

First description of the male and redescription of the female of *Ixodes tapirus* Kohls, 1956 (Acari: Ixodidae), a parasite of tapirs (Perissodactyla: Tapiridae) from the mountains of Colombia, Costa Rica and Panama

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Received: 7 June 2016 / Accepted: 7 February 2017 / Published online: 15 February 2017
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Abstract The male of *Ixodes tapirus* Kohls, 1956 (Acari: Ixodidae) is described for the first time and the female is redescribed in greater detail. Adults of *I. tapirus* are similar to those of *Ixodes guatemalensis* Kohls, 1956, *Ixodes lasallei* Méndez & Ortiz, 1958, *Ixodes montoyanus* Cooley, 1944 and *Ixodes venezuelensis* Kohls, 1953 but can be distinguished by their overall size, the amount of sclerotisation of the conscutum and accessory plates, the shape of the scutum, the number of punctations and their pattern on the conscutum and scutum, the depth of the punctations on the basis capituli dorsally, the shape and size of the porose areas and the size and shape of the auriculae. Adults of *I. tapirus* were collected from tapirs and vegetation in the mountains of Colombia,

Panama and recorded from Costa Rica for the first time.

Introduction

The genus *Ixodes* Latreille, 1795 (Acari: Ixodidae) is the most species rich hard tick genus, comprising nearly 244 species worldwide, of which 45 occur in the Neotropics (Guglielmone et al., 2003, 2014). Many aspects in the taxonomy and biology of Neotropical *Ixodes* remain unknown or poorly studied. This is particularly true for the species inhabiting remote geographic areas or parasitising wild and/or rare hosts.

One of these species is *Ixodes tapirus* Kohls, 1956 which was described from a single female collected on the mountain tapir, *Tapirus pinchaque* (Roulin, 1829) (Perissodactyla: Tapiridae) from the Colombian Andes (Kohls, 1956). Later, Fairchild et al. (1966) reported two collections totalling six females found on Baird's tapir, *Tapirus bairdii* (Gill, 1865) in two highland localities of western Panama. The male and the immature stages were unknown.

Recent studies on the diversity of ticks in the mountains of Volcán Barú National Park and La Amistad International Park, both in the western highlands of Panama, have resulted in the collection of multiple females and males of *I. tapirus* from vegetation. Additionally, we have found collection lots of 42 females and two males of *I. tapirus* collected from *T. bairdii* in Costa Rica; of these, three females belonging to the United States National Tick

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Collection (USNTC) and the rest to Universidad Nacional de Costa Rica (UN-CR-MV). In this paper, the male of *I. tapirus* is described for the first time and the female of this species is redescribed in greater detail. Data on its distribution and hosts are also provided.

Materials and methods

Only field-collected ticks were available for study. The specimens that were examined are deposited in the USNTC (James H. Oliver, Jr. Institute for Coastal Plain Science, Georgia Southern University, Statesboro, Georgia, USA), Field Museum of Natural History (FMNH) (Chicago, USA) and “Dr. Eustorgio Méndez” Zoological Collection (Instituto Conmemorativo Gorgas de Estudios de la Salud, Panama, Panama). Collections with “USNMENT” numbers are deposited in the USNTC, those with “FMNHINS” number in the FMNH, with “CoZEM” numbers in the “Dr. Eustorgio Méndez” Zoological Collection and with UN-CR-MV numbers in Universidad Nacional, Costa Rica. For comparative purposes, males and females of *Ixodes guatemalensis* Kohls, 1956, *Ixodes lasallei* Méndez & Ortiz, 1958, *Ixodes montoyanus* Cooley, 1944 and females of *Ixodes venezuelensis* Kohls, 1953 stored in the USNTC were examined. Males of *I. tapirus* were associated with described females of this species based on findings of both at the same time on same individual host (2 collections) and same individual plant (4 collections).

Adult ticks were studied using a stereoscopic microscope (Olympus SZX16, Olympus Corporation, Tokyo, Japan) and a scanning electron microscope (JEOL JSM6610LV, JEOL Ltd., Tokyo, Japan). Measurements are in millimetres and are given as the range followed by the mean \pm standard deviation and the number of specimens measured (n) in parentheses.

Family Ixodidae Murray, 1877

Genus *Ixodes* Latreille, 1795

Ixodes tapirus Kohls, 1956

Holotype: Female, from *Tapirus pinchaque*, Rio Majuas ($\sim 1^{\circ}57'N$, $76^{\circ}24'W$), 2700 m alt., San Agustín, Huila, Colombia, 21.x.1951, P. Hershkovitz; deposited in the FMNH (FMNHINS 3474346).

