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Q fever as an anthropological prism for revealing how farmers live with microbes

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Abstract
To develop effective public health management strategies, it is necessary to account for the viewpoints of all stakeholders. Thus, anthropological approaches can potentially inform strategies for preventing and managing zoonotic diseases. Here, we use Q fever as a starting point for exploring how small ruminant farmers perceive the reality of microbes by disentangling the farmers' often subtle relationships with their livestock, disease, and the world in general. We found that livestock farmers feel like they exist in the borderlands between two worlds: the non-naturalistic World A, characterised by long timespans and complex relationships with non-humans, and the naturalistic World B, characterised by short timespans and the control of non-humans. The occurrence of diseases leads to tension and shifts between the worlds, depending on how much farmers entrust World B with health risk management and relations with non-humans. Significant or complete delegation of these responsibilities may result in a sense of unease and dispossession, particularly when World B fails to provide productive solutions. Whether farmers view Q fever as mysterious and threatening is also highly dependent on the degree of health risk delegation. Overall, the agent that causes Q fever is perceived in one of two ways: as a fearsome pathogen or a normal denizen in the farm's ecosystem. These results have implications beyond Q fever and clearly illustrate the concept of the "microbial turn", which emphasizes the plurality and ambivalence of the relationships between humans and microbes.

Keywords Social anthropology · Transdisciplinarity · Microbial turn · Zoonotic disease · Small ruminant · *Coxiella burnetii* · Ontologies · Risk delegation

Introduction

In this study, we use Q fever as a starting point for exploring how anthropological approaches could inform strategies for preventing and managing zoonotic diseases. We argue that it is crucial to co-construct public health policies, which implicitly implies accounting for the perspectives of livestock farmers. This approach has two key requirements: (1) to treat the perspectives of livestock farmers as fully legitimate, given the expertise they acquire from their daily lived experiences and (2) to assign the same weight to their perspectives as is assigned to those of scientists and public health authorities. Both steps are essential to allowing farmers to share their extensive acquired knowledge and to engage in fruitful dialogue with other stakeholders, including health authorities (Lainé 2023).

Q fever through an epidemiological lens

A ruminant-borne zoonosis with airborne transmission

Microbiologists and veterinary epidemiologists view Q fever through a scientific lens, which has been moulded by the research and knowledge produced since the disease's

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causal agent was first discovered in the 1930s (McDade 1990). Q fever is a zoonosis caused by the bacterium *Coxiella burnetii*, whose transmission is air-borne. The pathogen's main reservoir is ruminant livestock, especially goats and sheep. The bacterium is most often excreted during parturition or abortions. It may take the form of highly resistant "pseudo-spores" that may remain detectable in the environment for months (Joulié et al. 2015), making disease control and eradication very difficult. Animals and humans may become infected by inhaling contaminated dust that has become suspended in the air, most commonly as a result of livestock giving birth or manure being spread (EFSA 2010a; Mori and Roest 2018).

A frequently asymptomatic infection as well as a disease underdiagnosed by medical doctors

In humans, Q fever is largely underdiagnosed and gives rise to variable symptoms. Serological studies suggest that the infection is often asymptomatic. However, it can also cause varying degrees of illness, from simple flu-like symptoms to persistent disabling conditions, such as osteoarticular infections or chronic fatigue (Morroy et al. 2016; Eldin et al. 2017). Doctors tend to suspect they are seeing an acute case of Q fever when a patient is experiencing anicteric hepatitis, pneumonia, endocarditis, or an isolated fever (HCSP 2013). The disease can also cause adverse pregnancy outcomes, although this risk is not well described given the lack of quantitative epidemiological data (Ghanem-Zoubi and Paul 2020); such is especially true in the case of early miscarriage because tests for *C. burnetii* are rarely conducted. The above explains the underdiagnosis of Q fever.

Q fever outbreaks in human populations

Cases of disease in human populations are generally sporadic. For example, in 2018, the French National Reference Centre for *Rickettsiae*, *Coxiella*, and *Bartonella* (CNR) reported the occurrence of 143 and 48 cases of acute and chronic Q fever, respectively, in mainland France (CNR 2019). It is noteworthy that these numbers are likely underestimates because the CNR possesses only partial information on Q fever incidence; indeed, many other medical laboratories also run diagnostic tests, and no system exists for centralising the data. Additionally, local disease outbreaks occasionally occur, most commonly in urban populations. Over the last 25 years, 9 such case clusters have been reported in mainland France, including one that involved just over a hundred people in the city of Chamonix (Rousset et al. 2023). The origins of these outbreaks frequently remain unknown despite investigations by health authorities. Given that *C. burnetii* is found in ruminant farms across France (Gache et al. 2017; Carrié et al. 2019), outbreaks of human Q fever are surprisingly rare. Further research is therefore needed to identify the risk factors associated with such outbreaks as well as to more generally explore the dynamics of livestock-to-human transmission and the development of clinical symptoms.

Disease prevention and management guided by "experts"

In France, when outbreaks of human Q fever occur, health authorities frequently call upon researchers studying the disease, whose expert advice then informs the ensuing epidemiological studies and management measures. As the COVID-19 pandemic has recently illustrated, these appeals for counsel are common. They underscore the role and authority of modern science in Western societies (Stengers 2019). Such requests to scientists most commonly occur in response to public health emergencies, whose urgency strongly contrasts with the broader time frames inherent to the production of scientific knowledge (Maniglier 2021). Indeed, research is engaged in both short-term and long-term processes. Over the shorter term, researchers define problems, queries, and hypotheses that are then addressed using specific methodologies and analyses to yield results. Over the longer term, research also encompasses extensive debate and dissension within scientific spheres; there, the epistemic value of knowledge is explored through discussions of its general applicability and of the methodologies employed in its production. All these steps are necessary to reach eventual equilibrium. For zoonotic diseases with environmental reservoirs, such as Q fever, the state of scientific knowledge is far from settled, and there are many persistent controversies (Keck 2009; Eldin et al. 2017, Mori and Roest 2018; Dragan and Voth 2020; Rousset et al. 2023). For example, there is lively debate as to whether vaccinating ruminants against Q fever is helpful under all epidemiological circumstances[1]. Thus, when faced with requests from public authorities, it behoves researchers to position themselves differently than they usually would, such as when applying for grants or submitting work for publication. Instead, they must adapt their expertise to provide prompt recommendations geared towards urgent and uncertain public health situations, whether the latter reflect reality on the ground or arise from overblown media hype.

[1] The main concerns are the following: Is vaccination useful if a flock has already become infected? Should vaccination exclusively target young and/or previously unexposed individuals? For sheep, does vaccination make sense at all, given that immunity has been declared to last no more than four months in this particular species? (source for the latter: EU/2/10/110, https://ec.europa.eu/health/documents/community-register/html/v110.htm)

A lesson in humility

Researchers know exactly how to clean and disinfect their laboratories to comply with health and safety standards. It is another matter entirely to decontaminate a farm whose ruminant livestock excrete a bacterium whose pseudo-spores are extremely resistant to physical and chemical treatments. It is unrealistic to believe that the same cleaning and disinfection procedures could be applied efficiently within livestock farm buildings, where work surfaces are irregular and conditions are not airtight. And yet, armed with our laboratory expertise, we have sought to help farmers prevent the zoonotic transmission of Q fever by encouraging them to apply chemical sporicidal agents within their farm buildings. This process has been quite humbling. We confidently went in with seemingly self-evident, science-based recommendations for managing situations on farms. At best, they were useless, ill-suited to field conditions; at worst, they had deleterious effects, notably on cheese flora. These experiences led us to question how our "expert" advice might be misaligned with the material, social, and economic realities faced by livestock farmers, who are dealing with issues beyond our domains of knowledge and proficiency.

