The «Econologics» of Genetic Autonomy—Ex-Situ Genetic Resources and Corporeal Articulations of Interests

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Abstract

Gene banks are one of the most visible embodiments of the complex articulation of changing interests in non-human life during the last decades of the 20th century and the first decade of the 21st. During the past decades, they have become an ever more central means for the corporeal management of 'biodiversity' in the face of the loss of genetic diversity. Materially, the banks come in many forms—being globally centralised 'vaults' or more local, heterogeneous ones consisting only of small collections. What gene banks all share is that they have become more and more subject to international politics and governance over nature.

In the article I ask how three different interests—ecological, economic and national—articulate in 'gene banking' in the making and are finally embodied in the corporeality of the 'genetic resources' themselves. What I argue is that the collection, identification, standardisation and banking work that goes into the making of national gene banks operates within a very special space of 'economic' and 'ecological' interests framed by international politics of nature. This space is a contemporary articulation of intersecting material interests, which I call the 'econologics' of genetic nationhood.

This peculiar intersection of multiple interests is what gives gene banking work its special characteristics, and enacts a novel techno-scientific time-space—one that transforms non-human life into pure potentiality and provides for an eternal reproduction of the genetic autonomy of nationhood.

This article draws from an illustrative case study of such practices in Finnish genetic resources programmes. The material analysed consists of key documents of inter/national animal genetic resources movements and ethnographic fieldwork notes within the Finnish genetic resources programmes between 2004 and 2007.

Introduction

On 16 February 2008, the London 'Daily Telegraph' published an article under the headline 'Svalbard Global Seed Vault: ark of the Arctic'. The article described how a new global seed bank had been launched based in the archipelago of Svalbard, one of the most northerly places on earth, with an account of why it had been situated in the Arctic zone. The article said: 'Inhospitable to life it may be, yet Spitsbergen's singular geography is precisely the reason it has been chosen for a project its instigators believe will safeguard human existence. In the town of Longyearbyen, high above an icy fjord and deep inside a frozen mountain, the Svalbard Global Seed Vault, nicknamed the "Doomsday Vault", has been built to house samples of all the world's agricultural seeds. It is able to withstand wars, pestilence and attack by missiles, not to mention rising tides and other by-products of global warming.'

In the interview for the same article, Dr. Cary Fowler, a scientist with an international reputation, a proponent of gene banks and the executive director for the Gene Bank Trust running the Svalbard gene bank commented: 'Every nation has been invited by the Norwegian government to place its seeds in this vault. It's the last line of defence against extinction for all the crops we have, and the most long-lasting, most futuristic and most positive contribution to humanity being made by the international community today.'[1] Not short of hubris, the bank, situated in inhospitable conditions of remote and cold areas of the Arctic carries the hope of saving humanity from itself, from wars to climate change, and from their *ecological* impact on crops. Should 'Doomsday' come, the vault will be able to restore *humanity* by allowing the restoration of *nature*: the vault guarantees the coming community of human and non-human life of the future.

The gene bank is protection not only against ecological but also economic crises. On 29 February 2008, the New York Times commented the Svalbard seed bank in another way. It explained that '[t]he Global Vault is part of a broader effort to gather and systematize information about plants and their genes, which climate change experts say may indeed prove more valuable than gold'. In a very telling way, the article is titled 'Near

Arctic, Seed Vault Is a Fort Knox of Food'[2]. Parallels drawn between the national treasury and the corporeal material of genetic resources in the form of plant seed stored in the gene bank is not merely a journalistic trope. Genetic resources are becoming more and more important as central elements of the *national* wealth of any nation as a novel form of biocapital—and to some, this is considered to be a more valuable form of natural resource than gold.

Gene banks, such as the Svalbard Vault, are one of the most visible embodiments of the complex articulation of changing interests in non-human life during the last decades of the 20th century and the first decade of the 21st. When first introduced in early 20th century their predecessors—introduction stations—were a means for the mobilisation of parts of nature. Economically valuable plant species were circulated within and by the global networks already in place in the mid century and 'introduced' to new regional ecologies for agricultural advancements. Ironically, during the past decades, gene banks have become an ever more central means for the corporeal management of 'biodiversity' in the face of the loss of genetic diversity their predecessors were helping to weed out.[3] Gene banks are not, however, for plants only. Animal genetic resources have been a subject of increasing international concern for the last 15 years. Starting in the early 1990s, the United Nation's Food and Agricultural Organisation (FAO) has prepared a number of visible measures to promote and to conserve animal genetic resources. The first 'Global Strategy for the Management of Farm Animal Genetic Resources' was released in 1999 and the follow up strategy in 2007 (FAO 1999a; FAO 2007).

Materially, gene banks come in many forms—being globally centralised 'vaults' like Svalbard or more local, heterogeneous ones consisting only of small collections. The central distinction here is the mode employed by the bank: both 'in-situ' and 'ex-situ' banks exist. Where in-situ banks are conservation practices mostly taking place in the normal ecological environment of conserved species such as nature parks or farms, ex-situ banks are institutions that conserve the material outside of its 'natural' ecology, most often translated as cryopreservation measures. Regardless of the in-situ / ex-situ division, they both can conserve either plant or animal material, seeds or gametes.[4] One of the central matters of concern in global animal genetic programmes and other working documents for animal biodiversity conservation is the urgent call for preservation of animal genetic resources in ex-situ gene banks (e.g. Barker 1994; Boa-Amponsem & Minozzi 2006; Ruane & Sonnino 2006).

What gene banks all share is that they have become more and more subject to international politics and governance over nature. One of the most important international treaties of nonhuman genetic regulation is the UN Convention on Biological Diversity (CBD), which was signed by 150 states in 1992 and ratified in 1993. Hailed as an international political move to save the 'biodiversity' of planet Earth, it may be a surprise to anyone reading the Convention to find only one article enjoying a 'hard law' status enforceable within international jurisdiction.[5] In Article 15 the CBD recognised the sovereign rights of nation-states over their genetic resources as a form of biological heritage, a new form of national patrimony (Parry 2001), and made this declaration legally binding under international jurisdiction. It also put the ratifying states under the obligation to identify their national genetic resources.

