between *A. tenellum* and *A. mixtum*. *Amblyomma tenellum* is, therefore, removed from the synonyms of *A. cajennense*, and its taxonomic status will be discussed separately.

The mentions of *I. cayenensis* (Conil, 1877) and, later (Aragão, 1911; Neumann, 1911; Floch and Abonnenc, 1940, 1942) of *A. cayennense*, are very likely the result of a lapsus calami. Berlese (1888) described *Amblyomma sculptum* from ticks supposedly retrieved from under the bark of a tree in Mato-Grosso, Brazil. His description and illustrations are insufficient for formal identification. Neumann (1899, 1911) was undecided about the taxonomic status of *A. sculptum* and cites it as a synonym of *A. cajennense* in 1899 and as a species with uncertain status in 1911. The type of *A. sculptum* is listed as missing from the Berlese collection in Firenze, where the curator also confirmed that the type is not available anymore. However, Tonelli-Rondelli (1937) saw the Berlese types and provided detailed illustrations of both male and female specimens. Her illustrations of the male and of the scutum of one female are consistent with the morphology of our samples from the peri-Amazonian areas of Brazil and the humid areas of north-western Argentina. The second female specimen illustrated by Tonelli-Rondelli (1937) has very reduced ornamentation confined to the posterior margin of the scutum. While examining a large number of females, we noted some variations in the scutal pattern. Thus, *A. sculptum* is resurrected based on the descriptions and illustrations of the male and of one female in Tonelli-Rondelli (1937). A positive identification of the second female sample cannot be reached. In order to help clarifying the taxonomic status of *A. sculptum*, a male neotype is designated among recently collected samples from Mato Grosso do Sul deposited at the USNTC (RML 122966).

Dugès (1891) described *Ixodes herrerae*, a tick from a tapir collected in Motzorongo, Mexico (State of Veracruz). Although the tick he describes is definitively an *Amblyomma*, the description is too poor to warrant identification, and his illustration is not informative. Dugès (1902) synonymized *I. herrerae* with *A. cajennense* after collecting and examining additional specimens from horses and cattle. The 1891 and the 1902 descriptions deal with fairly different morphological features, making it impossible to establish whether or not the ticks he described in his 2 publications were the same. The type of *I. herrerae* is not available for comparison. Consequently, we propose to consider it to be a nomen dubium.

Nuttall and Warburton (1908) described the male and female of *Amblyomma versicolor* collected from a horse in Oaxaca, Mexico. The description and illustrations of this tick match the overall morphological features of *A. mixtum* (ornamentation in males, ornamentation and presence of tubercles in females), although a 2:2 dentition, very unlikely for Mexican *Amblyomma* taxa, is also reported. *Amblyomma versicolor* is, therefore, transferred to synonymy under *A. mixtum*.

Neumann (1899) is responsible for synonymizing *A. mixtum*, *A. sculptum*, and *I. herrerae* with *A. cajennense*, while he designated a new species, *Amblyomma parviscutatum*, from a female tick collected from an anteater in Brazil. This species differed from *A. cajennense* only by the overall size of the scutum and the mouthparts and, therefore, *A. parviscutatum* was first relegated to subspecies of *A. cajennense* (Neumann, 1904), and then synonymized with it (Aragão, 1911). Neumann's descriptions of *A. cajennense* (Neumann, 1899, 1904, 1911) listed morphological characters of specimens from Argentina, Brazil, Mexico, Central America, Colombia, French Guiana, Venezuela, the West Indies, and Paraguay. He attributed all morphological variability to intraspecific polymorphism. Robinson (1926) followed Neumann's classification, but his illustrations apply to *A. mixtum*. It is impossible to establish, based on Neumann's description of *A. parviscutatum*, if this synonym refers to *A. cajennense* s.s. or to *A.*

*sculptum*, and because the types are not available for comparison, we consider it to be a nomen dubium.

Tonelli-Rondelli (1937) examined the types of Koch, Berlese, and a number of new collections. She reinstated *A. mixtum*, *A. tenellum*, and *A. sculptum* as valid species, redescribed *A. cajennense*, and described 2 additional closely related species, *Amblyomma finitimum* and *Amblyomma tapiri* from specimens collected from a tapir in Guiana. We had the opportunity to examine Tonelli-Rondelli's types. After close scrutiny, all the specimens of *A. finitimum* appear to belong to *A. cajennense* s.s. The type series of *A. tapiri* consists of 1 male and 2 female specimens. The male of *A. tapiri* was found to be identical to the neotype male of *A. cajennense*. The conditions of conservation of the 2 female specimens are very poor with many diagnostic characters missing (festoons, genital aperture, setation) or covered by a whitish coating. Although their ornamentation pattern may appear distinct from that of *A. cajennense* s.s., the female samples of *A. cajennense* s.s. examined for this study showed sufficient intraspecific variability in their ornamentation for us to conclude that *A. tapiri* is a junior synonym of *A. cajennense*.

Aragão and Fonseca (1953) discussed in detail the synonymy of *A. cajennense* s.l. and, apparently without examining type specimens, decided that the morphological diagnostic characters listed by Tonelli-Rondelli (1937) were simply the effect of intraspecific variability. They, therefore, returned all of Tonelli-Rondelli's species names to synonymy. Kohls (1958) examined Koch's types and reached the same conclusion as Aragón and Fonseca (1953). Neither Aragón and Fonseca (1953) nor Kohls (1958) documented the details of the morphological features supporting their opinions. We concur, however, with their opinion in considering *A. finitimum* and *A. tapiri* as junior synonyms of *A. cajennense* s.s.

Each of the authors who dealt with this species since Fabricius' first description, had good reasons for reaching his/her conclusions, but they had access to a limited subset of samples, which often did not represent the whole spectrum of species included in *A. cajennense* s.l. After examining a large number of specimens for each of the 6 species, we were able to recognize fixed diagnostic morphological characters for each of them.

## Redescription of *Amblyomma cajennense* (Fabricius, 1787)

### Synonyms:

*Acarus cajennensis* Fabricius J.C. 1787, p. 372

*Ixodes cajennensis* Fabricius J.C. 1805, p. 427

*Amblyomma finitimum* Tonelli-Rondelli M. 1937, pp. 293–294, Figs. 15 and 16

*Amblyomma tapiri* Tonelli-Rondelli M. 1937, pp. 295–296, Figs. 17 and 18

**Material examined:** Neotype ♂ (RML 124079). Material deposited at the USNTC, the CNC, and the MSNS: BRAZIL – State of Pará: Marabá (05°21'S 49°07'W) 1♂ 1♀ ex *Cuniculus paca* (CNC 599), 4♂♂ 3♀♀ ex *Tapirus terrestris* (CNC 502); Parauapebas (06°04'S 49°54'W) 1♂ 5♀♀ ex *T. terrestris* (CNC 827). State of Rondônia: Gov. Jorge Teixeira (10°38'S 63°30'W) 5♂♂ 10♀♀ ex vegetation (CNC 446), 1♂ ex *T. terrestris* (CNC 413), 1♀ ex *Tayassu tajacu* (CNC 415); Vilhena (12°39'S 60°13'W) 3♀♀ ex vegetation (CNC 626). State of Roraima: Estação Ecológica de Maracá (02°50'N 61°47'W) 4♂♂ 1♀ host unknown (RML 116162). State of Tocantins: Goiatins (07°52'S 47°25'W) 6♂♂ ex *Equus caballus* (CNC 1059), 1♀ ex cattle (*Bos* sp.) (CNC 1062). FRENCH GUIANA – Canet (03°57'N 51°47'W) 3♀♀ ex *Homo sapiens* (RML 46157); Montagne de Montabó, hiking trail (04°56'N 52°18'W) 5♂♂ 4♀♀ ex vegetation (RML 124079), 3♂♂ ex vegetation (RML 124080); Montagne du Tigre (04°54'N 52°18'W) 1♂ 1♀ ex *H. sapiens* (RML 46156); 10 km W from Cayenne, in a rehabilitation farm for sloth (04°55'N 52°23'W) 1♂ 1♀ ex *Bradypus*

*tridactylus* (RML 124081); 20 km S from the Floramazon camp, Kaw region (04°33'S 52°10'W) 1♀ ex “pig” (RML 124017). GUYANA – Camp II on the Demerara river 3♀♀ host and locality unknown (MSNS); Canister Falls (04°48'N 58°26'W) 7♀♀ host unknown (as *A. finitimum*, MSNS); Great Falls (03°11'N 58°40'W) 1♂ *Hydrochoerus hydrochaeris* (MSNS), 1♀ host unknown (MSNS); Kurupukari (04°42'N 58°39'W) 1♂ host unknown (MSNS), 1♂ 7♀♀ ex *T. terrestris* (as *A. finitimum*, MSNS), 1♂ 2♀♀ ex *T. terrestris* (as *A. tapiri*, MSNS); Mabura (05°16'N 58°38'W) 3♂♂ ex *H. sapiens* (MSNS), 1♀ host unknown (MSNS); Potaro-Siparuni, Iwokrama Reserve (04°44'N 58°51'W) 1♂ ex *H. sapiens* (RML 122906), 1♀ ex *H. sapiens* (RML 122909). SURINAME – District of Brokopondo: Brownsberg Nature Park (04°43'N 55°24'W) 1♂ ex *H. sapiens* (RML 116858). VENEZUELA – State of Bolívar: Ciudad Bolívar (08°07'N 63°29'W) 1♀ ex *Tamandua tetradactyla* (RML 50091), 5♂♂ 3♀♀ ex *Tayassu pecari* (RML 50093), 20♂♂ 20♀♀ ex *T. terrestris* (RML 50103), 3♂♂ 3♀♀ ex *Myrmecophaga tridactyla* (RML 50902); El Manteco (07°15'N 62°19'W) 10♂♂ 2♀♀ ex *T. pecari* (RML 47382), 10♂♂ 3♀♀ ex *T. pecari* (RML 47383), 2♂♂ ex *T. pecari* (RML 47391), 12♂♂ 5♀♀ ex *T. pecari* (RML 47412), 1♀ host unknown (RML 47417), 1♀ ex *T. pecari* (RML 47417), 7♂♂ 7♀♀ ex *T. pecari* (RML 47432), 1♀ ex *H. hydrochaeris* (RML 47433), 4♂♂ 4♀♀ ex *T. pecari* (RML 47437), 2♂♂ 2♀♀ ex *T. pecari* (RML 47438), 2♂♂ 2♀♀ ex vegetation (RML 47448), 2♂♂ 4♀♀ ex *T. pecari* (RML 47457), 1♀ ex *Dasyprocta* sp. (RML 47458), 2♂♂ 5♀♀ ex *T. pecari* (RML 47460), 10♂♂ 3♀♀ ex *T. pecari* (RML 47461), 7♀♀ ex *Choeroniscus minor* (RML 47469), 10♂♂ 10♀♀ ex *T. pecari* (RML 47480), 18♂♂ 4♀♀ ex *H. hydrochaeris* (RML 47831), 3♀♀ ex vegetation (RML 47871); Icabarú (04°20'N 61°45'W) 1♀ ex *T. terrestris* (RML 52129). State of Guárico: Guayabal (07°59'N 67°22'W) 1♀ ex *T. pecari* (RML 51931).

**Male.** Total length  $3.67 \pm 0.18$  (3.27–4.00); length from apices of scapulae to posterior body margin  $2.88 \pm 0.15$  (2.60–3.10); breadth  $2.38 \pm 0.16$  (2.13–2.67). Outline oval, scapulae rounded, and cervical grooves deep, short, comma-shaped (Fig. 2A and B). Marginal groove complete, delimiting all festoons, deep up to the level of coxa IV, and then as a line of deep punctations reaching level of eyes (Fig. 2A). Eyes flat. Scutum ornate, glabrous, with brown spots delimited by whitish enamelled stripes (Fig. 19A). Cervical spots elongated posteriorly; limiting spots merging anteriorly with antero-accessory spots; small ocular spots; first and second lateral spots fused but distinct; third lateral spot clearly delimited and horizontally oriented; postero-accessory spot small; postero-median spot long, sometimes club-shaped, and narrower than enamelled stripe separating it from accessory spot. Foveae not clearly distinguishable from background. Narrow marginal white stripe. **Festoons:** longer than wide with numerous medium-sized punctations; parma clear, internal half of festoons 1, 2, and 5 brown, external half clear, festoons 3 and 4 white with a very narrow internal brown border. **Punctuation (Fig. 2A):** posterior scutum heavily punctated in all areas, but the spots with large punctations becoming deeper on stripes separating postero-median and accessory spots; anterior part of scutum with smaller, shallower, numerous, and uniformly distributed punctations, becoming finer in scapular areas and around eyes. **Dorsal capitulum (Fig. 2B):** length from palpal apices to cornua apices  $1.00 \pm 0.07$  (0.74–1.13), basis capituli sub-rectangular, breadth  $0.55 \pm 0.05$  (0.43–0.66), length  $0.32 \pm 0.04$  (0.27–0.46), posterior margin slightly concave, cornua rounded. **Ventral capitulum (Fig. 2C):** basis capituli ventral length  $0.34 \pm 0.03$  (0.26–0.40); palpi total length  $0.74 \pm 0.05$  (0.64–0.85), length segment I  $0.09 \pm 0.03$  (0.06–0.17), length segment II  $0.45 \pm 0.04$  (0.37–0.53), length segment III  $0.19 \pm 0.02$  (0.12–0.24), width segment I  $0.09 \pm 0.01$  (0.06–0.10), width segment II  $0.11 \pm 0.01$  (0.10–0.13), width segment III  $0.14 \pm 0.02$  (0.10–0.17); segment I with small and blunt posteriorly projecting spur. **Hypostome (Fig. 2C):** length  $0.72 \pm 0.06$  (0.57–0.83), width  $0.24 \pm 0.02$  (0.20–0.26), dental formula 3/3 in 7–8 rows; apex

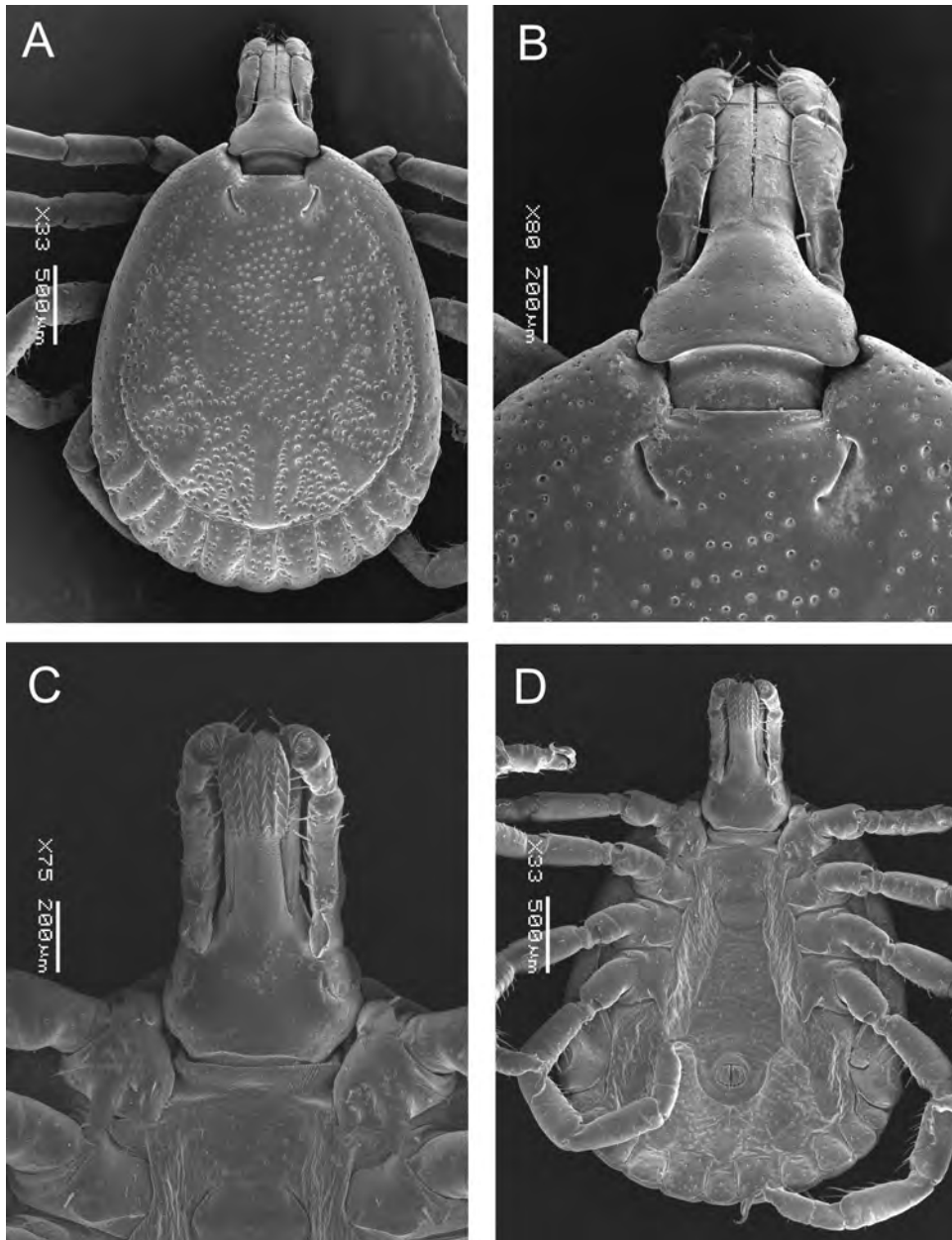


Fig. 2. Male of *Amblyomma cajennense* s.s. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum and (D) ventral view.

