



The genus *Ixodes* (Acari: Ixodidae) in Mexico: adult identification keys, diagnoses, hosts, and distribution

El género *Ixodes* (Acari: Ixodidae) en México: claves de identificación para adultos, diagnosis, huéspedes y distribución

Carmen Guzmán-Cornejo^{1*} and Richard G. Robbins²

¹Laboratorio de Acarología, Departamento de Biología Comparada, Facultad de Ciencias, Universidad Nacional Autónoma de México, 04510 México D.F., México.

²DPMIAC/AFPMB, Walter Reed Army Medical Center, 20307-5001 Washington, D.C., USA.

*Correspondent: mcgc@fciencias.unam.mx

Abstract. Identification keys, diagnoses, hosts, and distribution data are provided for adults of the 26 species of *Ixodes* known from Mexico. Data are from specimens deposited in the Colección Nacional de Ácaros (CNAC), Instituto de Biología, Universidad Nacional Autónoma de México, and from the literature.

Key words: *Ixodes*, Ixodidae, keys, hosts, distribution, Mexico.

Resumen. Se presentan claves de identificación, diagnosis, huéspedes y datos sobre la distribución de 26 especies de *Ixodes* conocidas para México. La información proviene de especímenes depositados en la Colección Nacional de Ácaros (CNAC), Instituto de Biología, Universidad Nacional Autónoma de México y de la literatura.

Palabras clave: *Ixodes*, Ixodidae, claves, huéspedes, distribución, México.

Introduction

Ticks of the genus *Ixodes* Latreille, 1795 are common parasites of reptiles, birds and mammals worldwide. Many *Ixodes* species are of great medical and veterinary importance, transmitting microorganisms that cause disease in wild and domestic animals, as well as humans. This genus is said to constitute section Prostriata of the family Ixodidae, because the anal groove embraces the anus anteriorly, forming an arch; all other ixodid ticks belong to section Metastricata, in which the anal groove curves posterior to the anus or is absent. Additionally, all *Ixodes* lack eyes and festoons and possess an inornate scutum. Sexual dimorphism is pronounced in this genus: the male venter is largely covered by 7 sclerotized plates, and the denticles of the female hypostome are well developed, while those of the male are usually few and small, often appearing only as mild crenulations. Most species inhabit the nests or burrows of their hosts, but others occur in wooded or grassy environments (Cooley and Kohls, 1945; Sonenshine, 1991).

Ixodes is the largest genus in the Ixodidae, comprising

243 species (Guglielmone et al., 2003, 2006); 45 of these are known from the Neotropical region (Guglielmone et al., 2003). In Mexico, the distribution and host relationships of *Ixodes* spp. were recently reviewed by Guzmán-Cornejo et al. (2007), who identified 26 species in this country: *I. affinis*, *I. angustus*, *I. bequaerti*, *I. boliviensis*, *I. brunneus*, *I. conepti*, *I. cookei*, *I. cuernavacensis*, *I. dampfi*, *I. dentatus*, *I. eadsi*, *I. guatemalensis*, *I. loricatus*, *I. luciae*, *I. mexicanus*, *I. murreleti*, *I. pacificus*, *I. rubidus*, *I. scapularis*, *I. sinaloa*, *I. spinipalpis*, *I. tamaulipas*, *I. tancitaris*, *I. texanus*, *I. tovari*, and *I. woodi*. All these species are parasites of birds or mammals, and 1 or more of them have been collected in 20 of Mexico's 32 states (Fig. 1). Veracruz possesses the greatest diversity of *Ixodes* species (6), and *I. boliviensis* is the most widespread and associated with the greatest number of hosts.

Based on our studies of *Ixodes* specimens deposited in the Colección Nacional de Ácaros (CNAC), Instituto de Biología, Universidad Nacional Autónoma de México, we herein present identification keys and diagnoses for adults of all *Ixodes* species currently known to occur in Mexico.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 2010		2. REPORT TYPE		3. DATES COVERED 00-00-2010 to 00-00-2010	
4. TITLE AND SUBTITLE The genus Ixodes (Acari: Ixodidae) in Mexico: adult identification keys, diagnoses, hosts, and distribution				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Armed Forces Pest Management Board ,Defense Pest Management Information Analysis Center (DPMIAC),Walter Reed Army Medical Center,Washington,DC,20307-5001				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT Identification keys, diagnoses, hosts, and distribution data are provided for adults of the 26 species of Ixodes known from Mexico. Data are from specimens deposited in the Colección Nacional de Ácaros (CNAC), Instituto de Biología, Universidad Nacional Autónoma de México, and from the literature.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 10	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Materials and methods

Morphological characters were compiled for males and females of *Ixodes*, based on original descriptions and subsequent publications, together with direct observation of specimens housed in CNAC. Separate dichotomous keys were then constructed for males and females. The female stage is known for all 26 species that occur in Mexico, but the male key includes only 17 species (males of *I. bequaerti*, *I. cuernavacensis*, *I. dampfi*, *I. mexicanus*, *I. murreleti*, *I.*

rubidus, *I. sinaloa*, *I. tamaulipas* and *I. tancitaris* are unknown). The keys are followed by brief diagnoses that summarize the salient character states of each sex. For the convenience of readers, we have also recapitulated some of the distribution and host data from Guzmán-Cornejo et al. (2007), occasionally referencing new information published afterward. Hosts cited as Muridae in Guzmán-Cornejo et al. (2007) have been changed to Cricetidae, in accordance with Musser and Carleton (2005).

Results

Key to females.