Since 1992, every non-human form of life has a nationality given that it is identified as a genetic resource by a signatory nation-state—any 'genetic material of actual or potential value' (definition given by CBD) became identified with nationhood. Genetic resources are very interesting objects—a generative effect of novel relations between nature and culture, not reducible either to 'biological populations' or 'genes', but considered best at once as culture understood as natural heritage and nature understood as cultural heritage from the earliest discourses of conservation geneticists (Frankel 1974; Frankel & Soulé 1981). The new objects of knowledge here, *national genetic resources*, are located both within the category of culture and the category of nature. In short, they are a generative effect of biopower (Foucault 1985; 2003) over the non-human populations of a nation-state, legitimised by international politics.

Whilst a number of recent analyses have been carried out on the politics of genetic resources (see e.g. Fowler & Mooney 1993; Hayden 2003; Kloppenburg 1988; Parry 2001; Pistorius 1997), I claim in the article that the crucial aspects of the global event of *genetic autonomy* nations—implied by the CBD in its declaration of national sovereignty over genetic resources of signatory states—become best visible within scientists' ex-situ practices of genetic conservation. This article draws from an illustrative case study of such practices in Finnish genetic resources programmes. The analysed material consists of key documents of inter/national animal genetic resources movements and ethnographic fieldwork notes within the Finnish genetic resources programmes between 2004–2007.

In the article I ask how three different interests—ecological, economic and national—articulate in the 'gene banking' in the making and are finally embodied in the corporeality of the 'genetic resources' themselves. More specifically I ask how the process of interessement (Callon 1986) of different parties involved in the gene banking practices happen with the concepts of 'ecological' and 'economic' and how do these take on a corporal form as 'genetic resources' when they all articulate with 'national' interests in the post-CBD world.

What I argue is that the collection, identification, standardisation and banking work that goes into the making of national gene banks operates within a very special imploded (Haraway 1997) space of 'economic' and 'ecological' interests framed by international politics of nature. This space is a contemporary articulation of intersecting material interests, which I here term the *econologics* of genetic nationhood. This peculiar intersection of multiple interests is what gives gene banking work its special characteristics, and enacts a novel techno-scientific time-space—one that transforms non-human life into pure potentiality and provides for an eternal reproduction of the genetic autonomy of nationhood.

Finnsheep ex-situ banking: Biological life and problems of national interest

In response to the Convention of Biological Diversity, Finland started its national genetic resources for plant and animal genetic resources in 2003 and 2004 respectively. The central issue in these continuing programmes is to decide what are the most valuable resources from a national viewpoint and how they are to be conserved. One of the valuable genetic resources recognised at the outset of the animal programme was a particular breed of sheep, the Finnsheep. The nativity—in both natural and cultural terms—of the Finnsheep is not only expressed by its clearly evocative name but is also backed up by powerful political and scientific claims. Finnsheep is one of the 9 officially recognised animal breeds included in the Finnish genetic resources conservation programmes (Suomen kansallinen eläingeenivaraohjelma [The Finnish National Animal Genetic Resources Programme] 2004). It is also one of the 20 or so sheep breeds identified as native to northern Europe, and its genetic origins are considered as Finnish as evidenced by various historical documents. In addition, Finnish population scientists working with the breed have done a number of studies which indicate that the Finnsheep population is genetically isolated enough to claim its nativity in Finland (see e.g. Tapio et al. 2006a; Tapio et al. 2006b).[6] Accordingly, the breed can be considered, not only historically but also genetically, as Finnish.

One of the explicit goals of the national programmes, as stated by the special genetic resources group within the Ministry of Forestry and Agriculture in charge of the work, was to establish an ex-situ collection—a gene bank—of Finnsheep genes. A number of conflicting interests at different levels and deriving from different temporal trajectories, however, made this task difficult. To start with, most of the 'national herd', or the total recorded population of Finnsheep, is scattered around Finland in smaller herds kept by private farmers. This is why the population scientists working for the national programmes first had to enrol sheep farmers and their sheep to help the establishment of a gene bank—they had get a permission to 'bank' their genes. The population scientists resorted to their current ecological and economical interests that were to be translated to the interests of the future with particular techniques.

I start with the 'ecological' interest related to the Finnsheep breed. The inter/national movements in constructing ex-situ banks lead to two interconnected matters of concern (Latour 2004). The first concerns what can generally be termed ecological. The worry about the destruction of viable populations of non-human (national) life by human action has prompted action since the early 20th century and has become a global concern following the green revolution (see the history of plant genetic resources movements, e.g. in Pistorius 1997, and for animals, Barker

1994). The reason and the effect usually found in the literature of genetic conservation is the impact of human action on the biosphere characterised by the 'growing proportion of unusual ecosystems which have substantially lower species diversity with lower genetic variation than most of the natural systems. In other words, there is a global loss of both species and their genetic diversity' (Vida 1994, 9).

In corporeal terms, the problem of Finnsheep genetic diversity is palpable in the fleeting presence: only 5000 individuals are alive today consisting of ten purebred 'lines'. This indicates a close genetic relationship. The Finnsheep as a breed *and* its genetic diversity are rapidly approaching ecological peril.[7] For conservation practices this means that the genetic diversity of a large enough population must be guaranteed. The effective population size must be large enough not to result in inbreeding (the crossing of too close siblings resulting in the loss of genetic diversity and the increase in pathogens within the population) in order to guarantee their sufficient genetic diversity. But at the same time the breed must remain 'pure' by controlled reproduction. Thus the paradoxical conditions of genetic diversity and the purity of the breed must be guaranteed by strict population management practices.

Biological life of any large scale animal breed, such as Finnsheep, is hard to sustain. These breeds need a specific type of environment, a special *ecology* of their own sort for a successful stability of the breed—to guarantee the very 'beingness' of the particular form of life. Currently, this ecology is disappearing at a fast pace. This is the general 'ecological' concern about the extinction of Finnsheep in Finland. The ecology, however, is not purely an environmental question pointing to a diminishing grazing area suitable for the breed or their problems in adapting to climate change. The concept derives from the Greek 'oikos' (household) and 'logos' (knowledge), or the knowledge of keeping a household. The etymological roots point to how any life brought to the sphere of domestication needs a special kind of knowledge: the multitude of practices of keeping a pure bred line of animals such as Finnsheep.

