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Re-capturing bovine life: robot-cow relationships, freedom and control in dairy farming.

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Abstract

Robotic milking machines are novel technologies that take over the labour of dairy farming and reduce the need for human-animal interactions. Replacing 'conventional' twice-a-day milking managed by people with a system that supposedly allows cows the freedom to be milked automatically whenever they choose, it is claimed that robotic milking has health and welfare benefits for cows, increases productivity, and has lifestyle advantages for dairy farmers. Such claims are certainly contested, but the installation of robotic milkers clearly establishes new forms of relationships between cows, technologies and dairy farmers.

This paper draws on in-depth interviews with farmers and observational research on farms to examine relationships between representations of robotic milkers as a technology which gives cows freedom and autonomy, and practices and mechanisms which suggest that bovine life is re-captured and disciplined in important ways through the introduction of this technology. We focus on two issues. First, we explore changes in what it is to 'be bovine' in relation to milking robots, drawing on a combination of a discursive framing of cows' behaviour and 'nature' by dairy farmers and on-farm observation of cow-technology interaction. Second, we examine how such changes in bovinity might be articulated through conceptions of biopower which focus on knowledge of and intervention in the life of both the individual cow body and the herd. Such knowledge and intervention in the newly created sites of the robotic milking dairy are integral to these remodelled, disciplinary

farm systems. Here, cows' bodies, movements and subjectivities are trained and manipulated in accordance with a persistent discourse of agricultural productivism. In discussing these issues, the paper seeks to show how particular representations of cows, the production of embodied bovine behaviours, technological interventions and micro-geographies contribute to a re-capturing and re-enclosure of bovine life which counters the liberatory discourses which are used to promote robotic milking.

Key words: robotic milking; dairy farming; nonhuman animals; technology; biopower

1. Introduction

In this paper we explore some of the implications for dairy cows of being milked in systems using robotic or automatic milking machines. The paper's key objective is to examine relationships between representations of robotic milkers as a technology which gives cows freedom and autonomy, and practices and mechanisms which suggest that bovine life is re-captured and disciplined in important ways through the introduction of this technology. The paper draws on in-depth empirical research on dairy farms and with the manufacturers of robotic milking systems to explore the interplay between notions and practices of freedom and control in a particular animal-technology relationship.

Geographers have increasingly become attentive to the geographical dimensions of technologies in general (e.g. Kirsch, 1995; Hinchliffe, 1996; Thrift, 2005; Dixon and Whitehead, 2008). Within rural (and perhaps especially agricultural) geography there has been a shift from an emphasis on simplistic notions of 'technology transfer' and 'innovation adoption' (see Ruttan, 1996) to research which focuses on the complexities of technologies, the difference that the particularities of place and context makes to whether and how technologies are engaged with in particular circumstances, and the ways in which technologies are bound up with (for example) gendered identities (Brandth, 1995; Bryant and Pini, 2006). More recent work has responded to Bingham's (1996, pp. 641) call to move beyond technological determinism, rejecting notions of the essentialised technological object and refocusing on objects as 'social ties' (p. 654). As such, the focus has been on

processes of co-constitution in which technologies and their 'users' make and remake each other (see, for example, Holloway and Morris, 2008 and Holloway et al 2009 on the use of genetic technologies in livestock breeding, Holloway, 2007 on robotic milking, and Tsouvalis et al. 2000 on the use of precision technologies in arable farming).

In developing these ideas in rural and agricultural contexts, geographers have been informed by approaches derived from Science and Technology Studies which emphasise the material-semiotics of technologies. That is, a technology is not simply an artefact, but is tangled up with the constitution of knowledge-practices and cultural meaning (e.g. see, for example, Kline and Pinch's social constructivist work on farmers' innovative experiments with mechanisation, 1996; and for a wider perspective on sociotechnical change, Bijker, 1995). There is a recognition, too, of how technologies are socially produced through the ways they are promoted and marketed: Brown (2003), for example, writes about the consistent 'hyping' of new technologies (an idea explored in relation to genetic techniques in agriculture by Holloway and Morris, 2008), and Kinsley (2010, 2011) describes how futures are envisaged and enacted by developers of technologies in their efforts to produce futures in which their technologies will become imperative. In such work, human users are simultaneously configured around technological futures, their bodies and subjectivities, practices and desires, necessarily co-imagined with particular technologies. In examining robotic milking machines we extend existing work on this technology (Holloway, 2007; Porcher, 2006; Porcher and Schmitt, 2012), to focus specifically in this paper on how a particular group of nonhuman animals, dairy cows, should also be considered as co-constitutive users of technologies, alongside the humans involved. From this perspective, the introduction of a new milking technology leads to the playing out of new bovine-technology relationships, to representations and constitutions of bovine subjectivities, and to processes of technological-bovine co-constitution which suggest the remaking of both machine and animal as they encounter and engage with each other.

We start by outlining how this relatively novel and unusual technology works and is different from conventional milking parlours. We then briefly summarise a theoretical framework which draws on Foucault's arguments about disciplinary power-

knowledge relations and the emergence of biopower as a set of knowledges and mechanisms which foster 'life itself' in accordance with agendas concerning improving individuals' capacities and productivity. We suggest that using Foucault's ideas in relation to nonhuman animals in their relationships with or co-constitution with technologies, provides a useful perspective on how the bodies, subjectivities and productivity of farmed animals are produced.

To explore these theoretical issues empirically, we draw on in-depth field research which has had a number of different elements. First, we have interviewed representatives of the three manufacturers of robotic milking systems which are available in the UK, focusing on their views of the advantages of robotic milking and on how they interact with and advise farmers who are considering adopting, or who have adopted, robots. Second, interviews have been conducted with two groups of dairy farmers: ten who are using robots and ten who use conventional milking technologies. Farms using robots were selected on the basis of suggestions made by the manufacturer representatives. Farms using conventional milking technologies were identified by those farmers using robots: we asked them to recommend neighbouring dairy farmers who were known to them, in the hope that they would have knowledge of each other's technologies and farming practices and thus be able to provide informed comment on the differences between robotic and conventional systems. Interviews focused on the three way interactions between humans, cows and milking technologies, on the processes of converting from conventional to robotic milking, and on debating the advantages and disadvantages of different milking technologies. Supplementing these interviews, we conducted observational and interview research on three case study farms, including one established robotic milking farm, one farm which is run in part as a teaching farm at an agricultural college and which has a robotically milked herd run alongside a conventionally milked herd, and a farm which converted from conventional to robotic milking over the course of the research. This research involved extended periods of time spent observing the interactions between cows, robots and people. Interviews were recorded and transcribed, and analysed with the assistance of QSR NVivo 9 software.

