Veterinary Parasitology 208 (2015) 2–8

Contents lists available at ScienceDirect

Veterinary Parasitology

journal homepage: www.elsevier.com/locate/vetpar

The taxonomic status of *Rhipicephalus sanguineus* (Latreille, 1806)

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ARTICLE INFO

Keywords:
Rhipicephalus sanguineus
Type specimens
Description
Taxonomic status
Neotype

ABSTRACT

The brown dog tick, *Rhipicephalus sanguineus* sensu stricto, is a species with considerable public health and economic importance. However, the taxonomic status of this species is far from resolved. After more than 110 years of scientific work on *R. sanguineus* s.s., the situation is that there is no type, no solid description, nor is there a consensus about the range of morphological variability within the species. Recent findings based on laboratory crosses and molecular genetics strongly suggest that there are several entities grouped under the same name. Here we review the history of the taxon, and we point out the caveats behind any further work on this tick. The current taxonomic status of *R. sanguineus* s.s. thus lacks an informative original description, and is based on the existence of several morphological descriptions based on ticks originating from different populations, which show, in some cases, biological incompatibility and significant genetic divergence. We suggests that as a result it is not possible to assign the specific name *R. sanguineus* s.s. to any population. Further work is required based on the rules issued by the International Code of Zoological Nomenclature to clearly define the morphological range of the different populations.

1. Introduction

The *Rhipicephalus sanguineus* complex (Acari: Ixodidae) includes 12 tick species, namely, *R. sanguineus* (Latreille, 1806), *Rhipicephalus sulcatus* Neumann, 1908, *Rhipicephalus rossicus* Yakimov and Kohl-Yakimov, 1911, *Rhipicephalus schulzei* Olenev, 1929, *Rhipicephalus pumilio*

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http://dx.doi.org/10.1016/j.vetpar.2014.12.021
0304-4017/

Schulze, 1935, *Rhipicephalus pusillus* Gil Collado, 1936, *Rhipicephalus turanicus* Pomerantzev, 1940, *Rhipicephalus leporis* Pomerantzev, 1946, *Rhipicephalus guilhoni* Morel and Vassiliades, 1963, *Rhipicephalus moucheti* Morel, 1965, *Rhipicephalus bergeoni* Morel and Balis, 1976 and *Rhipicephalus camicasi* Morel, Mouchet and Rodhain, 1976 (Pegram et al., 1987a)[1]. In terms of geographical distribution, public health relevance and economic impact, *R. sanguineus* (Latreille, 1806) (from now on, *R. sanguineus* sensu stricto) is the most important species of this group, however, the taxonomic status of this species is not clearly resolved. The original description of *R. sanguineus* s.s. was poor, not illustrated, and the type specimen has been lost. Thereafter, this name has been applied to *Rhipicephalus* populations worldwide. Recent studies focusing on morphological, genetic and biological differences among the different populations of what has been defined as *R. sanguineus* s.s have demonstrated that, in some areas what may be more than one species is included under this name (Oliveira et al., 2005; Szabó et al., 2005; Burlini et al., 2010; Moraes-Filho et al., 2011; Levin et al., 2012; Nava et al., 2012; Dantas-Torres et al., 2013; Liu et al., 2013), whereas in others ticks designated as *R. sanguineus* or *R. turanicus* are genetically indistinguishable (Zahler et al., 1997, Beati and Keirans, 2001). Besides the biological meaning of this taxon, there are additional problems related to formal nomenclatural aspects of the usage of the name "*R. sanguineus* (Latreille, 1806)". In light of this situation, the aim of this work is to present and discuss the taxonomic problems related to the name *R. sanguineus* s.s. and to propose potential solutions to this issue.