Thus, ecology is not only an environment in its narrow 'biological' sense. Rather, a more open understanding is required, keeping in mind the prerequisites of a pure breed: the constant care that goes into the management of herds, keeping the breeding lines pure and above all traceable to the breeders. In addition, a location dedicated to these animals, a barn and sheep pens to keep the herds, is required. 'Breeds' cannot be defined only by their relation to the natural environment, in which they are said to have evolved and to which they have adapted. Instead, they must be understood by the relationship to the historical breeding processes that made them a distinguishable 'breed' (Derry 2003; Ritvo 1995): a spatio-temporal continuity of some corporeal characters and processes are expected from 'pure bred' animals belonging to a breed. Breeds are constructed with meticulous practices—it is only by keeping the kinship structure visible and individual animals reliably identifiable within that system that the identity of Finnsheep can be maintained pure.

These conditions led to three interlinked economic problems with the conservation of 'Finnsheep' within the national genetic resources programmes. First, because of the ecological conditions posed by the upkeep of a herd, not just anyone can keep live sheep since they need constant care plus expertise in sheep breeding, and all of this costs money and time. Agricultural policies in Finland have changed during the past few decades, especially with EU membership, which abolished domestic subsidies to sheep breeders. Market prices for all agricultural products were also cut from 30–70% (MMM 2003). As a result sheep breeding has become a non-profitable form of business for most of the farmers. Most of the national sheep herd is in the possession of individual farmers, who, in the changing agricultural economy, are abandoning the sheep for more economical animals (e.g. bovine species). National and international subsidy policies have devastated the agricultural niche of Finnsheep contributing to their nearing extinction. The farmers—the guardians of the national herd—are resigning their commitment and shall continue to do so unless the Finnsheep proves to be an animal of economic interest in the future.

Second, population scientists had to address the questions about economic ordering of the national conservation. The yearly budget for the animal genetic resources programme is very limited meaning that keeping a sufficient population of animals alive in a dedicated 'in-situ' gene bank (a farm that keeps the Finnsheep 'true' by breeding practices) financed by the government was not a viable option. The number of animals needed for such a bank would be too numerous, thus too costly an option for their genetic conservation. Of the 5000 individuals only 280 today are kept in a state operated farm, and this small number of individual animals is not enough to keep the genetic variability at desired levels for their conservation. This is also why the biological modality of Finnsheep is a problem for the genetic programmes. To keep an acceptable level of Finnsheep genetic diversity with live animals is too costly business both to the conservation scientist and the farmers.

Finally, the decline of the breeding population and its genetic diversity is an economic problem in a third sense. To secure the interest of sheep production globally, a certain level of genetic variation should be provided to make future animal breeding possible and to keep industrial animal husbandry alive. Here, it is not the question of keeping any one local herd alive but to harvest most of its genetic diversity for non-local breeding purposes. The 'Global Strategy for the Management of Farm Animal Genetic Resources', a declaration jointly created by FAO and the Initiative for Domestic Animal Diversity (iDad) in 1999 illustrates this point nicely. It casts the genetic variation in terms of ecological necessity and agricultural commodity and states: '[l]ocally adapted breeds also tend to retain significant genetic diversity, which provides for adaptability over time to changing environmental conditions and provides options for farmers to select for characteristics in response to changes in the marketplace' (FAO 1999, 8).[8] Quite simply, the upkeep of the Finnsheep ecology is a question of a novel international agricultural economy. Genetic variation has become a novel form of biocapital and in Finland farmers act as central stakeholders in this new global market for genetic diversity.

The same is true for all animals in general and for Finnsheep in particular. Even if the value of live animals have sunk, Finnsheep's ecological adaptation in terms of genetic characteristics now provides farmers with the opportunity to adapt to changing national and global agricultural markets. The Finnsheep breed is a 'superior breed' well known to sheep farmers around the world for one of its special characteristics: it has what is called 'unusual fertility genes' (see e.g. MMM 2003; Owen 1977). These genes make the breed very prolific even in the harsh climatic conditions of Finland. In addition, with these 'fertility genes' Finnsheep will also breed at any time of the year—a rare quality among the sheep breeds of the world. Thanks to its special genes it is very much sought after as a crossing breed, a very valuable sheep breed for reproductive purposes.

And it is precisely here that the 'ecological', 'economic' and 'national' interests articulate with each other at the first level. The three are interlinked by the *interests* in conserving the Finnsheep as a national genetic resource. The conservation scientists acting on behalf of the government and the individual farmers who own most of the national herd of Finnsheep have differing interests for both economic and ecological reasons. The differing interests face the problem of *biological life* of sheep—a form of life not easily conserved nor capitalisable because of its corporeal form and the changing agricultural markets and European subsidy policies. The problems pertaining to that corporeal form of animal life are encountered both in ecological and economic fields of operation of scientists and farmers alike.

The most viable solution the programme officials came up with was the transformation of the Finnsheep to its reproductive material. Reproductive materials contain the 'fertility' genes in an easily transportable manner—making them easily capitalisable—and making the sheep breed easier to conserve because of a significant reduction of both the animal and the physical space required for conservational aims. 'Finnsheep' was translated to 'genetic resources' in the form of reproductive material, which become the first obligatory point of passage (Callon 1986) aligning differing interests for conservation purposes. The problem of biological life in the form of living sheep was solved by a reduction to its reproductive materials—a transformation of animal life into its pure potentiality. This transformation was done by particular reproductive technologies well known in the animal industry.

More crossing interests: Animal industry, cryopreservation and genetic conservation

Maintaining animals in their natural biological state (the 'in-situ' mode of genetic resources)—as in the national herd—within the Finnish genetic resources programmes poses then both an ecological and economic problem.

Bringing the divergent interests to pass through an obligatory passage point can solve the problems: cryopreservation, a technology first invented in animal breeding sciences that aimed for breeding improvement. This technology no longer needs the animal itself, but concentrates only on its reproductive material in a frozen state.

This second intersection of the three interests is an interesting articulation of animal industry, biotechnological methods of animal (re)production and genetic conservation in their broader, transnational disciplinary and institutional settings. Making this intersection visible is essential because it is only by understanding the historical trajectory by which ex-situ banking of animal gametes has become a possible and desirable means of genetic conservation that one can start to understand the corporeal character of the national gene banks. I start here with the economic aspects of animal breeding.