Q fever through an anthropological lens

Surpassing the limits of the life sciences

We thus learned an important lesson: the solutions to such public health problems lie beyond veterinary medicine and epidemiology alone. Indeed, any response must account for much more than the pathogen's biological and ecological characteristics. There are impacts on livestock farmers, their production systems, their income streams, their commercial interactions, their health and safety practices, their relationships with other people (e.g., farm employees, the general public), and even their mental health. In other words, our past work as public health consultants has led us to broaden our biological and ecological conception of *C. burnetii*. Drawing on scientific exchanges with our colleagues in anthropology, we now consider that this bacterium possesses social agentivity. Consequently, answering the epidemiological questions raised by *C. burnetii* is a task that extends beyond the purview of the life sciences. Thus, while the veterinary and epidemiological sciences are needed to explain the bacterium's biology, ecology, and transmission, these elements cannot shed light on the world in which the bacterium exists, nor can they clarify how farmers experience the pathogen's arrival on their farms.

Given the challenges we had faced as biological researchers serving the role of public health consultants, we came to recognise that our understanding of *C. burnetii* was greatly coloured by our scientific experiences and practices, which are firmly tied to laboratory conditions. The latter greatly contrast with what livestock farmers face on their farms, where the bacterium's presence has practical, social, and economic implications. Therefore, we came to understand that we had to grapple with the system as a whole. This learning process involved acknowledging that there are myriad ways of understanding and interpreting the world that are shaped by each person's experiences and practices (Chateauraynaud and Dubois 2019).

Valuing farmers' perspectives on Q fever

In particular, we realised that we needed to better understand and account for farmers' diverse perspectives on Q fever, the danger they feel it represents, and the coping strategies they have developed. Farmers are knowledgeable about *C. burnetii* because of their daily work experiences, which are entirely unlike those of researchers in their laboratories. Therefore, livestock farmers view the pathogen from a different lens than that employed by researchers or public policy managers. They may know the scientific definitions of bacteria or zoonoses, thanks to the societal dissemination of information via groups, networks, or professional training programmes. However, they are also confronted with different yet equally real facets of bacteria and zoonoses on a daily basis. More specifically, microbes signal their presence in various ways—such as through certain animal behaviours—that are not necessarily considered by veterinarians or other agriculture professionals. In contrast, livestock farmers attentively watch for these signals that something is "off" and react accordingly. This combination of observation and action is not specifically triggered by microbes. It is the foundation of a farmer's daily work: indeed, because they are in constant contact with living organisms, they incessantly engage their senses to interpret reality on the ground.

Objectives

We aimed to describe how small ruminant farmers perceive and react to the agent of Q fever, specifically, and microbes, more generally, using a pragmatist approach (i.e., considering what the study participants shared with us as truth). Using ethnographic methods, we sought to clarify the types of relationships that farmers establish with microbes through their practices, which we analysed through the prism of perceived risks or threats.

Materials and methods

We used an ethnographic method (Kilani 2012; Géraud et al. 2016) that is foundational in anthropological research. This method has three sequential phases, which are in practice intertwined: (1) data collection in the field; (2) data analysis, synthesis, and interpretation; and (3) analytical reflection around the social system's general properties, leading to a broader, anthropological understanding of its overall functioning.

In addition, because this study was carried out within a transdisciplinary context, with specific expectations from field epidemiologists regarding Q fever and its management, we had to take up the challenge of generating results that may be intelligible by the various stakeholders and serve to establish a common culture around what the anthropologist observed. The latter explains why the present manuscript is not written and structured as anthropological studies usually are. We also produced graphic interpretations of the main results to gain in clarity for the uninitiated.

Data collection in the field

Individual interviews

Between June and August 2019, long and free-flowing interviews were conducted with individuals ($n=26$) working on small ruminant farms ($n=13$) in Nouvelle-Aquitaine, France. We focused on areas where clusters of human Q fever cases of unknown origin had recently occurred. All the interviews were performed by a single experienced female researcher on the team. The focal farms had dealt with Q fever infections among livestock and/or were open to the public (i.e., educational farms, agricultural high schools). When possible, multiple people from each farm were interviewed to gather diverse perspectives (e.g., related to differences in gender, age, or professional status). That said, it is important to note that our sampling efforts were neither exhaustive nor representative at the regional level. Indeed, since we had no anthropological data to use as a starting point, we had no way of designing a research strategy that could ensure the representative sampling of all existing perspectives. Consequently, at this stage of the project, our objective was not to arrive at general conclusions, but rather to characterise the heterogeneity that exists in how livestock farmers relate to Q fever and, more generally, to "microbes". To establish a broader context for the above, we conducted additional interviews with professionals ($n=15$) working in the areas of livestock farming, animal health, and human health.

Participant observations

Additionally, the researcher conducting the interviews took part in a conference on Q fever organised by a veterinary advisory group following an outbreak in humans. She was thus able to implement another classical ethnographic approach: participant observation. In this method, anthropologists engage in cultural immersion and observe the individual and collective behaviours of study participants under real-life conditions. Consequently, it is possible to achieve a deeper understanding of situations and relationships through reflective sensitivity.

Data analyses and analytical reflection in a transdisciplinary context

No hypotheses were formulated a priori. Instead, we sought to understand the world through the eyes of the interviewees. There were two stages in our analysis: first, we wanted to deeply delve into how farmers position themselves relative to their animals and their animals' potential diseases; second, we wanted to situate Q fever within these "worlds", by considering all the elements that underlie farmers' actions, perceptions, self-representations, and discourse around the disease.

Taking stakeholders seriously

Our approach was to take seriously all that the study participants shared with us. Indeed, in anthropology, such is a pragmatic approach in which the narratives of research subjects are viewed as truth (Hache 2011). This methodology is informed by the Chicago school of pragmatism and, more specifically, by its members Charles Sanders Peirce and John Dewey (Mounce 2010). To Dewey, something can be qualified as "objective" if it is manifest in facts; it need not be "objectifiable" (i.e., quantifiable using measurement instruments). He considered that, to understand complex phenomena, no preliminary framework should be adopted. Instead, it is through observation and listening that we can clarify how our study subjects think and perceive the world on a daily basis. As a science, social anthropology employs this approach with the aim of identifying categories, trajectories, and trends. It seeks to establish objectivity by viewing the world through the lens of those who are taking action.

Describing how livestock farmers understand and interpret reality

Through our data analyses, we sought to distinguish the different ways of understanding and interpreting reality (Chateauraynaud and Dubois 2019). To this end, we analysed

and classified the language used, which included noting the objects mentioned (e.g., "bacteria", "spirits", "analysis") and the traits attributed to them (e.g., "friendly", "bad", "expensive"). We attempted to define the nature of each study participant's universe through a series of processes, which included understanding what the person valued; characterising the presence of new objects, human beings, and non-human beings; clarifying the factors that create differentiation versus intimacy; and establishing relationship types. Then, we specifically noted the character traits that emerged as essential, with the goal of constructing a deliberately simplified "model" of reality for distinguishing among different "ideal types", which, as defined by Weber (1965), are forms of storytelling that accentuate certain character traits to make more obvious what differentiates them. From an anthropological point of view, the most important task is to identify trajectories, without seeking to determine their relative frequencies. Finally, we used the ontologies established by Philippe Descola (Descola 2005, 2019) as an interpretative framework for understanding the subtleties of how farmers relate to their animals, diseases, the world, and Q fever. These ontologies are based on differences and similarities in "interiority" and "physicality", which give rise to continuities and discontinuities between humans and non-humans.

Results and discussion

Below, we present the results of our anthropological research, which focused on how small ruminant farmers experience their reality. Yet, our results have implications beyond Q fever and possess all the more value for having been obtained before the COVID-19 pandemic, an event that has irrefutably changed how people perceive and understand public health issues (Maniglier 2021).

The farmers see themselves as straddling the border between two worlds with very different ontologies. Over their lifetimes, they have learned to negotiate with the denizens of both worlds by building relationships, creating space for dialogue, and reaching compromises. When faced with health challenges, such as the occurrence of Q fever, they employ variable trajectories that are influenced by their position within the borderlands. A key difference is whether they accept or delegate the responsibility of dealing with health risks.

