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Cross-sectional survey of ticks (Acari: Ixodidae) in sheep from an area of the southern Italian Apennines

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Abstract. A cross-sectional survey of ticks was conducted on 197 ovine farms with animals pasturing in an area (3971 km^2) of the southern Italian Apennines. The farms were selected to be uniformly distributed throughout the study area using Geographical Information System (GIS). Ticks were collected from 309 (31.4%) out of the 985 sheep sampled, belonging to 92 (46.7%) out of the 197 farms included in the study. The following tick species were found (farm prevalence): *Dermacentor marginatus* (37.6%), *Haemaphysalis punctata* (29.4%), *H. sulcata* (2.5%), *H. parva* (2.0%), *H. inermis* (0.5%), *Ixodes gibbosus* (2.0%), *I. ricinus* (0.5%), *Rhipicephalus sanguineus* group (1.0%), and *R. bursa* (0.5%). A point distribution map (PDM) was drawn by GIS in order to display the distribution of each tick genus in the study area. The general trends of the PDM show that *Dermacentor marginatus* and *Haemaphysalis* spp. were widely and homogeneously spread throughout the study area, whereas *Rhipicephalus* spp. and *Ixodes* spp. were present only in a few concentrated zones of the study area in accordance to their biological and ecological characteristics.

Introduction

The infestation of ticks has always represented one of the most important problems affecting sheep and goat livestock in developed and developing countries (de Castro 1997; Ghirotti and Maroli 1997; Jongejan 1999).

In the Mediterranean region, ticks are a major constraint on ruminant production because they cause direct harm and they are also responsible for the transmission of pathogens such as *Babesia, Anaplasma* and *Theileria*. The mild Mediterranean climate, together with the adequate vegetation conditions in the region, provide adequate conditions for the survival of several xerophilic tick species (Castellà et al. 2001).

Even though in the past few years the interest around ticks and tick borne diseases (TBDs) has increased, the epidemiological reports on ticks infesting small ruminants in the Mediterranean region are still scanty if compared to cattle and horses. This is due to the fact that sheep breeding is mainly confined to

marginal areas in developing countries and to the difficulty to quantify the economical losses caused by tick infestation (Liebisch 1997).

Sheep breeding is a very important activity in large areas of central and southern Italy, not only for meat, milk and cheese production but also because this species can utilise vast marginal areas of mountain pastures unsuitable for other species (Di Todaro et al. 1999). Up to now, 13 species of ticks affecting sheep have been reported in Italy (Manilla 1998).

Since ticks are vectors of numerous TBDs, causing morbidity and mortality of small ruminants, reduced body weight gain, milk production, and devaluation of hide and skins, it is necessary to have accurate and reliable data regarding their distribution. The present paper reports the results of a cross-sectional survey designed to study the presence and distribution of ticks in pastured sheep living in a well-defined area of the southern Italian Apennines, utilising a Geographical Information System (GIS) to plan the sampling protocol and to display the results.

Materials and methods

Study area

The study was conducted in a 3971 km^2 area of the southern Italian Apennines (Figure 1) that contains 92 contiguous municipalities located in portions of the three southern Italian regions, Campania, Apulia and Basilicata (40°39′–41°22′N, 14°50′–16°01′E). The area is mainly hilly, with small areas of either mountainous or flat land and extends from 100 to 1800 m a. s. l. There are no lakes. However, a few rivers, some streams and many brooks run through the area; the latter two hold water only from autumn to late spring. The climate is Mediterranean with dry summers and rainy winters. *Quercus* spp., *Fraxinus* spp. and *Acer monspessulanum* are the most frequent arboreous vegetation.

In this area there is a strong impact by man and the small agrozootechnical farms are widely distributed with an average area of approximately 50 ha. Small pasture areas are dispersed throughout the zone, which is mainly cultivated with cereal crops. Animals graze mainly in areas of uncultivable topography; in the past 50 years, some of these areas have been planted with coniferous trees.

Sample size

The samples of interest in the present study are farms (flocks). The survey was conducted on 197 sheep farms. This sample size was calculated using the formula proposed by Thrusfield (1995) inserting the following values: study population (6864 sheep farms), expected prevalence of tick infestation (95%: based on our previous studies), confidence interval (95%), and desired absolute precision (3%).