1. Trochanters I-III with spurs2
Trochanters I-III without spurs3
2. Hypostome large, broad, denticles 6/6 apically, then 5/5, 4/4 and 3/3 to base; auriculae distinct but rounded *I. murreleti*
Hypostome narrow, denticles 4/4 apically, then 3/3 and 2/2 to base; auriculae sharp-edged *I. brunneus*
3. Auriculae weakly developed or absent4
Auriculae prominent, usually as distinct ridges or recurved horns14
4. In ventral view, basis capituli flared laterally but auriculae absent; coxa I robust and bifid, posterior margin between internal and external spurs curved5
Ventrally, basis capituli not flared laterally; coxa I not as above6
5. Coxa I with spurs about equal in length *I. loricatus*
Coxa I with external spur much longer than internal spur *I. luciae*
6. Palps elongate, length:width ratio generally greater than 3:17
Palps shorter, often thick and clublike, length:width ratio generally less than 3:111
7. Auriculae present as slight lateral ridges8
Auriculae absent9
8. Cornua small but distinct; scutum almost circular, punctations larger peripherally *I. scapularis*
Cornua absent; scutum oval with uniformly small punctations *I. pacificus*
9. Spurs of coxa I about equal in length; hypostome Christmas tree-shaped, not borne on median extension of basis capituli, denticles 3/3 *I. angustus*
Internal spur of coxa I longer than external spur; hypostome borne on median extension of basis capituli, denticles 4/4 or 3/3 apically, then 2/2 to base10
10. Internal spur of coxa I moderately long, overlapping anterior margin of coxa II; venter of basis capituli broad and elongate; legs normal *I. woodi*
Internal spur of coxa I long, overlapping half or more of coxa II; venter of basis capituli broad but not elongate; legs long, spiderlike *I. conepti*
11. Basis capituli with prominent rounded hump on either side of hypostome *I. texanus*
Basis capituli without rounded hump on either side of hypostome12
12. Dorsally, posterior margin of basis capituli sinuous *I. dampfi*
Dorsally, posterior margin of basis capituli nearly straight13
13. Cornua short but distinct; cervical grooves narrow and shallow but long, approaching posterolateral margins of scutum *I. cookei*
Cornua absent, but posterolateral corners slightly emphasized in some specimens; cervical grooves shallow and short, visible only posterior to middle of scutum *I. rubidus*
14. Hypostomal dentition 5/5 or 6/6 *I. dentatus*
Hypostomal dentition less than 5/515
15. Auriculae as lateral saliences or ridges; scutum with conspicuous deep punctations near posterior margin *I. affinis*
Auriculae broadly rounded, or retrograde spurs or horns; scutum otherwise16
16. Palpal segment I ventrally with a short, sharp spur17
Palpal segment I lacking a ventral spur19
17. Hypostomal dentition 4/4 apically; transverse suture distinct *I. spinipalpis*
Hypostomal dentition 3/3 apically; transverse suture faint or absent18
18. Anterior margin of genital aperture smoothly curved; internal spur of coxa I overlapping anterior half of coxa II *I. sinaloa*
Anterior margin of genital aperture notched; internal spur of coxa I overlapping anterior margin of coxa II *I. tovari*

19. Auriculae broadly rounded	20
Auriculae curved, retrograde horns.....	22
20. External spurs absent on coxae I and II; scutal punctations chiefly in lateral fields and posteriorly	<i>I. guatemalensis</i>
External spurs present on all coxae; scutal punctations evenly distributed.....	21
21. Hypostome relatively broad, dentition 4/4 apically, then 3/3 and 2/2 to base	<i>I. tamaulipas</i>
Hypostome relatively narrow, dentition 3/3 apically, then 2/2 to base	<i>I. tancitarium</i>
22. Hypostome Christmas tree-shaped, attenuated and sharp; punctations distinct, moderate in number, and more or less evenly distributed.....	<i>I. mexicanus</i>
Hypostome with sides almost parallel for much of length; punctations otherwise	23
23. Punctations small and scattered.....	24
Punctations large and numerous or clustered near posterior scutal margin.....	25
24. Scutum widest near midlength, broadly rounded posteriorly.....	<i>I. cuernavacensis</i>
Scutum widest just anterior to midlength, narrowing posteriorly.....	<i>I. eadsi</i>
25. Punctations large, numerous and evenly distributed	<i>I. bequaerti</i>
Punctations sparse and small over most of scutum, but with few to several large deep ones near posterior scutal margin.....	<i>I. boliviensis</i>

Key to males.

1. Trochanters I-III with small but distinct spurs.....	<i>I. brunneus</i>
Trochanters I-III without spurs	2
2. Large, elongate, heavily sclerotized ticks with wide lateral body folds; in ventral view, basis capituli flared laterally; coxa robust and bifid, posterior margin between internal and external spurs curved	3
Body neither elongate nor heavily sclerotized; ventrally, basis capituli not flared laterally; coxa I not as above	4
3. External and internal spurs of coxa I equal or subequal in length.....	<i>I. loricatus</i>
External spur of coxa I much longer than internal spur.....	<i>I. luciae</i>
4. Basis capituli dorsally with 8-9 deep punctations in lateral fields, suggesting porose areas; coxa I with long, narrow internal spur but external spur absent; coxa II lacking spurs	<i>I. guatemalensis</i>
Without this combination of characters	5
5. Hypostome with large, sharp lateral denticles, distinctly different from the smaller median denticles, which are arrayed in diagonal or transverse rows of crenulations.....	6
Lateral and median hypostomal denticles similar in structure.....	9
6. Central area of scutum posterior to pseudoscutum with a group of conspicuously large, deep punctations.....	<i>I. affinis</i>
Scutal punctations arranged otherwise.....	7
7. Pseudoscutum present, somewhat darker in color, and indicated by smaller punctations; larger punctations posteriorly	<i>I. spinipalpis</i>
Pseudoscutum usually absent; scutal punctations uniformly small, numerous, evenly distributed.....	8
8. Spiracular plate oval; median plate with small punctations.....	<i>I. pacificus</i>
Spiracular plate elongate; median plate with large punctations.....	<i>I. scapularis</i>
9. Internal spur of coxa I short or of only moderate length, barely reaching anterior margin of coxa II	10
Internal spur of coxa I long, extending to middle of coxa II or beyond	13
10. Large tick, scutum usually at least 3 mm long; pseudoscutum present, its posterior margin indicated by an area devoid of punctations	<i>I. conepati</i>
Smaller tick, scutum usually ≤ 2 mm long; pseudoscutum faint or absent.....	11
11. Scutal punctations numerous, large and deep; scutal surface faintly rugose.....	<i>I. texanus</i>
Scutal punctations moderate in number and small, except in lateral areas.....	12
12. Dental formula 3/3, crenulations large, arranged in overlapping rows.....	<i>I. angustus</i>
Dental formula 4/4, crenulations small, arranged in nonoverlapping rows.....	<i>I. woodi</i>
13. Cornua prominent; hypostome elongate, pointed	<i>I. tovari</i>
Cornua small or absent; hypostome not pointed.....	14
14. Scutal punctations numerous, moderately large and deep; punctations of median plate numerous but small.....	<i>I. cookei</i>
Larger scutal punctations confined to median and posterior areas; punctations of median plate large.....	15
15. Apex of hypostome notched	<i>I. eadsi</i>
Apex of hypostome rounded.....	16
16. Hypostome with median crenulations arranged diagonally.....	<i>I. dentatus</i>
Hypostome with median crenulations arranged transversely	<i>I. boliviensis</i>

