

## Conservation of animal genetic resources – A new tact



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### ABSTRACT

For the past 20 years countries have initiated programs to sustainably conserve farm animal genetic resources. At the same time the growing need for increased animal productivity has emerged. Viewing gene banks and *in vivo* conservation in the context of food security, climate change, and product demand suggests the need for a more efficient use of these mechanisms to support sustainable productivity. Some advances have been made in developing and implementing *in-vivo* conservation programs, but those efforts appear to be predicated upon various types of government subsidies, which are subject, to policy changes. Given the *in-vivo* situation, it is suggested conservation efforts shift toward gene banks as the primary conservation mechanism. Globally, national gene banking efforts have increased and they have the capacity and potential to become more dynamic, incorporate different biological materials and facilitate increased use of genetic diversity. The next steps for gene banks are to better utilize information systems to integrate and store data from genetic/genomic assessments, cryopreservation, phenotypes and environmental conditions. These types of benefits plus the reduced conservation costs gene banks can speed the rate of conserving breeds while freeing the livestock sector to increase productivity with the breeds of their choosing.

### 1. Introduction

Over the past twenty years substantial progress have been made in conserving animal genetic resources for food and agriculture (AnGR).<sup>1</sup> Globally, national programs, non-government organizations (NGOs), and producer-based activities are executing *in vivo* and *in vitro* (gene banking) conservation (FAO, 2007, 2015). Across regions well-established and newly formed national gene banks are operating and providing genetic security for AnGR (Table 1). Our objective is to highlight the growth in gene banking efforts and to explore future roles on how they might be more fully utilized.

Global drivers of population growth, income, and climate change are and will impact AnGR. Improved animal productivity will be required to meet the projected 2.4% annual increase in meat consumption from 2013 to 2022 in developing countries (USDA, 2013). Increased animal productivity, not gross production levels, should be a primary format for addressing food security needs in a sustainable manner. For example, for the least developed countries spread across regions, animal productivity has been stagnant or decreasing, especially for ruminant species (Fig. 1, FAOSTAT, 2014). This finding suggests greater emphasis is needed on a variety of mechanisms to

increase animal productivity as well as choices about breeds and breed improvement are necessary. In addition, climate change will be impacting food security (Jones and Thornton, 2009; Godfray and Garnett, 2014). Seo and Mendelsohn (2008) have shown, for example, that under climate change scenarios there could be a shift from cattle production to small ruminant production in parts of Sub Saharan Africa. Such a shift would likely mean a substantial loss of capital for producers in that region. Therefore new or existing genotypes of interest will have to be modified or developed. Such changes in allelic frequencies may require access and utilization of a broad array of genetic variation, which may fit an environmental niche more easily (Krehbiel et al., 2015).

Scherf and Baumung (2015) reported progress in FAO's Global Plan of Action for AnGR, however they also recognized biases in evaluating the survey data. But while *in vivo* activities are in place for many countries, there is a lack of change in the same report's indicators for sustainable development. Furthermore FAO (2015) reported unknown breeds have not significantly decreased since an earlier report (FAO, 2007) and it is unclear if this situation will change. In addition, a recent multivariate analysis from the reports that were the basis for the Second State of the World's (SOW) for Animal Genetic Resources for

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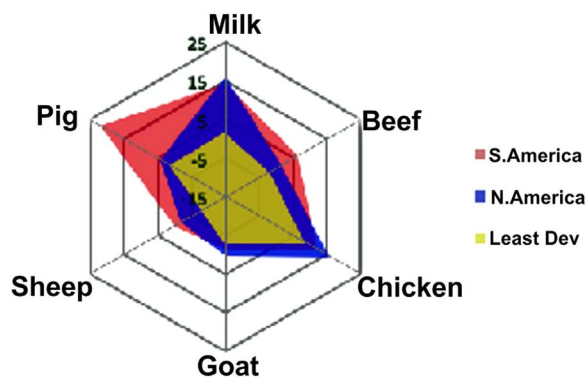
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<sup>1</sup> A glossary about all the main terms used in Animal Genetic Resources field might be found in FAO 2016.

**Table 1**  
Exemplary *in vitro* collection sizes from selected countries<sup>a</sup>.

Country	Species	Breeds/ lines	Animals	Number doses/ straws <sup>a</sup>
Austria	5	29	491	12,095
Brazil	12	25	2,508	93,803
Canada	9	31	3,077	261,083
Colombia	3	16	721	48,220
Finland	2	6	268	399,600
France	9	181	6,704	334,941
India	8	38	276	123,483
Italy	4	30	1,230	296,945
Japan	8	97	5,553	123,927
Netherlands	7	59	7,252	311,182
Norway	2	18	1,071	283,850
Philippines	3	11	118	208,754
Poland	2	9	214	53,382
Portugal	3	36	399	195,046
South Korea	4	18	2,123	159,047
Sweden	1	7	256	75,744
Ukraine	4	30	209	130,805
United States	38	149	35,554	779,720
Total	–	–	67,906	3,982,714

<sup>a</sup> Data from public and available material in April 2016.