Using empirical evidence from this research process we look in detail at three themes. First, we look at manufacturers and farmers' discursive framings of animal behaviour and freedom in robotic milking systems, looking at how what it is to 'be bovine' is understood specifically in relation to robotic milking. Second, in contrast, we use interviews with manufacturers to look at the disciplinary potential afforded by robotic milking systems, pointing at how such systems are associated with the emergence of new power-knowledge relations in which cows might become represented in rather different ways. The third theme follows from this: using interviews with farmers and our observations of what happens on robotic dairy farms, we critically revisit the arguments made for bovine freedom and autonomy, arguing that robotic milking, and its associated farm architecture and information-generating capacity, has effects of discipline and subjectification on cows, inserting them into a regime of biopower which re-captures, re-encloses or re-determines what it is to be bovine.

2. Robotic milking technologies.

Robotic milking machines replace 'conventional' twice-a-day milking managed by people with a system that supposedly allows cows the freedom to be milked automatically whenever they choose (Meijering et al, 2004) (Figure 1). They consist of six different 'modules'; the milking stall, the teat detection system, the robotic arm for attaching the teat cups, the teat cleaning system, the control system (sensors and software) and the milking machine itself (Hogeveen et al 2001). While all robots share these essential features, there are some differences in the technology between the small number of competing manufacturers, particularly concerning the robotic arm and the type of sensory location system used. Different manufacturers also promote different 'traffic' systems for guiding the cows round the system using one-way gates or food as enticement. The cows can, in principle, visit the robot for milking as many times as they wish throughout the day and night, rather than being herded into the milking parlour at times convenient to the farmer. Cows wear radio tags around their necks, which enable the robot to identify each individually, keeping a record of their milk yield and milking frequency, and determining how much food to provide during each milking. More advanced options allow the robot to sample the milk as a way of recording infections, such as mastitis, to which the farmer can be alerted.

[Figure 1 about here]

It is claimed by manufacturers that robotic milking has health and welfare benefits for cows, increases milk yields, has economic benefits for dairy farms and has lifestyle advantages for dairy farmers. Such claims are of course sometimes disputed by farmers on the ground and the advantages of robotic milking are by no means certain; both the scientific literature on cow health and welfare, and cost-benefit analyses, are ambivalent towards robotic milking. The main advantages are represented by manufacturers as labour savings; reduced operational costs; higher milk yields; better herd health management; and improved welfare. Freedom and flexibility for farmers and cows form a key message in manufacturers' marketing material for the robots. For farmers, the opportunities afforded by the robots are contrasted starkly to the drudgery of conventional milking practices: manufacturer Fullwood promotes 'no more early morning milkings' and 'not having to plan the day around strict milking times'. For cows, a straightforward association is drawn between the autonomy they supposedly experience and their welfare and quality of life: manufacturer Lely (undated), for example, claims that, for cows, 'freedom = happiness'.

It is difficult to determine how many robots are actually in use worldwide¹, but they are becoming increasingly common particularly in northern Europe (especially the Netherlands), and are increasingly seen as an option by UK farmers despite their expense (robots cost approximately £80,000, with one robot needed for around every 60 cows in a herd). A recent European Dairy Farmers Benchmark Survey of 2600 dairy farmers across the EU suggested that robotic milking systems were likely to be increasingly popular. The survey claimed that over 40% of all new parlour investments were into robots, with the proportion of cows being milked by robots in Europe doubling from a current level of 9% to an estimated 18% in 2016 (Pugh, 2011). As such, although robot use is still relatively unusual and attracts much debate within dairy farming communities, its profile is rising and different manufacturers are keen to promote the benefits of their particular ways of enacting

¹ Manufacturers are reluctant to release sales figures due to intense competition between companies in the sector.

robotic milking. In doing so, they necessarily represent both human and bovine 'users' of their technologies in particular ways, providing important insights into how human *and* nonhuman identities are imagined and configured in relation to ongoing processes of technological intervention in agricultural practices.

3. Robots and dairying 'biosocial collectivities'.

It is a tenet of science and technology studies that 'users matter' (e.g. Oudschoorn and Pinch, 2003): both that users influence how a technology is developed and put into practice, and that the users of a technology are themselves co-constituted with that technology. In the case of robotic milking, there are two different sets of users – humans (farmers) and the cows themselves. These human and nonhuman users of robotic milking technologies are also co-constitutive (affecting each others' identities, behaviours and bodies). As such, in relation to robotic milking, we are interested in a three way, human-animal-technology, co-constitutive set of relationships. For the purposes of this paper two theoretical perspectives drawn from Foucault's writings are useful in our analysis of these relationships. In both cases, we follow existing work which uses Foucauldian concepts in relation to livestock to make the argument that an application of Foucault's ideas to analysing situations involving nonhuman animals is appropriate, notwithstanding that Foucault obviously directed his own attention to human animals.

First, as Dawn Coppin (2003) has argued in relation to intensive pig farming, nonhuman farmed animals can become caught up in what Foucault referred to as disciplinary relations. Coppin draws on Foucault's *Discipline and Punish* (1979) to show how both pig farmers and pigs in big North American farms are affected by an industrialised style of agriculture. Farmers are subjectified in their relationships with the companies to whom they are contracted to produce pigs. At the same time, pigs are disciplined by the architectures and technologies of the farms, for example by being more continuously monitored, by being subject to ever more precise dietary and veterinary regimes, and by the spatial segregation and confinement imposed on them, in some ways analogous to the prisons and asylums discussed by Foucault.

