TRENDING BIOTECHNOLOGIES ON OESTRUS DETECTION, BREEDING AND REPRODUCTIVE EFFICIENCIES FOR SEASONAL AND NON-SEASONAL BREEDERS

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ABSTRACT

Oestrus detection in livestock is reliant on close analysis of behavioural and physical changes on the females in oestrous. The greatest reproductive performance can be achieved optimally as reproduction is directly affected by several management factors effectively operated. More advance techniques are evolving that will be most reliable than the observation of primary signs displayed by the female in response to the male, currently in use. Oestrus detection is a valuable tool for use in artificial insemination techniques, hand mating, and for use in predicting parturition dates. Control of post-partum ovarian activity, control of seasonal breeding, control of multiple births and litter size, pregnancy testing technology, controlling parturition, controlling onset of puberty are connected to manipulation of breeding strategies.Development of novel reproductive biotechnologies are; assisted reproductive techniques (ARTs) that includes: artificial insemination (AI), embryo transfer (ET), multiple ovulation embryo transfer (MOET), oestrus synchronization (control) and superovulation, *In Vitro* Embryo Production- laparoscopic ovum pick up (LOPU), *in vitro* maturation, fertilization and culture (IVMFC), intra cytoplasmic sperm injection (ICSI), cryopreservation of sperm, oocytes and embryos, sperm and embryo sexing,embryo splitting, embryo cloning, nuclear transfer (NT), gene transfer, gene-edited livestock 'surrogate sires' etc.Oestrus detection signs and aids are numerousas such crucial in livestock reproduction whichpromotesmost favorable breeding and reproductive efficiencies. Seasonal breeders like sheep and goats have diversified products of commercial value. Maximizing reproductive efficiency leads to significant increase in productive ability of seasonal breeder's number of biotechnological reproductive methods enumerated and newer ones in perspective.

Keywords: Assisted reproductive techniques (ARTs), breeders, breeding,efficiencies and oestrus

INTRODUCTION

Oestrus detection ranges from primary, secondary, physical signs and evolving aids that elicit helpful guides to establishing pregnancy, its management as well as prediction of foetuses health, sexes, litter sizes and hosts of fertility enhancements procedures naturally or artificially. Pregnancy detection aids are numerous and include; marker animals, teasers, "Gomer", electronic heat-detection, use of colored paint, dyes, oil, or grease smeared on the brisket or attached to the collar or halter of the bull, chin-ball marker, ballpoint pen, KaMar heat detectors, electronic pressure-sensitive devices-heat watch, tail painting or tail chalking, electronic pedometers or motion sensors, use of milk or blood progesterone kits, rag that has been rubbed on the buck, marking harness, back pressure test, heat patch, presence of boar in adjacent pen, Flehmenresponse etc. Controlling the onset of puberty and manipulation of reproduction using efficient breeding techniques has been the subject of scientific interest for many years to come. High level of reproductive performance can be achieved under optimum management conditions because reproduction is directly affected by various management factors. Manipulation of these factors causes changes in reproductive performance. Biotechnology is among the fastest growing discipline of modern progress in scientific domain. Technologies such as nuclear biology, genetic engineering and stem cell research have made scientists to have wide vision on the design and function of living organisms now and in the future. These technologies resulted to revolution in commercial livestock production as well as other animal related sectors. The application of these biotechnologies enables intensification of the rate of genetic progress, reproductive efficiency and significant increase in productive ability (Rahman *et al.,* 2008).

Modern assisted reproductive techniques (ARTs) allow animals of high genetic merit to produce more offspring than would be possible by natural or conventional breeding. This has enhanced improvement, preservation of livestock genetics, as well as enhancements of both breeding and reproductive proficiencies. Besides, ARTs have allowed both in seasonal breeders to successfully mates during certain times of the year, thereby allowing for births with optimum conditions for the

survival of the young. Female breeders having one or more estrous cycles in specific season of the year can not express this cycle at other times of the year, rather than as being anestrous. Male seasonal breeders may exhibit changes in testosterone levels, testes weight and fertility depending on the time of year (Table 1). Seasonal breeders like sheep and goats are convenient domestic species for biological investigation and application because these species have diversified products of commercial value (Yager *et al.*, 2003).