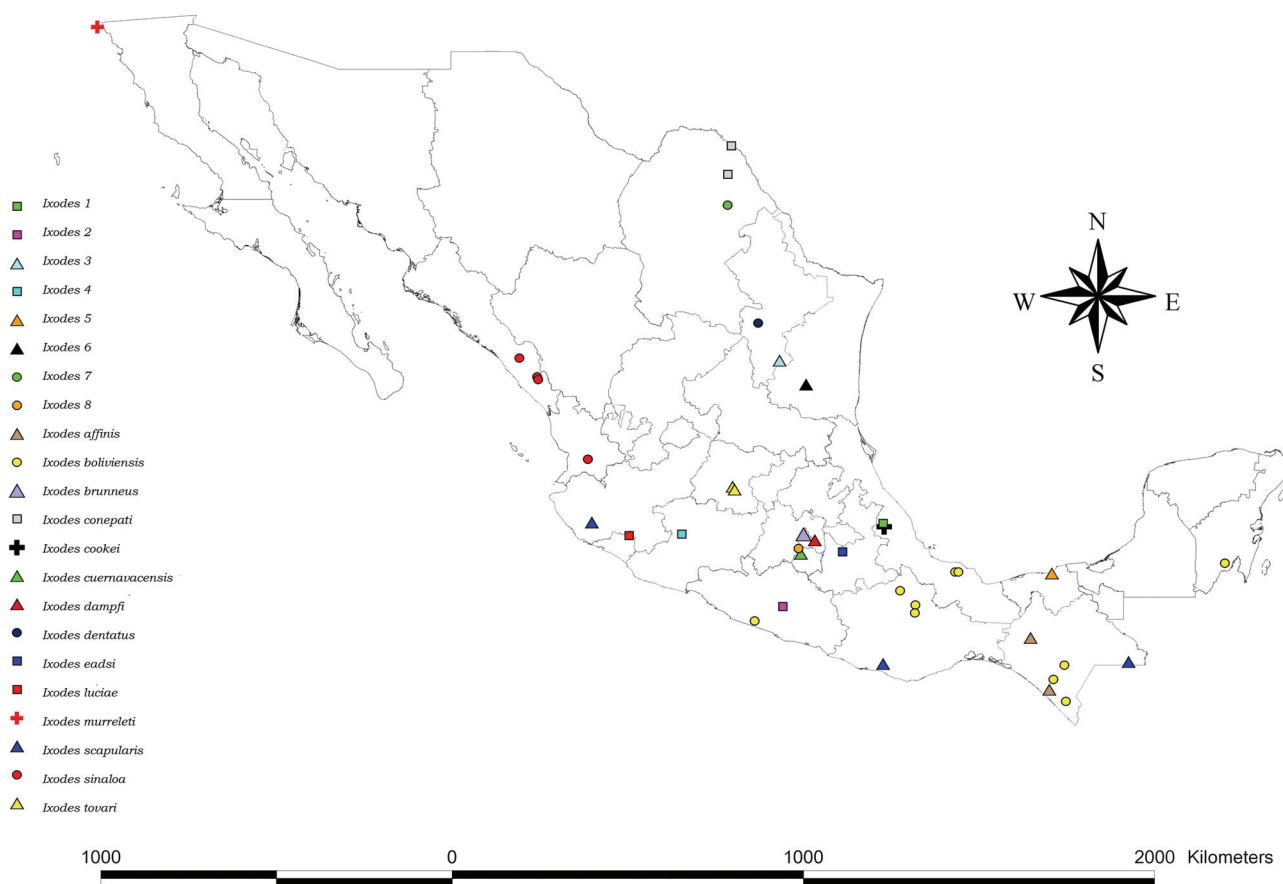


Figure 1. Geographical distribution of species of *Ixodes* in Mexico (based on Guzmán-Cornejo et al., 2007). *Ixodes* 1 (*I. spinipalpis*, *I. boliviensis*, *I. tancitaris*); *Ixodes* 2 (*I. guatemalensis*, *I. spinipalpis*, *I. rubidus*, *I. texanus*); *Ixodes* 3 (*I. cookei*, *I. texanus*, *I. scapularis*); *Ixodes* 4 (*I. mexicanus*, *I. tancitaris*); *Ixodes* 5 (*I. loricatus*, *I. luciae*); *Ixodes* 6 (*I. tamaulipas*, *I. woodi*); *Ixodes* 7 (*I. angustus*, *I. woodi*); *Ixodes* 8 (*I. woodi*, *I. spinipalpis*).

***Ixodes affinis* Neumann, 1899**

Ixodes affinis Neumann, 1899: 120, original description
 Synonym of *I. ricinus* var. *scapularis* (Say, 1821): Nuttall and Warburton, 1911: 156, 281.

