Genetics and livestock breeding in the UK: co-constructing technologies and heterogeneous biosocial collectivities

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Abstract

Cattle and sheep breeders in the UK and elsewhere are increasingly being encouraged to use a variety of genetic technologies to help them make breeding decisions. The technology of particular interest here is 'classical' statistical genetics, which use a series of measurements taken from animals' bodies to provide an estimate of their 'genetic merit' known as Estimated Breeding Values (EBVs). Drawing on empirical research with the representatives of national cattle breed societies and individual cattle breeders the paper explores the complex ways in which they are engaging with genetic breeding technologies. The concept of 'heterogeneous biosocial collectivity' is mobilised to inform an understanding of processes of co-construction of breeding technologies, livestock animals and humans. The paper presents case studies of livestock breeding collectivities at different scales, arguing that the ways in which the 'life' of livestock animals is problematised is specific to different scales, and varies too between different collectivities at the same scale. This conceptualisation problematises earlier models of innovation-adoption that view farmers as either 'adopters' or 'non-adopters' of technologies and in which individual attitudes alone are seen as determining the decision to adopt or not adopt. Instead, the paper emphasises the particularity and specificity of co-construction, and that the co-construction of collectivities and technologies is always in process.

Keywords: Genetic breeding technologies, Estimated Breeding Values, livestock animals, heterogeneous biosocial collectivities, 'life', co-construction

1. Rural studies and genetic technologies in agriculture

An established tradition of research in rural studies on genetic technologies in agriculture (e.g. Goodman et al. 1987; Kloppenburg, 1990) has been extended in recent years by further research on the political economy and also the gendered dimensions of these phenomena (Bryant and Pini, 2006; Pechlaner and Otero, 2008). A more emergent scholarship has begun to consider the farm level implications of genetically modified organisms (GMO) (e.g. Lane et al. 2007; Lassen and Sandoe, 2009; Oreszczyn et al. 2010) reflecting a wider call within the social sciences for more attention to be paid to "the purchase of ... biotechnologies and the discourses and images through which they circulate in social practices …" (Spencer and Whatmore, 2001, pp.140-1). Given the high profile and on-going nature of the debate about genetically modified (GM) crops within Europe (e.g. Seifert, 2008) it is understandable that popular and academic attention has been focused on genetic technologies within the context of plant based agriculture. However, the corollary is a relative lack, at least until very recently, of rural social scientific interest in the ways in which livestock agriculture is being influenced by genetic technologies (Holloway and Morris, 2008; Morris and Holloway, 2009; Holloway et al. 2009; Twine, 2010). This might be explained in part by the absence of controversy in this context. In the UK, for example, there has been some media interest in cloned cattle and genetically modified pigs and chickens, but debates about the legitimacy of such technologies appear to be largely confined to specialist, scientific arenas (Marris et al. 2001). However, although attracting relatively limited public attention, cattle and sheep breeders in the UK and elsewhere are increasingly being encouraged to use a variety of genetic technologies to help them make breeding decisions with the aim of producing 'better' animal bodies. Such breeding technologies are layered on to and compete with more established breeding knowledge-practices notably visual assessment and the use of pedigree records which remain significant, albeit to varying extents both between and within breed societies, in breeding decisions and in the sale of livestock (Holloway and Morris, 2008, 2012).

The most well developed examples of genetic breeding technologies are: genetic markers, which are identifiable genetic material supposedly related to particular phenotypic qualities such as enhanced productivity or reduced disease susceptibility; and 'classical' statistical genetics, used to provide an estimate of an animal's 'genetic merit' known as Estimated Breeding Values (EBVs). The latter technology currently has the most widespread practical impact and relevance to the livestock breeding community and is integral to a geneticising discourse in agriculture (Holloway and Morris, 2008). EBVs thus provide the empirical focus of this paper. EBVs involve the production of a set of figures derived statistically from a set of measurements of the animal body, for example its weight at particular points since its birth, and the depths of fat and muscle in particular places. A statistical algorithm is used to calculate an individual animal's 'breeding value' for each characteristic based on its own data and data from its relatives. These values can be used by breeders to indicate the relative breeding strengths and weaknesses of any animal, and to select animals for breeding in accordance with a particular breeding objective. The calculation of population average EBVs enables new norms or standards to be established because individual animals or herds / flocks can be compared - favourably or not - with these averages. "It can thus be suggested that animals or populations *should* embody particular statistical or genetic characteristics, and their conformity to or deviation from such norms are easily measured" (Holloway and Morris, 2012, p.65). EBV data are produced by organisations (e.g. publicly funded research institutes and commercial organisations such as breeding companies[1]) typically located 'at a distance' from the livestock animals themselves and the farms on which they are born and reared. Scrutiny of the subsequent results by breeders can take place electronically for example 'on screen' in a farm office where the animal itself is not present. Increasingly, however, EBV data are presented alongside the individual animal they represent at agricultural shows and sales (Holloway, 2005).

The emerging array of genetic breeding technologies has been described by their proponents as contributing to a 'genetics revolution' in livestock agriculture (Bulfield, 2000; Kues and Niemann, 2004; Outlook on Agriculture, special issue: Genomics and Genetic Engineering for the Meat Industry, December 2003). Although mobilisation of the dramatic concept of 'revolution' may indicate the over-hyping that often accompanies the introduction of new technologies (Brown, 2003) it is apparent that active efforts, both within the public and private sectors, are being made to construct a genetic agenda in this field (Holloway and Morris, 2008, 2012). For example, although EBVs have been in circulation for several decades consistent attempts, in the form of articles in the farming press and training events hosted by organisations such as the English Beef and Lamb Executive (EBLEX)[2], are being

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[1] In the UK, Signet is the major company producing EBVs, while ABRI is an Australian equivalent used by some UK breed societies.

[2] EBLEX is part of England's Agriculture and Horticulture Development Board, and is funded by a levy paid on sales of beef cattle and sheep in England. It works to promote the beef and sheep sectors and the more extensive

made to enrol breeders into their use. This entails responsiveness to user needs through the invention of new ways of presenting EBV data to enhance their accessibility and visual intuitiveness. Such promotional activities point to the efforts of technology designers to configure "the identity of putative users" (Woolgar, 1991, p.59), with livestock breeders who use these genetic breeding technologies being defined as confident, progressive and contributing to the current and future profitability of the livestock industry. On the other hand, those who resist use of the technologies can be represented as problematic obstacles to the modernization of livestock breeding (Holloway and Morris, 2012).

The purpose of this paper is to move beyond the claims made by those involved in the development of breeding technologies, to try to make sense of what is actually happening 'on the ground' as livestock breeders encounter these technologies within the practices of breeding. As such, the paper is in part a response to the call, by Greenhough and Roe (2006, p.417), for investigation into "non-expert (sic), micro-scale knowings" of biotechnology as it insinuates itself increasingly in everyday life (see also Michael, 2006), in this case, the lives of livestock breeders and their animals. It is also a response to and questioning of the continuing circulation, within policy and scientific domains, of the notion of 'innovation adoption' that tends to view farmers as either 'adopters' or 'non-adopters' of innovations, i.e. with identities that are coherent and singular in relation to a particular technology or policy initiative,[3] and in which the attributes and attitudes of individual humans alone are seen as determining the decision to adopt or not adopt. More specifically, our aim is to develop a conceptualisation of the use of genetic breeding technologies within livestock breeding that goes beyond a focus on the human 'users' or 'non-users' that is characteristic of past research in rural studies that has a technology focus, including in particular work on innovation-adoption. To do this we work with the idea of 'heterogeneous biosocial collectivity' (Holloway et al. 2009; Holloway and Morris, 2012), relating it specifically to the use / non-use of technologies within this context, exploring also the relationships between and the co-construction of these collectivities and breeding technologies. This paper is distinct from our previous work in that it *develops* the concept of a heterogeneous biosocial collectivity,

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use of breeding technologies such as EBVs is regarded as a valuable means of assisting the development of the British livestock industry.

