Burning issues for animal gene banks: news from IMAGE H2020 project

Stakeholders survey reveals positive attitude towards an increased use of bio banks to conserve genetic diversity in the livestock sector

Conservation of animal genetic resources is highly relevant to ensure adaptability of livestock production systems. New technologies create novel opportunities in this field, however there are numerous different stakeholders (such as farmers, citizens, breeding companies and rare breeds associations etc.), resulting in different needs and requirements.

IMAGE dialogue forum conducted a survey (led and analysed by partners from BOKU, Austria, SAVE foundation and INRA, France), resulted in unraveling views and expectations about gene banks from a range of different stakeholders across Europe (see **Fig. 1**). Overall, they considered the conservation of animal genetic resources to be very important and were concerned about the loss of genetic resources. A combined approach is preferred associating bio banks, genomic selection, and in-situ conservation. Bio banks should prioritise endangered breeds but at the same time, remain open to most profitable animals. The survey also suggested that access to stored resources should be free for breed societies and public research institutions, however at the same time, there should also be a fee for private research organisations and commercial companies.

A multi-actor governance should have authority in decision making, according to stakeholders, who also indicated that funding should come from public sources. This was also supported by the higher level of stakeholder trust in public organizations. Overall, there is a generally positive attitude of stakeholders towards an increased use of bio banks to conserve genetic diversity in the livestock sector, funded, and controlled by public institutions and breed societies. Despite this, less consensus was observed regarding the use of biotechnologies for preservation of genetic diversity, which is currently a hot topic under study within IMAGE.

What is the current state of play for animal genetic collections in Europe: banks or museums?

A large survey led by Wageningen Research from the Netherlands and IDELE from France, mapped the diversity and characteristics of European animal gene banks in 21 countries and delivered key messages. These included the fact that many European countries are hosting germplasm and genomic collections preserving farm animal breed diversity, but they differ a lot in organization, rules and development phases. In addition to this, it was also found that the main livestock species (the 'big six': cattle, sheep, goat, pig, horse and chickens) are well represented in the collections, as there is an extreme wide array of breeds. Whereas, the endangered breeds are the ones with the least amount of material. Although genetic collections are mostly in the phase of storing unique genetic material, use is limited so far. The IMAGE project is a great opportunity to shift the genetic collections from a static perspective (such as 'museum collections') to dynamic ones (such as 'bank collections', where material flows in and out).

Can we get more diversity conservation at a lower cost?

Animal gene banks are aimed at avoiding loss of resources and represent the so-called option value to society in terms of maintaining future breeding opportunities that might otherwise be foreclosed. Assuming an overall societal perspective, the questions arises of what is the most diverse collection that can be planned at a reasonable cost? Candidate breeds must be selected to maximize a variety of possible future eventualities. The scale of this managerial challenge involves choosing among nearly 2000 candidate breeds

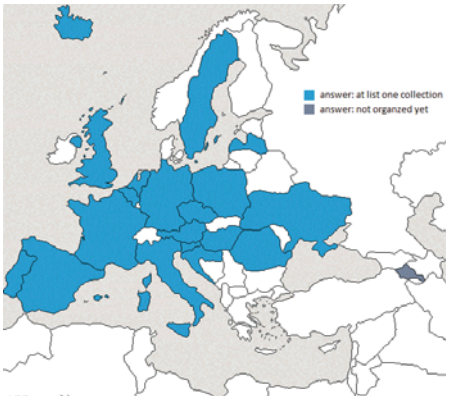

Fig. 1 Map displaying locations of stakeholders featured in the IMAGE survey

from various species and locations across Europe, while facing various budgetary constraints and limitations such as storage capacity, capital and specialised labor availability. Therefore, the use of optimisation techniques to address these challenges is needed.

Partners of the IMAGE project from Scottish Rural Agriculture College and University of Edinburgh, developed a mathematical model to find the best way to select breeds, gene banks and collection strategies. The model maximises breed diversity, measured as the number of preserved breeds, subject to a series of constraints. The model allowed IMAGE to construct 'efficiency curves' showing the supply of breed diversity potentially available for a given budget. The analysis allowed for cross-country collections, as well as considering region-specific costs and cryogenic capacity differentials.