Other material (19 males, 85 females): Costa Rica: San José: Chirripó Massif ($\sim 9^{\circ}30'N$, $83^{\circ}30'W$), 3353 m alt.: 3 females, from *Tapirus bairdii*, vi or vii.1970, R. Blas Monje, USNMENT 00860714; Santa María Dota, Sabagre ($9^{\circ}20'N$, $84^{\circ}1'W$), 2300 m: June 11, 2015, 1 male and 37 females, from *Tapirus bairdii*, 11.vi.2015, UN-CR-MV-60; Dota, Copey ($9^{\circ}36'N$, $83^{\circ}49'W$), 2449 m: 1 male and 4 females, from *Tapirus bairdii*, November 2, 2016, UN-CR-MV-61. Panama: Chiriquí: Rio Candela ($\sim 8^{\circ}46'N$, $82^{\circ}49'W$), 2012 m alt.: 3 females, from *Tapirus bairdii*, x.1953, R. Hartmann, USNMENT 00860715; Volcán Barú National Park, El Respingo Station ($\sim 8^{\circ}50'N$, $82^{\circ}32'W$), 2506 m alt.: 3 females from vegetation, iii.2015, S.E. Bermúdez, L.G. Domínguez, S. Torres, CoZEM IXO078; 5 males and 6 females, from vegetation, 11.v.2015, S.E. Bermúdez, L.G. Domínguez, S. Torres, CoZEM IXO078; 1 male and 4 female, from vegetation, 8.iii.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, CoZEM IXO079–80; 2 males, from vegetation, 8.iii.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, USNMENT 00860721; 5 females, from vegetation, 9.iii.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, CoZEM IXO081; 3 males and 5 females, from vegetation, 10.iii.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, CoZEM IXO082; 3 males and 9 females, from vegetation, 10.iii.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, USNMENT 00860720; 1 male, from vegetation, 25.iv.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, CoZEM IXO087; 1 female, from vegetation, 25.iv.2016, D.A. Apanaskevich, S.E. Bermúdez, L.G. Domínguez, S. Torres, USNMENT 00860717; 1 male and 2 females, from vegetation, 26.iv.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, CoZEM IXO089–91; 1 female, from vegetation, 26.iv.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, USNMENT 00860719; 1 male and 1 female, from vegetation, 27.iv.2016, Y. Aguirre, D.A. Apanaskevich, USNMENT 00860716; La Amistad International Park, Las Nubes Station ($\sim 8^{\circ}53'N$, $82^{\circ}36'W$), 2156 m alt.: 1 female, from vegetation, 29.iv.2016, S.E. Bermúdez, L.G. Domínguez, S. Torres, USNMENT 00860718.

Description (Figs. 1–4)

Male [Based on 6 specimens; Figs. 1A, B, 2, 3A.] Idiosoma (Fig. 1A, B) broadly elongate-oval with

broadly rounded posterior margin, widest just posterior to mid-length; length from apices of scapulae to posterior body margin 2.59–2.87 (2.77 ± 0.10), width 1.78–1.97 (1.86 ± 0.07), ratio 1.45–1.57 (1.48 ± 0.04). Lateral groove distinct; internal margin of lateral fold wrinkled posteriorly. Scutum (Fig. 1A) length 2.47–2.66 (2.58 ± 0.07), width 1.47–1.66 (1.54 ± 0.07), ratio 1.60–1.75 (1.67 ± 0.05); scapulae short, pointed; lateral carinae absent; cervical grooves distinct, shallow, diverging posteriorly for 1/4 of scutum length; dense large punctations along lateral margins and in central area, *c.*80–160 large punctations in central area; very fine punctations evenly distributed over scutum; setae numerous and short (*c.*0.06) (Figs. 1A, 2A). Venter (Fig. 1B) plate outlines as illustrated; accessory plates large, occupying entire accessory area; median plate: length 1.32–1.50 (1.40 ± 0.07), width 0.94–1.16 (1.07 ± 0.07), ratio 1.22–1.42 (1.31 ± 0.07); adanal plate: length 0.72–0.78 (0.75 ± 0.02), width 0.46–0.58 (0.50 ± 0.04), ratio 1.34–1.65 (1.52 ± 0.11); anal plate: 0.54–0.60 (0.57 ± 0.02), width 0.46–0.58 (0.51 ± 0.04), ratio 1.03–1.22 (1.12 ± 0.06). Median plate with dense, large punctations; other plates with numerous, small punctations (Figs. 1B, 2B). Genital aperture (Fig. 1B) located at level of coxae III. Ventral setae (Fig. 1B, 2B) numerous, moderately short, fine, evenly distributed on all plates; length of setae on median plate *c.*0.09. Anal groove (Fig. 1B) broadly curved and open posteriorly. Spiracular plate (Fig. 2C) broadly oval, slightly longer than wide, length 0.34–0.39 (0.36 ± 0.02), width 0.29–0.33 (0.31 ± 0.01), ratio 1.16–1.20 (1.18 ± 0.02).

