Tick-borne disease risks and livestock management: Farmer’s knowledge and practices in a Corsican valley (France)

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ABSTRACT
Tick-borne diseases are a major human and animal health problem for Western countries, particularly in view of climate change. However, farmers’ practices and knowledge of tick management remain poorly addressed. This paper examines this issue through a micro-local case study in a Corsican valley, France. Interviews using several methods were conducted with 17 ruminant or horse farmers. Despite considerable field experience, the farmers exhibit poor spatial and biological knowledge of ticks and related diseases, thus leading to a lack of appropriate management practices. However, the data collected show that these farmers could be an effective sentinel population. More efficient prevention could be developed locally through a hybridization of knowledge among farmers and scientists.

KEYWORD Livestock management; knowledge sharing; ticks; tick-borne diseases

1. Introduction
The majority of vector-borne diseases in temperate regions of the northern hemisphere are due to acarines, mainly ticks. Ticks acquire pathogens by feeding on the blood of an infected host. Transstadial transmission ensures that these ticks carry the pathogens throughout the different stages of their life and transmit the pathogens to other hosts when feeding again (Eskezia and Desta, 2016). Tick-borne diseases are a major problem, and industrialized countries are largely concerned. One of the reasons for this may be the transformation of agricultural areas in these countries, leading to significant changes in the abiotic and biotic environment that may increase the prevalence of infected ticks and human contact with them (Šumilo et al. 2008; Knap and Avšič-Županc, 2015). For example, abandoned agricultural fields have seen an increase of rodent and wildlife host populations (risk of transmission). In Europe, several tick species, such as
Ixodes ricinus, feed on humans and numerous animal species. They are important vectors of dangerous pathogens, including viruses of meningoencephalitis, and of course Lyme disease (Stanek, Wormser, Gray, Strle 2012; Dantas-Torres, Chomel, Otranto 2012; Mead 2015; Pavela, Canale, Mehlhorn, Benelli 2016). Aided by climate change, Crimean-Congo haemorrhagic fever (CCHF), which is the most widespread tick-borne viral disease affecting humans, has now reached southern parts of the European continent: the warming climate has provided favourable habitats for the Hyalomma tick mainly responsible for the disease (Ergönül 2006; Estrada-Peña et al. 2012; Bente et al. 2013; Fillâtre, Revest, Tattevin 2019). The first evidence (antibodies in bovine serums) of the emergence of the CCHF virus in France has been found recently, with the potential for its spread further north (Grech-Angelini et al. 2019). Agricultural workers appear to be the main population exposed to this virus (Bente et al. 2013), but there is insufficient knowledge about CCHF in health professions (Aydın and Dumanlı, 2017).

Furthermore, some tick agents are also highly pathogenic for livestock and cause diseases that can have a high economic impact (Pavela, Canale, Mehlhorn, Benelli 2016). Indeed, ticks and tick-borne diseases are principal factors negatively impacting livestock health and production (Almazan, Tipacam, Rodriguez, Mosqueda, Perez De Leon 2018). Although these problems are mainly found in tropical regions, livestock in industrialized countries could be increasingly affected by various tick species and the diseases they transmit, leading to significant losses in production (Eskezia and Desta, 2016). Ticks can affect cattle by causing open wounds that make the animal susceptible to secondary infection. Certain species can cause toxicosis which in turn can even lead to paralysis. Indirectly and more importantly, ticks act as vectors of fatal diseases such as babesiosis or theileriosis (Benelli 2016). Each tick bite induces stress and weakens the host’s immune response, affecting the health of the animals.

Several methods for controlling ticks and reducing livestock losses are being mobilized to address the wide range of related problems and diseases (Eskezia and Desta, 2016). For most tick-borne diseases, early treatment is essential. However, this is seldom possible because the first signs of infection are often imperceptible, and farmers rarely undertake a thorough, daily examination of their animals. Current prevention and control tools, as summarized by Pavela, Canale, Mehlhorn, Benelli (2016) and Mondal, Sarma, Saravanan (2013) include vaccines against the pathogens vectored by ticks, development of biological control programmes with agents such as biopesticides, and integrated pest management strategies that include pheromone-based control tools, grooming, pasture management, and more rarely, genetic manipulation. The most traditional mode of control and management of ticks affecting people and animals is the use of repellents and acaricides against ectoparasites (Debboun and Strickman, 2013), but these chemical controls must be applied frequently, which makes them costly and time-consuming. Moreover, today, the evolution
of resistance to acaricides among livestock tick populations renders this chemical control increasingly ineffective, thus adding impetus to the challenge of sustainable control of tick and tick-borne diseases.

