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Redescription of the male and description of the female of *Ixodes abrocomae* Lahille, 1916 (Acari: Ixodidae)

Alberto A. Guglielmone · Santiago Nava · Enrique A. Bazán-León · Rodrigo A. Vásquez · Atilio J. Mangold

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Abstract The male of *Ixodes abrocomae* Lahille, 1916 (Acari: Ixodidae) is redescribed and the female described for the first time from specimens collected on the rodents *Abrothrix longipilis* (Waterhouse), *A. olivaceous* (Waterhouse) and *Phyllotis xanthopygus* (Waterhouse) at Coquimbo, Chile. The males of *I. abrocomae* are peculiar in having the combination of the following features: length and width less than 2 mm and 1 mm, respectively; hypostome notched with two rows of stout denticles and several small internal denticles; article II of the palpi with two conspicuous dorsal setae; coxa I with two subequal spurs; coxae II–IV with a single spur plus an indication of a second spur; and a scutum with long, scattered hairs except for the glabrous postero-median field which reaches to the marginal fold. The females of *I. abrocomae* are peculiar in possessing a combination of: a pointed hypostome, with a 3/3 dentition of flared denticles; a long, narrow scutum with few 'hairs' and with punctations which are especially numerous in the posterior region; a triangular basis capituli, with oval porose areas lacking definitive borders and separated by the width of one area, and a sinuous posterior margin with small cornuae; one spur on coxae I–IV; and conspicuous setae on the interno-dorsal face of palpal article II and the ventral face of article I. Sequences of 16S rDNA were identical for male and female *I. abrocomae*, but differ by 3.8% and 5.5% from sequences of their closest relatives, *I. stilesi* Neumann, 1911 and *I. sigelos* Keirans, Clifford & Corwin, 1976, respectively. Characters enabling the separation of *I. abrocomae* from *Ixodes* spp. distributed in the southwestern Neotropics are presented. Records of *I. abrocomae* in different climatic areas and on different, widely distributed rodent hosts indicate that this species may be present beyond its known Chilean territorial range (Regions III and IV).

A. A. Guglielmone (✉) · S. Nava · A. J. Mangold
Instituto Nacional de Tecnología Agropecuaria-Consejo Nacional de Investigaciones Científicas y Técnicas, Estación Experimental Agropecuaria Rafaela, CC 22, CP 2300 Rafaela, Santa Fe, Argentina
e-mail: aguglielmone@rafaela.inta.gov.ar

E. A. Bazán-León · R. A. Vásquez
Instituto de Ecología y Biodiversidad, Departamento de Ciencias Ecológicas, Facultad de Ciencias, Universidad de Chile, Las Palmeras 3425, Ñuñoa, Santiago, Chile

Introduction

Ixodes abrocomae Lahille, 1916 has been known only from a brief, but informative, description lacking figures, of the holotype male collected from the rodent *Abrocoma murrayi* Wolffsohn (= *A. bennetti* Waterhouse) at Vallenar (28°34′S; 70°45′W), Chile by Lahille (1916). *I. sigelos* Keirans, Clifford & Corwin, 1976 was described from larvae, nymphs and females collected on *A. bennetti*, *Aconaemys fuscus* (Waterhouse), *Octodon degus* (Molina) and *Phyllotis*

spp. Waterhouse at Santiago, Maule and Malleco Provinces, Chile by Keirans et al. (1976). The latter species was occasionally reported subsequently based on specimens collected from rodents by Osorio (2001), González-Acuña et al. (2004) and Guglielmone et al. (2005) in Chile and Argentina.

In an addendum, Morel & Pérez (1977) stated that *I. abrocomae* is, perhaps, the male of *I. sigelos* but without any further elaboration. Later, Camicas et al. (1998) considered *I. sigelos* a probable synonym of *I. abrocomae*, but no explanation was given for this statement. Horak et al. (2002) considered both names valid, whereas Guglielmone et al. (2009) regarded the synonymy of *I. sigelos* with *I. abrocomae* as unjustified because of a lack of evidence to support their conspecificity.

One of us (EABL) conducted a survey of ticks from rodents in northern Chile, where males of *I. abrocomae* were found for the second time 92 years after its description, and females of this species were recorded for the first time. These adult stages of *I. abrocomae* are redescribed and described below, respectively. Both morphology and molecular evidence in the form of 16S rDNA sequences determined in the present study support the fact that *I. abrocomae* is a valid species different from *I. sigelos*.