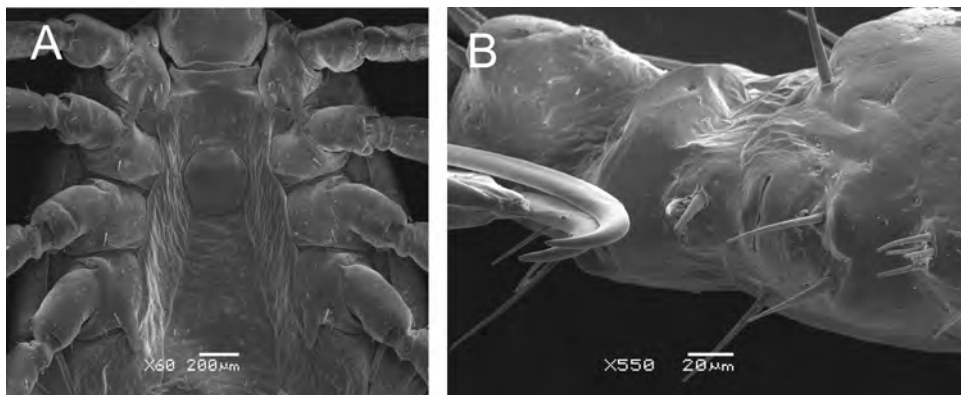


Fig. 3. Male of *Amblyomma cajennense* s.s. (A) coxae I-IV and (B) Haller's organ.

with corona of fine denticles. *Venter* (Fig. 2D): genital aperture located at level of coxae II, U-shaped. *Legs* (Fig. 3A): coxae I with 2 distinct spurs of medium length, the external one being the longest; coxae II–III with short rounded spur protruding from ridge-like edge; coxae IV with long, straight internal spur not reaching level of anus; trochanters with no spurs, tarsi I length  $0.76 \pm 0.06$  (0.66–0.90), width  $0.18 \pm 0.04$  (0.13–0.26); Haller's organ as illustrated in Fig. 3B, with transverse capsular aperture. *Spiracular plates*: comma-shaped, with caudal process at least as wide as adjacent festoon; length  $0.55 \pm 0.09$  (0.40–0.70), width  $0.29 \pm 0.04$  (0.20–0.36).

*Female*. Total length  $4.87 \pm 0.15$  (4.13–4.73); length from apices of scapulae to posterior body margin  $3.57 \pm 0.17$  (3.33–3.93); breadth  $2.93 \pm 0.14$  (2.67–3.20). Scutum length  $1.80 \pm 0.08$  (1.66–1.93), breadth  $1.99 \pm 0.08$  (1.83–2.13), length of posterior portion (from level of eyes to posterior margin)  $1.14 \pm 0.09$  (1.00–1.33). Scapulae rounded, cervical grooves deep and sigmoid, and marginal groove complete, delimiting all festoons (Fig. 4A and B). Eyes flat. Scutum ornate and glabrous (Fig. 20A). Cervical spots elongated sometimes merging posteriorly with limiting spots; limiting spots fused with ocular and accessory spots. Central area characterized by large patchy enamelled posterior spot. *Punctation* (Fig. 4A): fine, numerous, uniformly distributed punctations, deeper and larger in accessory spot. Notum hairy with 3 very narrow, very shallow, and glabrous grooves (Fig. 4A); median groove reaches median festoon, lateral grooves ending between festoons 2 and 3. Notal setae short and fine, densely distributed in posterior part of notum (Figs. 4A and 20A). Festoons: longer than wide, with 2 lines of setae on each festoon. Tubercles very small, about 1/5 width of festoons. *Dorsal capitulum* (Fig. 4B): length from palpal apices to cornua apices  $1.14 \pm 0.13$  (1.00–1.30), basis capituli sub-rectangular, breadth  $0.68 \pm 0.02$  (0.63–0.70), length  $0.37 \pm 0.04$  (0.30–0.47), posterior margin slightly concave, cornua rounded; distance between porose areas  $0.15 \pm 0.03$  (0.10–0.20), length of one porose area  $0.11 \pm 0.01$  (0.07–0.13). *Ventral capitulum* (Fig. 4C): basis capituli ventral length  $0.37 \pm 0.02$  (0.30–0.40); palpi total length  $0.93 \pm 0.05$  (0.80–1.05), length segment I  $0.12 \pm 0.01$  (0.07–0.13), length segment II  $0.57 \pm 0.04$  (0.46–0.64), length segment III  $0.22 \pm 0.03$  (0.16–0.30), width segment I  $0.11 \pm 0.01$  (0.10–0.13), width segment II  $0.14 \pm 0.02$  (0.10–0.16), width segment III  $0.17 \pm 0.01$  (0.13–0.20), segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 4C): length  $0.80 \pm 0.08$  (0.67–0.96), width  $0.23 \pm 0.02$  (0.20–0.27), dental formula 3/3 in 7–8 rows; apex with corona of fine denticles. *Venter*: genital aperture located between coxae II and III, with shape of truncated “V” and with 2 distinct lateral flaps (Fig. 4D). *Legs* (Fig. 5A): coxae I with 2 distinct spurs, external spur longer than internal spur, coxae II–III with ridge-like edge; coxae IV with short and round internal spur; trochanter with no spurs, tarsi I length  $0.92 \pm 0.08$  (0.70–1.03) width  $0.16 \pm 0.02$  (0.11–0.20); Haller's organ similar to that of male (Fig. 5B). *Spiracular plates*: comma-shaped, with caudal process as wide as the adjacent festoon, length  $0.64 \pm 0.03$  (0.60–0.70), width  $0.46 \pm 0.05$  (0.33–0.50).

### Description of *Amblyomma tonelliae* n. sp. Nava, Beati and Labruna

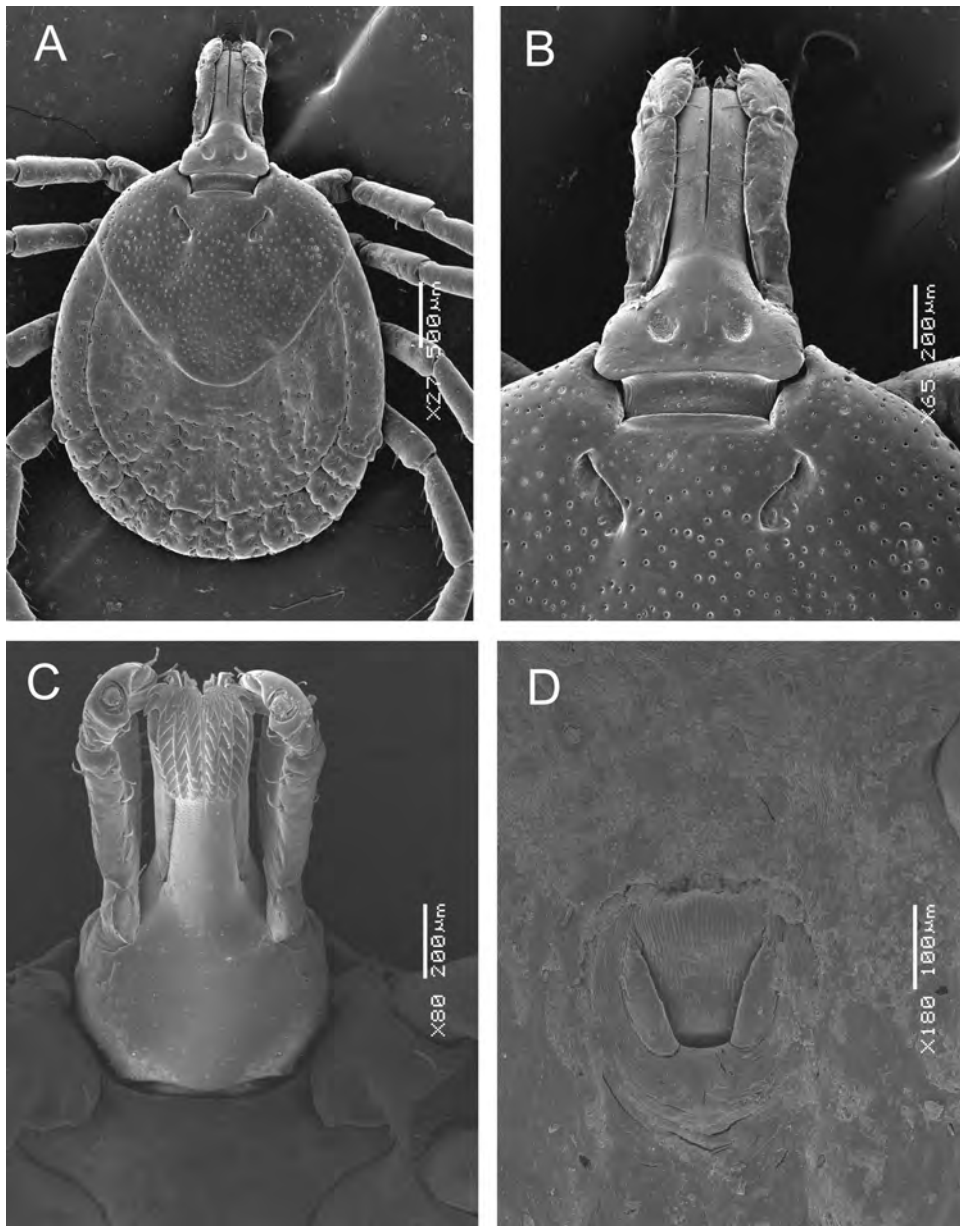
**Etymology:** This species is named for Maria Tonelli Rondelli, in recognition of her contribution to the taxonomic studies of Neotropical ticks.

**Type locality:** ARGENTINA, Pampa de los Guanacos (26°08'S 61°48'W), Santiago del Estero Province.

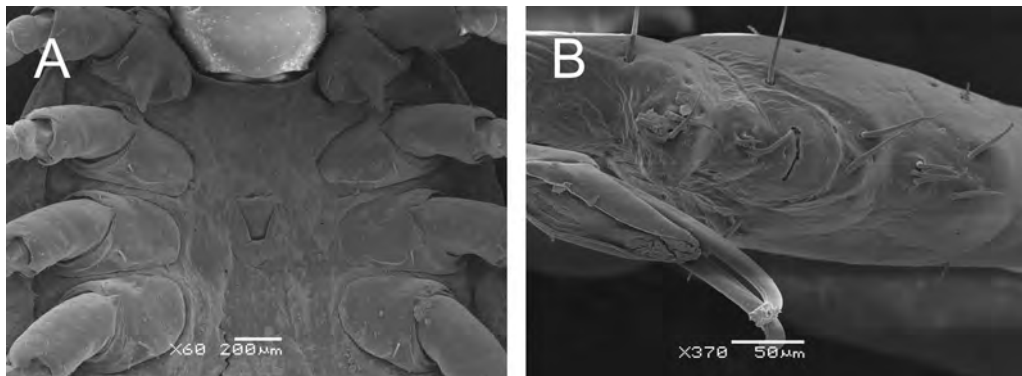
**Material examined:** Holotype ♂ and allotype ♀, paratype 5♂♂ and 4♀♀, collected December 2008 by A.J. Mangold, M. Mastropaolo, and S. Nava on vegetation, deposited at the USNTC

(RML 124455); paratypes 20♂♂ 20♀♀ ex vegetation, Pampa de los Guanacos (26°08'S 61°48'W), deposited at INTA (INTA 2146). Other material deposited at INTA: ARGENTINA – Province of Salta: Aguas Calientes (25°25'S 64°45'W) 3♂♂ 4♀♀ ex cattle (INTA 50); Apolinario Saravia (24°25'S 64°02'W) 25♂♂ 5♀♀ ex *E. caballus* (INTA 81); Campo Alegre (23°24'S 62°48'W) 3♂♂ 6♀♀ ex cattle (INTA 353); Campos del Norte (25°01'S 63°56'W) 2♀♀ ex cattle (INTA 936); Cañada Honda (23°47'S 63°23'W) 1♀ ex cattle (INTA 1014); Ceibalito (25°05'S 64°19'W) 1♀ ex *H. sapiens* (INTA 288); Coronel Olleross (25°05'S 64°15'W) 1♂ ex *H. sapiens* (INTA 283); Coronel Vidt (24°56'S 64°01'W) 1♂ ex *Canis lupus familiaris* (INTA 286); Cruz Quemada (25°02'S 64°48'W) 6♂♂ 2♀♀ ex cattle (INTA 315); Devisadero (25°20'S 64°48'W) 8♂♂ 1♀ ex cattle (INTA 67); Dragones (23°04'S 63°20'W) 2♂♂ 2♀♀ ex cattle (INTA 1954), 1♂ 1♀ ex *M. tridactyla* (INTA 2029); El Bordo (24°40'S 65°06'W) 1♀ ex cattle (INTA 530); El Chilcar (25°27'S 64°44'W) 7♂♂ ex cattle (INTA 273); El Ciénago (23°36'S 62°28'W) 1♂ 5♀♀ ex cattle (INTA 345); El Galpón (25°24'S 64°39'W) 22♂♂ 14♀♀ ex cattle (INTA 46); El Gramillal (25°16'S 64°36'W) 1♀ ex *E. caballus* (INTA 144); El Naranjo (25°44'S 65°00'W) 1♀ ex cattle (INTA 54); El Quebrachal (25°17'S 64°04'W) 5♂♂ 22♀♀ ex cattle (INTA 643); El Sauce (23°39'S 63°03'W) 1♂ 2♀♀ ex *E. caballus* (INTA 341); El Tunal (25°14'S 64°25'W) 1♂ ex cattle (INTA 357); Estancia Amakella (25°04'S 64°39'W) 3♂♂ 9♀♀ ex cattle (INTA 1955); Estancia San Francisco (24°54'S 63°44'W) 1♀ ex cattle (INTA 431); Guayacán (25°34'S 64°48'W) 1♀ ex cattle (INTA 948); Guemes (24°41'S 65°02'W) 1♀ ex *H. sapiens* (INTA 299); Horcones (25°43'S 64°55'W) 1♀ ex *H. sapiens* (INTA 1100); Juramento (25°10'S 64°58'W) 1♀ ex *H. sapiens* (INTA 1140); La Estrella (23°49'S 64°05'W) 1♀ ex vegetation (INTA 2037); La Salada (25°46'S 64°30'W) 15♂♂ 11♀♀ ex cattle (INTA 1047); Las Lajitas (24°41'S 64°15'W) 1♀ ex *T. tetradactyla* (INTA 939); Maravilla (25°36'S 64°48'W) 1♀ ex cattle (INTA 140); Morillo (23°28'S 62°53'W) 1♂ 2♀♀ ex cattle (INTA 346); Moromuerto (25°24'S 64°40'W) 1♂ ex cattle (INTA 74); Palma Horqueta (24°12'S 63°11'W) 3♂♂ 1♀ ex *Catagonus wagneri* (INTA 1990); Puesto Buen Lugar (24°42'S 63°51'W) 2♂♂ 2♀♀ ex cattle (INTA 755); Puesto El Picaflor (25°03'S 64°10'W) 3♂♂ 3♀♀ ex cattle (INTA 602); Puesto San Joaquín (24°14'S 62°48'W) 1♀ ex *T. pecari* (INTA 1989); Puesto San Vicente (24°39'S 63°57'W) 6♂♂ 5♀♀ ex *E. caballus* (INTA 889); Río Medina (25°16'S 64°32'W) 5♂♂ 2♀♀ ex cattle (INTA 65); Río Piedras (25°17'S 64°55'W) 1♀ ex cattle (INTA 35); Rivadavia (24°14'S 62°46'W) 1♂ 1♀ ex *T. pecari* (INTA 1999); Rodeadero (25°19'S 64°48'W) 6♂♂ 4♀♀ ex cattle (INTA 68); Rosario de la Frontera (25°48'S 64°58'W) 3♀♀ ex cattle (INTA 57); San Lorenzo (26°06'S 64°40'W) 5♂♂ 9♀♀ ex *E. caballus* (INTA 1179); San Luis (25°35'S 64°42'W) 9♀♀ ex cattle (INTA 1081); Tala Yaco (25°52'S 64°47'W) 1♀ ex *E. caballus* (INTA 1957); Talamuyo (25°05'S 64°15'W) 2♂♂ 3♀♀ ex *E. caballus* (INTA 1181); Veinticinco de Junio (24°55'S 63°59'W) 1♂ ex *H. sapiens* (INTA 497); Yaquiásmé (24°36'S 64°45'W) 1♀ ex cattle (INTA 306); Yatasto (25°35'S 64°56'W) 1♀ ex *H. sapiens* (INTA 527). Province of Santiago del Estero: Coronel Rico (26°41'S 61°50'W) 3♂♂ 5♀♀ ex cattle (INTA 1372); Pampa de Los Guanacos (26°08'S 61°48'W) 5♂♂ 2♀♀ ex vegetation (INTA 2147); Sachayoj (26°41'S 61°52'W) 13♂♂ 11♀♀ ex cattle (INTA 1281). BOLIVIA – Department of Santa Cruz: 30 km E from Boyuibe (20°25'S 63°00'W) 2♀♀ ex cattle (INTA 1582). PARAGUAY – Department of Boquerón: Estancia Faro Moro (21°41'S 60°01'W) 3♀♀ ex *Puma concolor* (RML 123654 and RML 123666); Filadelfia (22°28'S 60°00'W) 1♀ ex *H. sapiens* (INTA 2149), 1♂ 1♀ ex *H. hydrochaeris* (INTA 2150), 2♂♂ 2♀♀ ex *T. tajacu* (INTA 2156); Transchaco Road km 580 (21°10'S 61°40'W) 1♂ ex *Mazama* sp. (RML 105915).