Industrial animal husbandry has been highly dependent on various technological innovations ever since Robert Bakewell's experiments on selective breeding. Managing reproductive processes is what makes the value derivation from genetic capital possible—already Bakewell and his disciples understood the interlinked nature of reproduction and capital in the mid-18th century and capitalised on the 'genetic template' embodied in superior animals by hiring them for a breeding season for the use of other breeders (Ritvo 1995). The reproductive powers of one 'superior' male animal became an economic asset first for Bakewell and then for others capable of demonstrating the reproductive superiority of their sires of stallions, bulls and rams. Male animals were considered to be capable of fertilising a large number of females, thus keeping the herd patrilineally manageable and identifiable. The key here was the ratification of the 'breed' to the language and a linguistic codification for pedigreed lineage of animals 'pure' to a desired type (Ritvo 1995)—a principle of animal production still in use. 'Purity' of a breed is a linguistic construction made corpo-real in breeding practices. The management of purebred identities of animals is done via stud and herd books (Derry 2003; Nash 2005). The biopower of non-human life works through these special inscription devices (Latour & Woolgar 1979) providing an interface between the human and the animal, the farmer and the inscriptions made concerning the vital characteristics of the animal population.[9]

Thus, herd books and good animals, or lineage records and good genetic material are important because animal breeding is not dependent on individual animals but on the successful *management of their reproductive processes*. Ritvo describes how two of the earliest techniques were developed in Bakewell's time: 'The two most important components of an animal's genetic endowment—the best indication of its likelihood of passing on desirable qualities to its progeny—were both functions of its lineage: purity of descent, meaning a heritage that included a preponderance of forebears with the same qualities; and pre-potency, meaning a heritage sufficiently concentrated and powerful to dominate the heritage of potential maters' (Ritvo 1995, 419). This made it possible to use only a few well selected male animals for genetic enhancement in breeding work. The central point here is that this management of reproduction processes is not only about producing the next generation of animals but of *better pedigrees*: better pedigrees are reached through better embodiments of individual animals—'superior animals'—and their performances inscribed in the herd books. This is an assumption shared largely by researchers working in the area of animal science as well as the breeders themselves (Bracket 1981).

Keeping within the trajectory of Bakewell's techniques in coupling reproduction and economic interests subsequent research has concentrated on extending the reproductive powers of male animals. During the 20th century important advances in the management of reproductive processes were made principally by innovations in Artificial Insemination (AI) techniques. These slowly but surely removed the need for the *male* animal to be *corporeally* present in the process of animal reproduction. The aim of managing reproduction with sire animals led to the concentration of their reproductive material—*sperm*. This quickly led to various innovations in animal reproduction and to the rise of large scale animal industry. The research finally led to new techniques of sperm collection, storage and distribution providing ecological and economic viability for artificial insemination in various forms (Foote 1993; Rasbech 1993).

The large range of material apparatus and practical protocols provided for a new *ecology* for sperm—the vitality of sperm could be temporally extended from some hours to some days in suitable liquid mediums. A long period of research led to the perfection of an artificial environment, where sperm could survive after ejaculation. This ensured its transportability from farm to farm. First AI techniques did away with the animal: fresh semen could be preserved for a few days in either egg yolk or milk based extenders before the fertility was lost and the cells died. Second, the development of sperm dilutants—appropriately known as 'extenders'—allowed more than one insemination to take place with one ejaculate diluted with them (Foote 2002; Salamon & Maxwell 1995a). However, it was only the well known 'chance observation' (Polge, Smith & Parkes 1949, 666) of the possibility to cryopreserve sperm cells in a glycerol mixture during the mid-20th century that radically changed both the pace and the scope of genetic enhancement of animal breeds. (Foote 2002; Rasbech 1993).

Cryopreservation[10] quickly became a central means for AI: the possibility for cryopreservation changed both the ecology and economy of the work. The reasons for this derive from re-arranging the ecology in the corporeal management of life. The first was a material and spatial reconfiguration of objects of knowledge and interests of animal breeding—the change from field and sire animals to laboratories (or breeding centres) and sperm.

Bakewell had to hire whole animals for a breeding season to capitalise on their genetic template. This was necessary because the first selective breeding practices meant that the desired animals had to be corporeally close to their mating partners to be able to be fertilised—either the females had to travel to the male animals or vice versa (Wilmot 2007). The second phase in the AI movements was the national institutionalisation of reproduction in countries advancing the technology in their agricultural policies—local, but nationally centralised, breeding centres and various social practices such as institutionalised permits, officers and scientific disciplines emerged and re-arranged the relations between farmers and national authorities, and re-created social divisions of agriculture. Even on the large, national scale of AI, however, it remained in its main principles a spatially similar organisation of breeding (e.g. Wilmot 2007): the breeding animals (usually male) were held in dedicated breeding centres, where they either mated or where their reproductive materials were extracted and distributed within the few days provided by the new ecology of sperm extenders keeping their fertility viable enough.

Cryopreservation radically changed animal breeding in its spatial and temporal scales. It was this technique that gave the breeders a high level of control over the temporal and spatial dimensions of the reproductive powers of their animals—it did away with the constraints posed by cellular decay quite literally by stopping the biological clock of the cell by freezing it. With this technique the cells could now be preserved almost indefinitely (at least 10000 years). Suspension of cellular processes by freezing sperm gave it a new temporal, and with it a new spatial, scope of use.

First, this technique allowed the temporal cycle of natural conception to be broken—until cryopreservation the special sperm media only succeeded in stretching the time from sperm extraction to insemination by a number of days. Cryopreservation allowed the biological processes of the reproductive material to be arrested and restarted at will. This extended the possibilities of old principles of selective breeding in an important way. For example, the sperm of a selected, genetically superior male could be used to fertilise several generations in a row: inbreeding practised by Bakewell could be extended far more than with live animals as long as it was deemed appropriate and enhancing for the breed lineage. This also reorganised the way of marking genealogies and kinship structures in animals: their genealogical kinship relations as identified individuals in linear herd books gave way to the more important marker of relationship calculated by the heritability of traits and genetic distance. It also made possible the building of a narrow genetic variance in a breed lineage. And it was this possibility that breeders aim for—as a technique it was a clear and direct answer to their goals of producing more predictable offspring (see e.g. Derry 2003; Franklin 2007; Owen 1977).