Livestock farmers live between two worlds

The analysis of the observed heterogeneities led us to identified two "worlds", arbitrarily referred to as World A and World B. The latter are 'ideal types' in Weber's sense (Weber 1965), i.e. mental models that do not represent an existing reality but serve as an abstract framework to understand and analyze the results of our study. They represent the purest or most extreme forms of two types of 'stories' that compete against each other within individuals.

We found that the livestock farmers perceive themselves as living in the borderlands between these two poles, which are seen as each possessing their own logic, organizational schemes and constraints; they essentially come into contact via the intermediary role played by livestock farmers, who thus view themselves as occupying a unique and challenging position (Fig. 1). Indeed, they feel as though they must continuously create space for dialogues between both worlds and build relationships. Thus, they allow themselves to be drawn into one world or the other, depending on the nature of the situation, stakes, risks, or crisis. Both worlds are associated with heavy constraints for livestock farmers (e.g., death, disease, drought, storms, etc. for World A; regulations, inspections, bank loan, market prices, etc. for World B).

World A is non-naturalistic and requires complex diplomatic relationships with non-humans

The first world experienced by livestock farmers (hereafter, World A) is a place where collaboration and care for the living take precedence. In World A, reality is lived over long time periods and is structured around unending cycles. It is a world in which people are attuned to manifestations of things that have ever existed, such as animals, meadows, plants, birth, death, and organic matter, and there is blurring of the lines that distinguish its resident entities (e.g., humans/non-humans, nature/culture, material/immaterial, mind/matter, subjects/objects). Obscure and complex factors cause disturbances to the different cycles that operate at a daily, seasonal, or annual rhythm, such as cycles related to disease transmission or the generational renewal of livestock or humans. Therefore, much time must be invested to understand such cyclic patterns and to initiate dialogue and negotiations with non-humans.

Inherently, most farmers consider that the harmonious management of livestock health and production is only possible if complex diplomatic relations, borrowing Morizot's words (Morizot 2016), are established with non-humans. Most interestingly, 'feeling' appeared to be a real 'organ' for farmers, who precisely do exist as "farmers" because they develop intimate relationships with non-humans that overpass the senses. Such ties between humans and non-humans arise from lived experiences and rely on diplomatic exchanges, made of intersubjectivity and reciprocal signals, that may resemble an unarticulated and non-conceptual language: both humans and non-humans intermingle and

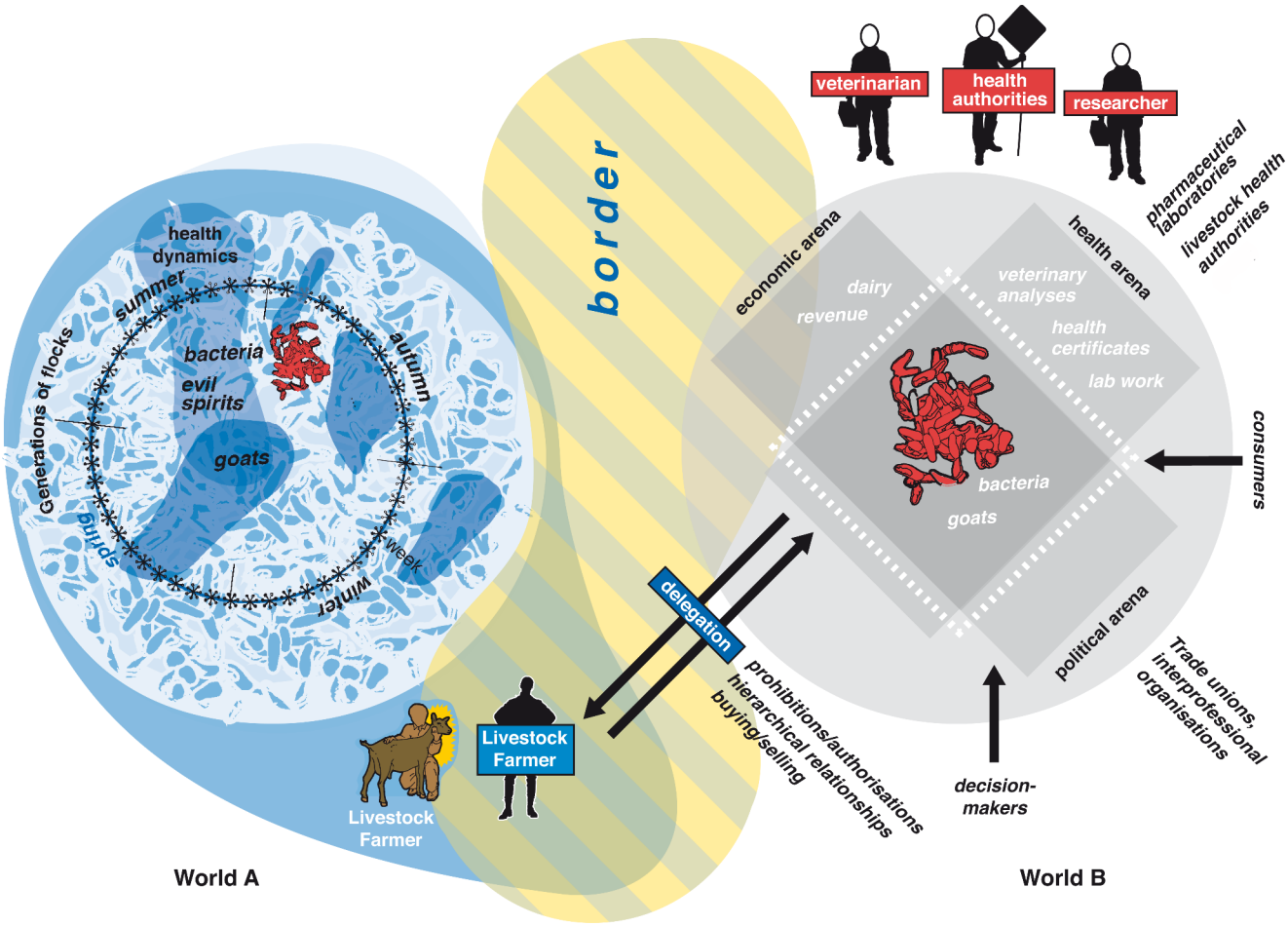

Fig. 1 Graphical depiction of World A, World B, and the borderlands occupied by the livestock farmers

build complex and difficult relationships whose foundation is reciprocal interdependence. These relationships, which were described as "authentic" and "nourishing", may be considered as typical of non-naturalist (animist or analogist) ontologies (Descola 2005, 2019).

Interestingly, during the interviews, the farmers would first avoid talking about such topics or refer to obscure practices of no interest. Then, when they perceived that the interviewer was open-minded and receptive to their non-naturalistic worldview, they would cautiously broach the topic of how they conduct such relationships. Then, they frequently ascribed biographical narratives and subjective experiences to non-humans (Table 1). In practice, they are fully invested in these relationships. Their degree of physical and sensorial attention allows them to detect minute variations that often prove essential in guiding their work and their devoted care of non-humans. It is also worth noting that women, if they felt themselves to be in a situation of trust during the interview, would describe these relationships with greater precision and intensity.

World B is a naturalistic world to which farmers delegate diplomatic relationships with non-humans

Livestock farmers also experience a second, parallel world (hereafter, World B), in which reality essentially relies on dualistic distinctions, such as those between humans and non-humans; nature and culture; and objectification and subjectivity. In this world, life is perceived to occur in short bursts of non-cyclical time. Relationships tend to be uncomplicated and often involve exchanges of a hierarchical or obligatory nature (e.g., commercial interactions, advisory services, inspections, prohibitions/authorizations). This state of affairs is punctuated by emergencies and unpredictable occurrences, such as epidemics, market shifts, and unanticipated climatic events. World B commonly struggles to interpret and understand complexities on the ground, mainly because of its inherently shorter timespans and focus on emergencies and specific metrics.