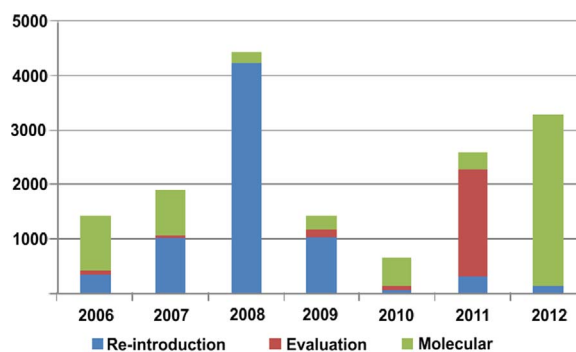
**Fig. 1.** Animal productivity comparison among North America, South America and Least Developed countries following FAOSTAT.

Food and Agriculture (Leroy et al., 2016) have shown that OECD and BRICS countries differed from less developed ones. This observation, besides to be expected, might suggest a review of conservation methods/ strategies in order to expand the AnGR conservation in developing countries.

Juxtaposed to these challenges is the ever-increasing information on livestock genomes and tools that can be used to bring genomic knowledge to bear on the previously stated problems (e.g., Fernández et al., 2016; Scherf and Baumung, 2015; Ouborg et al., 2010). In this paper we evaluate various aspects of conservation methods for animal genetic resources in the context of global challenges. Specifically we explore how the livestock community might make greater utilization of cost effective approaches like gene banking.

### 1.1. *In vitro* conservation via gene banks

Gene banks are the primary mechanism for *in vitro* conservation and may also be the most dynamic element in the conservation of AnGR today. Globally, FAO (2015) estimated 128 countries have reported the presence of gene banks across all regions. Since the early 2000's national gene banks have accumulated substantial inventories of germplasm and tissues. A review suggests the minimum size of this global collection likely exceeds 67,000 animals and approximately 4 million germplasm/tissue samples across species (Table 1). Most national collections have focused upon the primary livestock species, but species important to specific countries have also been collected (e.g., bison, equine, ducks, aquatic species). Another important aspect



**Fig. 2.** Number of samples released from the U.S. gene bank for molecular studies, germplasm evaluation and re-introduction of genetic resources into *in-situ* populations from 2006 to 2012.

was that the collection size does not appear to be strongly influenced by development status.

In addition to acquiring germplasm/tissue, gene bank collections in a number of countries have been accessed and used for a range of purposes (FAO, 2015). For example, samples in the US collection have been used to reconstitute a needed pig population; enhance the genetic variability for *in-situ* populations of rare breeds; provide breeders of larger commercial breeds with genetic variability to use in their breeding programs, and for molecular genetics and reproductive physiology research (Huson et al., in press; Blackburn et al., 2014; Blackburn, 2012). Notably, in 2012 alone 15% of the animals in the US collection were used for the above-mentioned purposes (Fig. 2).

With the emergence of gene banking, FAO (2012) published guidelines for establishing gene banks and cryopreservation protocols. A key change in that report compared to an earlier report (FAO, 1998) was the recognition that reconstituting breeds could be accomplished with greater efficiency than previously assumed. During the late 1990's the concept that gene banking was more expensive than maintaining *in vivo* populations (FAO, 1998) was advanced. But this concept was not supported in the past (Smith, 1984; NRC, 1993).

Recent work shows gene banking to be more cost effective than maintaining *in-situ* populations. In comparing the maintenance of *in-situ* poultry populations to gene banking over a 20 year time horizon it was shown that gene banking reduced the cost of conserving the populations by more than 90% when compared to *in-situ* conservation (Silversides et al., 2012). In Indonesia the government spent approximately \$400,000 over 10 years to conserve 56 Gembrong goats (\$714/goat/year), and it is now assessing the economic viability of the approach (FAO, 2015). When exploring community based conservation – external compensation required to maintain Borana cattle in a community based breeding program differed by 7 fold in Kenya vs Ethiopia (Zander et al., 2009). Unfortunately little if any consideration has been given to how once such subsidies are put in place how can they be effectively removed without causing the population of the effected breed to collapse. In addition, *in vivo* conservation methods often do not consider opportunity costs associated maintaining non-competitive breeds, although the results of Zander et al. (2009) suggest livestock owners internalized the cost associated with conserving a breed that underperform in different production systems. Acknowledging this shortcoming, there is a need for more market driven solutions with government interventions playing a secondary role (Blackburn, 2007). Furthermore, given the magnitude of these expenditures it becomes evident that these monetary inputs would be sufficient to support country or regional gene banks for all species and breeds within a country instead of one or two breeds (Pizzi et al., 2016; FAO, 2012; Silversides et al., 2012).

There has also been the assumption that gene bank collections only represent breeds for one fixed point in time and therefore overtime gene bank collections lose relevance as the *in vivo* allele frequencies

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