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Biopower and an ecology of genes: seeing livestock as meat via genetics.

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Introduction

In this chapter I focus on some of the implications of what has been represented as a radical change in livestock breeding for thinking about meat in relation to living farm animals: the use of genetic techniques in selecting breeding animals. The chapter draws on Foucault's theorisation of biopower to describe some of the key dimensions of this shift, articulating this concept with an argument that breeders' engagement with these techniques is part of a changing political ecology of livestock farming at the inter-related scales of the gene, the body, the herd or flock, the farm and the meat production system. Drawing on research funded by the UK's Economic and Social Research Council ('Genetics, genomics and genetic modification in livestock agriculture: emerging knowledge practices in making and managing farm livestock', RES-062-23-0642; see Holloway and Morris 2008, 2012, 2014; Morris and Holloway 2009, 2014), I begin by outlining the background to a significant shift in how meat-producing nonhuman animals (focusing here on sheep and beef cattle) are bred in UK agriculture, as there has been an emphasis placed on the deployment of genetic techniques alongside or instead of 'traditional' visual assessment of animals. This represents a change from assessing animals' 'quality' based on proximate 'looking' and touching (along with knowledge of pedigree and health records) to a more virtual mode of assessment based on differing kinds of genetic data theoretically available when the animal is corporeally remote. The chapter then briefly outlines Foucault's conception of biopower and shows how and why this theory is valuable in exploring changing techniques of livestock breeding, before looking at how biopower can inform a political ecological understanding of farmed animals and livestock breeding vis-à-vis meat. I then turn to primary and secondary empirical evidence from UK-based research with a wide range of actors in UK beef and sheep farming to explore some key issues of the geneticisation of meat-producing animals, focusing on a reorientation of how animals are represented, from fleshy bodies towards assemblages of genes and data, with implications for the ontological status of 'meat' as far as breeders and other actors are concerned. The chapter ends with some comments on the practical and ethical implications of this reorientation for livestock breeding and the political ecologies of livestock farming and meat systems.

Geneticising livestock breeding

The use of genetic techniques for breeding livestock has become increasingly prevalent in agricultural systems in the UK and elsewhere, something referred to by some as the 'geneticisation' of livestock breeding (Gannett, 1999) and regarded as part of a wider geneticisation of knowledges of life (Haraway, 1997; Keller 1992, 2000; Rose, 2001). For some, the reorientation of breeding towards genetics has been seen as revolutionary (Archibald and Haley 2003, Bishop and Woolliams 2004, Bulfield 2000; see also Holloway 2005, Holloway and Morris 2008), and while this may be hyperbolic it is clear that a powerful discourse of geneticisation has emerged. Farmers are thus persistently encouraged to move away from what are represented as outdated traditions of breeding 'by eye', and to adopt selection techniques which depend in different ways on a sense of the genetic composition of farmed animals. As a result, breeders' tacit, practical and perhaps aesthetic knowledges of livestock (Holloway and Morris, 2014), gained in many cases from very long term experience of livestock breeding and close relationships with animals, have become downplayed in sometimes dismissive terms by those who would promote what are often represented as more progressive, scientifically-informed selection techniques which purport to be able to see 'under the skin' of an animal and to quantify its genetic value, enabling supposedly objective calculations to be made about which animal to mate with which in the pursuit of livestock productivity.

Relevant techniques include Estimated Breeding Values (EBVs) and genetic markers (see Holloway 2005, Holloway and Morris 2007, 2008, Morris and Holloway 2009, Holloway et al 2009). EBVs are based on the principles of classical genetics and produce what is referred to as an animal's 'genetic value' (Bulfield, 2000). They are statistical calculations, based on records from individual animals and their relatives, of the probability that an animal will pass on specific heritable qualities to their offspring. EBVs for different specific traits (e.g. growth rate) can be combined to create more general indices, such as the Beef Value, to aid breeders with their selection decisions. Genetic markers are at a more experiment stage as far as most UK breeders are concerned although they have been more widely adopted elsewhere, for example in the US and Australia. Markers, identified from animals' blood or hair samples, are actual genetic material associated with a heritable quality such as meat tenderness. Commercially available tests can be purchased for use with a breeder's own animals, allowing them to select for particular genetic traits, and breeders can also purchase (usually male) animals specifically bred to 'contain' particular genes.