Ixodes ricinus aragãoi Fonseca, 1935

Ixodes aragãoi Fonseca, in Aragão and Fonseca, 1952

Diagnosis. Female: Cornua absent, auriculae as lateral saliences or ridges; dental formula 4/4 apically, then 3/3 to near base; scutum circular, with conspicuous deep punctations near posterior margin; internal spur of coxa I long, thin, and pointed, overlapping two thirds of coxa II; small external spurs on coxae I-IV. Male: Cornua absent; scutum with large, deep, conspicuous punctations in posteromedian area; similar large, deep punctations on median plate; hypostome long and heavy, with large lateral

and posterior denticles in addition to transverse rows of crenulations; internal spur of coxa I very long, overlapping most of coxa II.

Distribution in Mexico. Chiapas and Yucatán.

Hosts in Mexico. Bovidae, Cervidae, and Procyonidae (Mammalia).

***Ixodes angustus* Neumann, 1899**

Ixodes angustus Neumann, 1899: 136, original description

Ixodes angustus Neumann, 1901, sp. near *loricatus* Neumann, 1899, redescribed in error; see Nuttall and Warburton, 1911: 195.

Diagnosis. Female: Cornua and auriculae absent; hypostome Christmas tree-shaped, dentition 3/3; coxa

I with internal and external spurs about equal in length; coxae II-IV with small external spurs, decreasing in size. Male: Cornua absent or minute; auriculae as short, rounded lateral ridges; punctations fine in median area of scutum, generally larger laterally; dental formula 3/3, hypostomal crenulations large and arranged in overlapping rows; internal and external spurs of coxa I short and about equal in length; coxae II-IV each with a short but distinct external spur.

Distribution in Mexico. Coahuila.

Hosts in Mexico. Cricetidae (Mammalia).

***Ixodes bequaerti* Cooley and Kohls, 1945**

Ixodes bequaerti Cooley and Kohls, 1945: 173-174, original description

Diagnosis. Female: Cornua distinct, about as wide as long; auriculae as large pointed horns directed posteriorly; hypostome long, narrow and pointed, dentition 3/3; scutal punctations numerous and distinct, those in posteromedian area more numerous, large, circular and deep, those in anteromedian and anterolateral areas smaller and less definite; lateral carinae prominent; coxa I with small internal and external spurs; coxae II-IV with distinct external spurs, smaller on IV. Male: Unknown.

Distribution in Mexico. Chiapas (Cooley and Kohls, 1945; Hoffmann and López-Campos, 2000).

Hosts in Mexico. Trogonidae (*Trogon* sp.) (Aves) (Hoffmann and López-Campos, 2000).

***Ixodes boliviensis* Neumann, 1904**

Ixodes boliviensis Neumann, 1904: 457-458, original description

Ixodes bicornis Neumann, 1906

Ixodes boliviensis may prove to be a junior synonym of *Ixodes diversifossus* Neumann, 1899: Guglielmone et al., 2009: 320

Diagnosis. Female: Cornua present; auriculae well developed and curved; dental formula 4/4, then 3/3 and 2/2 to near base; scutal punctations sparse and small over most of scutum, but with few to several large deep ones near posterior margin; coxa I with internal spur very long, almost completely overlapping coxa II; coxae I-IV with progressively shorter external spurs, very small or absent on IV. Male: Cornua absent; auriculae as low, sharp ridges; large, deep punctations posterior to pseudoscutum; similar large, deep punctations on median plate; hypostome broad and heavy but without large lateral denticles; internal spur of coxa I long, extending over most of coxa II.

Distribution in Mexico. Chiapas, Guerrero, Nayarit, Oaxaca, Quintana Roo, and Veracruz.

Hosts in Mexico. "Pheasant" (Galliformes) (Aves),

Cervidae, Canidae, Felidae, Procyonidae, Hominidae, and Sciuridae (Mammalia).

***Ixodes brunneus* Koch, 1844**

Ixodes brunneus Koch, 1844: 232, original description

Ixodes californicus Banks, 1904

Ixodes kelloggi Nuttall and Warburton, 1908

Diagnosis. Female: Cornua short or absent; auriculae large, sharp-edged lateral extensions; dental formula 4/4, then 3/3, and 2/2 to near base; scutum suboval, much longer than wide; coxa I with 2 short spurs, the internal slightly larger and longer than the external; coxae II-IV with short external spurs; trochanters I-III with small but distinct ventral spurs. Male: Cornua absent; dental formula 3/3 and crenulate; pseudoscutum accentuated by scutal depressions posterolaterally; coxa I with internal and external spurs short and about equal in length; trochanters I-III with small but distinct ventral spurs.

Distribution in Mexico. México D.F.

Hosts in Mexico. Unknown.

***Ixodes conepti* Cooley and Kohls, 1943**

Ixodes conepti Cooley and Kohls, 1943: 144-147, original description

Diagnosis. Female: Cornua present and distinct; auriculae absent; dental formula 3/3, then 2/2 to base; scutum with distinct lateral carinae; internal spur of coxa I long, thin, overlapping half or more of coxa II; coxae I-IV with short rounded external spurs, about equal in size. Male: Cornua absent; auriculae present as long lateral ridges; pseudoscutum present, its posterior margin indicated by an area devoid of punctations; surface of scutum smooth except for indented punctate region in scapular areas; coxa I with very short internal spur, external spur faint or absent; coxae II-IV without internal spurs, but each with a short, blunt external spur, largest on coxa IV.

Distribution in Mexico. Coahuila.

Hosts in Mexico. Unknown.

***Ixodes cookei* Packard, 1869**

Ixodes cookei Packard, 1869: 67, original description

Ixodes cruciarius Fitch, 1872

Ixodes hexagonus var. *longispinosus* Neumann, 1901

Ixodes hexagonus var. *cookei* Nuttall and Warburton, 1911

Diagnosis. Female: Cornua short; auriculae faint as small lateral ridges; dental formula 3/3 apically, then 2/2; scutum with prominent lateral carinae; cervical grooves narrow and shallow but long, approaching posterolateral margins of scutum; internal spur of coxa I long and slim; external

spurs of coxae I-IV small, rounded, decreasing in size posteriorly. Male: Cornua absent; auriculae as mild lateral extensions; scutal punctations numerous, moderately large and deep; punctations of median plate numerous but small; hypostome broad and thick, rounded apically; coxa I with long, thin internal spur, overlapping anterior third to half of coxa II; short external spurs on all coxae, about equal in size.