In order to explain the failures of technical or organizational solutions and improve management methods, scholars have begun to develop original insights on actors’ practices and their perceptions of the danger (Bronner, Hénaux, Fortané, Hendrikk, Calavas 2014; Relun et al. 2015). The important links between farmers’ perceptions of tick-borne diseases, their actual knowledge and experiences, and the management practices employed on farms have been addressed in a few studies (Bayles, Evans, Allan 2013; Ricco and Vezzosi, 2018; Zöldi, Turunen, Lyytikäinen, Sane 2017), but these aspects remain poorly assessed in industrialized countries. Social sciences have also been less prominent than ethnoveterinary approaches in developing countries (Mugambi, Wesonga, n.d.ungu 2012; Nyahangare, Mvumi, Mutibvu 2015; Kioko, Baker, Shannon, Kiffner 2015; Sungirai, Moyo, De Clercq, Madder 2016). In light of this fact, the work by Mutavi et al. (2018) that distinguishes between techne and metis applications in tick control in Kenya is particularly interesting. Techne refers to technical scientific knowledge that is systematically derived, universal, and organized analytically. Metis addresses contextualized knowledge that is generated, repeated, and adapted by local users through local observations and experiments. In addition, Mutavi et al. (2018) incorporate the approaches of Shove et al. (2012) in order to define practice as combinations of competence (skills and routines), material (things and bodies), and meaning (attached) that are enacted and reproduced. Thus, disparity in farmers’ knowledge and practices of effective and accepted prevention strategies could lead to significant disparities in the management of tick-borne diseases and result in the coexistence of controlled and uncontrolled livestock systems.

In addition, studies of other diseases highlight that variations in the spatial perception of farmers (distance between cases of disease, distance of farm to an existing case) and associated spatial factors (viewing wildlife on their pastures, their proximity to neighbouring protected areas) have an important influence on disease management. They have also underscored the important differences between “objective” measures of risk, such as epidemiological estimates of disease prevalence, and subjective measures of disease concern, such as risk perception and acceptability of management actions (Brook and McLachlan, 2006; Mankad and Curnock, 2018). Thus, a better understanding of the livestock farmers’ knowledge is an essential element in developing effective health protection systems (Hoischen-Taubner, Bielecke, Sundrum 2018) where the farmers themselves are involved (Calba et al. 2015; Charrier, Hannachi, Barbier 2020).

Within a multidisciplinary research project combining epidemiology and social sciences, we have focused on these farmers’ perceptions of tick-borne disease risks. The purpose of this article is threefold: to highlight the elements
familiar to the farmers (local knowledge and experience) in their perceptions of tick diseases, to understand how this risk is framed at a local level, and to identify gaps between an individual’s understanding of the risk and his or her practices.

2. Material & methods

2.1. Study area & design

This study took place on the French island of Corsica, which is located off the western shore of the Italian peninsula, 11 km north of the Italian island of Sardinia. Corsica is sparsely populated (32 inhabitants/km²) and its economy is mainly based on tourism (European Union (EU) 2013). The centre of the island is mountainous, forming a single chain of 21 summits more than 2000 metres above sea level. On the eastern side of the island, the valleys descend to a plain with milder slopes and flatlands that differ significantly from the island’s other valleys. This study focuses on a specific valley shown in Figure 1, the Tavignano valley, situated between the central city of Corte and the eastern plane.

The valley’s topography is characterized by the relief typical of mid-mountain areas. The altitude varies between 450 m at the beginning of the valley (Corte) and 100 m at the end of the valley (arriving on the plain), but also along the valley between the bed of the Tavignano river and the ridges that border it. Vegetation in the pastures reflects the influence of both Mediterranean and mountain climates. We chose this location for three reasons. Firstly, markers of the emergence of CCHF virus were recently detected in Corsica (Grech-Angelini et al. 2019), raising an important health issue for French authorities, especially in Corsica where tourism is important, and agriculture is a significant activity. The emergence of the virus implies the permanent installation of the tick species, *Hyaloma marginatum*, implicated in vectoring the disease. This tick’s arrival in Corsica is probably a result of climate change dynamics that have participated in the creation of favourable conditions. CCHF virus antibodies have been found in cattle, sheep, and goats from farms located in municipalities in the Tavignano valley (Corte, Venaco, Focicchia, Tralonca, Casanova, Giuncaggio, Pancheraccia, Ponte Leccia). Secondly, there is a large amount of existing research experience focused on this valley, notably on livestock (Paoli and Kriegk, 2015) and epidemiological issues (Pavio et al. 2016; Jori et al. 2016; Charrier et al. 2018) because the valley has an important history of transhumant livestock systems, which are qualified as a zoonotic risk factor. Thirdly, the coexistence of tourism and farming professionals in the valley offers the opportunity to assess differences in their perspectives of tick-borne disease risks (Dernat and Johany, 2019a).

The study was conducted between the 3rd and the 27th of July 2019. In light of the study area, time, and resources available, 17 people were interviewed and are described in Table 1. These respondents represent the quasi-totality of livestock
professionals in the valley, lending local and territorial coherence. This is an important dimension of the study because the purpose is to understand practices and knowledge rooted in local culture and traditions. This aspect is not usually captured in the questionnaires typically used that are more likely to reflect global trends. A micro-local approach therefore provides a more exhaustive view and a social-territorial coherence even if the results are influenced by local particularities.