The aim of using both techniques is to progressively enhance the genetic 'quality' of livestock populations, and they are heavily promoted by government and commercial agencies, agricultural scientists and the farming press as 'the way forward' for livestock farming and meat production (Holloway and Morris, 2008). They are viewed, for example, as a key part of farming's response to recent concerns about future food security (Technology

Strategy Board, 2013). And yet the use of genetic techniques such as EBVs and markers is not uncontested (something evident in the persistence of efforts made to persuade breeders to adopt them). While there are many enthusiastic users, many breeders, in the UK at least, have been resistant to ‘adopting’ genetic techniques, or have been sceptical of their value even while using them, on a number of grounds (see Holloway and Morris, 2012). These include a perceived difference between animals’ ‘quality’ as measured by eye and by genetic techniques, a continued preference to rely on visual assessment, knowledge of pedigree and long experience to determine what a ‘good animal’ actually is, and the strength (again particularly in the UK) of the practice of breeding ‘for the show ring’, which makes particular aesthetic demands on animals and breeders which may, many argue, conflict with the commercial demands of efficient meat production. Regardless, in terms of the discourses and practices of livestock breeding, geneticisation is having a powerful transformative effect. The next section outlines a way of conceptualising these transformations, drawing on the idea of biopower, summarising how this theorisation of human power-knowledge relations can be used in the context of nonhuman animals (for more detail see Holloway et al, 2009; Holloway and Morris 2012) and suggesting how in the case of breeding livestock this can be articulated with a political ecological perspective.

[a]Livestock breeding, biopower and a changing political ecology of meat farming

There is an extensive literature which describes and works with Foucault’s conceptions of biopolitics and biopower, deploying his ideas in a diverse range of disciplinary and empirical fields. Here only a very brief outline can be provided. In essence, Foucault’s descriptions of biopower (Foucault, 1990, 2003, 2007) relate a turn to the *fostering of life* as the focus of power-knowledge relations from the late eighteenth century in Western Europe. Biopower implies a focus on the enhancing, or optimisation, of life. This was, Foucault argues, associated with the establishment of new forms of scientific and demographic knowledge-practices concerning humans as living entities and as populations. As such, for Foucault, biopower consists of a duality: an anatamopolitics centred around the capacities and subjectification of individuals, and a biopolitics focused around the metrics of populations (e.g. birth and death rates, productivity). Rose (2007, p.53) suggests that biopower emerged from struggles to understand and intervene in the specific problems of constituting and managing populations and ‘the vital processes of their subjects … a multitude of attempts to manage their life, to turn their individual and collective lives into information and knowledge, and to intervene on them’. For Foucault, then, biopower is centered

> … on the body as a machine: its disciplining, the optimisation of its capabilities, the extortion of its forces, the parallel increase of its usefulness and docility, and its integration into systems of efficient and economic controls. (1990, p.139)

This process, for Foucault, was an essential part of a shift towards industrial capitalism, which ‘would not have been possible without the controlled insertion of bodies into the machinery of production and the adjustment of the phenomena of population to economic processes’ (1990, p.141).

A useful heuristic framework for understanding particular incidences of biopower in operation is provided by Rabinow and Rose (2006). They argue that biopower comprises first, the establishment of truths concerning life by those regarded as holding appropriate authority to determine truth; second, specific and systematic interventions in the 'life' of individuals and populations; and third, modes of subjectification in which individuals actually come to work upon themselves as living beings, becoming projects of self-improvement dependent on aligning their consciousness and behaviour with truth discourses and strategies concerning the improvement of their life. Of particular relevance for this chapter is that Rabinow and Rose (see also Gibbon and Novas, 2008) identify the 'truths' about life told by genetic science as one key source for intervention in contemporary life.

Fostering life through interventions in the life processes which constitute populations demands the production of data on individuals and collectives, and means that ideas of normalisation become important, along with techniques for measuring and representing distributions around norms. The norm becomes something which circulates between and ties together anatamopolitics and biopolitics (see Nealon, 2008). Systems of measurement assess the individual and relate them to population level standards. Following that, it becomes important to develop techniques for interventions which can shift population-level norms in desirable directions. Deleuze for example, in his book on Foucault, writes that biopower implies 'administering and controlling life in a particular multiplicity, provided the multiplicity is large (a population) and the space spread out or open' (1988, p.61). This sense of a spread out or open field is echoed in Nealon's (2008) argument that relations of biopower extend beyond institutional settings and saturate the spaces of everyday life and entire populations.