*Male*. Total length  $4.59 \pm 0.14$  (4.0–4.80); length from apices of scapulae to posterior body margin  $3.67 \pm 0.13$  (3.06–3.93); breadth  $2.97 \pm 0.15$  (2.53–3.27). Outline oval, scapulae rounded, and cervical grooves deep, short, comma-shaped (Fig. 6A). Marginal groove complete, delimiting all festoons, deep up to level of coxa IV, then as line of deep punctuations becoming disperse from level

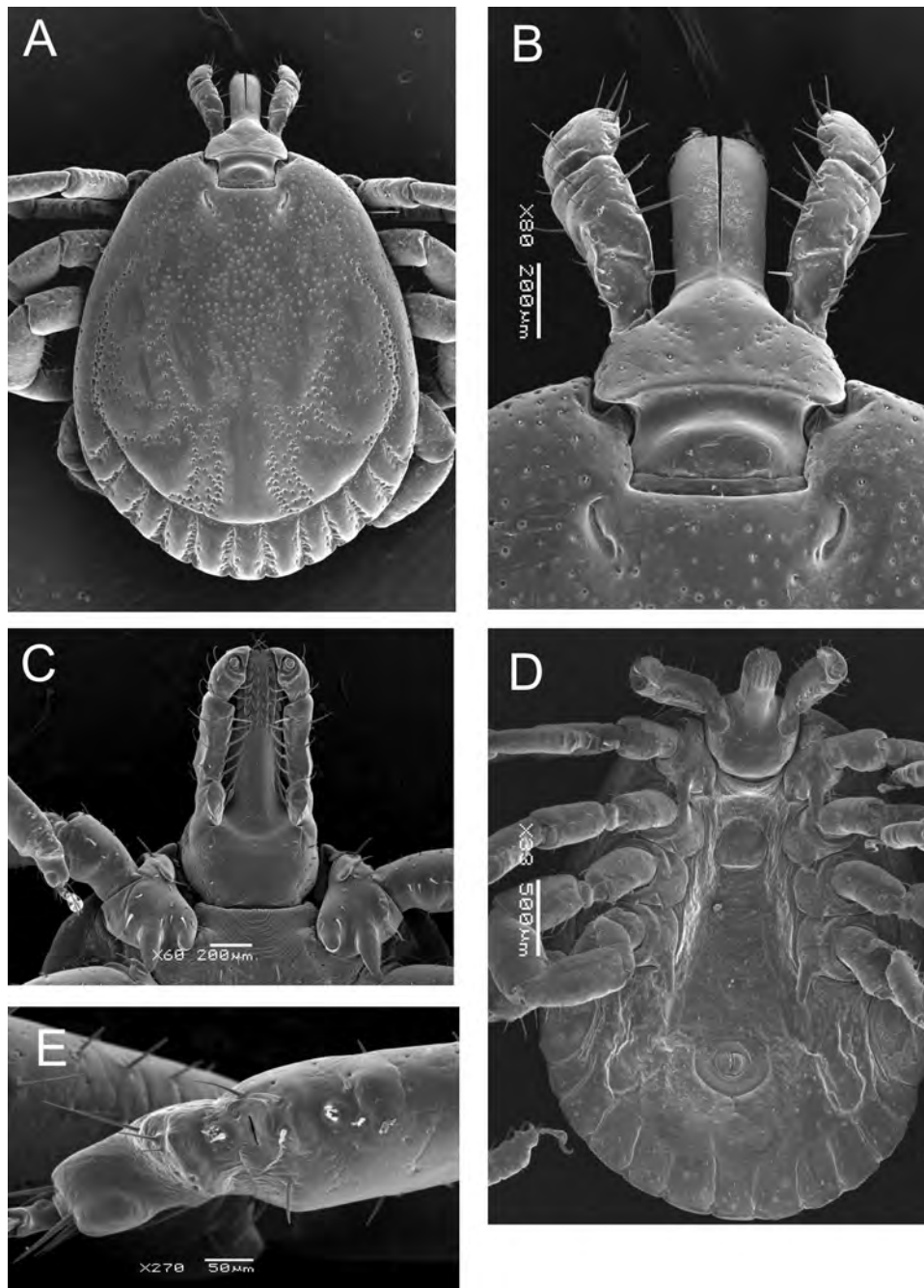


**Fig. 4.** Female of *Amblyomma cajennense* s.s. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum and (D) genital aperture.



**Fig. 5.** Female of *Amblyomma cajennense* s.s. (A) coxae I–IV and (B) Haller's organ.





**Fig. 6.** Male of *Amblyomma tonelliae* n. sp. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) ventral view and (E) Haller's organ.

of coxa IV to level of eyes (Fig. 6A). Eyes flat. Scutum ornate, glabrous, with brown spots delimited by whitish enamelled stripes (Fig. 19B); cervical spots elongated posteriorly; antero-median spot well-delimited; limiting and antero-accessory spots fused; posterior branches of limiting spots fused posteriorly; 3 lateral spots partially fused, but clearly recognizable; postero-accessory spots triangular; postero-median spot wider than adjacent enamelled stripe. Narrow and distinct marginal white stripe. *Festoons*: longer than wide, with few and small punctations, central festoon clear brown, festoon 5 with a broad dark stripe sometimes covering completely the festoon, festoons 1 and 4 clear brown, festoons 3 and 2 dark brown. *Punctuation* (Fig. 6A): in posterior part of scutum deep and large punctations outlining brown spots and less numerous in enamelled areas separating postero-median from accessory spots, in anterior part of scutum finer and uniformly distributed in

median area, larger and deeper laterally. *Dorsal capitulum* (Fig. 6B): length from palpal apices to cornua apices  $1.05 \pm 0.06$  (0.86–1.17), basis capituli sub-rectangular, breadth  $0.64 \pm 0.04$  (0.50–0.70), length  $0.32 \pm 0.03$  (0.23–0.36), posterior margin slightly concave, cornua rounded. *Ventral capitulum* (Fig. 6C): basis capituli ventral length  $0.29 \pm 0.03$  (0.23–0.33); Palpi total length  $0.85 \pm 0.06$  (0.70–0.97), length segment I  $0.10 \pm 0.03$  (0.07–0.13), length segment II  $0.54 \pm 0.04$  (0.46–0.60), length segment III  $0.20 \pm 0.02$  (0.13–0.23), width segment I  $0.11 \pm 0.03$  (0.08–0.13), width segment II  $0.15 \pm 0.02$  (0.10–0.17), width segment III  $0.17 \pm 0.02$  (0.13–0.20), segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 6C): length  $0.70 \pm 0.05$  (0.60–0.80), width  $0.24 \pm 0.02$  (0.20–0.26), dental formula 3/3 in 6–7 rows; apex with corona of fine denticles. *Venter* (Fig. 6D): genital aperture located at level of coxae II, U-shaped. *Legs* (Fig. 6D): coxae I with 2 spurs

of medium length, the external one being longest; coxae II–III with rounded short spur protruding from ridge-like edge; coxae IV with long, straight, and pointed internal spur not reaching level of anus; trochanters with no spurs, tarsi I length  $0.70 \pm 0.04$  (0.60–0.80) width  $0.17 \pm 0.02$  (0.13–0.20); Haller's organ as illustrated in Fig. 6E, with transverse capsular aperture. *Spiracular plates*: comma-shaped, with caudal process as wide as adjacent festoon, length  $0.66 \pm 0.03$  (0.57–0.76), width  $0.30 \pm 0.04$  (0.23–0.40).

**Female.** Total length  $5.20 \pm 0.19$  (4.60–5.46); length from apices of scapulae to posterior body margin  $4.06 \pm 0.14$  (3.66–4.30); breadth  $3.34 \pm 0.13$  (3.00–3.60). Scutum length  $2.0 \pm 0.08$  (1.66–2.13), breadth  $2.05 \pm 0.07$  (1.73–2.13), length of posterior portion (from level of eyes to posterior margin)  $1.34 \pm 0.07$  (1.13–1.46). Scapulae rounded, cervical grooves short and comma-shaped, and marginal groove complete, delimiting all festoons (Fig. 7A). Eyes flat. Scutum ornate and glabrous (Fig. 20B); cervical spots elongated covering cervical grooves and sometimes touching posteriorly limiting spots; limiting spots fused with ocular and sometimes with accessory spots. Central patch covered by large enamelled spot. *Punctation* (Fig. 7A): punctations large, numerous, uniformly distributed, deeper in frontal and cervical spots. Notum corrugated, hairy and with 3 deep grooves. Median groove reaches parma, lateral grooves ending between festoons 2 and 3 (Fig. 7A). Setae long and stout, distributed in such a way that setae appear to create a bridge over the 3 grooves of notum (Figs. 7A and 20B). Festoons: longer than wide and separated by deep depressions; hairy, with 2 lines of long stout setae originating from lateral margins of festoons and covering depressions between festoons. Tubercles visible dorsally, broad, about one-half width of festoon. *Dorsal capitulum* (Fig. 7B): length from palpal apices to cornua apices  $1.22 \pm 0.04$  (1.16–1.23), basis capituli sub-rectangular, breadth  $0.74 \pm 0.03$  (0.66–0.83), length  $0.30 \pm 0.02$  (0.26–0.35), posterior margin slightly concave, cornua rounded. Porose areas oval diverging anteriorly; distance between porose areas  $0.15 \pm 0.01$  (0.13–0.16) and length of one porose area  $0.11 \pm 0.01$  (0.10–0.13). *Ventral capitulum* (Fig. 7C): basis capituli ventral length  $0.33 \pm 0.02$  (0.29–0.36); palpi total length  $0.91 \pm 0.03$  (0.82–0.97), length segment I  $0.11 \pm 0.01$  (0.10–0.13), length segment II  $0.57 \pm 0.04$  (0.46–0.64), length segment III  $0.24 \pm 0.02$  (0.23–0.26), width segment I  $0.11 \pm 0.01$  (0.10–0.13), width segment II  $0.15 \pm 0.01$  (0.13–0.17), width segment III  $0.17 \pm 0.02$  (0.15–0.20), segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 7C): length  $0.87 \pm 0.04$  (0.76–0.93), width  $0.25 \pm 0.02$  (0.23–0.30), dental formula 3/3 in 7–8 rows; apex with corona of fine denticles. *Venter*: genital aperture located between coxae II and III, in shape of narrow truncated “V”, and with distinct lateral flaps (Fig. 7D). *Legs* (Fig. 7E): coxae I with 2 spurs, external spur longer than internal spur; coxae II–III with ridge-like edge; coxae IV with short rounded internal spur; trochanter with no spurs, tarsi I length  $0.86 \pm 0.03$  (0.80–0.92) width  $0.15 \pm 0.01$  (0.13–0.18); Haller's organs similar to that of male (Fig. 7F). *Spiracular plates*: comma-shaped, with small caudal process as wide as adjacent festoon, length  $0.63 \pm 0.03$  (0.58–0.66) width  $0.40 \pm 0.03$  (0.37–0.50).

### Description of *Amblyomma interandinum* n. sp. Beati, Nava and Cáceres

**Etymology:** This species is named for the inter-Andean valley of Peru, where the type specimens were collected.

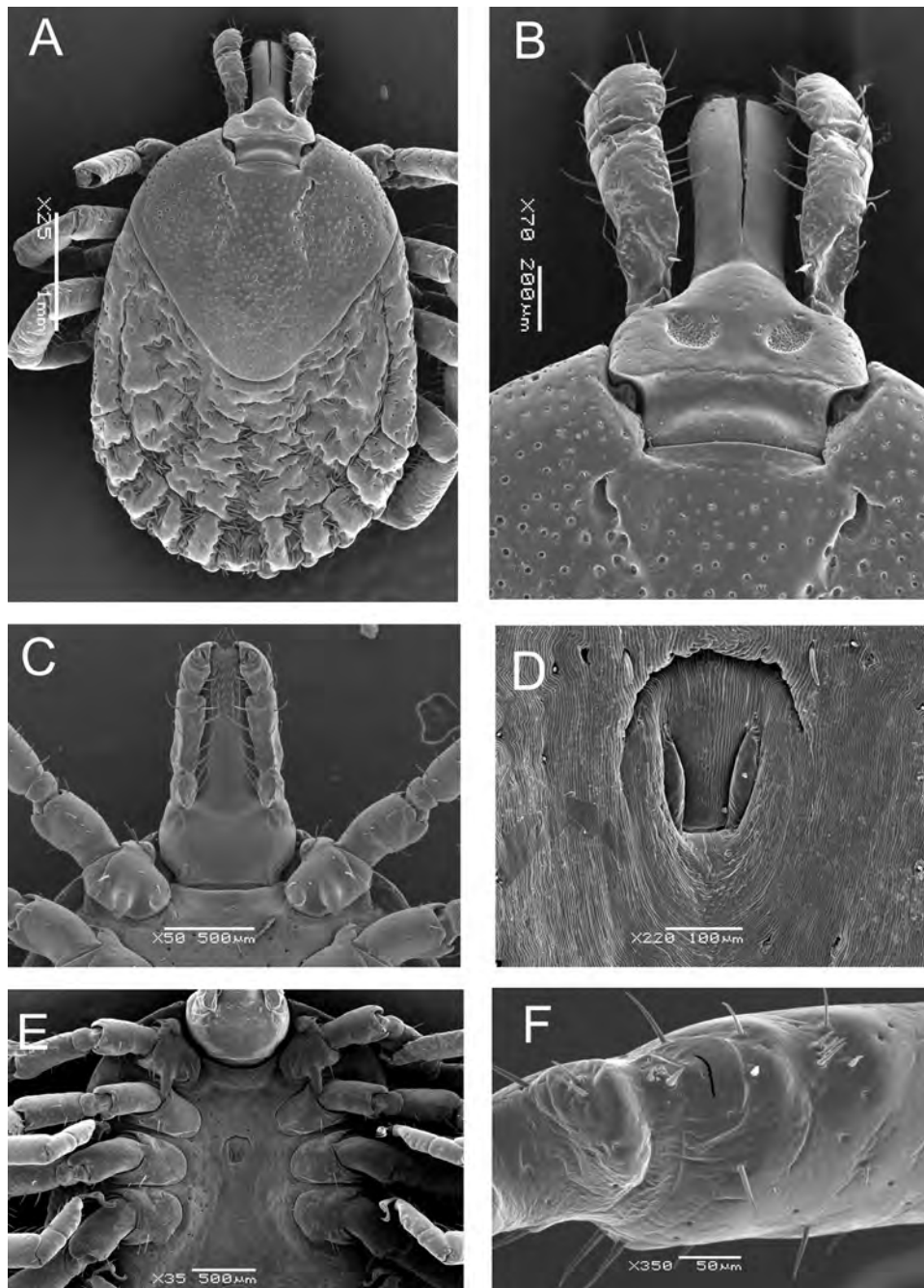
**Type locality:** PERU, Bellavista (5°41'S 78°42'W), Cajamarca Province.

**Material examined:** Holotype ♂ collected in January 2004 by Antero González Perez on “deer”, deposited at the USNTC (RML

124077), allotype ♀ collected January 2004 by Antero González Perez on “deer” in Bellavista (5°41'S 78°42'W), deposited at the USNTC (RML 124075); paratypes 100♂♂ and 30♀♀, Bellavista (5°41'S 78°42'W), deposited at the USNTC (RML 124074, RML 124075, RML 124076, and RML 124077).

**Male.** Total length  $3.66 \pm 0.24$  (3.33–4.07); length from apices of scapulae to posterior body margin  $2.91 \pm 0.19$  (2.53–3.20), breadth  $2.14 \pm 0.10$  (1.93–2.33). Outline oval, scapulae pointed, cervical grooves deep, short, comma-shaped (Fig. 8A). Marginal groove complete, delimiting all festoons, deep up to level of coxa IV, and then as a line of deep punctations reaching level of eye (Fig. 8A). Eyes flat. Scutum ornate, glabrous, with brown spots delimited by whitish enamelled stripes (Fig. 19C). Cervical spots elongated sometimes merging with limiting spots; branches of limiting spots broad; the posterior ones merging into each other posteriorly; ocular spot, antero-accessory, first and second lateral spots fused; third lateral spot partially fused with second spot, but distinctly visible; accessory spot triangular; postero-median spot wider than adjacent enamelled stripe. Conspicuous and long marginal white stripe. *Festoons*: longer than wide, with few and small punctations, central festoon clear brown, festoon 5 with broad dark stripe sometimes completely covering festoon, festoon 4 clear brown, festoons 1–3 with broad dark internal stripe. *Punctation* (Fig. 8A): In posterior scutum deep and large punctations outlining brown spots and less numerous in enamelled areas separating postero-median from accessory spots; in anterior part of scutum large, shallower, uniformly distributed punctations. *Dorsal capitulum* (Fig. 8B): length from palpal apices to cornua apices  $0.96 \pm 0.04$  (0.83–1.03), basis capituli sub-rectangular, breadth  $0.56 \pm 0.03$  (0.50–0.60), length  $0.33 \pm 0.02$  (0.30–0.43), posterior margin straight, cornua rounded and very pronounced. *Ventral capitulum* (Fig. 8C): basis capituli ventral length  $0.27 \pm 0.04$  (0.20–0.33); palpi total length  $0.74 \pm 0.07$  (0.63–1.03), length segment I  $0.08 \pm 0.02$  (0.06–0.13), length segment II  $0.41 \pm 0.03$  (0.36–0.50), length segment III  $0.21 \pm 0.02$  (0.18–0.23), width segment I  $0.08 \pm 0.02$  (0.07–0.11), width segment II  $0.12 \pm 0.02$  (0.10–0.16), width segment III  $0.14 \pm 0.02$  (0.13–0.20); segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 8C): length  $0.67 \pm 0.04$  (0.53–0.73), width  $0.16 \pm 0.02$  (0.10–0.20), dental formula 3/3 in 7–8 rows; apex with corona of fine denticles. *Venter* (Fig. 8D): genital aperture located at level of coxae II, U-shaped; *Legs* (Fig. 8D): coxae I with 2 distinct spurs of medium length, the external one being longest; coxae II–III with ridge-like spurs; coxae IV with long and straight internal spur not reaching the level of anus; trochanter with no spurs, tarsi I length  $0.44 \pm 0.07$  (0.33–0.53), width  $0.20 \pm 0.02$  (0.17–0.27); Haller's organ as illustrated in Fig. 8E, with transverse capsular aperture. *Spiracular plates*: comma-shaped, with caudal process as wide as adjacent festoon; length  $0.71 \pm 0.04$  (0.67–0.80), width  $0.16 \pm 0.04$  (0.10–0.23).