Essentially the model found alternative least cost collections relative to current breed allocations across eleven European gene banks: the overall estimated conservation costs of (~€23.2m) could be reduced by around 20% by selecting cryogenic banks that have relatively low fixed and collection costs, and that are geographically closer to collection regions. The results show how optimisation can potentially inform policy decisions on efficient ex situ conservation (see doi:10.1111/jbg.12368 for more information)

Which biological resources: overcoming biological limitations to conserve embryos in chickens

Primordial germ cells (PGCs) are the reproductive diploid 'stem' cells in the embryo that will make sperm or eggs in the adult animal. They can be collected from the peripheral circulation of an early stage chicken embryo (**Fig. 2**) and then transplanted to another embryo such that the resulting adult host animal will produce offspring with the genotype of the transplanted cells. Because it is impossible to store bird embryos (due to the telolecithal egg), PGC cryopreservation, followed by their reintroduction in host birds, is an alternative solution to semen preservation for genetic diversity conservation programs.

Partners from University of Edinburgh, INRA France, and Hungarian Institute in Godollo, have developed cell culture for PGC and were able to grow up to 100,000 cells within one month (see **Fig. 2**). These cells can then be safely cryopreserved in multiple independent cryovials, before being used in a genetic reintroduction program. This has been applied to the cryopreservation of two traditional Hungarian breeds and the French 'Noire de Berry' breed.

Mining vital information from DNA sequence data

Many questions regarding the origin of collections, the genetic diversity and kinship, and even phenotypic characteristics could be mined from the DNA. Whole genome sequence data contains signatures of demography, such as effective population size or geographic origin, which could be valuable in terms of the conservation of genetic diversity. It can also be used to estimate genetic relatedness between animals, and therefore can be used to guide breeding, e.g. to control inbreeding rates. Methods for inferring demographic parameters and the signatures of artificial ('breeding') selection are being applied to genetic collections to establish their origin. Moreover, whole-genome DNA sequence information contains the genetic blueprint for what makes an animal different from others of the same species. Although predicting the animals' phenotype directly from sequence data is still far into the future, we can currently start to predict some features, such as the presence of deleterious mutations.

DNA data can be derived from any tissue or semen collection as long as the quality of the DNA is still sufficient. Yet, obtaining good quality DNA from old semen samples has proven to be difficult, and so storing blood samples in addition to semen samples is highly recommended. DNA sequence data is the same in nature for any cellular organism and therefore is a 'natural' information source that can be readily databased and compared. The IMAGE project has generated sequencing data for 15 cattle, 100 pigs, 100 sheep, and 300 chickens from different gene banks. This will allow researchers and gene bank managers to quantify the contributions of collections to local and global biodiversity.

Training

In 2018, three post-graduate courses were launched. These courses enabled the training of postgraduate students and early career scientists in conservation genetics, population and gene bank management, *ex situ* and *in situ* conservation. Two of these courses were organised in third-countries (Argentina and Colombia) and attracted a large number of participants, as well as provided attendance by live streaming to students in other South American countries who were unable to travel to the course venue. Another course was organised in the Netherlands and attracted PhDs and young scientists from a broad group of countries from EU and some non-EU countries. They had the chance to practise on their own data sets and group work and were rated very positively by participants. New courses will take place in 2019 and 2020.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 677353

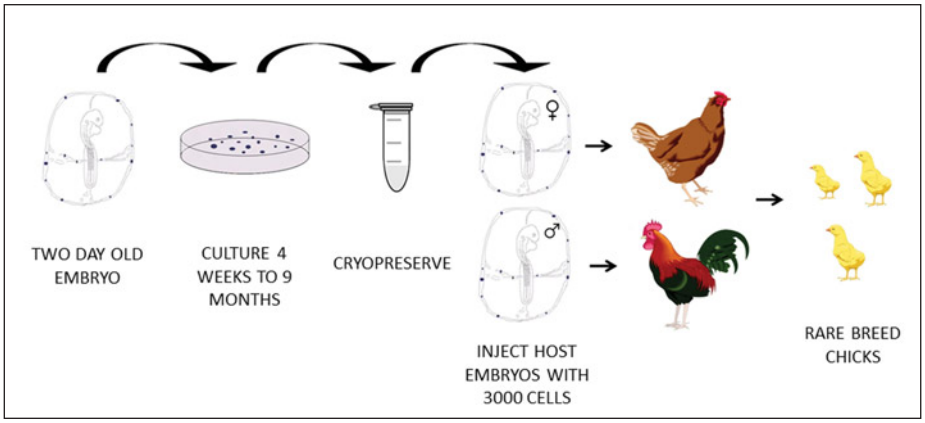

Fig. 2 Diagram of the cell culture for Primordial germ cells (PGC)

IMAGE Innovative Management of Animal Genetic Resources

Michèle Tixier-Boichard
IMAGE Project

+33 (0) 134 652 178

michele.boichard@inra.fr
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