From biosecurity to security ecologies: An analysis between old dairy farming traditions and routines and veterinary recommendations in Spain

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1. Abstract

Biosecurity has gained significant interest in farm animal health in recent years. However, in dairy cattle farms, there is slight, or no implementation of biosecurity practices recommended by official authorities and techno-scientific experts. This situation might be explained by the tension between old farming traditions and routines and veterinary recommendations. We draw upon Lefebvre's three-fold model of space, which addresses spatial practices (old traditions and routines), representations of space (recommendations) and representational space (final implementation of biosecurity measures), constituting security ecologies to understand what might be happening by using an ethnographic approach on two farms in Galicia and two in Catalonia in Spain. The three biosecurity practices considered are management of dead animals; control of vectors and pests; and animal management. The results show that farms have different specific contexts, and that the reasons behind the positions of farmers and veterinarians, effective communication and common sense need to be considered. Security ecologies based on Lefebvre's model could therefore be a positive mechanism for ensuring the implementation of biosecurity, beyond the visions of authorities or specialists.

Keywords: Biosecurity, Lefebvre's model, old farming traditions, security ecology, veterinary recommendations

2. Introduction

The concept of biosecurity can have specific meanings in different disciplines. This term has been used from threats of infectious origin to threats of human origin (Hinchliffe, 2017; Koblentz, 2010). Thus, it is possible to identify four areas of biosecurity: emerging infectious diseases, bioterrorism, innovation and transformation of life sciences, and food security (Collier & Lakoff, 2008). In this way, we see biosecurity as a strategic, integrated approach to the analysis and management of major

hazards to human, animal and plant health and life, as well as to the environment (WHO, 2010); where one of its main areas of attention is farm animal health in relatively recent years, being internationally led by the World Animal Health Organization (OIE; FAO, 2007).

Therefore, it is possible to define biosecurity within farm animal health as "*a set of management and physical measures designed to reduce the risk of introduction, establishment and spread of animal diseases, infections or infestations to, from and within an animal population*" (OIE, 2018). This notion includes a set of technical and political measures to prevent, control, manage and/or contain infectious diseases on livestock farms on an individual and collective level (Bingham & Hinchliffe, 2008; Braun, 2007).

International organisations and national governments, through standards and guidelines, seek to harmonise the various biosecurity measures that exist around the world (Dibden et al., 2011). In this sense, in the last two decades, several authorities have joined efforts to promote biosecurity protocols (EC, 2003). For instance, the OIE has generated biosecurity recommendations that can serve as the basis for legislation in each country (OIE, 2019) and the Food and Agriculture Organisation of the United Nations (FAO) has highlighted the importance of promoting such recommendations, emphasising the limitations that strict legislation on biosecurity could cause to developing countries and the need to create global, integrated biosecurity strategies (FAO, 2007). In this vein, Europe currently has its Animal Health Law (Regulation (EU) 2016/429), which states that biosecurity is a requirement to manage farm animal health in an efficient manner, and that it must be flexible, adaptable to different types of production and animal species and consider local circumstances. Following these recommendations, Spain has established regulations such as the Management of Livestock Farms (Decree 40/2014). However, it is important to highlight that there are no widespread or specific official regulations on biosecurity on dairy cattle farms, although this situation might change in the near future (MAPA, 2019).

Biosecurity measures are intended to prevent pathogens entering from outside (i.e., external biosecurity), or to control spread within the herd (i.e., internal biosecurity). As it is very well known, external biosecurity is the more efficient form of control, but if it fails and there is an outbreak, internal biosecurity becomes the more important line of defence (FAO, 2010). External biosecurity can include measures related to the entry and exit of animals, removal of dead animals, visits and personnel, vehicles and equipment, vectors and pests, and fodder and water. In turn, internal biosecurity includes animal management, cleaning and disinfection, and labour routines (Dewulf & Van Immerseel, 2018; Sarrazin et al., 2018). For example, biosecurity can address the main infectious diseases present on dairy cattle farms such as Bovine Viral Diarrhoea (BVD), Infectious Bovine

Rhinotracheitis (IBR) and Bovine Tuberculosis (BT), as is the case in Spain (MAPA, 2020a; Renault et al., 2018a). Biosecurity can therefore reduce mortality (Renault et al., 2020), improve animal health (Oliveira et al., 2017) and welfare (Hristov et al., 2011) and, consequently, increase animal productivity (Postma et al., 2016a). A relationship has also been described between greater biosecurity and less use of antibiotics (Isomura et al., 2018; Postma et al., 2016b; Laanen et al., 2013).

Different livestock farmers, such as cattle, swine and poultry farmers, have shared their perceptions about infectious diseases and biosecurity, and generally claim that there are little or no limitations on the implementation of biosecurity measures (Laanen et al., 2014). However, swine farms have a higher level of biosecurity than cattle farms (Sahlström et al., 2014; Nöremark et al., 2010). Dairy cattle farmers implement biosecurity practices in a heterogeneous manner that may not observe biosecurity standards, sometimes including little or no implementation (Renault et al., 2018b; Sahlström et al., 2014; Brennan & Christley, 2012). There are considered to be various (favourable and unfavourable) internal and external factors that determine whether farmers implement biosecurity practices, such as: experience, knowledge, understanding, attitude, motivation, sources of information, economy, perception of the importance and effect of biosecurity, animal welfare, internal and external cohesion, obligatory and voluntary biosecurity, availability of time and space, farm size and facilities, climate and behaviour of other agents, among others (Moya et al., 2020; Renault et al., 2018c; Ciaravino et al., 2017; Broughan et al., 2016; Frössling & Nöremark, 2016; Naylor et al., 2016; Toma et al., 2015; García & Coelho, 2014; Laanen et al., 2014; Sarrazin et al., 2014; Brennan & Christley, 2013; Toma et al., 2013; Nöremark et al., 2010).