[3] For example, within the research that provides the empirical basis of this paper, animal scientist members of the project's Consultation Panel were particularly interested in the research producing data that would provide conclusive evidence of the particular types of farmers who adopt EBVs and those who do not, so that more effective extension messages could be designed.

arguing that particular collectivities associated with different breeds but also identified at different scales within a breed afford different possibilities for the use, and co-construction, of breeding technologies.

In the subsequent sections of the paper we first provide further context by discussing approaches to technology and socio-technical change in rural studies and science and technology studies before elaborating the concept of heterogeneous biosocial collectivity and technology use. The methodology employed to produce data on livestock breeders' engagement with genetic breeding technologies will be described before four illustrative case studies are presented of collectivities associated with beef cattle breeding at different scales. These cases reveal the considerable complexities, ambivalences and ambiguities in engagements with genetic breeding technologies. These are produced because as technologies are encountered on particular farms, by particular breeders with distinct sets of experiences, skills and knowledge-practices, and working with particular groups of animals, a wide range of responses and outcomes are evident. In conclusion we reflect on what our case studies reveal about the co-construction of technologies and heterogeneous biosocial collectivities, both in relation to the specific example of beef cattle breeding but also more widely in relation to technological interventions in agriculture

2. Rural research, technology use and heterogeneous biosocial collectivities

The study of technology and socio-technical change has a strong tradition in rural studies, notably in the form of innovation-adoption research (e.g. Taylor and Miller, 1978; Rogers, 1983). As Padel (2001, p. 40) explains, the innovation-adoption model describes "the diffusion of an innovation into a community. It attempted to predict the adoption behaviour of individuals by looking at their personal characteristics, the time factor and the characteristics of the innovation itself". In spite of its considerable popularity as a research focus within the rural social sciences from the 1950s to the 1970s, and its practical relevance to agricultural extension workers and other change agents who – it is claimed - found the model "exceedingly useful in their educational programmes with farmers" (Ruttan, 1996, p.56), the innovation-adoption approach had largely gone out of fashion by the 1980s (Ruttan, op cit), although see Padel (2001) for a more recent application. Meanwhile, work in other fields continued to explore technological change, developing a variety of new ways of thinking about the relationships between 'users' (cf. 'adopters') and technology (e.g.

Oudshoorn and Pinch, 2003; von Hippel 1976, 2005). To take one 'rural' example, Kline and Pinch's (1996) work on the social construction of the early automobile in North America is in part concerned with how farmers innovated with them so that they could run farm machinery. Such *farmer-led* innovation and adaptation is part of the history of agricultural mechanisation. This kind of work informs the analysis in this paper because it takes seriously, and places at the centre of analysis, the users (and non-users) of technology, the co-constructed agency of these groups and their roles in the development of technology. More specifically, and following Oudshoorn and Pinch (op cit), one of the questions we seek to answer in this paper is: how do livestock breeders encounter, engage with, employ, reconfigure, contest and resist genetic breeding technologies? Importantly, and distinguishing this from earlier studies of innovation-adoption, we are interested in the co-construction of livestock breeders and genetic breeding technologies. In other words, we explore how breeders shape and adapt genetic breeding technologies, and in turn examine what these technologies do to users, in terms of their identities and social relationships. As such the paper moves "beyond technologically deterministic views of technology and essentialist views of users' identities" (Oudshoorn and Pinch, op cit, p.3).

However, we also seek to *develop* this research which tends to neglect the role of the non-human in shaping the use and non-use of technology. In particular, we argue that there is a need to pay attention to the animals enrolled within the practices of livestock breeding. Here we draw inspiration from work that has discussed the agential capacities of non-humans (e.g. Jones, 2003; Buller and Morris, 2007; Holloway, 2007). As Jones (2003, p.292) asserts:

> "the cows that produce milk or meat, the hens that produce eggs, the boars and sows that produce meat and other pigs for meat, the horse that learns to jump, the dog that learns to control sheep, or hunt, and so on are *in relation* with humans, technology, information and science, *productive actants who contribute vital affordances to achievements of one kind or another* emanating from networks. These are important conceptualisations which begin to place animals more visibly and precisely in these achievements" (Jones, 2003 p.292, emphasis added).

By conceptualising animals in this way further questions are raised about their role in the use and non-use of genetic breeding technologies and, by implication, how they too are reconfigured through the use of these technologies. The use / non-use of genetic breeding technologies can therefore begun to be understood as a heterogeneous process, encompassing not only relationships between breeders, a variety of other human actors and the technical artefacts that constitute the breeding technologies, but also relationships between breeders, technologies *and* animals (e.g. Latour, 1999; Whatmore, 2002). In approaching the use of breeding technologies in this way, as heterogeneous and relational, we acknowledge the influence of a 'co-constructionist' perspective developed by various scholars within and beyond science and technology studies (see Murdoch, 2001). Importantly, co-construction is about more than just *association* between diverse actants, both human and non-human, it is also concerned with the *modification* of these actants through their associations.

To explore these issues further we draw on the concept of biosocial collectivity. Following Rabinow (1990 and Rabinow and Rose (2006) we have argued elsewhere (Holloway et al. 2009: 397; Holloway and Morris, 2012) that biosocial collectivities are intentional groupings that come together because members have a shared concern for a fundamentally biological issue[4]. That is, what is at stake is a problem of 'life itself' (Franklin 2000), and how that problem is defined and responded to. We have suggested that biosocial collectivities do not need to be limited in their membership to humans and that nonhuman animals can also be regarded as members making it possible to conceptualise biosocial collectivities as heterogeneous. We have also suggested in our previous work (although not worked through in empirical detail) that such heterogeneous biosocial collectivities can emerge at different scales across which livestock breeding as a process and sets of practices takes place. For the commercially and numerically very significant Limousin cattle breed, for example, there is the International Limousin Council, the national scale British Limousin Cattle Society, several regional and local groupings of breeders working together to develop the breed (e.g. as so-called sire reference groups), and numerous individual farm-scale collectivities where actual matings take place and animal bodies are reproduced materially. In the sense that individuals can be, simultaneously, members of collectivities at more than one scale the scales can be said to overlap. Crucially, however, subjectivities are constructed differently in relation to collectivities at different scales. An individual breeder, for example, in a farm-scale collectivity consisting of themselves and the animals in their herd, might express a subjectivity vis a vis a breeding technology which is different to their subjectivity when acting as a representative of the larger-scale collectivity of a national breed society.

[4] It is because of the specific provenance of the term collectivity in the work of Rabinow and Rose that we use this rather than the allied concept of 'assemblage'.