Now, Foucault's theorisation of biopower was oriented towards his accounts of historical changes in power-knowledge relations with regard to human individuals and populations. Several writers have, however, engaged with biopower in their explorations of the nonhuman world in its relations with humans (see for example Haraway,1997; Holloway et al 2009; Rutherford, 2011; Shukin 2009; Twine, 2010; Wolfe, 2013). For these authors, nonhuman life, including nonhuman animals, can be conceptualised as co-enrolled, with people, into relations of biopower. They argue that the focus of biopower on the fostering or enhancement of life makes its power-knowledge relations something which permeates nonhuman as well as the human species. Going a little further, it can be argued that it is in particular human-nonhuman animal relations such as those associated with agriculture, that biopower can be seen in operation in heterogeneous associations, co-fostering human and nonhuman life towards enhanced levels of efficiency and productivity. Rabinow and Rose's (2006) threefold heuristic for biopower – emphasising truths, interventions and subjectification – can describe such agricultural relations. 'Truths' produced about farming and about livestock (for example, that farming should be 'efficient' or 'productivist', or that livestock are best understood through genetic as opposed to phenotypic assessments) are clearly in play, and interventions (breeding, feeding and killing animals, and deploying veterinary science) follow. Both clearly affect the humans *and* animals involved. Subjectification is a little more difficult as it is problematic to regard nonhuman animals as able to be subjectified so that they act in accordance with truths concerning (for example) genetics or productive farming. However if we understand livestock farming as a heterogeneous assemblage of humans and nonhumans, then the subjectification of the human components of the assemblage, so that they farm and breed animals in accordance with genetic truths for example, is a process which has material effects on the assemblage overall, and on its nonhuman animal components specifically.

It can thus be argued that biopower is an effective conceptualisation of contemporary livestock farming. The practice involves the controlled production of animal bodies suited for insertion into particular farming and food system assemblages, and it involves interventions which adjust animal bodies (for example, their bodily compositions of meat, fat and bone), behaviours (for example by manipulating light levels and stocking densities), and the processes (such as birth and death rates) which direct their population-level characteristics towards the particular economic ends of the meat industry. Genetic knowledge-practices are increasingly playing a role here: genetic 'truths' about animal bodies influence selection and mating decisions, affecting future population (herd or flock) characteristics. Geneticisation, along with other metrics, also leads to envisaging animal populations in terms of distributions around norms of (for example) growth rate or muscle depth. Individuals can be compared according to their EBVs, for instance, or measured against a breed average or norm. Such comparisons are likely to influence decisions about which animals will be used for further breeding and which will be culled from the breeding population. They thus have real effects on both individuals and (future) populations together, rendering some animals more expendable and killable (Haraway, 2008, Holloway et al, 2011) while enhancing the value of others for their future contribution to breeding populations and, ultimately, the meat industry.

Articulating biopower with concepts drawn from political ecology provides a further useful dimension to the analysis of geneticisation in meat production systems. Like biopower, political ecology, in its focus on the ineluctable interconnectedness of politics and ecology (Harvey, 1996; Robbins, 2012) in practices such as agriculture, is concerned with issues of life and death, and with the politics of establishing 'truths' about things which influence future practice. Farming is an inherently ecological set of practices, as it is fundamentally entangled with (both affected by and affecting) the flows and circulations of various things which constitute and are constituted by agro-ecological networks (e.g. nutrients, water, genes, and living entities including crop plants and livestock). But farming is also a highly politicised set of practices, as the political ecology of farming is supported and steered by political-economic interests and by associated, powerful discursive formations such as those associated with productivism, 'food security' or 'sustainable intensification'. In the UK context, for instance, the role of the European Union's (EU) Common Agricultural Policy (CAP) in structuring agro-ecological relationships is highly evident, even if very complex, while at the more local scale within the UK, politicised structures affecting the governance and regulation of on-farm agro-ecologies again serve to emphasise the value of a political ecological perspective on farm practice. To give an example related to meat production; in England, the English Beef and Lamb Executive (EBLEX), part of the Agriculture and Horticulture Development Board (AHDB, a non-departmental public body which operates independently of, but is sponsored by, the Department for Agriculture, Food and Rural Affairs, Defra) collects a statutory levy payment on all beef cattle and sheep entering the food system, using that to fund research into 'improving' agricultural production and promoting the meat to consumers. EBLEX is thus a powerful political-ecological actor able to create knowledge and truth about beef and sheep meat production, and to influence the direction of the meat sector in England in its farming practices and in the fostering of particular sorts of biopolitical intervention in the lives of farmed animals: it has, for example, been a vociferous advocate of the use of genetic techniques in beef and sheep breeding. As well as illustrating the conceptual linkage here between political ecology and biopower, this helps to emphasise a key point. The political ecology of farming does not just concern the 'non-domesticated' elements of farming ecologies, including the non-living elements (nutrients, soil, water etc.) and the 'wild' species (plants, micro-organisms and invertebrate and vertebrate macro-organisms associated with and affected *by* farming), but crucially also enrols the 'farmed' elements too. In particular, for this chapter, the lives and deaths of farmed animals are political ecological in the sense that political-economic institutions and discursive frameworks profoundly affect the animals as individuals and populations, through the fostering of particular biopolitical interventions in their lives, breeding and bodies. The promotion and deployment of genetic techniques is a good illustration of this, and in the rest of the chapter I look at how such techniques become bound into, are promoted by, and affect the political ecologies of beef cattle and sheep farming in the UK through their reconfiguring of animal bodies and their meatiness as a product of genetics and genetic calculability.

