ISSN: 0975-833X

Availableonlineathttp://www.journalcra.com

International Journal of Current Research
Vol. 11, Issue, 09, pp.7148-7152, September, 2019

DOI: https://doi.org/10.24941/ijcr.36630.09.2019

INTERNATIONAL JOURNAL OFCURRENTRESEARCH

RESEARCH ARTICLE

A REVIEW ON ECONOMIC AND COMMERCIAL VIABILITY IN PRACTICAL FIELD ONDITIONS IN NORMAL WORKING OF A DAIRY FARM UPON THE USE OF SEXED SEMEN IN INDIAN CONTEXT

***Aulakh, B.S.**

Department of Applied Pharmacology, Gregor Mendel Institute for Research in Genetics, No. 144/2, Netaji Park, Baloke Road, Haibowal Kalan, Ludhiana, India

ARTICLEINFO

Article History:
Received 19th June, 2019
Received in revised form
11th July, 2019
Accepted 16th August, 2019
Published online 30st September, 2019

Key Words:

Sexed, Semen,
Progenies,
Commercial,
Benefits.

***Corresponding author:** **Aulakh, B.S.**

ABSTRACT

Dairy farming is such a profession these days that has become very competitive and more or less organized on the lines of an industry. Just like industry, it has seen the application of many a new technologies and the trend is growing. Sexing sperm is acclaimed such a new development that has attracted the attention of farmers, organizations and governments alike. This technology of course promises to increase the dairy productivity to many times the existing levels. So, farmers are trying to eagerly implement this on their dairy farms. But dairying is business and just like any other business, it has to be very cautious about input costs, financial outputs and economics of course. Overall, it is a very complicated concern and recently we have seen many dairy farms closing due to a variety of reasons related with financial, social, governmental and management concerns. Sexing semen being a new entrant, also demands a genuine review so that it is implemented with a view to be efficient, successful and beneficial for the profession because the dairy farmer and his financial wellbeing is the central point in this discussion. So, an endeavor in this regard has been attempted in this article to critically examine the concerned operations and their intricacies with relevance to the general running of a dairy farm and the possible nitty-gritty that may be encountered upon the introduction of such a new breakthrough and various fallouts are discussed in greater depth therein.

Citation: Aulakh, B.S. **2019.** "A review on economic and commercial viability in practical field onditions in normal working of a dairy farm upon the use of sexed semen in indian context", *International Journal of Current Research*, 11, (09), 7148-7152.

INTRODUCTION

It is true that the relation of milk and man starts from birth and it is also true that cow milk and milk from other dairy animals has been man's preferred food from times immemorial. Even the civilizations and history can not disclose on the fact of the exact date when man started to rear the first cow to yield milk to him and his family. The concern may not be of any value as looked upon from a view point of today but it certainly highlights on the depth and intimacy of the relation that mankind holds with an important member of animal world known as a cow. In many ways cow and dairying sound synonymous and if we include certain other animals like buffaloes etc, the concept of modern dairying is almost complete. Now there is the question of carrying out the operations related with the profession of dairying on a scale that is more suitable to the farmer concerned and is also beneficial for the society at large. Here comes the concept of modern dairying. Modern dairying is a totally commercial proposition these days and it has become so organized, technologized and involves management skills too. Economics is the core of any business and the strategy and execution of commercial operations is the key to that. This is also true that proclaimingly a new technology of sexing sperm has been introduced in India a couple of years back. The concept seemed to fascinate farmers just immediately but commercial realities hindered the initial juggernaut. Now certain lobbies and governments have again started to display keen interest in this technology and big concerns on national and social fronts are automatically attached with this. But the thumb rule is that the success of anything related with this depends almost totally on the faring of this on the level of a dairy farm. The economics of a dairy farm is the key which will decide the application value as well as the future of this technology. So, a very fair and unbiased review of all activities and mechanisms connected with this new breakthrough is the need of the hour and this is also the motive of the present write up. There are certain benefits like the yield of more female progenies but there are definitely bottlenecks like the fall in conception rate. Now, to evolve a suitable and balanced on field business strategy that will be beneficial to a dairy farmer and ensure better yield to him and his family on commercial as well as financial front and also fruitful for the society and nation at large; we need to discuss all these processes and activities and their outcome of course. Hope, this will prove benefiting all.

