Exploring the human-animal-technology nexus: power relations and divergent conduct

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Abstract

This chapter develops an agenda for discussing less-than-convivial more-than-human relations. It reviews existing work on such relations before developing a terminology of 'divergent conduct' aiming to better express such relationships. The chapter uses an empirical case study of automated or robotic milking systems, and focuses on the relationships these establish between machines, humans, and cows in specific places. Divergent conduct aims to express how humans and nonhumans co-produce activities which are likely to differ from accounts of trouble-free introductions of technologies. The concept emphasises the agency of animals while paying attention to their relationships with people and machines. As such, it emphasises how automatic farming is constituted in relation to multiple human and nonhuman requirements, and their related conducts, which may pull in different directions. The chapter argues that divergent conduct provides a way of exploring problematic entanglements in which inequalities of power can be many-layered and intersectional.

Key words

Resistance; Transgression; Divergent conduct; More-than-human; Geography; Robotic milking

1. Introduction

Questions about the agency of nonhuman animals (henceforth, animals), their capacity to be mediators (Latour, 2000) and thus 'make a difference' to situations and events, have been at the core of much animal-geographical investigation. In this chapter, we develop a research agenda that builds on such themes by exploring the roles of animals in the constitution of, and resistance to, 'power'. In so doing we attempt to 'stay with the trouble' (Haraway, 2016), exploring difficult questions about the entanglement of human and animal lives in ways which cannot promise easy resolution. Specifically, we call for continued engagement with problematic situations such as intensive animal agriculture, developing our arguments about power relations associated with intensive dairy farming. We critically explore attempts to systematically enhance agricultural productivity and efficiency through the

deployment of novel technologies, and simultaneously intervene in and 'improve' animal lives. The chapter uses one example of particularly intensive human-animal-technology relations to explore how power is constituted around human and animal bodies and subjectivities, and how nonhuman agency might be articulated around divergence from (what is presented as) intended or ideal animal conduct.

We draw from our existing published research based on an in-depth investigation of automated dairy farming (i.e. 'robotic' or 'automatic milking systems' (AMS)) in the UK[1] to explore how animals, in this case dairy cows, caught up in human-animal-technology relationships, are not simply docile bodies, but can be understood as actively contributing to the constitution of those relationships (for social scientific investigation of robotic and other milking systems see, for example: Bear & Holloway, 2019; Butler & Holloway, 2015; Heutinck & Driessen, 2007; Holloway, 2007; Holloway et al., 2014a, 2014b; Holloway & Bear, 2017; Porcher & Schmitt, 2012; Stuart et al., 2013). Our research involved interviews with farmers and technology developers, and observational research on-farm with farmers, cows, and robots.

After describing the emergence and design of robotic milking systems in Section 2, in Section 3 we explore how cows are co-constituted as actors and subjects within automated dairying. We argue that bovine bodies and subjectivities are considered in the design of automated milking, that they have affected farming knowledge-practices, and that they are in part an effect of automated milking. Cows and robotic milking are, we suggest, co-produced. We discuss this in terms of the power relations implicated in automated dairy farming, drawing on Foucault's discussion of biopower (Foucault, 1990, 2003, 2007; Rabinow & Rose, 2006; Nealon, 2008) to explore how dairy cows are known and controlled in these systems, at the same time as farmers too are disciplined and subjectified in new ways by or with the technology.

Next, countering the sense that cows (and humans) are passive intermediaries in the face of technological interventions, we extend the discussion in Section 4 by focusing on how cows can act to disrupt automatic milking. The chapter questions terminologies of 'transgression' and 'resistance' which are commonly used in animal geographies and other writing on how animals can act counter to human and technological 'intentions'. These terms tend to focus on how animals transgress human boundaries or resist human control and, as such, recentre the importance of human intentionality. Instead, we introduce the idea of 'divergent conduct' (Bear & Holloway, 2019) as a conceptual tool to help us explore how entanglements of humans, animals, and technologies can produce different trajectories to those intended by human designers and users of (in our example) farming systems. The chapter aims to address anthropocentric limitations in thinking about human-nonhuman relationships by establishing an agenda concerned with reconceptualising

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ideas about resistance and transgression around divergent conduct. We conclude the chapter by highlighting some key pointers for an emerging agenda for animal geographies research.