Due to all the above, dairy cattle farms can be considered one of the agroeconomic sectors that faces the greatest problems with implementing biosecurity practices. The present research focuses on this problem and examines how biosecurity practices are carried out on dairy farms. Our main objective is to analyse and understand the problems associated with the implementation of biosecurity practices, and why this process sometimes fails, or even worse, is inexistent. We explore the relationship between the recommendations by veterinarians and the old traditions and routines that have traditionally guided biosecurity practices on dairy farms. To do so, we introduce the three-fold model of space proposed by the philosopher H. Lefebvre (1991) and the 'security-ecology' concept to understand how daily practices are developed and established by their users. After this introduction, we detail our empirical research from ethnographic approach, which focuses on the implementation of biosecurity practices on four Spanish dairy farms. Finally, we conclude that the problem described in the scientific literature of there being little or no implementation of biosecurity practices on such farms is a reductionist view of the real situation. Thus, biosecurity

practices are used on farms, and biosecurity recommendations are considered. However, these official measures are combined and mixed with old traditions and routines. We have regarded as security ecologies those daily practices that combine veterinary recommendations with farmers' traditions and routines, in a new way of securing life.

3. From Lefebvre's model to security ecology

In 2018, Fuchs observed that H. Lefebvre (1991) had been interested in understanding how human beings (for instance, veterinarians and dairy farmers) produce their own lives, consciousness, and worlds, and how they mobilise various elements to achieve a purpose (for example, biosecurity), and articulate their daily practices to order and give meaning to their existence. Such processes not only involve the production of social relations, but also spaces, where bodies are produced, and in turn, generate new spaces. Thus, spaces are considered a product and a means of production where various sets of relationships and forms coexist. It is also possible for causes and effects to be found in the same space, where past actions, such as old traditions and routines, can have an impact on future actions, such as recommendations, and vice versa. It is important to note that spaces are not only demarcated physically, but also by means of speech and signs that generate symbols, such as biosecurity measures and biosecurity legislation. In this sense, the real and the symbolic revolve around the imaginary (i.e., around the possible scenarios in which infectious diseases are transmitted on farms). It should be pointed out, however, the different modes of production that Lefebvre described are characterized by a lack of attention to historically concrete forms of difference (Kinkaid, 2020). Nevertheless, in this study such historical processes are considered, which are closely linked to old traditions and routines. In fact, considering the logic set forth by Hinchliffe & Ward (2014), old dairy farming traditions and routines that affect biosecurity contribute to the diversity of epidemiological units (i.e., groups of animals with a defined epidemiological relationship that approximately share the same probability of exposure to a pathogen, because they share common practices or environments; OIE, 2018). Such diversity, along with the existing spatial and microbiological diversity, could contribute to animal health.

Lefebvre (1991) defined three distinct sets of practices: a) spatial practices, where old traditions and routines are generated based on the historical knowledge of those who perform them (in our case dairy farmers); b) representations of space, where techno-scientific knowledge is relevant (in our case recommendations by veterinarians), and c) representational space, the final product or combination of the previous set of practices (in our case the space where biosecurity measures are ultimately implemented). Although Beyes & Steyaert (2011) also reframe the representational space as the rhythms, cycles, movements and flows, encounters, intensities, capacities and forces, events;

instincts, affects, atmospheres and auras; relations, knots and assemblages. In fact, we must consider that knowledge of farmers and veterinarians comprises both objective (independent of the social context) and subjective (context-dependent and not easily transferable to other contexts) attributes, possessing three fundamental fields: rational (explicit knowledge), typically characteristic of veterinarian' knowledge, and emotional (bodily, emotional and sentimental response to external stimuli) and spiritual (ethical values and principles), typically characteristic of farmer' knowledge (Bolisani & Bratianu, 2017). In this sense, a field of knowledge can be transformed into any other field, since they are in continuous interaction and transformation (Bratianu, 2016). Thus, decision making in relation to biosecurity is the product of a conversion and combination of two or more fields of knowledge and, therefore, the rational field alone is not adequate (Bratianu & Vătămănescu, 2018). Therefore, the three previous sets of spatial practices should not be understood as independent or hierarchical (Beyes, 2018). These dimensions must be tackled in an integrated way, which are interacting in a single moment of social space, within which power relations and hierarchies operate; although it may be useful to distinguish them to analyse potentially dominated and free spaces, and to pay attention to significantly different dynamics (Dale & Burrell, 2008; Taylor & Spicer, 2007).

According to Lefebvre (1991) it is also possible for there to be a dominant space that strives to mould other spaces on its periphery. This could be the case with the techno-scientific recommendations of veterinarians who have the support of various legislations of international and national bodies with regard to old farming traditions and routines. Thus, a dominant group is able to organise and instrumentalise a social space in its own interest. However, the dominant group does not necessarily benefit, since all those who live in this space can also do so, such as dairy farmers, even more so if there is a participatory design that includes the dominated group.