Table 1: Normal ranges of reproductive behaviour

Animal	Types of oestrus cycle	Length of oestrus cycle (days)	Duration of oestrus(Hrs/Days)	Time of ovulation
Cattle	Polyestrous	19-23 Average: 21	6-30 hrs Average: 18	12 hours at the end of estrous
Goats	Seasonal polyestrous in fall	12-24 Average:20	1-4 days Average: 2	30-36 hours after start of estrous
Sheep	Seasonal polyestrous in fall	14-20 Average: 17	20-42 Average: 31	At or near the end of estrous
Horse	Seasonal polyestrous in Spring	10-37 Average: 21	2-6 days Average: 4 days	24-48 hours before the start of 24 hours after the end of estrous
Swine	Polyestrous	18-24 Average: 21	1-2 days Average: 36 days	8-12 hours before the end of estrous or 37-40 hours after start of estrous

Source: Yager*et al.* (2003)

Besides, sheep and goats have a relatively short generation interval as compared to cows. Biotechnological alterations could make significant impacts on the quality of sheep, goat, swine, guinea pigs, rabbit and emerging micro livestock enterprises. The factors which influence the breeding efficiency of ruminants includes; number of ova, percentage of fertilization, embryonic death, age at first pregnancy, frequency of pregnancy, longevity, and they increase production potential of seasonal breeders essentially through reproductive rate. There are number of factors that affect reproductive efficiency such as climate, stress factors other than heat stress**,** social environment, nutrition, disease, population density, gonadotropins, photoperiod etc. The objective of this review is to present modern trending techniques of oestrus detection, breeding and reproductive efficiencies for fertility, reproductive rates enhancements for both seasonal and non-seasonal breeders. Although, most of the recent developments in optimizing reproductive efficiency are expensive, they guarantee improved reproductive performances through the following strategies:

Manipulation of breeding cycle: This is achieved by manipulating the activity of corpus luteum to synchronize the estrus cycle. Synchronization of oestrous during breeding season and anoestrus are made by stimulating the activity of the corpus luteum that produce progesterone in quantity for about 2 weeks and shutting off production sharply at the end of the oestrus cycle.

Control of post-partum ovarian activity: These includes manipulations of physiology and endocrinology of the post-partum animals through strategies for inducing resumption of ovarian activity, assessing nutritional status and current treatment protocols of any ARTs of interest and affordability.

Breeding at younger ages:The age at first parturition mainly depends on the growth rate of the animal species. The young age reduces maintenance costs, shortens the generation interval, increase the genetic gain and increase lifetime production.

Increasing fecundity:It is necessary to increase the fecundity of ewes and does to get more profit. Increase in fecundity can be achieved by the use of pregnancy mare serum gonadotropin (PMSG) on day 14 of the oestrus cycle and also by immunization of ewes and does against their own steroid hormones which cause rise in the ovulation rate.

*Multiple births and litter size***:** Development of control measures to achieve multiple births or litter sizes includes; historical, physiology and endocrinology of multiple ovulations, nutritional and environmental factors, genetic factors, use of gonadotropins, immunization approach, embryo transfer, litters, neonatal mortality and animal welfare considerations among many others(Gordon, 2005).

*Breeding and Non-breeding Seasons***:** Practical applications of hormonal and light regimes, animal management, melatonin treatment, light control in rams and stallions are very essential.

Controllingof parturition:Stimulation of parturition must be compatible with the survival and the normal development of the young ones' without or least possible deleterious effect on lactation, maternal behaviors' as well as to reduce lamb mortality by applying best management in highly sophisticated intensive farming. E.g.The injection of dexamethasone, a corticosteroid which mimics the action of the signal normally produced by the foetus to initiate parturition.

Enhancing female fertility: Nutritional, hormonal approaches and trophoblastic vesicles are very key to enhanced fertility in female species (Gordon, 2005).

Early pregnancy detection: This is necessary for better care and to detect pregnant animal carrying multiple foetuses or not, so that special management can be applied, to eliminate foetal mortality at the time of parturition. Pregnancy test techniques are; palpation per rectum, progesterone and oestrogen assays, faecal testing, predicting litter size, use of ultrasonics, early dipstick tests, radiology, PMSG detection in blood(Gordon, 2005).