[a]Genetic techniques and reconfiguring the meat of animal bodies
In this section I draw on two parts of the data collected during the research project identified above. These parts represent two scales at which the geneticisation of meat production is articulated: the scale of the *national breed society* and a larger scale representing the wider *commercial meat sector* in the UK. How both have become reorganised to take genetic techniques into account is of interest, but more conceptually, both are linked as part of an emerging political ecology of meat, involving a governance regime dependent on genetic knowledge to make the sector more efficient and productive at these different scales. Meat production thus depends on the interplay of these scales as part of an ecological regime of biopower. At both scales, the concept of population is crucial, whether this refers to a farm's herd or flock, or to the national herd/flock of cattle or sheep. At the same time, genetics become individualised as associated with specific animals, and thus how individuals stand, genetically, in relation to breed populations is also critical to making sense of their status within emergent meat political ecologies.

[b]Genetics and meat on the farm: breed society perspectives

Here, I outline beef cattle and sheep breed society perspectives on the implications of geneticisation for breeding practices, specifically focusing on how concepts related to the *meat* of their animals' bodies are re-articulated and made newly available for intervention within the localised ecologies of farms and herd/flock populations. Breed societies are institutions which take responsibility for the 'improvement' and promotion of particular pedigree livestock breeds, and are thus crucial in determining the extent to which, and how, the breed and its breeders engage with genetic techniques. Most of those involved in running breed societies are also breeders themselves. In the UK, breed societies tend to have charitable status. The larger societies associated with the numerically more important breeds employ professional staff, while smaller societies associated with numerically less important, minority or rare breeds, tend to be run by volunteers. Different breed societies, and different breeders, have widely differing perspectives on genetic techniques (see for example Holloway et al, 2009; Holloway and Morris 2012). In this subsection I draw on in-depth interviews conducted in 2008 with four representatives of some of the numerically and commercially most significant breeds (three beef cattle and one sheep) in the UK, selecting these as it is these numerically important breeds which tend to be most deeply involved with the development and use of genetic techniques. They thus are most useful in exploring the implications of these techniques for the changing practices and political ecologies of meat production. Interviews were conducted in confidence, I thus refer to BS1, BS2, BS3 (cattle breed societies) and BS4 (sheep breed society). Alongside material from these interviews, I also refer to a recent article in the UK trade journal *Farmers Weekly* which discusses farmers' deployment of genetic techniques in their farming practices in relation to a sense of the 'meat' their animals can represent.

At the simplest level, the EBV technique allows breeders to quantify certain carcase and meat-related characteristics, and to relate these to the genetic value. EBVs depend on the systematic and reliable collection of data from living animals. Some are actual measurements, such as weight and muscle depth records; others are proxy measurements (for example a cow's 'milkiness' might be recorded on the basis of the growth rate of her calf). These might more properly be referred to as 'capta' (see Kitchin and Dodge, 2011), implying a set of actual measurements recorded from the wider set of available measurements which in theory *could* be taken. The selection of particular capta illustrates a logic of measurement in which certain characteristics are deemed useful within a context of breed 'improvement' and the need to respond to certain market demands. In livestock breeding, sets of capta related to carcase production are clearly important, alongside other sets relating to so-called 'maternal' characteristics such as ease of birth and milk production.