Distribution in Mexico. Nuevo León and Veracruz.

Hosts in Mexico. Canidae, Cricetidae, and Procyonidae (Mammalia).

***Ixodes cuernavacensis* Kohls and Clifford, 1966**

Ixodes cuernavacensis Kohls and Clifford, 1966: 810-811, original description

Diagnosis. Female: Cornua faint; auriculae as large, curved, pointed horns; lateral carinae distinct; coxa I with moderate internal spur; coxae I-IV each with short external spur. Note: *Ixodes cuernavacensis* is known from a single female that is missing the distal portion of its hypostome. In our key (couplet 14), we assume that the dental formula of this specimen is less than 5/5, basing this assessment on the relative narrowness of the surviving proximal portion and the reduced dentition of the hypostomal base. Male: Unknown.

Distribution in Mexico. Morelos.

Hosts in Mexico. Apodidae (Aves).

***Ixodes dampfi* Cooley, 1943**

Ixodes dampfi Cooley, 1943: 21-24, original description

Diagnosis. Female: Cornua present and distinct; posterior margin of basis capituli sinuous; dental formula 3/3 apically, then 2/2 to base; scutum with pronounced lateral carinae; internal spur of coxa I long and thin; external spurs of coxae I-IV small and about equal in size. Male: Unknown.

Distribution in Mexico. Estado de México.

Hosts in Mexico. Geomyidae (Mammalia).

***Ixodes dentatus* Marx, 1899**

Ixodes dentatus Marx, 1899: 19, original description

Diagnosis. Female: Cornua distinct, rounded; auriculae nearly straight retrograde horns; dental formula 6/6 apically, then 5/5 and 4/4, and 3/3 to base; internal spur of coxa I long and pointed; external spurs of coxae I-IV small and about equal in size. Male: Cornua small; auriculae as mild lobes; scutum with punctations in median area somewhat larger and deeper than those elsewhere; hypostome long, crenulations arranged diagonally.

Distribution in Mexico. Nuevo León.

Hosts in Mexico. Leporidae (Mammalia).

***Ixodes eadsi* Kohls and Clifford, 1964**

Ixodes eadsi Kohls and Clifford, 1964: 466-470, original description

Diagnosis. Female: Cornua present; auriculae as fine, curved, pointed horns; dental formula 3/3 in anterior two thirds, then 2/2 to base; scutum widest just anterior to midlength, narrowing posteriorly, and with distinct lateral carinae; coxa I with long internal spur; moderate external spurs on coxae I-IV, smallest on IV. Male: Apex of hypostome notched; scutal punctations small except in the median and lateral areas, where they are much larger; coxa I with long, sharp internal spur; coxa II with a small internal spur; all coxae with moderate external spurs.

Distribution in Mexico. Puebla.

Hosts in Mexico. Heteromyidae (Mammalia).

***Ixodes guatemalensis* Kohls, 1956**

Ixodes guatemalensis Kohls, 1956: 636, original description

Diagnosis. Female: Cornua short, pointed; auriculae distinct as large rounded projections; dental formula 4/4 apically, then 3/3, and 2/2 to base; scutal punctations larger and more numerous in lateral fields and posteriorly; coxa I with long, thin internal spur but no external spur; coxa II without spurs; coxae III-IV each with a faint external spur. Male: Basis capituli dorsally with 8-9 deep punctations in lateral fields, suggesting porose areas; coxa I with long, narrow internal spur but no external spur; coxa II without spurs; coxae III-IV each with a small triangular external spur.

Distribution in Mexico. Guerrero and Veracruz.

Hosts in Mexico. Sciuridae (Mammalia).

***Ixodes loricatus* Neumann, 1899**

Ixodes loricatus Neumann, 1899: 139, original description

Ixodes coxaeifurcatus Neumann, 1899

Ixodes angustus Neumann, 1901; see synonymy for *I. angustus* Neumann, 1899

Ixodes didelphidis Fonseca and Aragão, 1952

Diagnosis. Female: Cornua and auriculae absent; basis capituli flared laterally; dental formula 2/2; coxa I robust and bifid, internal and external spurs about equal in length; coxae II-IV with large external spurs. Male: Cornua and auriculae absent; basis capituli flared laterally; hypostome similar to female but smaller; coxae as in female.

Distribution in Mexico. Tabasco.

Hosts in Mexico. Atelidae (Mammalia).

Ixodes luciae* Sénevet, 1940Ixodes loricatus* var. *spinosus* Nuttall, 1910*Ixodes luciae* Sénevet, 1940: 896-898, original description*Ixodes scuticrenatus* Vazquez, 1946*Ixodes loricatus vogelsangi* Santos Dias, 1954

Diagnosis. Female: Cornua and auriculae absent; basis capituli flared laterally; dental formula 2/2; coxa I robust and bifid, external spur slightly curved, sharp, and much longer than internal spur; coxae II-IV with large external spurs, rounded apically. Male: Cornua and auriculae absent; basis capituli flared laterally; hypostome similar to female but smaller; coxa I robust and bifid, external spur sharp and much longer than internal spur; coxae II-IV essentially as in female.

Distribution in Mexico. Chiapas, Colima, Tabasco, and Veracruz.

Hosts in Mexico. Didelphidae (Mammalia).

Ixodes mexicanus* Cooley and Kohls, 1942Ixodes mexicanus* Cooley and Kohls, 1942: 149-152, original description

Diagnosis. Female: Cornua absent; auriculae as short, curved horns; hypostome Christmas tree-shaped, attenuated and sharp, dental formula 3/3; scutal punctations distinct, moderate in number, and more or less evenly distributed; coxa I with short internal spur; coxae I-IV with very short external spurs. Male: Unknown.

Distribution in Mexico. Michoacán.

Hosts in Mexico. Emberizidae and Troglodytidae (Aves).

