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Status of embryo production in the world

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Abstract

In the last century, agriculture has seen the introduction of innovating reproductive biotechnologies that have permitted this field to grow significantly. In the early 20th century, introduction of semen cryopreservation and artificial insemination has propelled animal agriculture worldwide with the possibility to import and export in a biosecure way genetics from different species. Then, with the development of embryo transfer, it was possible to import and export not only half of the genetic component by disseminating frozen embryos in biosecure manners. Later, the introduction of ultrasonography (which gave us transvaginal ovum pick-up) and *in vitro* fertilization (IVF) revolutionized the speed at which generations of embryos could be produced thus shortening the generation gaps between these important genetics for farmers. Finally, the introduction of genomics again revolutionized the precision and speed at which farmers could identify the desired genetics. The bovine industry is an example of a niche that profited by the development of these technologies. In the last 15 years, IVF embryo production has increased significantly year after year with an all-time high of 42% of the total embryos produced in 2013 were of IVF origin. There are several reasons why IVF is being used more and more in the embryo transfer business: *in vitro* culture media have improved significantly; Introduction of sexed semen for IVF permits farmers to get over 90% of embryos of the desired sex; The interval between generations has reduced significantly with the identification of the next elite male and female genetics using genomic technology. The international agricultural community will benefit by integrating new technologies such as IVF in their operations. It is important that international societies such as SBTE and IETS continue to support scientists and players in this field to develop these technologies.

Keywords: genomics, *in vitro* fertilization, IVF, sexed semen.

Mini-Review

The last 80 years have seen great innovations in the field of Assisted Reproductive Technologies (ARTs). The introduction of innovating ARTs throughout history has rendered farmers and their agricultural businesses more efficient and more profitable. Between the 1930s and 1960s, agriculture has seen the introduction of great innovations such as artificial insemination, semen cryopreservation, oestrous synchronisation and embryo transfer (ET). It is not before the 1980s and 1990s that we witnessed the next generation of biotechnologies that revolutionized the ET world - ultrasonography, embryo freezing and sexing, *in vitro* fertilization (IVF), cloning and semen sexing. Finally, it is in the 21st century that we witnessed yet another innovation that has revolutionized the agricultural business - genomics.

As president of the International Embryo Transfer Society (IETS), I have the opportunity to exchange with many peers in the ET field. IETS's Data Retrieval Committee, chaired by Dr George Perry, consists of a group of individuals from around the world that collect and present world-wide data on activities related to ET technologies in domestic farm animals. The most recent report can be found in the 2015 March IETS Newsletter (Perry, 2015). It is important to note that the data reported in this report is only as valid as the number of countries that have participated. In 2013, only 40 countries have offered embryo data. But the report still gives a good representation of the embryo production status world-wide.

The bovine industry remains the niche that uses extensively ARTs to propagate genetics. Figure 1 illustrates the evolution of both *in vivo* and *in vitro* bovine embryo production between 1997 and 2013. In this figure, it is apparent that *in vivo* embryo production increased significantly between 1997 and 2005. Then *in vivo* embryo production leveled off in 2006 and seemed to decrease slightly with the following years up to 2013. On the other hand, although hardly used in the late 1990s, IVF embryo production has increased significantly year after year with an all-time high of over half a million IVF embryos produced in 2013, which represents 42% of the total embryos produced that year (Fig. 1). It is important to note that in 2013, South America alone produced 73% of the IVF embryos while North America produced 22% of these embryos. Interestingly, of the IVF embryos transferred in North America, approximately 20% of these are frozen, while only 5% of the IVF embryos transferred in South America are frozen.

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There are several reasons why IVF is being used more and more in the last 5 years in the ET business.

In vitro culture media have improved significantly in the last 15 years. The migration from a 1-step system that used serum supplementation and/or cell co-culture to sequential defined or semi-defined media resulted in embryos of higher quality, similar to embryo produced *in vivo*. Older IVF systems resulted in embryos that were less cryotolerant to conventional slow-freezing protocols when compared to *in vivo* embryos (Abe *et al*., 2002) and in calves that exhibited abnormal offspring syndrome (Farin *et al*., 2006). Recent defined IVF media result in embryos that survive slow-freezing protocols making it possible to apply Direct Transfer (DT) techniques just like *in vivo* produced embryos. Because DT of frozen embryos is a technique utilized world-wide, this opens up opportunities to export IVF embryos as easily as *in vivo* embryos. Although the import/export of frozen IVF embryos is still limited, different players, whether from the private sector, the universities, or the government, are working with appropriate regulatory agencies to open these markets to meet the global demand for bovine genetics.