In general, Lefebvre's triple space model is not usually applied in biosecurity studies, although there are other investigations within the rural field that have used it, such as that carried out by Halfacree (2006). In this research it can be evidenced how Lefebvre's model addresses rural localities (spatial practices), formal representations of the rural (representations of space) and everyday lives of the rural (representational space). In this sense, there could be a complementarity with the present study in the way in which this model has been used, such as dissolving the duality between spatial practices and representations of space, generating a tension among all the parts to varying degrees. Therefore, Lefebvre's model could have several applications that could be perfectly used by the rural sector, to help not only go beyond dualisms, but even understand new processes that embrace disparate elements that may be in tension dynamics. Thus, in this study, Lefebvre's model is of value in understanding what happens behind the final implementation of biosecurity measures,

specifically in relation to the representational space, where there is tension between farmer knowledge, through its old traditions and routines, and veterinarian knowledge, through its recommendations.

In relation to biosecurity practices, dairy farmers could be committed to them, but not necessarily take into account the official biosecurity measures recommended by techno-scientific experts and are instead more flexible and adaptive (Higgins et al., 2016a). It is also interesting to consider the complexity and specificity of farmers' contexts (Naylor et al., 2016), as biosecurity practices have limited value if they are not localised. Hence, it is necessary that biosecurity practices, that are heterogeneous, are adequate to farmers, who should decide for themselves which measures to implement (Enticott et al., 2012; Enticott, 2008a). In addition, the way farmers perceive and respond to the risk of infectious diseases might influence such implementation (Enticott & Wilkinson, 2013). Thus, biosecurity can generate processes of adaptation to local social and ecological conditions that could coexist alongside the uncertainty of infectious diseases (Higgins et al., 2016a; Enticott et al., 2012). This generates mixed practices that we have called security ecologies, which describe how tensions between recommendations and old traditions and routines ultimately lead to the implementation of biosecurity.

To understand security ecologies, it is useful to briefly explore the 'disease-ecology' concept. This term originally only considered a disease agent and a host, whose contact at the same time and place generated the occurrence of disease (May, 1950). However, this concept has been incorporating and combining social, cultural, political, economic and environmental factors (Oppong & Harold, 2009; Mayer, 1996). In this sense, the effects of anthropogenic elements can have various effects on the disease process within disease prevention and control strategies, integrated by the relationship between disease, humans and animals, and their environment (Oppong & Huddleston, 2014; Keesing & Ostfeld, 2011; Wilcox & Gubler, 2005). It is possible to appreciate the extension of disease ecology in other related areas such as epidemiology, combining different subjectivities, spatialities and materialities that can address diseases in different ways (Enticott & Ward, 2019). In this regards, new configurations of epidemiology are created, which are transformed into a border practices that are remodelled to adapt to a context. Thus, these configurations, with their social and biological dimensions, must be recognized to facilitate disease management (Enticott & Ward, 2019; Hinchliffe et al., 2013).

Collecting some of the previous elements, the security-ecology concept is derived from a social ecological perspective whose subject of analysis is situated within a specific context, which can determine the behaviour of its environment through the influence of intrapersonal, interpersonal,

community, socio-political and institutional factors (Green et al., 1996). In this sense, security ecology refers to the creation of spaces that shape specific situations where agents deal with unpredictable dimensions, such as infectious diseases, by incorporating local elements to predict and adjust to their environment (Lorway et al., 2018). In fact, security ecology is very close to the practices described above, where borders are mixed and crossed to maintain a pathological life (i.e., the interactions of the elements that are behind the disease in relation to the powers and threats active to life; Hinchliffe et al., 2013). Although, in this case, it is to maintain a biosecurity adapted to the various contexts through a hybridization of old farming traditions and routines and veterinary recommendations. Thus, security ecology describes how dairy farmers, veterinarians, and the tensions between them can intervene in and modify their environment through the final implementation of biosecurity, which ultimately achieves the biosecurity objectives, whether or not recognised by the authorities or experts. This helps to appreciate how dairy farmers can create their own security environments, where both forms of knowledge (i.e., old farming traditions and routines and recommendations) are intertwined and create a heterogeneous space. Lefebvre's model is therefore ideal since it is mainly based on practices that can permeate biosecurity practices, and in turn, organize these perfectly, thus generating security ecologies.

4. A conflictive relationship between recommendations and old traditions and routines

Generally speaking, at present, dairy cattle farmers and veterinarians are mainly responsible for carrying out biosecurity practices (Higgins et al., 2016b; Donaldson, 2013; Gunn et al., 2008). However, farmers tend not to agree with that situation, believing the contribution from organisations and governments, which they do not fully trust, to be insufficient (Palmer et al., 2009; Heffernan et al., 2008; Gunn et al., 2008). In Spain, as established by the Ministry of Agriculture, Fisheries and Food, those responsible for implementing biosecurity are all the people who, directly or indirectly, work with animals, such as farmers, veterinarians, transporters, farm maintenance personnel, slaughterhouse personnel, among others (MAPA, 2020b).

In Spain there are private veterinarians (e.g. clinical, reproduction, milk-quality or nutrition specialists, among others), animal health veterinarians (AHV) and official veterinary services (related to the public administration). Of these, AHV have training and experience in biosecurity practices above other veterinarians and participate in control programs of regulated and/or non-regulated diseases. For example, in Galicia (northwest of Spain), AHV are contracted by an animal health defence association (HDA) to carry out control programs of non-regulated diseases such as BVD, but not for regulated diseases such as BT, which are controlled by AHV contracted by public companies through programs of mandatory eradication. While in Catalonia (northeast of Spain), AHV of an HDA

only carry out control programs of regulated diseases, and there are no control programs of non-regulated diseases. Veterinarians are key agents in the livestock industry, being an important source of information that could influence farmers with regard to infectious diseases and biosecurity management (Moya et al., 2020; Ciaravino et al., 2017). In some European countries, such as Belgium, France and Spain, most cattle veterinarians consider biosecurity a priority for their profession, and their perceptions of biosecurity can influence its proper implementation (Renault et al., 2018c). It is therefore important, in general terms, for veterinarians to have sound knowledge of epidemiology when developing and implementing control programs for biosecurity and infectious diseases on farms, at regional and national levels (Robertson, 2020).