Second, the scope of the reproductive powers of an animal could be extended from a local farm to global agricultural business. With the suspension of the biological processes the sperm of the superior animals could be transported virtually anywhere in the world to meet the large demand as long as it was kept within an ecology—the unbroken ‘cold chain’ of cryopreservation—that provided the suspension of cell life in a frozen state. The genetic information embodied in sperm went from a local to global commercial product in a very short period of time. It is easy and cheap technology for fast genetic enhancement and easy to circulate around the world on some animals such as cattle. It thus became popular and in great demand quickly, which also widened the spatial scope of the cryopreserved reproductive material enormously and created a novel global economy of frozen reproductive material (Brackett et al. 1981; Cole & Cupps 1977; Foote 2002; King 1993).

At the present, it is globally the most widely used biological technology in livestock farming.[11] Globally, over 100 million AIs in cattle, 40 million in pigs, 3.3 million in sheep and 0.5 million in goats are performed annually. Of these only about 4.5% are performed with 'fresh' semen—the remainder is cryostored, making AI and cryopreservation in most cases synonymous with each other (Thibier & Wagner 2001). Over 200 million frozen semen doses were produced worldwide every year during the last 20 years of the 20th century. With these numbers the theoretical size of the cattle sperm economy thus reached a value on a conservative estimate of up to 4–5 billion US dollars per year (the average price for a dose is around 20–25 dollars, see FAO 1995).

However, no large-scale Finnsheep ram sperm markets have emerged for two reasons: for a long time no properly working protocols were available, which resulted in low profitability. The problem with protocols has been a decrease in the fertility of frozen sperm: even if cryopreservation with glycerine extenders protect from most of the damage, the living sperm cells suffer from a 'cold shock' when frozen to extreme temperatures, some of the cells will eventually die in the process of freezing and thawing lowers their reproductive capabilities (Salaman & Maxwell 1995a). Thus, conception rates have remained low until recent years. The profitability of the technique has also been questioned from the start as the margins from sheep operations are small. The two benefits achieved—speeding up the development of higher fertility in lambing in ewes and better meat production in flocks—by cryo-biotechnologically assisted AI have been too costly for individual sheep farmers, who still favour the easy and cheap selective breeding techniques invented by Bakewell and perfected by his followers (Inskeep & Peters 1981; Rasbach 1993; Salaman & Maxwell 1995a, b.).

The practices of animal genetic conservation adopted the cryopreservation technique as one of the viable potential strategies from a very early stage (see FAO 1986). Only recently, however, as the international animal genetic resources movement has gathered more momentum (e.g.

FAO 2007) has the technique been re-evaluated in the context of genetic conservation (e.g. Boa-Amponsem & Minozzi 2006; Hiemstra, van der Lende & Woelders 2006). According to the latter study the technique of conservation has the benefit of allowing 'virtually indefinite storage of biological material without deterioration over a time scale of at least several thousands of years but probably much longer' but resonates with its problems of use in the sheep business by stating that '[i]n general, cryopreservation and associated reproductive technologies are costly; the main limitations for extensive development of ex situ collections are high costs of collection and limited use of preserved material' (ibid. 2006, 46–53). The Finnish Animal Genetic Resources Programme (2004) has adopted cryopreservation, however, hoping that it will solve the related economic problem by trying to align the interests of sheep farmers with its own.

This is where the international animal industry, the cryopreservation technology developed by it, local farmers and the interests of the national conservation programme of the Finnish government come together again. Local farmers are interested in cryopreservation techniques of the Finnsheep sperm —they know it is valuable as they have already had numerous enquiries from around the globe to sell it.[12] However, cryopreservation cannot succeed without the technological knowledge embedded in the national genetic resources programmes—the viable techniques for freezing. Not surprisingly, then, the scientists in the national programme have been able to channel the farmers' interest through their knowledge of cryopreservation, making it the second obligatory point of passage (Callon 1986) for them.

The scientists, on the other hand, are interested in extracting sperm from the animals in the possession of the individual farmers, because the individual animals and the herds they make up constitute the *national herd*—the sum of all registered Finnsheep animals of Finland. This is what the scientists are to conserve as national genetic resources. Hence, the alignment of interests. The farmers have agreed to provide access to their herds for the scientists as they are interested in witnessing the viability of the cryopreservation technique. The farmers are interested in cryopreservation because its successful performance on their rams would multiply their value and provide a possible opening for the inter/national markets. Successful cryopreservation would open a way to innovative new business opportunities for national Finnsheep farmers and make their husbandry activities much more attractive for them. One standardised sperm dose—and with the right technique one can produce anywhere from 10–20 batches from one ejaculate—could fetch as much as € 200, or almost as much as a single live animal fetches on the market. With the cryopreserved reproductive material the economic value of a pedigreed ram could then be increased many times. The producers of cryopreserved sperm could carve out an entirely new economic niche for themselves in the worldwide animal reproduction industry as well as helping the government at home in its efforts in conserving the animal breed.[13]

The two problems—ecological and economic—relating to the conservation of Finnsheep would be solved if cryopreservation for its sperm were possible. First, it would allow the indefinite storage of the animal sperm in ex-situ gene banks. Second, it would make the Finnsheep an interesting and viable form of agricultural economy to the Finnsheep farmers. Finnish sheep producers could become a provider of goods for worldwide sheep markets as they posses the two crucial resources animal breeders primarily deal with: detailed genealogical information about the purebred Finnsheep and their superior genetic material embodied in the gametes (Seidel & Brackett 1981, 8). In this way, the *in-situ* (*in vivo*) preservation of the Finnsheep would also gain new vitality—the keeping of Finnsheep in their living corporeal form would be in the interests of the farmers. Thus, the enrolment of the farmers and the Finnsheep in the national conservation programme's aims is dependent on the successful cryopreservation practices.

From in-situ to ex-situ: Technical management of interests and shifting ontologies

Cryopreservation marks a total change in the object of knowledge and material interest—it is founded in the move from the animal to its reproductive material by a long chain of translations. A total re-configuration of the ontology of the Finnsheep breed occurs as it moves from 'in-situ' to 'ex-situ'. The ecology of this novel 'genetic resource', is totally different from the farms, barns and herds required for the Finnsheep to survive *in vivo*.