Gnathosoma (Fig. 2D–F) length from palpal apices to posterior margin of basis capituli dorsally 0.56–0.59 (0.58 ± 0.02), width of basis capituli 0.36–0.37 (0.36 ± 0.01), ratio length to width 1.53–1.67 (1.60 ± 0.05). Basis capituli dorsally subrectangular (Fig. 2D); posterior margin nearly straight or slightly convex, length 0.18–0.22 (0.20 ± 0.02), ratio width to length 1.65–2.05 (1.82 ± 0.16); cornua lacking; punctations small, shallow. Basis capituli ventrally (Fig. 2E, F) pentagonal; ventromedian projection indistinct; short, arcuate ridge-like auriculae. Palpi (Fig. 2D, E) short, broad; length dorsally (segments I–III) 0.39–0.42 (0.41 ± 0.01), width 0.16–0.19 (0.18 ± 0.01 ; *n* = 6), ratio 2.18–2.42 (2.27 ± 0.08); segment II nearly equal to segment III in length; segment I well developed without spurs; segment II

narrow proximally and gradually widening to distal end; segment III laterally straight and medially converging to bluntly rounded apex. Hypostome (Fig. 2E) blunt at apex; length 0.29–0.32 (0.30 ± 0.01), maximal width 0.15–0.17 (0.16 ± 0.005), ratio 1.75–2.00 (1.86 ± 0.09); widest at base; dental formula 5/5 throughout hypostomal length with approximately 7 to 9 denticles in file; all denticles uniform in shape with lateral denticles being slightly larger; crenulations and large basal denticles lacking.

Legs moderately long, slender. Coxae (Figs. 2G, 3A): coxae I each with long triangular internal spur with sharply pointed apex, reaching mid-length of coxae II, without external spur; coxae II each with short, triangular, blunt internal spur and without external spur; coxae III each with short, triangular internal and external spurs narrowly rounded apically, external spur longer than internal; coxae IV each with short triangular external spur narrowly rounded apically; coxae I–II each with syncoxae occupying approximately 1/3 of coxal width. Trochanters I–IV without spurs. Tarsi I–III slightly humped subapically, tarsus IV with indistinct hump subapically and gradually narrows distally; tarsus I: length 0.80–0.86 (0.83 ± 0.02); tarsus IV length 0.67–0.71 (0.69 ± 0.01).

Female [Figs. 1C, D, 3A, 4.] Idiosoma (Fig. 1C, D) suboval, widest at level of spiracle plates; length from scapular apices to posterior body margin in unfed specimens 2.69–3.25 (2.95 ± 0.15 ; *n* = 14), width in unfed specimens 1.72–2.19 (1.95 ± 0.15 ; *n* = 14), ratio 1.45–1.61 (1.52 ± 0.05 ; *n* = 14). Scutum (Fig. 1C, 4A) broad, outline broadly rounded, length 1.34–1.66 (1.50 ± 0.08 ; *n* = 20), width 1.22–1.64 (1.50 ± 0.10 ; *n* = 20), ratio 0.96–1.10 (1.00 ± 0.03 ; *n* = 20); lateral carinae indistinct, as broadly rounded elevations; cervical grooves distinct, broad and moderately shallow; dense large punctations clustered posteriorly and in lateral fields; *c.*30–60 medium to large punctations at scutal posterior margin; very fine punctations evenly distributed over scutum; transition of very fine punctations in central part of scutum to larger punctations in posterior margin abrupt; setae (Figs. 1C, 4B) relatively sparse and short (*c.*0.03), nearly equal to those on alloscutum, distributed as figured. Alloscutum (Fig. 1D) as illustrated. Setae of alloscutum (Figs. 1C, 4B): numerous, evenly distributed, short, length *c.*0.04. Venter (Fig. 1D) as illustrated. Genital aperture (Fig. 1D) medial to

anterior margin of coxae IV. Genital groove (Fig. 1D) well developed. Anal groove (Fig. 1D) circular with open posterior margin. Ventral setae (Fig. 1D) numerous, length of preanal setae $c.0.07$, evenly distributed. Spiracular plates (Fig. 4C) broadly oval, wider than long, length $0.29\text{--}0.40$ (0.34 ± 0.03 ; $n = 20$), width $0.38\text{--}0.50$ (0.43 ± 0.03 ; $n = 20$), ratio $0.73\text{--}0.85$ (0.79 ± 0.03 ; $n = 20$).