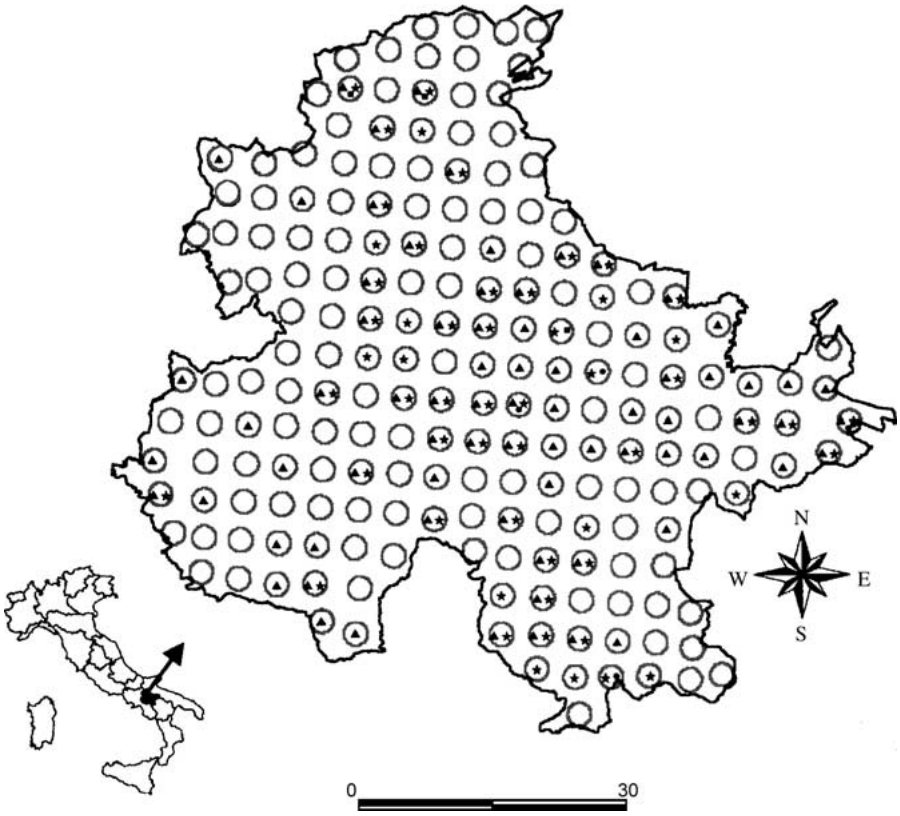

Figure 1. PDM of ticks in the study area (3971 km^2 – southern Italian Apennines). Legend: (○) = 3 km diameter sampling area in which animals from a single farm were tested; (▲) *Dermacentor*; (⋆) *Haemaphysalis*; (●) *Rhipicephalus*; (■) *Ixodes*.

Only pasturing farms (occasional/seasonal/permanent pasturing) which had 50 or more sheep, composed the study population.

Sample distribution

The 197 sheep farms that formed the sample were selected to be uniformly distributed throughout the study area. For this purpose, a GIS was used to divide the study area into 197 equal sub-areas. The centroid of each sub-area was identified and geo-referenced within the GIS. The sampling areas of the present study were circular areas of 3 km diameter centered on the centroids (Figure 1). In each sampling area, the specific farm to be studied was randomly selected by local veterinarians and designated by the number associated with that area (Cringoli et al. 2002a, b).

The GIS software used in this study was IDRISI, distributed by 'The IDRISI Project', Clark University, Graduate School of Geography, Worcester, MA, USA.

Tick collection

Ticks were collected from animals on the selected sheep farms between September and December 2000. Eleven private veterinarians were each assigned a number of the 197 sheep farms from which to collect the study samples. Each veterinarian was provided with a copy of the trial protocol, and uniform materials for tick collection and transport. In order to randomly select study farms within the 3 km in diameter sampling areas, each veterinarian was given a map universal transverse mercator (UTM) projection (scale 1 cm = 1 km) of the study area under his/her responsibility indicating the sampling areas, and a handheld geographic positioning system (GPS GARMIN 12XL distributed by Garmin International Inc. 1200 E. 151st St. Olathe, KS 66062, USA) to identify the precise geographical location of the farms selected with an accuracy of < 40 m. On each flock, ticks, when present, were collected from five sheep. Although the entire animal was explored for ticks, special attention was paid to the head, udder, perineum, and the internal sides of the legs. Ticks were removed using entomological tweezers and then placed into glass vials containing ethanol (70%) and transported to the Entomological Laboratory of the Veterinary Medicine Faculty of Bari University for morphological identification.

