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Altitudinal and seasonal differences of tick communities in dogs from pastoralist tribes of Northern Kenya

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ABSTRACT

Studies regarding the distribution and ecology of ticks in dogs from Eastern Africa are scarce. Our research was based on a long-term screening of ticks parasitising the domestic dogs living with indigenous people around Lake Turkana, Mt. Kulal and Mt. Nyiru areas, Northern Kenya. A total of 9977 ticks were collected from 1464 dogs of all ages and both sexes. Identification was performed using morphological keys and data were analyzed using the Repeated Measures ANOVA, post-hoc Scheffe test and F test, relating independent variables as seasons and regions. Final results were translated to maps using GIS software. Five species of ticks were identified: *Rhipicephalus pulchellus*, *Rhipicephalus sanguineus* sensu lato (s.l.), *Rhipicephalus armatus*, *Amblyomma gemma* and *Hyalomma truncatum*. Our results suggest a statistical difference of the tick community structure related to seasonal and altitudinal distribution. Parasitism with *R. armatus* and *R. pulchellus* was higher in September–October than in January, whereas, *R. sanguineus* s.l. was not influenced by the season. *Rhipicephalus armatus* was present exclusively on dogs living in semi-desert areas, while *R. sanguineus* s.l. was the dominant species present on the shores of Lake Turkana. Although *R. pulchellus* was present in the all studied areas, this species had a significantly higher abundance in the afromontane region of Mt. Kulal and montane xeromorphic forest of Mt. Nyiru; these regions are characterized by elevated humidity and cooler climate. Similar geo-climatic distribution is typical also for *A. gemma*, which was found in dogs exclusively in Mt. Kulal afromontane area. The current work represents the most extensive study performed on the tick community structure of dogs in Eastern Africa. The results showed a relatively limited tick species diversity, with clear seasonal differences and altitudinal distribution.

1. Introduction

Almost half of the world's pastoral people live in Africa (Roth and Fratkin, 2005). It is estimated that more than twenty five million pastoralists and agro-pastoralists live in East Africa alone (Roth and Fratkin, 2005). Northern Kenya is particularly known for its harsh environment with prolonged drought and famine, constant demographic increase, ethnic conflicts and political insecurity, which have gradually induced the decrease of pastoralists' mobility (Roth and Fratkin, 2005). The Northwest territory of Kenya between Lake Turkana and Mt. Kulal is inhabited by several pastoral tribes where humans and domestic animals share both resources and diseases. The pastoralists of Turkana, Samburu and Rendille tribes depend on domestic animals such as cattle, camels, goats, sheep, and donkeys for milk, meat, transport, trade and ceremonials (Fratkin and Roth, 2005). The domestic dogs, which are believed to come to the

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area with Nilotic people 2000 years ago, represent a valuable part of the communities. They are traditionally used for protection of the villages and livestock against wild animals and human intruders.

Together with fleas, ticks represent the most common blood feeding arthropods of dogs worldwide. Their complex life cycles and ecology make ticks important vectors for pathogens. Due to their free roaming lifestyle, dogs represent a valuable epidemiological sentinel species for tick-borne pathogens (Halliday, 2010; Millán et al., 2013). Among several tick species from *Amblyomma*, *Hyalomma*, *Haemaphysalis* and *Rhipicephalus* genera that have been reported on domestic dogs in equatorial Africa, members of the latter are the most diversified and frequent (Walker et al., 2003).

Despite the ubiquitous presence of domestic dogs in areas inhabited by semi-nomadic pastoralists and the potential source of infection they represent for humans, livestock and wildlife, only few studies have addressed pathogens other than the zoonotic cestode *Echinococcus* and rabies virus. Most of the ticks occurring on dogs are reported also on humans. Hence, the tick-host associations and their ecology and distribution are important for understanding the natural cycle of tick-borne pathogens. Our aim was to evaluate the community structure of ticks collected from dogs during multiannual rabies vaccination campaigns organized in remote areas of Lake Turkana region. Based on the extensive spatial and temporal set of samples, we provide an insight into the ecology and seasonal differences of ticks collected in localities covering an extreme range of ecological conditions: from the hot desert of the Lake Turkana shores to mist afromontane forest located in the high altitudes of Mt. Kulal and Mt. Ngyiru.