The sexed semen technology and advantages thereof: One of the better goals of science and technology has ever been to increase production efficiency at the same or decreased input

cost value. Same principles have been found to be applicable in agriculture when we saw the advent of 'green revolution' phenomenon and farm outputs just multiplied. Similarly, in dairy farming we became witness to 'by-pass feed technology' and other advances that led to increase in dairy outputs. Sexing sperm is another such entrant that promises to increase female herds on a dairy farm and thereby have more milk productions apparently at the same or relatively lesser farm input costs. This involves the production of fractions rich in X sperm for production of more milk or the ones rich in Y sperm for more production of male cattle for beef industry. The benefits are double edged. The more milk production is always better for the profession of dairying and the dairy industry as well. It ensures the farmer more profits for unchanged commercial inputs. The other loftier goals of this technology seem to be the feeding of increased human populations worldwide with nutritious milk and hence in a way to eradicate poverty from this planet.

Expectations: Idealism and clash with reality: It is not a bad idea to increase milk production but any forward action for betterment may have a reaction for the worse in backward direction too. This is the natural rule. The female numbers on the dairy farm should ideally be increased and this prompts the scientists and progressive research organizations to evolve techniques like sexing sperm but the natural fallouts of such advances are just inevitable. One of such bottlenecks in the methodology of sexing sperm is the fall in conception rate that has been a practical hindrance of considerable value. Of course, there may be other drawbacks like the cost factor of the resultant sexed sperm which increases dramatically upon the production of it and the exoticness factor of the high yielding sires etc. These are practical usual field obstacles that are encountered when we hope to have a discussion on the application of this technology on dairy animals.

The sperm damage and fall in conception rate: It is a fact that conception rate does fall upon the application of the technique of sexed semen on dairy animals. No more, it is a hidden truth now. The conception rate falls and since this fall is real; so, there are bound to be certain factors responsible for that. There is lot of material available in prior art on the subject that tells us about the various reasons responsible for this fall (Aulakh, 2018; Hafez, 1985; Hunter, 1982; Garner and Seidel, 2008; Gordon, 1956). One of the big reasons that are quoted as responsible for this fall is the sperm damage that is incurred to the sperm during sexing (Seidel, 2014). It is a known and established fact that conception fall occurs mainly due to this only. And since it is proved that such a thing happens; so, there are also bound to be fallouts of this on the commercial running of the normal and practical on field aspects of a dairy farming business.

Fall in conception turns into economic loss: Any change be it on the positive or negative side; is bound to have a similar fallout. A positive change alters the things for the better and a negative one does it so for the worse. Since conception is an important criteria on a dairy farm that determines the successful running of it; so, a change in it on the better side helps in generating more of the profits for the dairy farmer involved and the opposite dos it just the reverse. There is a thing called lactation cycle that is connected with every milk yielding animal and at the end of it when an animal turns dry, there has to be the start of another lactation cycle so that the animal becomes productive again.

But if the conception fails, the start of the next lactation cycle just stops or it is prolonged as far as the process of conception does not happen and if it is prolonged too long or forever, it definitely means that the on farm productivity of the animal concerned is also delayed too long or forever, whatever the case it may be. So, the conception should happen at the earliest on a dairy farm and it is in favor of the dairy farmer and it ensures better efficiency for him and his business. Naturally, there are compulsory two to three months of 'no heat' after an animal delivers a baby calf and if upon completion of such a period of time it gets pregnant again, then the situation is considered normal but in case the animal does not do so and after consecutive periods of about 21 days of heat cycle, it continues to repeatedly come to heat and does not bear a pregnancy; the phenomenon becomes of repeated conception failures and such an animal is declared as unproductive and removed from the herd and is disposed off in ways definitely more than one. To have animals those do not conceive means to have the running of a dairy farm in commercial loss.

The extent of damage on commercial front: It is definitely a different question so as to know about the extent of the loss that usually occurs when a dairy farmer repeatedly faces the phenomenon of conception failure on his dairy farm. The main question is that it happens and happens it definitely upon the occurrence of such a phenomenon. Now, we can have an estimate as to what may be the extent of this when we consider from the view point of an on field dairy farmer. Here under practical conditions, everything turns out to be so real and any miscalculation or hollow imagination may turn out to be just economically suicidal for the dairy farmer. So, we have to be very realistic and accurate in drawing on our decisions and calculations.