Materials and methods

Live-trapping of rodents for tick collection was carried out with official permission of the Chilean authorities in the Servicio Agrícola y Ganadero and the Corporación Nacional Forestal of Region IV (Coquimbo) in northern Chile. The complete results of this study will be published in another article. Here we focus on two localities where rodent hosts harboured males or males and females of ticks of the genus *Ixodes* Latreille, 1795.

Tick specimens were preserved in 70% ethanol and deposited in the tick collection of the Instituto Nacional de Tecnología Agropecuaria, Estación Experimental Agropecuaria Rafaela, Santa Fe, Argentina (INTA), with the exception of the neotype that is deposited in the United States National Tick Collection (USNTC), currently at the Institute of Arthropodology and Parasitology, Georgia Southern University, Statesboro, Georgia, USA. Ticks were first classified using stereo-microscopy. Selected specimens were prepared for scanning electron microscopy (SEM) following Corwin et al. (1979) and two specimens (one male and one female), preserved in ethanol and stored at −20°C, were used for DNA extraction and polymerase chain reaction amplification, as described in detail in Guglielmone et al. (2004, 2006). Mitochondrial 16S rDNA sequences of *I. sigelos* available in GenBank (AF549858) were used for pairwise comparisons.

Ixodes abrocomae Lahille, 1916

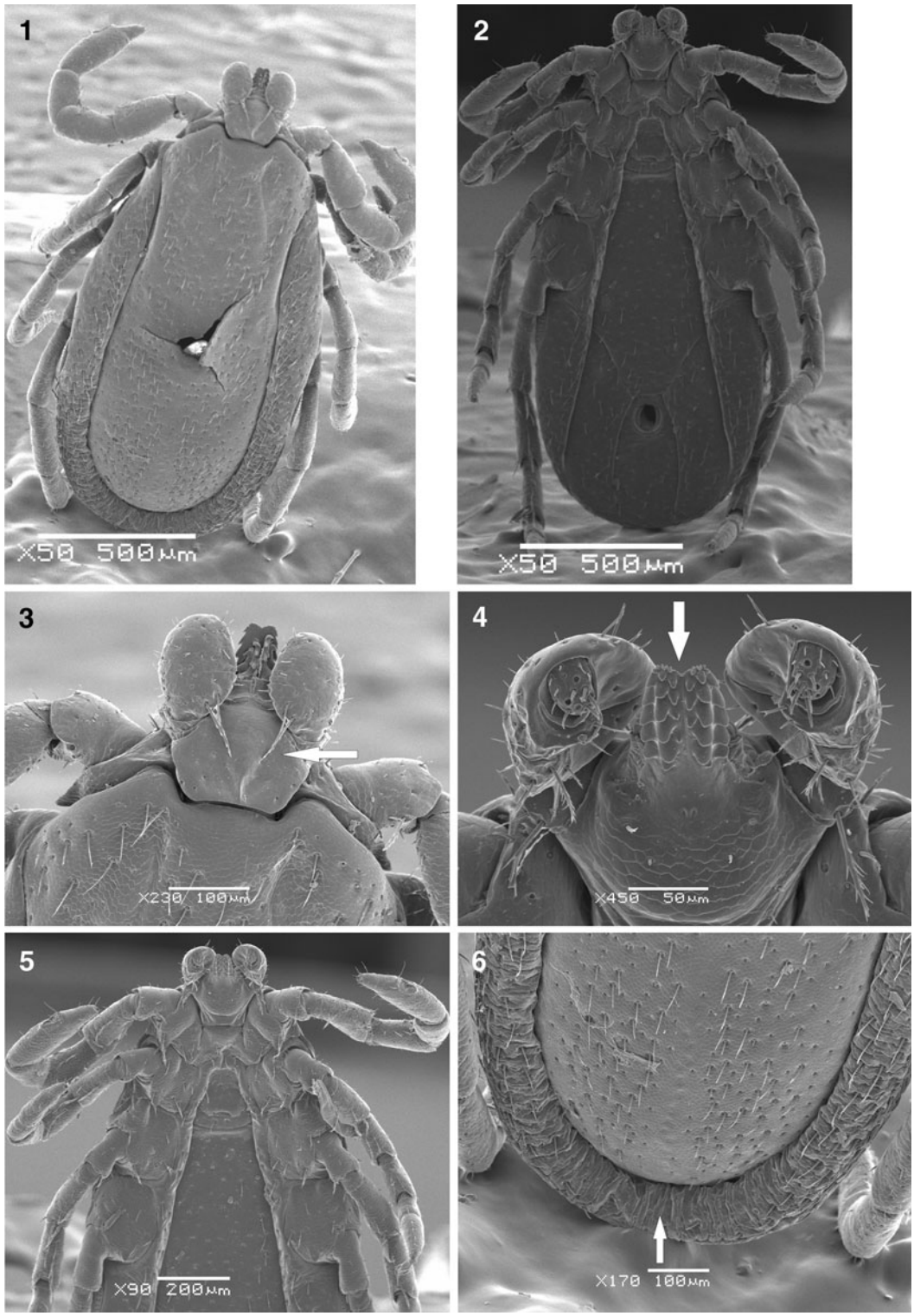
Material studied

Three males and two females of *Ixodes abrocomae* collected by one of us (EABL) as follows: one male, neotype, USNTC RML124421, ex *Abrothrix longipilis*, Parque Nacional Fray Jorge (30°40′S, 71°39′W), altitude 187 m, February 8, 2009; two males INTA2119 (one used to obtain 16S rDNA sequences, one used to obtain SEM images), ex *Abrothrix olivaceous*, Río Los Molles (30°45′S 70°25′W), altitude 2,518 m, December 3, 2008; two females, INTA2120 (one used to obtain 16S rDNA sequences and SEM images), ex *Phyllotis xanthopygus*, Río Los Molles, December 3, 2008.

Additionally, 2 females of *Ixodes* were found on *P. xanthopygus* at Río Los Molles; their morphology generally agrees with the description of *I. sigelos* given by Keirans et al. (1976), although the spurs on coxae I–IV are not identical to the spurs presented in that description. We provisionally consider these specimens to belong to *I. sigelos*. These specimens are in possession of one of the authors (EABL).

Redescription of the male (Figs. 1–6)