2.2. Data collection

The selected individuals were subjected to a one-to-one semi-structured interview lasting between one and two hours. The interview was designed to reveal knowledge and perception of ticks and tick-borne diseases and to collect data on their livestock management practices related to tick development. First, the participants are presented with a map on which the survey area is represented by a polygon. This location mapping exercise is based on the mental map method used to understand the participant’s socio-spatial representations of tick risks (Dernat and Johany, 2019b). During the exercise, they are asked to explain the reasons for placing ticks on the map. This makes it possible to see whether or not they associate the presence of ticks with spatial elements, and if so, which ones (specific locations, particular vegetation, the presence of animals, altitude, etc.). Their reasoning also helps identify the source of this
spatial knowledge: personal experiences, local knowledge derived from word of mouth, scientific knowledge. Then, a standardized questionnaire is proposed in order to assess the participant’s knowledge of ticks and the factors that influence their presence, the tick’s functioning and relationship to diseases, and his or her personal practices of prevention and management with regard to ticks and animals. The questionnaire is a proven and common method to assess knowledge and identify shared behaviours and practices regarding ticks (Aenishaenslin, Bouchard, Koffi, Ogden 2017). The questions are based on several studies, including a recent study on pharmacists’ knowledge of ticks and Lyme disease. Finally, a comprehensive interview (inspired by Claeys and Mieulet (2013) was conducted to explore how the participant’s representations and their knowledge about tick biology and prevention are linked to their tick management practices. Although the participants’ interviews followed an established grid, the questions were allowed to evolve in order to improve the understanding of the problem.

The data collection process was pre-tested with three researchers and farmers in Corsica and modified accordingly before being implemented in the study. The final version was administered by one interviewer who was also involved in its design. The interviewer recorded all the interviews in situ with a dictaphone, and the data were entered in a database.

### 2.3. Analysis methods

The collected data were classified and recorded under a key enabling the identification of each set of data, each place of collection, and each individual participating anonymously. The audio recordings were fully transcribed. Mental maps and their transcriptions were analysed individually and manually by a specifically developed method.
For the graphical analysis, each map was studied individually. To do this, the digitized figures were drawn for each of them. These figures were then compiled on the same map to give an overview of the presence of ticks within the defined territory. Then, an analysis of the discourse was carried out by identifying the elements of the space (places, types of vegetation or other) that the participants refer to when locating the presence of ticks.

The knowledge about tick and tick-born disease from questionnaires was analysed statistically: univariate statistical analyses for each question.

A thematic analysis of the interviews was made on the basis of the monographic analysis of each interview. A transversal analysis table of the central themes discussed during the interviews was drawn up and then interpreted by the researchers on the basis of a rating index visible in Appendix. This provides an overview of the participants’ perception, knowledge, practices and experience of ticks, and allows us to observe the different tendencies with respect to the different themes studied. This more qualitative analysis makes it possible to confirm or invalidate, but above all to clarify the elements of the previous questionnaire.

Finally, the data set was cross-referenced to obtain response profiles.

3. Results

3.1. Map analysis

The compilation of all the figures on the same map covers the entire territory of investigation. With the exception of a few individuals, the vast majority of participants represented their grazing areas on the map. They designated these spaces in a more or less precise manner and showed a more or less accurate knowledge of the random presence of ticks within the spaces they designated. The spaces were represented on the basis of their personal experience. Their maps show that the entire survey area is an area where ticks can be found. This demonstration of knowledge on the location of ticks corroborates the data obtained by the analysis of the discourse, namely the representation of ticks as being omnipresent in the Tavignano Valley. The cross-referencing of the figures shows that, overall, the hollow of the valley is the most represented space, but it also highlights three areas along the river (Figure 2).

The perception of ticks as almost omnipresent in the valley could explain the difficulty participants had to precisely locate them spatially. However, all the participants did make reference to the small number, or even the absence, of ticks in the mountains as soon as a certain altitude was crossed.

"Except that you can remove the high mountain, where for me [...] on the high mountain you have no risk, you see less ticks". – ID8.
This perception of ticks as being scattered throughout nature, as well as the binary vision of their presence according to altitude, reflects certain but imprecise knowledge of their presence in the valley. Nevertheless, the participants subsequently supported their comments by identifying the different spatial elements to which they associate the presence of ticks. Almost all of the participants associate the presence of ticks with types of environment where vegetation is lower and mainly composed of grasses.

“Yes, rather the grass, the vegetation, it’s not . . . We’re not going to find that in the rocks, in the Tavignano” – ID11.

In addition to the frequent mention of ticks in tall grasses, a significant proportion of participants associate the presence of ticks with cistus shrubs (commonly called rockrose in English). Cistus and their flowering appear as a spatio-temporal indicator of the presence of ticks.

“When a rockrose starts to bloom, I don’t know if you’ve seen it, there comes out a little white beard, now it’s tick season”. – ID1.