Fig. 2 *Ixodes tapirus* Kohls, 1956. Scanning electron micrographs of male (El Respingo Station, Volcán Barú National Park, Chiriquí, Panama, USNMENT 00860721). A, Idiosoma showing conscutum and lateral fold with punctations and setae, dorsal centrolateral portion; B, Idiosoma showing median, adanal and accessory plates with punctations and setae, ventral posterolateral portion; C, Spiracular plate (arrows show orientation of spiracular plate: a, anterior; d, dorsal); D, Gnathosoma, dorsal view; E, Gnathosoma, ventral view; F, Gnathosoma, anteroventral view; G, Coxae. Scale-bars: A–F, 0.1 mm; G, 0.2 mm

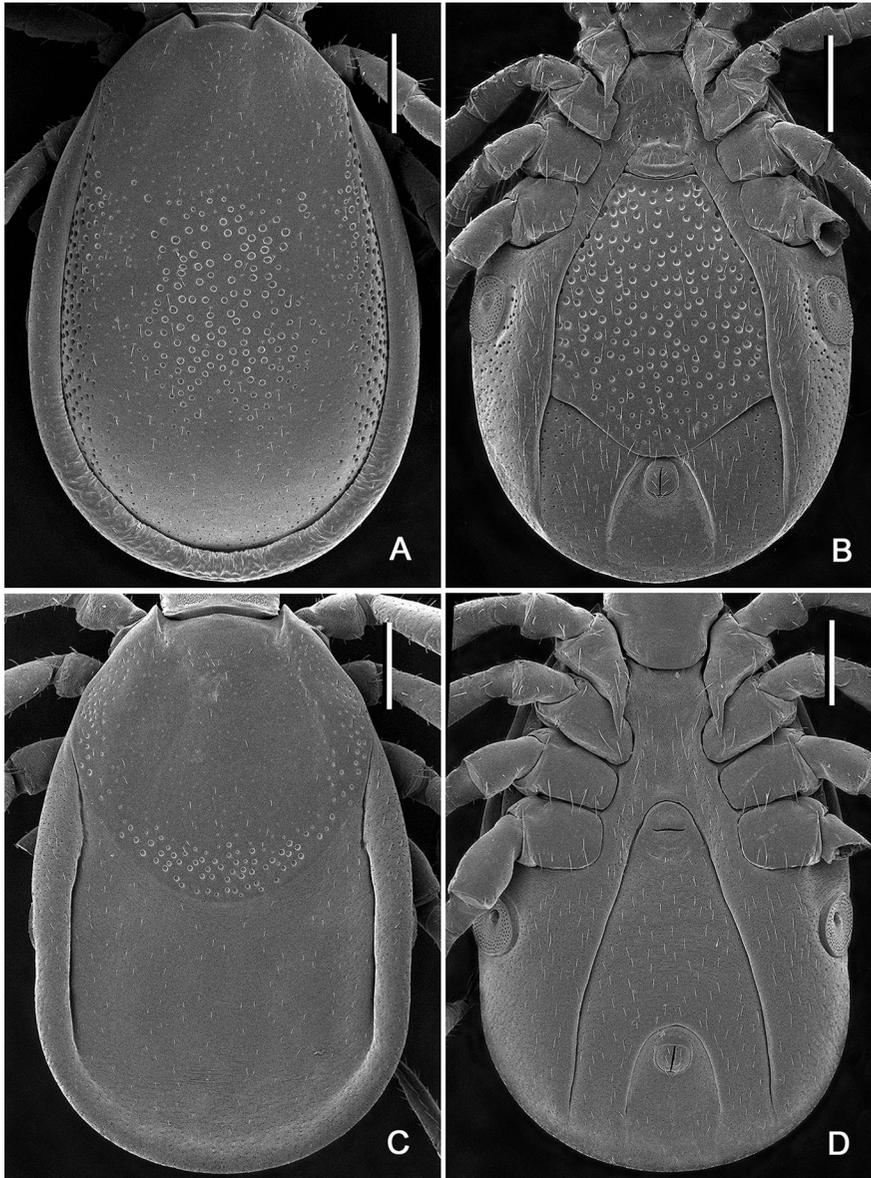
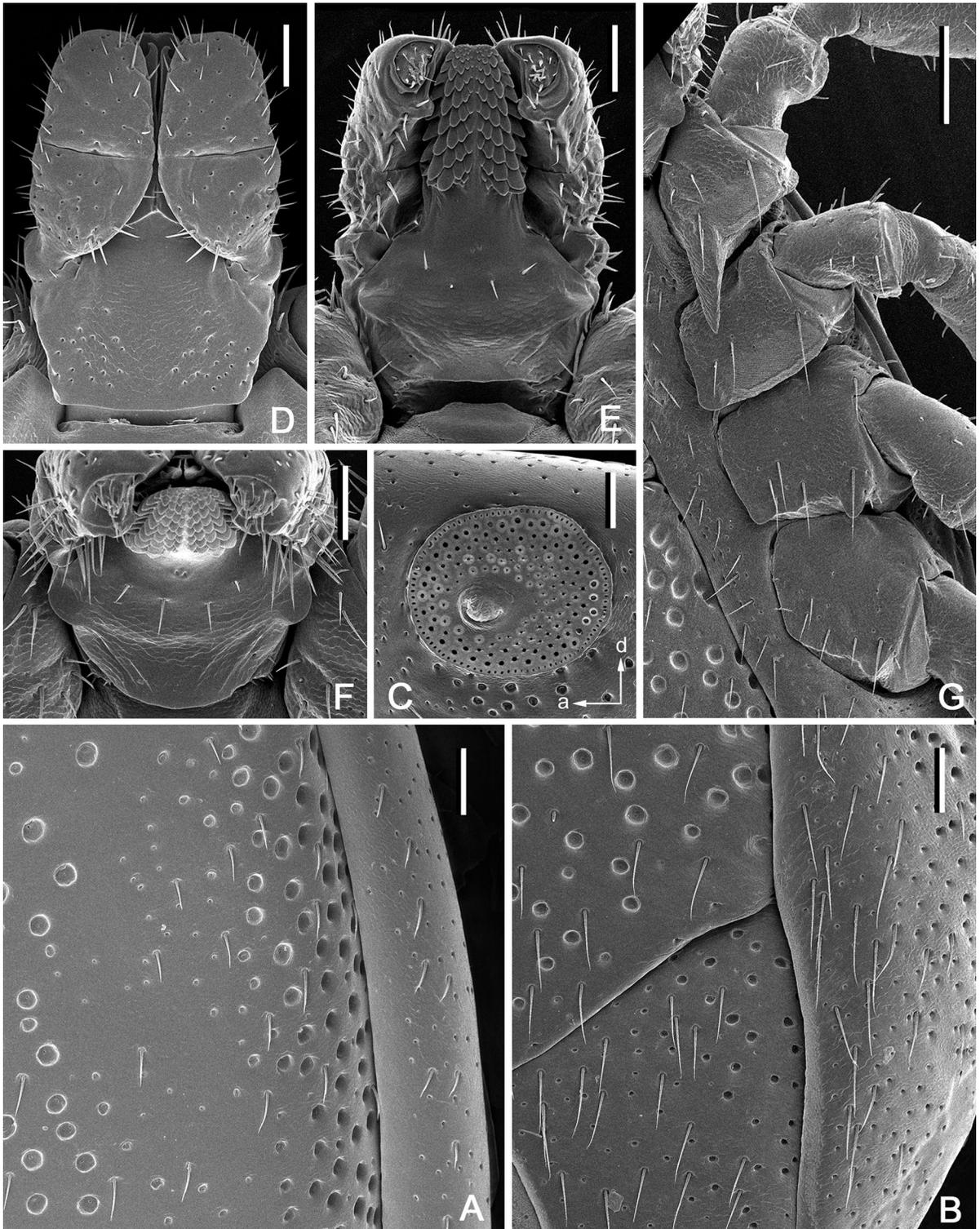


