Research Report

Background

This project set out to study the history of artificial insemination (AI) in cattle in Britain from 1890 to 1951. AI was the first widely used conceptive technology in agriculture yet it has received little attention from historians. At the time of writing there is one unpublished MPhil thesis on the development of AI in Britain and a handful of accounts written by animal breeding scientists ('insiders' histories'). These accounts are generally framed by a 'diffusionist' model of technology, one that seeks to document the spread of AI as an innovation without problematising the social construction of the technology itself. A case was made for studying artificial insemination 'in the making' to explain how it moved from being a technique occasionally used by stud grooms and veterinarians to assist conception in horses, to a procedure that dominated mating in Britain's dairy cattle, becoming part of everyday dairy farming routines. A sociologically informed history of artificial insemination is of interest to a wide research constituency: among the many now interested in the road from farming to biotechnology we may include environmentalists, campaigners against factory farming, social scientists studying agro-industrial development, analysts of global 'agri-food networks', and commentators on new laboratory technologies. Yet, notwithstanding that all of these literatures acknowledge the significance of reproductive technologies in animal agriculture, there is as yet very little historical material from which these other fields can draw. In following the history of AI it has been possible to further understanding of the traditions of scientific enquiry that led ultimately to Dolly the sheep and to bring 'animal breeding science' and its contribution to animal production into sharper focus.

In executing this project I was able to draw on prior experience in the fields of agricultural history, history of science and veterinary history, and also benefited from fruitful collaboration with colleagues working on the history of reproductive medicine. There is an active research community in Cambridge that comes together regularly for seminars to discuss aspects of medical history 'From generation to reproduction'.

Objectives

The core objectives of the project were to provide a new history of artificial insemination in cattle in Britain from 1890 to 1951, to document the rise of a new 'animal breeding science' in the twentieth-century and to explain how State intervention in stock improvement became central to the livestock industry. In practice the research has concentrated on the period from the introduction of government licensing of bulls intended for 'public service' (1914) to the setting up of a national AI service (completed in 1951). Originally I planned for a substantial amount of archive work in Edinburgh and other Scottish archives but early on in the research it became clear that the Edinburgh Department of Animal Breeding Research (later Institute of Animal Genetics) actually played a lesser role in the early history of artificial insemination than anticipated and that existing printed sources would suffice to reconstruct their part in this history. On reflection it was felt that the Scottish history of artificial insemination would probably

take the study beyond the time frame chosen and that it deserves a research project of its own.

The investigation of crossovers between reproductive technologies in agriculture and medicine extended aspects of the work further into the 1960s and beyond. This has been for the specific purpose of documenting the construction of new networks of research in reproduction, networks that I show were generated by scientific, producer and government investment in the new national network of artificial insemination centres from 1946. In general the project has successfully contributed new insights by viewing the early history of reproductive technology from agricultural sites of research in Britain. I have made my findings accessible by presenting the work at conferences and workshops. I believe that I have met the core objectives and that the outputs will be of interest to the target audiences of agricultural historians, historians of science and technology, historians of medicine and social scientists. Further outputs are planned (see below) specifically to engage the interest of agricultural historians.

Methods

Methodologies developed to assist in the study of the social shaping of technology include the overlapping approaches of social construction of technology, technological systems theory, actor-network theory, and social worlds theory. Together they provide a warrant for rejecting the 'diffusion of innovation' model within which earlier histories discussed AI. They suggest that diffusion models will mislead, especially when applied to a technology 'in the making'. In my choice of methodology I wanted an approach that focussed the study of artificial insemination on multiple perspectives, including those of cattle breeders, veterinarians, animal breeding scientists, and government departments, allowing a rich exploration of the social shaping of this reproductive technique. Primarily these aims were met by drawing on social worlds theory (as developed by Adele Clarke,1990). This theory, developed from the community studies approach of Chicago sociology and the symbolic interactionist sociology of work, pays close attention to the daily work of all the participants involved in the arena of concern (cattle breeding), work which in turn is structured by the larger groups (social worlds) to which the participants belong. The consequences of their activities in the shared arena (in terms of relationships or relative power) are analysed, including the social construction of the 'rightness' or 'wrongness' of particular tools for getting the work done. Applied to my study it is clear that animal-breeding scientists (geneticists, physiologists and veterinarians), Livestock Officers, commercial and pedigree breeders, beef and dairy industries belonged to different (if sometimes overlapping) social worlds and had multiple perspectives on stock improvement and the appropriateness of 'tools for the job'. Social worlds theory helped to make this study sensitive to the practice and experiences of all of the actors involved. A secondary methodological approach that proved useful was actor-network theory, particularly the insight that scientific objects or facts are human constructions that depend on making alliances and securing resources to make them 'work' (Latour, 1988). Correspondence and other documents were used to recover the perspectives of scientists, government *and* breeders on AI.