Second, building on this sense in which both humans and nonhumans in at least some farming situations can be subject to similar regimes, some writers have begun

to explore Foucault's conception of biopower as a means of analysing particular sets of agricultural relationship (see, for example, Holloway, 2007; Holloway et al, 2009; Holloway and Morris, 2012, Twine, 2007, 2010). For Foucault (1990, 2003, 2007; see also Rabinow and Rose, 2006; Nealon, 2008), biopower suggests a set of interventions aimed at fostering 'life itself' in relation to both individuals, as an anatamopolitics, and populations, as a biopolitics. In relation to anatamopolitics, biopower, centres 'on the body as a machine: its disciplining, the optimisation of its capabilities, the extortion of its forces, the parallel increases of its usefulness and docility, its integration into systems of efficient and economic controls' (Foucault, 1990, p.139). With regard to biopolitics, biopower is focused on the measurable biological processes which constitute populations. Birth, morbidity and death rates, for example, can be measured and interventions made in order to effect change. Anatamopolitics and biopolitics become articulated in relation to each other through the concept of the norm; briefly, an individual's measurable behaviour, performance or traits can be assessed against the norms evident in a population. Social, political, economic or medical interventions, for example, might thus aim at the 'normalisation' of those who deviate from expected norms, within a wider process of attempting to 'improve' population-level norms of health, productivity and behaviour. In extending debates around biopower away from the contexts envisaged by Foucault, Holloway et al (2009) for example have focused on the increasing use of genetic techniques in cattle and sheep breeding as an instance of agricultural biopower, arguing that the emphasis of biopower on biological capacities and processes means that as an approach it is applicable to nonhuman as well as to human animals.

Key to Foucault's conception of biopower is that individuals become subjectified in relation to the particular truth discourses that are involved in structuring a field of activity: individuals internalise such discourses, influencing their behaviours and social practices, and taking responsibility for the 'care' of their selves in line with particular discursive framings of how the good self and good body should be fostered. While it is clearly problematic to argue that nonhuman animals can be similarly subjectified, Holloway et al (2009) and Holloway and Morris (2012) argue that nonhumans can nevertheless be enrolled along with humans into what they term 'heterogeneous biosocial collectivities'. Biosocial collectivity is the term coined by Rabinow (1999) to express the nature of social groups formed around particular

geneticised truth discourses; members share, for example, a medical experience which is constituted in terms of a common genetic inheritance or abnormality (Gibbon and Novas, 2008; Rose, 2007). More widely, perhaps, biosocial collectivity can be understood as something cohering around particular biological issues, or issues to do with the 'life' of the collectivity's members. Developing this idea, in *heterogeneous* biosocial collectivities, the lives, bodies, subjectivities and behaviours of humans and nonhumans are powerfully influenced by particular regimes of truth: again Holloway et al (2009) and Holloway and Morris (2012) use the example of genetic techniques to explore this in detail. In these biosocial collectivities, care is exercised in relation to both the human and nonhuman members of a collectivity.

We might consider taking this a step further in the case of a technology such as robotic milking. We argue that robotic milking technologies and farm architectures, like Coppin's pig farms, discipline cows and humans through the creation of certain behavioural and bodily expectations, and by particular practices of confinement and control. In addition, the specific discourses and practices of robotic milking technologies suggest that there are particular regimes of truth surrounding dairy farming which produce specific interventions in the co-constituted lives of dairy cows and dairy farmers, and that as such dairy farming is comprehensible in terms of relations of biopower. But, the discourses and practices of robotic milking also imply the constitution of a certain *bovine subjectivity*, in ways which make this technology different from both pigs in close confinement and cattle and sheep bred using genetic techniques. As mentioned above, robotic milking is associated with key notions of cow choice making, or bovine freedom. In other cases, as we show below, some cows might be ascribed subjectivities which suggest that they are 'lazy'. In some ways this might align the position of cows within a robotic milking regime more closely with Foucault's descriptions of biopower as involving truth discourses, interventions in the life of individuals and populations, and the production of particular subjectivities which accord with those truth discourses (Rabinow and Rose, 2006).

To be clear, we are arguing here that nonhuman animals, cows in this case, can become enrolled through technological interventions into modes of subjectification which constitute their subjectivities (in terms of their behaviours and experiences) or

ascribe a particular subjectivity to them within the framing of a particular technology and its 'demands'. This is in distinction to either simply seeking acknowledgement of a 'centred' bovine subjectivity *or* arguing that cows are able to 'work' reflexively and self-consciously on their subjectivities in the ways that Foucault describes for humans. In this case, perhaps, subjectification is something which is done to cows, rather than something they do to themselves. However, at the same time it might be considered that nonhuman animals *do* interiorise aspects of their relations with humans, that their subjective behaviours and experiences change as their relations with humans change (Palmer, 2001). As such, we also want to avoid arguing that cows lack any capacity to respond actively to the changing agri-technological conditions in which they are 'kept'. Bovine agency and subjectivity, we argue, are key to understanding the effects of the interventions of new technologies in the lives of dairy cows. As Porcher (2006, p.60) argues, 'livestock animals invest their cognitive, affective, and relational potential in the work context and if they did not do so, livestock farming work would be impossible' (for an alternative take on animals' perspectives of their 'working' environments, see Grandin and Johnson, 2005). We are wary, however, of expressing bovine subjectivity in terms of a reflexivity analogous to that of humans, even though, following the cautions against dualistic thinking expressed by Latour (2007) and others, we would not want to draw firm lines of distinction between human and nonhuman subjectivity. In this sense, we follow Haraway in wishing to move beyond simple humanist subject categories towards an understanding of beings as made-through-encounter. For Haraway, 'specific difference is at least as crucial as continuities and similarities across kinds' (2008: 67). In other words, while we highlight bovine subjectivity and agency, the focus is more on the cows' 'own intrinsic worth, autonomy and difference rather than on the basis of their similarity to humans' (Fox, 2006: 527).