Laboratory procedures

The ticks were identified using a stereomicroscope with a magnifying capacity of 12 – 80 using morphological keys of Estrada-Peña and Estrada-Peña (1991) and Manilla (1998). Some ticks were cleaned using potassium hydroxide before their identification.

Data mapping

In order to display the distribution of each genus of tick in the study area, a point distribution map (PDM) was overlaid on area map using IDRISI. It shows the following information: (1) tick genus studied; (2) study area; (3) distribution of the sampling areas; (4) sampling areas with infested animals; and (5) sampling areas with not infested animals.

Results

Ticks were collected from 309 (31.4%) out of the 985 sheep sampled, belonging to 92 (46.7%) out of the 197 farms included in the study. Nine-hundred-twenty-seven

Table 1. Species of adult ticks, prevalence, and number of specimens identified on animals of the 197 sheep farms.

Ticks	Farms (197)		Number of ticks		
	Positive no.	Prevalence (%)	Males	Females	Total
D. marginatus	74	37.6	261	165	426
H. punctata	58	29.4	182	277	459
H. sulcata	5	2.5	4	1	5
H. parva	4	2.0	6	3	9
H. inermis	1	0.5	0	1	1
I. gibbosus	4	2.0	2	4	6
I. ricinus	1	0.5	1	0	1
R. sanguineus group	2	1.0	0	5	5
R. bursa	1	0.5	0	2	2

ticks were collected of which 914 (98.6%) were adults: 456 males and 458 females. Ticks species found were: *Dermacentor marginatus*, *Haemaphysalis punctata*, *H. sulcata*, *H. inermis*, *H. parva*, *Rhipicephalus sanguineus* group, *R. bursa*, *Ixodes ricinus*, and *I. gibbosus* (Table 1).

In addition, eight nymphs have been identified as belonging to the genus *Rhipicephalus* and three to the genus *Haemaphysalis*; one larva to the genus *Haemaphysalis* and one to the genus *Rhipicephalus*. The spatial distribution of the sampling areas with infestations of *Dermacentor*/*Haemaphysalis*/*Rhipicephalus*/*Ixodes* is shown in the PDM (Figure 1).

Discussion

The results of the present survey add data to the limited epidemiological information regarding tick faunal composition in sheep from the southern Italian Apennines. All the nine species identified were previously found on sheep in central and southern Italy (Genchi and Manfredi 1999), and they were also reported on pastured cattle from the same area of the southern Italian Apennines (Cringoli et al. 2002a).

The ecological and biological characteristics of these species are congruent with the environment and biotypes from which they were retrieved. The most prevalent species were *D. marginatus* and *H. punctata*. This agrees with reports from other authors who have observed a high adaptability of these two species to the oro-mediterranean climate; they are most frequently found on small ruminants that are reared in the traditional manner on extensive pastures, mainly in central-southern Italy and on islands (Gilot et al. 1989; Genchi and Manfredi 1999). The high prevalence of *D. marginatus* and *H. punctata* is also in accordance with the sampling period, since peaks of these two species are usually reported in September–October (Ghirotti and Maroli 1997).

In the present study, the GIS was utilised for a new type of sampling protocol in order to uniformly select the farms throughout the study area. GIS have been

previously used to produce forecast models to assess the occurrence of different species of ticks (Hugh-Jones 1989; Daniel and Kolar 1990; Daniel et al. 1998; Estrada-Peña 1998, 1999, 2001, 2002). Without good descriptive maps of species' distribution, based on ground observations, however, we do not have the essential starting point to generate predictive maps based on statistical pattern-matching (Randolph 2000). In the present survey, we collected uniformly distributed geo-referenced data about tick faunal composition throughout the study area which will be essential in further studies using GIS and remotely sensed data. The PDM designed for the present study shows that *Dermacentor marginatus* and *Haemaphysalis* spp. were widely and homogeneously spread throughout the study area, whereas *Rhipicephalus* spp. and *Ixodes* spp. were present only in a few concentrated zones of the study area. In conclusion, this study confirms the importance of such surveys on the tick fauna of sheep and on other species of animal to monitor their distribution, following environmental conditions and set up control programs to limits TBDs in these areas.

References

Castellà J., Estrada-Peña A., Almerìa S., Ferrer D., Gutiérrez J. and Ortuño A. 2001. A survey of ticks (Acari: Ixodidae) on dairy cattle on the island of Menorca in Spain. Exp. Appl. Acarol. 25: 899–908.