The normal conception rate during AI (artificial insemination) with normal semen in India is about 35-40% in cows. It is 55-60% in case of heifers and buffaloes which are thence considered good conceivers. There is nearly a fall of 15-20% upon the use of sexed semen in all these animal groups. Various explanations are given for this decrease in conception rate and there is almost a unanimous consensus in scientific fraternity that this fall is due to sperm damage during sexing (Seidel, 2014). Another reason is that sexed semen straw contains lesser number of sperms i.e. 1×10^6 as compared to the 2×10^6 sperm count in the normal semen straw. So, it seems that if the sexed semen contains double the number of sperms to its normal dosage i.e. equal to the number of sperms in a normal semen straw, the conception rate should increase but this is not the case in reality as increase in number of sperms in a sexed semen straw even up to concentrations of 10×10^6 sperms did not have a perceptible effect on conception increase (Dejarnette et al, 2008). So, presently we are locked on a situation where the chances of increasing conception success by increasing sperm count in a sexed semen straw are very, very remote. Lactation cycle holds a central position in calculating the overall productivity and efficiency in the running of a dairy farm. So, it draws that after expatriation, when an animal comes to heat after two, three months and the animal conceives upon first insemination, then it is a point of overall profitability for the successful running of a dairy farm. This is an ideal condition but as we know that national conception rate in normal insemination with normal semen is about 35-40% in cows, so it follows that about 35-40 animals do conceive upon first insemination out of every 100 animals that are subjected to such an application.

The remaining animals may come to heat upon next heat cycle or they may do so upon further next cycles, is a crucial thing that may determine the commercial viability of a dairy farm. The drop in conception may play such a role that it may even decide the running of a dairy farm in high profit or even it may sow the seeds of it to head for a heavy loss and ultimate to shut down.

The viability criteria: Comparative study with normal semen usage: The fall in conception is no doubt a serious issue upon the use of sexed semen. By now this fact has been proved beyond doubt. Even Seidel attributed this to the damage to sperm during sexing (Funston & Meyer, 2012; Inaba et al, 2016; Seidel, 2014). Now, the question is that if an animal fails on a certain insemination and it may conceive or not further upon the next insemination during next heat; this means that it certainly misses the number of days of productivity for at least one heat cycle i.e. 21 days or more if it misses more heat cycles. So, the happening of conception is a very crucial thing for the successful commercial viability of a dairy farm. These animals that fail on conceiving, continue to consume the usual farm resources like feed and fodder. Even they continue to consume additional expenses like food supplements and medicines because anytime, any animal may fall to illness or disease. These expenses are in addition to the usual infrastructural, organizational and operational expenses. So, the expenses continue to be incurred but overall, the animal becomes unproductive for this extended period of no conception.