2. Historical review and taxonomic problems

R. sanguineus s.s was originally described by Latreille (1806) as Ixodes sanguineus using a brief and vague description: "Sanguineus, punctatus, postice lineolis tribus impressis, dorso antico macula nulla thoracica, distincta. Habitat in Gallia; I. Ricino paulo minor: vide Acarum lipsiensem celeberrimi Frabicii" ("Blood-colored, punctate, with three linear depressions posteriorly, with no distinct spot on the anterior part of the dorsal surface. Lives in France; slightly smaller than I. ricinus: see Acarus lipsiensis [described] by the famous Fabricius")[2]. The current taxonomic position of this species within the suborder Ixodida was determined by Koch (1844a) who transferred it to the genus Rhipicephalus. Although Koch (1847) presented a brief description of *R. sanguineus* s.s. from Portugal, the first comprehensive description of this species was given by Neumann (1897). The male, female and nymph of *R. sanguineus* s.s were described by Neumann (1897) based on the types of Rhipicephalus limbatus Koch, 1844 (male, type locality in Egypt), Rhipicephalus siculus Koch, 1844 (male and female, type locality in Italy), Rhipicephalus stigmaticus Gerstäcker, 1873 (male, type locality in Kenya) and Phauloixodes rufus (Koch, 1844) (nymph)[3], all of them considered by Neumann to be synonyms of *R. sanguineus* s.s. There is also an informative description of *R. sanguineus* s.s. (male and female) by Canestrini (1890). Although this author does not indicate clearly the origin of the ticks he used for the description, he mentions having seen many specimens of this species from southern Italy. Afterwards, several morphological descriptions of *R. sanguineus* s.s. were published during the 20th century, and these represented landmarks for the taxonomic determination of this taxon. Neumann (1911) differentiates three subspecies (*R. sanguineus* sanguineus (Latreille, 1806), *R. sanguineus* punctatissimus Gerstäcker, 1873 and *R. sanguineus* brevicollis Neumann, 1897) based on scutal punctuations, the marginal and cervical grooves, the length of the scutum and position of the eyes. Neumann (1911) indicated that R. s. sanguineus was found in Africa (Algeria, Tunisia, Egypt, Ethiopia, Somalia, Tanzania, Madagascar, Angola, "Congo" (sic), Senegal, South Africa, Togo), southern Europe (France, Italy, Greece, Romania, Turkey), America (Brazil, Panama, French Guiana, Dominican Republic) and Asia (India, "Oriental China" (sic), Iran), while R. s. punctatissimus and R. s. brevicollis were described only from specimens from Africa. Currently, R. s. punctatissimus is considered a synonym of *R. sulcatus* in Camicas et al. (1998) and a synonym of *R. sanguineus* s.s. in Walker et al. (2000), and R. s. brevicollis is regarded as synonym of *R. sanguineus* s.s. in Camicas et al. (1998) and Walker et al. (2000). After carrying out a comparative morphological analysis with ticks from the Ukraine, Russia, Armenia, Azerbaijan, Uzbekistan, Tajikistan and Kazakhstan, Zumpt (1939) diagnosed a group of subspecies formed by R. s. sanguineus and *R. sanguineus* rossicus Yakimov and Kohl-Yakimov, 1911[4], based principally on differences in size, shape and scutal punctations, adanal plates, spiracles and palpal article II. In subsequent works, this author added *R. sanguineus* schulzei Olenev, 1929 to this group (Zumpt, 1940, 1950) and presented a detailed morphological characterization of male and female specimens which he considered to be *R. sanguineus* s.s. (Zumpt, 1946). The scheme proposed by Zumpt (1939, 1940, 1950) was substantially modified by Russian workers (Pomerantzev et al., 1940; Pomerantzev, 1946, 1950; Filippova and Panova, 1983; Filippova, 1997), who stated that *R. rossicus* and *R. schulzei* are valid species and not subspecies of *R. sanguineus* s.s. They also included another three species which are morphologically closely related to this group: *R. turanicus*, *R. pumilio* and *R. leporis*. According to Pomerantzev (1950), the principal morphological characters which are useful for achieving accurate species

[1] The authorities and years of publication of *R. turanicus*, *R. rossicus* and *R. moucheti* were modified from those published in Pegram et al. (1987a) and Walker et al. (2000) following Guglielmone and Nava (2014).