The principal archive collections used were those held at the Museum of English Rural Life, Reading; the National Archives, Kew; the Wellcome Trust, London, and the Dartington Hall Trust Archive in Devon. The Central Science Library, Cambridge proved to be a rich source of specialist printed material from collections that had once

formed part of the now defunct School of Agriculture. The collection is particularly comprehensive on the scientific literature of AI because staff from this School pioneered the science of bovine reproduction and sperm physiology in the interwar period in pursuit of workable AI techniques in cattle. Correspondence between these scientists and the Dartington Hall Estate was discovered in the Dartington Archive. This was extremely valuable because it documented the problems scientists encountered in trying to design AI technology for cattle in the 'prototype' phase of development, and illuminated the difficulties they had gaining support for field trials from the farming interest. The views of pedigree breeders were gauged using manuscript collections at the Museum of English Rural Life, and the National Archives yielded correspondence between scientists, government, cattle breeders and the Milk Marketing Board when proposals for a national network of AI centres were first debated and negotiated.

These methods and resources were part of the original plan submitted to the ESRC, but the methodology was also added to. The project was originally based entirely on archive and library resources, but one of the key suggestions made by the panel reviewing the proposal was that every effort should be made to obtain the oral testimony of people working with AI in the early days. This was done and oral sources have added a valuable (and probably unrepeatable) dimension to this reconstruction of artificial insemination in the early twentieth-century. In the course of this study I interviewed two farmers (from two generations, the oldest aged 97) who were actively involved in the introduction and use of AI in the Dartington area, complementing Dartington's written archive; an 'AI man' (field technician) who in his career had performed over 100,000 inseminations for the Dartington Hall Cattle Breeding Centre; the reproductive scientist Christopher Polge (d. August 2006) who pioneered the low temperature preservation of sperm and worked with other AI scientists at the Animal Research Station, Cambridge; and John Frappell, MRCVS. Frappell was veterinarian in charge of the Milk Marketing Board's AI station at Gloucester from April 1948, Regional Vet for the South West and South Wales from 1958 to 1971, and Head of MMB's AI Division from 1971 to 1987. Together with supplementary printed materials these resources were marshalled to answer the central objectives of the project.

Results

Objective 1: A new history of artificial insemination in cattle

This study makes several revisions possible to the existing AI historiography. Firstly, it complicates the story of the 'adoption' of AI in cattle by drawing attention to the changing identity of AI technology. Particularly important to note are the changes these techniques underwent between the 1920s and the 1930s. In the 1920s breeders viewed AI as a cumbersome procedure in cows, and indeed, veterinarians did not find the available techniques easy to use. Early methods were problematic because they required the collection of semen by syringe from the cow's vagina after natural mating. An alternative method was to insert a sponge into the vagina before service and squeeze the seminal fluid out afterwards. These procedures were attended by some quite important disadvantages, including the risk of transferring infection between cows and the destruction of sperm in the process of squeezing sponges. Insemination, which involved inserting a speculum to dilate the vagina, then guiding a glass inseminating syringe

through it to inject sperm one or two inches into the cervical canal, also required practice. Partly due to these practical difficulties the veterinary profession did not take a great deal of notice of AI until this was forced on them by the interest of other groups. Between the 1930s and 1940s collection methods were improved by getting the bull to serve into a sterile 'artificial vagina', which with veterinary screening of bulls made AI safer than natural service in relation to sexually transmitted diseases. Insemination was also made more efficient by the introduction of a 'recto-vaginal' method to locate the cervix. It is important to take into account changes in the minutiae of doing 'AI' because these differences framed the choices breeders made about whether to use natural or artificial mating.