**Female.** Total length  $4.60 \pm 0.15$  (4.40–4.93); length from apices of scapulae to posterior body margin  $3.57 \pm 0.13$  (3.50–3.93), breadth  $2.72 \pm 0.07$  (2.60–2.86). Scutum length  $1.90 \pm 0.08$  (1.73–2.06), breadth  $1.97 \pm 0.08$  (1.80–2.13), length of posterior portion (from level of eyes to posterior margin)  $1.24 \pm 0.06$  (1.05–1.40). Scapulae pointed, cervical grooves short and sigmoid, and marginal groove complete, delimiting all festoons (Fig. 9A and 9B). Eyes flat. Scutum ornate and glabrous (Fig. 20C). Cervical spots elongated merging posteriorly with limiting spots; limiting spots fused with ocular and accessory spots; central patch long, brown, rhomboid not reaching enamelled posterior margin of scutum. *Punctation* (Fig. 9A): numerous fine punctations, uniformly distributed, deeper in antero-lateral areas. Notum hairy with 3 deep grooves. Median groove reaches parma, lateral grooves ending between festoons 2 and 3 (Fig. 9A). Setae long and stout and distributed in such a way that setae appear to create a bridge over the 3 grooves of notum (Figs. 9A and 20C). Festoons longer than



**Fig. 7.** Female of *Amblyomma tonelliae* n. sp. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) genital aperture; (E) ventral view and (F) Haller's organ.

wide, hairy, with at least 2 lines of setae on each festoon. Tubercles visible dorsally and as wide as 1/3 of festoons' breadth. *Dorsal capitulum* (Fig. 9B): length from palpal apices to cornua apices  $1.19 \pm 0.06$  (1.03–1.26), basis capituli sub-rectangular, breadth  $0.69 \pm 0.04$  (0.30–0.40), length  $0.34 \pm 0.04$  (0.30–0.40), posterior margin slightly concave, cornua rounded. Porose areas oval and diverging anteriorly; distance between porose areas  $0.16 \pm 0.01$  (0.14–0.17), length of one porose area  $0.13 \pm 0.01$  (0.11–0.13). *Ventral capitulum* (Fig. 9C): basis capituli ventral length  $0.35 \pm 0.05$  (0.26–0.43); Palpi total length  $0.88 \pm 0.04$  (0.80–0.96), length segment I  $0.10 \pm 0.01$  (0.07–0.13), length segment II  $0.55 \pm 0.03$  (0.50–0.63), length segment III  $0.25 \pm 0.02$  (0.20–0.30), width segment I  $0.10 \pm 0.01$  (0.09–0.12), width segment II  $0.13 \pm 0.01$  (0.12–0.13), width segment III  $0.15 \pm 0.01$  (0.13–0.17), segment

I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 9C): length  $0.90 \pm 0.08$  (0.77–1.00), width  $0.27 \pm 0.05$  (0.23–0.43), dental formula 3/3 in files of 7–8; apex with corona of fine denticles. *Venter*: genital aperture located between coxae II and III, with shape of truncated “V” and with 2 distinct lateral flaps and vestibular portion of vagina conspicuously bulging (Fig. 9D). *Legs* (Fig. 10A): coxae I with 2 distinct spurs, external spur longer than internal spur; coxae II–III with ridge-like edge; coxae IV with short rounded internal spur; trochanter with no spurs, tarsi I length  $0.87 \pm 0.09$  (0.73–0.87), width  $0.18 \pm 0.02$  (0.13–0.23); Haller's organ similar to that of male (Fig. 10B). *Spiracular plates*: comma-shaped, with small caudal process narrower than adjacent festoon, length  $0.51 \pm 0.06$  (0.40–0.63), width  $0.40 \pm 0.03$  (0.30–0.43).

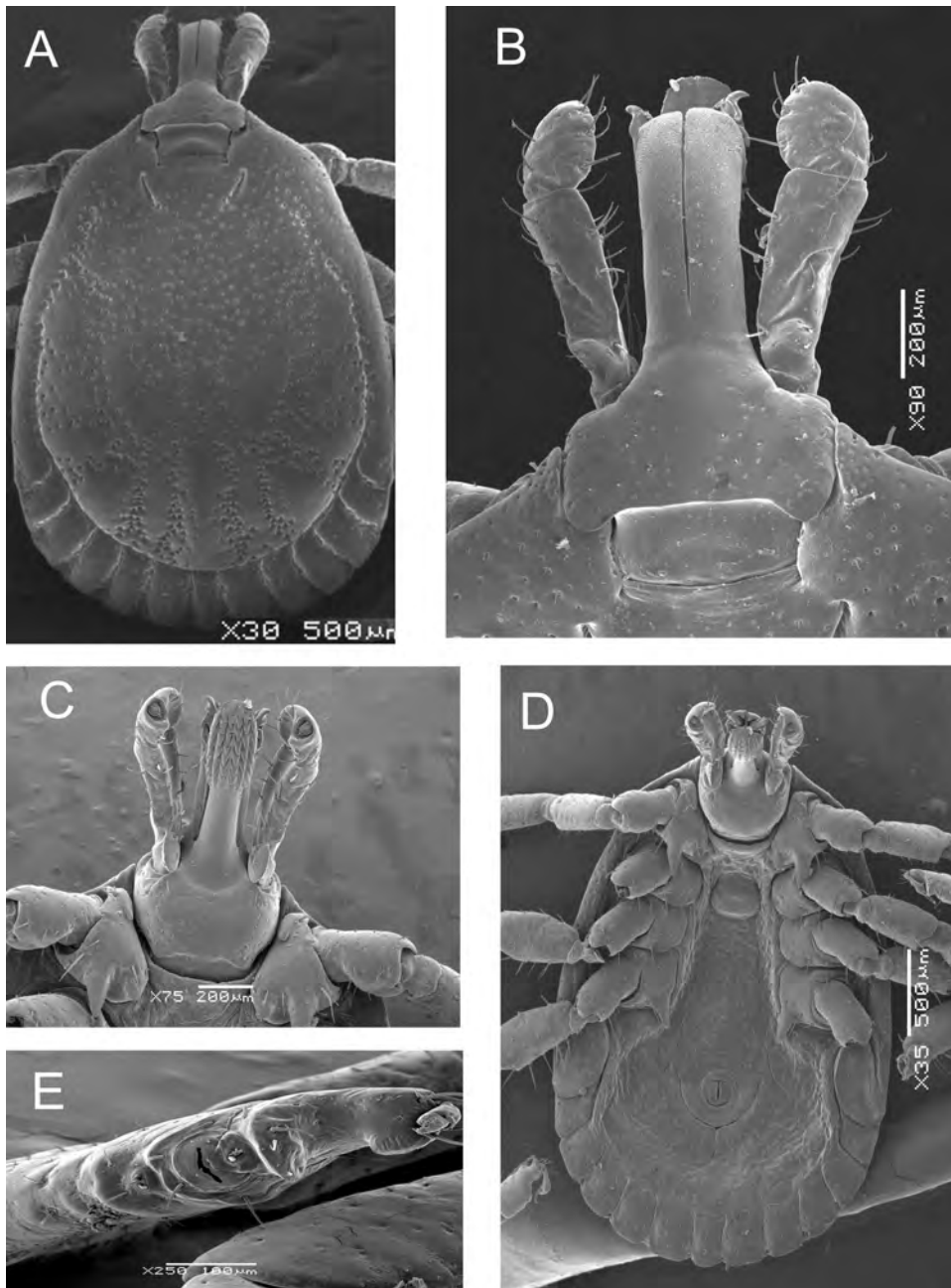


Fig. 8. Male of *Amblyomma interandinum* n. sp. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) ventral view and (E) Haller's organ.

#### Description of *Amblyomma patinoi* n. sp. Labruna, Nava and Beati

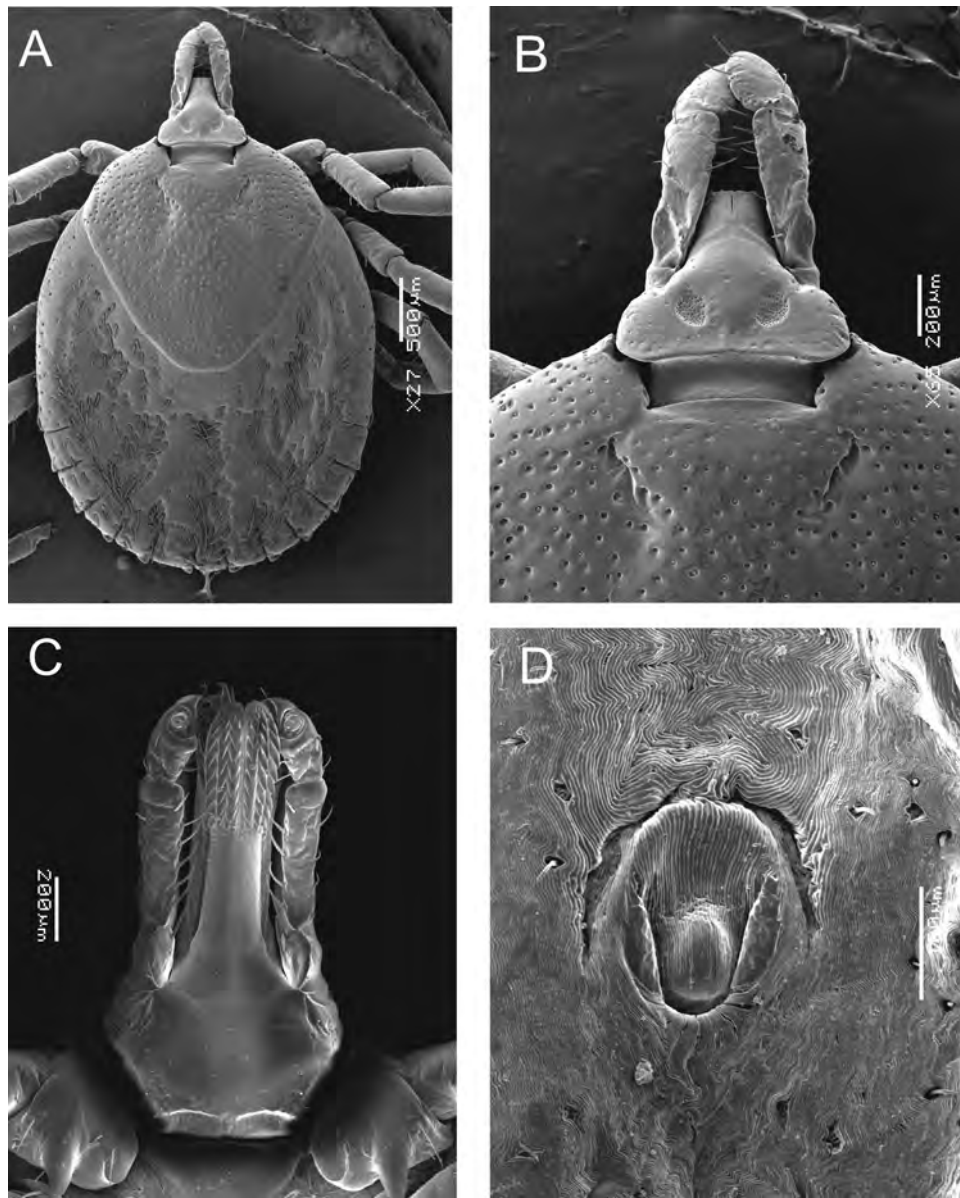
**Etymology:** This species is named for Dr. Luis Patiño Camargo, in recognition of his pioneering contribution to the study of tick-borne rickettsioses in Cundinamarca, Colombia.

**Type locality:** COLOMBIA, Villeta (05°01'N 74°28'W), Department of Cundinamarca.

**Material examined:** Holotype ♂ and allotype ♀, collected July, 2005 by M.B. Labruna, E. Benavides, and G. Valbuena on cattle, deposited at the CNC (CNC 1584); paratypes 8♂♂ and 3♀♀, collected July 2005 by M.B. Labruna, E. Benavides, and G. Valbuena on cattle in Villeta (05°01'N 74°28'W), deposited at the CNC (CNC 1582); paratypes 5♂♂ 1♀♀ ex vegetation, deposited at CNC (CNC 1583); paratypes 10♂♂ 10♀♀ laboratory colony derived from engorged females collected on cattle in Villeta (05°01'N 74°28'W), deposited

at CNC (CNC 1585). Other material deposited at the USNTC: Villeta (05°01'N 74°28'W) 5♂♂ 1♀♀ ex *E. caballus* (RML 124454).

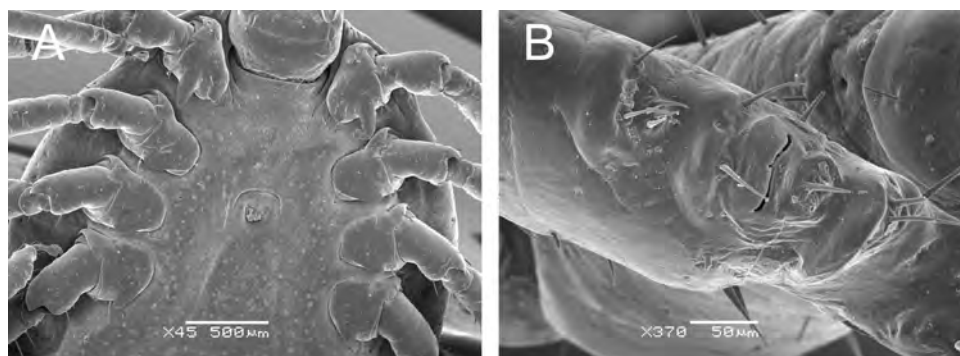
**Male.** Total length  $4.67 \pm 0.14$  (4.40–5.00); length from apices of scapulae to posterior body margin  $3.76 \pm 0.14$  (3.40–3.93), breadth  $2.90 \pm 0.11$  (2.66–3.00). Outline oval, scapulae rounded, and cervical grooves deep, short, comma-shaped (Fig. 11A). Marginal groove complete, delimiting all festoons, deep up to level of coxa IV, and then as a line of deep punctations reaching level of eyes (Fig. 11A). Eyes flat. Scutum glabrous with overall smooth and shiny appearance, ornate, with brown spots delimited by whitish enamelled stripes (Fig. 19D). Cervical spots large and elongated posteriorly; antero-accessory spots large and distinct, separated from ocular spots by fine whitish line; branches of limiting spots broad, posterior branches of limiting spots not fused posteriorly; first, second, and third lateral spots partially fused but distinct; third lateral spot clearly delimited and horizontally oriented; postero-accessory



**Fig. 9.** Female of *Amblyomma interandinum* n. sp. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum and (D) genital aperture.

spots as broad as 2 adjacent festoons along marginal groove, and postero-median spot long, club-shaped, basally narrower than adjacent enamelled stripe. Narrow marginal white stripe, sometimes indistinct. *Festoons*: clear brown, longer than wide, with few

small punctations, festoons 1–5 with darker internal stripes. *Punctuation* (Fig. 11A): posterior scutum moderately punctated with large and shallow punctations deeper and more numerous on enamelled stripes; anterior part of scutum with finer and less numerous



**Fig. 10.** Female of *Amblyomma interandinum* n. sp. (A) coxae I–IV; (B) Haller's organ.

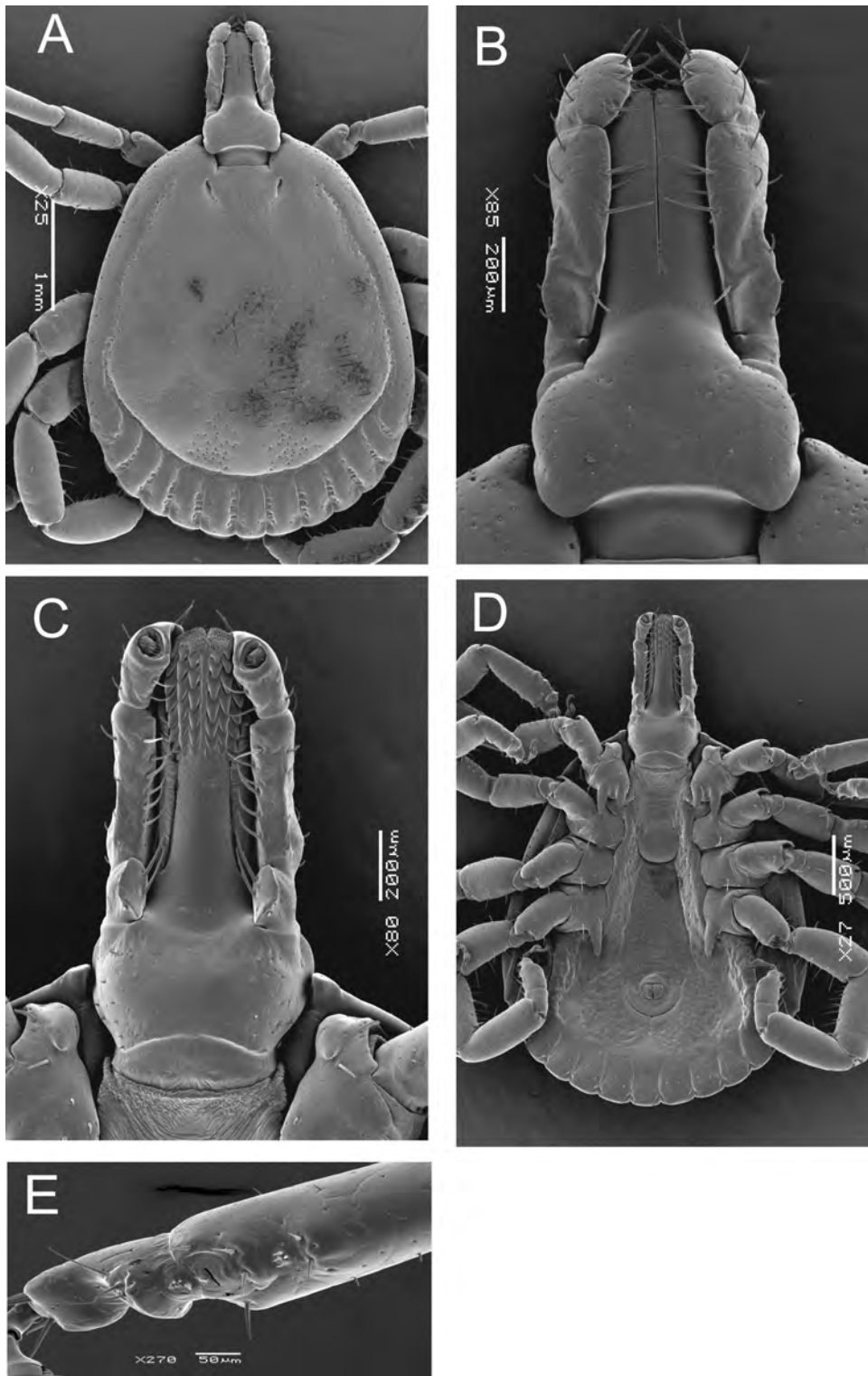
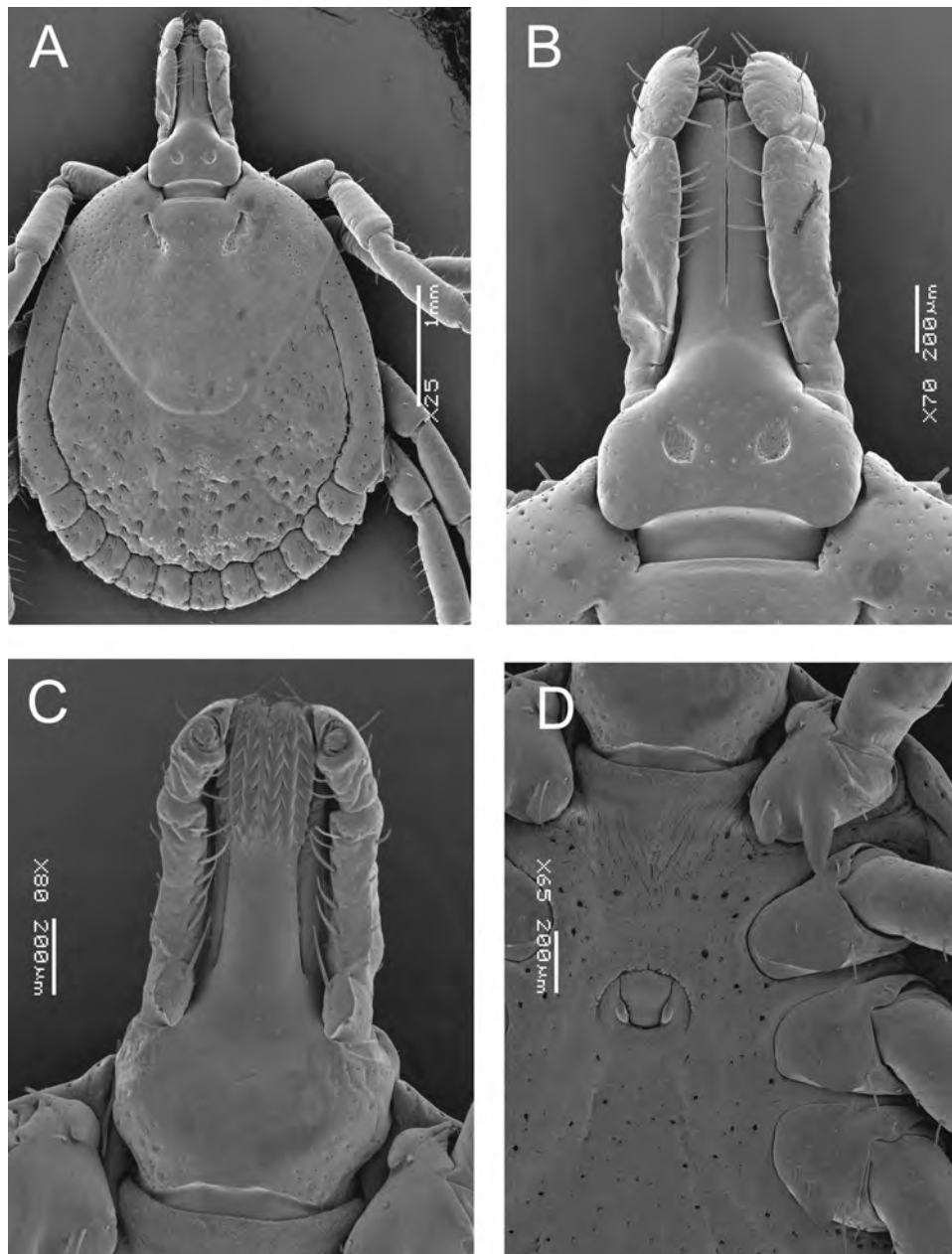