In the context of livestock breeding it is possible to identify a number of different problems of life itself concerning, for example, issues surrounding biosecurity, health and welfare. However, key to the practices of breeding is the relationships between the definition of what the 'good animal' is *in theory*, and the identification *in practice* of a 'good animal' from which to breed, and it is on this particular problem that we focus in this paper. As such, we are interested in both the 'reality' of life itself as a set of biological processes (in our case, for example, combinations of genotype and phenotype) *and* a particular *means* of understanding and intervening in life processes e.g. the breeding technology of EBVs along with other breeding knowledge-practices mobilised by breeders and breed societies. Crucial to the argument we are developing here is that the problem of life itself in livestock breeding emerges differently in different collectivities. For different collectivities, at different scales (e.g. the breed society or the farm), how the 'good animal' is specified will vary, and is determined partly in terms of what *in the abstract* are desirable characteristics (e.g. colour, size, growth rate, maternal 'instinct', or calving ease), and partly in terms of the biological problem *in practice* of attempting to breed for several different and perhaps incommensurate characteristics simultaneously (a process that can sometimes produce unexpected outcomes, reflecting and reinforcing the indeterminacy of life itself). We argue that this biological issue, at the heart of the heterogeneous biosocial collectivities that are constitutive of livestock breeding at various scales, is central to understanding the use / non-use of genetic breeding technologies. As such, rather than simply focusing on individual *users* of technologies we are interested in the relationality of use by heterogeneous collectivities.

Further, because this biological issue or problem of life itself becomes conceptualised differently for different collectivities, this *particularity* will necessarily shape the relationship between and co-construction of the collectivity and technology. Thus, for example, the particular conceptualisations which pertain at the 'larger' scale of a national breed society might be different to those which pertain at the 'smaller' farm scale of individual breeders and their herds, and indeed, different breed society collectivities, and different farm-scale collectivities within the same breed, might be constituted around different constructions of the problem of life itself. As such, particular collectivities (comprising a unique combination of human and non-human components) at different scales afford distinctive possibilities in relation to breeding technologies. The construction of both the collectivity and the breeding technology will be specific and different in each particular case.

In order to demonstrate this conceptualisation, the sections subsequent to the next on methodology present empirical material in the form of detailed case studies of collectivities associated with the breeding of beef cattle[5].

3. Methodological points

The empirical material in this paper derives from a larger research project that sought to explore the ways in which genetic knowledge-practices are reconfiguring livestock breeding in the UK. The project involved interviews with a committee member from each of 21 breed societies[6] representing the range of types of beef cattle and sheep in the UK. A Consultation Panel of eight members, with expertise in different aspects of the livestock sector, informed selection of interviewees. Breed society representatives identified breeder members for follow-up interviews and these interviewees suggested other breeders to whom we might speak. Interviews with 21 'pedigree' (nine beef cattle and 12 sheep) and five 'commercial' (two beef cattle and three sheep) livestock breeders in the UK were conducted. These interviews included breeders who were deeply engaged with genetic technologies and others who knew about them, and even used them, but were deeply sceptical, making a straightforward quantification of 'use' at this scale very difficult. Interviews with breeders were semi-structured and explored how breeding was planned on each farm, and of the role of genetic breeding technologies. Interviews explored the pros and cons of genetic technologies, breeders' knowledge and experience of the technologies, the extent to which they were used, the particular farm contexts which influenced how genetic technologies were engaged with in practice, and breeders' assessments of the future of genetic technologies. Interviews were fully transcribed and analysed thematically.

In order to develop and demonstrate our theoretical point four case studies are used. The selection of these cases is justified in relation to three axes of comparison (see Figure 1). The

[5] Although it is acknowledged that there is considerable variation *within* this category, not least associated with breed itself, which is evidenced, for example, in the targeting of beef animals at different markets, there is more likely to be greater variation *between* livestock animal species, notably beef cattle and sheep, in terms of the economic structure of the sectors and the engagement with breeding technologies (in simple terms the beef sector is, overall, currently more engaged than the sheep sector), justifying our focus on *one* species.

[6] Breed societies are responsible for recording the animals which are legitimate members of their particular breed via their pedigree, for guiding the 'improvement' of the breed, and for promoting the qualities of the breed.

first of these is between heterogeneous biosocial collectitivies at the *same* scale; the scale of national breed societies. A breed society can be understood as a collectivity operating at a national scale since it associates diverse members – both human and nonhuman – distributed across the UK. It is constituted around a particular set of biological issues and problems that contribute to defining and producing collectivity-specific 'good animals' and which in turn afford possibilities in terms of the use of EBVs. Two beef cattle breed societies are selected – the British Blue and North Devon - because they express differences both in terms of the biological 'problem(s)' associated with their respective breeds of cattle and in terms of the nature and extent of their engagement with EBVs. The second axis of comparison is between collectivities at different scales and to illustrate this we present a case study of a farm scale collectivity associated with the same breed as one of the breed society collectivities – the British Blue. Here we explore how the particular ways in which life is problematised at this scale have distinctive implications for technology use when compared with the breed society scale. A third axis of comparison is similar to the first, in that it explores heterogeneous biosocial collectivities at the same scale but here the focus is on comparing two *farm* scale collectivities associated with the *same* breed, the British Blue, where differences in the problematisations of life afford particular possibilities for technology use.

Figure 1 here

The following questions were used to develop the case studies and were shaped by our conceptualisation of heterogeneous biosocial collectivities and informed by the literature on technology use. First, how is the problem of life specified in this particular collectivity? Second, what are the specific characteristics or particularities of the collectivity – in terms of the ways that the problem of life itself is specified - that afford, or not, possibilities for use of breeding technology? Third, how are the collectivity and the breeding technology co-constructed: how do they change in relation to each other?

4. Specifying the problem of life within national-scale heterogeneous biosocial collectivities: comparing breed societies

In this first case study we discuss two national breed society collectivities, based principally on the interviews with their committee members, in terms of how they problematise life and what these problematisations mean for the use of breeding technology. The first is focused on breeding British Blue and the second North Devon cattle. Each collectivity is discussed in turn with comparative comments made at the end.

Initially a multipurpose breed in Belgium in the 19th century, the Belgian Blue was subsequently developed as a dairy breed, and then in the latter parts of the 20th century Belgian scientists and breeders selected for doubling muscling to produce a heavily muscled 'carcass animal'. The breed was imported into the UK in 1983 and it has since been developed by British breeders for various markets both domestic and international. Efforts have been made to address some of the mobility and calving problems associated with the Belgian version of the breed. In 2000 discussion commenced around 'branding' the cattle as a British type of Blue, a process that culminated in a formalised rebranding of the British Blue in 2009. The colour of the breed varies considerably from white to black and it is claimed that the breed produces "a quality carcass" that has a very high meat yield in excess of eighty five percent. There are now approximately 650 members of the British Blue cattle society in the UK, of which about 90 use EBVs.

A number of biological issues contribute to defining and producing collectivity-specific 'good animals' within the British Blue breed society. First, there is double muscling, the result of a particular genetic mutation that represses the myostatin protein and which leads to augmented muscle growth. Second, there is the issue of meat quality and quantity, both within the breed and also in terms of what a British Blue sire imparts to commercial suckler cows or to dairy cows. That British Blues are celebrated by their breeders for their high 'killing out percentage'[7] is a specified biological issue, signalling that this particular breed offers something that others do not or cannot (e.g. it is claimed that the bulls can even father a 'meaty' calf from a notoriously bony Holstein dairy cow). Third, there is the welfare issue. The Belgian version of the breed is widely known for welfare problems created by breeding for double muscling which can compromise calving ease and cause mobility problems. In breeding British Blue cattle particular efforts have been made within the breed society to resolve the tension between selection for double muscling and selection for calving ease. Specifying the *British* Blue, as against the *Belgian* Blue in these terms shows how a 'new' (British) collectivity defines the biological issue in different ways to the longer-standing Belgian collectivity.