[2] It is likely that when Latreille saw Fabricius' *Acarus lipsiensis*, he already knew that *A. lipsiensis* was a synonym of *Ixodes ricinus*. The type specimen of *A. lipsiensis* is also lost (N. Scharff, personal communication).

[3] *Phauloixodes rufus* (Koch, 1844), renamed *Ixodes rufus* by Koch in 1847, is a synonym of *Ixodes ricinus* (Linnaeus, 1758) as stated by Neumann (1901, 1911). However, the name *Phauloixodes rufus* was used by Berlese (1889) for ticks that Neumann in 1897 considered to be *R. sanguineus*. The specimen described by Koch (1844b) is undoubtedly an *Ixodes* (see fig. 39-7), but the *P. rufus* nymph used by Neumann (1897) to describe the nymph of *R. sanguineus* s.s. corresponds to the specimen of Berlese (1889).

[4] The authority and year of publication *R. sanguineus rossicus* were modified from those published in Zumpt (1940, 1950) following Guglielmone and Nava (2014).

discrimination among these six species are the shape and size of the adanal plates and spiracles, the 3rd palp segment (for males), the shape and size of the scutum, marginal and cervical grooves, and the external angles of the basis capituli (for females). Filippova and Panova (1983) and Filippova (1997) presented a very comprehensive description of the immature and adult stages of those specimens that the Russian workers considered to be *R. sanguineus* s.s. in the extreme east of Europe and the Caucasian region.

An additional taxon was added by Feldman-Muhsan (1952) to the *R. sanguineus* species group. This author described a new species closely related to *R. sanguineus* s.s., which was named *Rhipicephalus secundus* Feldman-Muhsan, 1952. According to Feldman-Muhsan (1952), the principal difference between adults of *R. sanguineus* s.s. and *R. secundus* corresponds to the shape of the genital aperture of the female, while larvae and nymphs can be distinguished by the form of the capitulum. The only information about the origin of the type specimens given by Feldman-Muhsan (1952) is "...description of larvae, nymphs and imagines of the two species is based on laboratory-bred ticks...". Feldman-Muhsan (1952) considered that the ticks previously determined as *R. sanguineus* s.s in Europe and the Middle East in fact corresponded to *R. sanguineus* s.s. and *R. secundus*, but Pegram and Walker (1988) considered *R. secundus* as a synonym of *R. turanicus* and stated that "...when she (Feldman-Muhsam) described *Rhipicephalus secundus* as a new species in 1952 (=*R. turanicus*), she apparently overlooked the numerous species and synonyms in this group.". In addition, Hoogstraal (1956) stated that "...Mr. Kaiser and I have been unable to distinguish *R. secundus* after weeks of study of a very considerable number of kennel ticks from tropical Africa, North Africa, Arabia, and the near East.". Currently, *R. secundus* is regarded as a synonym of *R. turanicus* in Camicas et al. (1998) and Walker et al. (2000).