2. Robotic or automatic milking: technological fixes

Robotic or automatic milking presents itself as a solution to several problems associated with contemporary dairy farming in the UK and elsewhere. On the one hand, farmers have increasingly struggled to find and retain suitably skilled farm workers willing to carry out the milking practices associated with conventional machine-milking systems (Holloway & Bear 2017). Labour is also expensive on dairy farms which are currently economically marginal. Even where farmers undertake this labour themselves, there is a decreasing willingness to undertake the demands of milking a herd of cows twice or three times a day by conventional milking. On the other hand, conventional milking is seen to create problems for the 'welfare' of dairy cows[2] because: limiting milking to two times per day can be regarded as 'unnatural'; conventional milking machines are not sensitive to the fact that each 'quarter' of the udder might need a different amount of time to complete milking; and the reliance on humans to carry out milking can result in variability of milking practices with possible effects on cow health and hygiene.

As an alternative to conventional milking, robots are represented as addressing both sets of problems outlined above. Automatic milking machines have been commercially available since the 1990s and have become increasingly popular in the UK and elsewhere. Hogeveen et al. (2001) describe them as having six components: the milking stall; a teat detection system; a robotic arm which attaches the milking cups to the teats; a teat cleaning system; an electronic monitoring and recording system; and the vacuum milking machine itself. Cows can choose to attend the robot several times a day to be milked, incentivised by the provision of food. The cow enters the stall and is identified by the robot using the RFID tag she wears. On entering the stall the robot checks whether the cow has been milked very recently, as some cows will attend too regularly to obtain food; if she has, the robot will open the gate and release her back into the barn. (Conversely, where cows do not attend the robot regularly enough, the farmer will be alerted by the robot so they can intervene). If the cow is to be milked, a robotic arm cleans the teats and attaches the milking cups. Milking proceeds and, once complete, the cow is released back into the barn. This process takes place without the direct intervention or presence of people: the robots and cows conduct milking, potentially continuously, all day and night. During milking, the robot collects information about the yield and quality of the milk (and potentially other indicators such as the cow's weight) which can be used by

[2] Almost all dairy farming can be associated with significant 'welfare' issues, including the early separation of cows from their calves, and the stress placed on cows' bodies, engendered through selective breeding practices, to produce high volumes of milk. See Buller and Roe (2018) for detailed discussion of the problematics of defining and intervening in farm animal welfare.

the farmer in managing the cows. Its proponents thus claim that automated milking has the potential to significantly change dairy cow management, as the data collected allows more individualised management, and the ability to identify health issues at an early stage.

Robotic milking responds to a longer-term set of concerns about milking practices relating to the objectification of the cow as a 'machine', variability in human abilities and skills in milking, and health and hygiene issues associated with different kinds of milking technology (Holloway & Bear, 2017). Although the capital outlay on robots is high, it is argued that they compare well with the costs of human workers. At the same time they 'liberate' humans from the routines of conventional milking, allowing them to undertake other work or have more leisure time. Second, by allowing cows the flexibility to 'choose' when to be milked, it is argued that robots better mimic the 'natural' process of feeding a calf. Robots also provide a consistent milking experience for the cow compared to the variabilities associated with human milking. They can respond to the needs of each udder 'quarter' so that there is a reduced risk of over- or under-milking and its associated health problems, especially mastitis. Manufacturers thus argue that robots improve dairy cow welfare on the basis that housed cows will be closer to the robot and more likely to attend milking (although they are also associated with more contentious practices such as keeping cows inside all the time instead of allowing them out to graze (see Fraser & Broome, 1990; Webster, 1994; Holloway, 2007)). We turn to the implications of these changes in the next section.