Ixodes murreleti* Cooley and Kohls, 1945Ixodes murreleti* Cooley and Kohls, 1945: 213-214, original description

Diagnosis. Female: Cornua very short; auriculae distinct lateral rounded extensions; hypostome large, broad, dental formula 6/6 apically, then 5/5, 4/4, and 3/3 to base; coxa I with 2 short spurs, internal as a projected corner; coxae II-IV with small external spurs. Male: Unknown.

Distribution in Mexico. Baja California.

Hosts in Mexico. Alcidae (Aves).

Note. This record was cited by Hoffmann (1962) and Guzmán-Cornejo et al. (2007) from Baja California Sur; however, the locality for this record (Isla Los Coronados) is in Baja California.

Ixodes pacificus* Cooley and Kohls, 1943Ixodes californicus* Banks, 1908 (*non* Banks, 1904)Reduced to subspecies *Ixodes ricinus* var. *californicus* (Banks): Nuttall and Warburton, 1911: 159*Ixodes pacificus* Cooley and Kohls, 1943: 139-144,

original description

Diagnosis. Female: Cornua absent; auriculae mildly developed as low ridges; dental formula 4/4 distally, then 3/3, and 2/2 at base; scutum oval with uniformly small punctations; internal spur of coxa I long, overlapping coxa II; very short external spurs on all coxae. Male: Cornua absent; auriculae as lateral ridges; hypostome with large lateral teeth; coxae as in female but internal spur of coxa I shorter.

Distribution in Mexico. Baja California.

Hosts in Mexico. Under the junior synonym *I. ricinus californicus* Banks, 1908, Bishopp and Trembley (1945) state that this species "is of distinct importance as a pest of man, domestic animals, and deer" in Mexico. Canidae (*Canis familiaris* Linnaeus, 1758) (Mammalia) (Hoffmann and López-Campos, 2000).

Ixodes rubidus* Neumann, 1901Ixodes rubidus* Neumann, 1901: 282, original description

Diagnosis. Female: Cornua and auriculae absent; dental formula 2/2; lateral carinae present; cervical grooves shallow and short, visible only posterior to middle of scutum; internal spur of coxa I long and slender; all coxae with very short external spurs. Male: Unknown.

Distribution in Mexico. Guanajuato and Guerrero.

Hosts in Mexico. Canidae and Procyonidae (Mammalia).

Ixodes scapularis* Say, 1821Ixodes scapularis* Say, 1821: 79, original description*Ixodes fuscous* Say, 1821*Ixodes reduvius* Neumann, 1899 (*pro parte*)*Ixodes pratti* Banks, 1908 (*pro parte*)Reduced to subspecies *Ixodes ricinus* var. *scapularis* (Say, 1821) by Nuttall and Warburton, 1911: 156-158; see synonymy for *I. affinis* Neumann, 1899*Ixodes ozarkus* Cooley and Kohls, 1944*Ixodes dammini* Spielman, Clifford, Piesman and Corwin, 1979

Diagnosis. Female: Cornua small but distinct; auriculae as lateral ridges; dental formula 4/4 apically, then 3/3, and 2/2 to base; scutum almost circular, punctations larger peripherally; coxa I with moderately long internal spur, partly overlapping coxa II; all coxae with short external spurs. Male: Cornua absent; auricula as a small prominence, pointing backward; hypostome large and with a few large lateral teeth; coxae as in female.

Distribution in Mexico. Coahuila, Jalisco, Oaxaca, and Tamaulipas. Woodham et al. (1983) described a broader Mexican range, including Baja California, Baja California Sur, Campeche, Coahuila, Colima, Durango, Hidalgo, Jalisco, Nuevo León, Quintana Roo, San Luis Potosí, and

Tamaulipas. Since Guzmán-Cornejo et al. (2007), records have been published from Chiapas (Romero-Castañón et al., 2008) and Nuevo León (Gordillo-Pérez et al., 2009).

Hosts in Mexico. Bovidae (*Bos taurus* Linnaeus, 1758), and Canidae (Mammalia). Since Guzmán-Cornejo et al. (2007), records have been published from Cervidae (*Mazama americana* Erxleben, 1777 and *Odocoileus virginianus* Zimmermann, 1780) (Romero-Castañón et al., 2008) and Leporidae (*Silvilagus floridanus* J.A. Allen, 1890) (Mammalia) (Gordillo-Pérez et al., 2009).

Note. Romero-Castañón et al. (2008) incorrectly state that their specimen of *I. scapularis* from *O. virginianus* constitutes a new locality record, when, as we have shown (Guzmán-Cornejo et al., 2007), this tick has long been known from Mexico.

***Ixodes sinaloa* Kohls and Clifford, 1966**

Ixodes sinaloa Kohls and Clifford, 1966: 811-813, original description

Diagnosis. Female: Cornua distinct, as long as wide; auriculae as slender, pointed, curved horns; hypostome with dental formula 3/3 for most of its length, 2/2 near base; scutum longer than wide, with distinct lateral carinae; internal spur of coxae I long and pointed; external spurs on all coxae short and progressively smaller from I to IV. Male: Unknown.

Distribution in Mexico. Nayarit, Sinaloa, and also from Jalisco (Keirans and Jones, 1972).

Hosts in Mexico. Cricetidae and Heteromyidae (*Liomys pictus plantinarenensis* Merriam, 1902) (Mammalia) (Keirans and Jones, 1972).

***Ixodes spinipalpis* Hadwen and Nuttall, 1916**

Ixodes diversifossus Neumann, 1911 (*non* Neumann, 1899)

Ixodes diversifossus Bishopp, 1912 (*non* Neumann, 1899)

Ixodes dentatus var. *spinipalpis* Hadwen and Nuttall in Nuttall, 1916: 301-304, original description

Ixodes neotomae Cooley, 1944

Diagnosis. Female: Cornua present; auriculae as fine, curved pointed horns; dental formula 4/4 apically, then 3/3, and 2/2 to base; lateral carinae as low, rounded ridges; internal spur of coxa I long, thin, and somewhat curved; external spurs on all coxae short and progressively smaller from I to IV. Male: Cornua small but distinct; auriculae as mild rounded lateral extensions; hypostome large and mildly notched apically, lateral teeth large and sharp; pseudoscutum present, somewhat darker in color, and indicated by smaller punctations, larger punctations posteriorly; coxae as in female.