First, cryo-biotechnically assisted suspension of reproductive life of Finnsheep radically changes the scale of operations. A Finnsheep is big—an adult ewe weighs about 65–75 kilos, a ram 85–105 kilos. A gamete is microscopic. But Finnsheep gametes cannot stay vital unless special arrangements are provided *in vitro*, including a novel ecological environment consisting of liquid nitrogen, extender liquids and cryo-protectants, -196 degrees Celsius and other conditions.

Thus, cryopreserved 'genetic resources' need a special laboratory ecology (Kohler 1998)—a fact that becomes visible analysing how the making of these kinds of special ecologies are possible and what kind of networks they themselves are. An enormous input of skills, materials and infrastructure goes into making 'gene banks'. For example, the liquid nitrogen where the gametes are placed *in vitro* and the container keeping both the liquid nitrogen and the gametes need to be kept at a facility, which guarantees extremely low temperatures (generally at least -150C). The cooling requires a large and secure supply of electricity—a condition not met everywhere.[14] As with other technologies, the material infrastructure of gene banks is embedded in another infrastructure, the electricity grid network of modern western societies (Hughes 1983; Star 1999).

If you have reproductive material stored correctly, biological Finnsheep can always be revived from these reproductive materials called ex-situ genetic resources. However, not all gamete material is capable of sustaining life in that novel, quite artificial and hostile laboratory ecology: the passage from *in vivo* to *in vitro*, from in-situ animal to ex-situ genetic resource, is not without problems as it poses a novel kind of selection process to the sperm compared with the 'natural' one. Hiemstra, van der Lende & Woelders (2006) for instance note the following in their analysis of cryopreservation as a means of genetic conservation: 'There may be considerable differences between breeds and between males in the "freezability" of the semen. As a consequence, frozen semen of some genetically interesting breeds or males may not be suitable as a gene bank resource, or can be used only with a poor efficiency' (ibid. 47).

The selection process operates in an inherently economic historical trajectory: only the *most efficient*—biologically and economically—gametes are selected for the bank. This co-consideration translates to the concept of 'freezability' of the sperm. Only the sperm judged the most 'freezable' will become ex-situ genetic resources. This technique not only works as a novel conservation practice but also as a *national identification process* for the ex-situ genetic material of Finnsheep to be conserved. It is here that ecology, economy and national interests articulate again and become embodied in the ex-situ genetic resources of Finnsheep.

The actual cryopreservation of sperm includes four basic steps. Their successful performance depends heavily on local contingencies—conducting the freezing protocol within the barn requires more articulation work (Star 1991) than in standardised laboratories. The barn must first be turned into a laboratory and the freezing protocol itself is embedded within other practices that make the whole process possible (see Jordan & Lynch 1998; Lynch 2000).[15] I will, however, concentrate here only on the evaluation process of a 'viable' sperm.

First, once the sperm is extracted from the ram, it is put through a series of trials of strength—a lethal process during which some batches die and some survive. The first one is the visual judgement of the vitality of the sperm performed with the help of a microscope (see picture 1a, b). A certain level of concentration, viability (the normality of the morphology of individual gametes), overall motility and direction of movement of spermatozoids are expected from the sample under evaluation.[16] The calculation procedure proceeds by assigning the sperm batch under evaluation a discrete value from 1 to 5 and a symbolic notation consisting of plusses (+). If the sperm batch is judged to have up to 20% motility then it is assigned to category '1', if it is over 40% it will be in category '2' and so on, '5' being the best quality possible displaying at least 80% motility with a good direction of the overall movement. The direction of movement is indicated by plusses: if most of the sperm cells move in the same direction in multiple waves the sample will get five plusses (+++++), decreasing to one the fewer waves the sample has. In addition, the number of spermatozoids within the volume is calculated by using visual translations of volume to area—the number of individual spermatozoids is calculated with the help of a special square engraved slide (see Figure 1c).

If the first evaluation indicates that the overall quality of the sperm is good enough it will then be 'extended'.[17] The economic effectiveness of

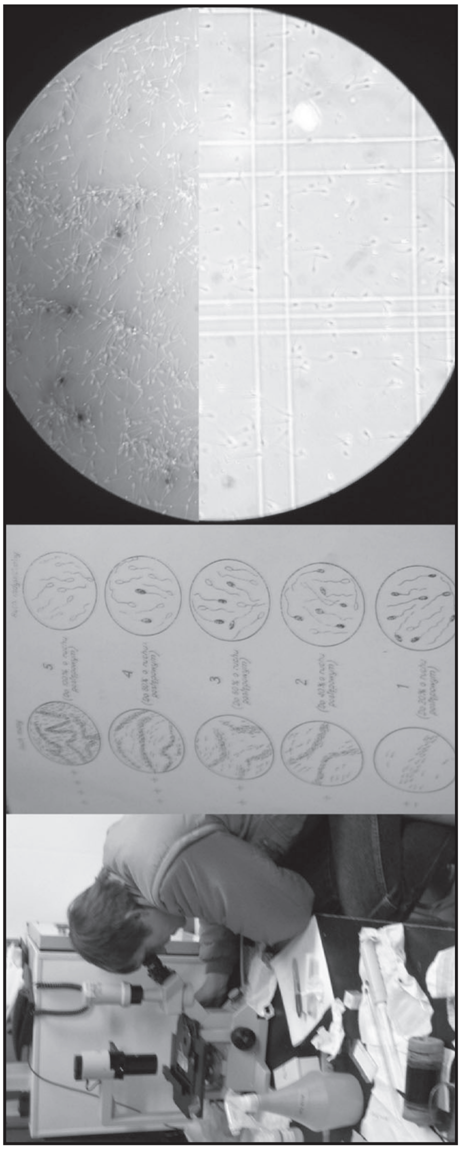
AI lies partly within this invention—it was noted from the early days that the initial sperm ejaculate can be divided into smaller volumes without excessive reproductive vitality loss. Smaller volumes simply meant smaller volumes of sperm, and since the ejaculated volume normally contains a huge amount of individual spermatozoids—with Finnsheep rams the number of individual spermatozoids within one ejaculate is around 4 billion, almost double that of other sheep breeds—volume division did not pose too many problems in terms of its reproductive powers.