Despite the above, typically veterinarians seem to lack effective strategies to turn their knowledge of infectious diseases and biosecurity into actual practice among farmers (Ruston et al., 2016), even though they regularly come from the farming industry and their gradual entry into this sector is increasing (Shortall et al., 2018). There are often communicative inconsistencies or contradictions between veterinarians and cattle farmers with regard to their opinions and the implementation of biosecurity, which, at the same time, might be influenced by regional, age and farm size differences (Sayers et al., 2014; Sayers et al., 2013). Additionally, as Silvasti (2003) highlighted, an understanding of these inconsistencies or contradictions requires knowledge of the farming way of life, in which old traditions and routines are important.

To understand the problem in Spain, it is important to know about the history of dairy farming in the country, and its traditions and routines. In the 19th and 20th centuries there was an increase in the number of heads of cattle on Spanish dairy farms, mainly due to the need to supply cities, especially in Autonomous Communities (AC) such as Galicia (Langreo, 1995). In the 1920s and 1930s, there was an intense process of industrialisation of the dairy sector in such regions as Catalonia (Hernández, 2017). Following the Spanish Civil War, certain principal productive areas such as Galicia were maintained, while others were isolated and punished, such as Catalonia, which had to seek new trade channels. In the post-war era, dairy farming was one of the slowest agricultural sectors to recover. Although the agricultural sector underwent modernisation in the 1950s, there was little industrialisation of farms, despite their rapid increase in production. The greatest increases occurred between 1965 and 1970, while progress was slower from 1975 to 1985, despite improved yields. Moreover, 84% of farms had fewer than 10 cows per farm, making them difficult to modernise, and 45% of farmers were over 55 years old, while only 8-9% were under 40 years. The dairy sector was finally expanded and modernised in the late 1980s (Langreo, 1995). It can therefore be observed that Spanish dairy production has been characterised by high regional specialisation and high heterogeneity. Nowadays, Galician dairy farms tend to be medium to large, and modernised; while

in Catalonia they tend to be large and are often owned by large production companies (De Llano, 1989; MAPAMA, 2016). Galicia has 55% of the country's dairy farms with an average of 43 cows per farm, while Catalonia has 4% of the farms but an average of 144 cows per farm (MAPAMA, 2018).

Generally, that historical process can be associated with consolidation of the use on dairy cattle farms of old traditions and routines related with the security, animal production and conservation of land, and farmers and their families (Singleton, 2010). This point is important because issues related to old traditions and routines in terms of identity and symbolic meaning can clearly determine the direction of dairy sector and are relevant for understanding how farmers perceive and respond to the world (Burton, 2004). Authors such as Waage & Mumford (2008) consider these elements of animal production to be key factors for understanding processes of resistance and resilience on farms.

Some initiatives have included old dairy farming traditions and routines among their main elements, such as the Amsterdam Treaty on animal welfare, which is closely related to biosecurity (Kümmerlen et al., 2019; EU, 1997). These old traditions and routines can have various effects on dairy farming contexts. For example, in some parts of Europe as Spain, the matter generates major difficulties for young people looking to join the livestock sector and help to restructure its identity (Góngora, 2019; Fischer & Burton, 2014; Kontogeorgos et al., 2014), which is leading to greater aging and less generational turnover, as opposed to other European countries (Lobley, 2010). However, this might be positive for the continuity of rural practices (Joosse & Grubbström, 2017). Gender issues are another example, wherein men tend to work with machinery, while women focus more on animal health and welfare (Kallioniemi & Kymäläinen, 2012).

Despite these initiatives, the conflictive relationship between official measures, especially those focused on biosecurity, and old traditions and routines that have survived on dairy cattle farms for decades, is still present. For some researchers, this is the direct reason for there being little or no implementation of the former on many dairy farms, and for the failure of solutions proposed by institutional sectors, which include pressurising and even strongly penalizing dairy farmers. However, there is a blind spot in the literature, namely that institutional actors do not usually consider traditional and routine farming practices to hold any value in themselves or be able to guarantee any kind of security. To better understand this value and why it has survived so strongly and for so long, as well as the relationship established between the official measures and the old traditions and routines, we can refer back to Lefebvre's model and security ecology dimension previously explored.

5. Data collection

The present research was conducted on four dairy farms in Spain, in Galicia (two) and Catalonia (two), which are described in Table 1. Furthermore, veterinarian data was obtained from private clinical and reproductive veterinarians. The research was based on a mainly ethnographic approach, whereby the ethnographer spent time collecting data on people's daily lives, to thus give shape and content to social processes (Hammersley & Atkinson, 1994). Several studies have used ethnographic approach, such as those by Høg et al. (2018) on the perception of biosecurity among key agents in production; Rimi et al. (2016) on the kind of messages that raise awareness of bird flu among rural people; and Keck (2015) on the practices of people from farms and laboratories with regard to biosecurity and bird flu, among many others. The ethnographic approach involved full-time participant observation for about two weeks on each farm, together with personal notes collected in a field diary for later analysis.