3. Knowing and controlling cows and farmers: biopower and (non)human subjectivities.

In this section, we introduce Foucault's concept of biopower and outline its relevance for our discussion of the relationships among humans, animals, and technologies. Using our example of robotic milking, we discuss how cows become involved in the deployment of technologies. We consider how human and nonhuman subjectivities are produced in robotic milking systems, and how both people and cows are disciplined by these systems despite rhetorics of 'freedom' and 'choice' deployed in their promotion.

Space precludes a detailed discussion of biopower (see Rabinow & Rose, 2006, for further detail). Briefly, it refers to the emergence of sets of interventions by the state in the lives of people from the late 18th Century onwards, which aimed at fostering the productivity of both individuals and populations by focusing on the capacities of 'life itself' in furthering objectives including the security and competitiveness of the nation state and an emerging need to secure economic output and growth. Biopower supplemented previous sovereign and disciplinary modes of power in specific ways in different situations. It did not supplant them but enabled new and different ways for the state to 'imagine' its people (as a 'population' for example) and to conduct their activities and behaviours. Populations could be understood in terms of life processes, such as birth, death or morbidity (sickness) rates which could be influenced by state intervention, for example in the availability of healthcare,

improved diets or clean water. Foucault associated biopower, then, with new ways of knowing about and intervening in the lives of individuals and populations which were related to emergent social scientific, statistical and scientific/medical understandings of (for example) health and behaviour. Rabinow and Rose (2006) provide a valuable schema for analysing relations of biopower for our purposes. They argue that situations in which biopower is expressed involve: the articulations of particular truths about life by authorities (such as science) regarded as legitimately able to determine such truths, interventions in the life of individuals and populations, and the subjectification of individuals in relation to truth discourses associated with their areas of activity. This last dimension of biopower suggests that individuals internalise truth discourses, influencing their behaviours and social practices, and learning to 'care' for themselves in producing themselves as 'good' individuals.

Although developed by Foucault in his analysis of human populations, the emphasis on 'life itself' in the concept of biopower has appealed to many in thinking about animals too. Thus, many animal geographers and other writers have drawn on biopower and biopolitics in their analysis of human-animal relationships in agriculture and elsewhere (see for example, Asdal et al., 2017; Hinchliffe et al., 2017; Holloway et al., 2009, 2014a; Wolfe, 2013). With reference to Rabinow and Rose (2006), it is argued that 'truths' about life can apply to both human and animal life, and that significant interventions aimed at influencing how that 'life' is (re)produced and its energies directed are made in relation to both humans and animals (for example, ideas about health, diet, 'breeding'/reproduction and productivity can be applied to humans and animals simultaneously). It is, however, more problematic to argue that animal subjectivities are effected in the same way as human subjectivities. In this case arguments have been made that within biosocial collectivities (Rabinow, 1999) of humans and animals cohering around specific issues related to the fostering of productive life (such as animal agriculture), the subjectivities of both are co-produced (Holloway, 2007; Holloway et al., 2009; Holloway & Morris, 2012). Humans and animals together become expected to behave in particular ways and care for themselves in accordance with narratives concerning their bodies. We explore this here in relation to robotic milking.

In their writing on robotic milking, Heutinck and Driessen (2007, p. 253, original emphasis) argue that 'the development of the AMS can be seen as part of a process of (the automation of) dairy farming in which 'good farming' is changing from *caring for the animals*, towards *allowing the animals to take good care of themselves*'. This comment suggests a significant change in the relationship between humans and cows in the shift from conventional to robotic milking. As we explore here, it also implies an important change in what bovine subjectivity is - a change in what being a cow is understood to be. A key dimension of this change is an argument that cows gain in 'freedom' and autonomy in robotic milking systems. Cows become actors, in robotic milking, who make choices about when to be milked. Individual cows might make different choices for various reasons. This contrasts with conventional milking parlours, where the timing of milking is determined by the farmer, and the cows are milked together as a herd.

As one manufacturer argued, in attributing a new subjectivity to robotically-milked cows,

> [in] any robotic system the cows are left to their own devices. They do what they want … the cow takes control of her own destiny.