Focusing on meat production, for example, one interviewee said that,

> We input all the information and put in things like birth weight, and 200, 400 and 600 day weights. We scan the animals, live scan. We are scanning for eye-muscle area, fat depth, marbling. So we record all the data here and put it into the computer

system and we are also linked to Australia ... and it gets analysed, then it is fed back down the line here. (BS1)

Another said that,

> EBVs come from background data from sire and dam, so the more information you've got, the correct accuracy of the figures, and also they're measuring different weights at so many days, 200, 300, 400, 500 day weight and that's all ploughed into the system and crunched up. The muscle score is measured, the muscle depth, the fat depth, you know, elements like that all go into giving you a figure for an animal ... So you are selecting on figures (BS3)

Recording might also begin to focus on meat *quality* as well as quantity, for example, as suggested here:

> ... you are scanning for your eye muscle areas which is your ribeye steak and you are scanning for your marbling. Which obviously gives you tenderness quality, eating quality for the marbling through the beef, you are measuring that on a live animal, and obviously, these traits are heritable, so you're going to get that in the next generation (BS1)

Once performed, EBV measurements thus enter into wider realms of calculation, in which they can be combined and manipulated to create new indices (such as an overall Beef Value, for example) which are designed to help farmers make sense of the complexity of the 'raw' capta. The manipulability of capta enhances the sense in which the 'genetics' of an animal, rendered as an EBV, comes to represent a particular truth about the life of farmed animals: this life is something which can be measured and itself manipulated on the basis of genetic knowledge-practices. And going beyond the individual animal, EBVs become important in the understanding of breed populations too. Comparisons of animals' 'genetic value' can be made for the different characteristics captured by EBVs, or by comparing the indices derived from combinations of specific capta. Breed norms or averages can be established for each EBV, with individuals then compared against that norm. These processes then allow, stimulate, or even make imperative, particular breeding practices or interventions, as breeders deploy EBVs in deciding which animals to keep for breeding (and, of course, which to rear for meat and cull from the future population of the breed), and in deciding which animals to mate in order to produce and 'improve' (in the sense of them having 'better' EBVs as well as 'better' bodies) future generations.

To illustrate, another representative discussed their practice as follows:

> What we can do then is to take EBVs plus economic factors and create an index, right ... and each of the societies can decide how we are going to calculate them. Now the calf has a yield index, basically it is telling you the level of profitability that you are likely to get out of a calf [sired by] that bull (BS2)

Such practices allow the digital envisaging of existing and future, as yet unbred animals, as part of a set of interventions which guide the future of the breed population in particular directions. In the series of comments below, for instance, the interviewee (BS2) is looking at EBVs on a computer screen. The numbers conjure up fleshy animals for him, and he begins to show how his envisioning of these animals, and the performance of calculations using EBVs, informs intervention practices which foster the 'improvement' of future generations of the breed population.

> [This bull is] top of the breed for growth, carcase traits, that's retail beef yield is quite good ... The eye muscle area happens to be down a bit, but it's just above breed average, but he is top of the breed for everything else ... [looking at another bull] he is quite a well muscled beast, tremendous length and I mean basically it will drive our genetics forward so we don't lose these traits.
>
> ... with that cow its eye muscle area is awful right, so I need to pull up a bull with good eye muscle area and so I go into here and I want something at least above average on eye muscle area, which is 1.1. So, I put in here eye muscle area 1.1, submit that, so a minimum of 1.1 on eye muscle area and ... that will pull up 37 animals ... I can then go to the semen catalogue and pick any of those bulls and if I use one of those bulls on that [cow] it will improve that data. ... I can go a stage further and I can go to 'mating predictor' and I can put in the identity of the sire ... and the dam's identity [...] and it will tell me the EBVs of the subsequent calf, and [the programme] reckons it will be no more than 5% out either way.

We see here in this detailed commentary, recorded while the interviewee was pulling up information on different animals on a computer screen and talking through a decision making process, how he uses EBV capta to try and 'correct' what have been identified by genetic techniques as defects in specific animals, something referred to in interview as 'plugging the gaps' in a population by mating animals according to a forecast of their offspring's genetic 'qualities'.