There are at least two further issues which need to be taken into account in the case of robotic milking. First, as suggested earlier, we are dealing here with a three-way human-animal-technology relationship, such that the mutual or co-subjectification of humans and nonhumans in robotic milking regimes adds a further layer of complexity. Second, despite discourses of choice and freedom, cows' lives in robotic milking systems are, as we shall explore, closely circumscribed and constrained by various disciplinary means imposed by the robot, the architecture of the farm layout,

and by the humans managing the farm. Thus the rhetoric of choice and freedom suggested by manufacturers of robotic milking systems needs some interrogation, since the discipline and subjectification of cows in robotic milking systems is clearly more complicated than that.

In the following three empirical sections of the paper, we begin to explore how these issues work out on the dairy farms we have investigated by looking at the three themes identified at the start of the paper. We begin by focusing on how robotic milking systems are framed by manufacturers and farmers as offering cows freedom and autonomy. Next we look at how such systems instead offer the possibility of establishing alternative power relations with cows. Finally, we investigate how in practice these human-animal-technology relations are played out on dairy farms in ways which necessarily question representations of bovine freedom.

4. Framing animal autonomy in robotic milking.

In this section we set out some of the ways in which manufacturers and farmers frame ideas about dairy cow behaviour and freedom in robotic milking systems, drawing on secondary sources produced by manufacturers, and on interviews with manufacturers and farmers. We explore representations of what it is to be bovine in these systems, in part relating to cows as individuals, and in part relating to concepts of the herd and herd dynamics.

During our interviews with farmers a fairly consistent set of ideas emerged which suggested that being bovine in a robotic milking system was somehow different to being bovine on a conventionally milked dairy farm. Key to this representation of the robotically-milked cow are comments concerning how robotic systems gave cows freedom to choose when and how often to be milked. These comments are clearly aligned with the arguments of the manufacturers, for whom cow freedom and choice is an important part of explaining, marketing and advocating robotic milking. As one manufacturer told us, 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 (Manufacturer A²)

Farmers made similar comments. For example,

The cows are very much free to do their own thing ... you let them just get on with the job really (Farmer A)

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? (Farmer B)

For most farmers, this radically different milking technology produced new, and for them better, forms of cow subjectivity and behaviour. Cows are described variously as 'relaxed', 'happy', 'quiet', 'cool' and 'chilled out', compared to their equivalents in conventionally milked herds. One farmer who had recently converted from conventional milking to robotic milking noted how, within only a few months of starting to use the robots, the cows had become quieter, particularly when the farmer or other people moved amongst them. This is frequently tied to the way that robotic milking dispenses with the need to manage a group of cows as a herd, herded around and milked all together. In robot systems, it is argued, cows are able to behave as individuals, with their own routines. Herds of cows on conventional dairy farms tend to develop a hierarchy including dominant and subordinate individuals, with subordinate cows often experiencing bullying. Manufacturers claim that the opportunity to behave more autonomously and less as a member of a herd reduces the stress experienced particularly by low-ranking cows in a herd hierarchy. Some examples of the claims made here include the following:

Yeah from day one they were just quieter, just chilled out and happy. You're not forcing them to do anything that they don't want to do. (Farmer C)

they're individuals, not a herd any more, that's the difference of milking in this system ... They're all individuals...there's no herding anymore because they do what they want to do ... So yeah it breaks up the herd instinct I think. (Farmer C)

² Interviewee and company names are concealed to protect confidentiality.

It's maybe just they're happier because they do seem genuinely happy, they're free range cows as opposed to...they've been managed and driven around. (Farmer D)

Well everyone that comes on the farm tells me how relaxed the cows are, how well they look ... the vets make positive comments about the temperament of the cows, and their appearance, and you know overall health. (Farmer E)

In the final comment given here, we see that along with the farmer's understanding of his cows' emergent relaxed subjectivity, is a linked sense of improved bovine health and welfare. Again, this concurs with the arguments made by manufacturers concerning the benefits of robotic milking, and is something used by them in promoting the technology. The final point here concerns hints that these emergent phenomena of bovine subjectivity and physical health are also related to a fostering of productive bovine life, suggestive of the relations of agricultural biopower raised at the start of the paper. One example of this is a framing of the farmer's exploitation of dairy cows' bodily productivity in terms of assisting cows to achieve their potential via robotic milking technology.

you let them just get on with the job really, 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 (Farmer A)

This farmer's comment, and the examples presented throughout this section, suggests that somehow this is all to the benefit of the cow, rather than ultimately to the farm business. Indeed, the implicit suggestion is that the cow might be expected to care for herself or to foster the productivity of her own body life in pursuit of the higher yields of milk which are a key biological issue or 'problem' around which dairy farming biosocial collectivities are constituted. We explore this theme further in the next section, which develops the idea of the possibility of a particular mode of biopower being evidenced in robotic milking systems.

5. Robotic milking and the possibilities for relations of biopower

We move in this section to explore the *possibilities* embodied by robotic milking systems for fostering bovine life, and for co-fostering bovine and human life within

heterogeneous biosocial collectivities. We look at the disciplinary potential afforded by robotic milking systems, pointing out how such systems are associated with the emergence of new power-knowledge relations in which cows might become represented in rather different ways. In doing this, an important relationship between disciplinary relations and biosocial collectivity also begins to emerge. While the concept of collectivity might imply a relatively benign shared concern, the simultaneous existence and even intensification of disciplinary relations in robotic dairy farming suggests an incorporation into dairy farm collectivities of rather more complex relations of control and subjugation. We focus on how manufacturers discuss the potential for robotic milking technologies to intensify disciplinary and biopower relations in dairy farming before moving in the final section to explore farmers' responses to the possibilities raised for intervening in the lives of their cows in particular farm settings.

To set the scene for this, the following text from a manufacturer's website points to how robotic milking systems have been designed to intensify the amounts of data derived from cows' bodies and behaviours which can be made available to farmers. Under the suggestive heading 'knowledge is power'; manufacturer DeLaval argues that through the robot 'you gain access to a level of knowledge and control unheard of until now. Your cows can no longer hold any secrets from you!' (DeLaval 2011).

Interviews with manufacturers produced similar points, focusing on how robotic milking produces data and on how the *use* of those data relate to enhancing bovine productivity. Examples from two different manufacturer interviews are presented below.