The initial sperm is divided into smaller volumes and diluted with a special 'extender' liquid. Extender liquids consist of a mixture of ingredients in which spermatozoids can survive (milk, egg yolk etc.), antibiotics for sterilising the mixture from bacteria, and cryo-protective agents (normally glycerine) (Foote 2002; Salamon & Maxwell 1995b). 'Extenders' are used, as the name aptly describes, to extend one batch of sperm to several batches and readying it for the actual freezing process. By adding a certain mixture of ingredients and cryo-protective agents a single ejaculate can be extended to many batches and standardised by their volume and concentration of spermatozoids[18]—the initial volume is diluted. The extended sperm is packed in small containers and sealed making their new mode of being literally one of *in vitro*.

After counting, evaluation and standardisation, the small containers ('straws') are immersed in liquid nitrogen and frozen. The last phase is the most crucial trial of strength: the spermatozoids are evaluated by their 'freezability'. The more freezable, the more motile the gametes are once a sample batch is thawed. The threshold for 'freezable' sperm is 40%—if the number of motile individual gametes is below the number the whole batch is deemed as unsuitable for cryopreservation. All the standardised straws belonging to the same batch are taken from the container and disposed of.

This is ultimately the last trial in the long series of visual judgements by which and where the 'normal' and the 'pathological' (Canguilhem 1991) status of cryopreserved sperm is assessed. With reference to specific local thresholds (see note 14) the degrees of viability (morphological characters of sperm), motility of the whole sperm population and the forward movement exhibited by individual spermatozoids are summed up and judged either ‘non-freezable’ or ‘freezable’ and thus suitable for the national Finnsheep ex-situ gene bank. A normalisation process (Foucault 1984) of the *national gene bank population* occurs.

Figure 1. a, b, c



From left to right (a) visual judgement, (b) visual judgement standard, (c) transformation from volume to area—normal slide (top) and calculation of concentration with the graticule slide (bottom).

The collection, identification, standardisation and banking processes create, craft, select, process, and transform the Finnsheep breed from a biological animal into its genetic resources, with all the consequences that go with it. The most apparent aspect is that only certain genetic materials (gametes) are selected for the ex-situ bank, and that the decision thresholds derive both from the resistance of the biological material to the transformations of ecologies with cryopreservation and from the economic rationality for deciding upon the sperm that is most probably fertile to be frozen.

At this very corporeal level, then, we see how the ecological (the cryo-environment consisting of extremely low temperatures and various extender liquids and the sperms' vital resistance to their lethal powers) and the economic (the rationality behind the multiple processes of selection and the various characters and capabilities taken as a sign of fertility of the corporeality of the sperm) intersect in the creation of a national gene bank for Finnsheep. The ecological, the economic and the national interests are now materially aligned in the gene bank itself, changing both the very meaning and ontological form of Finnsheep. A passage from the living corporeal animal to a suspended state of its reproductive material is made.

Biopower, non-human gene banks and 'life itself': The «econologics» of genetic nationhood

Ex-situ banks are a very interesting object of study as particular forms of biopower (Foucault 1984), power over the reproductive materials of non-human life. What is at stake here, and what I take as a central question in my study is the reflection of the question Giorgio Agamben has presented echoing Foucault:

> Foucault's thesis—according to which 'what is at stake today is life' and hence politics has become biopolitics—is, in this sense, substantially correct. What is decisive, however, is the way in which one understands the sense of this transformation. What is left unquestioned in the contemporary debates on bioethics and biopolitics, in fact, is precisely what would deserve to be questioned before anything else, that is, the very biological concept of life (Agamben 2000, 6.7).

The most interesting question then, in this constant alignment of interest within genetic conservation, turns out to be something other than the alignments themselves—what kind of form of life is deemed viable for conservation for national interests? A number of conditions derive from the contingent nature of field laboratory and the resistance of gametes to cryopreservation. These conditions alone, however, do not dictate what is to be conserved as Finnsheep genetic material on the level of national priority. This should not come as a surprise as already the early laboratory studies (e.g. Fujimura 1987; Knorr-Cetina 1982; Latour & Woolgar 1979; 1986) in STS have argued that there is more to laboratories than the local conditions of knowledge production. To be sure, the Finnsheep is a complicated beast. Not only is it an object of economic interests—a prolific breed with much future potential in its fertile genes—but the making of a national ex-situ bank containing those genes in its reproductive material requires the establishment of a local laboratory ecology (Kohler 1994) or a set of practical conditions that allow for a successful collection on site, storage in gene banks and their possible circulation for profit.

Corporeally, life here takes the form of reproductive material stored in a very special laboratory ecology capable of suspending biological processes of cells—to literally stop the biological cell clock, thus preventing the processes of cellular life from taking place. But, there is more to it than this. I claim that within genetic resources movements aiming at securing 'biodiversity', the ecological and the economic cannot be thought of as separate rationalities, or relations that provide the common ground for the whole work, but are tightly interlaced. It is true that these relations constitute the possibility to create ex-situ gene banks, but it is also true that they traverse the conditions of the actual work at multiple levels: from policies to the cryo-banking processes themselves in the work of replacing biological animals with their reproductive material. In addition, these two articulate within the idea of 'national property' and 'nationhood' in very interesting ways.

The words 'ecological' and 'economic' derive etymologically from the same root 'oikos'—they are both the art and the rationality of governing the 'home'. Perhaps not surprisingly, I have tried to show how the two former rationalities are entangled not only etymologically but also in very practical terms and that they articulate with *the interests of taking care* of a non-human population of Finnsheep in their native homeland—*a form of non-human biopower*. I am not the first to explore the inseparable relations of economic and ecological. Writing in the 1980s, Raymond Williams once urged the consideration of the relationship between economics and ecology, Man and Nature in a novel way. He argued that:

> [i]t will be ironic if one of the last forms of the separation between abstracted Man and abstracted Nature is an intellectual separation between economics and ecology. It will be a sign that we are beginning to think in some necessary ways when we can conceive these becoming, as they ought to become, a single discipline (Williams 1980, 84).