Fig. 11. Male of *Amblyomma patinoi* n. sp. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) ventral view; (E) Haller's organ.

punctations, deeper in marginal areas. *Dorsal capitulum* (Fig. 11B): length from palpal apices to cornua apices  $1.07 \pm 0.05$  (1.00–1.67), basis capituli sub-rectangular, breadth  $0.66 \pm 0.02$  (0.60–0.70), length  $0.31 \pm 0.02$  (0.25–0.37), posterior margin slightly concave, cornua rounded. *Ventral capitulum* (Fig. 11C): basis capituli ventral length  $0.32 \pm 0.04$  (0.26–0.40); palpi total length  $0.85 \pm 0.05$  (0.73–0.94), length segment I  $0.12 \pm 0.02$  (0.08–0.13), length segment II  $0.51 \pm 0.02$  (0.43–0.53), length segment III  $0.21 \pm 0.03$

(0.13–0.26), width segment I  $0.11 \pm 0.01$  (0.08–0.13), width segment II  $0.15 \pm 0.01$  (0.13–0.17), width segment III  $0.17 \pm 0.02$  (0.15–0.21), segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 11C): length  $0.76 \pm 0.04$  (0.67–0.83), width  $0.30 \pm 0.01$  (0.28–0.33), dental formula 3/3 in 6–7 rows; apex with corona of fine denticles. *Venter* (Fig. 11D): genital aperture located at level of coxae II, U-shaped. *Legs* (Fig. 11D): coxae I with 2 distinct spurs of medium length, the external one being longest,



**Fig. 12.** Female of *Amblyomma patinoi* n. sp. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) genital aperture and coxae I–IV.

coxae II–III with short rounded spur protruding from ridge-like edge; coxae IV with long, straight, and internal spur not reaching level of anus; trochanters with no spurs, tarsi I length  $0.73 \pm 0.04$  (0.67–0.83), width  $0.16 \pm 0.01$  (0.15–0.18); Haller's organ as illustrated in Fig. 11E, with transverse capsular aperture. *Spiracular plates*: comma-shaped, with caudal process as wide as adjacent festoon, length  $0.66 \pm 0.03$  (0.60–0.73), width  $0.30 \pm 0.04$  (0.25–0.34).

**Female.** Total length  $5.12 \pm 0.19$  (4.60–5.40); length from apices of scapulae to posterior body margin  $4.00 \pm 0.21$  (3.33–4.39), breadth  $3.12 \pm 0.16$  (2.73–3.33). Scutum length  $2.02 \pm 0.05$  (1.93–2.13), breadth  $2.10 \pm 0.11$  (1.93–2.33), length of posterior portion (from level of eyes to posterior margin)  $1.29 \pm 0.06$  (1.20–1.40). Scapulae rounded, cervical grooves deep and sigmoid, and marginal groove complete, delimiting all festoons (Fig. 12A). Eyes flat. Scutum ornate and glabrous (Fig. 20D). Cervical spots elongated merging posteriorly with limiting spots; limiting spots reach and merge with ocular spot, ocular spot fused with accessory

spot. Central area characterized by large brown patch outlined by enamelled contour. *Punctuation* (Fig. 12A): uniformly distributed, fine punctations in central area, deeper in lateral fields. Notum hairy with 3 very narrow, shallow, and glabrous grooves (Fig. 12A). Notal setae fine and short, sparsely distributed (Fig. 20D). *Festoons*: longer than wide, with 2 lines of setae on each festoon. Tubercles very small about 1/5 of festoon's width. *Dorsal capitulum* (Fig. 12B): length from palpal apices to cornua apices  $1.35 \pm 0.04$  (1.23–1.43), basis capituli sub-rectangular, breadth  $0.75 \pm 0.04$  (0.67–0.80), length  $0.32 \pm 0.03$  (0.26–0.38), posterior margin slightly concave, cornua rounded; distance between porose areas  $0.20 \pm 0.02$  (0.16–0.24), length of one porose area  $0.14 \pm 0.02$  (0.09–0.16). *Ventral capitulum* (Fig. 12C): basis capituli ventral length  $0.33 \pm 0.02$  (0.28–0.37); palpi total length  $0.98 \pm 0.04$  (0.83–1.10), length segment I  $0.13 \pm 0.01$  (0.10–0.14), length segment II  $0.60 \pm 0.03$  (0.46–0.67), length segment III  $0.25 \pm 0.02$  (0.23–0.30), width segment I  $0.12 \pm 0.01$  (0.10–0.13), width segment II  $0.15 \pm 0.01$

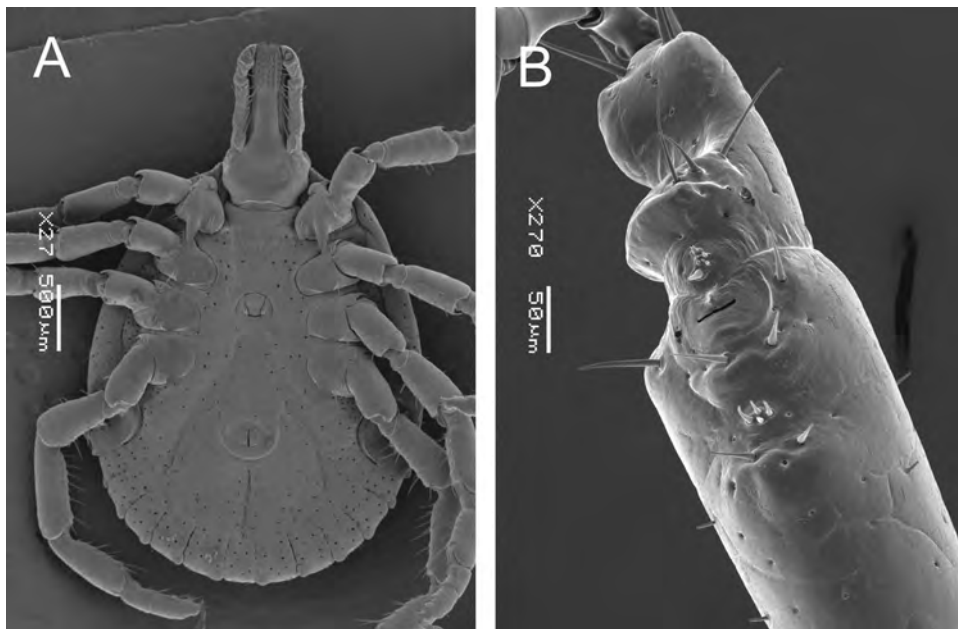


Fig. 13. Female of *Amblyomma patinoi* n. sp. (A) ventral view; (B) Haller's organ.

(0.13–0.17), width segment III  $0.20 \pm 0.01$  (0.18–0.22), segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 12C): length  $0.88 \pm 0.05$  (0.80–0.96), width  $0.31 \pm 0.02$  (0.27–0.33), dental formula 3/3 in 7–8 rows; apex with corona of fine denticles. *Venter*: genital aperture located between coxae II and III, U-shaped with short and bulging flaps (Fig. 12D). *Legs* (Fig. 13A): coxae I with 2 distinct spurs, external spur longer than internal spur; coxae II–III with ridge-like edge; coxae IV with short and round internal spur; trochanter with no spurs, tarsi I length  $0.87 \pm 0.09$  (0.73–1.00), width  $0.18 \pm 0.02$  (0.15–0.21); Haller's organ similar to that of male (Fig. 13B). *Spiracular plates*: comma-shaped, with caudal process as wide as adjacent festoon, length  $0.64 \pm 0.04$  (0.58–0.73) width  $0.48 \pm 0.04$  (0.43–0.56).

#### Redescription of *Amblyomma mixtum* Koch, 1844

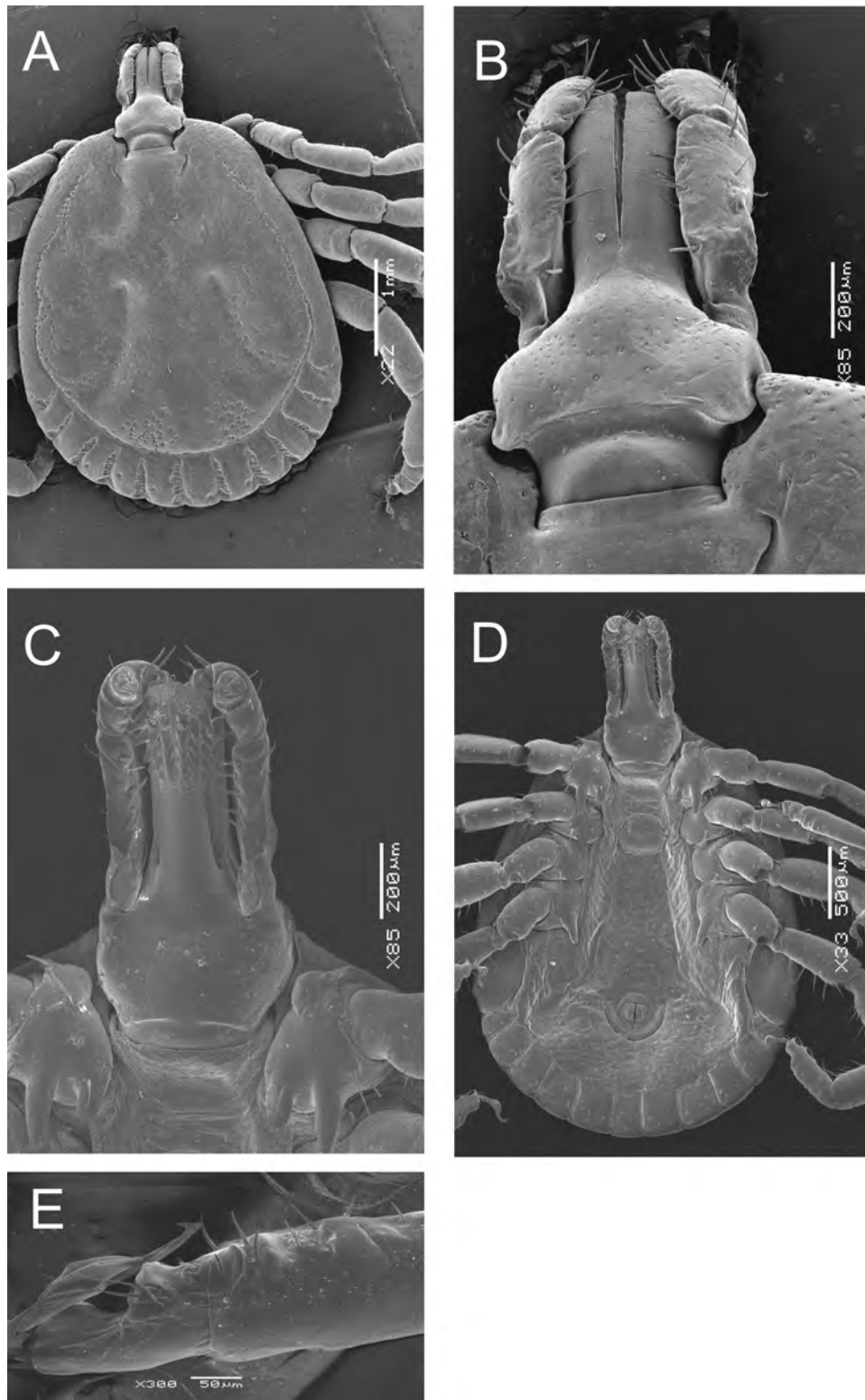
##### Synonym:

*Amblyomma versicolor* Nuttall G.H.F. and Warburton M.A. 1908, pp. 407–408, Figs. 27–29.

**Material examined:** A female lectotype from Mexico was selected within Koch's type series (ZMB 1061). Material deposited at the USNTC: COSTA RICA – Province of Guanacaste: Guanacaste ( $10^{\circ}37'N$   $85^{\circ}22'W$ ) 1♀ host unknown (RML 23247), Parque Nacional Palo Verde ( $10^{\circ}19'N$   $85^{\circ}16'W$ ) 1♀ ex *H. sapiens* (RML 123174). CUBA – Isla de la Juventud ( $21^{\circ}39'N$   $82^{\circ}48'W$ ) 1♀ ex mule (RML 57540). ECUADOR – Province of El Oro: Los Amarillos ( $03^{\circ}49'S$   $80^{\circ}04'W$ ) 4♂♂ 4♀♀ ex *Equus asinus* (RML 99810); Machala ( $03^{\circ}16'S$   $79^{\circ}57'W$ ) 3♂♂ 6♀♀ ex *E. caballus* (RML 57566). Province of Guayas: La Grecia ( $02^{\circ}42'S$   $79^{\circ}37'W$ ) 1♂ ex *E. asinus* (RML 66101); Pasaje ( $01^{\circ}10'S$   $79^{\circ}54'W$ ) 7♂♂ 2♀♀ ex *E. caballus* (RML 34066); Pedro Garbo ( $01^{\circ}48'S$   $80^{\circ}14'W$ ) 12♂♂ 11♀♀ ex cattle (RML 99808). Province of Manabí: Banchal ( $01^{\circ}36'S$   $80^{\circ}24'W$ ) 3♂♂ 1♀ ex *E. caballus* (RML 99809). Province of Los Ríos: Quevedo ( $01^{\circ}01'S$ ,  $79^{\circ}89'W$ ) 5♂♂ 2♀♀ ex cattle (RML 34067). Province of Pichincha: Puerto Quito ( $00^{\circ}05'N$   $79^{\circ}16'W$ ) 12♂♂ 10♀♀ ex vegetation. GUATEMALA – Department of Chimaltenango: Acatenango ( $14^{\circ}32'N$   $90^{\circ}56'W$ ) 1♂ ex cattle, 1♀ ex *E. caballus* (RML 28467), 1♀ ex *E. caballus* (RML 28468), 2♂♂ ex *E. caballus* (RML 28469), 4♂♂ 2♀♀ ex *E. caballus* (RML 28470), 1♂ ex *E. caballus* (RML 28478), 2♂♂ ex *E. caballus* (RML 28479), 4♂♂ 4♀♀ ex *E. caballus* (RML 28487), 15♂♂ 1♀ ex *E. caballus* (RML 30309),