Fig. 1 *Ixodes tapirus* Kohls, 1956. Scanning electron micrographs of idiosoma of male (El Respingo Station, Volcán Barú National Park, Chiriquí, Panama, USNMENT 00860721) and female (El Respingo Station, Volcán Barú National Park, Chiriquí, Panama, USNMENT 00860720). A, Male, dorsal view; B, Male, ventral view; C, Female, dorsal view; D, Female, ventral view. Scale-bars: 0.5 mm



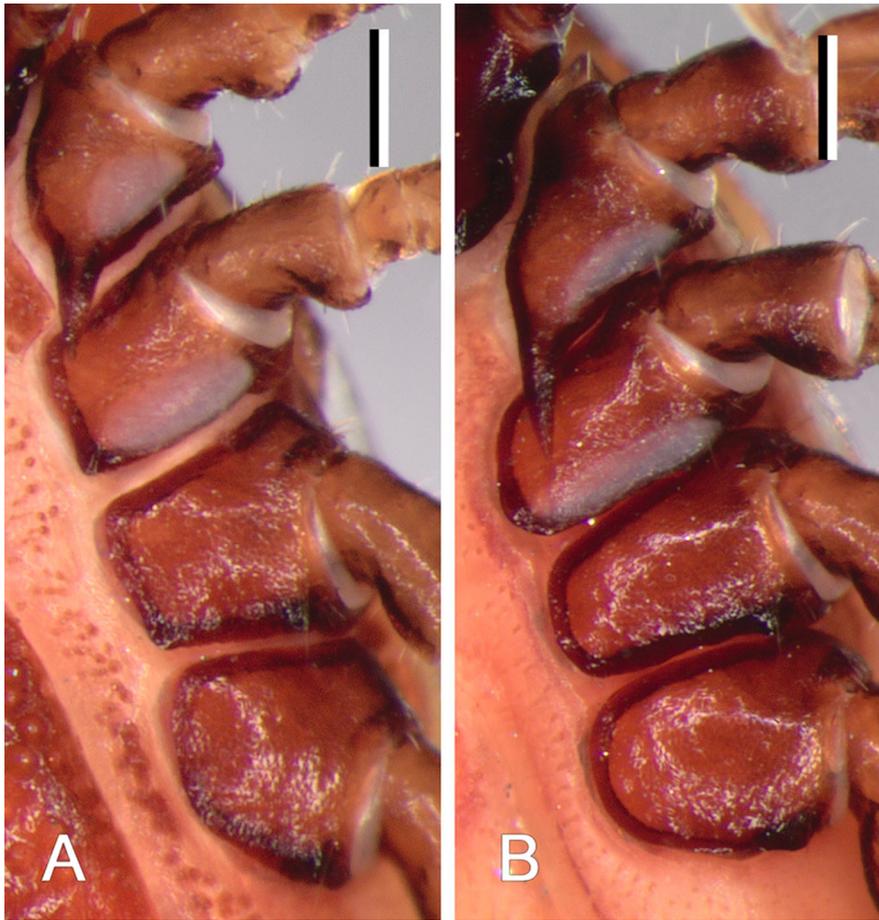


Fig. 3 *Ixodes tapirus* Kohls, 1956. Digital photographs of coxae. A, Male (El Respingo Station, Volcán Barú National Park, Chiriquí, Panama, USNMENT 00860720); B, Female (El Respingo Station, Volcán Barú National Park, Chiriquí, Panama, USNMENT 00860720). Scale-bars: 0.2 mm

Gnathosoma (Fig. 4D–F) length from palpal apices to posterior margin of basis capituli dorsally $0.92\text{--}1.17$ (1.07 ± 0.07 ; $n = 20$), width of basis capituli $0.54\text{--}0.66$ (0.62 ± 0.03 ; $n = 20$), ratio $1.64\text{--}1.83$ (1.73 ± 0.05 ; $n = 20$). Basis capituli dorsally (Fig. 4D) rectangular; posterior margin nearly straight or convex, length from insertion of palpal segment I to cornual apices $0.26\text{--}0.36$ (0.30 ± 0.03 ; $n = 20$), ratio width to length $1.83\text{--}2.27$ (2.06 ± 0.11 ; $n = 20$); cornua short, triangular with blunt apices, total length of basis capituli, including cornua, $6.25\text{--}22.00$ (11.54 ± 4.95 ; $n = 20$) cornual length; triangular or broadly oval porose areas indented with well-circumscribed borders, separated by a distance approximately equal to $1/2$ their own width, width of basis capituli $2.78\text{--}3.40$ (3.07 ± 0.16 ; $n = 20$) porose area width. Basis capituli ventrally (Fig. 4E, F) pentagonal;

anterior angle $c.83^\circ$ ($78^\circ\text{--}87^\circ$); auriculae short, arcuate, ridge-like. Palpi (Fig. 4D, E) elongate, narrow; length dorsally (I–III segments) $0.74\text{--}0.91$ (0.83 ± 0.05 ; $n = 20$), width $0.21\text{--}0.27$ (0.24 ± 0.02 ; $n = 20$), ratio $3.10\text{--}3.74$ (3.47 ± 0.17 ; $n = 20$), length of segments in descending order: 2, 3, 1, 4; segment I well developed, without spurs; segment II narrow proximally, gradually widening to mid-length, nearly parallel-sided from midlength to distal end; segment III laterally straight, medially converging to bluntly rounded apex. Hypostome (Fig. 4E): narrowly rounded at apex; arising from a medial anterior extension of basis; length $0.54\text{--}0.64$ (0.59 ± 0.03 ; $n = 14$), width $0.20\text{--}0.24$ (0.22 ± 0.01 ; $n = 14$), ratio $2.50\text{--}2.94$ (2.75 ± 0.12 ; $n = 14$); widest in anterior half; dental formula in anterior third $4/4$, then $3/3$ in medial third and $2/2$ in proximal third (in holotype