This association of ticks with cistus probably has its origin in local beliefs that have not been specifically identified here. But another insect (*Philaeus spumarius*) is often found on cistus during the insect’s larvae stage and could be a source of confusion. The participants directly describe certain biotopes as favourable to the presence of ticks. This is explicitly reported by the farmer/veterinarian (ID 17) who is competent to differentiate between the two

![Figure 2. Map locating main areas of tick presence as indicated by respondents.](image)
insects and who believes that this confusion exists among other farmers. Globally, farmers suggested that ticks could be found in both dry and wet areas as long as the vegetation is low, but some participants believe that ticks are more often found in wetlands. The borders of the Tavignano are frequently mentioned because they are seen as having a higher tick density than the rest of the area. Most of the participants appear to identify tick habitats based on their personal experience of observing ticks on their animals in places where the presence of ticks is well known.

The spatial knowledge of tick density seems limited: Although the perception of a large tick presence is held by most of the participants (13 out of 17), only a few of them distinguish places with a large number of ticks from places with a small number of ticks (5 out of 17). During the interviews, most spatial representations of ticks are noted graphically on the surface map (14 out of 17). This type of representation can be explained by the fact that the observation of ticks on livestock is the dominant way that the participants spatially localize ticks. In the discourse, they assume that ticks are everywhere, but graphically, they only locate them in the spaces that they and the livestock frequent.

### 3.2. Questionnaire analysis

A total of 15 questionnaires were completed. One participant did not wish to respond to the questions, and a choice was made not to send the questionnaire to the veterinarian who participated in the study.

- Identification of ticks and factors influencing their presence

All of the participants in the study have been confronted with ticks. The questionnaire shows that they are able to identify the ticks themselves and the factors that influence their presence. They have some spatial and temporal knowledge of ticks acquired through experience on the terrain, but they also make reference to elements of natural spaces that are not commonly identified in risk-prevention messages. Contrary to scientific modelling at the national level, half of the participants have noticed no change in the tick population, and one-third of them report a decrease in the tick population. One-third of the participants, particularly ranch managers and farmers who are also hunters, report obtaining information on ticks through the veterinarian. Two-thirds of them maintain that they do not have access to information or that they obtain it through the media and word of mouth. The responses to the questionnaire indicate that the participants’ knowledge of the subject is primarily based on personal experience and local wisdom and thus lacks precise scientific knowledge about ticks.
• Knowledge of ticks and tick-borne diseases

The participants have much less knowledge about issues related to the functioning of ticks and tick-borne diseases. They are aware of the ability of ticks to transmit diseases, but they have little knowledge of the different diseases that can be transmitted to humans and animals. Lyme disease is the risk most familiar to the participants; they explain that they became aware of this disease either through the media or through the knowledge of people affected. They do not know the different stages of development when the tick can transmit diseases, nor the different species of ticks present in Corsica. This shows that the participants have limited knowledge about the tick lifecycle and do not understand the mechanism of disease transmission (principle of reservoir hosts and vectors, and the fact that not all ticks are vectors of all diseases). In terms of potential hosts, participants responded by citing their experience and observation. Therefore, they mainly identify host animals among those that they have personally seen with ticks (dogs, cows, wild boars, horses). Half of them believe that the risk of contamination exists immediately or within the first few hours after a bite. However, more than a third of them indicate that they do not know when the risk occurs or estimate that contamination occurs at least 24 hours after a bite. This belief is a factor that increases the risk of contamination in the event of a tick bite.

• Prevention practices for individuals and animals

In terms of prevention, the questionnaire shows that less than half of the participants are aware of the different methods of prevention recommended by public health messages (wearing long clothes and high socks, using repellents). However, even among the participants claiming knowledge about prevention, most explained that they know these methods but refute their effectiveness, always with a reference to their personal experience. Most of the participants maintained that the most effective way to protect against ticks is through body inspection after exposure. Almost all of them carry out a total body inspection, or at least inspect specific parts of the body after potential exposure to ticks. To remove a tick, half of them reported using only manual techniques (fingers, tick puller), while the other half reported using solvents (gasoline, alcohol, ether). When solvents are used to sedate or poison the tick, the process can dissolve blood and body tissue; the risk of contamination is increased by the potential spread of disease pathogens. Following the bite, everyone claims to disinfect the area and more than half of them monitor the bite area for the possible appearance of a red spot. On the subject of animal prevention, the participants mainly use chemical treatments and do not know of any alternative means.
3.3. Interview analysis

A table was created (Table 2) based on the monographic analysis of each interview followed by a thematic analysis. It provides an overview of the participants’ representation, knowledge, practices and experiences with ticks. The objective of this overview is to observe the different trends with regard to the different themes studied and to identify profiles.

The table shows the degree of risk from tick bites as perceived by the participants. Half of them did not perceive ticks as a risk. The other half perceived ticks as either a low (five individuals), moderate (one individual), or high risk (two individuals), or as a central health concern in their activities (two individuals). This highlights the relatively low perception of tick-bite risk. Indeed, three quarters of the participants did not perceive ticks as a risk to themselves or their activities, or they did so only to a small extent.

