PHOTO BY SHAUNA ROSE HERMEL

The 'ART' of Delivering Genomics

Assisted reproductive technologies help deliver high-quality genetics.

by ***Kasey Brown,*** *senior associate editor*

Sometimes what seems like science fiction can actually help shape the future of technology. *Star Trek* and *James Bond* movies had new-fangled wrist communicators, and now several companies offer "smart watches," which can receive and send phone calls, text messages and emails. Cloning was a far-off idea, but Dolly the sheep made animal cloning a reality in the mid-1990s. With the cow herd in a rebuilding phase, technology could be the key to quicker generation intervals and increased access to higher-quality genetics.

Pablo Ross, assistant professor in the Department of Animal Science at the University of California–Davis, explains that genetic progress stagnates without the use of assisted reproductive technologies (ARTs). ARTs include artificial insemination (AI), embryo transfer (ET), *in vitro* fertilization (IVF) and more. Without ART, it is a lot tougher to incorporate genetic selection tools.

Genomic progress

He illustrates the point sharing that winning times in the Kentucky Derby, in which the horses run 1.25 miles, from 1950 to 2010 have ranged from 119 seconds to 125 seconds. In 60 years, the trend line of winning times is pretty flat, due to mostly phenotypical selection of racehorses (see Fig. 1).

Genomic selection uses genetic markers distributed across the whole genome, and by using a reference population for which both phenotypes and genotypes are available, accurate predictions are made of the phenotypic potential of animals. Analysis can be done as soon as DNA can be obtained, such as at calving or even at the embryonic stage, he explained.

Angus producers have a host of genomic information at their fingertips already with genomic-enhanced expected progeny differences (GE-EPDs), notes Dan Moser, president of Angus Genetics Inc. (AGI) and director of breed improvement for the American Angus Association. In addition to GE-EPDs, Angus breeders have several options for genomic testing for further information on specific animals. Many bulls have high- or low-density tests done, and even commercial cattlemen have genetic tests available to them to help select the best-performing steers or replacement heifers. Blood or hair follicle samples are necessary for these genomic tests.

Ross notes that genetic progress equals selection accuracy times genetic variation times selection intensity, all divided by generation interval. With beef cattle, the biggest inhibitor to genetic improvement is the generation interval. However, there are ways to speed up that interval, and the technology is already available.

Using technology

In particular, Ross says ET and *in vitro* embryo production (IVP) could be used to shorten the generation interval dramatically.

PHOTO BY TROY SMITH

►To build a larger, high-quality cow herd faster, Pablo Ross, assistant professor in the Department of Animal Science at the University of California–Davis, highlights the opportunities to use genomics to select top females and the use of sexed semen to produce replacement females.

To build a larger, high-quality cow herd faster, he highlights the opportunities to use genomics to select top females and the use of sexed semen to produce replacement females. For instance, he suggests, through superovulation and ET, a young female could be superovulated three times beginning at 12 months of age, producing 15 embryos and thus 11 female calves.

AIing the heifer at 15 months of age would produce another female calf. Then, six sessions of ovum pickup and IVF during gestation could produce 18 embryos and, say, 10 female calves. In this scenario, one heifer could produce about 20 replacement females, potentially from different high-quality sires.

"This allows for selection of the top 5% of the herd to contribute to the next generation," Ross says.

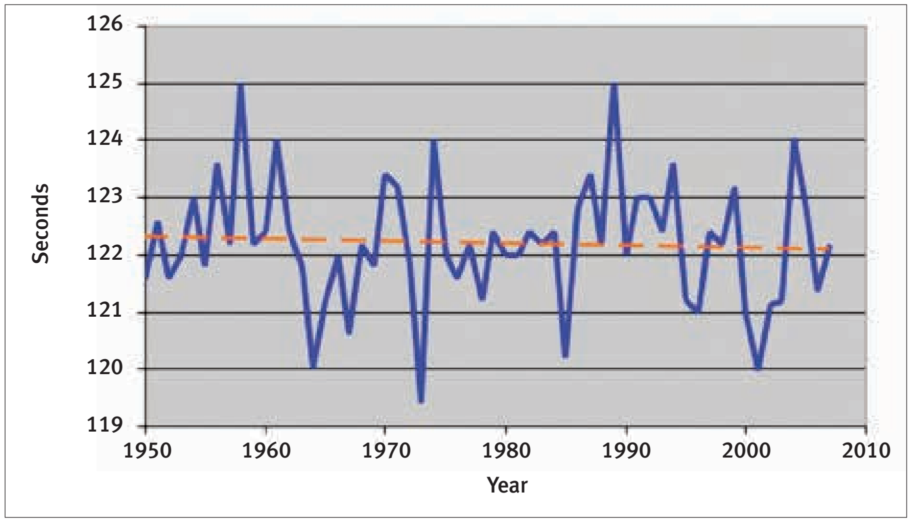
IVP, which includes procedures to retrieve oocytes and sperm from animals, fertilize them in a laboratory and culture the embryo to a certain stage of development, is another option to produce calves more quickly. IVP can be used in gamete/embryo cryopreservation, preimplantation genomic selection, cloning by somatic cell nuclear transfer, and gene editing and transgenics.

