2 - Ticks on the magnifying glass

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Taxonomy and systematic

Ticks are obligatory ectoparasites which belong to the Phylum Arthropoda, Class Arachnida, Subclass Acari, Order Parasitiformes, Suborder Ixodida (Barker; Murrell, 2004). There are currently an estimated 899 species of ticks divided into the families Nutalliellidae, Argasidae and Ixodidae, the latter comprising the largest number of species, with great medical, veterinary and economic importance (Anderson; Magnarelli, 2008; Dantas-Torres, 2008; Nava et al., 2015).

The member of the family Ixodidae, constituted of 702 species (Guglielmone et al., 2014), have the mouthparts inserted in the anterior scutum of the body, as well as a chitinous scutum covering almost the entire dorsal part
in the males and almost half or one third in the females, allowing the enlargement of the body during engorgement. Ticks, therefore, present gender dimorphism in adult stage (Sonenshine; Roe, 2014). The family Argasidae comprises 193 species (Sonenshine; Roe, 2014). The main characteristic of these ticks is the absence of a dorsal scutum. Their mouthparts are located on the underside of the body and they ingest less blood in comparison with the ones belonging to the family Ixodidae (Walker, 1994).

The third family, Nutalliellidae, is constituted of a single species called Nuttalliella namaqua, recently reported in South Africa (Mans et al., 2012). It is considered the most basal lineage of ticks, and differs from the other families mainly for the heavily corrugated integument and the form of fenestrated plates (Roshdy et al., 1983).

Ticks in general represent a great public health concern, once they cause considerable livestock losses (*Rhipicephalus (Boophilus) microplus*), and are vectors of zoonosis that affect domestic/wild animals and the human beings as well (*Rhipicephalus sanguineus* s. l., brown dog tick, *Amblyomma sculptum*, and *Amblyomma triste*).

**Rhipicephalus (Boophilus) microplus**
(Acari: Ixodidae)

Popularly known as the cattle tick, this species is endemic to tropical and subtropical areas of the world (Estrada-Peña et al., 2006). Despite having cattle as preferential hosts, they can be occasionally found parasitizing buffalo, horses, goats, sheep, dogs and wild animals (Franque et al., 2007). This species has great veterinary significance by transmitting pathogens that cause babesiosis (*Babesia bovis* and *B. bigemina*) and anaplasmosis (*Anaplasma marginale*), affecting consequently cattle...
health and productivity (Giglioti et al., 2016; Mekonnen et al., 2002). Therefore, *R. (B.) microplus* is responsible for causing noteworthy economic losses in livestock industries (Grisi et al., 2014).

*Rhipicephalus sanguineus* sensu lato
*(Acari: Ixodidae)*

The species *R. sanguineus* sensu stricto (s. s.) was first described by Latreille in 1806. The original morphological description presented is not sufficient to allow an accurate identification of this species. Moreover, there is no type specimen available for comparisons, making its identification even more difficult (Walker et al., 2005). It is currently a group of uncertain morphological definition, once recent molecular studies demonstrated that *R. sanguineus* sensu lato (s. l.) actually consists of a complex of species (Moraes-Filho et al., 2011; Nava et al., 2015). The species remains object of discussion among taxonomists (Dantas-Torres; Otranto, 2015).

*R. sanguineus* s. l. ticks have the dog as preferential host and are vectors of pathogens, such as bacteria, protozoa and nematodes, which are responsible for transmitting several diseases to domestic animals and the human beings as well (Dantas-Torres, 2010).

*Amblyomma cajennense* sensu lato
*(Acari: Ixodidae)*

The *Amblyomma cajennense* complex, also called *A. cajennense* sensu lato is composed of two species in Brazil, *A. cajennense sensu stricto* (s. s.) and *A. sculptum* (Martins et al., 2016). While *A. cajennense sensu stricto* (s. s.) is
restricted to Amazonian region, *A. sculptum* can be found in coastal and central-western states (Martins et al., 2016; Nava et al., 2014). Thus, many specimens that had been classified as *A. cajennense* s. s. corresponds, in fact, to *A. sculptum*.

*Amblyomma sculptum* is popularly known as star ticks, are mainly equine parasites, and are occasionally found on other hosts including cattle, deer, domestic animals, birds, reptiles and the human being (Oliveira et al., 2003). This species is the main transmitter of the bacteria *Rickettsia rickettsii*, the causative agent of spotted fever, a disease that seriously affects animal health in several regions of Brazil (Szabo et al., 2013; Labruna et al., 2007).

**Amblyomma triste** (Koch, 1844)  
(Acari: Ixodidae)

The geographic distribution of the species *Amblyomma triste* is restricted to South America. These ticks parasitize cattle, deer, capybaras (*Hydrochoerus hydrochaeris*), dogs and human beings. The species is considered the main vector of rickettsiosis, caused by the bacteria *Rickettsia conorii*. The disease is characterized by skin lesions with a black ulcerous crust (*tache noire*), high fever and severe headache (Oliveira, 2006).