Two further points can be made. First, the use of EBVs and other genetic techniques depends on the establishment of a 'truth' of geneticisation, in the sense that Rabinow and Rose (2006) argue is key to the operation of biopower. This truth has to be made visible to breeders to become accepted: they have to trust and believe in the truths concerning their animals revealed by genetic techniques. A recent *Farmers Weekly* article thus included a comment from a sheep breeder that, using genomic marker techniques,

> This animal, 08147, came back as being in the top 5% for fat yield and top 10% for meat traits, which was just exceptional. The phrase "trust and verify" sums up what genomics is all about. You trust some of the traits, but genomics allows you to verify, giving you the confidence to use ram lambs and speed up the genetic gain (Alderton, 2014, p.34)

Secondly, going beyond the individual breeder and into the political ecology of the meat system more widely, genetic techniques become entangled with systemic processes of ensuring productivity, and meat quality and traceability, within a supply chain. I discuss this further from the industry perspective in the next subsection, but here outline breeders' takes on the importance of this point.

The following comment, for example, points to how the use of EBVs is manipulable to suit different rearing systems: the political economic structure and demands of the meat sector is here given particular inflections by on-farm ecologies.

> ... you need to have a carcase and as quick as possible to get to that carcase on your system. So that's why we give the different weight indices, if it's a one-year [rearing] system, or if you are going to finish off calves in 18 months ... if you're in cereal growing, or a good grass area, you want them away at 14 to 16 months, then you want something with a large 400 day weight, big carcase (BS1)

Alongside responding to local ecological differences, breeding practices also have to co-respond to market demands for particular types and qualities of fleshy body:

> We've been using EBVs and indices ... and we've managed to get the fat levels down [... but ...] we've been listening to what our customers have said and a number of them have said they've actually had a job to try and get the lambs to finish, to handle right, there is just not enough fat on them ... you need a bit of fat cover, but if you are going to handle a lamb, you can feel the fleshing, especially over the spine, you just need that bit of fat to get them to handle right (BS4)

As this interviewee suggests, EBVs can cause problems as their use in steering populations in particular directions (e.g. to reduce fat cover) can conflict with other ways of knowing animal bodies – in this case the manual handling of bodies to assess their quality in other ways. This is sometimes seen as a problem with EBVs more widely: a focus on 'improving' numbers only can lead to what might be later seen as the misdirecting of population-level traits which then need correction, as the following comment suggests.

> A number of people [have] just gone for high final index score EBV and the way it was tilted [i.e. calculated], on weight gain, muscle depth when we do the ultrasound scanning and, as it was then, basically the leaner the better, and they were getting very high scores and these lambs were being used [for breeding] across the group and it was having a detrimental effect really on what our customers were wanting, so we just had to tilt it back a bit to correct it (BS4)

In terms of deploying genetic techniques within a meat system political ecology where trust in quality increasingly needs to be secured, a future is imagined which closely ties calculations of animals' genetics to meat processors', retailers' and consumers' demands for guaranteed quality and consistency. One interviewee thus imagined a future of:

> the whole traceability of the animal, this animal is destined eventually for beef and when we've taken a hair sample, this animal, complete traceability through, will turn up on your plate ... and it's guaranteed to be 10 out of 10 for tenderness and 8 out of 10 for marbling, 7 out of 10 for taste and it's guaranteed, because that is a tremendous marketing advantage for whatever breed of animal you've got. Obviously you've got to work with the processors, from the supermarkets, from the consumers, but we want to move from this relatively small pedigree top of the pyramid right through to the 600,000 [breed name]-sired calves which are destined for meat production. You know, if we can get all the information on all of those calves, that would give us tremendous power (BS3)

Along with the other points made, this final comment sums up the particular nature of a geneticised political ecology of meat production. In essence, specific, genetically-inflected interventions are being made in ecologies at different scales (for example the localised ecologies and domestic biodiversities of breed populations on farms, farm-scale ecologies which entangle cattle or sheep populations with other components of agro-ecological systems, and national or even international domestic livestock agro-ecologies). At the same time, farm-scale interventions (in essence, which animal to breed with which) are co-produced with political economic/bio-economic institutions (e.g. processors, retailers, breed societies, genetics companies, government agencies) which act as authorities establishing biopowerful genetic truths about life which demand interventions aimed at constituting particular sorts of animal life.