Oocytes can be collected in various ways and from various sources. In addition to donor females, he says oocytes can be collected from deceased animals at slaughterhouses, which allows for collecting a large number of eggs for efficient and low-cost production. However, the genetics of these oocytes are unknown. Another option for oocyte collection, Ross mentions, is ovum pickup (OPU) with ultrasound-assisted oocyte aspiration. This retrieves oocytes from specific, genetically high-quality animals. It does require specialized equipment and technicians, though.

Embryos are produced by allowing the oocyte to mature for 24 hours in the lab, then *in vitro* fertilization for about 12-18 hours, then the embryo cultures for six to seven days.

While some of these techniques sound like science fiction, he says IVF maximizes genetic improvement by optimizing the use of top sexed semen and higher embryo donor flexibility. IVF increases and standardizes embryo production, he says, adding that AI produces about six calves in a cow's lifetime, multiple ovulation and embryo transfer (MOET) can produce about 40 calves and OPU/IVF can produce more than 80 calves.

Fig. 1: The consequence of not using ARTs
Kentucky Derby winning times (1.25-mile race time)

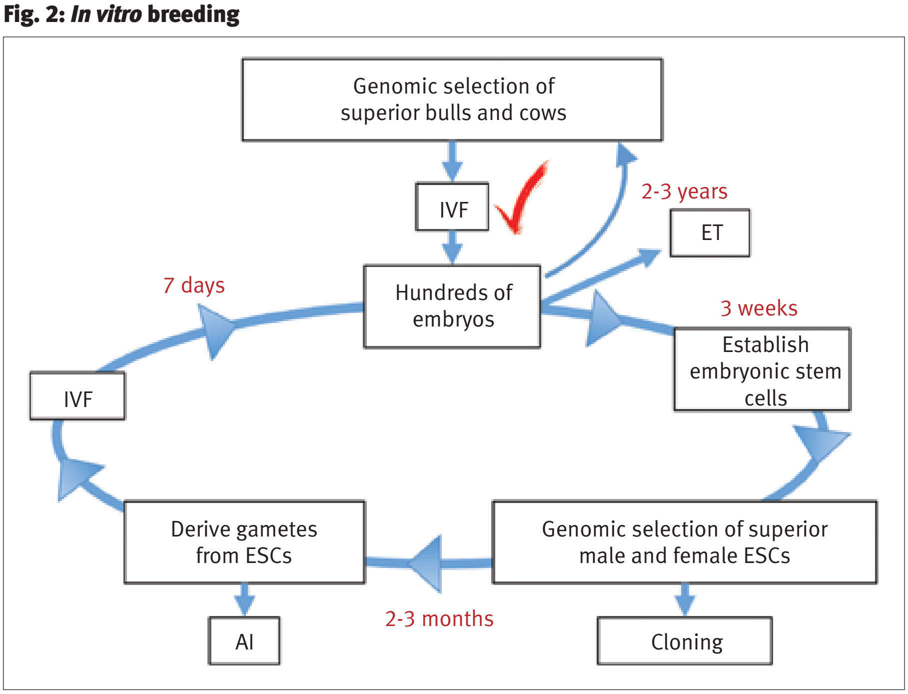


IVF also allows for more flexibility in embryo donors. Donors can be prepubertal heifers, females with uterine or oviductal defects, females refractory to hormonal stimulation, pregnant cows, and dead or castrated animals. IVF can also produce up to 120 calves from one straw of semen, he says, comparing it to one calf from 1.5 straws of semen in AI and three calves per two straws in MOET.

The future for ART and genetic improvement

In vitro breeding and precision breeding may be the way of the future, Ross says. *In vitro* breeding could decrease the generation interval to as little as three or four months (see Fig. 2). Ross explains it would start with genomic selection of superior bulls and cows. Then IVF could produce hundreds of embryos, which could be used in ET, taking two to three years, or to establish embryonic stem cells (ESCs), which would take three weeks. Then genomic selection of superior male and female ESCs could occur. Genetically selected ESCs could then be used to derive gametes, such as through cloning, blastocyst complementation, or eventually completely *in vitro*. Finally, the ESC-derived gametes would be used in AI and IVF to restart the cycle.

Fig. 2: *In vitro* breeding



While sounding like science fiction, about half of the technology already exists and is in use. Deriving gametes from ESCs is coming soon, he says. He adds that the step after cloning presents an obstacle in blastocyst complementation.

Precision breeding takes a concept used now and builds upon it. Instead of making breeding decisions with selection emphasis on certain traits, precision breeding promotes desired alleles that already exist in the population or eliminates undesired alleles without modifying the genetic background. Essentially, it would include editing the genome itself.

New ideas are always necessary to make improvements, and ART, no matter the method used, can deliver high-quality genetics to one's herd.

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Editor's Note: *Ross spoke during the final Applied Reproductive Strategies in Beef Cattle session. Visit the Newsroom at* www.appliedreprostrategies.com *to view his PowerPoint, read the proceedings or listen to the presentation. Compiled by the* Angus Journal *editorial team, the site is made possible through sponsorship by the Beef Reproduction Task Force.*