[7] That is, the proportion of the carcass which is marketable meat.

In terms of the relationship between the breed society collectivity and breeding technologies, performance recording began in the 1990s through the Meat and Livestock Commission[8] but in the early 2000s the society moved to the BreedPlan system which is run by the Australian company ABRI. An active effort has been made by the breed society to use EBVs to shift the biological ground of the breed i.e. to reconstitute the breed at the scale of the breed society collectivity through the application of breeding technology. It is doing this by emphasising breeding for calving ease in an attempt to dispel the reputation of the breed for difficult calvings and the associated need to use caesarean-sections. Crucially, as well as the use of EBVs as a practical tool for selection with respect to this biological problem, EBV data are also being used to provide *evidence* that calving ease is improving. The breed society representative commented that the breed is now close to the "bovine norm for c-sections", and this can be clearly demonstrated through EBVs. What is also apparent from our empirical evidence is that for *some* breeders this third, biological problem of welfare is less of an issue and high rates of c-section are acceptable if the key issue for them is maintaining high meat yields tied to more 'extreme' double muscling. Within farm scale collectivities, then, the resolution of the biological issue can be specified in quite different ways, as we discuss in more detail in sections 5 and 6.

The Breed Society has been particularly active in working with both the Roslin Institute and geneticists at Breed Plan to modify the breeding technology, by suggesting changes to the algorithm used to calculate EBVs i.e. to alter the weighting of different variables used in the calculations to better suit the breed and the society's breed improvement objectives. As the breed society representative explained:

> "…when we joined this BreedPlan [EBV system] … they [ABRI] told us at the time that we could alter it to our, make it what we wanted like I said, the Blue is a different breed from other breeds with heavy muscle and if we lose … our muscle, we haven't got a breed any more [...] I wanted it, a few of us wanted it weighting more to muscle than growth, than weight you know, it just goes off weight like, but everything that we've asked them to do up to now they've come back and said that's not possible"

The fact that this attempt failed does not invalidate it as an example of the potential for co-construction of the technology. Rather, it illustrates that there are ongoing processes of

[8] A non-departmental public organisation funded principally by levies which aims to promote British meat.

negotiating how the technology is to work. The particular characteristics of this breed society collectivity may be limiting its agency in relation to this process of (co)construction. Specifically, British Blues tend to be bred in small herds and so, it is claimed, the amount of statistical data being fed into the EBV system is insufficient to make it reliable.

We turn now to discussion of a second breed society scale collectivity which contrasts with the first both in terms of the history and biological 'character' of the breed and also the nature of the engagement with EBVs. North Devon cattle are a well established British breed, with the first herd book published in 1851 and the society formed in 1884. Traditionally, many farmers in the south west region kept North Devons and used them both for milk and meat but the breed went out of fashion in the 1970s, being seen as undesirable by the supermarkets probably because it produces a relatively small carcass compared to the Continental breeds that were in the ascendancy at that time. However, the breed has undergone something of a revival during the last decade and there are currently 550 registered breeding herds, representing approximately four and half to five thousand breeding females.

The biological issues and problems that contribute to making a 'good animal' in the context of this breed society collectivity afford a very different set of possibilities for the use of EBVs compared with the British Blue case. First, the breed has a number of qualities that make it desirable. As the breed society representative explained, "(t)hey are very fertile. They are very long lived, thirteen, fourteen calves with an annual calving is the normal…They are very milky. They are [also] very docile." Also significant is the ability to reach slaughter weight solely on grass, without the need for concentrates, including from relatively low quality grazing. "They are very, very efficient converters of forage and the cows will live on not the best forage. They suit organic systems". As such, the breed has attracted the interest of environmental organisations for use within 'conservation grazing' programmes which often entail management of grazing areas that, in the terms of agricultural productivism, would typically be regarded as low quality. Second, as with the British Blue collectivity, claims are made for this breed's meat quality and quantity, albeit associated with rather different biological properties. The breed society representative claimed that the North Devon "produces a premium product because it's naturally marbled meat. It is an early maturing breed so you get full taste in meat in twenty four months old… They are a medium sized carcass and a premium product". The 'manageable' size of the carcass makes the breed attractive to small butchers and producers who want to retail their own meat. The characteristics of the breed's carcass were also highlighted with respect to cross-breeding:

> "And they produce really good, really good crosses, and they are…they are demanded by high street butchers, a little bit more superior fleshing....And nice carcass weight, a lot of the Continental, Blonde and Simmental[9] particularly, especially when they are purebred, carcasses are too heavy for normal butchers".

Unlike the British Blues, North Devon cattle are not regarded as having any characteristics that pose major difficulties for the breed's reputation. Nevertheless, breed society policy is to "make the breed slightly heavier within its own genetic base". Further, the Society's breed improvement committee has identified a couple of biological problems with the breed:

> "And I would say that if the breed has any faults, they have two faults. They tend to have too much brisket and some of…because of, you know, the period that they were out of favour, they did lose a bit of quality of feet, so we are hoping to improve the feet on them. ...It's easily sorted. But I would say probably, as we sit here now, twenty five to thirty percent of the breed suffer from one of those two problems".

In neither case, however, were these 'faults' regarded as a significant concern for the breed and there was no indication given that genetic breeding technologies might be helpful in their resolution. Rather, there was an implicit acknowledgement of a role for 'traditional' methods of selective breeding.

In terms of the relationship between the breed society collectivity and breeding technologies, the breed society encourages its members to performance record through Signet[10]. However, only a small number - approximately 25 breeders - actually use this system. The reason given for this limited engagement with performance recording was as follows:

> "I think the reason that is, is we don't sell a lot of crossing bulls on fast growth and muscling, and basically your EBV's are based on that….Now that is changing, Signet are changing and ABRI are changing the goal posts on that, so we are going through a period of review…But historically we sold

[9] The Blonde d'Aquitaine and Simmental are two further 'Continental' breeds.
[10] The inclination to engage with performance recording at the scale of the breed society was not entirely clear but might be related to the society's 'classification system' which bears comparison with the process at least of recording information used to produce EBVs.

> crossing bulls because of their docility and their fertility…And their ability to pass on this marbling to progeny".

EBVs then are seen as a 'poor fit' with the desirable and proven biological characteristics of the North Devon breed at least as these are identified and promoted by the breed society. In particular, the breed society representative characterised the North Devons as a 'female breed', whereas EBVs tend to be associated with what are regarded as the 'male' characteristics of growth rate and size. The low take-up of EBVs is seen, therefore, to relate to the 'femaleness' of the breed:

> "Signet only recently have been doing female traits, and a lot of our members haven't bought into that…They still have this traditional view that EBV's are [for] fast growth, heavy muscles…Which is what it has been up until the last four or five years really"

Currently, therefore, there is little evidence that EBVs are reconstituting the breed at the scale of the breed society collectivity. Nevertheless, its representatives have not ruled out the possibility as evidenced in the efforts by the breed improvement committee to meet with the producers of this genetic knowledge, to discuss with them the opportunities for developing EBVs that are more breed appropriate: "We are going to ABRI [in Australia] to sit down for half a day and talk to them about things that we need, and that's being spearheaded by the Breed Improvement Committee".