Farmers agreed, commenting that,

> The cows are very much free to do their own thing … you let them get on with the job really,

and

> Well it's choice isn't it? [The cows] have the choice … to do what they want, when they want really don't they?

For respondents in our research, one result of this freedom was that (in their view) their cows were much happier and more relaxed. The cows were also described as healthier, and as more productive animals. Such ideas relate back to the discussion of the functioning of biopower in relation to animals. Robotic technologies can be regarded as interventions in the bodily and subjective life of cows, as cows fulfil their 'destiny' (sic) of being economically productive in accordance with prevailing truths about the genetic capacities of farm animal bodies and about the economic logics of contemporary food production.

However, we should not uncritically accept this rhetoric of 'freedom'. First, as we have already noted, cows are not simply given the option of doing as they like in robotic milking systems. They are instead expected to behave in accordance with expectations about productivity. Fundamentally this means they *must* 'choose' to visit the robot regularly, eat and digest sufficient food, and produce sufficient quantities and qualities of milk. They might be seen, in effect, as responsibilised to care for themselves and to be productive. In recognising this we are arguing that, instead of robotic milking liberating a subjectivity previously constrained by the routinized herd behaviour required by conventional milking, an alternative subjectification occurs which places responsibilities on the cow to make her choices appropriately. Importantly, cows' behaviours and productivities become knowable, to a level of great granularity, as their movements into the robot and the amounts and qualities of milk produced are recorded in great detail and become available for further intervention in their lives. Second, then, as noted above, for Foucault, biopower is articulated with pre-existent disciplinary modes of power: in robotic milking freedom, autonomy, and choice are articulated with modes of disciplining cows' bodies and behaviours. Gates can be programmed to permit or deny access to food and water (depending on whether the cow has been milked), the robot will eject cows who try to be milked too frequently, and the information collected by the system can be used to guide human interventions such as herding reluctant cows (sometimes referred to as 'lazy') towards the robot (Holloway et al., 2014a; Bear & Holloway, 2019).

We can make similar points about the discipline and subjectivity of the human actors (farmers) in robotic milking systems (Holloway et al., 2014a). As noted above, it is claimed that farmers too are given freedom, particularly from the routine drudgery of milking. And yet it was noted by manufacturers and farmers themselves that different kinds of obligation were placed on them, as they were expected to think about farming in new ways and to engage in new farming practices. For example, a manufacturer said that:

> For a farmer who's never managed his [sic] cows properly the robot computer will force him to do so … There's heaps of information that they've never ever had before and if they don't take account of that things can quickly go wrong.

While a farmer, discussing how robotic milking changed his relationship with his cows, said that his interventions in fostering bovine productivity meant that,

> … it's up to you to provide for them, your whole mindset has to be providing for those animals and helping them achieve what they can do without forcing them.

In parallel with cows, then, the claim that farmers are 'freed' from milking by the AMS needs some caution. The liberation from certain kinds of mundane work is coupled with a new obligation to be alert, in different ways, to the behaviour and productivity of cows and robots. There is an obligation to make interventions, to an extent at least, as directed by the robot. The identity of the 'good farmer' undergoes a shift from being associated with physical work and the proximal care of cows, to being able to respond to robotic and information technologies, and to 'care' more from a technologically-mediated distance.

In this section we have used a Foucauldian framing of biopower to briefly set out a more critical analysis of robotic milking which emphasises how, despite claims concerning human and animal freedom and choice, this technology involves the discipline and subjectification of humans and nonhumans together. In the next section, we discuss situations where processes of discipline and subjectification are resisted by actors who counter the expectations placed on their bodies and behaviours.