Indeed, in World B, reality is built up around established measurement tools, rules, and standards that allow policy managers to monitor farm conditions and take regulatory

Table 1 Non-exhaustive list of the relationships between livestock farmers and non-humans within World A

Categories of non-humans	Types of relationships
Live animals	Examples include the gentle words, caresses, attention, care, and friendship that farmers give to animals. Sometimes there is no expectation of reciprocation; it is simply a sign of empathy or affection. In other cases, the goal is to elicit better behaviour, facilitate parturition, improve feed management, encourage mutual support among animals, boost lactation, or shorten the dry period.
Plants	Farmers direct words, caresses, attention, and care towards crop species, to bolster establishment and productivity, and towards forage species, so that pastures provide abundant grazing.
Spirits	Farmers drive away evil spirits by performing prayers or rituals (e.g., hanging holly near building entrances); they give thanks to good spirits.
Microbes, viruses, parasites, bacteria	Farmers view beneficial bacteria and yeasts with benevolence and establish relationships with them that are based on mutual aid (e.g., keep their welfare in mind, ensure conditions are welcoming, avoid violent disinfection regimes, protect them, defend them against those who want to ban raw milk). They encourage their dissemination and diversification via other animals. For example, they encourage young cats to sleep and spend time with the goat flock, thus promoting the circulation of viruses and parasites to naturally boost goat immunity.
Medication	Farmers pray for medications to work. They develop a strong attachment to specific compounds that have proven their effectiveness and are thus viewed as precious aids worthy of respect. For example, a livestock farmer may travel to Belgium to obtain a specific medication because it is no longer available in France.
Physical forces and landscape elements	These relationships have yet to be observed and remain to be explored. World B seems to be intrigued by the Earth's electromagnetic forces. The Chamber of Agriculture has employed a geobiologist to ensure proper grounding in the electrical systems of a farm's buildings and pens so as to reduce disease and stress in animals.

action. For instance, the use of standards (e.g., regarding the quantity of milk produced, or the quality of the milk through the routine counting of cells) impacts the very nature of the farmer's daily work and results in the establishment of a surveillance regime. World B is tightly connected to capitalist industrial agriculture, which generates a distance and a categorization between animals and humans. Hence, it tends towards the ontology of naturalism, which posits that, although humans and non-humans are made of the same physicality (i.e., matter, such as atoms, molecules), they are distinct because of a difference in interiority: humans possess a spirit, which positions them as "subjects", whereas non-humans lack a spirit and are therefore deemed to be "objects" (Descola 2005).

Interestingly, some farmers thoroughly described what they used to do, the intimate relationships that they used to have with living beings, and reported how modernization took away everything they felt and how the intellect stripped the world of the intimacies they formerly had with their animals. In practice, today's livestock farmers have no choice but to comply with World B's reality. This is particularly true if they wish to completely or partially delegate responsibility for health and economic risks to this world: they may turn to World B as a way to protect themselves from risks that they feel they cannot control without assistance.

During the study, World B's perception of reality was generally encountered among stakeholders working in the domain of animal health, including dairy farm staff, veterinarians, health inspectors, livestock traders, researchers, pharmaceutical laboratory staff, and rendering staff. Livestock farmers also recognise the presence of two other groups within World B, consumers and decision-makers, with whom they have symbolic and intangible relations. Both groups are seen as existing in a clearly defined, influential, and yet fluctuating form; they shape World B's conditions in literal and symbolic ways. Notably, farmers perceive consumers as making unreasonable demands for cheap, yet high-quality food and for production systems that are free of pollution, strong odours, and disease risks. They see decision-makers as equally unreasonable because they adopt policies that are disconnected from reality on the ground. In some cases, these relationships are not distant or symbolic experiences; instead, they may occur quite close to home, in the form of direct sales on farms or at farmer's markets or interactions with interprofessional trade organisations. Most of the time, livestock farmers perceive these two groups as imposing constraints and ridiculous obligations while simultaneously radiating insufferable social contempt because of the farmers' proximity to World A. Indeed, in the interviews, the farmers expressed their sense that the two groups see World A as filled with dirt, microbes, foul odours, disease, and archaic traditions.

A fluctuating position within the borderlands

Livestock farmers see themselves as occupying the borderlands between both worlds because they are continuously confronted with ontological shifts between World A's and World B's types of rationality, i.e. different manners to give intelligibility to the world. Indeed, their activity as farmers places them both within World A's cyclical world and within World B' professional organizations, which impose them working practices.

On the one hand, livestock farmers feel that their proximity to World A renders them incapable of escaping from the social contempt described above. At the same time, they have often developed strategies for demonstrating real or symbolic intimacy with World B, which can take the form of positive discourse around science, innovation, cleanliness, trade, and rationality as well as negative discourse around anti-intellectual currents and peculiar practices. Thus, the farmers' functional relationships with World B (i.e., excluding consumers and decision-makers, with whom ties remain largely symbolic) are frequently tense and defensive and are expressed through reserved or reticent behaviour on the part of farmers. There may be more intimacy and trust manifest in exchanges if the relationship is long standing, the interaction is routine (e.g., with certain veterinarians), or hierarchical dynamics are absent (e.g., with rendering staff).

Overall, livestock farmers feel that their position within the borderlands means that only they or their peers can understand their experiences. The existence of a line that separates "*them*" from "*us*" is a given. When farmers delegate more to World B, they feel a greater sense of proximity to the latter. Yet, they never consider themselves as fully belonging. When farmers delegate less to World B, they feel a greater sense of distance, which may even translate into a sensation of estrangement or active resistance. These relationships fluctuate, and the relative degree of tension and distancing determine where livestock farmers find themselves within the borderlands. Relationship intensity seems to remain fairly static over time, for reasons related to the farmers' personal histories, family histories, and views of the two worlds.

Diseases lead to tensions and shifts between worlds

When diseases enter the picture, occurring in either animals or humans, livestock farmers tend to position themselves closer to either World A or B, resulting in greater polarisation as relationships shift and the magnitude of differences grows. Such greatly changes the role of farmers, requiring them to make what are often difficult decisions. Thus, the polarisation process can potentially lead to two distinct outcomes. On the one hand, livestock farmers may move closer to World B, to which they significantly or entirely delegate risk management and relations with non-humans. Alternatively, they may move closer to World A, in which case they minimally delegate relations with non-humans and risk management (Fig. 2). Of course, our description of this situation is simplified, and livestock farmers may occupy a vast range of positions between these two extremes.

Type B farmers: farmers who significantly or completely delegate health risk management to World B

In the face of a disease, Type B farmers significantly or entirely delegate risk management to World B. Such delegation relates not only to humans (i.e. actors from the animal or public health sectors, such as medical doctors, veterinarians, food advisors, etc.) but also to non-human artefactual devices, such as measurement tools (e.g., laboratory analysis of the milk composition, veterinary analyses searching for infectious germs as a cause for goat abortion, resort to sporicide disinfectants, etc.). Then, World A is completely absorbed by World B: the farmers no longer occupy a unique space within the borderlands. Instead, they are simultaneously drawn into both worlds. This conjunction of spheres is seen as giving rise to a struggle, as World A and B successively overtake each other. For example, a disease arrives, disturbing the flock and sometimes killing animals, a temporary win for the pathogen. Next, the administration of antibiotics, or other medical drugs, briefly brings the disease under control. The back and forth then continues. This external tug of war between the two worlds elicits a dramatic internal tug of war within farmers.

Indeed, when a pathogen such as *C. burnetii* occurs in World A, it is not simply seen as a biological entity by livestock farmers. Instead, the pathogen is inherently affiliated with World B because of its objectifying nature: it exists via instruments of analysis, methods of control, and sets of dictates. Type B farmers never fully trust World B, which demands that they adopt a "thinned" version of reality that is potentially incompatible with their reality within the borderlands. However, when faced with the presence of disease, they acquiesce to the demands of World B, to which they partially or completely delegate responsibility for health risk management.