**External morphology of ticks**

The external structure of the ticks comprises the capitulum and the body, also called idiosoma (Figure 8A). The former contains the mouthparts, which are responsible for fixation and feeding (Figure 8B), and is constituted of: a) a pair of palps with chemiosensorial structures that
select the site on the host body where the tick will attach; b) a pair of chelicerae, with the function of perforating the host skin; and c) a hypostome, which acts as a fixation organ and as a food channel, passing out the saliva into the host and the host blood into the tick digestive tube. The hypostomal shape and dentition are important features used in the identification of species (Anderson; Magnarelli, 2008; Barker; Murrell, 2004).

Figure 8 – (A) Dorsal region of a *R. sanguineus* s. l. unfed female; (B-C) Ventral region of a *R. sanguineus* s. l. unfed female in detail; (D) Ventral region of a *R. sanguineus* s. l. unfed male in detail. a = anus; i = idiosoma; bc = basis capitulum; cp = capitulum; h = hypostome; ga = genital aperture; p = palpi; s = spiracular plate; sp = spur; sc = scutum

The legs, segmented in coxa, trochanter, femur, larva, tibia, tarsus and ambulacrum, are located in the anterior part of the body (Figure 9 C-F) (three pairs in larva, four pairs in the nymphs and adults) (Anderson; Magnarelli,
Figure 9 – (A, C) Dorsal region of a *R. sanguineus* s. l. unfed female; (B) Dorsal region of a *R. sanguineus* s. l. engorged female; (D) Dorsal region of a *R. sanguineus* s. l. unfed male; (E) Ventral region of a *R. sanguineus* s. l. unfed female; (F) Ventral region of a *R. sanguineus* s. l. unfed male; a = anus; i = idiosoma; cp = capitulum; ga = genital aperture; leg = leg; s = spiracular plate; sc = scutum; ad = adanal plate.
2008; Dantas-Torres, 2008). The coxae may have spurs (Figure 8 C and Figure 9 E-F) which are also used in tick’s taxonomy. The genital pore is in the ventral anterior regions (closed in larvae and open in nymphs and adults) (Figure 8 C and Figure 9 E-F). The spiracle and anus are situated in the posterior region (Figure 8 D) (Sonenshine; Roe, 2014). Males of some tick genus can also present a group of ventral plates represented by adanal (Figure 9 F), accessory and subadanal plates (Koneman et al., 1997).

The scutum is a sclerotized plate, ornamented or no, that covers the whole dorsal region of the males, but a small anterior part in the females (Figure 9 C-D), allowing cuticle expansion during feeding and oogenesis (Figure 9 A-B) (Anderson; Magnarelli, 2008; Sonenshine; Roe, 2014).

**Tick’s biology**

The life cycle of ticks consists of four stages of development: egg, larvae, nymph and adult. Some species are monoxenous, as the cattle tick (*R. (B.) microplus*), i.e., they parasitize a single host during the whole life cycle. Other species are heteroxenous, feeding on different hosts, including: mammals, rodents, birds, amphibians, reptiles, other ticks, and the human beings as well (Denardi et al., 2004; Oliveira et al., 2003). An important characteristic of these ectoparasites is that, during their biological cycle, they can survive for long periods after dropping off the host, sheltered in the vegetation or soil cracks and crevices (Walker, 1994).

After fully engorged and having completed oogenesis, the females drop off the host and start oviposition, which can last approximately 18 days and produce up to 7,000 eggs, as reported for the species *R. sanguineus* s. l.
The female dies after laying the eggs, and the incubation period will last approximately 20 days, depending on the environmental conditions. The larvae will find and feed on a host, to eventually undergo ecdysis (Sonenshine; Roe, 2014).

Ticks need to find a host to feed on to complete their development and ensure their reproductive success. In this phase, stimuli as odor, vibration, visual appearance (some species have simple eyes located in the scutum margin) and the temperature of the host are essential parameters. The site for fixation on the host is selected by chemoreceptors located on the palps and chelicerae, used to “taste” the host. After the host dermis and epidermis are perforated by the chelicerae, the hypostome is introduced in the lesion and there remains, anchoring the tick with the aid of a protein substance named cement, secreted by the salivary glands. Through the hypostome (food channel), the tick saliva is passed out into the host, and host blood fluids sucked into the tick (Anderson; Magnarelli, 2008).

Medical and veterinary importance

Geographically, ticks are globally spread, being found in all regions of the world (Gray et al., 2013). This wide distribution can be attributed to the diversity of hosts, including mammals, birds, reptiles, amphibians, other arachnids, other ticks (Labruna et al., 2007) and the human beings. The slow feeding process of the ectoparasites is another important factor, once ticks cover long distances transported by the hosts (Anderson; Magnarelli, 2008).

Ticks have great medical and veterinary importance, not only for the host blood spoliation, but also for being vectors of several pathogens, such as bacteria, viruses,
protozoa and helminths, affecting domestic/wild animals and the human beings as well (Dantas-Torres, 2010). These pathogens are transmitted through the saliva, which, according to Sonenshine and Roe (2014), consists of a species-specific complex mixture of molecules, varying according to the interaction parasite/host and the physiological state of the tick.

The multifunctional molecules of the saliva modulate the immunoinflammatory and hemostatic systems of the host, ensuring not only the biological success of the ectoparasites, but also their role as pathogen vectors, once its immunomodulatory action facilitates the transmission of microorganisms, minimizing the obstacles to their penetration into the host organism (Francischetti et al., 2009; Nuttall; Labuda, 2004).