[Place Table 1 around here]

The dairy farms were selected in two stages. Several dairy farmers were contacted who had previously been linked directly or indirectly to one of researchers. They were told of the general and specific objectives and the activities that could be conducted during data collection, and then agreed or refused to participate. Together with the farmers who agreed to participate, the roles and rules that ethnographer would perform and respect on each farm were established, and the participants filled out an informed consent form.

It is important to note that the ethnographer was a veterinarian with theoretical experience in infectious diseases and epidemiology and practical experience on dairy farms, and who had received training in sociological methodologies and techniques. The ethnographer therefore played a mixed role, mainly using his profession as a veterinarian, but also as a farm worker (depending on situations that arose) to gain access to the field and collect data. For example, as a veterinarian, they made recommendations on animal health and biosecurity, while, as farm worker, they performed everyday chores such as milking and feeding cattle and cleaning beds. In general, the ethnographer was permanently in the company of dairy farmers and farm workers and, ultimately, of veterinarians who visited these farms.

From those ethnographic experiences, we selected three vignettes to illustrate how security ecologies emerge from the combination of official biosecurity measures and old traditions and routines. These were selected on the basis of three criteria: a) transversal (i.e., biosecurity measures present on two or more farms), b) variability (i.e., heterogeneous implementation of biosecurity practices), and c) availability of data (i.e., quantity and quality of empirical material that involves

biosecurity practices). We present the results in the following manner: management of dead animals (external), control of vectors and pests (external), and animal management (internal).

6. The tug and pull between veterinarians and dairy farmers

7.1 Management of dead animals:

Dead animals were removed from farms by specialised companies. The veterinarians instructed that dead animals should be disposed for collection in an isolated, enclosed place:

> *"(…) The veterinarian told the farmer: 'I'm tired of saying this again, but if I have to, I'll keep saying it until you do it'. These words alluded to biosecurity practices regarding dead animals. The veterinarian pointed out that the farmer needed to keep dead animals far apart from healthy animals, ideally in an isolated, enclosed area adjacent to a driveway. However, the veterinarian also reminded the farmer that the best option would be to invest in building a special place just for those animals (...)"* (Field diary, Galicia II).

The purpose of that recommendation was to prevent trucks entering the farm to collect dead animals, because neither the veterinarians nor the dairy farmers knew exactly where those trucks had been before. The reason for the recommendation was therefore to prevent the trucks from bringing new pathogens onto the farm and animals from being a source of infection for the healthy animals.

The above extract shows that there was apparent insistence on the part of veterinarian that the dairy farmer should implement that biosecurity practice, even recommending investment in a new space. It can be deduced from this that old traditions were deeply rooted among farmers, who emphasised the use of old facilities over the creation of new ones, although in part it was also due to an economic factor.

On the other hand, it was possible to observe the inexistence of an effective communication space between the dairy farmer and the veterinarian since both parties seemed to ignore the arguments of the other without reaching a definite and concrete agreement. In fact, the dairy farmer had another short-term plan in mind, as they were thinking of investing in renewable energy using the farm's own waste, and the veterinarian knew this. Moreover, the farmer had told the veterinarian that they were willing to implement that biosecurity practice in the future, but only after carrying out the energy plan. So, it is worth asking why both agents were trapped in a kind of vicious circle in which the veterinarian apparently insisted on one recommendation, despite knowing that the farmer had other plans, and the farmer apparently ignored it, because they had other priorities; and neither agent seemed able to appreciate the reasons why and why not. Hence, communication was

somehow failing. Three main elements can therefore be observed: a) different prioritisations of the farmer and veterinarian, b) apparent insistence by the veterinarian and ignoring by the farmer, and c) practically non-existent dialogue and consensus between the veterinarian and farmer. Such disharmony between the veterinarian and the dairy farmer's priorities and decision-making can be known as counter-intuitive rhythm (Lefebvre, 2013), where both the veterinarian and the farmer have different action times, which may or may not coincide. In this sense, their rhythms are discordant, being disorderly and mobile, being able to generate that arrhythmia. Thus, these rhythms could be an important factor to consider in terms of effective communication when implementing biosecurity practices, since both agents must agree minimum points within such dynamic.

In other cases, veterinarians reported that they were exhausted by the stubbornness of dairy farmers. This could come from the old traditions of dairy farms themselves and led to the veterinarian leaving biosecurity completely in the farmer's hands. This particular veterinarian even warned the farmer of the consequences of culling:

> *"(…) The veterinarian told me: 'There's nowhere suitable for dead animals. Look, they just leave them in the middle of the dairy farm. Then the truck has to come inside'. The veterinarian also told me that the farmer could quite easily make a space to leave such animals at the entrance to the farm, but they won't do it. The veterinarian finished by adding: 'If something gets in and they end up needing to cull all the animals, it won't be because we didn't tell them, but because it's always the same story' (…)"* (Field diary, Catalonia II).

The veterinarian pointed out that the farmer could easily make a space to dispose of dead animals, as mentioned above, and not in the middle of the farm, and also argued that there was plenty of space and money. But again, there was no communication to explain the reasons behind the apparent lack of implementation of that biosecurity practice. So, the farmer ended up trying to follow the veterinarian's recommendation as far as possible, without necessarily observing all the details:

> *"(…) The dead-animal zone was about six metres away from the area for calves. So, I advised the farmer to move it somewhere else, and they agreed to temporarily move it to another corner of the farm, about twelve metres away. Although the new place was not enclosed, it was closer to the driveway and more isolated than the previous one. It was also much easier for the farmer to move these animals than calves, even though they also planned to move the calves in the future. A different situation arose in the rearing area, where there was only*

> *one place for dead animals, at the back of the farm, close to a driveway, although it was about two metres away from the healthy animals. However, this situation did not depend directly on the farmer, since there were no more spaces and infrastructures available for the purpose (…)"* (Field diary, Galicia II).