Accepting the decisions coming from World B may be especially difficult as farmers are frequently accustomed to working alone or in small groups (usually comprising family members). In this situation, they experience conflicting sentiments in response to support from World B: lucky yet dispossessed, assisted yet "trapped" (e.g., compelled to follow vaccination regimes or official recommendations); they perceive a loss of freedom in their decision-making process; and, at the same time, while they feel dispossessed, they are also relieved to not be facing the problem alone. Veterinarians are quick to take action, administering remedies or vaccines. Accepting this response is seen as the only viable option in order to control or even eliminate the significant threats to farm economic viability and health. They feel that "*there is no other choice*".

If it becomes routine for veterinarians to take charge when disease strikes, farmers can establish a degree of

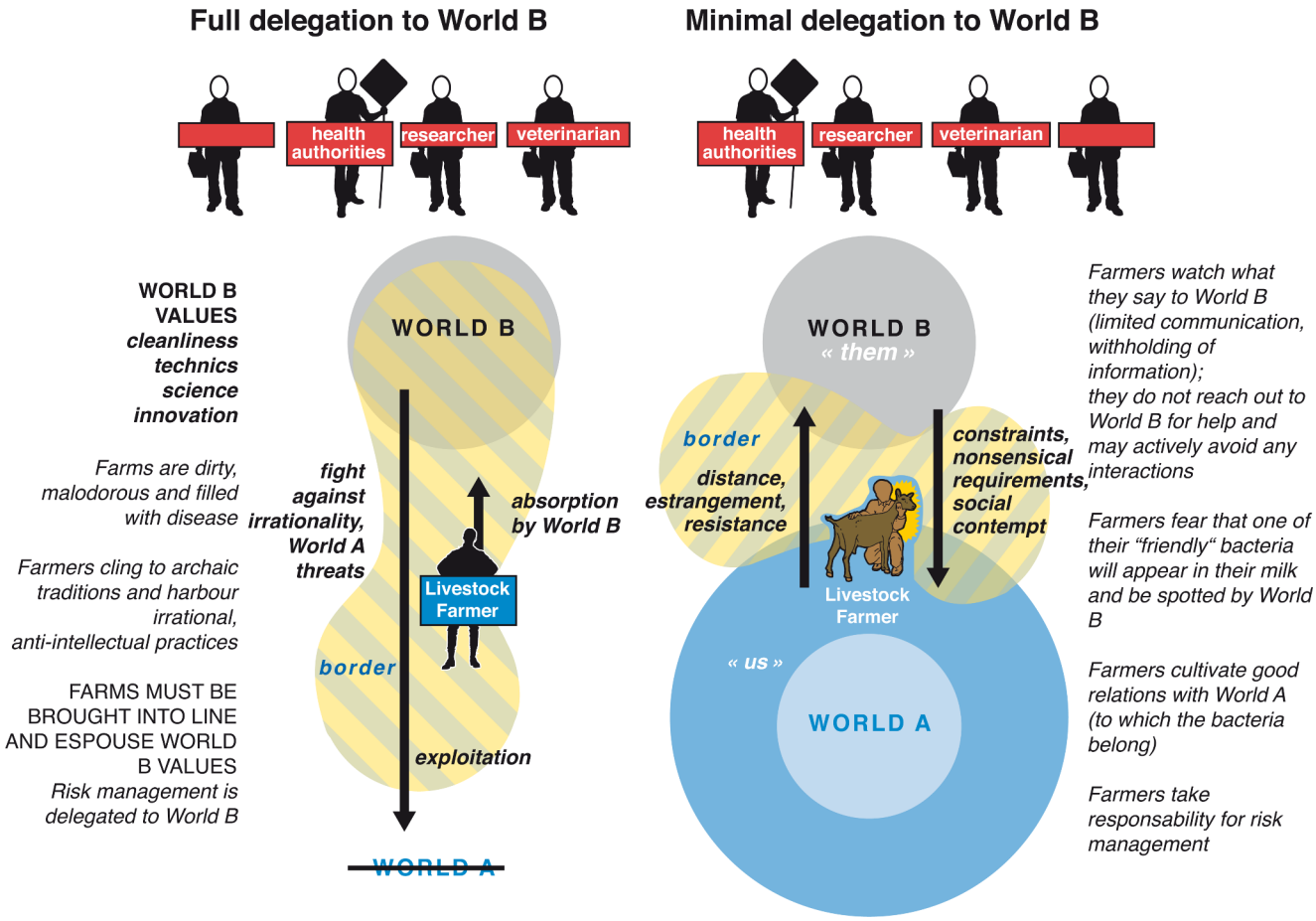

Fig. 2 Polarisation between Worlds A and B illustrated using livestock farmers who either completely delegate (left) or minimally delegate (right) health risk management to World B

control over a situation that would otherwise feel unmanageable. They know the illnesses that often tend to occur. They are familiar with certain medications, a familiarity that breeds a sense of connection and that allows the farmers to request them by name. They may also have preferences for certain health practices, such as "giving shots" of antibiotics to the animals themselves. Consequently, they may feel a greater sense of control.

Moreover, because the entire economic cycle of their farms is already subject to the constraints imposed by World B (e.g., dairies, cooperatives, health authorities), livestock farmers may perceive themselves as having already delegated far more than their diplomatic relations with non-humans. When confronted to diseases, their position may have shifted, and their perception of themselves along with it. As a result, they may then allow themselves to be "*absorbed*" by World B, or they may attempt to re-establish their proximity to World A. In either situation, they are forced to reconsider their position, which is no longer determined by the relative equilibrium between Worlds A and B. They must occupy the borderlands in a new way, which will inherently involve a certain amount of stress. This process sometimes leads to moments of profound distress, deep inquiry, and hard decisions.

In particular, when the farmers perceive contradictions in the advice they receive or if the recommendations fail to provide solutions, they may lose confidence in World B. Simultaneously, they may be unable to reconnect with World A, from which they have distanced themselves. This situation can lead to a loss of meaning and a rise in discomfort which, for some, prompts an even greater degree of delegation to World B. As a result, the positioning of farmers shifts even further, as they question their ability to manage circumstances on their own. For others, it provokes fear and disassociation which, in some cases, can lead farmers to consider suicide.

Type A farmers: farmers who minimally delegate health risk management to World B

When livestock farmers minimally delegate risk management when disease occurs, a greater amount of space is taken

up by how they experience and relate to World A. World B is generally ignored or even excluded as much as possible from diplomatic relations with non-humans. Livestock farmers remain in the borderlands but turn away from World B to devote themselves to World A. When their animals fall sick, their position is more firmly rooted than that of farmers espousing a high degree of delegation, namely because no absorption has occurred (by either World A or B): World B is rejected as much as possible (e.g., farmers refuse to conduct analyses or call a veterinarian) whereas relations with non-humans within World A remain diplomatic according to Morizot's meaning (Morizot 2016).

That said, livestock farmers cannot fully end relationships with World B, given that they must interact with authorities around product standards (most often milk quality) and commercial authorisations. This situation leads to intense anxiety for these farmers. They have a good relationship with World A and fear that one of the "*friendly*" bacteria or viruses from this world will be discovered in their milk by World B. The latter's reaction is perceived as violent and highly unreasonable: "*they are prohibiting the sale of milk when microbes are everywhere*" or "*and now they also want to ban raw milk!".*

In the face of a disease, diplomatic relations with non-humans within World A are intensified. Different mediators become involved, some from the realm of humans (e.g., counsel from community "elders", books, magazines, and training courses) and some from the realm of non-humans (e.g., plants, healthy farm animals, or non-agricultural animals [birds, bees, dogs, and cats]). There is also the internet, which is viewed as an essential entity that dispenses generous diplomatic advice regarding non-humans. The appearance of disease on the farm may be perceived as an opportunity for intense experimentation, whose results will guide the establishment of stronger and more advantageous diplomatic relations with animals. While such situations are challenging, World B may be seen by farmers as the true problem, as it pre-empts any possibility of exploring options, performing experiments, and broadening understanding. Therefore, livestock farmers often deliberately distance themselves from World B. Such may take the form of ignoring emails about health alerts, forgoing veterinary help even in serious cases, or confirming their diagnoses themselves using practices such as animal autopsies.

