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Review

Cryobanking of farm animal gametes and embryos as a means of conserving livestock genetics

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ABSTRACT

In the last few decades, farm animal genetic diversity has rapidly declined, mainly due to changing market demands and intensification of agriculture. But, since the removal of single species can affect the functioning of global ecosystems, it is in the interest of international community to conserve the livestock genetics and to maintain biodiversity. Increasing awareness on the reduction of breed diversity has prompted global efforts for conservation of farm animal breeds. The goals of conservation are to keep genetic variation as gene combinations in a reversible form and to keep specific genes of interest. For this purpose two types of strategies are usually proposed: in situ and ex situ conservation. In situ conservation is the breed maintaining within the livestock production system, in its environment through the enhancement of its production characteristics. Ex situ in vivo conservation is the safeguard of live animals in zoos, wildlife parks, experimental farms or other specialized centres. Ex situ in vitro conservation is the preservation of genetic material in haploid form (semen and oocytes), diploid (embryos) or DNA sequences.

In the last few years, ex situ in vitro conservation programs of livestock genetic resources have focused interest on cryopreservation of gametes, embryos and somatic cells as well as testis and ovarian tissues, effectively lengthening the genetic lifespan of individuals in a breeding program even after the death. However, although significant progress has been made in semen, oocytes and embryo cryopreservation of several domestic species, a standardized procedure has not been established yet.

The aim of the present review is to describe the cryobanking purposes, the collection goals, the type of genetic material to store and the reproductive biotechnologies utilized for the cryopreservation of farm animal gametes and embryos.

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1. Introduction

Breed development is a dynamic process of genetic change carried out by environmental conditions and selection by humans. The fact that ecosystems are dynamic and complex and that human preferences change, has resulted in the evolution of breeds and, until recently, a net increase in diversity over time (FAO, 2007a,b). However, in the last few decades, farm animal genetic diversity has rapidly declined, mainly due to changing market demands and intensification of agriculture. But, since the removal of single species can affect the functioning of global ecosystems, it is in the interest of international community to conserve the livestock genetics and to maintain biodiversity (Myers et al., 2000).

Increasing awareness on the reduction of breed diversity has prompted global efforts for conservation of farm animal breeds for several reasons, for example, to keep potentially useful genes and gene combinations, to take advantage of heterosis, and to overcome selection plateaus, as well as for cultural reasons, research, and food security. Maintaining genetic diversity also provides insurance against climate change, disease, changing availability of feedstuffs, social change, selection errors, and unforeseen catastrophic events (Skuterud et al., 2005). The goals of conservation are to keep genetic variation as gene combinations in a reversible form and to keep specific genes of interest (Prentice and Anzar, 2010).

For this purpose two types of strategies are usually proposed: in situ and *ex situ* conservation. In situ conservation is the breed maintaining within the livestock production system, in its environment through the enhancement of its production characteristics. *Ex situ* in vivo conservation is the safeguard of live animals in zoos, wildlife parks, experimental farms or other specialized centres. *Ex situ* in vitro conservation is the preservation of genetic material in haploid form (semen and oocytes), diploid (embryos) or DNA sequences.

Ideally, population are saved as live animals, by in situ conservation strategies but, since this approach is too expensive, *ex situ* conservation strategies have been developed to cryopreserve animal genetic resources in order to regenerate a particular population in future (Holt and Pickard, 1999). In the last few decades, *ex situ* in vitro conservation programs of livestock genetic resources have focused interest on cryopreservation of gametes, embryos and somatic cells as well as testis and ovarian tissues, effectively lengthening the genetic lifespan of individuals in a breeding program even after the death (Andrabi and Maxwell, 2007; Lermen et al., 2009).

However, although significant progress has been made in semen, oocytes and embryo cryopreservation of several domestic species, a standardized procedure has not been established (Prentice and Anzar, 2010).

The aim of the present review is to describe the cryobanking purposes, the collection goals, the type of genetic material to store and the reproductive biotechnologies utilized for the cryopreservation of farm animal gametes and embryos.

2. Cryobanks

2.1. Cryobanking purposes

For the past few years, a growing awareness of the importance of genetic resources went along with an increased number of actions aiming to preserve and enhance them. European and international consultative forums were created within the European Union, European Association for Animal Production (EAAP), and the FAO (Food and Agricultural Organization of the United Nations) to discuss this important topic and trigger specific actions to preserve the genetic resources worldwide (Dauchin-Burge et al., 2002). However, turning this idea into reality is a complex process, requiring interdisciplinary collaboration and clearly defined goals (Holt and Pickard, 1999).

Cryopreservation of animal germplasm is not new, indeed semen from cattle has been viably cryobanked and stored since the late 1950s. Meantime, cryobanking techniques have been improved extending our capacity to store semen from other species and to store a variety of other tissues (e.g., embryos, blood cells, fibroblast cells, primordial germ cells) for farm animal species of interest (Amstislavskii and Trukshin, 2010). However, cryobanking of germplasm and animal tissue has been an under utilized tool in national conservation programs. The often heard comment is that the approach is too costly or that it requires greater technical expertise. One common purpose of a germplasm repository is to provide the