Distribution in Mexico. Morelos, Guerrero, Veracruz, and

also from Estado de México as *I. neotomae* Cooley, 1944 (Hoffmann and López-Campos, 2000).

Hosts in Mexico. Cricetidae, Sciuridae, and Leporidae (*Romerolagus diazi* Fernando Ferrari, 1893) (Mammalia) (Hoffmann and López-Campos, 2000)

***Ixodes tamaulipas* Kohls and Clifford, 1966**

Ixodes tamaulipas Kohls and Clifford, 1966: 813-815, original description

Diagnosis. Female: Cornua present, about as long as wide; auriculae as broad, rounded extensions; hypostome relatively broad, dentition 4/4 apically, then 3/3, and 2/2 to base; scutum longer than wide, with distinct lateral carinae; internal spur of coxa I long and pointed, reaching anterior margin of coxa II; external spurs on all coxae short and about equal in size. Male: Unknown.

Distribution in Mexico. Tamaulipas.

Hosts in Mexico. Sciuridae (Mammalia).

***Ixodes tancitarium* Cooley and Kohls, 1942**

Ixodes tancitarium Cooley and Kohls, 1942: 152-154, original description

Diagnosis. Female: Cornua present and distinct; auriculae as large rounded projections; hypostome relatively narrow, dental formula 3/3 apically, then 2/2 to base; scutum suboval, broadly rounded posteriorly, with distinct lateral carinae; internal spur of coxa I long and narrow, overlapping anterior half of coxa II; short but well-defined external spurs on all coxae. Male: Unknown.

Distribution in Mexico. Michoacán, Veracruz, and also from Estado de México (Hoffmann, 1969).

Hosts in Mexico. Cricetidae and Hominidae (*Homo sapiens* Linnaeus, 1758) (Mammalia) (Hoffmann, 1969).

Note. The tick from Valle de Bravo, Estado de México, was identified as near *Ixodes tancitarium*, and was implicated in paralysis of a human (Hoffmann, 1969).

***Ixodes texanus* Banks, 1909**

Ixodes pratti Banks, 1908 (*pro parte*)

Ixodes texanus Banks, 1909: 170-173, original description

Diagnosis. Female: Cornua moderate in size, occasionally absent; basis capituli with prominent rounded hump on either side of hypostome, which is rounded apically, dental formula 2/2; scutum rugose, lateral carinae absent; internal spur on coxae I very short; external spurs on all coxae small or almost absent. Male: Cornua absent; auriculae absent but suggested by lateral pointed extensions; hypostome faintly notched, broad at base, with faint crenulations; scutal punctations numerous, large and deep, scutal surface faintly rugose; internal spur of coxa I very short

and rounded; external spurs on all coxae as low ridges.

Distribution in Mexico. Guerrero (Guzmán-Cornejo et al., 2007) and Nuevo León (Gordillo-Pérez et al., 2009).

Hosts in Mexico. Procyonidae (Guzmán-Cornejo et al., 2007) and *Bassariscus astutus* (Lichtenstein, 1830) (Procyonidae) (Mammalia) (Gordillo-Pérez et al., 2009).

***Ixodes tovari* Cooley, 1945**

Ixodes tovari Cooley, 1945: 144-148, original description

Diagnosis. Female: Cornua prominent, as long as wide; auriculae as pointed, curved horns; dorsum of basis capituli with lateral margins indented toward porose areas; hypostome pointed, dental formula 3/3, then 2/2 at base; scutum oval, cervical grooves inapparent; internal spur of coxa I long, overlapping anterior margin of coxa II; all coxae with small external spurs, progressively decreasing in size. Male: Cornua prominent, as long as wide; auriculae short and rounded; hypostome elongate and pointed, denticles crenulate and arranged diagonally; coxae as in female, but internal spur on coxa I somewhat longer.

Distribution in Mexico. Guanajuato, Nuevo León.

Hosts in Mexico. Leporidae (Mammalia).

***Ixodes woodi* Bishop, 1911**

Ixodes angustus woodi Bishop, 1911: 205, original description

Diagnosis. Female: Cornua indistinct or absent; auriculae absent; hypostome apically rounded, dental formula 3/3 apically, then 2/2 to base; scutum with prominent lateral carinae; internal spur of coxa I moderately long, overlapping anterior margin of coxa II; external spurs on all coxae, triangular on I and II, bluntly rounded on III, rounded and reduced on IV. Male: Cornua absent; auriculae broad and laterally salient; hypostome notched apically, dental formula 4/4, crenulations small, arranged in nonoverlapping rows; internal spur of coxa I short and sharp; coxae I-IV each with a short, blunt external spur.

Distribution in Mexico. Coahuila, Morelos, and Tamaulipas.

Hosts in Mexico. Cricetidae (Mammalia).

Discussion

This is the first of a projected series of papers on the ixodid tick genera of Mexico. Tick taxonomists rely on key morphological characters, information concerning host specificity, and distributional data whenever they are confronted with unknown specimens. Summarizing such knowledge facilitates prompt and accurate specimen identification, which is of paramount importance to physicians, veterinarians, public health personnel, and

environmental biologists. Our understanding of Mexican *Ixodes* is still in its infancy, with several species known from only 1 or a few specimens. Males and nymphs are unknown for 9 species, and larvae are unknown for 11 species. Additionally, 11 of the species discussed here (*I. angustus*, *I. bequaerti*, *I. cuernavacensis*, *I. dampfi*, *I. loricatus*, *I. mexicanus*, *I. murreleti*, *I. pacificus*, *I. sinaloa*, *I. tamaulipas*, and *I. tovari*) are not even represented in CNAC. These gaps in our knowledge are better comprehended when otherwise diffuse biosystematic data are gathered into single summary reports, such as the one at hand.