I have argued in this article that the collection, identification, standardisation and banking work that goes into the making of national gene banks takes place within a very special imploded space of 'economic' and 'ecological' interests—inseparable as they are, I have termed this a space of 'econologics'. I have tried to show how ecological and economic interests traverse each other and materially articulate in the context of national gene banks embodying national genetic resources: within novel biocapital, the forms of materialisation of diverse interests are gene banks of all sorts, currently holding the non-human genetic heritage of nations.

The new spaces of existence for national non-human genetic resources are gene banks and cryo-circuits that are made possible by agro-biotechnology and animal production. Time within the networks of gene banks is a specific enactment of 'timeless time' (Anderson 1983) of nationhood, a suspension of biological time and life processes at extremely low temperatures. Gene banks thus embody not only various interests, but also occupy a highly specific time-space, a novel chronotope (Bakhtin 1981) of techno-science. Within this chronotope 'life' exists only insofar as it its suspended—no biological processes take place within this chronotope, 'life' exists as potentiality. All of which make Agamben's question about the (biological) concept of 'life' once more one in urgent need of rethinking.

The Finnsheep genetic resources are a novel form of non-human genetic nationhood—a form that poses the question of 'what is life' in its novel non-human forms. This is one of the new forms of articulation of national culture understood as non-human life, and life understood as national culture. The non-human biocapital finds its new corporeal forms in the new techno-scientific *econologics* allowing for standardization, circulation and processing of reproductive forms of life as national genetic resources. Econologics not only gives the gene banking work its special characteristics but it also shows how the entire network has come to occupy a novel techno-scientific time-space, and moreover one which provides for an eternal reproduction of the genetic autonomy of nationhood—as life in a suspended state.

Notes

[1] http://www.telegraph.co.uk/earth/main.jhtml?xml=/earth/2008/02/16/sm_seeds16.xml&page=1

[2] http://www.nytimes.com/2008/02/29/world/europe/29seeds.html

[3] The rapid growth of agriculture—selecting the best cultivars and animal species for production and enhancing them with biotechnological means—after the green revolution would not have been so rapid if the means for rapid global circulation of plants and animals had not already been in place (e.g. Fowler & Mooney 1990; Pistorius 1993).

[4] Their predecessors can be traced even earlier to colonial collecting practices of exotic forms of non-human life (see e.g. Parry 2004).

[5] Other articles remain on the bona fide level of policy agreements and best practices on the management of biodiversity not enforceable in international courts. Thus, seen from a legal perspective, CBD could best be acknowledged as an international convention on the access and benefit sharing issues concerning genetic resources.

[6] Most of the analyses of genetic origins rely on mitochondrial (matrilineal) DNA and microsatellite analysis.

[7] Recent genetic research suggests that the efficient population (N_e) is not yet in immediate peril, but is approaching this state if no action is taken. Li, Strandén and Kantanen (2008, in press) write that 'the current level of N_e suggests genetic diversity in the Finnsheep population is approaching critical levels both in conservation and in selection programmes. If the annual change in mean inbreeding coefficient increases, for example, as a result of intensive use of a few rams, maintenance of genetic variability would become more difficult, and, then, strong actions would be needed'.

[8] The same is true for plant genetic resources: For example, Fowler and Mooney (1990, 53), writing on plant genetic resources, claim that 'In the long run, the future of agriculture and the very survival of crops depend not so much on the fancy hybrids we see in the fields, but on the wild species growing along the fence rows, and the primitive types tended by the world's peasant farmers in the centres of diversity'.

[9] Depending on the animal and its use, these usually include at least descent lineage for the calculated degree of relatedness to other individuals and morphological and productive characteristics, e.g. milk yield.

[10] Even if reproductive capabilities of animals have been recently reinvented by cell nucleus transfer in the case of Dolly displacing many of the prerequisites of sexual reproduction—most notably the rams so central to the AI techniques and reversing the sexual politics of procreation—and largely complicating issues of identity, life and reproduction (see Franklin 2001, 2003, 2007), contemporary sheep breeding still works with older techniques such as selective breeding and AI. The astonishing experimental technique used with Dolly is laborious and requires costly equipment and special skills, and while it has redefined some aspects of biology, it has yet to prove itself as a viable large scale technique of animal reproduction. Compared to this novel promissory technology of nucleus transfer, cryo-biotechnology is one that has already lived up to its promises.

[11] The intense genetic enhancement practiced with AI has also led to considerable genetic erosion in some animal breeds: for example 50% of 5000 Holstain bulls born in 1990 in 18 different countries were bred using the sperm of only five (5) sires (Boa-Amponsem & Minozzi 2006, 4).

[12] This argument is based on personal communication with a Finnsheep farmer keeping one of the largest purebred Finnsheep farms in Finland, October 2005. In his evaluation of the potentiality of the new sperm economy the lucrative international markets were already there if the national farmers could just 'deliver' —the farm he ran had already experienced a steady flow of cryopreserved sperm demand from other breeders around the world over the past few years.

[13] The rationality and the value-derivation process reminds of the emerging global human tissue economies (Waldy & Mitchell 2007).

[14] For example, genetic resources programmes operating in so called 'third world' countries report problems in securing electricity for their ex-situ gene banks rendering this form of conservation problematic.

[15] To take two examples, the ram and the ewes must be physically separated prior to the extraction in order to standardise the maturity of the sperm and some ewes

must be induced into heat by injecting them with a special hormone some days prior to the whole event.

[16] The statistics for these are not usually reported, thus the relationships of viable vs. unviable are hard to assess. However, Piperelis et al. (2008) report that in Greece about 20% of ram ejaculates are rejected as they do not conform to standards of viability.

[17] The'goodness' of the sperm derives from visual evaluations and local thresholds, however, in most cases the cut off point is at the halfway point of each scale and the sperm count must adhere to or surpass the expected mean of the whole population of the breed for the sperm to be economically considered as 'freezable'. For example Amann and Hammerstedt (1993), in their discussion of the general goals of in vitro evaluation of sperm state that: 'The evaluation of sperm quality is usually linked with the desire to (…) enable maximum number of offspring from a valuable sire' (ibid. 397) and that '[t]he most important biologic and economic motivations for the evaluation of sperm quality are to identify males with a high probability of reduced fertility or to ascertain if the fertility of a male is likely to increase or to decrease' (ibid. 405).

[18] The volume of one batch of cryopreserved sperm is 25 microliters with a standardised number of spermatozoids (2 x 109).

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