The table shows that the most of the participants’ knowledge of risk was limited to the simple fact that ticks are capable of transmitting diseases to humans and animals (14 individuals). Two individuals did not know about the ability of ticks to transmit diseases to animals. One individual did not know that ticks can transmit any diseases (knowledge of allergic risk only). Three individuals had specific knowledge of ways to mitigate the risk of disease in the event of being bitten. And among these individuals, two have knowledge about the tick’s life cycle and functioning, knowledge which helps in the adoption of appropriate management practices.

The table also shows the use of different animal health management practices among livestock farmers and equestrian centres. Practices indexed between 1 and 3 are defined as weak or non-preventive management practices. Among the participants, five individuals have poor health management practices: three of

Table 2. The rating for each theme of the thematic analysis (n = 17). Each numbers’ signification is described in a rating index provided in the Appendix.

| ID | Risk perception | Knowledge | Practices | Experiences |
|----|-----------------|-----------|-----------|-------------|
| ID 1 | 2               | 1         | 4         | 4           |
| ID 2 | 2               | 5         | 5         | 4           |
| ID 3 | 1               | 2         | 2         | 4           |
| ID 4 | 2               | 2         | 4         | 4           |
| ID 5 | 1               | 3         | 4         | 4           |
| ID 6 | 1               | 3         | 1         | 3           |
| ID 7 | 1               | 3         | 4         | 3           |
| ID 8 | 1               | 3         | 1         | 4           |
| ID 9 | 1               | 3         | 3         | 4           |
| ID 10 | 1              | 3         | 4         | 4           |
| ID 11 | 5              | 3         | 5         | 4           |
| ID 12 | 5              | 3         | 5         | 4           |
| ID 13 | 1              | 3         | 4         | 1           |
| ID 14 | 1              | 3         | -         | 3           |
| ID 15 | 4              | 3         | 5         | 5           |
| ID 16 | 3              | 5         | 1         | 5           |
| ID 17 | 4              | 5         | 5         | 5           |
them have no management practices, one practices grazing, and the last one uses chemicals only on a case-by-case basis in response to health problems, but not in their prevention. On the other hand, a clear majority of the participants (11 individuals) have strong health management practices. Six of them systematically use chemical treatments (once or twice a year), and five of them systematically use chemical treatments throughout the year.

Finally, the table shows the participants’ degree of personal experience with tick risk. Eleven individuals in the population have already been bitten by a tick and are aware of at least one person who has suffered health complications from a tick bite. Four individuals have themselves suffered health complications from a tick bite, three individuals have already suffered tick bites without complications. Only two individuals claim to have no experience with humans and tick bites. These figures confirm the participant’s status as a particularly exposed population. Another significant fact is that three-quarters of them have experience with health complications due to tick bites, either directly or through their relatives.

3.4. Cross-referencing map, questionnaire and interview data

Observation of tick-risk management practices for animals shows that individuals who have intensive management practices have either a strong perception of risk, a personal experience with health consequences from tick bites, or a high level of knowledge about ticks. The choice to classify the population into different profiles based on practices was obvious for two reasons. First, the practices reflect a certain relationship to their environment that the participants do not always express explicitly. Second, when observing the practices of individuals, three categories of practices were clearly evident and evenly distributed among the participants. Information from the spatialization and the questionnaire helped to refine the profiles.

- Implementation of intensive tick management

The individuals in equestrian centres had the highest perception of risk. Ticks represent a significant risk to the health of these individuals who are in constant contact with animals. But above all, tick management is an obligation for them because ticks have a strong and continuous impact on the health of their animals. They represent health consequences that involve difficult treatments that are themselves a risk to the animal’s health as well as posing a financial burden.
“Last year, we had a few, even with the treatments, we are not immune to piroplasmosis, and it costs money. It’s expensive because in addition to the treatment of the horse, there is still a convalescence of a month, a month and a half for healing. It is an expensive treatment and the risk of losing a horse that we miss during the season”. – ID11.

Ticks represent such a significant health and financial impact that the intensive use of chemical treatments, in spite of their substantial cost, is perceived as mandatory by equestrian centre managers.

“We stopped Versatrine® for two years because it was no longer funded. We couldn’t get it; it was very expensive. We tried to find other solutions that were not very effective, and we went back to Versatrine®. We make a financial effort for the well-being of our horses”. – ID12.

Tick management appears to be a considerable financial challenge for the equine sector. The financial burden is reflected by a strong perception of tick risk. This perception of risk is accentuated by certain beliefs. Local actors believe that Equidae are particularly prone to ticks. They also believe that Corsica and the Tavignano valley are particularly infested with ticks.

“What I know about the continent [continental France], what I believe, is that there are not as many ticks, piroplasmosis in many regions in France, they do not know about it”. – ID11.