5♂♂ 5♀♀ ex *E. caballus* (RML 30313), 15♂♂ 3♀♀ ex *E. caballus* (RML 30316), 10♂♂ ex mule (*E. caballus* × *E. asinus*) (RML 30317), 1♂ ex *E. caballus* (RML60426); Yepocapa ( $14^{\circ}29'N$   $90^{\circ}56'W$ ) 1♂ 1♀ ex cattle (RML 28456), 1♀ ex *T. pecari* (RML 57521). Department of Petén: Macanche ( $16^{\circ}57'N$   $89^{\circ}39'W$ ) 1♂ 1♀ ex cattle (RML 123384). HONDURAS – Department of Olancho: Catacamas ( $14^{\circ}50'N$   $85^{\circ}53'W$ ) 2♀♀ ex cattle (RML 37534), 2♀♀ ex *E. caballus* (RML 37535). Department of Yoro: Yoro ( $15^{\circ}07'N$   $87^{\circ}05'W$ ) 2♀♀ host unknown (RML 119716). JAMAICA – Amity Hall ( $17^{\circ}56'N$   $76^{\circ}14'W$ ) 1♂ host unknown (RML 39451), 2♀♀ ex mule (*E. caballus* × *E. asinus*) (RML 39452); Fort Simonds ( $17^{\circ}59'N$   $77^{\circ}14'W$ ) 1♂ ex *H. sapiens* (RML 20018), 1♂ ex mule (*E. caballus* × *E. asinus*) (RML 20019). MEXICO – State of Aguascalientes: Rincón de Romos ( $22^{\circ}15'N$   $102^{\circ}17'W$ ) 3♂♂ 1♀ ex cattle (RML 57501). State of Chiapas: Ozocoautla ( $16^{\circ}46'N$   $93^{\circ}22'W$ ) 1♂ 1♀ ex *Nasua narica* (RML 23776), 1♀ ex *Mazama americana* (RML 23777); San Cristobal ( $16^{\circ}44'N$   $92^{\circ}32'W$ ) 3♂♂ 1♀ ex *Homo sapiens* (RML 22125), 3♂♂ ex *E. caballus* (RML 25892); Tuxtla Gutiérrez ( $16^{\circ}43'N$   $93^{\circ}06'W$ ) 2♀♀ ex cattle (RML 57495). State of Chihuahua: Tomate ( $27^{\circ}16'N$   $106^{\circ}17'W$ ) 11♂♂ 1♀ ex *E. caballus* (RML 25895). State of Coahuila de Zaragoza: El Bañito ( $26^{\circ}53'N$   $102^{\circ}05'W$ ) 2♀♀ ex *H. sapiens* (RML 17459), 1♂ 1♀ ex *H. sapiens* (RML 17465), 1♂ ex *Sciurus aureogaster* (RML 17468). State of Guanajuato: Aguirre ( $20^{\circ}36'N$   $100^{\circ}50'W$ ) 3♂♂ ex cattle (RML 57505). State of Guerrero: Zihuatanejo ( $17^{\circ}38'N$   $101^{\circ}33'W$ ) 1♂ ex *H. sapiens* (RML 64441). State of Durango: San Jacobo ( $24^{\circ}10'N$   $103^{\circ}49'W$ ) 7♂♂ ex *E. caballus*; Santa Fe ( $24^{\circ}34'N$   $106^{\circ}17'W$ ) 4♂♂ 1♀ ex *E. caballus* (RML 25888). State of Morelos: Zacatepec ( $18^{\circ}39'N$   $99^{\circ}11'W$ ) 11♂♂ 1♀ ex *E. caballus* (RML 25884). State of Nayarit: Compostela ( $21^{\circ}14'N$   $104^{\circ}53'W$ ) 4♀♀ host unknown (RML 57519). State of Oaxaca: Ayotzintepec ( $17^{\circ}39'N$   $96^{\circ}07'W$ ) 10♂♂ ex *E. caballus* (RML 25889); Ixtepec ( $16^{\circ}35'N$   $95^{\circ}08'W$ ) 2♂♂ ex dog (RML 21198); Ozumacín ( $17^{\circ}39'N$   $101^{\circ}39'W$ ) 7♂♂ 1♀ ex *E. caballus* (RML 25886); San Antonio ( $17^{\circ}30'N$   $97^{\circ}46'W$ ) 2♂♂ 1♀ ex *E. caballus* (RML 25891); San Gabriel ( $16^{\circ}05'N$   $97^{\circ}03'W$ ) 1♀ ex *H. sapiens* (RML 120169). State of Quintana Roo: Cozumel ( $20^{\circ}30'N$   $86^{\circ}56'W$ ) 4♀♀ ex *E. caballus* (RML 57494), 5♂♂ 2♀♀ ex cattle (RML 57499). State of San Luis de Potosí: Ciudad Valles ( $22^{\circ}00'N$   $99^{\circ}00'W$ ) 1♀ host unknown (RML 46325); San Luis de Potosí ( $27^{\circ}09'N$   $100^{\circ}53'W$ ) 1♀ ex *H. sapiens* (RML 37555). State of Tabasco: Chiltepec ( $18^{\circ}24'N$   $93^{\circ}03'W$ ) 1♀ ex *Homo sapiens* (RML 120171). State of Veracruz de Ignacio de la Llave:

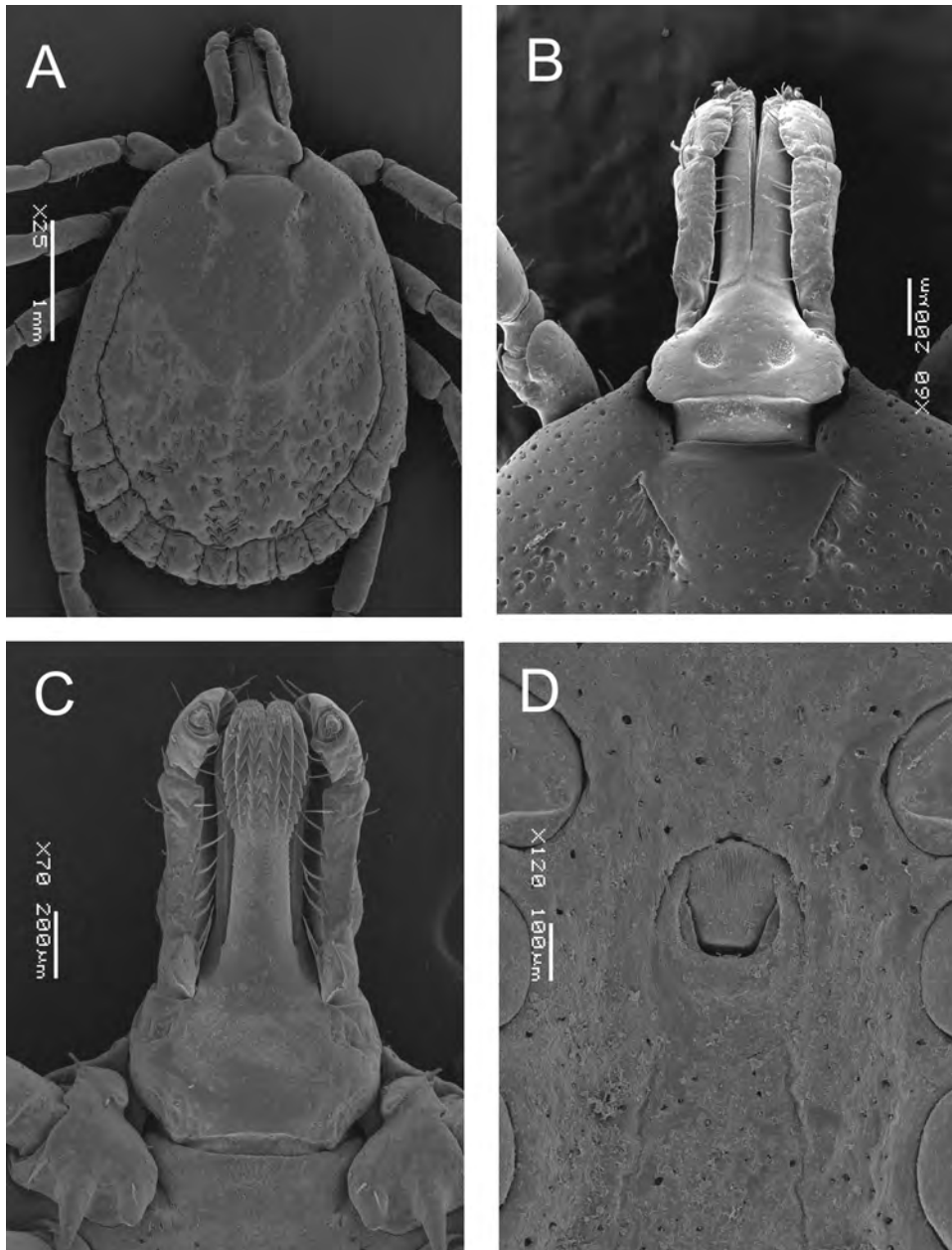




**Fig. 14.** Male of *Amblyomma mixtum*. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) ventral view; (E) Haller's organ.

Tampico (22°12'N 97°99'W) 1♀ ex cattle (RML 57522), 2 ♂♂ 3♀♀ ex *E. caballus* (RML 57548). NICARAGUA – Department of Chinandega: Corinto (12°31'N 87°10'W) 1♀ host unknown (RML 56807). Department of León: Río Grande (12°58'N 86°30'W) 1♀ host unknown (RML 13307). PANAMA – Province of Coclé: El Valle de Antón (08°36'N 80°08'W) 8♂♂ ex *Tapirus bairdii* (CNC 1108). Province of Darién: Darién dos Bocas (08°16'N 77°47'W) 3♂♂ 4♀♀ ex *E.*

*caballus* (CNC 1109). Province of Panama: Ancon (08°47'N 79°33'W) 1♀ host unknown (RML 56874); Canal zone (08°55'N 79°34'W) 1♀ host unknown (RML 57520). TRINIDAD Y TOBAGO – Mayaro (10°11'N 61°05'W) 3♂♂ 5♀♀ ex *E. caballus* (RML 34651), 6♂♂ 7♀♀ ex cattle, 1♂ 1♀ ex cattle (RML 34787). UNITED STATES OF AMERICA – Texas: Armstrong (26°55'N 97°48'W) 2♂♂ 2♀♀ ex *T. pecari* (RML 57545); Austwell (28°22'N 96°51'W) 1♀ host unknown (RML



**Fig. 15.** Female of *Amblyomma mixtum*. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) genital aperture.

57517); Brownsville (25°53'N 97°33'W) 1♀ ex dog (RML 57531), 5♀ ex *E. caballus* (RML 57630); Harlingen (26°10'N 97°42'W) 1♀ ex *Dasyptus novemcinctus* (RML 57530); Kingsville (27°30'N 97°51'W) 10♂♂ 10♀♀ ex *T. pecari* (RML 11434), 2♂♂ 2♀♀ ex vegetation (RML 11442), 1♀ ex *T. pecari* (RML 14833); Norias (26°46'N 97°46'W) 2♀♀ ex *Taxidea taxus* (RML 14333); Port Isabel (26°04'N 97°13'W) 1♂ 1♀ ex *Canis latrans* (RML 57541); Raymondville (26°28'N 97°47'W) 1♂ 1♀ ex *T. pecari* (RML 57526); San Patricio (27°58'N 97°45'W) 5♂♂ 5♀♀ ex cattle (RML 121394), 1♀ ex *Sus scrofa* (RML 122491); Zavala (28°51'N 97°48'W) 1♀ ex *S. scrofa* (RML 122487).

**Male.** Total length  $3.78 \pm 0.25$  (3.33–4.53); length from apices of scapulae to posterior body margin  $2.93 \pm 0.26$  (2.60–3.46), breadth  $2.52 \pm 0.20$  (2.26–3.00). Outline round, scapulae rounded, and cervical grooves deep, short, comma-shaped (Fig. 14A). Marginal groove complete, delimiting all festoons, deep up to level of coxa IV, and then as a line of deep punctations reaching level of eyes (Fig. 14A). Eyes flat. Scutum glabrous with overall smooth and

shiny appearance, ornate, with brown spots delimited by whitish enamelled stripes (Fig. 19E). Cervical spots large and elongated posteriorly; antero-accessory spots large and distinct; branches of limiting spots broad, posterior branches of limiting spots not fused posteriorly; first, second, and third lateral spots fused but distinct; third lateral spot clearly delimited and horizontally oriented; postero-median spot long, club-shaped, basally narrower than adjacent enamelled stripe. Foveae clearly distinguishable on white background. Narrow marginal white stripe, sometimes indistinct. *Festoons*: longer than wide with few and small punctations; parma brown, enamelled stripes on festoons 3, 4, and 5, variable small patches of white enamel on festoons 1 and 2. *Punctuation* (Fig. 14A): posterior scutum moderately punctated with large and shallow punctations deeper and more numerous on enamelled stripes; anterior part of scutum with finer and less numerous punctations, deeper in marginal areas. *Dorsal capitulum* (Fig. 14B): length from palpal apices to cornua apices  $0.96 \pm 0.10$  (0.76–1.28),

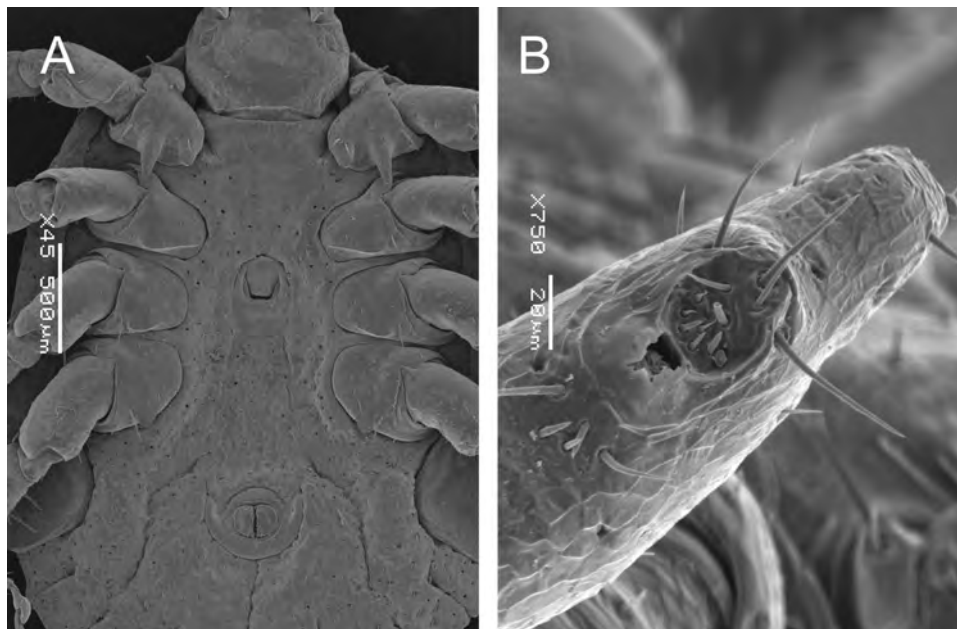


Fig. 16. Female of *Amblyomma mixtum*. (A) coxae I–IV; (B) Haller's organ.

basis capituli sub-rectangular, breadth  $0.54 \pm 0.05$  (0.46–0.63), length  $0.36 \pm 0.03$  (0.33–0.47), posterior margin slightly concave, cornua rounded. *Ventral capitulum* (Fig. 14C): basis capituli ventral length  $0.31 \pm 0.04$  (0.23–0.36); palpi total length  $0.75 \pm 0.04$  (0.66–0.90), length segment I  $0.09 \pm 0.02$  (0.06–0.13), length segment II  $0.49 \pm 0.06$  (0.37–0.60), length segment III  $0.18 \pm 0.03$  (0.12–0.25), width segment I  $0.10 \pm 0.02$  (0.07–0.10), width segment II  $0.11 \pm 0.02$  (0.10–0.14), width segment III  $0.15 \pm 0.01$  (0.13–0.19), segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 14C): length  $0.68 \pm 0.04$  (0.63–0.83), width  $0.21 \pm 0.02$  (0.17–0.23), dental formula 3/3 in 4–5 rows; apex with corona of fine denticles. *Venter* (Fig. 14D): genital aperture located at level of coxae II, U-shaped. *Legs* (Fig. 14D): coxae I with 2 distinct spurs of medium length, the external one being longest, coxae II–III with short rounded spur protruding from ridge-like edge; coxae IV with long, straight, and internal spur not reaching level of anus; trochanters with no spurs, tarsi I length  $0.72 \pm 0.06$  (0.60–0.84) width  $0.17 \pm 0.03$  (0.15–0.23); Haller's organ as illustrated in Fig. 14E, with transverse capsular aperture. *Spiracular plates*: comma-shaped, with caudal process as wide as adjacent festoon, length  $0.60 \pm 0.07$  (0.43–0.73), width  $0.25 \pm 0.06$  (0.21–0.32).

*Female*. Total length  $4.52 \pm 0.20$  (3.90–4.87); length from apices of scapulae to posterior body margin  $3.45 \pm 0.20$  (3.00–3.87), breadth  $2.79 \pm 0.15$  (2.53–3.14). Scutum length  $1.85 \pm 0.11$  (1.66–2.20), breadth  $1.96 \pm 0.12$  (1.66–2.20), length of posterior portion (from level of eyes to posterior margin)  $1.18 \pm 0.10$  (1.00–1.53). Scapulae pointed, cervical grooves deep and obliquely linear (from external to internal) and marginal groove complete, delimiting all festoons (Fig. 15A). Eyes flat. Scutum ornate and glabrous (Fig. 20E). Cervical spots elongated but not merging posteriorly with limiting spots; limiting spots reach and merge with ocular spot, ocular spot fused with accessory spot. Central area characterized by large brown patch outlined by enamelled contour. *Punctation* (Fig. 15A): uniformly distributed, fine punctations in central area, deeper in lateral fields. Notum hairy with 3 very narrow, shallow, and glabrous grooves. Median groove reaches parma, lateral grooves ending between festoons 2 and 3 (Fig. 15A). Notal setae stout and long, more densely distributed on posterior half of notum (Fig. 20E). *Festoons*: longer than wide, with 2 lines of setae on each festoon. Tubercles visible dorsally

and about 1/5 of festoon width. *Dorsal capitulum* (Fig. 15B): length from palpal apices to cornua apices  $1.17 \pm 0.07$  (0.93–1.26), basis capituli sub-rectangular, breadth  $0.69 \pm 0.03$  (0.56–0.70), length  $0.36 \pm 0.03$  (0.30–0.40), posterior margin slightly concave, cornua rounded. Porose areas oval and diverging anteriorly; distance between porose areas  $0.16 \pm 0.02$  (0.13–0.20) and length of one porose area  $0.10 \pm 0.01$  (0.08–0.13). *Ventral capitulum* (Fig. 15C): basis capituli ventral length  $0.34 \pm 0.03$  (0.30–0.43); palpi total length  $0.91 \pm 0.04$  (0.80–0.96), length segment I  $0.12 \pm 0.02$  (0.10–0.16), length segment II  $0.55 \pm 0.03$  (0.50–0.60), length segment III  $0.21 \pm 0.02$  (0.18–0.27), width segment I  $0.10 \pm 0.01$  (0.08–0.12), width segment II  $0.13 \pm 0.02$  (0.12–0.16), width segment III  $0.16 \pm 0.02$  (0.13–0.18), segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 15C): length  $0.87 \pm 0.05$  (0.73–0.96), width  $0.25 \pm 0.02$  (0.20–0.30), dental formula 3/3 in 7–8 rows; apex with corona of fine denticles. *Venter*: genital aperture located between coxae II and III, U-shaped with 2 narrow lateral flaps (Fig. 15D). *Legs* (Fig. 16A): coxae I with 2 distinct spurs, external spur longer than internal spur; coxae II–III with ridge-like edge; coxae IV with short rounded internal spur; trochanter with no spurs, tarsi I length  $0.91 \pm 0.08$  (0.76–1.00), width  $0.16 \pm 0.03$  (0.12–0.27); Haller's organ similar to that of male (Fig. 16B). *Spiracular plates*: comma-shaped, with small caudal process as wide as adjacent festoon, length  $0.61 \pm 0.04$  (0.50–0.68), width  $0.39 \pm 0.04$  (0.30–0.53).