Artificial insemination(A.I): Thishas great influence in the improvement of productivity with least detrimental effect on conception and birth rates.

Embryo transfer (ET):ET techniques are numerous; superovulation, embryo recovery and evaluation, *in vitro* culture and cryopreservation of embryos, donor–recipient synchrony, non-surgical embryo transfer procedures, selection and management of recipients, applications for breeding improvement, gender pre-selection and genetic preservation of endangered breeds or species(Gordon, 2005).

Mature and juvenile in vitro embryo transfer: Transferrable embryos can be produced in vitro after ovum pick-up from super-stimulated donor ewes. The ewes can either be matured, in which case the

technique is termed “mature *in vitro* embryo transfer” (MIVET), or immature/ pre-pubertal ewe that is as young as 3 weeks old “juvenile *in vitro* embryo transfer” (JIVET); which offers rapid genetic improvement via reduction of generation interval (G.I.) to as low as 6 months (Mujitaba *et al.* 2021).

In vitro embryo production and transfer:Embryo production by *in vitro* includes;*in vitro* maturation, fertilization and culture (IVMFC) of embryos, which have the potential to improve the number of offspring produced by genetically valuable female. Immature oocytes are collected from slaughterhouse ovaries by aspiration of follicles or slicing. The various steps involved in IVMFC are in vitro maturation of the immature oocytes, fertilization of the matured metaphase II (MII) oocytes with in vitro capacitated fresh or frozen-thawed semen and culture in vitro of presumptive zygotes for 7-8 days until formation of blastocysts that can be transferred to recipients or cryopreserved for future use (Mishra *et al.,* 2010).

Laparoscopic ovum pick up(LOPU): This is one of the best techniques for oocyte recovery from live animals. It is the most effective and non-invasive technique, which cause less adhesion related problems compared to laparotomy or surgical oocyte collection. LOPU technique improves poor results observed with superovulation, such as poor ovulation rate, early regression of corpora lutea, poor fertilization and repeated production of oocytes/embryos from a single donor (Baldassarre and Karatzas, 2004).

Intracytoplasmic sperm injection(ICSI): This is the mechanical insertion of a single sperm directly into the cytoplasm of a matured oocyte using a microscopic needle. It is a special type of *in vitro* fertilization (IVF) and one of the advanced ARTs that is now widely used to overcome male factor infertility in human. In livestock, this technique facilitates multiple live births in a number of species. Although the technique has potential to improve livestock production, however, till now it has not been commercially used in animal production (Jimenez-Macedo *et al.,* 2007).

Cryopreservation of sperm:The cryopreservation technique of sperm can be used for sperm storage indefinitely; it is used widely and exported easily. The frozen sperm facilitates exchange of genetic material, allows AI in both the reproductive and non-reproductive seasons and extends the effective reproductive life of a valuable male beyond its own life time.

Cryopreservation of oocytes and embryos:Oocytes and embryos are preserved for long period of time in liquid nitrogen by using a programmable freezer, quick freezing, direct plunging and vitrification techniques. Various cryoprotectants such as glycerol, dimethyl sulfoxide (DMSO), ethylene glycol, polyethylene glycol and sucrose can be used. Ethylene glycol is considered to be the most suitable cryoprotectant though excellent results were reported with DMSO or glycerol (Sharma *et al.,* 2010).

Sexing of sperm and embryos:Sperm sexing is based on the well-known difference in X and Y sperm in the amount of DNA present. Although sex-sorted sperm for AI, IVF or ICSI has increased efficiency of reproduction in livestock, yet the process of commercialization of sexed sperm is not without constraints of high costs, technical challenges and lower pregnancy rates.

Sperm sex-sorting: Thisis among emerging technologies such as nanotechnology and microfluidics that may enhance the fertility potential of samples of sex-sorted semen; for improved reproductive management, conservation programs, while embryo sex-selection using IVF and pre-implantation genetic testing (PGT) is accepted only for medical reasons in humans (Neculai-Valeanu and Ariton, 2021).

Embryo splitting:The facility to split embryos generating identical twins was developed few years ago. The purpose of embryo splitting is to provide genetically identical twins to be used for experimental purposes or to increase the number of transferable embryos.