As with the British Blues, the breed society collectivity envisages the potential at least for co-constructing the technology. However, in his reflections on what the future of the breed is likely to hold, the breed society representative could not imagine how it would be possible to develop EBVs that would usefully inform breeders about some of the other 'essential' – biological – characteristics of their breed (in this case 'foraging ability'); qualities that are well-known, widely established and readily demonstrated without the use of performance recording:

> "I'm not clever enough to be able to work out how they are going to have an EBV for foraging ability…I think it's, you know, it's…our future is on what we tell people and what we can show them. I mean, the breed's been around since the 1500's, you know, Sinclair and his first documentation of livestock in the UK talks about Devons. Everyone knows about Devons".

At the scale of national breed societies then, it is apparent that the biological problem of life itself is specified very differently within collectivities associated with particular breeds. A 'good animal' for the British Blue breed society is quite distinct from the North Devon case and this particularity matters in terms of the nature of these collectivities' engagements with EBVs. Although the 'policy' of both breed societies is to engage with performance recording the depth of this engagement and degree of enthusiasm is much more pronounced in the case of the British Blues where the opportunities to develop better animals through the use of EBVs are perceived to be much greater and appear to have been already actively employed in reconstituting the collectivity at this scale. However, there are limits to the use of EBVs in the context of both collectivities, albeit for rather different reasons, principally the typically small size of herd in the case of British Blue and key aspects of breed 'character' in the case of the North Devons. In both cases attempts have been made to 'co-construct' the technology through breed society level discussions with scientists at ABRI and Signet although to date with limited success. Nevertheless, the potential for co-construction is demonstrated.

5. Re-specifying the problem of life at different scales: breed society and farm collectivities

In this second case study we return to the British Blue breed but address the use of EBVs within a biosocial collectivity at the farm scale. In particular, we consider how, at this scale as opposed to the scale of the breed society, life is specified in ways that present different possibilities for technology use. The pedigree beef breeder who represents this collectivity is Peter Stephenson[11], a dairy farmer in the north of England. A secondary enterprise is a pedigree breeding herd of 23 or 24 British Blue cattle. Superficially at least this collectivity is engaging very positively with EBVs as the breeder sees them as very important to his breeding strategy. And yet there are more complex layers to the engagement with EBVs.

A first key point, and one that reflects the problematisation of life at the scale of the breed society, is that Peter was anxious about the British Blues' reputation for difficult calvings. However he was also concerned about worsening the bodily conformation of the breed if too much emphasis is placed on 'easy calving'. Here, then, is an instance at the scale of the farm collectivity of 'translation' of the particular biological issues specified at the scale of the breed society collectivity. In this *particular* farm scale collectivity, the biological issues are

[11] A pseudonym.

respecified in a distinctive way as here the biological problem concerns the *balance between* bodily conformation and calving ease. Peter was thus cautious about the precise aims of any breeding strategy;

> "When you go for easy calving, to go for easy calving, pedigree ones, it's a very fine line. You can lose your shape... and all your conformation and that's what sells your animal.... or you can go too far and you can add too much birth weight, you know, too much hot blood in as I call it and you can start to get added birth weight, which, when you try to calve these animals you don't really want ... So it's a very fine line, you've got to keep adding little bits in and taking little bits away"

This illustrates the process of constituting the farm scale collectivity in practice in relation to the biological issue which it centres around: the collectivity is or embodies a *process* which is seen very much in terms of how bodies are represented ('hot blood') and known in relation to each other. 'Adding bits' and 'taking bits' is a practice which is oriented towards the abstract ideal of the 'good animal', but is dependent on making judgements about what is good or poor about *real* animals. In this case what is also emphasised is that dealing with biology requires balance and carefulness within an *overall* breeding strategy:

> "I'm sort of middle of the road I would like to say. There are those that are above and those below ... I like to produce an animal that calves naturally, doesn't have too much stress on the cow during calving. She can recover and get back in calf quickly. She has enough milk to raise that calf to a certain extent and that animal to go on and grow and sell well".

What Peter considers to be a good animal, therefore, is particular to this collectivity and shapes the collectivity's relationship with EBVs. Peter's engagement with this technology has evolved over time. He referred to his earliest experiences of buying cattle using 'traditional' visual assessment and pedigree records, before becoming gradually enrolled into using EBVs through the promotional efforts of the breed society. In response to a question about his earliest breeding selections, Peter said, "(w)ell, that was before figures. It was just visual appearance. We spent a couple of years going round sales, just trying to look for the right animal". At this stage, in relation to 'figures' (i.e. EBVs), "we weren't taking any notice of them anyway ... we hadn't learned enough about them, because just visual appearance and learning a little bit about past pedigrees ..." But later, via 'the society', and in particular its Chair who is a powerful advocate of EBVs within the organisation, Peter became more interested. He now considers the use of figures as 'progressive' and something which will become more important in the future of beef farming. As Peter says;

> "Anybody down at the market, an old farmer would say that he only uses his eye. The next generation is starting to look at figures. We're ahead of the game, we've got the figures in place as a breed and we're ready to meet that head on which I think can only be good".

Peter argues that EBVs already add something to the practice of breeding and will add more in the future. The effects of EBVs on the identity of the farm scale collectivity but also the breed scale collectivity are clear: not only will the technology enhance their commercial potential, they will also be identified as more advanced or progressive. The use of EBVs will simultaneously affect the material constitution of the collectivity: the influence on specific breeding selections of favouring particular EBVs (e.g. privileging calving ease or weight gain) will be to shift the conformation and performance of the bodies of the bovine members of the collectivity. And yet, at the same time, there are limits to the transformative potential of EBVs in this context, bringing us to our third point concerning the biological issue of breeding for the 'good animal' which is central to the constitution of this farm scale collectivity.

In discussing his selection of new bulls, Peter's first reference point is visual assessment, looking not only at the bull itself but also at its offspring.

> "I prefer to see what the bull has done for others ... And I like to go and have a look at the farm, where he's been used and see if it's thrown [i.e. sired] anything bad"

Peter's valorisation of visual inspection is, perhaps, related to his role as an official breed society inspector, which involves, on behalf of the society, inspecting and approving bulls to be sold at breed society sales, and as such, being in an authoritative position to guide the 'improvement' of the breed in particular directions.

> " ... when you do that [inspection] you start to appreciate why an animal needs to be correct and probably because of that, I'm a little over cautious at going for over-muscling [...] it can at times restrict mobility and with that extra birth weight it can increase birth weights [causing calving problems]"

The ‘good animal’ from which to breed must *look* right – it must embody particular qualities - and this visual knowledge cannot be overridden by the genetic knowledge produced by EBVs. As such Peter negotiates a balance between traditional and genetic breeding technologies, mirroring his attempt to balance the biological challenges of calving ease and bodily conformation. His argument is that neither takes priority in his breeding decisions; instead both can represent the value of a good bull and as such either can represent an appropriate solution to the biological problem posed by the demand to breed future generations of ‘good animals’. At the same time, ‘good’ visual appearance should be *complemented* by ‘good’ figures; both ‘answers’ to the problem should coincide. He would not select a bull which was weak by either set of criteria, even if the other set represented the bull very positively. Talking about a particular bull, he said that;

> Peter: The EBV was very good on that. It was physical. It was the way he presented himself, it just happened he was very good on figures as well.
>
> Interviewer: If you had bad figures, but good appearance ...?
>
> Peter: It wouldn’t have been as attractive. We probably wouldn’t have bought him.
>
> Interviewer: Right. So you put a lot of trust in the figures?
>
> Peter: We do when it’s coupled to something with a good physical appearance, oh yes ...
>
> Interviewer: Right, ok. So have you bought on bad figures, but good appearance before?
>
> Peter: No.
>
> Interviewer: The other way round?
>
> Peter: No, I wouldn’t.
>
> Interviewer: Right. So it’s got to be both.
>
> Peter: For me yes, because 12-13 years work into getting good figures on my cattle, I don’t want to ruin that, just on a gamble really.