#### Redescription of *Amblyomma sculptum* Berlese, 1888

**Material examined:** Neotype ♂ collected on *Bubalus bubalis* in BRAZIL, Corumbá, Alegria Farm (19°08'S 56°46'W), Mato Grosso do Sul (RML 122966). Material deposited at INTA, the CNC, and the USNTC: ARGENTINA – Province of Formosa: Reserva el Bagual (26°10'S 58°56'W) 1♂ ex vegetation (INTA 2148); San Hilario (26°03'S 58°38'W) 1♂ 1♀ ex *H. hydrochaeris* (INTA 41). Province of Jujuy: Ingenio Ledesma (23°50'S 64°47'W) 25♂♂ 5♀♀ ex *E. caballus* (INTA 1458); Palma Sola (23°53'S 64°21'W) 1♂ ex vegetation (INTA 1987); Santa Bárbara (23°42'S 64°44'W) 14♂♂ 4♀♀ ex *T. terrestris* (INTA 1265). Province of Salta: Coronel Cornejo (22°45'S 63°51'W) 2♂♂ 1♀ ex cattle (INTA 1510); General Ballivián

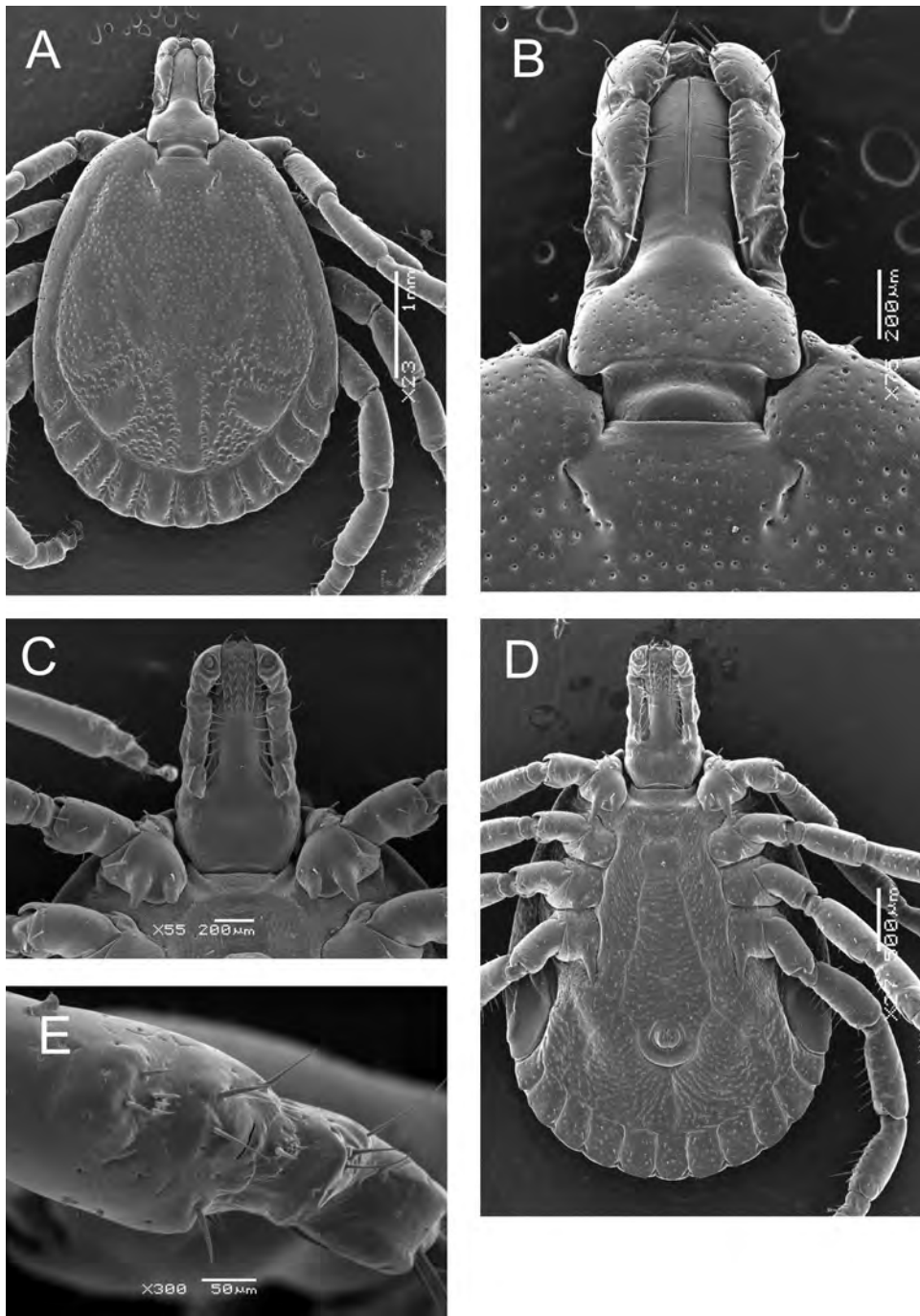
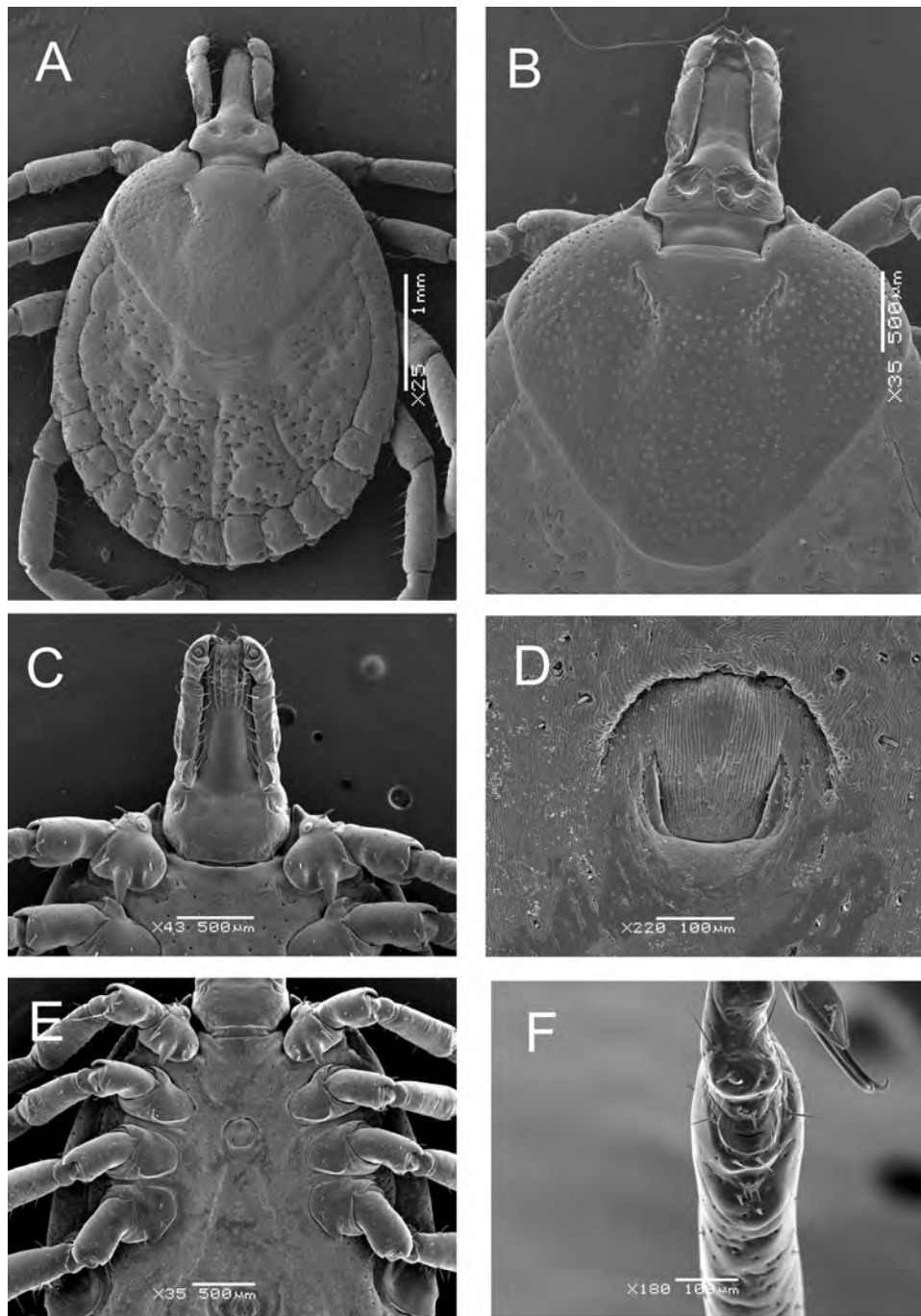


Fig. 17. Male of *Amblyomma sculptum*. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) ventral view; (E) Haller's organ.

(22°56'S 63°53'W) 1♂ ex cattle (INTA 1494); El Oculito (23°06'S 64°32'W) 1♀ ex *C. l. familiaris* (INTA 1385); Estancia González (24°54'S 64°39'W) 2♂♂ 1♀ ex cattle (INTA 327); La Caldera (24°37'S 65°23'W) 2♂♂ 1♀ ex *H. sapiens* (INTA 1269); Laguna del Cielo (22°26'S 63°57'W) 1♂ ex vegetation (INTA 1330); Parque Nacional El Rey (24°41'S 64°36'W) 2♂♂ 1♀ ex *S. scrofa* (INTA 509), 3♀♀ ex *T. terrestris* (INTA 1342), 2♂♂ 1♀ ex cattle (INTA 1875), 1♀ ex *H. sapiens* (INTA 1877), 35♂♂ 40♀♀ ex *E. caballus* (INTA 2055), 1♂ 2♀♀ ex (*E. caballus* × *E. asinus*) (INTA 2056), 28♂♂ 40♀♀ ex vegetation (INTA 2057); Santa Rita (24°40'S 64°59'W) 2♂♂ 1♀ ex *E. caballus* (INTA 295); Villa Aurelia (24°36'S 64°17'W) 3♀♀ ex cattle (INTA 179); 40 km W from Las Lajitas (25°03'S 64°39'W) 4♂♂ 3♀♀ ex *E. caballus* (INTA 1374). BOLIVIA – Department of Beni: locality unknown, 1♂ 1♀ ex vegetation (RML 45610). BRAZIL – State of

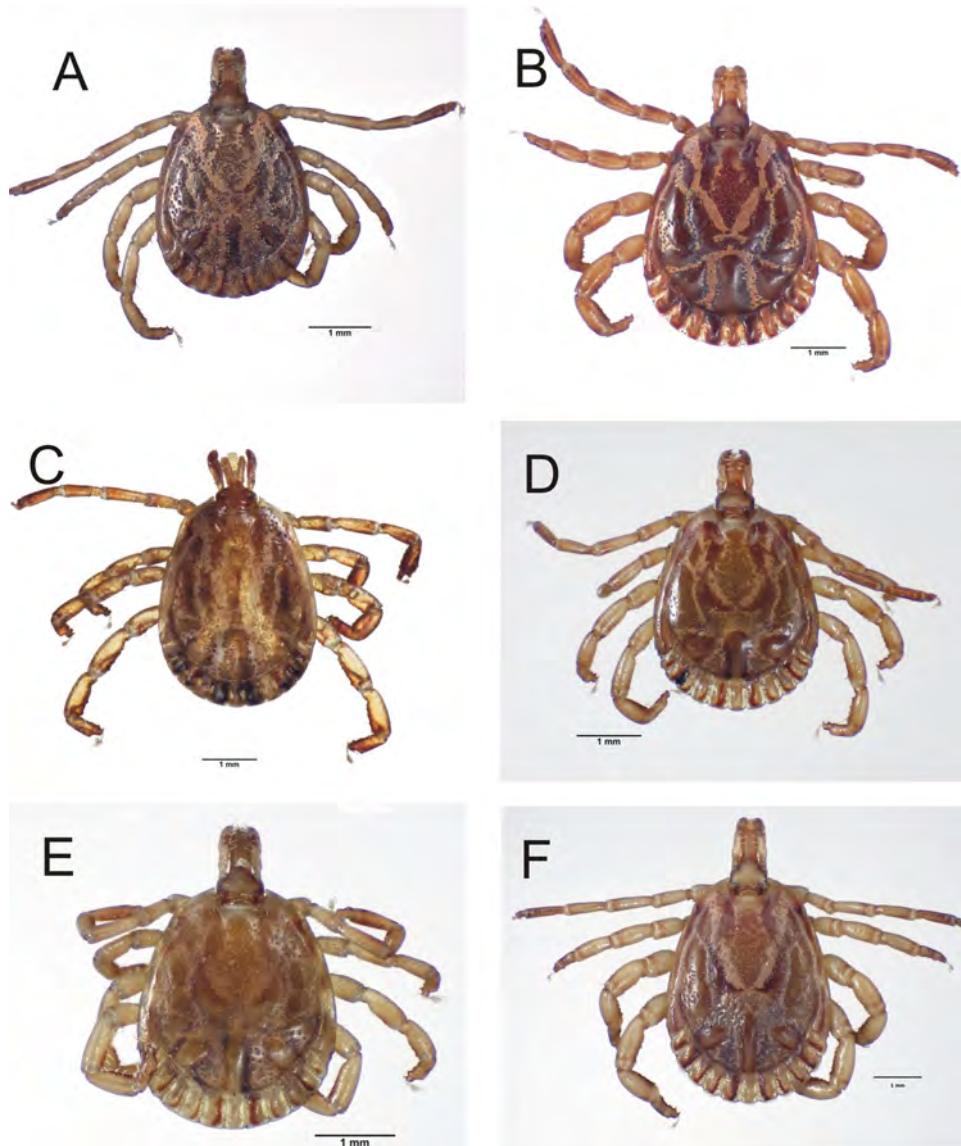
Espírito Santo: Guarapari (20°39'S 40°31'W) 1♂ 8♀♀ ex *E. caballus* (CNC 529). State of Goiás: Mineiros (18°19'S 52°45'W) 2♀♀ ex *M. tridactyla* (CNC 259). State of Mato Grosso: Barão de Melgaço (16°16'S 55°57'W) 1♂ 3♀♀ ex *P. concolor* (CNC 598); Chapada dos Guimarães (15°27'S 55°45'W) 5♂♂ 4♀♀ ex *T. terrestris* (CNC 554); Jauru (15°20'S 58°51'W) 1♂ 1♀ ex *Homo sapiens* (CNC433); Poconé (16°15'S 56°37'W) 1♀ ex *Panthera onca* (CNC 144). State of Mato Grosso do Sul: Anaurilândia (22°10'S 52°25'W) 3♂♂ ex *T. tajacu* (CNC 447); Bataguassu (21°42'S 52°25'W) 1♂ 1♀ ex *Blastocercus dichotomus* (CNC 420); Bonito (21°06'S 56°34'W) 1♂ 1♀ ex *T. terrestris* (CNC 625); Corumbá, Alegria Farm (19°08'S 56°46'W) 1♂ 1♀ ex *Nasua nasua* (RML 122933), 5♂♂ 6♀♀ ex *B. bubalis* (RML 122953), 1♂ ex *N. nasua* (RML 122935), 1♂ 6♀♀ ex *S. scrofa* (RML 112959), 3♂♂ 4♀♀ ex *S. scrofa* (RML 122951), 1♀ ex *N. nasua*



**Fig. 18.** Female of *Amblyomma sculptum*. (A) dorsal view; (B) dorsal view of capitulum; (C) ventral view of capitulum; (D) genital aperture; (E) ventral view; (F) Haller's organ.

(RML 122929), 1♀ ex *S. scrofa* (RML 122941), 1♂ 6♀♀ ex *S. scrofa* (RML 122938), 1♀ ex *N. nasua* (RML 122931), 3♂♂ 11♀♀ ex *S. scrofa* (RML 122965), 5♂♂ 5♀♀ ex *B. bubalis* (RML 122939), 2♂♂ 1♀♀ ex *S. scrofa* (RML 122942); Santa Rita do Pardo (21°12'S 52°50'W) 1♀ ex *T. tedradactyla* (CNC 352); Três Lagoas (20°45'S 51°40'W) 1♂ 1♀ ex *H. sapiens* (CNC 215). State of Minas Gerais: Chapada Gaúcha (15°18'S 45°37'W) 18♂♂ 30♀♀ ex *Leopardus pardalis* (collected as nymphs or larvae) (CNC 1452); Doresópolis (20°17'S 45°54'W) 1♀ ex cave (CNC 1341); Pratinha (19°45'S 46°22'W) 1♂ 2♀♀ ex *M. tri-dactyla* (CNC 1114); São Roque de Minas (20°14'S 46°21'W) 3♂♂ 2♀♀ ex "fox" (collected as nymphs) (CNC 980); Vargem Bonita (20°19'S 46°22'W) 10♂♂ 9♀♀ ex vegetation (CNC 1116). State of Paraná: Foz do Iguaçu (25°32'S 54°34'W) 1♂ 1♀ ex *T. terrestris* (CNC 126). State of Pernambuco: Amaraji (08°23'S 35°27'W) 13♂♂

5♀♀ ex *E. caballus* (CNC 1314). State of Piauí: Gibués (09°40'S 45°25'W) 1♂ 1♀ crawling on *H. sapiens* (CNC 889). State of Rio de Janeiro: Três Rios (22°07'S 43°12'W) 10♂♂ 44♀♀ ex *H. hydrochaeris* (collected as nymphs) (CNC 1159). State of São Paulo: Bonfim Paulista (21°09'S 47°49'W) 30♂♂ 9♀♀ ex *H. hydrochaeris* (CNC 960); Campinas (22°54'S 47°04'W) 2♂♂ 5♀♀ ex vegetation (CNC 1406); Franca (20°32'S 47°24'W) 1♀ ex *E. caballus* (CNC 520); Itu (23°15'S 47°17'W) 1♀ ex *T. terrestris* (collected as nymphs) (CNC493); Mogi das Cruzes (23°31'S 46°10'W) 270♂♂ 237♀♀ ex vegetation (CNC 964); Paulicéia (21°07'S 51°56'W) 32♂♂ 41♀♀ ex vegetation (CNC 588); Pedreira (22°44'S 46°54'W) 5♂♂ 2♀♀ ex *H. sapiens* (collected as nymphs) (CNC 425); Piracicaba (22°43'S 47°38'W) 5♂, 6♀ ex *H. hydrochaeris* (CNC 436); Pirassununga (21°59'S 47°25'W) 1♂♂ 4♀♀ ex *E. caballus* (CNC 16); Presidente Prudente (22°07'S