Secondly, this analysis challenges the view that pedigree breeders were the main problem facing scientists in their endeavours to promote AI in the early twentieth-century. It is clear that up to the end of the 1930s there were many who doubted the value of AI to the British livestock industry. Sceptics included opinion-formers like the Professor of Animal Husbandry at the Royal Veterinary College, London, the Professor of Agriculture and the Director of the University farm at Cambridge, and livestock specialists advising the Agricultural Research Council (ARC). By paying attention to the 'social world' of cattle breeding it became clear that objections to AI resulted from a widely shared culture of breeding in which competitive individualism, craft skills, breed variety and pedigree were more highly valued than standardisation and mass production. In the late 1930s these values overrode the principal arguments for an AI service in England and Wales and were important factors in the ARC's refusal to support field trials. For their part, although some pedigree breeders vigorously opposed AI, the councils of most (dairy) pedigree societies kept an open mind about the technique while falling short of taking active steps to promote it.

Thirdly, the research revealed that the introduction of new administrative structures into the social world of cattle breeding was important in forming the conditions of possibility for a national AI service (see objective 3, below). That a Livestock Improvement Scheme had been operating over the preceding thirty years helped to make a centralised AI network thinkable, and also went some way towards disciplining an industry of dairy farmers into a community of cattle improvers. This is an important dimension of twentieth-century cattle breeding that has been neglected in earlier histories of AI.

Fourthly, although the story of AI has long been commemorated as a scientific 'success story', this research project was able to follow the scientists involved in trying to build a national network of AI centres in the early 1940s and reveal that the network evolved in a way that was unintended by the AI scientists. Archive work enabled the relative roles of the scientists, the Ministry of Agriculture, farmers' and breeders' organisations and the Milk Marketing Board in the making of the network to be assessed for the first time. There is nothing obvious in the idea that the entire country's herds should be managed as one single reproductive entity whose productive performances have to be extensively recorded and monitored in order to organize national selection programs. My work is able to show how this transformation came about, and that the artificial insemination network built in England and Wales was the result of economic problems and political priorities, of negotiated change in cultures of cattle breeding, as well as the product of scientific research.

Objective 2: The rise of a new 'animal breeding science' in the twentieth-century

This project confirmed that there was little scientific research directed to intervening in the reproductive processes of farm animals (as distinct from selection and crossing experiments) before the twentieth-century. The early years of the twentieth-century saw scientific investment, firstly, in the delineation of reproduction as a bounded and clarified research area, and secondly, in the foundation of new institutions dedicated to reproductive physiology on the farm. As Adele Clarke has argued, the first development was accomplished when Francis Marshall published his book *The Physiology of Reproduction* in 1910 (Clarke, 1998). The second development followed between the 1910s and the early 1930s. Marshall, a Lecturer (later Reader) in animal physiology at Cambridge University, led the first small research group in existence within the Institute of Animal Nutrition, an Institute attached to Cambridge University's School of Agriculture. By the late 1920s a research group on reproductive physiology had also come into being at Edinburgh, within the Department (soon to be Institute) of Animal Genetics of the University. A third centre developed at the National Institute for Research in Dairying at Reading (NIRD) under biochemist Sydney John Folley in the 1930s. The objective of their investigations was to get a complete knowledge of all the reproductive processes of farm animals, and by so doing 'to obtain practical control' of the factors regulating fertility, periodicity of breeding, udder development and lactation. Wider than this, these scientists felt the need to make their work economically and socially useful.

The research undertaken for this project was able to document a new science focused on the 'breeding and individuality' of the cow growing up within Britain's agricultural institutions. Studies were directed to understanding the lactation patterns of individual cows and the intervals between pregnancies; through this sex and fertility in the bovine species came under increasing scrutiny. At the end of World War I this kind of research into dairying had barely begun in Britain: teachers, lecturers and government officials alike had to rely on dairy science imported from other countries. 'Statistical physiology', born in the 1920s, began to provide dairy data specifically related to British experience. Workers around the country undertook herd wastage studies (reasons for and rates of replacement of cows in the herd), and milk record analyses (yields related to month of calving, service period, age of cow, and dry period). Statisticians analysed these records, throwing the performance of 'good' and 'bad' cows into sharper relief. Attention was drawn to the large proportion of cows culled for low milk yield, the large number culled for sterility, and the short herd life of many cows, which were too often disposed of before they reached the age of peak milk production. The already perceived need to regulate the milk supply throughout the year was given more detailed statistical shape, as was the dependency of this goal on a controlled periodicity of breeding.