[b]Geneticisation and the commercial meat sector
Following the above discussion of farmers' and breeders' perspectives, here I turn to briefly examine a wider political ecology of genetic intervention in farm and national-scale bovine and ovine populations by looking at the perspectives and activities of some of the commercial and associated institutions involved in fostering and steering the use of genetic techniques in livestock breeding. I outline material from two sources: the first, an EBLEX publication distributed in Spring 2014; the second an interview conducted with a meat processing company representative in 2008.

EBLEX's (2014) *Beef Breeding Bulletin Extra* focuses on encouraging more breeders to use EBVs, including showing them how to access the capta and how to base decision making on them. In doing so, EBLEX contributes to a metrics of livestock breeding in which knowing and practicing genetics is a crucial part of an ecology of farm management which aims to make meat production more efficient at different scales (the individual body, the farm-level herd/flock and the national-level livestock population). Meat production depends on the interplay of these scales – and on the metrical knowing of each as part of an ecological regime of biopower. EBLEX's need to continue promoting EBVs to what is represented as a reluctant or 'backward' population of beef and sheep farmers is itself interesting, in that the claims to truth and authority made by proponents of genetic techniques are by no means fully accepted, although they are enthusiastically embraced by many. EBLEX thus exemplifies one dimension of the *politics* of this meat political ecology. As mentioned above, the agency is linked to government, and has political authority to sanction its funding by compulsory levy. More widely, it embodies the political economics of agricultural and food system productivism. These features affect its interventions in cattle and sheep breeding, that is, in the ecologies of farm life. This *Bulletin* is interesting in the way it exemplifies relations of biopower functioning through this meat political ecology. Three brief points are worth making.

First, there is a focus on how EBVs can foster animal life in enhancing qualities which align with a productivist agenda. And second, in doing this, the *Bulletin* continues a process of cementing and legitimising the authority of science to determine genetic truths about life. In particular, this is achieved by reference to ten case studies of trials conducted at research institutes, agricultural colleges and companies, all of which provide evidence for the benefits of using genetic techniques in breeding beef cattle. These benefits are determined in various ways, including the greater financial value of animals sired by bulls with high 'genetic merit', their greater weight, speed in reaching slaughter, higher 'killing out percentage' (i.e. useable proportion of the carcase), and superior carcase conformation. Summarising this survey of trials, EBLEX's breeding specialist comments that 'The evidence is overwhelming. High EBV bulls can significantly increase herd profitability. This BRP Breeding Bulletin explains why this is so and which traits to look for when selecting a bull. It also shows how EBVs should be interpreted to optimise their impact' (p.1).

Third, the *Bulletin* attempts to 'nudge' reluctant breeders towards using EBVs themselves; that is, it tries to intervene in their subjectivity as breeders, and in their breeding practices. It provides basic guidance on how to find and interpret EBV data, illustrating the different sorts of graphic illustrations of EBVs which are used. There's also a quiz, in which readers are prompted to 'have a go!' at selecting which bull to use for particular breeding goals, purely on the basis of EBV data. This 'game' tries to demystify the use of EBVs and make them accessible to all breeders. At the same time, however, it is quite reductive, presenting breeding decisions as simple and one-dimensional, and, in suggesting that a breeder can just use the numbers to make a decision, can effect a disempowering of the breeder through an exporting of decision making authority to the organisation which calculates and presents EBVs.

The second example of a wider political ecology of genetic intervention is of a meat processing company which has formed a meat network based around contractual relations between itself and farmers who are paid to rear carefully-bred calves in carefully-specified ways (see Holloway et al, 2014 for more detail). Through such intensive, genetically-informed, integration, animals are bred and reared to be of consistent and appropriate quality for the company's downstream customers in the meat supply chain. A company representative mapped out the biopowerful interventions made here in the life of livestock animals and in on-farm ecologies and practices.

> What we're trying to do is a total system in that, all to do with meat quality basically. So we've got a bull that we know is genetically superior ... producing us calves that grow quickly. We've got a rearing system which ... it's a very prescribed system, alright, different from other organisations [...] We actually contract the rearer to rear our calves, pay them a fee, we put in all the medicines, all of the feed, all of the milk powder. So we dictate to that rearer ... we dictate protocol, health protocols, feed protocol as well.