In Africa, ticks from the Sudan were used by Hoogstraal (1956) to perform a morphological analysis (and diagnosis) of *R. sanguineus* s.s. male and female. Hoogstraal's work (1956) showed noteworthy intraspecific variability in important morphological characters, such as overall size, the shape of the spiracular plate, the density and size of punctuations, the grooves of the scutum and the adanal plates of males. Morel and Vassiliades (1963) used specimens from Senegal (Dakar) to describe all of the stages of *R. sanguineus* s.s., but in the first line after the description, they indicated that their descriptions also took into consideration those of Pomerantzev (1950) and Feldman-Muhsan (1952). Hence, it is difficult to know whether the description of Morel and Vassiliades (1963) only includes the characters of ticks from Dakar or whether it is a synthesis of the Dakar ticks with those presented by Pomerantzev (1950) and Feldman-Muhsan (1952). In any case, Morel and Vassiliades (1963) decided to follow the opinion of Pomerantzev et al. (1940) in associating *R. sanguineus* s. s. with dogs in the Mediterranean area and the rest of the world, while other closely related species, and in particular *R. turanicus*, were associated with wild and domestic ungulates. More recently, ticks from a colony that originated from an engorged female collected on a dog in central Zambia were used by Pegram et al. (1987b) to describe the larvae, nymphs and adults of *R. sanguineus* s.s. They also examined ticks from Mauritania, Senegal, Mali, Congo, Egypt, Sudan, Ethiopia, Somalia, Uganda, Kenya, Tanzania, Angola, Zambia, Malawi, Namibia and South Africa, as well as tick collections from America, Europe, Asia and America (no countries are specified), concluding that the morphotype that they defined as *R. sanguineus* s.s. is present in these African countries and also on the other four continents. In their morphological study of *R. sanguineus* s.s., Pegram et al. (1987b) noted variations in the punctuation patterns of both sexes, and in the shape of the adanal plates of males and the genital aperture of females. In a very extensive work on the genus *Rhipicephalus*, Walker et al. (2000) presented a description of all stages of *R. sanguineus* s.s. with figures illustrating the morphology of the ticks considered as belonging to *R. sanguineus* s.s. in South Africa. Walker et al. (2000) also observed intraspecific morphological variation in some male characters from Africa, such as the form of the cervical fields, the size of the posteromedian and posterolateral grooves, the density of scutal punctuations and the shape of adanal plates.

Regarding the morphological analysis of *R. sanguineus* s.s. from other continents, Roberts (1965) provided a description of the immature and adult stages of *R. sanguineus* s.s. in Australia. This author compared the morphology of the Australian ticks with the morphological diagnosis of *R. sanguineus* s.s. presented by Pomerantzev (1950), Feldman-Muhsan (1952), Hoogstraal (1956) and Morel and Vassiliades (1963), concluding that the ticks present in Australia corresponded to *R. sanguineus* s.s. However, Roberts (1965) found that variation exists in the scutal punctuation pattern of the male and female, the shape of the adanal plate of the male and the length width ratio of the scutum in the female when the Australian ticks were compared among each other and with *R. sanguineus* s.s ticks from northern Africa and the Caucasian region. In North America, specimens from the southern USA and Mexico were assigned by Banks (1908) to a new species, *Rhipicephalus texanus* Banks, 1908, but this was subsequently synonymized with *R. sanguineus* s.s. by Bequaert (1945) and Cooley (1946). In the descriptions of Banks (1908), there is only a morphological description of the male and female, but not a taxonomic justification for his decision to create a new species (e.g., a comparison with the previous descriptions of *R. sanguineus* s.s. by Latreille (1806), Koch (1847) and Neumann (1897)). Bequaert (1945) confirmed that the types of *R. texanus* were indistinguishable from European and African *R. sanguineus* s.s. after morphological comparison. The most detailed morphological description of *R. sanguineus* s.s from the U.S.A. was made by Cooley (1946), who described the larvae, nymphs and adults using specimens collected from different localities, although a discussion on the morphological differences with *R. sanguineus* s.s. ticks from other continents was not presented. Finally, Oliveira et al. (2005) studied the morphology of ticks determined as *R. sanguineus* s.s. in South America through a comparison of adult ticks from Argentina (Rafaela) and Brazil (Jaboticabal). They found differences in size, in the shape of the genital aperture of the female and in the number of setae on the anal valves between Argentinean and Brazilian ticks, suggesting that