The delegation of health risks as an anthropological prism for interpreting our results

In our research, we were struck by this idea that relations with non-humans (i.e., health risk management here) are a responsibility that can be delegated. This realization allowed us to combine several recent theoretical advances in the social sciences, such as work around taking non-humans seriously (Morizot 2016) and accounting for diplomatic relations among living organisms (Kohn 2017). Based on this foundation and other previous research (Landivar and Ramillien 2015; Landivar and Ramillien, 2017; Ramillien et al. *in prep*), we posit that such delegation is a defining characteristic of naturalistic modernity in Western cultures. Indeed, the concept of delegation allows us to connect and collectively ponder questions related to autonomy, local knowledge, and our common state of health. It also adds to our understanding of the complexity and interrelatedness of many pressing issues, from zoonoses to climatic and ecological crises. In the specific case of Q fever, we can ask the question: "Is the responsibility for health risks delegated?" The answers are a new lens for clarifying how different stakeholders perceive the disease and make it possible to explore the challenges that these stakeholders are facing. Indeed, when considering concerns such as delegation failures or attempts to disengage from delegation, this lens could help prompt new ways of thinking about the tangled connections among all types of human and non-human stakeholders (e.g., livestock farmers, animals, microbes, veterinarians, infected humans, researchers, experts) by bringing them back into a shared space.

How livestock farmers view Q fever: the microbe's two modes of existence

Setting aside its biological, ecological, and epidemiological properties, which remain fairly uncharacterised and the target of research in various domains (Eldin et al. 2017; Mori and Roest 2018), *C. burnetii* has two modes of existence that depend on the world in which the pathogen manifests itself. The difference lies in the sway that the pathogen and stakeholders hold over each other (Fig. 3). This result echoes the concept of the "microbial turn", which emphasizes the plurality and ambivalence of the relationships between humans and microbes (Sariola and Gilbert 2020; Brives et al. 2021; Brives and Zimmer 2021).

Q fever possesses qualities of both worlds

There is a marked difference in how Q fever is perceived depending on farmer type. For Type B farmers, real or anticipated Q fever outbreaks cause a complete overhaul of relations with World B, which results in a shift in their self-perceived location within the borderlands. Indeed, they almost systematically see Q fever as possessing qualities of both worlds, which leads to a dramatic degree of disturbance.

First, Q fever is "*a slippery disease*": it is equally elusive in Worlds A and B for three key reasons.

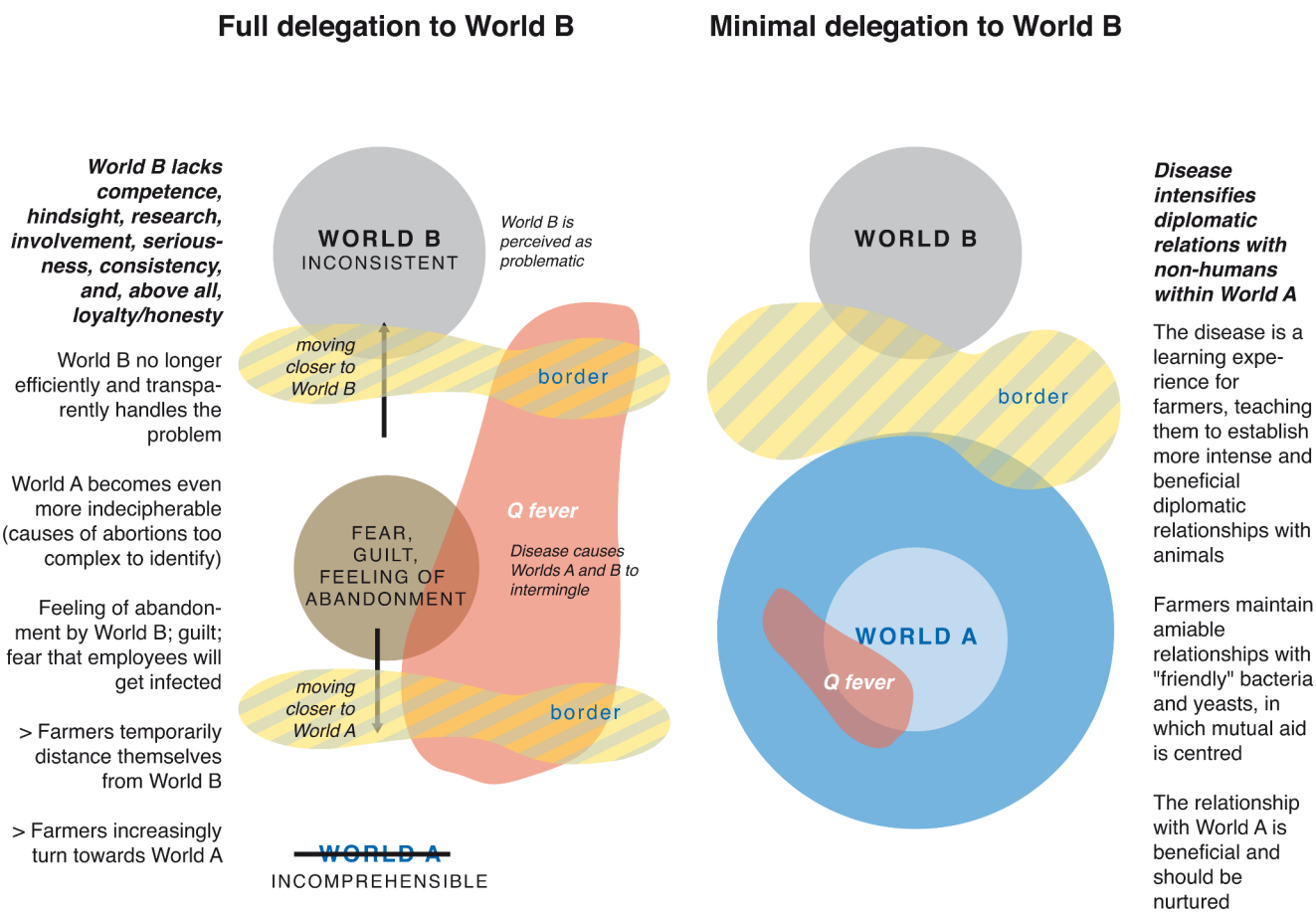

Fig. 3 Illustration showing how Q fever is perceived by livestock farmers who differ in how much they delegate health risk management to World B: Type A = minimal delegation (right) and Type B = significant delegation (left)

(1) Q fever infections are largely invisible. Unless they experience abortions, ruminant livestock show no visible symptoms: "*the disease hides*". Under normal circumstances, World A will clearly communicate the causes of abortions, using signals that farmers can interpret thanks to their extensive experience and knowledge (e.g., a goat is carrying excessively large kids, has received inadequate feed, has been hit, is tired). However, in the case of Q fever, such information is absent. Abortions happen without any forewarning, and their causes remain obscure after the fact.

(2) Q fever can only be diagnosed via laboratory analyses. Tests are needed to determine whether the disease is present, which means that World B must be called upon to validate a potential unknown. Livestock farmers view testing as unreliable: a farm's animals may test negative even though the farmer has tested positive and is symptomatic. Conversely, animals may be diagnosed as having been infected with Q fever at some point in the past (e.g., upon sale to breeders), even though the farmer never witnessed any unexplained serial abortions. Interestingly, these observations on the ground are consistent with scientific findings highlighting issues around rates of false positives and false negatives during Q fever diagnostic testing (Rousset et al. 2018; Lurier et al. 2021). Thus, based on what they are seeing in World A, livestock farmers feel that World B is furnishing unsatisfactory services and unverifiable information, with veterinarians referring to the latter as "*variability in bodily responses*".