[Measurements (mm) for 3 specimens, which are dry, not well preserved and curved probably due to dehydration; first measurements correspond to neotype.] *Body* (Figs. 1–2) length from apex of hypostome to posterior body margin 1.58, 1.60, 1.85; outline oval; width greatest near mid-length, 0.73, 0.85, 0.83. *Capitulum* (Figs. 3–4) length from palpal apices to posterior margin of basis capituli 0.16, 0.18, 0.18. *Basis capituli* (Figs. 5–6) 0.16, 0.20, 0.20, broad dorsally at level of palpal insertion, pentagonal in shape, widest at mid-level; posterior margin very slightly concave with inconspicous cornua; surface



Figs. 1–6 *Ixodes abrocomae*, male. 1. Dorsal view. 2. Ventral view. 3. Basis capituli, dorsal view; the arrow indicates the distinct setae on palpi article II. 4. Basis capituli, ventral view; the arrow indicates the notched hypostome and denticles. 5. Coxae. 6. Posterior area of the scutum and marginal fold; the arrow indicates the glabrous median area. *Scale-bars*: 1, 500 µm; 2, 500 µm; 3,6, 100 µm; 4, 50 µm; 5. 200 µm

with few postero-lateral punctations; ventrally 2 pairs of very short hypostomal setae (1 broken in Fig. 4); posterior margin straight; auriculae in form of triangular lateral extensions at mid-level. *Palpi* clavate, short; articles II and III subequal in length with indistinct suture between them; combined lengths 0.12, 0.13, 0.13, breadth 0.07, 0.08, 0.08; article II has small dorsal depression near base and 2 long conspicuous postero-internal setae. *Hypostome* short, stout and notched; dentition with 2 rows of 5 stout denticles each, and additional internal row with 3 small denticles. *Scutum* (Fig. 1) elongate-oval in outline, length 1.16, 147, 1.46, width 0,50, 0,53, 0.58; cervical grooves very shallow, slightly convergent; numerous punctations and whitish setae scattered all over scutum but absent on postero-central field; lateral body fold stout (0.06, 0.08, 0.10 broad) (Figs. 1, 6) with numerous punctations containing conspicuous whitish setae covering 3/4 of its length, thereafter disappearing towards posterior end, wrinkled posterior to level of spiracles; ventral plates as figured, with scattered setae, but with very few on anal plate. *Genital aperture* situated between coxae II and III. *Spiracular plate* similar to corresponding plate of female, almost circular in outline, with 2–3 files of goblets; macula in anterior half of spiracular plate (no figure). *Coxae*: coxa I (Fig. 5) with 2 sub-equal, well separated spurs reaching following coxa; coxae II and III each with short triangular external spur; coxa IV with short triangular central spur; coxae II–IV have indication of internal spur. Trochanters lack spurs.