R. sanguineus s.s is represented by at least two species in the Neotropics.

Over the last few decades, data obtained from genetic studies and cross-mating trials have shown a complex relationship among populations of ticks identified as *R. sanguineus* s.s. from different parts of the world, and also between *R. sanguineus* s.s. and the remaining species of the *R. sanguineus* group. DNA sequences of the internal transcribed spacer (ITS2) of rRNA were employed by Zahler et al. (1997) to infer the relationships among species of the *R. sanguineus* group. The principal result of this work was the close genetic relationship between *R. sanguineus* s.s. and *R. turanicus*, since the sequences of ITS2 were identical. The authors thus suggested a possible conspecificity between the two species. Ticks for this study were determined by N.A. Fillipova (*R. sanguineus* s.s from Azerbaijan and *R. turanicus* from Turkmenistan) and P.C. Morel (*R. sanguineus* s.s from Burkina Faso) (see page 2 of Zahler et al., 1997). Both Morel and Filippova were two of the principal workers who established the taxonomic status of these two species in northern Africa and Asia, respectively (see Morel and Vassiliades, 1963; Morel, 1969, 1976; Filippova, 1997). Therefore, it is difficult to assign these results based on ITS2 sequences to an incorrect taxonomic determination of the ticks. In a similar way, the molecular phylogenetic analyses of Mangold et al. (1998) and Beati and Keirans (2001) performed with sequences of the mitochondrial genes 16S rDNA and 12S rDNA, respectively, also suggested that ticks determined as *R. sanguineus* s.s. and *R. turanicus* in Europe (Spain and France) are very closely related, to such an extent that they could be considered to be conspecific. However, *R. turanicus* from Greece and Israel were found to diverge markedly from *R. sanguineus* s.s., and *R. turanicus* from Zimbabwe differed from *R. sanguineus* s.s. as much as other recognized species (Beati and Keirans, 2001). More recently, genetic population studies performed with sequences of mitochondrial genes (16S and 12S) of *R. sanguineus* s.s. from the Neotropical Region (Szabó et al., 2005; Burlini et al., 2010; Moraes-Filho et al., 2011; Nava et al., 2012; Dantas-Torres et al., 2013) suggested that this taxon is formed by two well differentiated clades. One of these, the tropical lineage, occurs from northern Mexico, Central America, and tropical areas of South America, while the other, the temperate lineage, includes ticks from temperate and cold localities from the southern cone of South America. The *R. sanguineus* s.s. ticks belonging to the tropical lineage were closely related to *R. sanguineus* s.s. from South Africa and Mozambique, whereas the ticks from the temperate lineage formed a clade with *R. sanguineus* s.s. ticks from western Europe (Spain, France and Italy) (Moraes-Filho et al., 2011; Nava et al., 2012). These studies also showed that *R. sanguineus* s.s. from South Africa and Mozambique are genetically different to *R. sanguineus* s.s. from Western Europe. Eremeeva et al. (2011) showed that the tropical lineage is also related to a tick identified as *R. turanicus* in Zimbabwe (Beati and Keirans, 2001; tick identified by Dr R. Pegram) and to *R. sanguineus* s. s. from the Caribbean. They also revealed that the tropical and the temperate lineages occur in different North-American regions. These results are supported by data from cross-breeding trials. Crosses between *R. sanguineus* s.s. ticks from Brazil (Jaboticabal) and Argentina (Rafaela) produced sterile hybrids (Szabó et al., 2005), and the hybrid females originating from cross-mating between North American (Oklahoma) and African (Reunion Island) ticks produced no viable progeny (Levin et al., 2012). Finally, the difference in the full mitochondrial genome between the *R. sanguineus* s.s. isolate from the USA (tick from Oklahoma State) and China (tick from Guangdong Province, which is related to the tropical lineage) was 11.23% (Liu et al., 2013).