(3) Q fever makes livestock farmers feel that Worlds A and B have lost all sense of logic. They have the sensation that neither world has any support to offer: animals are aborting for no clear reason, and veterinarians proffer recommendations "*without really knowing anything*", or they "*give animals shots that do nothing*". The landscapes of Worlds A and B have dramatically shifted, leaving farmers in the lurch, struggling to adapt their positioning. The farmers are ill at ease with the sudden levels of mortality and the numerous unexplained abortions. In other words, World A has taken a negative and inscrutable turn, becoming elusive, dangerous, and illogical. Farmers have simultaneously lost confidence in the care provided by veterinarians and doctors, meaning World B can no longer be trusted just when farmers are being forced to rely upon it.

Second, Q fever is "*a poorly defined threat*". The actual risks associated with Q fever are a source of confusion, blurring the lines between Worlds A and B. Livestock farmers feel trapped in a web of uncertainty: the worlds now intertwine in the borderlands, rendering diffuse causes and responsibilities that are normally well defined. This perception of Q fever arises for three main reasons.

(1) Whether Q fever actually represents a threat remains controversial. Indeed, not all livestock farmers perceive Q fever as dangerous for their animals' health. Although some see the disease as presenting significant risks, others consider it has long been a benign presence on farms. World A may be viewed as the typical source of Q fever, which may or may not be threatening ("*no more dangerous than other [diseases], and maybe even less so!*"). World B is seen as sounding the alarm about the disease's risks without providing any concrete advice or, alternatively, while issuing unrealistic recommendations (e.g., covering or composting manure before spreading it, cleaning boots, retrieving placentas).

(2) The human health risks associated with Q fever are largely unknown. Most frequently, livestock farmers are unaware of the specific human health risks of Q fever, or they are generally unfamiliar with the disease. Some believe that transmission is blood borne (i.e., occurs via contamination of open wounds), while others believe that infection results from eating cheese or touching aborted or stillborn goats. Messages from World A are equally vague, given that infections in humans can manifest themselves in a variety of ways (miscarriages, flu-like symptoms, chronic fatigue, or several days of high fever). World B further fails to provide any clarity. Certain veterinarians want to vaccinate quickly after abortions occur to limit the potential zoonotic risk, while others argue that vaccines are ineffective in such situations. Furthermore, most medical doctors are unfamiliar with the disease ("*fortunately, the substitute doctor was there when I got sick because no one would have figured it out otherwise*"; "*I had Q fever… My wife got it too and she still suffers from it; since then, she has been tired all the time… she was followed [by medical doctors] at the beginning but after six months the doctors referred her to a psychologist*").

(3) Q fever can endanger farm viability and economic stability. In the interviews, farmers familiar with the disease mentioned that their main fear was that their flock would need to be slaughtered or that they would be banned from selling their products. As Worlds A and B intermingle, occupying atypical spaces, livestock farmers hang on by focusing on the economic and legal status of their farms, a fixation that can also be a source of great anxiety.

While many other diseases cause temporary polarisation before the borders settle back into their baseline fluctuations, Q fever completely transforms the worlds' contours. Relations with Worlds A and B are greatly disrupted, come under intense scrutiny, and undergo major modifications. Thus, farmers experience feelings of abandonment, of being left to navigate the risks and fears that partially spurred their initial choice of risk delegation. Indeed, the representatives of World B are aware that farmers pay a steep economic, social, and symbolic price for risk delegation, but the representatives themselves are still wrestling with the elusive, complex, and threatening nature of the disease. Moreover, World B itself seems to have only recently recognised the importance of Q fever. Consequently, livestock farmers view its representatives as lacking in competence, perspective, and scientific expertise ("*they'd do better to focus on finding solutions at INRA[E] rather than sending you out to my place*") as well as in involvement, seriousness, consistency, and, especially, loyalty/honesty. Overall, livestock farmers expect members of World B to display greater transparency and integrity and want them to admit to their weaknesses (i.e., the aforementioned incompetence and lack of knowledge). They adopt this stance even though it threatens to further disrupt their positioning within the borderlands, since it may further distance them from World B, for whom mistrust has grown. Further examples of these interactions are available in the online Supplementary Materials. In our study, we saw no examples of Type A livestock farmers among the farms affected by Q fever. However, there were farms affected by other diseases whose farmers did fit the Type A profile. These farmers indicated that they would adopt the same approach if confronted by Q fever, viewing the disease as a manifestation of a broader imbalance to be dealt with using vigilance, experimentation, and specific efforts to boost animal and human immunity.

Microbes from the perspective of World B, which seeks to manage and control living organisms

In World B, *C. burnetii* is a dangerous biological agent because it poses significant health risks to animals and humans. However, science has yet to clearly determine the threat that it poses. Indeed, researchers underscore the numerous uncertainties around Q fever ecology and the interacting factors that favour its transmission and pathogenicity (Cerf and Condron 2006; O'Neill et al. 2014; Duron et al. 2015; van den Brom et al. 2015; Eldin et al. 2017; Koehler et al. 2019; Dragan and Voth 2020). Consequently, official guidance on the degree of risk associated with *C. burnetii* remains vague (Keck 2009), as illustrated by the various scientific opinions and regulatory texts discussing this pathogen (AFSSA 2004; AFSSA 2010; ANSES 2010; ECDC 2010; EFSA 2010a; EFSA 2010b; ANSES 2012; HCSP 2013). World B nonetheless feels compelled to

dictate what should be done, which is expressed in the form of management recommendations. Yet, making such recommendations is intricate, first because of the large gaps in knowledge about *C. burnetii*, but also and most importantly because it is difficult for stakeholders to base their suggestions and actions on new discoveries about the microbial world and its ambivalence (Sariola and Gilbert 2020; Brives et al. 2021). Indeed, this new knowledge, which arose from the technological revolution of metagenomics in the early 21st century, challenges the ways in which World B imagines responding to health crises: it reveals that it is very difficult, if not impossible, to domesticate and control microbes that are part of complex ecosystems.

In fact, recent research in microbiology has not only expanded the frontiers of the microbial world, which intrinsically contributes to biodiversity, but it has also introduced new concepts of ecosystems, such as the holobiont, the microbiota, or the microbiome (Brives et al. 2021). As a result, the distinction between "good" and "bad" microbes is becoming blurred, and the complex interdependencies between microbes on the one hand, and animals and humans on the other hand, are becoming more apparent (Dethlefsen et al. 2007; McFall-Ngai et al. 2013). These concepts of complex microbial entities have changed the way microbes are considered. Born in the 19th century, the early field of bacteriology focused on isolating and cultivating pathogenic agents outside of their natural habitats. Therefore, the world of microbes was simplified, and its "biosocial" dimensions were entirely ignored (Brives and Zimmer 2021). The sole concern was the medical impact of microbes: they were labelled as "pathogenic" and converted into the enemies of public health. This narrative, which drove efforts to sanitise environments, eradicate bacteria, administer vaccines and antibiotics, and cull animals, is still the main public health's motivation for action today. Yet, the ecosystems revealed by metagenomics challenge this view of the microbial world as a collection of enemy "species" from which we need to protect ourselves by acting on the environments in which they thrive. World B nevertheless continues to nurture this latter narrative and struggles to grasp the existence of these complex microbial entities and their tangled web of relationships and interdependencies. The fact is that such microbial entities exist in the realm of ongoing research: they are still hard to characterize and cannot easily be quantified through "biological indicators" on which actionable recommendations could be based.

Also, World B is characterised by oft-repeated health emergencies, during which it "must take action". This state of affairs fosters an inability to serenely grasp the dynamics of microbial proliferation and complexity. The world's response is then to rely on what it knows how to do: measure, monitor, and control pathogenic microbes. It also draws on its reliable established tools, namely regulations, standards, vaccines, antibiotics, disinfectants, and eradication via sanitation procedures. The attribute "pathogen" prevails within World B's narrow view of the microbial universe, and "micro-biopolitics" play out as stakeholders wage a war on microbes, in which relationships between humans and micro-organisms are governed by policies based on management and control (Paxson 2008).