The other two participants with intensive management practices had a significant tick bite experience with health consequences. One of them contracted Lyme disease and had to be hospitalized twice; the other had a severe swelling of the arm that lasted several days. However, linking the intensive management practices of these two individuals to their personal experiences with disease or physical reactions seems risky when looking closely at each case. One of the individuals is a veterinarian (ID 20) and, as such, has a singular awareness of health problems. The second individual (ID 2) manages a horse farm. While she does treat her animals intensively, these treatments are mainly intended to control flies. Her concern for ticks is based almost exclusively on a perception of the risks to herself. She shows a relatively low perception of tick-bite risk but justifies the management practices by an overall awareness of health issues. This respondent justified her sensitivity to these questions and practices with reflexive feedback on her scientific training and knowledge about ticks. The two cases testify to the fact that their management practices are not simply a response to the phenomenon in question, but also a function of the way in which health management is conceived in its entirety and the related knowledge.

- Implementation of systematic tick management

The participants who implement systematic management practices (periodic chemical treatment not related to intermittent use) have either a strong perception of tick-bite risk or significant personal experience. However,
another group (one-third) of individuals who systematically use chemical treatments do not have a strong risk perception or significant personal experience. It is important to understand the meaning these individuals give for their practices. During the interviews, participants were frequently asked to explain their management practices. The interviews showed that in most cases the chemical treatments are not used on a fixed date but occur between mid-spring and early summer. Each farm manager has his own set of criteria for determining the date of application. Some take into account the appearance of ticks, while others rely on the weather.

“We are going to treat them at the beginning of June, in July, I will give a treatment boost, but here too, in relation to bluetongue, it will protect them a little bit and inevitably the ticks will also be affected”. – ID13.

“Before that, no, it’s rare to treat. It’s when the tick season starts”. – ID7.

Still others never treat before the period when they shear the animals (shearing of the animals and weather are linked). Overall, these individuals apply treatment between mid-April and late June.

“You have to do this after mowing, because it takes time and the sheep leave (on pasture). They are mowed, a week later, we put the product through and it’s effective”. – ID1.

“The treatment, we’re going to do it the moment we get into the heat of the sheep. Let’s say at the end of April.” – ID5.

These livestock farmers systematically treat their entire herd once a year. They may treat a second time when they consider it necessary. The most frequently used treatment is Versatrine® but some farmers also use Butox® or Deltanil®. In France, these treatments are generally indicated for use in ectoparasite control, and for Butox® and Deltanil® this includes ticks (Coudert 2019). But in these particular cases, the treatments are primarily intended to prevent mosquitoes that can be vectors of BTV (bluetongue virus). It is the prevention of bluetongue that introduced and made the practice systematic among these farmers. Most of them are not sure of the impact of these treatments on tick populations. These circumstances reflect their limited technical knowledge on the control of ticks.

“We do this for ticks too … but especially mosquitoes, related to bluetongue”. – ID5.

“We treat for mosquitoes, but I think it must be against ticks too”. – ID10.

Farmers unanimously consider these chemical treatments to be effective. Especially, those who have experienced the difficulties of managing health issues before the arrival of chemical treatments. This may explain the fact that the use of chemical treatments has been integrated into their practices.

“There was no Versatrine®, nothing. Even when the sheep had worms, there was only a little bit of Cresyl®. Now you put a little spray on a sting, and the next day there are no ticks left”. – ID10.

• No management practice
Another group of farmers do not implement external pest management practices. All but one of these individuals offer similar reasons as justification for the absence of practices. Overall, they explain that they are not confronted with ticks, or that they are confronted with them in insignificant proportions that do not require the use of chemical treatments or other methods of control.

“I don’t treat because I don’t have a problem with ticks”. – ID6.

Some of them feel the use of chemical treatments does not seem necessary, because the current situation is much less problematic than they experienced in the past. In addition the price of chemical treatments is perceived as high.

“Twenty years ago, there were many more [ticks], cows were systematically treated every two months. Since then, in a manner of speaking, I haven’t seen any more.” – ID9.

“Now a bottle of ¾ of a litre is two hundred euros and we have to pay for it. Since there are no ticks, we don’t use them”. – ID3.

These individuals have similar characteristics with respect to ticks. They have a low risk perception, their knowledge of ticks is consistent with their experiences and observations, and they have had at least one bite experience. Only one individual (ID16) has a different perspective on ticks. This participant showed a strong perception of tick risk and a high level of knowledge at the time of the interview. He also claimed extensive experience with tick bites due to fishing and hunting activities, during which he is particularly attentive to the quantities and varieties of ticks he meets. This individual is the only pig farmer in this study. In his opinion, pigs are not particularly affected by ticks, but he does not offer any further explanation.

3.5. Possible bias

The sample of livestock professionals in the valley is very representative, and we have used triangulation to cross different data and reinforce the analysis, which makes the results more reliable. Nevertheless, it remains possible that unidentified cultural elements specific to this area could have influenced the interviews, despite our coordination with Corsican scientists.