Quarter milking I mentioned, each one comes off individually, and each yield is recorded individually³. Conductivity is recorded individually for each teat and also for any blood in the system as well. We also have an option of what we call an online cell counter which ...gives

³ A contrast with 'conventional' milking is made here. In conventional milking all four suction cups are removed together, regardless of the fact that each 'quarter' of the udder might contain different volumes of milk. Under or over milking of a quarter may thus occur, each associated with health and welfare issues. Robotic systems can treat each quarter individually so that under/over milking does not occur.

you a true reading for the total sample of the cells, somatic cell count in the milk⁴. And moving on to the next step we've got something called Herd Navigator [software] coming along which will look for progesterone, and different...the makeup of the milk and you can look at issues on heat, if she's pregnant, if there's any feeding issues, all based on detection in the milk of certain criteria. And that's coming along ...in the next couple of years, it's a little bit far advanced at the moment but that's the next step in analysing the milk sample and...trying to get the best information from the cow ... Blood detection, we sample the milk if the farmer so wishes for NMR⁵ recording, all done automatically. The cell counter, ...essentially it takes a sample, pushes it through a digital camera, adds a reagent and then it will then tell you how many cells are in the milk...somatic cell counts. It gives you the results on the PC. (Manufacturer A)

I think ...with robotics you're looking at managing by exception, you really...the data you can...let's say pull off the cows i.e. yield, activity⁶, and start collating that information it allows you to manage and fine tune the animals you know accordingly which then brings the efficiencies into play of the feed. And it's keeping that balance and that efficiency so...I think...it gives you the tools to manage by exception; it gives you all the information to actually manage the animals accordingly. I would say that's one of the sorts of core strengths of the system. (Manufacturer B)

The information generated by the system allows the farmer to intervene in the lives of the cows in various ways, suggesting that the 'freedom' we articulated in the first empirical section can be compromised or managed out of the system where particular cows fail to behave and be productive in the ways expected of them. The ascribed subjectivity of robotically milked cows becomes constructed around certain behavioural expectations – for example that they *will* choose to be milked frequently. At the same time, because robots and their associated technologies generate large amounts of data about *individual* animals in the ways described in the quotations above, the micro-management of individuals' dietary and veterinary regimes, and even of their individual routines and movements, become increasingly possible. The data allows the establishment of what Higgins and Dibden (2011), after Mitchell (2008), call metrological regimes. In such regimes, measurement and calculability are key to power-knowledge relationships and come to perform such relationships as crucial to

⁴ Electrical conductivity and somatic cell count are both tests carried out on milk as indicators of the cow's health, in particular of the presence of udder infections such as mastitis.

⁵ The National Milk Recording scheme, which registers the quality of milk produced by cows in a national database.

⁶ Activity collars collect data on how much a cow moves around; 'high' activity can be used to indicate that a cow is on heat (i.e. ready to be mated/artificially inseminated), and 'low' activity can indicate ill health, such as lameness.

the economics of dairy farming, akin to the way in which other forms of calculability are constitutive or performative of economic relations more widely (Millar, 2008). In robotic dairy herds, then, metrological regimes which measure and analyse the inputs to and outputs from bovine bodies are increasingly important to the ability to foster productive life.

So, on the one hand, robotic milking focuses on the productivity and effectiveness of the bovine body as a component of a technological system which is dependent on particular human-animal-technology relationships. At the same time, on the other hand, there is a focus on the spatial and temporal ordering of the robotically milked herd and on the environment the cows live in, aimed at fostering the overall productivity of the herd as a population of animals. For example, depending on each cow's productivity, the space of the barn can be set up to manage her movements, either to persuade cows that they ought to be milked more frequently, or to dissuade cows who attempt to be milked too often (cows often enter the robot in search of the food it dispenses during milking) from using the robot. This process aims at co-producing material efficiency in the cow (by aiming at the optimum number of milkings per day) and the robot (by ensuring that its valuable time is not taken up processing cows who are not 'due' to be milked). As one manufacturer said in interview,

Now each cow's biology is different ... So the system will know how long and how much milk each cow will give so when she comes to this gate the choice is made quite accurately whether or not she needs to go to the milking station. And that prevents crowding in the waiting area, and also means it gives you a good even spread of animals throughout the barn. They're not all doing the same thing at the same time some will be eating, some are lying down, some are...waiting or being milked. (Manufacturer A)

We refer to this as the careful design of 'cow-space' in robotic milking systems. This refers particularly to how a shift to robotic milking tends to go along with a move to keeping cows confined to a barn all the time, with feed being brought to the cows rather than the cows going out to graze in the fields. This is known as a 'zero grazing' regime. Although it is not unique to robotic milking systems, it is proportionately much more common within them, and, it is argued, provides farmers with a greater ability to monitor and control the diets of their cows. Within the barn, there can be different spaces for eating, resting and queuing for the robot. As described below, some

designs allow free movement between these spaces, others deploy systems of passages and gates linking and controlling access to different spaces (Figure 2). Manufacturers tend to advise farmers who are starting out with robotic milking on how their cow-space should be ordered. For example the following comment discusses the different ways in which the movement of cows around the robotic milking system can be controlled,

... the layout very often is the success of VMS [voluntary milking system] or a new robot and ...we've tried to ...present a slightly different method of cow traffic we call Feed First, which is something competitors don't have. And because of that we get sort of slated in the market for it, but it has helped us to differentiate the product from our competitors in some ways. ...[T]here are four or five different ways you can walk cows around a barn. You can let them go free, you can have Feed First, Semi Feed First, you can have forced, guided, pasture coming into it as well now ... But our best option, the one we always try and offer the customers is feed first cow traffic. And what this means is the cows have their normal cubicle area but they have free access out into the feed barrier here although there are cubicles, that is a feed barrier. Now to come back to lie down they go through what's called a smart gate and that gate selects the cows either to go into a waiting area to be milked or it selects them to go back into the cubicle area where they have access to parlour feeders. And the advantage of this is that the cows that go to the milking station will actually get milked. (Manufacturer A)

This comment suggests that the technology of a robotic milking system extends beyond the robot itself to take in complex layouts of fences and gates which 'guide', 'force' or discipline cows' movements and intervene in their diurnal rhythms. As such the 'freedom of choice' to be milked when a cow wants is clearly constrained by sets of expectations surrounding her behaviour and productivity.