2. Materials and methods

2.1. Tick sampling

The study was conducted between 2006 and 2012 in 16 pastoral communities in Northern Kenya, under the frame of an international collaborative project focused on preventive veterinary medicine (Mt. Kulal Dogs' Preventive Vaccination). Tick samples were collected in the following months: October (2006), September (2007–2009) and January (2012), covering both the dry and the rainy seasons. The study areas were located in the Marsabit (Eastern Province) and Samburu (Rift Valley Province) counties. Altogether, 1464 dogs were examined for the presence of ticks (Table 1).

2.2. Ecological and climatic characteristics of the area

The settlements included in this study were grouped into four ecological categories based on the majority of the vegetation types and altitude, as follows: margin of high afromontane forest (I), dry savanna/semi-desert (II), montane xeromorphic forest (III) and desert (IV) (Fig. 1). The climate is hot, arid tropical (Nicholson 1991) with median monthly temperatures ranging from 17 to 19 °C in the mountains to 20–26 °C at lower altitudes. August is usually the coldest month, while March is the hottest (Nicholson 1996; de Leeuw et al., 2001). There are two rainy seasons, one short between mid September and November and one long between March and May, intercalated with dry seasons (December–February and June–September (Nicholson 1996).

2.3. Collection and identification of ticks

Ticks were collected from household dogs presented for veterinary screening and anti-rabies vaccination (D'Amico et al., 2013). As the number of ticks on each dog was often of several hundreds, the collection of all the ticks was technically not achievable. If the number of visible ticks on a dog was lower than 20, all the ticks were collected. If the number of ticks was higher than 20, the number of collected ticks was dependent on the estimated level of infestation, and ranged between 30 and 100. In the latter case, for the reliability of morphologic identification, ticks which were not fully engorged were preferred for collection. A total number of 9977 adult ticks were collected. A number of nymphs ($n = 251$) were also collected, but because of their difficult and uncertain specific identification due to full-engorgement, these were not included in the statistical analyses. All ticks were preserved in absolute ethanol and identified in the laboratory. Morphological identification was done individually for each tick to species level by using morphological keys and descriptions (Walker et al., 2000, 2003).

2.4. Statistical analysis

Each dog received a unique ID number, and information regarding age, sex and locality was collected. All the raw data were included in a database and statistically analysed using the Repeated Measures ANOVA (Analysis of Variance); the species was used as an independent variable, and the season and ecological region as dependent variables. The subsequent comparisons were performed using post-hoc Scheffe and *t*-protected tests. The results were considered statistically significant at an alpha level of 5%. Classical tests (F test and post-hoc tests) were complemented by estimation indexes (effect size—eta squared) and statistical power. Maps were generated using the ArcMap version 10.3 software.

3. Results

3.1. Characteristics of the tick community structure

Out of 1464 examined dogs, 1121 (76.5%) were infested by ticks. A total number of 9977 adult ticks and 251 nymphs were collected (Table 1). The latter were not included in the statistical analyses because of their difficult and uncertain specific identification due to the full-engorgement. In the adult tick population, 5 different species were identified: *Rhipicephalus pulchellus* (Gerstäcker, 1873), *Rhipicephalus sanguineus* (Latreille, 1806) sensu lato (s.l.), *Rhipicephalus armatus* Pocock, 1900, *Amblyomma gemma* Dönitz, 1909 and *Hyalomma truncatum* Koch, 1844. The prevalence (percent of infested dogs) of each tick species based on the season and region is shown in Table 2. The community structure (percent of individuals of particular species from the total number of collected ticks) of ticks based on season and region is shown in Table 3 and Fig. 2. The statistical analysis showed that there was no significant difference between different host age and sex categories. However, significant differences were detected between the prevalence and community structure among the seasons and the ecological regions.

3.2. Season-based statistical analysis

The overall prevalence of ticks was higher during September–October than in January [F (14,044) = 114.69 ($p = 0.0001$, $\eta^2 = 0.1$, $1 - \beta = 0.98$)]. The prevalence and frequency of individual tick species were also influenced by the season. *R. armatus* [t (1011) = 2.622 ($p = 0.009$, CI 95%: 0.35193, 2.4462)] and *R. pulchellus* [t (1011) = 12.45 ($p = 0.001$, CI 95%: 26.48685, 36.39834)] were more common on dogs in September-October compared to January. *A. gemma* was found on dogs only in September–October. No seasonal statistical difference was found for *R. sanguineus* s.l. and *H. truncatum*. No significant difference was detected for the same season between the years of the study.

3.3. Region-based statistical analysis

The statistical analysis showed significant differences between the prevalence and the community structure between the regions