Cringoli G., Otranto D., Testini G., Buono V., Di Giulio G., Traversa D., Lia R., Rinaldi L., Veneziano V. and Puccini V. 2002a. Epidemiology of bovine tick-borne diseases in southern Italy. Vet. Res. 33: 421–426.

Cringoli G., Rinaldi L., Veneziano V., Capelli G. and Malone J.B. 2002b. A cross-sectional coprological survey of liver flukes in cattle and sheep from an area of the southern Italian Apennines. Vet. Parasitol. 108: 137–143.

Daniel M. and Kolar J. 1990. Using satellite data to forecast the occurrence of the common tick *Ixodes ricinus* (L.). J. Hyg. Epidemiol. Microbiol. Immunol. 34: 243–252.

Daniel M., Kolar J., Zeman P., Pavelka K. and Sadlo J. 1998. Predictive map of *Ixodes ricinus* high-incidence habitats and a tick-borne encephalitis risk assessment using satellite data. Exp. Appl. Acarol. 22: 417–424.

de Castro J.J. 1997. Sustainable tick and tickborne disease control in livestock improvement in developing countries. Vet. Parasitol. 71: 77–97.

Di Todaro N., Piazza C., Otranto D. and Giangaspero A. 1999. Ticks infesting domestic animals in Italy: current acarological studies carried out in Sardinia and Basilicata regions. Parasitologia 41(Suppl. 1): 39–40.

Estrada-Peña A. 1998. Geostatistics and remote sensing as predictive tools of tick distribution: a cokriging system to estimate *Ixodes scapularis* (Acari: Ixodidae) habitat suitability in the United States and Canada from advanced very high resolution radiometer satellite imagery. J. Med. Entomol. 35: 989–995.

Estrada-Peña A. 1999. Geostatistics and remote sensing using NOAA-AVHRR satellite imagery as predictive tools in tick distribution and habitat suitability estimations for *Boophilus microplus* (Acari: Ixodidae) in South America. National Oceanographic and Atmosphere Administration – Advanced Very High Resolution Radiometer. Vet. Parasitol. 81: 73–82.

Estrada-Peña A. 2001. Forecasting habitat suitability for ticks and prevention of tick-borne diseases. Vet. Parasitol. 98: 111–132.

Estrada-Peña A. 2002. A simulation model for environmental population densities, survival rates and prevalence of *Boophilus decoloratus* (Acari: Ixodidae) using remotely sensed environmental information. Vet. Parasitol. 104: 51–78.

Estrada-Peña A. and Estrada-Peña R. 1991. Notes on *Dermacentor* ticks: redescription of *D. marginatus* with the synonymies of *D. niveus* and *D. daghestanicus* (Acari: *Ixodidae*). J. Med. Entomol. 28: 1–15.

Genchi C. and Manfredi M.T. 1999. Tick species infesting ruminants in Italy: ecological and bio-climatic factors affecting the different regional distribution. Parasitologia 41(Suppl. 1): 41–45.

Ghirotti M. and Maroli M. 1997. Ticks and tick-borne diseases as a contraint to sheep and goat production in Italy. Selected features. Parasitologia 39: 111–114.

Gilot B., Pichot J. and Doche B. 1989. Les tiques du Massif Central (France). 1. Les ixodides (Acariens, Ixodoidea) parasites des carnivores et d'ongulés domestiques sur la bordure orientale du Massif. Acarologia 30: 191–207.

Hugh-Jones M. 1989. Applications of remote sensing to the identification of the habitats of parasites and disease vectors. Parasitol. Today 5: 244–251.

Jongejan F. 1999. Integrated control of ticks and tick-borne diseases. Parasitologia 41(Suppl. 1): 51–58.

Liebisch A. 1997. General review of the tick species which parasitize sheep and goats world-wide. Parasitologia 39: 123–129.

Manilla G. 1998. Fauna d'Italia Vol. XXXVI Acari-Ixodida. Ed Calderini, Bologna, Italy.

Randolph S.E. 2000. Ticks and tick-borne disease systems in space and from space. In: Remote Sensing and Geographical Information Systems in epidemiology. Adv. Parasitol. 47: 217–240.

Thrusfield M. 1995. Veterinary Epidemiology. Blackwell Science Ltd., London, UK, pp. 138–188.