In this example, genetic knowledge-practices are presented as part of a wider integrated set of interventions which mesh together in the pursuit of efficiency and quality. But for the interviewee, genetic truth is the basis of the rest of the system. As he said, 'genetics is the initial foundation step alright. If you get the genetics right, and you get the right bull with the right potential, then it leads on to more efficiencies down the chain'. On the basis of this 'truth', the company has worked in partnership with a major UK cattle breeding company which supplies semen from high quality bulls for artificial insemination, to select one particular Aberdeen Angus bull with the desired genetic characteristics. Semen is supplied to breeders in the network, who use it to breed the calves which will be reared under the precise terms of the contract described above. For the company, involvement in genetic intervention was planned to increasingly intensify through experimenting with genetic markers as well as EBVs.

> This bull here, we'll do a total gene marker on him, as much as we can, then get our bull, the progeny of that bull on farms, through the system, and we could monitor all the way through ... even to the meat end [i.e. retailer and consumer] of the operation, it's going to come out with some validated evidence, you know.

What is described here mirrors the comments made by the representative of BS3 above, suggesting a further integration of breeding and rearing with the rest of the meat supply chain, using a process of traceability to monitor meat quality and to collect more capta which would be fed back into further rounds of political economic intervention in the life and ecologies of livestock farming. Genetic truths about breeding would be more deeply embedded, leading to further interventions in life, in on-farm practices, and in the subjectification of those who breed and rear animals under contract to the company.

Both examples referred to in this subsection point to an ongoing redistribution of power and knowledge in meat political ecological networks. This takes on particular inflections in relation to the emergence of genetic knowledge-practices, where off-farm political and economic actors are involved in the calculation and representation of genetic information. The articulation of biopower through this political ecology of agricultural life focuses attention on how genetic interventions affect human subjectivity and animal life together. Breeders thus become expected to align their practices with (what become established as) genetic truths, with consequences for the lives and bodies of the animals they farm.

Conclusions

This chapter has outlined some of the implications of geneticisation of livestock breeding for the lives of animals and breeders caught up in meat production systems. It has framed the geneticisation of livestock breeding in terms of a mode of biopower which is articulated through changing meat system political ecologies which are played out at a range of different, interconnected scales: genes, bodies, farm- and national-scale breed populations, and meat systems consisting of farms, other economic actors (e.g. processors and retailers) and political and quasi-political institutions. This political ecological network is increasingly centred around discourses of genetic truth, and the interventions which result affect breeders' subjectivities and knowledge-practices, and animals' bodies and lives (and deaths). Breeders become subject to a process of 'nudging' towards using genetic techniques, and may acquire new identities as a result – for example as 'progressive' or 'backward'. Animals may become more valued or prized, or conversely more killable, by being associated with particular genetic qualities.

Ecologically, what can be referred to in terms of domestic animal biodiversity is affected by geneticisation. How animals are viewed in relation to others of their breed is changed (e.g. by quantitative comparisons of their 'genetic merit', and by the ability to assess individuals in relation to breed norms), with potentially significant effects on the genetic composition of breeds and of species, particularly when combined with other technologies such as artificial insemination and embryo transfer which enable a single, genetically highly valued animal to be parent to very large numbers of offspring. In terms of biopower, what is being intervened in and changed are the metrics of the population, its collective life channelled towards particular political-economic ends (e.g. productivism, or food security).

Finally then, geneticisation can be said to allow a further intensification of biopowerful interventions in the political ecologies of livestock breeding systems which, for many, are ethically problematic. How millions of animals are bred, reared and slaughtered is already a cause for concern for many. Geneticisation is potentially associated not only with a genetic reductivism in respect of animals (so that they risk being seen only as the product of their genes) but with further ethical issues associated with genetic interventions in the life of individuals and populations, and with the effects of that on farming ecologies which are necessarily *political* ecologies since they are affected by an agricultural political economy focused on an agenda of continued industrialised livestock farming and increasing farm output and efficiency. A narrowing of biodiversity, for example, may reduce farm system resilience, while a focus on breeding for a narrow range of valued genetic characteristics (e.g. size, growth rates and muscle depth) might mean neglecting other characteristics(such as disease resistance) important to animals' welfare and, again, to the resilience of farming systems. Many breeders and others are alive to these issues and are cautious as a result about the deployment of genetic techniques as the sole determinant of breeding decisions.

Countering genetic truths there are thus alternative perspectives on livestock breeding, and a process of negotiation between different ways of selecting which animals to breed with which, which takes place on individual farms as well as within the wider political ecology of the meat system. Geneticisation is currently proving to be a powerful truth, however, and understanding some of its consequences, particularly in the context of recent drives for the 'sustainable intensification' of agriculture, remains important.

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