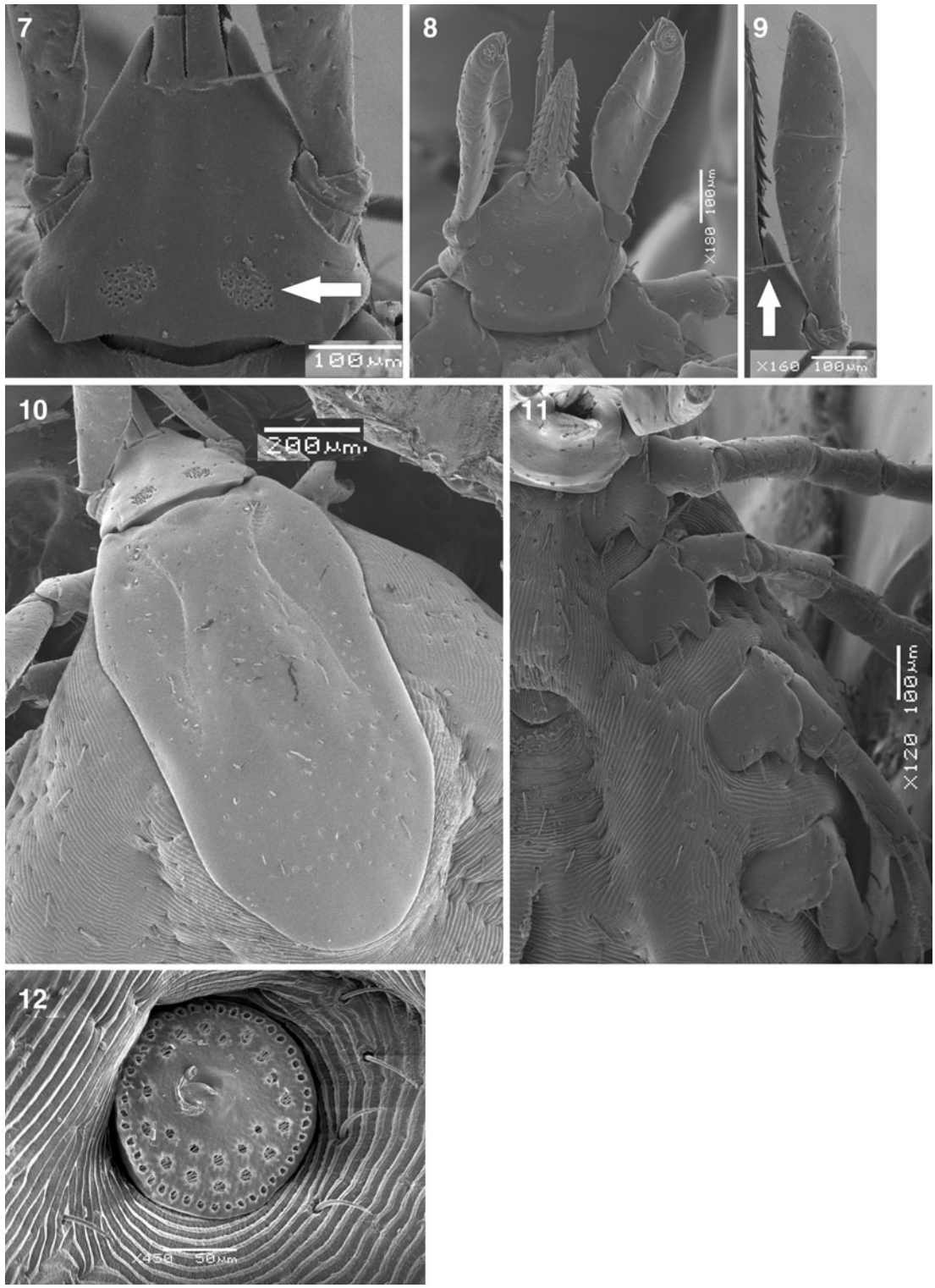
Note. The description above coincides with the original description of Lahille (1916), with the following exceptions: (1) the small internal denticles in the hypostome are not mentioned in Lahille's description; and (2) according to Lahille, the spurs on coxa I do not reach coxa II; a difference that may be due to distortion in poorly preserved material.