In the thematic analysis, the rating index is based on a condensed measure of several elements: this gives a transversal view of knowledge and practices. Interpretations can be difficult and carry a risk of bias in the representation of actual knowledge possessed. For example, someone could be knowledgeable about tick biology (life cycle, spread) but lack knowledge of risks for tick-borne human and animal diseases and human prevention practices. However, being aware of this, we cross-referenced the analysis to avoid misinterpretation. In any subsequent scientific use of this analysis, attention must be paid to these limits and the need to adapt an index to different contexts.
4. Discussion

4.1. A risk underestimated by farmers in terms of local knowledge and practices

There is a link between the perception of tick-bite risk and the implementation of management practices. With respect to the incidence of ticks, the results attest to a monitoring posture among participants. Although in general, the participants do not have a high level of biological knowledge about ticks and are not overly concerned about them, we can see from their various discourses that they are attentive to the phenomenon. This attitude is confirmed by the analysis of the three methods. Many livestock farmers have developed a predictive reasoning based on the presence of ticks (in what quantity and at what time of the year) and according to climatic conditions (winter and spring temperatures and spring rainfall) as can be seen in the results of Kioko et al. (2015). Here we see the farmers’ use of contextualized or situational knowledge (metis) previously described by Mutavi et al. (2018) as it relates to their practices. During our initial interviews, farmers were not surprised by the low density and late arrival of ticks after a particularly cool and rainy spring. At the same time, some anticipated a sharp increase in early summer due to the mild winter climate. Finally, others believed that the cold snap that hit the area in mid-May must have decimated tick populations.

In contrary to the observations of Ricco and Vezzosi (2018), for the majority of farmers interviewed, ticks are perceived as a low risk. The phenomenon is seen as a normal and almost inseparable part of livestock farming. Since they observe few visible health consequences in animals and consider the incidence of tick-borne diseases in humans to be rare, they do not see ticks as a problem for their personal health or for their livestock activities. Among the study’s sheep and cattle farmers over 45 years of age, there is even a tendency to see lower risks of tick-bite today than in the past. They explain this phenomenon by the widespread use of chemical treatments in livestock farming: a practice financed and generalized in the early 2000s as part of the prevention against bluetongue. This use of chemical treatments as a livestock health management practice was introduced at the same time as an overall transformation of livestock systems. This transformation was symbolized by the decline of transhumant pastoralism, in which the ascent to the summer pastures was seen as the traditional way of managing parasites in livestock farming. The use of chemical treatments has replaced this practice for new farmers as well as for those who no longer practice transhumance.

The case of equestrian centres presents an exception. There seems to be a close link between the way tick-bite risk is perceived and the professional activity of the study’s participants. For equestrian centres, ticks represent a particularly significant financial impact because of the cost of preventative treatment. There are also the consequences of the affected animals’ health
(which can limit their usefulness), the extra working time involved, and a risk to human health (although to a much lesser degree). The fact that these centres are also dependent on tourism can add to the financial and health concerns of tick-bite risk.

All of these elements raise questions about information access and sharing between an exposed public and the scientific and medical world. In France, there is no readily available centre of knowledge specific to information about ticks. Some information can be found on the internet, but this source was not identified by the farmers. In this respect, the veterinarians could be major actors: in France, they are the local source for livestock disease prevention strategy. But, in the results, they are only rarely mentioned by farmers as a direct source of information, their contribution often appeared to be limited to the act of providing a prescription. As also seen in the results of a study on pig diseases in Corsica (Calba et al. 2015), this type of relationship without dialogue has a direct impact on farmers’ practices. They might apply the veterinarian’s instructions without being fully aware of the consequences. Chemical treatments, which are aimed at the global prevention of external parasites, might be used without any real knowledge of their effects. A lack of information and awareness leaves considerable latitude for farmers to interpret the rationale and use of these products.

As discussed by Enticott (2008, 2012) and Coquil et al. (2018), top-down interventions based on generic knowledge are not adapted to local particularities (ecological processes, micro-climates, etc.) or to the individual needs of farmers. These types of interventions independently define the choice to use these treatments without precise knowledge about the products used or the pest controlled, or on the modalities of when and how often they should be applied. This tends to increase the phenomenon of autonomization or individualization of management practices. The relatively weak status of veterinary advice as seen in this study provides a good example of the limits of a scientific knowledge-based approach (techne) in a context dominated by an experiential knowledge-based (metis) perspective, represented here by the local knowledge and practices of farmers (Mutavi, Aarts, Van Paassen, Heitkönig, Wieland 2018).

4.2. The need for a local approach to manage risks and share knowledge

Despite limited interaction with veterinarians as a source of information, our results show that livestock farmers and equestrian centres in the Tavignano Valley, clearly constitute a typical sentinel population for tick surveillance, specifically in terms of their non-academic and situational knowledge (Toffolini, Jeuffroy, Mischler, Pernel, Prost 2017). These individuals notice the presence of different varieties of ticks according to both their appearance and their behaviour (ability to move, time of year). Most of the farmers seem to have observed the more or less recent appearance of \textit{Hyalomma}
Marginatum, and some have clearly identified it. They are actually confronted with this tick, even if they have not yet been given any specific information about it. They have access in the field to precise information on the presence and evolution of ticks, information that is not always available to scientists. These “local experts” (Callon, Lascoumes, Barthe 2001; Davis and Wagner, 2003) therefore have the ability to detect the small but essential signals and sound the alert that measures are needed for the prevention of emerging diseases such as CCHF.