In addition to physiological and survey work, all three Institutes were found to be playing an important role in the early twentieth-century in the promotion of a new 'biological responsibility' among cattle breeders. Both regular breeding and breeding for higher yield were fore-grounded, bringing both diseases associated with mating and practices of sire selection under public discussion. In the interwar years the staff of Edinburgh University's Animal Breeding Research Department was particularly active in arguing for the elimination of defective and less productive cattle, drawing on the scientific authority of genetics, particularly the doctrine of recessives. They used whatever influence they had to shift livestock policy away from simply widening access to pedigree sires and instead directed attention to the need to prevent the 'spread of bad germ plasm among the

livestock population of the country', collecting together evidence of inherited defects in the various cattle breeds. After 1939 the history of the reproductive physiology of farm animals is really a history of the Institutes at Reading and Cambridge since Edinburgh, lacking the resources to keep its physiology section going, concentrated its efforts on genetics and animal breeding. This study has focused particularly on the Institute of Animal Nutrition and Animal Research Station at Cambridge since this was where artificial insemination was pioneered. However, collaboration with NIRD at Reading was important to AI research, the staff there contributing experimental animals and expertise in bovine reproduction.

Objective 3: How State intervention in stock improvement became central to the livestock industry

Research confirmed that before World War I the State was not involved in the business of cattle breeding, it was an entirely private affair. This situation began to change in 1914 with the launch of a Livestock Improvement Scheme, signalling the start of a new 'public service'. The government took the decision that the problem of livestock improvement in Britain centred on the farming community's restricted access to superior (pedigree) sires; this the Livestock Improvement Scheme was designed to change. Funded by the Development Commission, a body set up in 1909 to oversee the investment of public money in rural development, the scheme provided a small measure of State assistance to farmers, both to enable them to procure better sires (heavy horses, bulls and boars), and to encourage the spread of milk recording as a guide to bull selection. These measures were targeted at small farmers and conceived as a temporary exercise in farmer education, the grants being organised through a network of provincial centres of agricultural instruction. The Scheme also provided for the creation of a new body of civil servants, the 'Livestock Officers', one based at each of the ten English provincial headquarters of the network, and two in Wales. Their job was to supervise the scheme and give local advice on livestock selection. Grants for bulls were made to individual owners, clubs, or societies, the stipulation being that the bull would be made available to an appreciably greater number of cows belonging to small farmers than before.

The Scheme originated purely as a positive measure to widen access to better sires and promote milk recording in dairy herds; the Livestock Officer's main duties were to advise on eligibility for grants and to inspect milk records to make sure that they were being kept accurately. It was intended that these records would guide farmers in the culling of poor yielding cows and in better sire selection. However, as time went on negative restrictions were introduced into the Scheme. These prohibitions were modelled on the Horse Breeding Act of 1918, which stipulated that no stallion could move from its home base to stand for public service unless it was licensed by a government Livestock Officer. Archives revealed that it was representations from pedigree bull breeders in the mid-1920s that led the Ministry of Agriculture to consider similar measures to eliminate the worst bulls (the 'scrub' bulls) from the breeding market. The Improvement of Livestock (Licensing of Bulls) Act followed in 1931, after agreement was reached with the National Cattle Breeders' Association (a body reorganised in 1926 to represent the interests of the pedigree breeding industry) and a generally supportive (but not unanimous) National Farmers' Union. This is a very different picture to that portrayed by Walton (1987) whose work suggested that bull breeders were uniformly opposed to sire licensing. The bull licensing system made it an offence for a farmer to keep a bull over 10 months old unless a permit was in force, and the Ministry of Agriculture had power to require the slaughter or castration of the bulls that did not qualify. In the public interest, and with the

negotiated support of the cattle industry, the State's officers decided which bulls would be allowed to breed.