4. Resistance, counter conduct, and divergent conduct

Robotic milking does not always proceed as smoothly as might be anticipated from the promotional material produced by the manufacturers. Cows kick or butt robots; they do not attend to be milked or they try to attend too frequently; and farmers 'tinker' with robots in ways the manufacturers would not anticipate. In this section, we use the notion of divergent conduct (Bear & Holloway, 2019) as a way of describing how the idealised process of automated milking can be subverted by human and nonhuman practices and capacities which 'diverge' from those required or expected by system manufacturers. In these instances, humans are no longer assumed to be in (full) control of the farming system, with Philo and Wilbert (2000, p.14) arguing that if we are to take animals seriously, we need to 'look at animals themselves as

embodied, meaty beings who evade human attempts to place them in space … [and who] … inject their own agency into the scene, thereby transgressing, perhaps even resisting, the human placements of them'. We thus emphasise the importance, in studying human-animal relationships, of those which are 'awkward' (Ginn et al., 2014), 'dissonant' (Brown & Dilley, 2012) and violent (Griffin, 2012), alongside those which might be more amenable or companionate.

We use the term divergent conduct to differentiate our approach from terminologies of animal transgression and resistance which have frequently been used to describe animals' behaviours when they are counter to human expectations or involve conflictual or violent encounters between humans and animals. Our argument is that transgression implies a crossing of human-imposed boundaries, while discussions of resistance have focused on resistance to human intentions and desires. Both remain centred on humans, and this anthropocentrism is limiting when we wish to decentre people and think about humans and animals (and other actors) more symmetrically. In addition, the notion of resistance has been complicated by its association with an anthropocentric sense of intentionality which is problematic when considering animals (Pearson, 2017). Certainly, we could use transgression and resistance to describe some of the events and behaviours we observed on farms or were told about by interviewees. However, divergent conduct allows an alternative perspective which describes the entanglements of heterogenous actors in particular situations (such as robotic milking) in ways which maintain a decentering of human agency and intentionality. These remain important but are complemented by the agency of nonhuman actors. 'Entanglement', here, refers to 'the ongoing coconstitution of people and (living and non-living) things' (Nading, 2014, p. 202), including relationships which produce 'attachments and affinities' and those which involve 'antagonisms and animosities' (ibid, p. 11).

Returning to the discussion of Foucault and biopower in the previous section, we want to recast resistance as not necessarily dependent on an intentional countering of expectations. Following Foucault (2007), Holloway and Morris (2012, p. 67) interpret this kind of resistance as 'something which is always alongside power and which is part of capillary processes of counter-conduct'. This interpretation does not pit animals against humans per se, nor view resistance as simply located in the agency or intentionality of individual actors (Wolfe, 2013). Instead, they describe 'heterogeneous resistances' where resistance is distributed and emergent as part of 'heterogeneous biosocial collectivities'. Geographically, we emphasise how a topological perspective (Law, 1999; Murdoch, 2006; Hinchliffe et al., 2017) contributes a sense of relationality to the study of resistance. This perspective questions a 'topographical' view of space as a backdrop for action, instead focusing on how space is produced through the complex interrelationships between different actors, often challenging commonsense understandings of what actors and entities are close together or far apart. Topographical approaches focus on the specificities of places, but can risk seeing them as bounded 'containers' for action. Topological approaches emphasise how places are created within networks of relationships extending over space. As Murdoch (2006, p. 86) has argued, a topology is 'an

undulating landscape in which the linkages established in networks draw some locations together, while at the same time pushing others further apart'. Although we argue for the importance of topological understandings because they allow us to explore the interconnectedness of entities and places, we also maintain a focus on specific dairy farms as individual sites with particular sets of characteristics and qualities. In this way, topology (space as relational) and topography (with a focus on particular sites) interact: the specific conditions of particular sites (farms) are enmeshed in wider sets of relationships with other sites, entities and actors which affect what happens on those farms.

Our emphasis, informing our notion of divergent conduct, is thus on the social and spatial relationality of resistance. Resistance necessarily co-exists with power relations such that divergences emerge within human-nonhuman entanglements, disturbing the intentions and expectations of human designers to control and make productive various nonhuman actors (such as cows and robotic milking machines). It also emphasises the importance of the specific qualities of particular places, such as individual farms.