There was a mix of facilities, some old and some modern, a result of the historical evolution of dairy farms. So, the main elements that dairy farmers considered in the management of dead animals included farm spaces and infrastructures, where old traditions and routines were perpetuated based on each farmer's definitions and uses (Broadbent et al., 1980). Space and infrastructure thus generate a kind of reluctance for farmers to follow veterinary recommendations. In turn, these facilities acquire different meanings depending on the specific contexts of farms with regard to biosecurity, as Lefebvre proposed. In addition, as Enticott (2008a) points out, the interaction between modern (ordered) buildings and old (disordered) buildings can influence the entry and spread of infectious diseases, whereby spaces and infrastructures can become reproducers of social reality (Gregory & Urry, 1985). However, historical and social contexts are directly linked to social reality, which is dynamic and in permanent transformation. The sets of practices based on social reality are in continuous transformation as well, because they are always subject to a process of convergence between the old and the new. Such a situation could be observed on another farm:

> *"(…) The farmer told me that their habits are always changing. They now dispose of dead animals in the middle of the farm because that is the easiest area to manage, given the facilities. It is easy to reach from anywhere on the farm in a similar amount of time (Figure 1). However, although trucks do have to come onto the farm to get to the area, it was isolated to some extent. The farmer also told me that if they did what the veterinarian had recommended, they could end up having other problems because families with children often came near to farm, and they might be curious and try to explore the area (…)"* (Field diary, Catalonia II).

[Place Figure 1 around here]

As can be deduced from the above, the management of dead animals on a dairy farm involves a series of spatial practices that are combined with representations of space in two different ways. First, the farmer noted that their habits were changing, in other words, old traditions were gradually being affected, but were still present. And second, the farmer considered access to the dead animal area from anywhere on the farm, but also the consequences of biosecurity practices for the surrounding communities. Finally, a representational space emerged that mixed both sets of practices, which is where the biosecurity measures were eventually implemented. These practices

are not the official biosecurity protocols established by institutions but are instead influenced by the availability and distribution of spaces and infrastructures, and the simple use by farmers of common sense (Hinchliffe, 2015). Ultimately, a space is created that is not lacking in security, but that neither meets official protocols nor is limited to the old traditions and routines that have prevailed on the farm for decades. This is what we have called a security ecology, where two issues are respected: a) the need for security, even though there is no implementation of official biosecurity measures; and b) the clash between the official, the new and the old.

7.2 Control of vectors and pests:

The farms not only had dairy cattle, but also other animal species. However, the veterinarians advised against other domestic or wild animals, mainly because they could be reservoirs for certain infectious diseases that could affect cattle. The farmers were also told that they needed to prevent these animals from getting into other areas of farms, particularly the place where feed was stored:

> *"(…) The farm had different domestic animals, such as dogs, cats, chickens and ducks. So, I pointed out to the farmer that it was not a good idea to keep such animals because they could easily come into direct or indirect contact with the cattle. I told them that there was evidence that certain infectious diseases can be transmitted by domestic animals, such as Neospora canis by dogs, Streptococcus canis by cats or Salmonella by chickens and ducks, which could cause abortions, mastitis or diarrhoea, respectively. Besides, carnivorous species, such as dogs and cats, might theoretically transport infected tissues from outside or around farm (…)"* (Field diary, Catalonia I).

The veterinarians also said that carnivorous species used for pest control, such as rodents and birds, should be replaced with other control methods or techniques and be kept off farms.

In relation to wild animals, the veterinarians recommended the use of physical measures:

> *"(...) The farmer told me that the veterinarian had advised them that building a perimeter fence, both around the farm buildings and land, could be effective for preventing wild animals from contacting the herd or destroying crops (…)"* (Field diary, Galicia I).

The farmers again implemented biosecurity measures in consideration of that recommendation, since both their residences (i.e., personal spaces) and their businesses (i.e., professional spaces) shared common spaces. They lived on their farms because they had been handed down over generations, in accordance with old farming traditions and routines. They were aware that certain areas should not be crossed, but without neglecting typical domestic activities like commerce and recreation:

> *"(…) Chickens and ducks were kept in pens near to the rearing shed and used mainly for sale of meat and eggs. Some of these birds were free-range, but they did not pose a risk to cattle, as they did not share the same spaces. Dogs, kept in a kennel on the other side of the rearing area, were sold as hunting dogs, while there were cats scattered all over the farm, both inside and outside of the farmhouse. They were kept as pets but were also used as an effective form of rodent control. In fact, I often saw rodents scuttling around the farm (…)"* (Field diary, Catalonia I).

The farmer tried to keep the cattle separate from the other domestic animals, but they did not always have absolute control over their movements, although this was not a concern either. This situation was also observed on another dairy farm, although this farmer claimed to have absolute control and said that the dogs did not come into direct or indirect contact with cattle:

> *"(…) The dogs were mainly used as protection against wild animals, such as boars and wolves, which often come close to the farm buildings and land. Crops were planted about eight metres from the farm, and when we were clearing the fields, I could see that boars had been wreaking havoc the night before just a few metres from the farm itself. It is also important to note that the dogs never went close to the herds. They often followed the farmer to the gates of sheds where cattle were kept, but never went inside (…)"* (Field diary, Galicia I).