The Livestock Improvement Scheme remained the State's primary tool for directing animal breeding until the introduction of artificial insemination in the 1940s, when the new artificial insemination centres enabled the Ministry's Livestock Officers to extend their reach over cattle breeding to include cows as well as bulls. Service records kept at artificial insemination centres proved to be a useful new instrument of surveillance, as detailed in the interview I conducted with John Frappell, former Milk Marketing Board AI centre veterinarian. Farmers found guilty of 'indiscriminate crossbreeding' could find themselves censured and threatened with being barred from using the AI service by Livestock Officers. The action of these officers was possible because the notion that service was a public interest issue had become accepted in the interwar period. That a Livestock Improvement Scheme had been operating over the preceding thirty years helped to make a centralised AI network thinkable, and also went some way towards disciplining an industry of dairy farmers into a community of cattle improvers.

In that both of the periods of government intervention in cattle breeding occurred during the world wars this history touches on the relationship between technology and war. Plans for rationalising reproduction in the cow were first made during World War I to provide greater regularity in the supply of milk to Britain's consumers. These fell into abeyance in the interwar years though animal breeding experts continued promoting ideologies of co-ordinated planning, increased output and standardization. The onset of World War II hastened the movement of science and technology to the farm as war preparations brought government backing to experts and agencies interested in reorganising the 'biopower' of the livestock industry (including a national scheme for AI). This might be read as another example of the 'warfare state' described recently by Edgerton (2006), one that supported science and technology initiatives and took an increasingly interventionist and directive approach to the economy (c.f. Brassley, 2000, pp. 60, 76–77). The history of AI in cattle thus encapsulates both the importance of war and the rise of a new peacetime culture of mass measurement, intervention, standardization and mass production in animal agriculture in the making of this new role for the State in cattle breeding.

Objective 4: Investigating crossovers between reproductive technologies in agriculture and medicine

Of the three institutes working on the physiology of reproduction in farm animals in the early twentieth-century, Edinburgh's Institute of Animal Genetics was the only one to be self-consciously oriented to the medical clinic. Under Francis Crew's directorship, and with the encouragement of Edinburgh's Professor of Physiology, Edward Sharpey-Schafer, the Edinburgh workers not only developed links with clinical researchers in medical research institutions and hospitals (aided by grants from the Medical Research Council), they also produced products for the clinic, including standardised hormone preparations for clinical trials and a lucrative pregnancy diagnosis service. In the 1930s Crew attracted funding from public and private donors for research intended for clinical experiments, and postgraduates from the medical school wanting to work on reproductive physiology. Birth control advocates in America recognised in the department an opportunity to get work done on a chemical contraceptive and also provided funding. But these directions gave Crew's institute an anomalous position as an agricultural institution; Crew had to reassure his government sponsors that his policy was to use 'national funds for experiments on animals of economic importance', and private

contributions for 'work of more purely theoretic interest'. Ultimately Edinburgh's physiology section did not survive the financial difficulties of the 1930s and, as already mentioned, after the War the Institute concentrated on genetics and animal breeding.

In contrast to Edinburgh, the Cambridge and Reading institutes were oriented much more closely to the farm. Nevertheless in the course of developing the panoply of skills associated with artificial insemination and (later) embryo transfer technologies, their animal-breeding research also expanded easily into the fields of endocrinology and the physiology of reproduction. The extent to which farm animal researchers ranged over this fundamental territory of reproductive biology can be seen from a glance at their contributions to the third edition of *Marshall's Physiology of Reproduction* (A. Parkes Ed., 1952–66). On the male side, AI work led to fundamental research on sperm physiology and biochemistry, and investigations into male fertility. Out of this work came material for collaboration with clinical researchers on human infertility through meetings of the Society for the Study of Fertility (whose membership included most of the handful of clinicians who offered donor insemination in Britain). On the female side, research on cows led to fundamental work on oestrus cycles and ovulation. It was axiomatic to researchers that farm animal work would shed light on problems encountered in the reproduction of humans. Workers on human reproduction took an interest in the results newly generated from the AI centres. Investigators in animal breeding also had much to offer on the hormonal control of ovulation to those working with primates or human patients. In Britain the comparative section of the Royal Society of Medicine provided a forum for the discussion of common themes in human and animal reproduction, in addition to the specialist journals for biochemistry, endocrinology, and the study of reproduction and fertility. Research undertaken to follow the workers at Cambridge's School of Agriculture and Animal Research Station through their professional careers revealed that the links established between the farm and the clinic were across the board of reproduction. Examples were found of the transfer of AI, embryo transfer and IVF technologies between the farm and the clinic, and of direct collaboration between animal and human researchers.