[Figure 2 about here]

Manipulating the barn environment in order to induce particular behaviours and technological efficiencies is related to techniques and technologies of spatial ordering. Lighting, for instance, is used to stimulate use of the robot and, for cows, to internalise appropriate and expected behaviours:

Something else which is important for robotic barns is the lighting, we say you should have sixteen hours of daylight and eight hours of darkness controlled, and that gives the cow the

right thinking of when she should go to sleep and wake up. And some farmers actually play around a bit with the lights, they'll turn them on at two o'clock or...off at four o'clock and that stimulates the cows to move around. Usually night time is the time which is ...more quiet from a milking point of view, usually between three and five o'clock and if you can do something to get the cows moving then like feed them then ...that couple of hours where you get less milkings per hour if you can increase that you can increase the capacity in the system (Manufacturer A)

A final point here is that alongside these efforts to discipline cows by fostering their 'right thinking', and to foster their productive life by constructing complex dietary, movement, milking and veterinary regimes, robot technologies also demand a co-disciplining of the farmer and the co-constitution of particular human subjectivities. As manufacturers told us,

my view would be you've got to have a...a good farmer, you've got to have somebody who's got a real passion and interest in cows. If the farmer isn't committed and interested to the extent they need to be with cows you're not going to make a system work because the whole management of a robot, the production of a robot, making the system work and function a lot of it hinges on the feeding regime of the cows and the management of the cows, the welfare i.e. their feet. (Manufacturer B)

And

For a farmer who's never managed his cows properly the robot computer will force him to do so. It tells him about blood in the milk, conductivity, yield per quarter, if a cow's possibly lame it can indicate that, it tells him how many times a cow has been fed every day. 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. And...farmers sometimes put these in thinking that's all automatic, it's like...you know the cows will feed themselves automatically, and milk themselves automatically. The vacuum pump will service itself automatically, but it doesn't work like that. And those are the things that we've got to...make sure the farmer understands. (Manufacturer A)

The opening sentence of this second comment is particularly interesting in illustrating a situation where humans, animals and technology are co-constituted; robotic milking is positioned here as a disciplinary response to a failing in a farmer which will lead to a reformation of their character. We return to this point about interventions in the behaviours and attitudes of farmers in the conclusion in suggesting that the

biosocial collectivity of the dairy farm depends on this simultaneous subjectification of the cows *and* the humans in accordance with the establishment of a particular regime of care.

6. Recapturing bovine life.

In this section, we draw on the interviews with farmers using robotic milking machines, and on observational work on dairy farms, to explore what actually happens on farms and to revisit the notions of freedom and choice which are inherent in many representations of robotic milking systems. Again, we examine here the working out in practice of a biosocial collectivity which disciplines certain of its members in accordance with the demands of a novel technology. We suggest in this section that cows' lives and capacities are 'recaptured' in robotic milking systems, countering discourses of freedom, autonomy and choice. As a result, distinctions become evident between simplistic representations of a bovine subjectivity 'freed' by robotic milking, and more complex processes of bovine subjectification which take effect as part of the practices of establishing robotic milking on farms.

We start with this example drawn from an interview with a farmer:

I think the most important thing is getting the cow correct, getting her...not just her mobility but actually get her health status, her rumen correct, get her actually...as healthy as can be. Have no other ongoing issues beneath the surface, you've got to have these cows happy and healthy and looking for feed, getting that nutrition right to get the visits [to the robot] right, if you have the nutrition wrong and you just fill their bellies what incentive is there for a cow to go and get milked. You've got to have...you've got to have something to drive that cow; you've got to think differently, how am I going to entice this cow to the feed fence? How am I going to entice this cow to the milking station? How do I go about this differently? (Farmer F)

Farmers thus told us about how they focused on fostering the bodies and bodily performances of their cows through their diets and veterinary interventions: the concept of 'getting the cow correct' is interesting here in its suggestion of a need to control the animal's body, its processes of digestion and so on, and is crucial to an understanding of the 'problem' of life which is the focus of these heterogeneous biosocial collectivities. This much is perhaps to be expected, although it is given a new inflection, as we demonstrate below, by the availability of data generated as part

of the robotic milking process. However, and more interestingly, this comment also describes a need to foster the cow as a subject and as an actor – she must be motivated and incentivised to behave in such a way that the whole system (robot and cow *together*) performs in an efficient and productive manner.

In terms of cows' bodies and bodily performance, the same farmer described the data his robot generated and how this was used to monitor animal bodies, performance and behaviour.

But the computer will [record] deviation in yield, low activity, we've activity collars on the cows and ...they're maybe not that good for probably heat detection as they could be, but by god they're damn good for low activity. That's one of the things that we do look at in the morning, low activity; ...we just look for deviation in milk yield which is very good. If there's like 20% deviation, 60% whatever, and just check her out, look at her conductivity, when she was last milked to see if there was anything going and just going and doing a visual on that cow and if you're just not sure take her temperature, get her temperature taken and then see what we're going to do with her if we need to do anything. (Farmer F)

The data then become part of a metrological regime which can be used to make decisions on what interventions in the life of each cow are necessary. For example, there may be a need for particular veterinary treatment in response to the calculation of a Mastitis Detection Index from conductivity testing of milk as it is drawn from the cow, or there may be a need for the farmer or a worker to fetch some cows from the barn and literally push them into the robot if they haven't 'chosen' to be milked at the expected frequency. As we noted above, the concept of the norm takes on particular significance here, as something must be established so that deviations from it can be measured, recorded and acted on (Foucault, 1990; Nealon, 2008). In the comment above, norms of yield can be established in relation to individual animals, but at the same time, as other comments have illustrated, herd or population norms can also be constructed, against which the performance of individuals can be compared (thus allowing the 'management by exception' referred to in Section 4, by Manufacturer B). Again, using milking robots does not necessarily establish such a regime, and is not essential to it, but it does tend to intensify metrological regimes by automating data collection and recording, facilitating analysis of data, and allowing or encouraging the farmer to manage their cows in this way. As we also noted in relation to the comment

from Manufacturer A in the previous section of the paper, along with the cows there is a simultaneous subjectification of the dairy farmer in robotic milking, as they become *expected* to manage cows in ways which accord with the scope and amount of data afforded by the robot. Management practice becomes much more directed by the robot-generated data. The robot will identify, for example, particular cows that the farmer should go and check or fetch to be milked. The new herd-management practices associated with robotic milking can thus challenge other notions and practices of stockmanship which centre much more around observing and touching cows.