It would seem necessary to think of tick management in terms of both surveillance and prevention, and as a collaborative approach built at the local level (Dernat and Johany, 2019b). It is imperative to enrol farmers, equestrian centres and other actors as a “sentinel population”, but also to share their local knowledge and confront them with scientific knowledge (Thomas, Riley, Spees 2020). It is also about reaching out to people who are usually excluded from the debate (Coudel et al. 2017) those found outside the traditional circle of political or administrative representatives. Taylor and De Loë (2012) have shown that scientists’ and public managers’ “epistemological anxiety” about local knowledge was a significant barrier to its effective use in decision-making. Moreover, the owners of local knowledge (such as farmers) do not always feel concerned, legitimate or even competent to participate in the governance of their sector (Sterling et al. 2017). As seen in the results of Mutaví et al. (2018), hybridization would make it possible for them to share experiences and express feedback on their practices and observations, in conjunction with experts. The experts could transmit their academic knowledge and guarantee a certain expertise in the discussions by validating or invalidating certain information or beliefs. This hybridization incorporates the benefits of both forms of knowledge rather than using knowledge selectively without contextual meaning for users (Lin et Law, 2014). Similarly, maps like the one created from all the representations of the study sample, could interest scientists and be a reference point on the presence of ticks in the valley. It would also be interesting for locals to have access to direct input from epidemiologists, doctors or veterinarians on tick-related issues: actual risks for animals and humans, information on the ticks’ life cycles, the tick population’s evolution over time. This would enable exchanges on the issues pertinent to the dynamics of both livestock farming and tourism in the Tavignano valley.

With these interactions, local actors could certainly become more aware of the risks, but they could also learn about management practices and how to take greater responsibility for the effective use of chemical treatments. Formalization through a living lab might be a particularly suitable modality. It would allow the organization of the described interactions while enhancing the knowledge of each person. For example, in eastern France there is a living lab initiative on ticks conducted by researchers (CiTique 2019). Currently, this initiative is focused on involving the general public and environmental
facilitators to promote the sharing of scientific and local knowledge on ticks. Our study shows that extending this type of initiative to livestock farmers in a context such as Corsica would be beneficial for both research and local livestock farming.

5. Conclusion

This study highlights the importance of questioning the relevance of traditional top-down knowledge transfer as an operating mode for the management of ticks and tick-borne diseases. The current situation in the Tavignano Valley reveals a weak level of scientific knowledge among livestock farmers and a high level of risk-prone practices. However, there is an opportunity in terms of their experience and local knowledge: they can become sentinels. This could be accomplished by incorporating their knowledge in hybridization strategies that might be inspired by the responses to other health issues, such as the mobilization of living labs.

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Ethics

The implementation of interviews among French citizens did not require a specific Ethics review process at the moment of the research. Participation of farmers to the interviews was done on a voluntary basis after phone call contact. Participants were informed in advance about details of how the data would be used, assuring anonymity, and in accordance with French regulations at the time of data collection, each participant signed a consent form authorizing the collection and secure storage of their data.

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Appendix

Rating index of each theme in the thematic analysis.

Perception of the risk of ticks and tick-borne diseases for professional activity:
1: a perception of no risk.
2: a perception of low risk.
3: a perception of moderate risk.
4: a perception of high risk.
5: ticks are a major concern.

Knowledge about risks due to tick-borne diseases:
1: knowledge limited to the risk of allergic reactions or skin rashes (erythema).
2: knowledge about the risk of human diseases transmitted by ticks-bites (e.g. Lyme).
3: knowledge about the risk of tick-borne diseases for both humans and animals.
4: knowledge about the risk of diseases for humans and animals and of how diseases spread (hosts).
5: knowledge about tick biology (life cycle, spread), the risk of tick-borne human and animal diseases and human prevention practices.

Management practices:
1: Lack of health management practices regarding ticks (purging is a management practice against internal parasites).
2: Moving herds to summer pastures believed to be a management practice.
3: Use of chemical treatments on a case-by-case basis depending on the presence of ticks, rashes or other health problems.
4: Use of chemical treatments on an annual and systematic basis (1 or 2 treatments maximum).
5: Intensive and systematic use of chemical treatments for several months of the year (more than 2 treatments).

Personal experience with tick bites:
1: No personal experience of tick bites.
2: Heard of experiences of tick bites with health consequences (illness and/or hospitalization).
3: Personal experience of tick bites without health consequences.
4: Personal experience of tick biting + heard of experiences of tick biting with health consequences (illness and/or hospitalisation).
5: Personal experience of tick bites with health consequences (illness and/or hospitalisation).