Description of the female (Figs. 7–12)

[Measurements are for 2 ticks, 1 slightly engorged and other engorged but with broken hypostome, dried and curved because of rather poor preservation. First measurements are for slightly engorged specimen.] *Body* length from apices of hypostome to posterior margin 2.55, 6.65, breadth 1.50, 3.45; outline oval, widest at level posterior to spiracular plates (not shown). *Capitulum* (Figs. 7–8) length from palpal apices to apices of cornua 0.61, 0.61. *Basis capituli* broadly triangular dorsally, widest (0.32, 0.30) at level of porose areas, with sinuous posterior margin and small triangular cornua (note that in Fig. 7 right cornua is broken); porose areas oval, not depressed into basis, separated by about width of single porose area, widest diameter 0.06, 0.06.; postero-ventral margin of basis capituli straight, with triangular auriculae and faint transverse suture close to posterior margin. *Palpi* (Figs. 8–9) fusiform, length 0.5, 0.6, width 0.12, 0.12; article II, 0.28, 0.30 long, 1/3 longer than article III (0.20); articulation between these 2 segments discrete; article IV recessed within ventro-lateral surface of article III; article II with two long interno-dorsal setae; article I with 1–2 long fringed setae. *Hypostome* (Fig. 8) pointed apically with noticeable flared denticles; length of toothed portion 0.33; second specimen with broken hypostome; dental formula 3/3, with *c*.12 denticles in files 1 and 2 plus *c*.9 in file 3 (data from single specimen). *Scutum* (Fig. 10) long and narrow, with sinuous outline, length 1.14, 1.16, width 0.57, 0.66. *Lateral carinae* absent; *scapulae* small, pointed; *cervical grooves* shallow, converging then diverging for anterior 1/3 of scutum; punctations on scutum evident, with no uniform pattern but especially numerous in posterior areas, with few long, scattered setae. *Spiracular plate* (Fig. 11) circular in outline; goblets as illustrated; macula in anterior half of plate, diameter 0.14, 0.15. *Coxae* (Fig. 12): coxa I with single stout, triangular external spur just reaching coxa II in slightly engorged specimen; coxae II and III each with single triangular external spur; coxa IV with single small central triangular spur. Trochanters lacking spurs. *Alloscutum* (partly shown in Figs. 10 and 12) presents abundant, short, whitish dorsal and ventral setae. *Genital aperture* situated between coxae II and III, but its relative position may change in specimens with different degrees of engorgement (Guglielmone et al., 2007). *Anal groove* impossible to determine due to engorgements folds in 1 specimen and damage to area as a result of DNA extraction in other specimen.

16S rDNA sequences

The DNA sequence of 438 bp of 16S rDNA were identical for the male and female *I. abrocomae*



Figs. 7–12 *Ixodes abrocomae,* female. 7. Basis capituli, dorsal view; the arrow indicates an oval porose area with no definitive borders. 8. Basis capituli, ventral view. 9. Palpi, dorsal view; the arrow indicates the interno-dorsal setae on article II of the palpi. 10. Scutum. 11. Coxae. 12. Spiracular plate. *Scale-bars*: 7–9, 12, 100 µm; 10, 200 µm; 11, 50 µm

(GenBank accession numbers: GU188043 for male sequence, GU188044 for female sequence), supporting their conspecificity. See below for differences in the DNA sequences compared with related species.