We briefly describe an example from our field research to illustrate (see Bear & Holloway, 2019, for more detail). The example discusses the emergence of a new 'disease situation' (Hinchliffe et al., 2017), where a disease risk is inherent to a set of farming practices, in this case robotic milking. It exemplifies situations of divergent conduct, and emphasises the topological interconnectedness of diverse things, as they affect what happens on specific dairy farm sites. In part, divergence is understood in terms of things proceeding in ways which the human architects of robotic milking did not intend, but as we explore further below, it also describes how divergence is multi-directional because of the different human and nonhuman actors involved.

On some farms where we conducted research, the introduction of robotic milking had become associated with a rise in instances of mastitis. Mastitis is a bacterial udder infection and is a persistent problem in dairy farming (Webster, 1994). It is a welfare issue, and can reduce cows' productivity. Some proponents argue that robotic milking will reduce the incidence of mastitis, but in some of our example farms the opposite was true. We look here at one case study. In the following comment, a farmer discusses mastitis with reference to the bacteria *Streptococcus uberis* and *Staphylococcus aureus*, and emphasises the inadequacy of the robot's disinfectant spraying system which is meant to kill the bacteria.

> One of the biggest problems we had with the robot from the mastitis point of view was the spraying was absolutely pathetic … what we did was get a very small minute drill and bored out the nozzle of all things and it gave a better spray … […] We measured the volume of … stuff [disinfectant] that they were using on each robot and it varied unbelievably per cow from 12 mls to 20 odd mls … [so] we've altered that, we've done the pre-spraying, we change our liners more than what [the manufacturer] were recommending. We also, for *Strep uberis* we put on a Dosatron pump with paracetic acid to back flush with the acid to stop this spread … and then this flushing system on the [manufacturer name] system was fine but it was totally ineffective if you've got *Staph aureus* or *Strep uberis*. So we put on this paracetic acid pump

> just to stop cross contamination. So as these cows then leave this robot and got to the cubicles, they're not bringing the bugs with them to then cross-contaminate on the other cubicle robots.

In terms of more-than-human divergent conduct, we emphasise three things. First, cows are important actors in this 'disease situation', even though they are not directly mentioned in this farmer's comment. Their embodied agency is present in their interactions with robots and in their needs (which the robots might or might not meet) and capacities (which the robots might or might not help to fulfil). Cows are clearly key here in their capacities as milk producers, but they might also suffer in this system because of their particular embodied interactions with (inter alia) robots and bacteria. This is in part a divergence from what human actors intended from the system, although our notion of divergence is multi-dimensional because of the interactions between different kinds of actors; it is not intended to simply imply a move away from human intentions but suggests that resistances or divergences, if they can be found, are distributed within, constitute, and are constituted by, the relationships between many different actors.

Second, then, as already hinted, the cows are not the only living nonhuman actors making a difference to this situation of divergent conduct. Here, for example, bacterial populations evidently affect the functioning of a robotic milking system, and their interrelationships with robots, cows and people affect how the system accords with or is divergent from human expectations.

Third, this example emphasises relationality alongside the characteristics, capacities, and agencies of individual entities. It includes humans 'tinkering' (Singleton, 2010) with robots, robots interacting with bacteria, and cows in their relationships with bacteria, people, and machines. This, and the associated topological connectedness that enfolds humans, robots, bacteria and cows on a UK farm into a close relationship with technology manufacturers in Denmark or the Netherlands, re-emphasises how an agenda for animal geographies must maintain a focus on the constitution of animal bodies and subjectivities within relationships which simultaneously co-constitute other entities, including humans and machines, and spaces.

5. Conclusions

In this chapter we have used the empirical example of robotic milking on UK dairy farms to discuss, first, how animals can be seen as entangled (with humans) in relations of biopower, and second, the concept of divergent conduct as a way of exploring disruptions to smooth flows of conduct in situations involving human and animal actors. The chapter emphasises several focal points for a research agenda for animal geographies.

First, taking our lead from existing work drawing on Foucault's conception of biopower and applying it to animals, the focus of this approach on individual and collective life continues to prompt important questions about the entanglement of the 'life itself' of animals with the power relations associated with agricultural (and other)

systems. These question the status and roles of animals in such systems, how their lives are both fostered and exploited, but also how they might become involved in the capillary forms of ‘resistance’ which Foucault insists are already part of relations of power.