Studies of Mexican ticks, and of *Ixodes* species in particular, have been hampered by the tendency of some workers not to cross international borders. Thus, while Cooley and Kohls (1945) and Robbins and Keirans (1992) addressed the Nearctic fauna without regard to national boundaries, Keirans and Clifford (1978) confined their otherwise invaluable synopsis to *Ixodes* found north of the Río Bravo, even though the *Ixodes* fauna of the United States includes half the species known from Mexico. Keys to ticks of particular countries, rather than biogeographic regions, face several limitations, including the omission of endemic species with limited ranges or restricted host preferences.

It is hoped that this and forthcoming compilations will stimulate Mexican acarologists and parasitologists to further contribute to our knowledge of tick taxonomy, ecology, biogeography, and host-parasite coevolution. Such subjects are the indispensable underpinnings of research on ticks as disease vectors or reservoirs, and of investigations of local and regional biodiversity.

Acknowledgments

The senior author thanks the Dirección General de Asuntos del Personal Académico (DGAPA), Universidad Nacional Autónoma de México, for the award of a postdoctoral scholarship under the Programa de Formación e Incorporación de Profesores de Carrera en Facultades y Escuelas para el Fortalecimiento de la Investigación (PROFIP). Tila María Pérez, Curator of CNAC, generously granted access to specimens and literature. Thanks also to Griselda Montiel-Parra for her assistance in preparing the *Ixodes* distribution map.

Literature cited

Aragão, H. de B. and F.O.R. da Fonseca. 1952. Notas de ixodologia. III. Confirmação de *Ixodes aragãoi* Fonseca, 1935, de *Ixodes amarali* Fonseca, 1935, e lista das espécies

- do gênero *Ixodes* que ocorrem no Brasil (Acari, Ixodidae). Memórias do Instituto Oswaldo Cruz 50:727-728.
- Bishopp, F. C. and H. L. Trembley. 1945. Distribution and hosts of certain North American ticks. Journal of Parasitology 31:1-54.
- Cooley, R. A. and G. M. Kohls. 1945. The genus *Ixodes* in North America. National Institute of Health Bulletin 184:1-246.
- Gordillo-Pérez, G., M. Vargas, F. Solórzano-Santos, A. Rivera, O. J. Polaco, L. Alvarado, O. Muñoz and J. Torres. 2009. Demonstration of *Borrelia burgdorferi* sensu stricto infection in ticks from the northeast of Mexico. Clinical Microbiology and Infection 15:496-498.
- Guglielmone, A. A., A. Estrada-Peña, J. E. Keirans and R. G. Robbins. 2003. Ticks (Acari: Ixodida) of the Neotropical zoogeographic region. Special Publication, International Consortium on Ticks and Tick-borne Diseases, Atalanta, Houten, The Netherlands. 173 p.
- Guglielmone, A.A., J. M. Venzal, D. González-Acuña, S. Nava, A. Hinojosa and A. J. Mangold. 2006. The phylogenetic position of *Ixodes stilesi* Neumann, 1911 (Acari: Ixodidae): Morphological and preliminary molecular evidences from 16S rDNA sequences. Systematic Parasitology 65:1-11.
- Guglielmone, A. A., R. G. Robbins, D. A. Apanaskevich, T. N. Petney, A. Estrada-Peña and I. G. Horak. 2009. Comments on controversial tick (Acari: Ixodida) species names and species described or resurrected from 2003 to 2008. Experimental and Applied Acarology 48:311-327.
- Guzmán-Cornejo, C., R. G. Robbins and T. M. Pérez. 2007. The *Ixodes* (Acari: Ixodidae) of Mexico: Parasite-host and host-parasite checklists. Zootaxa 1553:47-58.
- Hoffmann, A. 1962. Monografía de los Ixodoidea de México. I Parte. Revista de la Sociedad Mexicana de Historia Natural 23:191-307.
- Hoffmann, A. 1969. Un caso de parálisis por picadura de garrapata. Revista Latinoamericana de Microbiología y Parasitología 11:75-77.
- Hoffmann, A. and G. López-Campos. 2000. Biodiversidad de los ácaros en México. Fideicomiso Fondo para la Biodiversidad, México D. F. 230 p.
- Keirans, J. E. and E. K. Jones. 1972. Description of the immature stages of *Ixodes (I.) sinaloa* Kohls and Clifford (Acarina: Ixodidae) from rodents in Mexico and Nicaragua. Acarologia 13:471-475.
- Keirans, J. E. and C. M. Clifford. 1978. The genus *Ixodes* in the United States: A scanning electron microscope study and key to the adults. Journal of Medical Entomology, Supplement 2:1-149.
- Musser, G. M. and M. D. Carleton. 2005. Superfamily Muroidea. In Mammal species of the world: a taxonomic and geographic reference, 3rd ed., D. E. Wilson and D. M. Reeder (eds.). The Johns Hopkins University Press, Baltimore. p. 894-1531.
- Nuttall, G. H. F. 1916. Notes on ticks. IV. Relating to the genus *Ixodes* and including a description of three new species and two new varieties. Parasitology 8:294-337.
- Nuttall, G. H. F. and C. Warburton. 1911. A monograph of the Ixodoidea. Part II. Ixodidae. Cambridge at the University Press, London. p. i-xix, 105-348.
- Robbins, R. G. and J. E. Keirans. 1992. Systematics and ecology of the subgenus *Ixodiopsis* (Acari: Ixodidae: *Ixodes*). Thomas Say Foundation Monographs. Vol. XIV. Entomological Society of America, Lanham, Maryland. viii + 159 p.
- Romero-Castañón, S., B. G. Ferguson, D. Güiris, D. González, S. López, A. Paredes and M. Weber. 2008. Comparative parasitology of wild and domestic ungulates in the Selva Lacandona, Chiapas, Mexico. Comparative Parasitology 75:115-126.
- Sonenshine, D. E. 1991. Biology of Ticks. Volume I. Oxford University Press, New York, xix + 447 p.
- Woodham, C. B., A. González-Origel, A. López-León and R. Guereña-Morales. 1983. Progress in the eradication of *Boophilus* ticks in Mexico 1960-80. World Animal Review 48:18-24.