Here, the requirement for a match between visual and genetic value is clearly expressed, and in the final sentence of the excerpt, it is apparent that engagement with EBVs is at this stage strong enough to suggest to Peter that making breeding decisions *without* taking EBVs into account would be to put at risk the quality of his herd. In association with the collectivity's other members, the technology of EBVs can therefore be seen to be making a difference to - co-constructing - this heterogeneous biosocial collectivity through its deployment in notions of herd 'improvement'. However, the visual appearance of the animals continues to shape breeding decisions and the likely future evolution of the collectivity.

Although there is clearly some measure of correspondence here with the problematisation of life within the breed society collectivity there is, nevertheless, evidence that biological issues at this particular farm scale collectivity are respecified in a distinctive way, notably with respect to a perceived need to 'balance' calving ease and bodily conformation. Also, because the good animal is, in the context of this specific farm scale collectivity, specified in terms of its visual character this makes a difference to EBV use. Although EBVs are enthusiastically engaged with and have already begun to reconstitute this farm scale collectivity, they need to align with the aesthetic qualities of an animal and the associated judgements concerning that animal's suitability for breeding. This is not to say that the visual qualities of an animal are not important at the scale of the breed society which is revealed by the following statement from the society's website concerning the 'ideal' British Blue animal:

> "A large long bodied animal with a straight back and sloping rump, hidden hips and very muscular hindquarters, strong legs with a fine bone... Coat colour can be from white through to black. If they are marked they are either a blue roan or black and white"

However, at this scale the visual is important in a more abstract sense. At the scale of the farm collectivity it is an ideal that has to negotiate the reality of trying to choose or breed actual good animals in practice.

6. Specifying the problem of life in different farm-scale collectivities

In this final empirical section comparison is made between different farm scale collectivities, and how the particular ways in which the problem of life is specified at this scale shape the use and co-construction of the breeding technology. In order to do this we present a second farm scale collectivity that breeds British Blue cattle and compare it with the farm scale collectivity discussed in section 5. A husband and wife (Duncan and Angela Varley[12]) represent this collectivity which is located on a farm in the north of England. Unlike the British Blue breeder in the previous section, Duncan and Angela express a quite negative attitude towards the use of EBVs on their 12 cow pedigree herd. However, to characterise this collectivity as an example of 'non-use' of this breeding technology is too simplistic; there are subtle layers of engagement with different breeding technologies here based on the breeders' specific breeding strategy and on their quite lengthy experience of cattle breeding.

A 'good animal' here is a particular *type* of British Blue cattle. Resisting what they represent as the current fashion for taller bulls, these breeders continue to breed a more 'traditional', heavily muscled type of cattle. They argue that there is a market for bulls of this type, and that they breed that kind of bull in order to exploit that market. Partly as a result, Duncan and Angela accept that a very high proportion of the births on their farm (75%) are by caesarean section. In part this is because the heavily double muscled animals they breed tend to have a high rate of difficult calvings anyway, and in part it is due to the fact that they use expensive embryo transfer techniques to breed between 50 and 60% of their calves and feel that caesarean section reduces the risk of losing such an expensively produced calf. Their approach to breeding, they recognise, causes other potential welfare problems for the cattle and as such represents a further way in which the problem of life is specified in this particular context. For example, they acknowledge that breeding for particularly muscular 'back ends' can lead to cattle having difficulties with their legs:

> "We tend to try to get as much back end as we can, but that tends to just push the legs under them a little bit and makes them a little bit what we call sickle ... it just pushes the back legs forward" (Duncan)

The specification of a good animal here is being driven by the needs of a particular market. Duncan and Angela commented that the people who purchase their bulls are themselves using them to breed animals for a specific export market in Italy; this export market demands these more heavily muscled animals and as such Duncan and Angela's breeding strategy, and their resistance to the fashion for taller bulls (Duncan refers to these as more 'showy' animals), is strongly linked to their perception of their market.

[12] Pseudonyms.

> “there is a farmer that’s looking for a fancy, a real fancy show bull and you’ll get a commercial man looking for our sort of bulls ... they don’t need to be showy, but they need to be heavily muscled and lean” (Duncan)

Duncan and Angela put a high value on their own experience and knowledge in making breeding decisions i.e. in identifying a ‘good animal’ in practice; their comments on this process indicate how they attempt to negotiate between different breeding demands very much on an experiential basis.

> “... you know if you put a bull, on the mother, you know roughly what you’d get ...” (Duncan)

> “We go to Belgium at least once a year to see calves and, well we like to see progeny up to 12 months old from a particular bull, just to see how they’ve grown and the height for age and weight for age, and style with them and shape obviously, and legs ... critical on legs, if we see two or three calves with bad legs from a bull we won’t use it at all” (Duncan)

In making their breeding selection decisions, then, Duncan and Angela focus on a combination of what they see in front of them (an aesthetic sense of the animal’s ‘style’ along with more objective assessments of bodily conformation such as weight at a certain age) and their extensive experience of breeding *particular* cattle in the past.

What possibilities for technology use are afforded by the particular problematisations of life expressed within this collectivity? Duncan and Angela do submit data on their animals using the breed society’s contract with ABRI. As such they have been at least partially enrolled into the breed society’s policy of active engagement with EBVs. Despite their involvement with the process of data collection and EBV calculation, however, Duncan and Angela express rather negative views on this genetic technology. This is informed by at least two considerations. First, they argue from the experience of seeing others breed with the aim of improving particular figures, and in particular those EBVs for traits such as size and growth rate, that EBVs have had a detrimental effect on what they define as a good animal:

> “generally speaking, anyone that has followed EBVs, and looking for growth is probably the one part of it that people pick out time and time again, any pedigree breeder that has just bred for the highest EBV all the time, has generally finished up with a tall, plain animal with not a lot of muscle on it” (Duncan)

Animals produced within other farm scale collectivities literally embody the limits of or problems with the technologies, according to these breeders. In fact, these are only revealed through this embodiment. Second, they are clear that the particular market sector they are facing does not demand or require EBVs, and that selection 'by eye' is paramount in that market. A condition of more intensive engagement with EBVs would thus be that the market demanded this:

> "So, like I said before, our market is Carlisle auction and again, generally speaking, a very good bull with poorer figures and a very good bull with very good figures won't, there won't be much difference in price. People, most commercial men, aren't switched on about EBVs ... we consider it a waste of money because people, most of the commercial men, actually don't take any notice of them like, and even if you have a bull with good figures, if he doesn't look, if he's not a good bull, he won't, he'll only, he'll sell poorly like" (Duncan)[13]

Here then, for Duncan the 'good bull' is defined in terms of appearance, with the EBV data unable to contribute to a process of defining 'goodness' – even good figures will be disregarded. The market is only interested in the animal's body (in terms of what it looks like), not its EBVs which are therefore doing no work at the present time in reconfiguring this particular collectivity and, crucially, the animals that are the majority of its members.