Cloning and transgenesis:Thisis the asexual production of genetically identical animal that can be obtained by embryo splitting or by nuclear transfer (NT) with larger clones’ efficiently generated. Though cloning can be generated by embryo splitting, however embryo sectioning for more than once will drastically reduce chances of survival.

Gene-edited livestock 'surrogate sires':Zaske (2020) for the very first time reported that scientists were able to produce pigs, goats and cattle that served as viable 'surrogate sires', male animals that produce sperm carrying only the genetic traits of donor animals. The CRISPR-Cas9 technique was used to produce mice, pigs, goats and cattle that lacked a gene called NANOS2 which is specific to male fertility. The male animals grew up sterile but otherwise healthy, so when they received transplanted sperm-producing stem cells from other animals, they started producing sperm derived from the donor's cells hence crucial for selective breeding.

Conclusion: Oestrus detection is a valuable tool for use in artificial insemination techniques, hand mating, and for use of predicting parturition dates. Animal production directly depends on reproduction and optimum reproductive efficiency is a pre-requisite for animal production. Seasonal breeders like sheep and goat have diversified products of commercial value. To maximize these, reproductive efficiency and significant increase in productive ability of seasonal breeders using a number of biotechnological reproductive techniques discussed above can be applied.

REFERENCES

Baldassarre, H. &Karatzas, C.N. (2004). Advanced assisted reproduction technologies (ART) in goats. *Animal Reproduction Science*, 82-83: 255-266.

Gordon, I.R. (2005).Reproductive Technologies in Farm Animals. Pp. 16-297.CABI Publishing, CAB InternationalWallingfordOxfordshireOX108DEUK: 875 Massachusetts Avenue 7thFloorCambridge, MA 02139USA

Gupta, S.**,** Agarwal, A.**,** Banerjee, J. & Alvarez, J.G. (2007). The role of oxidative stress in spontaneous abortion and recurrent pregnancy loss: a systematic review. *Obstetric Gynecological Surv*ey, 62(5): 335-347.

Jimenez-Macedo, A.R., Paramio, M.T., Anguita, B., Morato, R., Romaguera, R., Mogas, T. &Izquerdo, D. (2007). Effect of ICSI and embryo biopsy on embryo development and apoptosis according to oocyte diameter in prepubertal goats. *Theriogeneology*, 67: 1399-1408.

Mishra, A., Chandra, V. & Sharma, G.T. (2010). Effect of epidermal growth factor on *in vitro* maturation of buffalo oocytes and embryo development with insulin like growth factor-1 and b-mercaptoethanol. *Indian Journal of Animal Science,* 80(8): 721-724.

Mishra, A., Reddy, I.J. & Mondal, S. (2015). Modern concept in optimizing reproductive efficiency of seasonal breeders. *Livestock Research International* | July-September, | Vol 3 | Issue 3 | Pages 51-57.

Mujitaba, M. A., Vass, N., Bodó, S. &Angyal, E. (2021). The recent state of embryo production techniques in sheep breeding - a review. *Hungarian Journal of Animal Production ÁllattenyésztéséstakarmÁnyozÁs,*2020. 69. 4.429-443.

Neculai-Valeanu, A.-S. &Ariton, A.M. (2021). Game-Changing Approaches in Sperm Sex-Sorting: Microfluidics and Nanotechnology. *Animals*, 11,1182. https://doi.org/10.3390/ani11041182

Rahman, A.N.A., Abdullah, R.B. & Khadijah, W.E.W. (2008). A review of reproductive biotechnologies and their application in goat. *Biotechnology,* 7: 371-384.

Sharma, G.T., Dubey, P.K. & Vikash, C. (2010). Morphological changes DNA damage and developmental competence of in vitro matured vitrified-thawed buffalo (*Bubalus bubalis*) oocytes: A comparative study of two cryoprotectants and two cryodevices. *Cryobiology,* 60:315-321.

Yager, A., Neary, M. & Singleton, W. (2003). Estrus detection in farm animals, *Farm Animal Management @Purdue,* Purdue University Department of Animal Sciences. AS-559-W, pp. 1-6.

Zaske, S. (2020) Washington State University. "Gene-edited livestock 'surrogate sires' successfully made fertile: Advance could transform selective animal breeding." *ScienceDaily*. 14 September.