The impression gained from manufacturers that in robotic milking systems cows have choice, freedom and autonomy, and that in that Foucauldian sense 'care for themselves', is countered by the re-capturing of bodies, performance and subjectivity which is a necessary part of the robotic milking farm's geography and ordering. The surveillance of cows is intensive as their health and movement are monitored as part of an ordering which promotes particular sorts of intervention; a cow's autonomy is limited by the process of being 'cared for' in this way, and by the consequences for a cow of not 'caring for themselves' in the required fashion. As one conventionally-milking farmer said of his robotically-milking colleagues,

they're tricking their cows to milk them, it's not really voluntary. At the end of the day the cow has to be milked, if she's not going to milk then she's not going to make it as a dairy cow. (Farmer G)

We have to take this sort of comment in the spirit in which it is made – that is, it's quite light hearted and an attempt to describe humorously the human-cow relationships this respondent has observed in robotic milking systems. The notion of bovine self-realisation – making it as a dairy cow – is thus not meant seriously. The 'tricking' referred to suggests the use of food to entice cows into the robot to be milked. Nevertheless, for farmers using robotic systems, dealing with cow subjectivity and what Foucault (2007) calls counter-conduct, that is, behaviour which runs counter to the demands of an efficient milking system, produces a need to design and manage cow-space, cows and the cow-robot system in particular ways and to make constant interventions in the life of the cows. The results for cows which

do not make it as dairy cows can actually be quite serious as they may be culled from the herd, or alternatively sold to a conventional milking herd.

Some farmers who attempted to allow their cows out to graze as part of a robotic milking setup, in particular, faced problems of inducing the cows to return from their fields to be milked. Describing how he dealt with 'lazy' cows, that is, cows whose conduct ran counter to the notion of effective choice-making, one respondent told us how there were some more 'reluctant' cows;

who know what to do ... but can't be bothered to ...compete to the same degree ...so to make sure that we don't have bad consequences with those cows we will ensure that they go through by penning them up in front of [the robot] ... We're just focused on the machines working and effectively when the cows are grazing ...and they are housed to a certain degree overnight in the grazing season, when they're grazing we basically run the machines like a conveyor belt, where we always keep the next lot of cows in front of it. (Farmer E)

Another set out his expectations for cows' behaviours, again suggesting serious consequences for those cows which do not conform to the discipline of the robotic milking system.

We have cows that are lazy cows no matter what you do they're only going to milk twice a day. There are some cows that only want to go and get milked once a day that just lie there all day. Well you know they're no use for a robotic system so...but we're slowly but surely weeding them out ... (Farmer F)

In comments like this, cows' freedom, choice and subjectivity is subordinated to the need to use the robotic technology efficiently and constantly. More immediately disciplinary measures can also be applied: some robots include a mechanism which administers a small electric shock (like that from an electric fence) or a puff of air to cows when they do not quickly vacate the robot following milking.

We were told by some farmers that cows had internalised an expectation that they had to behave in certain ways.

The cows do have their own individual routines and they know they can't get away with not

being milked. For example [my partner] will often see from the computer in the morning that [cows numbered] 56 and 31 have not been milked but by the time she gets into the shed they are already at the robot because they know it is their turn ... (Farmer H)

What is implied by such comments is that the cows' subjectivities become constituted around the demands of the robot: their behaviour becomes routinised in relation to the robot and they learn that certain actions will be expected of them. In other cases, the process of constituting cow subjectivity was apparent in the need for farmers to shift their perspectives on their cows following the introduction of robots. In this sense the robots are associated with the co-constitution of bovine and human subjectivity, as already suggested in the previous section where we referred to comments made by manufacturers. One example of this came in a comment which suggested that in response to the new modes of surveillance and management made possible by the robot, farmers' perspectives on their cows shifted in two simultaneous ways.

I think on the robots you manage them better, that's my personal opinion. You maybe don't see individuals, individual good ones you perhaps don't see as much. You see the bad ones that you need to round up etc. But in the past you'd go there's my best cow, I'd like to see my group of best cows giving X amount [of milk]. I could single out the best ones but I just want the herd as a whole to be doing well, not particular cows. (Farmer I)

Changes in what farmers are expected to do are identified in this comment. First, instead of focusing on exceptional 'good' cows, they are directed by the robot to concentrate on exceptional 'bad' ones. Second, there is a shift from a focus on the performance of the 'good' cows to a concentration on the overall, mean productivity of the population of cows, the herd. This second point actually counters the point made earlier about the way the introduction of a robot tends to produce an individualisation of the cows, so that less 'herd behaviour' is expressed. Here, the concept of the herd is re-instated but understood in terms of its mean productivity rather than in terms of its collective behaviour and its internal social structure. What this suggests in terms of biopower is a focus on the biological processes (in this case of milk production) constituting the bovine population, articulated with a simultaneous monitoring of individual performance. Once a mean or norm is established through this biopolitics of the herd, an anatamopolitics which pays attention to measuring

deviations each individual's bodily productivity makes from the norm allows the implementation of targeted, normalising, intervention strategies aimed at improving average herd efficiency or productivity.

7. Conclusions

In this paper we have drawn on our empirical research with the manufacturers and users of robotic milking technology to question the discourses of bovine freedom, autonomy and choice which are associated with it. Manufacturers in particular have emphasised these concepts, suggesting that robotic milking allows the expression of more 'natural' bovine behaviour, which has benefits in terms of animal welfare. Their argument suggests that robotic milking returns to cows a subjectivity based on their ability to choose and to be individuals rather than simply components of a herd. Manufacturer Lely, for example, states on its website that 'Successful robotic milking is a new style of farm management whereby decisions are transferred from the farmer to the cow' (Lely, 2011).