The literature review above shows clearly the existence of two important constraints to an accurate definition of *R. sanguineus* s.s. First, there are several morphological descriptions based on ticks from different regions of the world which show a high variability in diagnostic characters, as for example the shape of the genital aperture of the female, the adanal and spiracular plates of males, and scutal punctuation patterns, among others. In addition, genetic and biological studies have demonstrated that populations of ticks from different regions, determined as *R. sanguineus* s.s. following the classical morphological descriptions (e.g. Cooley, 1946; Filippova, 1997; Pegram et al., 1987b; Walker et al., 2000) are genetically divergent and sometimes biologically incompatible. This means that ticks identified as *R. sanguineus* s.s. in various diverse regions do not belong to an entire worldwide number of ticks consisting of individuals that can be identified as *R. sanguineus* s.s. and that are all capable of successful interbreeding. Second, the usage of the name *R. sanguineus* s.s. entails a formal nomenclatural problem. According to the International Code of Zoological Nomenclature (ICZN, 1999) it is not possible to objectively assign a name to a particular biological taxon in the absence of types or at least of an unambiguous description of the type. The name *R. sanguineus* s.s. falls in this case scenario because the type is lost and the original description is not informative. In spite of lack of comparative resources, through the years, the scientific community was led to believe that the name *R. sanguineus* s.s. was truly associated with a clearly defined tick morphology found in ticks that mostly parasitize dogs (Pomerantzev et al., 1940; Morel and Vassiliades, 1963). However, other species of *Rhipicephalus* described in the 20th century occur in France. Based on Latreille's description (1806), it is impossible to determine *a posteriori* which of these species he was referring to. Moreover, none of the authors who re-described *R. sanguineus* s. s. after 1806 actually examined Latreille's specimens. Their descriptions became, nevertheless, the basis for all future determinations.

3. Future perspectives and solutions

R. sanguineus s.s. could be relegated to a *nomen nudum* because the type is missing, the original description is uninformative, and the name may refer to a number of different unidentifiable entities. Nevertheless, the name *R. sanguineus* s.s. refers to ticks characterized by significant economic and public health relevance. They are involved in the transmission of diseases agents to both dogs and humans (Walker et al., 2000; Parola et al., 2005; Otranto et al., 2009; Bowman, 2011; Eremeeva et al., 2011; Labruna et al., 2011). In addition, *R. sanguineus* s.s. is also of considerable economic importance for the antiparasitic market of

companion animals (Graf et al., 2004). Therefore, the scientific, medical, veterinary, and pharmaceutical communities may be very reluctant to part with such a household name. A second option therefore, would be to redefine *R. sanguineus* s.s. as a biological entity against which we would have a benchmark to compare the taxonomic and ecological diversity represented by the ticks currently assigned to this name. This would also allow a more acute assessment of epidemiological and control issues. However, before dealing with this subject through the characterization of morphological and genetic traits, it is imperative to have a taxonomic frame of reference, in other words, a neotype.

The designation of a neotype is controlled by the rules of the ICZN. Citing the code (ICZN, 1999), the principal conditions and procedures to designate a neotype are as follows: (1) if no name-bearing type is believed to be extant a neotype may be fixed; (2) a neotype is the name-bearing type of a nominal species-group taxon designated under conditions specified in this article (number 75) when no name-bearing type specimen (i.e. holotype, lectotype, syntype or prior neotype) is believed to be extant and an author considers that a name-bearing type is necessary to define the nominal taxon objectively; (3) a statement is required that it is designated with the express purpose of clarifying the taxonomic status or the type locality of a nominal taxon; (4) a statement is required of the characters that the author regards as differentiating from other taxa the nominal species-group taxon for which the neotype is designated, or a bibliographic reference to such a statement; (5) data and a description sufficient to ensure recognition of the specimen designated are required; (6) the author's reasons for believing the name-bearing type specimen(s) (i.e. holotype, or lectotype, or all syntypes, or prior neotype) to be lost or destroyed, and the steps that had been taken to trace it or them are required; (7) evidence is required that the neotype came as nearly as practicable from the original type locality. Points 1 to 3 clearly indicate that the current taxonomic status of *R. sanguineus* s.s. and its clarification warrant the designation of a neotype. In order to designate a neotype, it is necessary also to find a type locality as close as possible to the original type locality. The only reference in the original description of Latreille (1806) is "Habitat in Gallia". Even though Gallia was formed during the Roman Empire by an area of Western Europe embracing the present-day territories of France, Germany, Belgium, Switzerland and the Netherlands (Bertier de Sauvigny, 1977), by 1806 the name Gallia was certainly used to refer to the present-day territory of France. Bequaert (1945), Hoogstraal (1956) and Walker et al. (2000) have considered the "Gallia" of Latreille (1806) as France, and Roberts (1965) stated that Koch (1847) interpreted Latreille's locality "Gallia" as Portugal. However, although in the description of *R. sanguineus* s.s. Koch (1847) indicated Portugal as the locality for the ticks he was examining (see page 131), on page 26 of the same publication this author specified France as the type locality. Taking into account this evidence, it seems reasonable to choose a point in France to collect the specimens that will be used to describe the neotype of *R. sanguineus* s.s. Unfortunately, the locality of the neotype within France must be chosen arbitrarily, because there is no indication of the exact site where the specimen described by Latreille (1806) was collected.