The dairy farmers implemented a biosecurity measure in consideration of old traditions and routines as well as modern recommendations. This consisted of their own domestic animals acting as controllers of wild animals that could cross all the physical barriers around their farms. They also indicated that there were no official plans to address the problem of wild animals, and that it was the duty of public administration and not of farmers to take care of the problem. So, rather than having no species other than dairy cattle, farmers kept other animals, but made sure they made no direct contact with the herd, thus seeking to strike some kind of balance between both spaces when species other than dairy cattle were present.

One possible explanation for that situation is the different understandings held by veterinarians and dairy farmers about infectious diseases, which are continually being restructured and rethought (Enticott & Franklin, 2009; Enticott, 2008b). Thus, the perception of infectious diseases also requires consideration within the heterogeneity of elements linked to biosecurity. So, the farmers employed common sense to develop their own biosecurity spaces to keep their farms free of infectious diseases as much as possible, generally related to trying to prevent contact between cattle and other species. They were aware that total control of infectious diseases on farms was practically

impossible and concentrated efforts on reducing those with the highest potential consequences on production. They therefore take risks rather than aiming for the total absence of infectious diseases (Hinchliffe, 2017). Veterinary recommendations may make the error of focusing all attention on avoiding the transmission of pathogens, while ignoring some of the specific factors involved such a situation (Hinchliffe et al., 2013).

As mentioned in the previous section, we observe a security ecology here, which maintains a security situation without completely renouncing old traditions and routines (i.e., existing historical, situated practices). In this way, it is possible to reach a hybridization of these traditions and routines and veterinary recommendations, which may even have a much greater scope considering the complexity of the various existing contexts.

7.3 Animal management:

Finally, a similar situation arose with the location of dairy cattle. The veterinarians recommended that new-born animals should be kept apart and housed in individual pens, located outdoors and with easy to clean surfaces, and that when these calves left these pens, they should be grouped in batches of the same age. However, one of the most important recommendations was for calves to be kept in different places to adult animals, avoiding all direct and indirect physical contact:

> *"(…) The farm was divided into three sheds: adults (lactation), weaners (rearing) and calves. However, the calves were all kept together in the same place, instead of being separated into individual pens, and the ventilation was poor. Meanwhile, there were other adult animals roaming freely around the farm. So, I told the farmer that ideally, the calves should be kept separate outdoors, and adults should be in yards. The cattle were not even separated by age in the sheds. So, I told the farmer how important this biosecurity practice was, mainly to detect sick animals by observing weight and growth problems (…)"* (Field diary, Catalonia I).

A similar situation occurred on another dairy farm, where the veterinarian commented the following:

> *"(…) Calves were kept in individual pens in the same shed as adult animals, about two metres away. Also, the rearing animals, due to high animal density, were not arranged based on age. The veterinarian stressed to the farmer: 'You've got a problem with BVD, if you want to fix the problem, you'll have to separate your animals and take samples from them all. Sorting counts for nothing if these animals all end up together in the same place' (…)"* (Field diary, Galicia II).

Considering Holloway (2019), there may be many knowledge practices that relate biosecurity with animal welfare that do not entirely consider veterinary recommendations, especially since dairy farmers try to ensure the life of their livestock in difficult times. This situation can be observed mainly on small farms such as those in the present study:

> *"(…) Calves were kept in a shed together because the farmer did not have enough space for individual pens, and it was winter. However, in the summer the farmer would take the animals away from there and put them in a small yard next to the house, mainly due to their concern about high temperatures. In the rearing shed there were two spaces for males and two spaces for females, where they were kept separate for mainly physiological, behavioural and spatial reasons. Meanwhile, the free roaming dairy cattle had some type of limb injury and were set free to reduce the likelihood of slipping and getting even more badly injured, so they would not have to go to slaughterhouse early (Figure 2) (...)"* (Field diary, Catalonia I).

[Place Figure 2 around here]

In that situation, despite possible limitations, the farmer generates a space that prioritises animal welfare as much as resources allow. This is a further case of common sense prevailing, but this time focused on animal welfare. Some elements of common sense apply to all farms, such as those regarding biosecurity, infectious diseases and animal welfare, and can sometimes be even more complex:

> *"(…) The dairy farm was being expanded, but calves were temporarily being kept near the yards where the adults were. This was the healthiest place for them to be, as the farmer was trying to solve a problem with BVD. However, although they were trying to separate calves and weaners, due to high animal density and limited facilities, they were in a difficult situation (…)"* (Field diary, Galicia II).

The common sense of dairy farmers is strongly influenced by spaces and infrastructures, which in turn are determined by old farming traditions and routines. Hence, various elements are generated with different understandings, such as those mentioned above.

Following Lefebvre, three biosecurity practices can be observed: a) the facilities that contain an important element of old traditions and routines, b) the three recommendations themselves, and c) the biosecurity implementation, which does not exactly follow the recommendations, but does fulfil the ultimate goals as much as possible while also considering old traditions and routines. In this way, the three elements are in constant interaction, generating different combinations depending on the

various contextual elements of each of the farms, as the elements of this empirical material, making security ecologies present.