The eradication narrative has progressively been replaced by a narrative focused on biosecurity and surveillance, in which the use of metrics is required because they reflect a rational approach to health risk management (Brives and Zimmer 2021). However, such a management regime is difficult to implement in the case of Q fever, and probably many other zoonotic diseases. Indeed, *C. burnetii* is widespread and remains "elusive" and difficult to monitor: first, because it is transmitted through the air; second, because a great deal of scientific uncertainty exists around how the bacterium persists and the circumstances under which it can become a health problem.

Microbes from the perspective of World A, which collaborates with and cares for living organisms

In World A, *C. burnetii* is not reduced to its status as a pathogenic microbe. Instead, the bacterium is perceived as part of a broader microbial world in which "*good and bad microbes"* lead a multifaceted coexistence that protects livestock farmers from health issues: "*I rarely use sanitation procedures when milking; I tell myself that my system is keeping us safe."* This practice echoes recent discoveries about the microbial world, which have been shared by popular science outlets (Sellosse 2017). However, it is less that livestock farmers have absorbed knowledge from the life sciences ("*it protects me, but I don't really know why or how")*, and more that they have negotiated and cultivated diplomatic relationships with microbes during intimate exchanges ("*If we get worried about everything, then we stop actually doing anything! There are lots of serious diseases out there, and it is up to us livestock farmers to decide which ones to prioritise…*").

More generally, livestock farmers see microbes as existing within a continuum that encompasses all living creatures. They do not rely on scientific knowledge, which is still being generated, but rather on their experiences. For example, one farmer stated: "*I also have cats everywhere because cats make everyone immune. We've never had Q fever*." By such statements, livestock farmers express ideas that are consistent with biological concepts such as the microbiome and immunity, without explaining reality using scientific scaffolding. In fact, the relationships between livestock farmers and microbes extend beyond the latter's

biological properties. They are rooted in a biosocial network that highlights the tightly woven connections among the environment, humans, and microbes, or between nature and culture.

In particular, the presence of microbes is the "promise" of a unique flavour for farmers who produce farmstead cheese, especially those who use raw milk (Paxson 2008): "*My cheeses owe their taste to the flora and microbes within my grasslands and my soils*." Such singular flavours are the fruit of skilled labour that is founded in a daily narrative lived by farmers. But this narrative also drives pricing and negotiations on the market. Thus, in World A, microbes lead multifaceted lives that unfold on stages other than those built upon sanitary control. World A resists bowing to World B's standards and regulations, intrusions that simplify and endanger the former's complexity.

Overall, with Q fever as well as numerous more "fearsome" and highly regulated zoonotic pathogens (e.g., those causing listeria and salmonella), pathogen management or eradication compelled by regulatory standards may actually threaten the health of complex ecological, social, and economic systems in which all microbes, including pathogens, are linked.

Conclusion

Biologists often call upon sociologists and anthropologists to help them identify the brakes and drivers of innovation, a product of presumably universal knowledge. This approach distinguishes "those who know" from "those who don't know". It is also tantamount to "disregarding" the experiences of those on the ground. Yet, as argued by Cohen (2021), farming takes place on the border between several forms of rationality that constantly enter in friction; hence, scientific rationality alone is incapable of fully grasping its complexity.

Life on a farm is a series of daily, weekly, and yearly cycles, which are inherent to an 'ideal type' that we designated here as World A. In this world repleted with risks and heavy constraints, livestock farmers are attuned to minute variations in these cycles and have established phenomenological "metrics" that allow them to assess and adjust their work (Cayre et al. 2024). Conversely, the veterinary and agronomical sciences, which refer to another 'ideal type' that we designated here as World B, lack the suite of tools available to livestock farmers. They can at best detect a tiny fraction of the many signs perceived by farmers within World A. The latter explains why public health officers are unable to see the realities that exist beyond the biological facets of their own reality. This truncated vision of the real nature of health problems is made visible in the way they take action when public health crises arise. Then, a collision may occur between the two worlds and the two modes of existence of microbes such as the bacterium *C. burnetii*. The impact point is the space occupied by livestock farmers, a borderland between both worlds. The encounter can give rise to various microbial modes of existence, which may be more or less vulnerable or consistent depending partly on how much livestock farmers delegate health risk management. These situations, which are highly diverse, are difficult for health authorities to tackle, given that they have few concrete tools for addressing public health emergencies.

In such contexts, science is summoned as a referee, insofar as it often continues to prevail and categorically state that "truth lies in reality". However, as discussed above, although research indeed produces knowledge, the latter is largely determined by a biological and ecological interpretation of situations and its process is continuously ongoing. While research is obviously useful and necessary, it is also incomplete as it currently fails to fully explain the tangled relationships and interdependencies among ecology, society, and the economy. These ways of understanding and interpreting reality are hallmarks of "modernity", which, despite some upheaval at the turn of the 21st century (de Fontenay 1998; Haraway 2008; Kohn 2017), remain very much present to this day. As discussed by Stengers (2019), who draws on the work of the philosopher Alfred North Whitehead, such views represent a "bifurcation of nature", where relationships between humans and non-humans involve the former exerting control, mastery, and domination over the latter. This "thinning of the world" (Stengers and Debaise 2023) results in simplistic relationships (e.g., subordination or obligation) and engenders significant constraints. Livestock farmers have no choice but to comply with this reality if they wish to completely or partially delegate responsibility for health and economic risks to World B. Yet, in contrast, livestock farmers experience these entanglements first hand within World A, through their intimate dealings with microbes, and especially with pathogens. As a consequence, they develop an understanding of reality that has much to tell us and that should also be taken seriously.

The anthropological research conducted here sought to shine the light on these diverse realities, focusing on the example of Q fever, about which we have extensive experience. Based on our results, we show that the difficulty of implementing public heath action is due to the coexistence of two realities, which are in friction and around which the actors at stake navigate. First, we explored how the reality experienced in World B engenders distrust and disrupts the agency of livestock farmers, who are found in the borderlands between Worlds A and B. Second, we highlighted that, upon delegating the responsibility for relations with non-humans to World B, livestock farmers may feel that they

are surrendering their autonomy. The occurrence of Q fever, and of other diseases, gives rise to this outcome by causing Worlds A and B to collide within the space occupied by livestock farmers, leading to tension and displacement.

The next step in our approach is to take action and put the stakeholders in dialogue. Our work strives to move towards more "health democracy", in which different forms of reality are considered and equal weight is given to knowledge generated by "scientists" *versus* other stakeholders, often referred to as "laypeople". Here, the latter are specifically livestock farmers. While establishing a public health democracy is obviously a complex process, the relevance and utility of this approach has been illustrated by the AIDS epidemic, where ongoing dialogue among researchers, doctors, and patients led to the development of triple combination therapy (Tabuteau 2021).

Anthropology does not simply seek to describe the various representations of a world that may have been objectified by the natural sciences. Instead, the goal is to comprehensively reveal the multiple realities that constitute the world (Herrera 2018). As a result, anthropology may foster exchanges between these realities as well as structuring discussions by identifying the synergies and commensurabilities among the underlying ontologies (Meulemans 2021). From a public health perspective, anthropology also faces the challenge of nourishing democratic debate, by serving as a translator or diplomat, with the greater objective of creating and exploring new types of public health services.

In our study, other interviews were conducted with health and public health professionals to compare the realities of farmers with those of institutional and regulatory stakeholders. All together, these results will be used to create a "serious game" aiming to facilitate stakeholder dialogue with a view to co-constructing health policies to prevent and manage Q fever, as well as other zoonotic diseases of concern for small ruminant farmers. Such collaborative and reflexive work is essential during "peacetime" so that crisis management strategies are in place when outbreaks arise.

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Data availability As the qualitative interviews could contain sensitive information, these data are not publicly available.

Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval The authors state that the research described in this article was conducted in accordance with the recommended standard principles of objectivity, transparency, and ethics.

Consent to participate Informed consent was obtained from all those who participated in the qualitative interviews, in compliance with the General Data Protection Regulation (GDPR).

Consent for publication Not applicable.

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