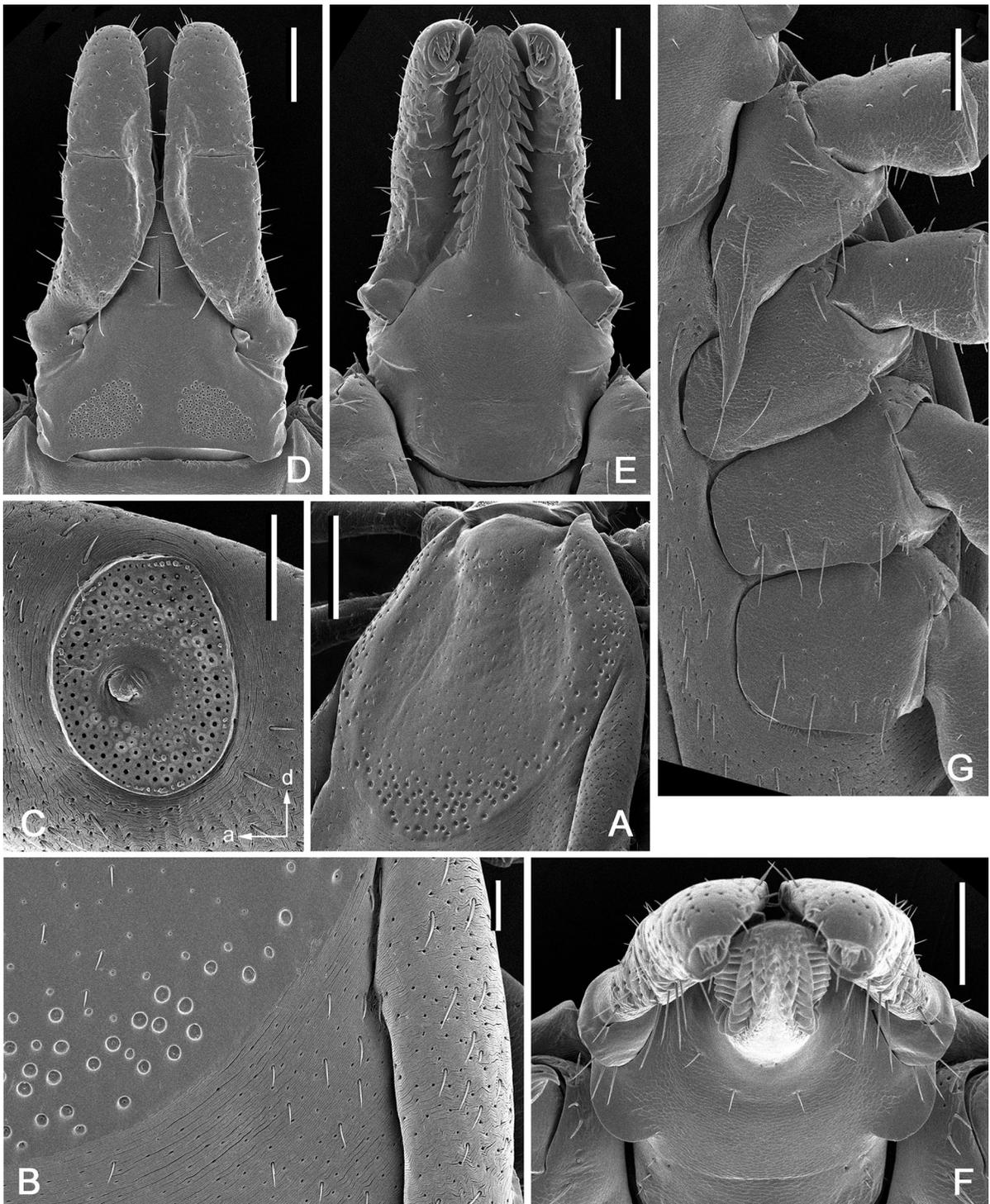


Fig. 4 *Ixodes tapirus* Kohls, 1956. Scanning electron micrographs of female (El Respingo Station, Volcán Barú National Park, Chiriquí, Panama, USNM 00860720). A, Scutum, dorsolateral view; B, Idiosoma showing scutum and alloscutum with punctations and setae, dorsal centrolateral portion; C, Spiracular plate (arrows show orientation of spiracular plate: a, anterior; d, dorsal); D, Gnathosoma, dorsal view; E, Gnathosoma, ventral view; F, Gnathosoma, anteroventral view; G, Coxae. Scale-bars: A, 0.5 mm; B, 0.1 mm; C–G, 0.2 mm



Fig. 5 Map showing the geographical distribution of *Ixodes tapirus* Kohls, 1956. Filled star shows the type-locality and filled circles show confirmed localities

only, 1 asymmetrical denticle forming 4th row in distal part of hypostome, dental formula of slightly more than half of hypostomal length distally 3/3, formula of proximal part 2/2); denticles sharply-pointed.

Legs moderately long, slender. Coxae (Figs. 3B, 4G): coxae I each with long triangular internal spur with sharply pointed apex, reaching mid-length of coxae II, without external spur; coxae II without spurs; coxae III and IV each with very short, poorly distinct, ridge-like external spurs; coxae I–II each with syn-coxae. Tarsi I–III slightly humped subapically, tarsus IV with indistinct hump subapically and gradually narrows distally; tarsus I length 0.85–1.05 (0.98 ± 0.05 ; $n = 20$); tarsus IV length 0.72–0.85 (0.81 ± 0.04 ; $n = 19$).