Discussion

Hosts

All records of *Ixodes abrocomae* are from Rodentia. The original description was based on a male tick collected from *Abrocoma bennetti* (Abrocomidae), whereas the present material is from *Abrothrix longipilis*, *A. olivaceous* and *Phyllotis xanthopygus* (all Cricetidae). *Abrocoma bennetti* is an exclusively Chilean rodent found in the central-northern area of the country which prefers rocky brushy areas from sea-level up to 2,000 m in altitude (Redford & Eisenberg, 1992; Wilson & Reeder, 2005). *Abrothrix longipilis* has a distribution that includes central to southern Chile and the west-central and south-central regions of Argentina. This rodent is found in many types of vegetation, but has a preference for moister areas (Redford & Eisenberg, 1992, as *Akodon longipilis*; Wilson & Reeder, 2005). *Abrothrix olivaceous*, which was considered to belong to the genus *Chroenomys* by Nowak (1999), is distributed from northern to southern Chile and adjacent areas of central and southern Argentina. It is found in grassy and brushy areas throughout its wide range (Redford & Eisenberg, 1992, as *Akodon olivaceus*; Wilson & Reeder, 2005). *Phyllotis xanthopygus* has a wide distribution form southern Peru to southern Argentina and Chile, where it lives in a wide variety of habitats from sea-level up to 5,000 m in altitude (Iriarte, 2008).

Distribution

Ixodes abrocomae appears to have a relatively narrow distribution area in the Chilean Regions III (Atacama) and IV (Coquimbo). However, this tick has been found in fairly contrasting climatic areas, such as to the south of the Atacama Desert (Vallenar), a rocky semiarid valley at 2,500 m above sea-level (Río Los Molles) and in the rather humid Valdivian relict forest in the Parque Nacional Fray Jorge. The records of *I. abrocomae* in different climatic areas and on rodent hosts with a wide distribution indicate that this tick may be present beyond the narrow territorial range shown in this study.

The designation of a neotype

The repository of the type-specimen of *I. abrocomae* is assumed to be the Lahille collection, but we were unable to locate that collection and thus consider the type-material lost. Therefore, we designate as the neotype a male of *I. abrocomae* (ex *Abrothrix longipilis* (Waterhouse), Chile, Region IV, Parque Nacional Fray Jorge, 30°40′S, 71°39′S, altitude 187 m, February 8, 2009, collector Enrique A. Bazán-León), which is deposited in the USNTC under accession number RML 124421.

Species relationships

Ixodes abrocomae, *I. chilensis* Kohls, 1956, *I. neuquenesis* Ringuelet, 1947, *I. sigelos*, *I. stilesi* Neumann, 1911 and *I. taglei* Kohls, 1969 are only found in the southwestern part of the Neotropical Region, i.e. in Argentina and Chile. *I. nuttalli* Lahille, 1913 from Argentina and Peru along with *I. longiscutatus* Boero, 1944 from Argentina and Uruguay are also species endemic to the southwestern Neotropics.

Of these species, males are known only for *I. abrocomae* (see above for hosts), *I. nuttalli* (main hosts, Rodentia: Chinchillidae), *I. stilesi* and *I. taglei* (main hosts for both species, Artiodactyla: Cervidae). These four species are characterised by a stout and notched (not very evident in *I. taglei*) hypostome, but the male of *I. abrocomae* is easily distinguished from the other species by its smaller dimensions (length 1.85 mm in *I. abrocomae* versus 2.7 mm for *I. stilesi* and *I. taglei* and 3.9 mm for *I. nuttalli*). Furthermore, the male of *I. nuttalli* exhibits a scutum with a division at the end of the anterior third that gives it a superficial appearance of the dorsum of a female tick (this feature is commonly described as a pseudoscutum, although it is in fact a part of the scutum that almost entirely covers the dorsum of the male); this feature is also evident in *I. taglei* and less so in *I. stilesi*, but not in *I. abrocomae*. *I. stilesi* has a wrinkled and glabrous area in the posterior region of the marginal fold and two distinct spurs on coxae II and III, whereas the male of *I. abrocomae* has a

wrinkled posterior region of the marginal fold with distinct 'hairs' (with the exception in the middle of this fold, which appears as a continuation of the glabrous postero-median area of the scutum); its coxae II and III bear one distinct external spur and an indication of an internal spur. *I. taglei* has the anterior third of the scutum (pseudoscutum of some authors) glabrous and is scattered with long 'hairs' on the rest of the scutum, coxa IV with an external spur, and article II of the palpi without distinct dorsal setae, whereas *I. abrocomae* has long 'hairs' scattered all over the scutum with the exception of the postero-median field, coxa IV with a central spur and an indication of an internal spur, and two long conspicuous dorsal postero-internal setae on article II of the palpi. In brief, the male of *I. abrocomae* is characterised by the combination of the following features: total length <2 mm and width <1 mm; hypostome notched, short, with two rows of stout denticles and several small internal denticles; article II of the palpi with two conspicuous dorsal setae; coxa I with 2 spurs, coxae II and III with a small external spur and coxa IV with a small central spur, and indications of internal spurs on coxae II–IV; and scutum with long 'hairs' scattered over its surface, with the exception of the postero-median field – this glabrous area continues to the central part of the wrinkled marginal fold.