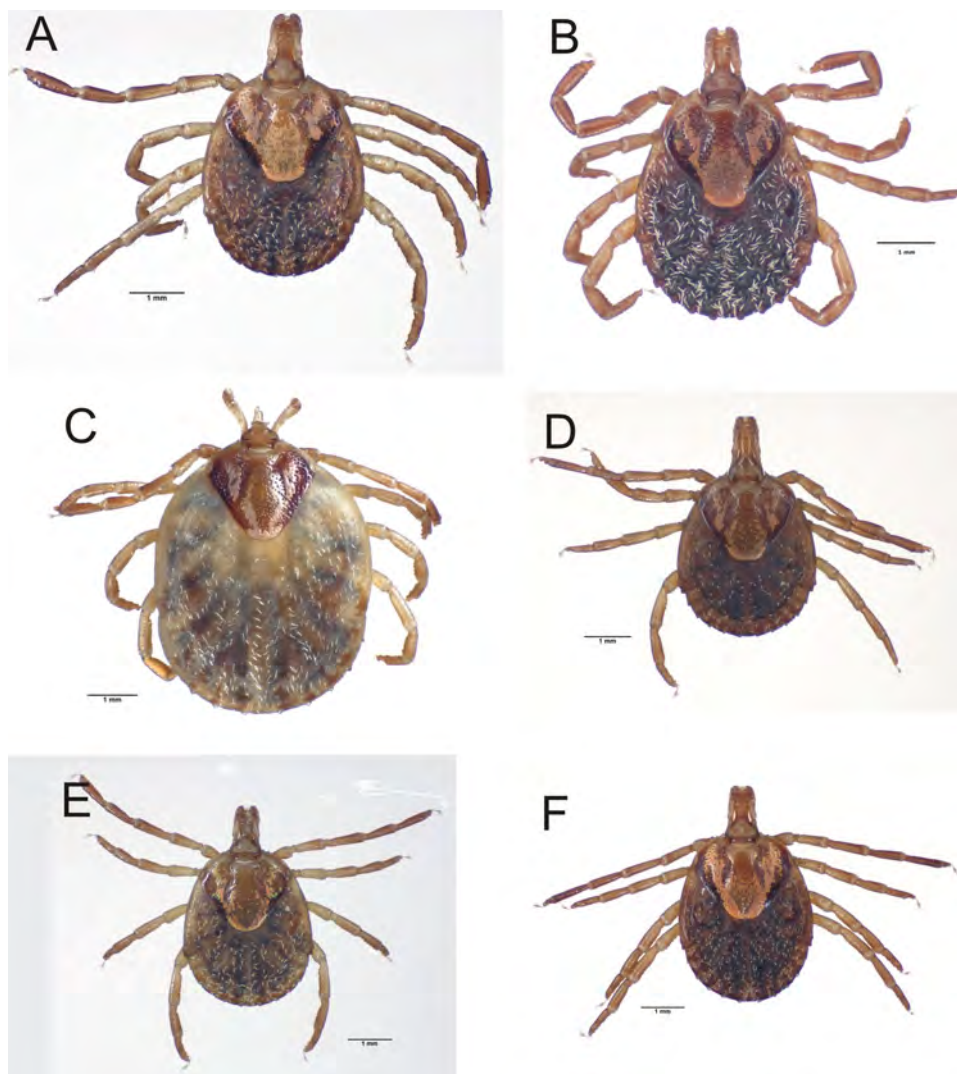


**Fig. 19.** Dorsal view of male specimens. (A) *Amblyomma cajennense* s.s.; (B) *Amblyomma tonelliae* n. sp.; (C) *Amblyomma interandinum* n. sp.; (D) *Amblyomma patinoi* n. sp.; (E) *Amblyomma mixtum*; (F) *Amblyomma sculptum*.

51°22'W) 3♂♂ 9♀♀ ex *E. caballus* (CNC 1005); Ribeirão Grande (24°05'S 48°21'W) 3♂♂ 12♀♀ ex *Mazama gouazoubira* (collected as nymphs) (CNC 606); Ribeirão Preto (21°10'S 47°48'W) 13♂♂ 11♀♀ ex *Chrysocyon brachyurus* (collected as nymphs) (CNC 297); São Paulo (23°32'S 46°38'W) 4♂♂ 1♀ ex *H. hydrochaeris* (collected as nymphs) (CNC 713); Sorocaba (23°30'S 47°27'W) 1♂ 1♀ ex *C. brachyurus* (CNC 92); Teodoro Sampaio (22°31'S 52°09'W) 1♀ ex vegetation (CNC 360). PARAGUAY – Department of Alto Paraguay: Parque Nacional Defensores del Chaco (20°14'S 60°12'W) 1♂1♀ ex *P. onca* (RML 123661 and RML 123662). Department of Concepción: Puerto Max (22°38'S 57°46'W) 1♀ host unknown (RML 56842).

**Male.** Total length  $4.63 \pm 0.42$  (3.8–5.30); length from apices of scapulae to posterior body margin  $3.63 \pm 0.32$  (3.0–4.0), breadth  $2.93 \pm 0.23$  (2.36–3.34). Outline oval, scapulae pointed, cervical grooves deep, short, comma-shaped (Fig. 17A). Marginal groove complete, delimiting all festoons, and reaching level of eyes (Fig. 17A). Eyes flat. Scutum ornate, glabrous, with brown spots delimited by whitish enamelled stripes (Fig. 19F). Cervical spots elongated posteriorly; branches of limiting spots narrow, posterior branches of limiting spots not fused posteriorly; anterior extremity of limiting spots sometimes merging with antero-accessory

and ocular spots; lateral spots fused but distinct and clearly delimited by deep punctations, postero-accessory spots small; postero-median spot narrower than adjacent enamelled stripe. Foveae clearly visible on white background. Narrow and distinct marginal white stripe. **Festoons:** longer than wide with punctations; central festoon clear, internal half of festoons 1, 2, and 5 brown, external half clearer, festoons 3 and 4 white with very narrow internal brown border. **Punctuation** (Fig. 17A): posterior part of scutum heavily punctated in all areas but spots with large punctations becoming deeper on stripes separating and outlining spots; anterior part of scutum with smaller, shallower, numerous, and uniformly distributed punctations. **Dorsal capitulum** (Fig. 17B): length from palpal apices to cornua apices  $1.0 \pm 0.09$  (0.76–1.23), basis capituli sub-rectangular, breadth  $0.62 \pm 0.05$  (0.50–0.73), length  $0.31 \pm 0.05$  (0.25–0.43), posterior margin slightly concave, cornua rounded. **Ventral capitulum** (Fig. 17C): basis capituli ventral length  $0.28 \pm 0.04$  (0.23–0.37); palpi total length  $0.74 \pm 0.06$  (0.56–0.83), length segment I  $0.08 \pm 0.02$  (0.05–0.10), length segment II  $0.43 \pm 0.03$  (0.33–0.50), length segment III  $0.19 \pm 0.01$  (0.16–0.23), width segment I  $0.12 \pm 0.01$  (0.10–0.13), width segment II  $0.15 \pm 0.01$  (0.13–0.17), width segment III  $0.15 \pm 0.01$



**Fig. 20.** Dorsal view of female specimens. (A) *Amblyomma cajennense* s.s.; (B) *Amblyomma tonelliae* n. sp.; (C) *Amblyomma interandinum* n. sp.; (D) *Amblyomma patinoi* n. sp.; (E) *Amblyomma mixtum*; (F) *Amblyomma sculptum*.

(0.13–0.17), segment I with small and posteriorly blunt projecting spur. *Hypostome* (Fig. 17C): length  $0.67 \pm 0.05$  (0.53–0.80), width  $0.23 \pm 0.02$  (0.16–0.27), dental formula 3/3 in 6–7 rows; apex with corona of fine denticles. *Venter* (Fig. 17D): genital aperture located at level of coxae II, U-shaped. *Legs* (Fig. 17D): coxae I with 2 distinct spurs of medium length, the external one being longest; coxae II–III with short rounded spur protruding from ridge-like edge; coxae IV with long, straight, and pointed internal spur not reaching level of anus; trochanters with no spurs, tarsi I length  $0.79 \pm 0.02$  (0.66–0.99), width  $0.18 \pm 0.02$  (0.16–0.23); Haller's organ as illustrated in Fig. 17E, with transverse capsular aperture. *Spiracular plates*: comma-shaped, with caudal process at least as wide as adjacent festoon, length  $0.65 \pm 0.04$  (0.60–0.72), width  $0.34 \pm 0.04$  (0.26–0.43).

**Female.** Total length  $4.91 \pm 0.27$  (4.53–5.34); length from apices of scapulae to posterior body margin  $3.90 \pm 0.25$  (3.46–4.33), breadth  $3.17 \pm 0.16$  (2.86–3.48). Scutum length  $1.94 \pm 0.12$  (1.66–2.13), breadth  $2.16 \pm 0.14$  (1.86–2.33), length of posterior portion (from level of eyes to posterior margin)  $1.26 \pm 0.06$  (1.20–1.33). Scapulae pointed, cervical grooves short and obliquely linear (from external to internal), and marginal groove complete, delimiting all festoons (Fig. 18A). Eyes flat. Scutum ornate and glabrous (Fig. 20F). Cervical spots elongated but not merging

posteriorly with limiting spots; limiting spots fused with ocular and accessory spots. Enamelling as continuous border around posterior part of central patch and extending anteriorly along internal border of cervical spots. Enamelling in middle of the central area patchy. *Punctuation* (Fig. 18A): numerous, fine, shallow punctations, uniformly distributed, deeper on antero-lateral margins. Notum hairy with 3 very narrow, shallow, and glabrous grooves. Median groove reaches central festoon, lateral grooves ending between festoons 2 and 3 (Fig. 18A). Notal setae short and fine, more densely distributed on posterior notum (Fig. 20F). *Festoons*: longer than wide and hairy, with 2 rows of setae per festoon. Tubercles visible dorsally and as wide as 1/3 of festoon width. *Dorsal capitulum* (Fig. 18B): length from palpal apices to cornua apices  $1.18 \pm 0.03$  (1.10–1.23), basis capituli sub-rectangular, breadth  $0.74 \pm 0.06$  (0.66–0.83), length  $0.30 \pm 0.02$  (0.26–0.33), posterior margin slightly concave, cornua rounded. Porose areas oval diverging anteriorly; distance between porose areas  $0.16 \pm 0.02$  (0.13–0.20) and length of one porose area  $0.11 \pm 0.01$  (0.10–0.13). *Ventral capitulum* (Fig. 18C): basis capituli ventral length  $0.31 \pm 0.02$  (0.30–0.33); palpi total length  $0.89 \pm 0.04$  (0.83–0.93), length segment I  $0.10 \pm 0.01$  (0.08–0.11), length segment II  $0.57 \pm 0.02$  (0.53–0.60), length segment III  $0.21 \pm 0.02$  (0.16–0.23), width segment I  $0.10 \pm 0.0$  (0.10–0.10), width segment II  $0.16 \pm 0.01$



**Fig. 21.** Distribution of the 6 species of the *Amblyomma cajennense* complex according to the material examined from 3 tick collections (Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Rafaela, Argentina; the Coleção Nacional de Carrapatos da Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Brazil; U.S. National Tick Collection, U.S.A.). \* *Amblyomma cajennense* s.s.; † *Amblyomma tonelliae* n. sp.; ¥ *Amblyomma interandinum* n. sp.; # *Amblyomma patinoi* n. sp.; ■ *Amblyomma mixtum*; ○ *Amblyomma sculptum*. X, record of *A. sculptum* in Department of Beni, Bolivia, locality unknown.

(0.13–0.19), width segment III  $0.19 \pm 0.02$  (0.17–0.20), segment I with small and blunt posteriorly projecting spur. *Hypostome* (Fig. 18C): length  $0.88 \pm 0.05$  (0.82–0.99), width  $0.25 \pm 0.02$  (0.20–0.30), dental formula 3/3 in 7–8 rows; apex with corona of fine denticles. *Venter*: genital aperture located between coxae II and III, large, U-shaped with 2 very narrow lateral flaps (Fig. 18D). *Legs* (Fig. 18E): coxae I with 2 distinct spurs, external spur longer than internal spur; coxae II–III with ridge-like edge; coxae IV with short rounded internal spur; trochanter with no spurs, tarsi I length  $0.86 \pm 0.07$  (0.70–1.00), width  $0.18 \pm 0.03$  (0.13–0.22); Haller's organ similar to that of male (Fig. 18F). *Spiracular plates*: comma-shaped, with large caudal process approximately as wide as adjacent festoon, length  $0.62 \pm 0.03$  (0.60–0.67), width  $0.35 \pm 0.04$  (0.30–0.45).

### Morphological comparisons

The morphological characters shared by the members of *A. cajennense* s.l. are in both genders extensive ornamentation of the

scutum corresponding to the patterns outlined in Figs. 19 and 20, conspicuous punctation, complete marginal groove delimiting all festoons and reaching level of the eyes, flat eyes, elongated palps with a small and blunt posteriorly projecting ventral spur on article I, hypostome spatulate, hypostomal dentition 3:3, absence of spurs on trochanter I and on metatarsi II–IV, and coxa I with 2 spurs, the external one being longer than the internal one. Furthermore, males have coxa IV with a long straight spur not reaching the level of the anus. Females have coxae II–III with a ridge-like spur, a visible small spur on coxa IV, setation on the notum, and tubercles on the festoons.

The males of *A. cajennense* s.s. and *A. sculptum* share ornamentation with a postero-median spot narrower than the adjacent enamelled stripe, the posterior half of the scutum heavily punctated in all areas but the spots, with punctations deeper and larger on the stripes separating the postero-median and the accessory spots. The males of these 2 species are not easily distinguishable. Nevertheless, the lack of discriminating characters is compensated by the fact that females are easily separated morphologically. Furthermore, geographical origin can help to corroborate the identification of these 2 species.

The diagnostic characters for the males of *A. mixtum* and *A. patinoi* are a club-shaped postero-median spot narrower than the adjacent enamelled stripe only in its posterior portion, punctations more numerous on the enamelled stripes, medium-sized and shallow punctation also in the posterior part of the scutum, giving the tick an overall smooth and shiny appearance. The males of *A. mixtum* are very similar to those of *A. patinoi*. The principal diagnostic character is the tick body outline, round in *A. mixtum* and oval in *A. patinoi*. This character, however, can be misleading depending on the conditions of tick preservation. As for *A. cajennense* s.s. and *A. sculptum*, however, females of *A. mixtum* and *A. patinoi* are easily differentiated. Males of *A. tonelliae* and *A. interandinum* are characterized by a postero-median spot wider than the adjacent enamelled stripe, an oval body outline, and the posterior part of the scutum moderately punctated, with large and deep punctations, much denser around the spots. They are closely related morphologically, but in *A. tonelliae* the scutal brown areas are of a rusty reddish colour, whereas in *A. interandinum* they are consistently of a more subdued beige colour.

Females of *A. cajennense* s.s. are characterized by 3 very narrow and shallow grooves on the notum, notal setae short, fine, and more densely distributed posteriorly, genital aperture in the shape of a broad truncated “V” with 2 broad lateral flaps, and elongated cervical spots sometimes merging posteriorly with the limiting spots. Females of *A. patinoi* and *A. sculptum* also have 3 very narrow and shallow grooves on the notum, and notal setae short and fine. However, *A. sculptum* has a U-shaped genital aperture with 2 narrow lateral flaps, whereas the flaps of the genital aperture of *A. patinoi* are short and bulging. Females of *A. mixtum* can be differentiated from females belonging to the other species of the group by the combination of notal setae stout and long, more densely distributed on the posterior half of the notum, small tubercles, and a U-shaped genital aperture with 2 narrow lateral flaps.

The notum in females of *A. tonelliae* and *A. interandinum* are similar, with long and stout setae converging over 3 deep grooves. However, the female of *A. tonelliae* has a notum deeply corrugated in unengorged specimens, and broad tubercles about one-half of the width of the festoon, whereas the female of *A. interandinum* has a notal groove not as deep, and slightly narrower tubercles, about 1/3 of the width of the festoon, and with the vestibular portion of vagina conspicuously bulging.

In both sexes, there are no major differences among the spiracular plates of the 6 species.



## Conclusions

This study shows that morphology is congruent with the results of the molecular and biological analyses (Labruna et al., 2011; Mastropaolo et al., 2011; Beati et al., 2013) which indicated that *A. cajennense* is a complex of 6 species: *A. cajennense* s.s., *A. interandinum*, *A. mixtum*, *A. patinoi*, *A. sculptum*, and *A. tonelliae*. Three of them, *A. interandinum*, *A. patinoi*, and *A. tonelliae*, represent new species, whereas *A. mixtum* and *A. sculptum* are resurrected. Morphological determination of these taxa is not easy as can be expected in closely related species. These difficulties increase when identifying partially-fed females, as engorgement may produce distortions of the diagnostic morphological characters of the notum. The combination of morphological, distributional, and molecular information may sometimes be necessary for the correct determination of problematic specimens. In terms of geographical distribution, *A. cajennense* s.s. is found in the Amazonian region of South America (Venezuela, the Guianas, and the states of Pará, Rondonia, Roraima, and Tocantins in Brazil), *A. interandinum* is so far only reported from the inter-Andean region of Peru, *A. mixtum* spans from Texas (U.S.A.) to western Ecuador, *A. patinoi* is presently only known to occur in the Eastern Cordillera of Colombia, *A. tonelliae* occupies the driest areas of the Chaco region in central-northern Argentina, Bolivia, and Paraguay, and *A. sculptum* has a distribution ranging from the humid areas of northern Argentina, Bolivia, and Paraguay to the Brazilian peri-Amazonian areas (states of Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo, and Paraná in the South; Pernambuco and Piauí in the North, and Mato Grosso, Mato Grosso do Sul, Goiás in the centre). Although our distribution records include data from 3 large collections (Fig. 21), we are aware that our information may be incomplete. In particular, it will be essential to acquire and examine new material from the areas between recognized distribution ranges, in order to establish whether or not there is any geographical overlap. Also, as it is now established that *A. cajennense* is a complex of species, it will be necessary to gather complete updated information on immature morphology, vertebrate host preferences, natural life cycles, and vectorial competence for each of the newly delimited species.

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