It would be easy to dismiss this perspective as simply negative. However, other comments from Duncan suggested that his attitude towards EBVs was rather more nuanced.

He argued that the financial and time costs and hazards of collecting the data are not be worthwhile. However, he also argued that there actually needs to be more intensive engagement at the breed society level with EBVs, and that the society ought to be able to have more of an input into how EBVs are calculated (i.e. more, not less, co-construction is needed) and used *in relation to the specific breed*. His present relative disengagement from EBVs, defined earlier in terms of the negative experience of others and the lack of market demand, is also in part, then, conditional on the limitations of what is represented as an inflexible EBV structure, geared, he argues, towards the needs of large 'ranch' scale farming

[13] The term 'commercial' breeding is used to refer to breeding with the objective of supplying animals to the meat trade, in contrast to 'pedigree' breeding which involves breeding 'pure-bred' livestock. But some 'commercial' breeders use pedigree livestock to achieve this aim, and most commercial breeders will buy in pedigree males to use with their non-pedigree females, counting on the 'superior genetics' which the pedigree animal can bring into their herds/flocks. The two practices thus overlap, with many breeders involved in both.

operations rather than towards the needs of what is, inevitably, a niche breed (the British Blues) bred in small herds. Duncan's conclusion from this experience is that "it's not worth anybody being in it [...] we're [the Breed Society] thinking of pulling out of ABRI". Duncan himself is considering abandoning EBVs altogether, although at the same time this is not a straightforward rejection. For example, he is supportive of EBLEX attempts to 'educate' breeders, including his commercial customers, about the potential benefits of EBVs:

> "anything to help the commercial man understand breeding values is bound to do good, like, and I think as younger farmers keep coming through, as I said before, it's the younger farmers that are more, they understand it better, the younger ones than the older ones. But like I said, with our own breed Blues ... because there isn't enough information going into the system it isn't as reliable as it should be and you see a big bull at Carlisle and he'll have bad figures and to us that shouldn't happen ... and the bull used has to look the part, he has to look what his figures are as well or people won't take any notice of them" (Duncan)

So despite the sense at the start of this comment that EBVs should have much to offer breeders (at least in principle), Duncan's experience is that good EBVs do not always coincide with what he regards as a good bull and as such his view is that they are unreliable; a condition of using them more intensively would be a higher degree of reliability of the match between EBV data and a subjectively-defined 'good' bull. Again, the aesthetic judgement of the animal takes precedence, for Duncan and, he suggests, for his customers.

The good animal in this particular farm scale collectivity is different, albeit by degrees, to the good animal that is specified within other farm scale collectivities associated with the same breed. As a result the constitution of this farm scale collectivity will differ from other farm scale collectivities associated with this breed, both in terms of the definition of the biological issue at stake and the bodies of the animals which form the collectivity in association with the breeder. A good animal is, in this collectivity, a heavily muscled animal that bears strong comparison with the British Blue's Belgian ancestors, not a 'tall' or 'showy' animal. Associated with this is the acceptance that caesarean sections are almost routine in the herd and that the breeding objective should be centred on conformation characteristics which maximise valuable meat even if that is at the expense of calving ease and animal welfare. This stands in contrast to the collectivity in the previous case study where a more 'balanced' breeding strategy was the aim, and has clear implications for the use of EBVs which, as currently configured to emphasise weight gain, do not enable enough emphasis to be placed on the quality of the animal which is most valued within this collectivity. Instead, the breeders themselves and their customers prioritise the 'look' of the animal which makes EBVs, as a strategy for assessing a good animal, much less relevant than in the previous case study where EBVs were used *alongside* and in relation to visual assessment. Interestingly the negative perspective expressed here is evident in spite of the breeder's involvement in the breed society's efforts to engage with EBVs and also to negotiate with ABRI the calculation of EBVs i.e. processes of co-construction of the breeding technology. However, this breeder is clearly frustrated by the lack of progress here in recalculating EBVs so that they better serve this farm scale collectivity's particular problematisation of life.

7. Conclusions

Building on a tradition of research into socio-technical change in rural areas, specifically work on genetic technologies in agriculture, and also work in science and technology studies that focuses on technology use this paper has argued that understanding the use / non-use of new genetic breeding technologies in livestock agriculture requires a relational and heterogeneous approach that takes into account the animals involved in breeding. In order to achieve this we have drawn on the work of Rabinow (1999) and Rabinow and Rose (2006) and our own previous work (Holloway et al. 2009; Holloway and Morris 2012), to develop the concept of heterogeneous biosocial collectivity. We have deliberately selected and worked with this concept because it focuses on the idea of 'life itself' and how this is problematised differently in specific collectivities. This has been illustrated through the use of case studies of beef cattle breeding. In this context we have suggested that the problem of life itself is associated with negotiating the identification of a 'good animal' in theory and in practice. The different problematisations of life that are expressed by particular collectivities in turn afford different possibilities for the use (and co-construction) of breeding technologies. Further, we have suggested that this is the case *between* breeds and at different scales *within* a breed. Farm scale collectivities or national breed society collectivities are differently constituted, they are associated with different specifications of the problem of life itself as well as with different 'actual' animal bodies and people; and as such the technology becomes co-constructed differently in the context of particular collectivities even when overlaps exist in the membership of collectivities at different scales. The same argument could be extended to different species since similar breeding technologies are also used, for example, by sheep breeders. A key conclusion arising from our specific case, then, is that in making sense of technology use it is necessary to take account of difference, particularity and specificity. This was not characteristic of earlier work on innovation-adoption in agriculture which tended to smooth out these differences in its attempts to identify over-generalised categories of adopters and non-adopters based on the characteristics of the humans involved in the process.

The case studies reveal the ways in which breeding technologies are beginning to reconstitute the collectivities associated with beef cattle breeding, involving changes to the bodies of the animal members and the identities and practices of breeders. Whether this amounts to the 'revolutionary' change that is claimed for genetic technologies by their proponents seems questionable, however, particularly given their partial use in association with existing methods of selecting 'good animals'. In this respect the paper has also been concerned to explore how the technologies themselves are constructed through engagement and use by collectivities, thereby recognising and reiterating that 'users matter' (Oudshoorn and Pinch, 2005; see also von Hippel 2005) in studies of socio-technical change. Again, the case studies provide evidence of at least *attempts* by breeders and breed societies to co-construct the breeding technologies. It is sometimes the case that an individual breeder or breed society acts to try to change the way EBVs are calculated, 'out there' away from the farm or the offices of the breed society (as was suggested in sections 4 and 5 in particular), through negotiations with the organisations that produce EBVs. However, at the same time the technology is *always and already* transformed *for the particular collectivity* at the moment at which it is engaged with. For instance the technology becomes something other than what it was (for example when it 'left' the office of ABRI) as it has to negotiate, in a way which is specific to a farm-scale collectivity, other (e.g. visual) means of evaluating an animal. So it is not that the technology is only re-constituted 'out there', it becomes re-constituted 'in here' as far as a particular collectivity is concerned. At the farm scale, the possibilities afforded by the technology have different effects in different collectivities, and as such 'the technology' stops being a definite externally derived 'thing' and becomes something different (a particular set of knowledge-practices) in association with a particular collectivity.