Remarks

By having syncoxal areas and external spurs absent only on coxae I and II, the male and female of *I. tapirus* most closely resemble *I. guatemalensis*, *I.*

lasallei, *I. montoyanus* and *I. venezuelensis* (see Cooley, 1944; Kohls, 1953, 1956; Méndez & Ortiz, 1958; Kohls & Clifford, 1966; Keirans, 1973; Keirans & Eckerlin, 2005). The male of *I. venezuelensis* remains unknown (Durden & Keirans, 1994).

The male of *I. tapirus* can be distinguished from that of *I. montoyanus* by the presence of large punctations aggregated in the centre of the conscutum and on the median plate (*vs* smaller punctations and not aggregated in the centre of the conscutum in *I. montoyanus*) and from the male of *I. lasallei* by the more sclerotised conscutum and ventral accessory plates (*vs* having a distinct non-sclerotised portion at the posterior margin of the conscutum and small reduced accessory plates in *I. lasallei*). The male of *I. tapirus* can be distinguished from that of *I. guatemalensis* by the following suite of characters: larger size, mean idiosoma length 2.77 mm, mean idiosoma width 1.86 mm (*vs* length 1.47 and width 0.91 in *I. guatemalensis*), the presence (usually) of more than 100 larger punctations in the middle of the

conscutum (*vs* nearly 40 in *I. guatemalensis*) and by having less deep punctations on the basis capituli dorsally (*vs* deep punctations in *I. guatemalensis*).

The female of *I. tapirus* can easily be distinguished from those of *I. lasallei*, *I. montoyanus* and *I. venezuelensis* by the short, arcuate, ridge-like auriculae (*vs* long, spur-like auriculae in *I. lasallei*, *I. montoyanus* and *I. venezuelensis*). The female of *I. tapirus* can be distinguished from that of *I. guatemalensis* by the following suite of characters: larger size, mean scutal length 1.50 mm and mean scutal width 1.50 mm (*vs* mean scutal length 0.93 mm and mean scutal width 0.77 mm in *I. guatemalensis*), subcircular shape of the scutum, ratio length to width on average 1.00 (*vs* elongatedly oval, mean ratio 1.24 in *I. guatemalensis*), the presence of clustered large punctations at the posterior margin of the scutum (*vs* scattered medium-sized punctations in *I. guatemalensis*) and larger triangular or broadly oval porose areas (*vs* smaller subcircular porose areas in *I. guatemalensis*).

The holotype female of *I. tapirus* collected in Colombia is slightly different from the studied specimens from Costa Rica and Panama by having smaller and sparser punctations along the posterior margin of the scutum and a reduced 4th row of denticles on the hypostome (there is only 1 denticle in the 4th row on one of the sides). However, based on other qualitative and quantitative characters it is similar to the other available specimens. Described deviations possibly can be attributed to geographic or individual variability.

Ixodes tapirus is confined to highlands of Colombia (Huila Department), Panama (Chiriquí Province) and for the first time it is recorded from Costa Rica (San José Province) (Fig. 5). All collections were made at elevations exceeding 2,000 (2,012–3,353) metres above sea level. Males and females of this species were collected from vegetation and females were also collected from two species of tapirs, *T. pinchaque* and *T. bairdii*. Females were collected from tapirs in May, “June or July”, October and November, and engorged females were collected in June and November. Both sexes were found on vegetation from March to May.

Acknowledgements We express our sincere thanks to Crystal A. Maier (FMNH, Chicago, USA) for making the holotype specimen available for examination. We also thank Lance A. Durden (Georgia Southern University, Statesboro, GA) for his editing of our manuscript and Maria A. Apanaskevich (Georgia Southern University, Statesboro, GA) for her editing of the

illustrations. We also thank the Environmental National Ministry for providing collecting permits (SE/A-100-2015, DAPVS-0743-2016), personnel at Volcán Barú National Park and La Amistad International Park, personnel of Sistema Nacional de Areas de Conservación (Costa Rica), Monica Delgado, Mariana Vargas, Alfaro and Morales (Pathology Department, UNA, Costa Rica) for their assistance with the samples from Costa Rica. Yusseff Aguirre and Luz Gonzalez (UNACHI, Panama) provided assistance in the field.

Funding This work was partially funded by UNACHI grant 184-CN-01-A095-04-2013. SB was supported by SENACYT grant APY-GC-2015-43. DA’s trip to Panama was partially supported by the James H. Oliver, Jr. Institute of Coastal Plain Science (Georgia Southern University).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All applicable institutional, national and international guidelines for the care and use of animals were followed.

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