- The introduction of sexed semen for IVF (Garner and Seidel, 2008) use has generated new appeal for this assisted reproductive technology. IVF remains an expensive technology with fixed costs that can result in a higher cost per embryo when compared to conventional *in vivo* flushes. Producing over 90% of female embryos for dairy producers following an IVF cycle provides an added-value that makes IVF appealing even at a higher cost per embryo. The beef market can use male sexed semen and produce over 90% male embryos. Additionally, scientists developed 'Reverse Sorting' which consists in thawing a few straws of conventional non-sexed semen, sex the semen after thawing, and use the freshly sexed semen right away in IVF (Morottia *et al*., 2014). This way, clients can sex almost any frozen semen available on the market.
- Genomics has changed the bovine genetic industry (Shojaei Saadi *et al*., 2014). The interval between generations has reduced significantly with the identification of the next elite male and female genetics using genomic technology. Therefore, the time interval a producer may have to profit from the new genetic he calved on his farm is shorter. So any assisted reproductive technology that can produce many embryos in a short period of time becomes very interesting and profitable. One of IVF's major advantage is that within a 40 to 60 day period, a producer would have time to perform 1 conventional flush *vs*. 4 IVF cycles using superovulated donors. So the gain in higher numbers of embryos per time period becomes significantly advantageous when using IVF.

In conclusion, as scientists worldwide acknowledge the challenges we are faced with feeding the growing global population, the international agricultural community will benefit by integrating new technologies in their operations to assure the sustainability of global livestock and meat demands. IVF seems to be one of these important innovations that will assure the trade of genetics of various species across the globe. It is important that international societies such as SBTE and IETS continue to support scientists and players in this field to develop and promote the different ARTs developed by our peers.

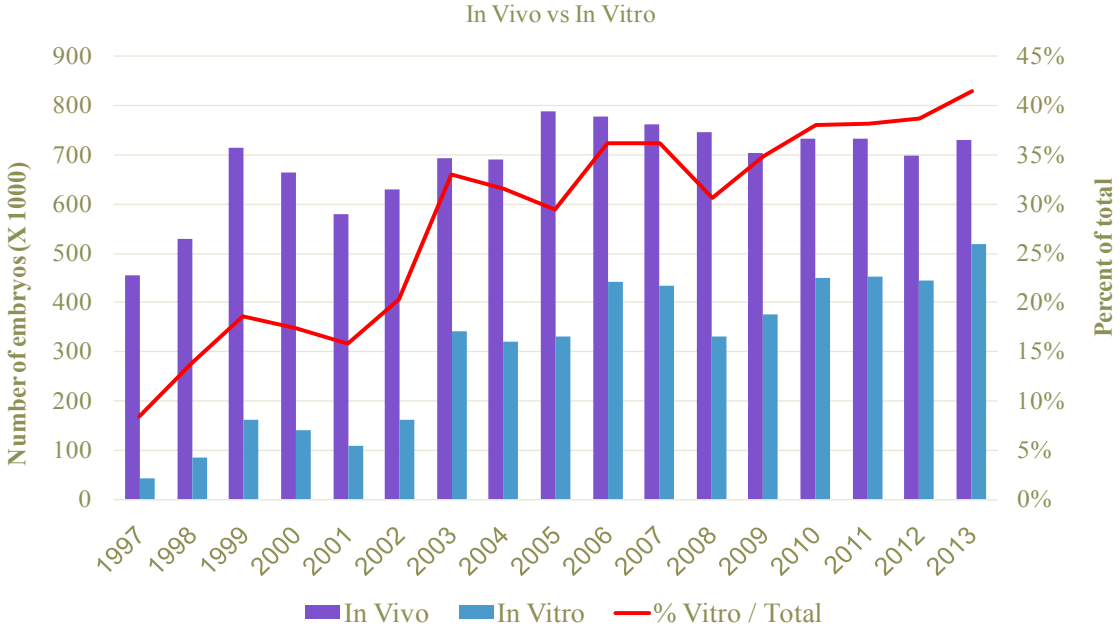

Figure 1. Worldwide *in vivo* and *in vitro* bovine embryo production between 1997 and 2013.

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