Our research has allowed us to be rather more critical of these claims, reflecting the way that the introduction of technologies into specific places and biosocial collectivities which encapsulate sets of human-nonhuman relationship, has effects which are more complex than are often allowed for. We have suggested that robotic milking systems depend on the recapturing, re-enclosing and fostering of particular aspects of bovine life. Instead of simply granting cows a bovine subjectivity, robotic milking involves processes of subjectifying cows in new ways and of ascribing particular subjective identities to them. Cows are expected to make the right choices, and can be variously persuaded, motivated, forced or 'tricked' into doing so through, for example, installing devices which enforce particular patterns of movement, or by direct human interventions such as 'fetching' or culling reluctant cows. As such, a key dimension to the (re)enclosure of bovine life is a micro-scale spatial reconfiguration of the dairy farm, using a related set of quite mundane technologies (such as one-way gates) to prescribe or proscribe animals' movements and behaviours, and in many cases a significant circumscribing of cows' movements and experiences associated with the imposition of a zero grazing regime. In this system, there is the possibility for new bovine subjectivities to become ascribed: while 'good' cows care for themselves by regularly visiting the robot to be milked, 'bad' or lazy

cows do not take sufficient care of themselves, and need to be managed more intensively or are removed from the system. At the same time, the processes constituting the bodily life of cows are monitored, recorded, fostered and intervened in, in order to ensure that the robotic milking system as a whole – the machine, the cows, inputs of feed and medicines – works efficiently and productively. This establishment of a particular metrological regime is key to the effectiveness of robotic milking as a system. The notion of the herd is re-articulated too, from being seen as a social structure in which individuals have a place, to being the basis of a production-oriented norm against which individuals can be compared.

Far from simply granting animals their freedom, then, cows are re-enclosed by a set of power relations and corporeal and behavioural interventions associated with this particular technology. The design of 'cow space', regulation of movement, feeding system, behavioural manipulation and so on are thus part of a robotic milking regime somewhat paradoxically associated with discourses of 'freedom', 'choice' and 'naturalness'. The affordances and demands of the technology produce a need for the affordances of cows to be rearticulated in terms of their making the *right* choices, of setting out to achieve their potential.

We have attempted to conceptualise these processes by drawing on work which has argued that Foucauldian perspectives on social processes are applicable to certain situations involving nonhumans. In the case of robotic milking, a combination of Foucault's descriptions of disciplinary and biopolitical/anatomopolitical (biopower) social relations is apt (this is not surprising – Foucault explains that the emergence of biopower from the late eighteenth century in Europe does not simply supersede previous disciplinary social relations, but that biopower incorporates, even intensifies, certain elements of previous regimes (Nealon, 2008)). The control of space, movement and routine in robotic milking systems, along with constant monitoring, is suggestive of disciplinary relations. The fostering of life seen in the way that robotic systems seem to encourage an intensified focus on processes of feed efficiency, the regulation of bodily movement, the ever more precise monitoring of milk quantity and quality, the whole regime of dietary and veterinary intervention, along with the articulation of herd-individual relationships through the establishment of norms and the measurement of deviations from norms, is equally suggestive that

robotic milking can be seen in terms of relations of biopower. We have expressed this in terms of heterogeneous biosocial collectivities, a term which articulates how in some circumstances humans and nonhumans can be regarded as coalescing around a shared biological concern, or problem of 'life itself' (Holloway et al, 2009; Holloway and Morris, 2012). The persistence of modes of disciplinary relation, especially as far as the cows are concerned, does however imply that we should question the nature of the 'sharing' present in these particular collectivities. Nealon's (2008) argument that to an extent disciplinary relations are intensified within biopower might also suggest that they permeate the biosocial collectivities outlined by Rabinow (1999). Heterogeneous biosocial collectivities in dairy farming and elsewhere are thus not necessarily benign groupings encapsulating a shared endeavour (e.g. increasing milk yields or efficient milk production), but capture, and perhaps reinforce and again intensify, lines of power both between different groups of humans and between humans and livestock animals. As such, the paper has begun to interrogate the complex lines of power which act within biosocial collectivities in ways which point to further questions concerning the ethics and practices of different modes of livestock farming. An understanding of biosocial collectivity as process, rather than noun, might be an effective way of further investigating the ongoing intertwining and working out of disciplinary relations and biopower in cases such as the one investigated in this paper.

To conclude, we argue that the co-existence of disciplinary relations and biopolitical relations in robotic dairy farming produces a particular inflection of biopower and causes us to rethink what can be meant by biosociality. Conceptualising robotic milking machines as interventions into biosocial collectivities comprised of humans and cows is a valuable approach because it forces us to think critically about human-animal-machine relations. First, it encourages focus on how these are articulated discursively in attempts to explain and legitimise particular interventions. Second, it encourages exploration of how they are actually practiced and experienced on farms. Foucault's emphasis on 'care of the (human) self', in this case, becomes something more distributed to include the care of specific (nonhuman) others. The discursive frameworks humans deploy about robotic milking seem to imply that cows need to learn to 'take care of themselves'. But at the same time, robotic milking as a technological intervention produces a need for, and a means of constituting, a

regime of care which embraces cows and humans together. This regime is established by means of a technology which facilitates a particular corporeal calculability or metrological regime, but which simultaneously depends on the fostering of very particular bovine and human subjectivities. Cows need to learn to 'take care of themselves' within this robotic system, but care is also distributed in the sense that cows are simultaneously worked on/taken care of by farmers. These humans are also 'taking care of' themselves in doing this, having to learn new ways to be with, observe and know about their cows. The freedom for both cows and humans promoted by the manufacturers as a benefit of robotic milking becomes a responsibility to take care/be taken care of and to foster productive life.

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Figure Captions.

Figure 1: Robotic milking machine in operation

Figure 2: Controlling 'cow flow' through a robotic milking system