This leads to the second point, which is the further development of divergent conduct as a concept for exploring multi-dimensional, topological and situated relationships between people and animals (Bear & Holloway, 2019). Adding to work which explores notions of animal transgression and resistance, divergent conduct provides a way of framing unintended (from a human perspective) outcomes of entanglements of humans, animals and (amongst other things) technologies.

Third, we emphasised the importance of perhaps less charismatic entities, such as bacteria, in our thinking about the sets of relationships associated with divergent conduct on dairy farms. As such, a research agenda for animal geographies needs to maintain an open mind regarding what counts as ‘animals’, and needs to consider how to conceptualise and study those nonhumans often disregarded in favour of more ‘charismatic’ and ‘relatable’ animals (e.g. Nading, 2014).

Finally, the chapter emphasises the importance of relational and topological thinking to an agenda for animal geographies. This encourages us to focus on how animals’ agencies, bodies, and subjectivities are produced in part through their geographical and embodied relations with people (Miele, 2016; Holloway, 2019), alongside thinking about animals’ inherent capacities. In doing this, and in thinking about animals and biopower, animals’ positions within human discursive frameworks are also important. For instance, understandings of cows and their behaviours, productivity, bodies and subjectivity have powerfully influenced the design of different kinds of milking technology.

While our empirical example is of a specific agricultural system and technology, the agenda we have begun to outline here will resonate with studies of animals in a wide range of situations, providing tools for further critical questioning of human-animal relationships in all their diversity.

References

Asdal, K., T. Druglitro and S. Hinchliffe (2017), ‘Introduction: the 'more-than-human' condition - sentient creatures and versions of biopolitics’, in K. Asdal, T. Druglitro and S. Hinchliffe (eds), *Humans, Animals and Biopolitics: the More-than-human Condition,* London: Routledge, pp. 1-29.

Bear, C. and L. Holloway (2019), ‘Beyond resistance: geographies of more than human conduct in robotic milking’, *Geoforum,* **104**, 212-221.

Brown, K. and R. Dilley (2012), 'Ways of knowing for 'response-ability'in more-than-human encounters: the role of anticipatory knowledges in outdoor access with dogs', *Area,* **44** (1), 37-45.

Buller, H. and E. Roe (2018) *Food and Animal Welfare*. London: Bloomsbury.

Butler, D. and L. Holloway (2016), 'Technology and restructuring the social field of dairy farming: Hybrid capitals,'stockmanship'and automatic milking systems', *Sociologia Ruralis*, **56** (4), 513-530.

Foucault, M. (1990), *The History of Sexuality, Volume 1: An Introduction*, Harmondsworth: Penguin.

Foucault, M. (2003), *Society Must Be Defended*, Harmondsworth: Penguin.

Foucault, M. (2007), *Security,Territory, Population. Lectures at the College de France 197-1978,* Basingstoke, Hants, UK: Palgrave Macmillan

Fraser, Andrew & Broom, Donald. (1990). Farm Animal Behaviour and Welfare. CABI

Ginn, F., U. Beisel and M. Barua (2014), 'Flourishing with awkward creatures: Togetherness, vulnerability, killing'*, Environmental Humanities,* **4** (1), 113-123.

Haraway, D.J. (2016), *Staying With the trouble: Making Kin in the Chthulucene*. Durham, NC: Duke University Press.

Heutinck, L. and C. Driessen (2007), 'The ethics of automatic milking systems and grazing in dairy cattle', in W. Zollitsch, C. Winckler, S. Waiblinger and A. Haslberger (eds), *Sustainable Food Production and E thics*, Wageningen, The Netherlands: Wageningen Academic Publishers, pp.249-254.

Hinchliffe, S., N. Bingham, J. Allen and S. Carter (2017), *Pathological Lives: Disease, Space and Biopolitics*. Hoboken NJ: John Wiley and Sons.