As such, another key conclusion to be derived from our specific case is that we cannot simply accept a technology as a 'thing' that is just imported into a situation and has effects without being changed itself. First, a technology is associated with a set of knowledges, expectations, and limits; a point that has also been demonstrated by Friese (2010) in the context of creating chimeras through somatic cell nuclear transfer for the purposes of endangered species conservation in US zoos. Second, and more important, the technology itself is transformed by or co-constructed with the other things in the situation in which it is engaged with – in our example farmers, their customers, beef cattle, beef consumers etc. Third, the process of co-construction is just that, a process; it is not the case that technologies and collectivities are co-constructed on a one-off basis with fixed results and a definite end point. Collectivities are not stable, they change constantly, in part (but only in part) *because* of the technologies they co-construct; as the collectivities change then the co-constructed technologies also keep on changing in a dialectical relationship.

Our final point concerns the nature of our approach as we acknowledge that a focus on the idea of 'life itself' and its problematisations is only one way of taking animals seriously in this type of investigation of genetic technology use in a rural context. Other forms of investigation, entailing the mobilisation of a range of conceptual resources, might consider the animals as actors themselves, or their experiences of technological interventions (e.g. Holloway, 2007). Such alternative approaches could be legitimately pursued in further research both in relation to breeding technologies but also a range of other highly topical issues pertaining to rural animals and technology use including in the context of biosecurity, animal health and welfare and changes in animal production systems.

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References

Brown, N., 2003 Hope against hype: accountability in biopasts, presents and futures. Science Studies, 16, pp. 3-21.

Bryant, L. and Pini, B., 2006. Towards an understanding of gender and capital in constituting biotechnologies in agriculture. Sociologia Ruralis 46 (4), pp. 261-279.

Bulfield, G., 2000. Farm animal biotechnology. Trends in Biotechnology 8 (1), pp. 10-13.

Buller, H. and Morris, C., 2007. Animals and Society. In: Pretty, J. et al., Editors, The Sage Handbook in Environment and Society. Sage, London.,

Franklin, S., 2000. Life itself: global nature and the genetic imaginary. In: Franklin, S., Lury, C. and Stacey, J. Editors, Global nature, global culture. Sage, London.

Friese, C. 2010. Classification conundrums: categorizing chimeras and enacting species preservation. Theory and Society 39, pp.145-172.

Goodman, D., Sorj, B. and Wilkinson, J., 1987. From Farming to Biotechnology: a Theory of Agro-Industrial Development. Basil Blackwell, Oxford.

Greenhough, B. and Roe, E., 2006. Towards a geography of bodily biotechnologies. Environment and Planning A 38 pp. 416-422.

Holloway, L., 2005. Aesthetics, genetics and evaluating animal bodies: locating and displacing cattle on show and in figures. Environment and Planning D: Society and Space 23 pp. 883-902.

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

Holloway, L. and Morris, C., 2008. Boosted bodies: genetic techniques, domestic livestock bodies and complex representations of life. Geoforum 39, pp. 1709-20.

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

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

Jones, O., 2003. The restraint of beasts: rurality, animality, actor network theory and dwelling. In Cloke, P., Editor, Country Visions, Pearson Education, Harlow.

Kline, R. and Pinch, T., 1996. Users as agents of technological change: the social construction of the automobile in the rural United States. Technology and Culture 37, pp.763-795

Kloppenburg, J., 1990. First the Seed: The Political Economy of Plant Biotechnology, 1492-2000.Cambridge University Press, Cambridge.

Kues, W. and Niemann, H., 2004. The contribution of farm animals to human health. Trends in Biotechnology 22 (6), pp. 286-294.

Lane, S., Oreszczyn, S., Carr, S., 2007. Farmers' understandings of genetically modified crops within local communities. Project report to the ESRC, Swindon UK.

Lassen, and Sandoe, P., 2009. GM plants, farmers and the public – a harmonious relation? Sociologia Ruralis 49 (3), pp. 258-272.

Latour, B., 1999. Pandora's Hope. , Harvard University Press, Cambridge MA.

Marris, C., Wynne, B., Simmons, B., Weldon, S., 2001. Public perceptions of agricultural biotechnologies in Europe. Final report of the PABE research project.

Michael, M., 2006. Technoscience and Everyday Life. Open University Press, Maidenhead.

Mitchell, S., Clark, D., 1999. Business adoption of information and communications technologies in the two-tier rural economy: some evidence from the South Midlands. Journal of Rural Studies 15, pp. 447–455.

Morris, C. and Holloway, L., 2009. Genetic technologies and the transformation of the geographies of UK livestock agriculture: a research agenda. Progress in Human Geography 33, pp. 313-333

Murdoch, J. 2001. Ecologising sociology: Actor Network Theory, co-construction and the problem of human exemptionalism. Sociology, 35, pp. 111-133.

Pechlaner, G. and Otero, G., 2008. The third food regime: neoliberal globalism and agricultural biotechnology in North America. Sociologia Ruralis 48 (4), pp. 351-371.

Oreszczyn, S., Lane, A. and Carr, S., 2010.The role of networks of practice and webs of influencers on farmers' engagement with and learning about agricultural innovations. Journal of Rural Studies 26 (4), pp. 404-417.

Oudshoorn, N. and Pinch, T., 2003. How users matter : the co-construction of users and technologies. MIT Press, Cambridge, MA.

Outlook on Agriculture, 2003. Special issue on genomics and genetic engineering for the meat industry 32 (4), December 2003.

Padel, S., 2001. Conversion to organic farming: a typical example of diffusion of an innovation? Sociologia Ruralis 41 (1), pp. 40-61.

Rabinow P., 1999. Artificiality and enlightenment: from sociobiology to biosociality. In Biagioli, M., Editor, The science studies reader. Routledge, London.

Rabinow P., and Rose N., 2006. Biopower today. Biosocieties 1, pp. 195-217.

Rogers, E.M., 1983. Diffusion of Innovations.The Free Press, New York.

Ruttan, V., 1996. What happened to technology adoption-diffusion research? Sociologia Ruralis 36 (1), pp. 51-73.

Seifert, F., 2008. Consensual NIMBYs, contentious NIABYs: explaining contrasting forms of farmer opposition to GMOs in Austria and France. Sociologia Ruralis 49 (1), pp.20-40.

Spencer, T. and Whatmore, S., 2001. Biogeographies: putting life back into the discipline. Transactions of the Institute of British Geographers 26, pp. 139-141

Taylor, D.L. and Miller, W.L., 1978. The adoption process of environmental innovations: a case study of a government project. *Rural Sociology* 43 (4), pp. 634–648

Twine, R., 2010. Animals as Biotechnology: ethics, sustainability and critical animal studies. Earthscan, London.

Valentine, G., Holloway, S., 2001. A window on the wider world? Rural children’s use of information and communication technologies. Journal of Rural Studies 17, pp. 383–394

Von Hippel, E. 1976. The dominant role of users in the scientific instrument innovation process. Research Policy, 5, 212-239.

Von Hippel, E. 2005 Democratising Innovation. MIT Press: Cambridge, Mass.

Whatmore, S., 2002. Hybrid Geographies. Natures Cultures Spaces. Sage, London.

Woolgar, S., 1991 Configuring the user: the case of usability trials.In Woolgar, S., and Law, J., Editors, A sociology of monsters Essays on power technology and domination. Routledge, London.