The female of *I. abrocomae* is similar to that of *I. sigelos*. However, the basis capituli has conspicous cornua in *I. sigelos*, but they are very small in *I. abrocomae*, and the porose areas that are almost circular in *I. sigelos* are broadly oval in *I. abrocomae*. The scutum has distinct cervical grooves and numerous long, evenly distributed setae in *I. sigelos*, whereas *I. abrocomae* has shallow cervical grooves and short, scarce setae and on the scutum. Coxa I has a large external and a short internal spur in *I. sigelos*, but the internal spur is lacking in *I. abrocomae*.

The female of *I. neuquenensis* (main hosts, Microbiotheria: Microbiotheriidae) can be readily distinguished from *I. abrocomae* because it has two distinct spurs on coxae II–IV, a quadrangular basis capituli, a scutum which is slightly longer than broad, plus several other features as shown in Guglielmone et al. (2004). The female of *I. stilesi* has a scutum that is longer than broad but the length/width ratio is less than in *I. abrocomae*; it also has two spurs on coxa I and rounded porose areas with definitive borders, as shown by Guglielmone et al. (2006, 2007), that further separate it from *I. abrocomae*. *I. taglei* has an apically rounded hypostome with a 2/2 dentition formula (with the exception of the first three files), coxa I with two spurs, and quadrangular porose areas and basis capituli (Kohls, 1969). The female of *I. chilensis* (host unknown) has unarmed coxae and no morphological features than can induce confusion with *I. abrocomae* (see Kohls, 1956). Finally, *I. nuttalli* has triangular porose areas and obvious carinae on the scutum, which is longer than broad but not as long as in *I. abrocomae* (see Nuttall, 1916). None of these species of *Ixodes* have flared denticles on the hypostome. The female of *I. longiscutatus* (main hosts, Rodentia: Caviidae and Cricetidae; few specimens on Artiodactyla: Bovidae and Perissodactyla: Equidae) has a long and narrow scutum and triangular basis capituli, but, according to Boero (1957), it differs from *I. abrocomae* by having well-developed carinae on the scutum, two spurs on coxa I, 2/2 dentition and a straight posterior margin of the basis capituli. However, this species was described on the basis of a female with a broken hypostome, and in fact has a hypostome with flared denticles and a 3/3 dentition formula, the internal file consisting of smaller denticles that were probably not observed by Boero (1957) (Venzal,J.M., personal communication), whereas the denticles are of similar size in all three rows in *I. abrocomae*. In summary, the female of *I. abrocomae* is characterised by the following combination of characters: a pointed hypostome with a 3/3 dentition and flared denticles; a long but narrow scutum with a few scattered 'hairs' and punctations which are especially numerous in posterior regions; a triangular basis capituli bearing oval porose areas with poorly defined borders which are separated by about the width of one porose area; a sinuous posterior margin with small cornua; just one spur on coxae I–IV; and distinct interno-dorsal setae on palpi article II and on ventrally on article I.

The 16S rDNA sequences showed a difference of 5.5% in relation to the sequence of *I. sigelos*, but even less when compared with the sequence of *I. stilesi* (GenBank DQ061292), its morphologically closest relative. This difference increased to 9.0% when compared with sequences of *I. abrocomae* and *I. neuquenensis* (AY254393), and to 14.9 % when compared with the sequence (DQ061294) of *I. longiscutatus*. No comparative 16S rDNA sequences are

available for *I. chilensis*, *I. taglei* and *I. nuttalli*. *I. sigelos*, *I. neuquenensis* and *I. stilesi* form a phylogenetic clade (Guglielmone et al., 2006) which is morphologically more closely related to *I. abrocomae* than to *I. longiscutatus*, the only member of the subgenus *Haemixodes* Kohls & Clifford, 1967. These incremental differences between *I. abrocomae* and *I. stilesi*, *I. sigelos* and *I. neuquenensis* and *I. longiscutatus* are in line with the morphological divergence between these species.

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