7. Discussion and conclusions: From biosecurity to security ecologies

The risks of infectious diseases that Spanish dairy farms face involve permanent tension between farmers and veterinarians, since both agents try to establish how these risks could be avoided. Both agents seek to generate a space free of infectious diseases by different means based mainly on avoiding direct or indirect contact between animals and such diseases, which is a core factor of biosecurity (Dewulf & Van Immerseel, 2018). Biosecurity therefore is in favour of life (Bingham et al., 2008), although there are major complexities involved in the biosecurity measures that are ultimately implemented due to the tension between old farming traditions and routines and veterinary recommendations. Implemented measures might be influenced by both elements to different degrees, depending on the specific contexts of each farm, without either of these completely prevailing over the other. For example, such a situation could be related with people showing how competent they are (Enticott, 2008a), whereby farmers employ their knowledge of the risks of infectious diseases and act in coherence with this in order to keep their farms safe. Meanwhile, the veterinarians used the techno-scientific knowledge available in their territories to generate recommendations influenced by their experience and training. This means farmers are continually pressured by these recommendations, but both agents continually question and remodel biosecurity practices, as a kind of continuous tug and pull against old farming traditions and routines. However, it is important to highlight that it is always the farmers who make the final decision as to which biosecurity practice to implement and how, which is influenced by various factors relating both to old traditions and routines and modern recommendations. Similarly, the biosecurity measures finally implemented might strike a good balance between the biosecurity concepts of veterinarians and farmers, or at least, fulfil the same ultimate objective.

Complete consensus between all parties is extremely rare and practically impossible (Hinchliffe & Bingham, 2008), and we should instead assume the existence of integration with historic farming knowledge, which also leads to different approaches to biosecurity (Enticott & Franklin, 2009) for which techno-scientific veterinary knowledge might be an important starting point (Bingham & Hinchliffe, 2008). So, biosecurity based on techno-scientific knowledge should be flexible enough to consider historic knowledge, and vice versa, thus increasing the likelihood of it being effective (Enticott & Wilkinson, 2013; Henke, 2000). In addition, famers' knowledge of infectious diseases can generate a complex space where social, economic and environmental relations interact (Enticott, 2016). It is not about farmers and veterinarians doing things their own way, but of biosecurity

devices being conformed in every sense around security ecologies, which are generated from Lefebvre's model.

On the other hand, the heterogeneity of so many Spanish dairy farms and their specific contexts could pose a problem for following veterinary recommendations. As Holloway & Morris (2012) pointed out, continuous effort is required to persuade farmers to implement biosecurity practices. However, although veterinary recommendations are generally disseminated as the sole, unquestionable truth, biosecurity measures ultimately contain both these recommendations and old farming traditions and routines. Similarly, it is important to consider that these recommendations could have a direct or indirect institutional component (i.e., from urban areas) that may involve a limited understanding what happens on farms (i.e., in rural areas) (Higgins et al., 2016b), and farmers are also aware that veterinarians may have different ways of promoting biosecurity practices, for example, through imposition and maintenance supported by an official regulatory framework, as has happened with some infectious diseases (Sok et al., 2016). Therefore, the finally implemented biosecurity measures could mainly be influenced by farmers, who respond in different ways to the promotion of biosecurity practices by veterinarians.

In general, farmers have shown resistance to almost everything that is linked to a regulatory framework (Gronewold et al., 2012), such as this one issued by international organisations and national governments that can influence veterinarians and cause greater tension among farmers with regard to their recommendations, and which can ultimately put biosecurity practices be at risk. It is therefore worth considering how official legislation can increase tension between farmers and veterinarians, and that alternative pathways should be sought. New approaches could be generated that might be relevant to the socio-political context of biosecurity, and even more so considering the complexities of each farm. New biosecurity traditions and routines might need to take security ecologies into account (Convery et al., 2008; Enticott, 2008b), which could also incorporate the different working timeframes of dairy farmers and veterinarians.

Finally, there is a need for further ethnographic studies conducted over longer periods in order to observe security ecologies in their entirety (i.e., beginning, development and final implementation), together with all the different biosecurity practices.

In conclusion, the security ecologies based on the Lefebvre's model effectively give us a better understanding of biosecurity practices and the possible elements behind their final implementation. These security ecologies are associated with the representational space, which can be flexible and adaptable to different farm contexts and are part of the dynamics of tension between dairy farmers with their traditions and routines (spatial practices) and veterinarians with their recommendations

(representations of space). They must also consider the specific current social context that is a product of historical processes (i.e., the different spaces), the reasons that farmers and veterinarians act or do not act in certain ways, and the need for effective communication and common sense in relation to infectious diseases and animal welfare (Diagram 1). Therefore, security ecologies should be seriously considered in local animal health plans, for they could be a positive mechanism that could enrich and enhance the biosecurity practices among different actors on the farms, such as dairy farmers and veterinarians, but there could also be other actors involved. Thus, these findings are aligned with studies such as that by Shortall et al. (2016), which demonstrates the limited success of biosecurity practices due to dairy farmers and veterinarians having very different ideas about everyday biosecurity to those of the authorities or experts. However, this limited success could be the result of the implementation of biosecurity measures generating tension between old farming traditions and routines and the recommendations by veterinarians but does not mean that biosecurity practices are not carried out.

[Place Diagram 1 around here]

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Dairy farm	Start year	Total number of animals	Number of animals in lactation	Number of animals in rearing	Own rearing (Int/Ext)	Staff amount	Territorial expansion (Hectares)
Galicia I	1951	220*	100	85	Int	4	60
Galicia II	1985	490	290	200	Int/Ext	5	100
Catalonia I	1963	100*	45	25	Int	2	30
Catalonia II	1933	580*	205	200	Int	3	90

Table 1: Characterization of dairy cattle farms explored. *Includes males.

Figure 1: Dairy farm Catalonia II. Red circle indicates place where the dead animals were arranged.

Figure 2: Dairy farm Catalonia I. Dairy cattle free roaming.