Hogeveen H., Y. van der Vorst, C. de Koning and B. Slaghuis (2001), 'Concepts et implications de la traite automatisée'. In: *Proceedings of the 25e Symposium Sur les Bovins Laitiers, Quebec, Canada, October 17th 2001*, CRAAQ, Canada, pp. 104-120.

Holloway, L. (2007), 'Subjecting cows to robots: farming technologies and the making of animal subjects', *Environment and Planning D: Society and Space,* **25** (6), 1041-1060.

Holloway, L. (2019), 'Smallholder knowledge-practices and smallholding animals: threats or alternatives to agricultural biosecurity?' *Journal of Rural Studies,* **69**, 19-29.

Holloway, L. and C. Bear (2017), 'Bovine and human becomings in histories of dairy technologies: robotic milking systems and remaking animal and human subjectivity', *BJHS Themes*, **2**, 215-234.

Holloway, L., C. Bear and K. Wilkinson (2014a), 'Re-capturing bovine life: Robot–cow relationships, freedom and control in dairy farming', *Journal of Rural Studies,* **33**, 131-140.

Holloway, L., C. Bear and K. Wilkinson (2014b), 'Robotic milking technologies and renegotiating situated ethical relationships on UK dairy farms', *Agriculture and Human Values,* **31** (2), 185-199.

Holloway, L., C. Morris, B. Gilna and D. Gibbs (2009), 'Biopower, genetics and livestock breeding:(re) constituting animal populations and heterogeneous biosocial collectivities', *Transactions of the Institute of British Geographers,* **34** (3), 394-407.

Holloway, L. and C. Morris (2012), 'Contesting genetic knowledge-practices in livestock breeding: biopower, biosocial collectivities, and heterogeneous resistances', *Environment and Planning D: Society and Space*, **30** (1), 60-77.

Latour, B. (2000), 'When Things Strike Back: a Possible Contribution of 'science Studies' to the Social Sciences', *British Journal of Sociology*, **51** (1), 107-123.

Law, J. (1999), 'After ANT: complexity, naming and topology', in J. Law and J. Hassard (eds), *Actor Network Theory and After*, Oxford: Blackwell, pp. 1-14.

Miele, M. (2016), 'The making of the brave sheep ... or the laboratory as the unlikely space of attunement to animal emotions', *Geohumanities*, **2** (1), 58-75.

Murdoch, J. (2006), *Post-structuralist Geography: A Guide to Relational Space*, London: Sage.

Nading, A.M. (2014), *Mosquito trails: Ecology, health, and the politics of entanglement*, Oakland: University of California Press.

Nealon, J. (2008), *Foucault Beyond Foucault: Power and its Intensifications since 1984*, Stanford CA: Stanford University Press.

Pearson, C. (2015), 'Beyond 'resistance': rethinking nonhuman agency for a 'more-than-human' world', *European Review of History*, **22** (5), 709-725.

Philo, C. and C. Wilbert (2000), 'Animal spaces, beastly places: an introduction', in C. Philo and C. Wilbert (eds), *Animal Spaces, Beastly Places: New Geographies of Human-Animal Relations*, London: Routledge, pp. 1-34.

Porcher, J. and T. Schmitt (2012), 'Dairy cows: workers in the shadows?', *Society and Animals,* **20** (1), 39-60.

Rabinow, P. and N. Rose (2006), 'Biopower today', *BioSocieties*, **1** (2), 195-217.

Singleton, V. (2010) 'Good farming: control or care?', in A. Mol, I. Moser and J. Pols (eds), *Care in Practice: On Tinkering in Clinics, Homes and Farms*. Piscataway, New Jersey: Transaction, 235-256.

Stuart, D., R. L. Schewe and R. Gunderson (2013), 'Extending social theory to farm animals: Addressing alienation in the dairy sector', *Sociologia Ruralis*, **53** (2), 201-222.

Webster, J. (1994), *Animal Welfare: A Cool Eye Towards Eden*. Oxford: Wiley-Blackwell.

Wolfe, C. (2013), *Before the Law: Humans and Other Animals in a Biopolitical Frame*. Chicago: University of Chicago Press.