Since recent works have shown that different genotypes of the *R. sanguineus* group can occur sympatrically, and because some studies have shown that ticks of the *R. sanguineus* group can produce viable hybrids (that are sterile), it would be desirable that the type series came from a laboratory colony (originating from engorged females collected in the type locality) that had been shown to be highly fertile under controlled conditions, in order to exclude any hybrid specimen. Laboratory colony ticks would provide another advantage, some of the intraspecific variability might be found in ticks from the same cohort and a better analysis of discriminating features would be potentially obtained.

The description of the neotype should be followed by the description of the remaining sex and the immature stages. Although the diagnostic characters of larvae and nymphs are less numerous than those of adults, they are more stable in shape and size (Walker, 1961). Walker et al. (2000) presented a comparison among *R. sanguineus* s.s., *R. camicasi*, *R. guilhoni, R. sulcatus* and *R. turanicus*, based on the shape of the basis capituli and palps of larvae and nymphs. These characters are an additional example of how confusing morphological features, even in immature specimens, can be particularly when comparing images of the same species from the Afrotropical and from the non-Afrotropical regions. Multivariate analyses of chaetotaxy and morphometric traits should, nevertheless, facilitate the identification of fixed morphological differences at the interspecific level. In this sense, Filippova (1989) successfully used chaetotaxy of the idiosoma and gnathosoma, and morphometric characters of the larvae (based on material reared in the laboratory) to differentiate species of the genus *Rhipicephalus* (*R. sanguineus* s.s., *R. turanicus*, *R. rossicus, R. pumilio, R. schulzei* and *Rhipicephalus bursa* Canestrini and Fanzago, 1878) in areas of the former USSR.

After that, the comparison of ticks from different areas of the world with the neotype ("real" *R. sanguineus* s.s.) will be crucial for determining the diversity and the taxonomic status of the species within the *R. sanguineus* group. Pegram et al. (1987b) recognized the need for comparative studies to define the phylogenetic and phenetic relationships among the species of this group. Besides the major descriptions of Filippova (1997) and Walker et al. (2000), there are several studies where morphological comparisons among species of the *R. sanguineus* complex from different countries were performed (Yakimoff, 1923; Pomerantzev, 1950; Morel and Vassiliades, 1963; Saratsiotis and Battelli, 1975; Pegram et al., 1987a,b, 1989; Estrada-Peña and Sanchez, 1988; Pegram and Zivcovic, 1989; Farid, 1996). Once the neotype of *R. sanguineus* s.s. is designated, the results of these studies should be re-evaluated. Due to the lack of a clear definition of *R. sanguineus* s.s., the current validity of these studies is, in the least, controversial.

In addition to the morphological description of the neotype, sequences of both mitochondrial and nuclear genes should be added to the description of the tick. This would allow a morphological and genetic comparison between

Rhipicephalus ticks from different geographic origins with the neotype of *R. sanguineus* s.s. Meanwhile, the term "*R. sanguineus* species group" or "*R. sanguineus sensu lato*" should be employed instead of "*R. sanguineus* sensu stricto".

Conflict of interest

There is no conflict of interest.

Acknowledgements

We are grateful to INTA, Asociación Cooperadora INTA Rafaela and CONICET for the financial support to SN, AJM and AAG.

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