Activities

I have given several conference papers to disseminate the 'work in progress' to historians of science, technology and medicine, agricultural historians, and social scientists. In reverse chronological order these were: '*Artificial insemination*', Free School Lane Workshop on Reproduction, organised by the Department of History and Philosophy of Science, the Department of Social Anthropology, and the Centre for Family Research, Faculty of Social and Political Sciences, University of Cambridge (October 2005); *'Breeding for the State: Science and artificial insemination in cattle in early twentieth-century Britain'*, part of the 'Science, Disease and Livestock Economies' Conference held at St Anthony's College, Oxford (June 2005); *'From public service to artificial insemination: animal breeding science in early twentieth-century Britain*', part of a one-day workshop held in the Department of History and Philosophy of Science, Cambridge (April 2005, see below); *'Brave new technology: the interwar origin of artificial insemination in cattle'*, seminar paper, Centre for the History of Science, Technology and Medicine, University of Manchester (March 2005); *'Replacing the bull with a small glass phial: artificial insemination and the ambitions of inter-war science',* History of Modern Medicine Seminar Series, Department of History and Philosophy of Science, Cambridge; *'Fashioning the standards of tomorrow: artificial insemination, scientific and farming communities in inter-war Britain'*, at 'Constructing Communities: place and

people in the countryside, 1918-1939', a conference organised by the Interwar Rural History Research Group (a sub-group of the British Agricultural History Society), held at Gregynog, Powys, Wales (April 2004).

Together with my colleague Nick Hopwood I organised a highly successful one-day workshop titled *Between the farm and the clinic: agriculture and reproductive technology in the twentieth-century* in the Department of History and Philosophy of Science, Cambridge (held on 29 April 2005). Designed to make contact with other researchers on reproductive technology, including historians of science, technology and medicine, agricultural historians, sociologists and anthropologists, this meeting attracted an international audience, including participants from USA, UK, France, Germany and Denmark. This workshop, as well as providing a 'showcase' for this ESRC project on artificial insemination, aimed to break new ground in two main ways: Firstly, to promote work on the making, organization and communication of reproductive knowledge among experts and laypeople in agricultural settings; Secondly, to explore the networks linking animal breeding, reproductive science, experimental biology, clinical medicine and the pharmaceutical industry in the twentieth-century. Importantly, this event generated the outputs included with this report.

Finally, I have contributed lectures to a course on 'Reproductive Technologies' in the Department of History and Philosophy of Science, Cambridge (Lent 2004 & 2005, Michaelmas 2006). These disseminated work on artificial insemination to undergraduates and graduate students in Cambridge.

Outputs

Since the spring of 2005 I have been working as Guest Editor of a Special Issue of *Studies in the History and Philosophy of Biological and Biomedical Sciences*. The Special Issue originates in a one-day workshop held in Cambridge in April 2005 (see above) and has the same title. This collection of essays brings together an interdisciplinary team of eleven contributors from England, USA, France, Germany and Italy. The final drafts have been submitted to the Editors and publication is planned for the Summer 2007 issue of the journal. The 'nominated outputs' supplied consist of my introduction and article for this Issue (bibliographic references made in this report will be found in these documents).

In addition I have completed a paper titled: 'Doctors, artificial insemination and eugenics: the interweaving of reproductive medicine and agriculture in mid-twentieth-century Britain'. This has been submitted to a medical history journal for publication.

Future research priorities

This study has served to underline the neglect of animals-as-technology in agricultural history and history of technology, the limited historiography available on British animal science, and the importance of reproductive research that lies between the farm and the clinic. Future research could be profitably directed at furthering the history of any one of these aspects of our biotechnological modernity. My immediate priority is to complete this research on AI: further outputs are planned to provide a detailed account of its agricultural history.