If we calculate average 10 liters of milk per day priced moderately at rupees 40 in Indian conditions (However full fat milk is sold definitely at a price of plus fifty rupees per liter these days in most parts of the country), then this means a loss of nearly 8,400 Indian rupees for this period. If further two or three misses are encountered, the total loss may amount to 16,800 or 25, 200 rupees each. On five and six such misses as we know that in cows the conception rate may fall to 20% or even lower to 15% with sexed semen, this loss may accumulate to rupees 42,000 and 50,400 even (Table 1). If on a rough estimate, there are 100 animals behaving accordingly; then the total loss may accumulate at rupees 8,40.000, 16,80,000, 25,20,000, 42, 00,000 and 50,40,000 each in all above case scenarios of conception misses on first, second, third, fifth or sixth heat occurrences . These are certainly huge figures. Need not to elaborate that they are more than enough to carry a good running dairy farm into heavy loss. But one thing should be kept in mind. One hundred animals is not a big figure in ordinary dairy farms in India today. With usual 35-40% conception failure with normal semen in India already prevailing, there are required nearly 2.5-3.0 times of inseminating to make an animal conceive. Further fall to about 15-20% with sexed semen means that almost double the number of inseminations i.e. 5-6 times of inseminating are required to make such an animal conceive. So, with sexed semen usage, the fall in productivity due to not conceiving is almost double than in case of normal semen use i.e. the exact value is the half of the total value of the mean of 42,00,000 and 50,40,000 in above example of 100 animals i.e. about half of rupees 46,20,000. This means a sum of about rupees 23, 10,000. This figure is again the same as of the mean for the 2.5-3.0 heat cycle days. This is a huge amount again. If this amount is not lost due to conception failure, this in itself is a high sum big enough to take a dairy farm into handsome profit. So, the fall in conception upon use of sexed semen may play a decisive role; may be on the negative side, for the overall commercial viability of a dairy farm. If this figure is projected for 10 million (one crore) and 100 millions (10 crores) animals across pan India, the total loss will be extremely exorbitant i.e. 23, 100 crores and 2, 31,000 crores in Indian rupees. Another much claimed and publicized motive for resorting to the use of sexed semen is the production of female progenies in greater numbers. This may be true. There is no questioning to the ability of sexed semen in producing female calves but when projected against its well known trait of lowered conception; the outcome just becomes turned turtle. We may be highly surprised to note that overall, we will land up getting lesser number of female calves. Anybody may be taken by a surprise astoundingly, but the outcome is remarkable and exactly in the reverse direction of which we were expecting due to our knowledge and mindset of getting more number of female progenies because the case is highly publicized and marketed of the ability of sexed semen to yield more offsprings of female sex. Here is a simple example (Table 2). Suppose we subject 100 cows in normal practical Indian conditions. We already know that national conception rate is about 35-40% in India and there is almost 15-20% fall in conception upon the subjecting to sexed semen usage. Now we take four different case scenarios.

One is of the normal conception rate at higher side i.e. 40% and the fall in conception is 20% upon the shifting of sexed semen usage in place of normal semen. The other case is of the conception rate again of 40% and the fall of 15% upon use of sexed variant of it. The third one is of the normal semen conception rate of 35% and a fall of 20% upon the use of sexed one and the fourth one is again the normal semen conception rate of 35% and the fall in 15% upon the use of sexed type of it. Now we get very interesting outcomes on simple analysis of all these situations. One thing is very important to note that almost all the sexed semen companies market it very cunningly when they claim that such and such variant of sexed straw produces female progenies with a success rate of up to 90% or so. This up to is a marketing gimmick and obviously the highest limit.

They never reveal about the lower limit. It may fall to 80%, 70% or even lower. Even on field experience may be that it may fall to less than 50% or further lower. These days, there is a change too and some companies in India have even started to come in the market and claim that they are intentionally producing the semen sexed at a sexing capacity of up to 75% or 80% of delivering female progenies and not the one of up to 90%. The rationale behind this marketing is best known to them only. We need not elaborate on this. Now we discuss the first case scenario. We subjected 100 cows to normal semen in one group and the same number of cows to sexed semen. In case of insemination with normal semen, we get 40 pregnancies; out of which we will get almost 20 male and 20 female calves. In case of the use of sexed semen, we get 20 offsprings; out of which, at a 90% sexing rate we get 18 female calves. This is a loss of two valuable female progenies. Anybody may raise a simple genuine question as to why anybody with a sound head and mind will go for such an elaborate exercise obviously of semen sexing to have the number of female progenies, even lesser than the ones obtained in a normal exercise done without the unwanted and avoidable big hassles of procuring, handling and using the sexed semen, of course involving a heavy financial investment too.

Table 1. Showing the total loss to a dairy farm due to conception failure due to the use of sexed semen instead of normal semen per lactation cycle

Sr. No.	No. of animals subjected to sexed semen usage	Approx. loss due to conception failure with normal semen i.e. between 2.5-3 months in crores of rupees	Approx. conception failure loss with sexed semen usage i.e. between 5-6 months in crores of rupees	Actual loss due to shifting of semen usage from normal to sexed in crores of rupees
1.	100	0.231	0.462	0.231
2,	10 millions	23,100	46,200	23,100
3.	100 millions	2,31,000	4,62,000	2,31,000

Table 2. Showing the comparative production of female offsprings with normal conception rate of 35-40% and a corresponding fall of 15-20% upon shifting to sexed semen usage on a sample size of 100 cows per lactation cycle

Sr. No.	Conception rate with normal semen	Fall in conception due to shifting to sexed semen usage	Female progenies with normal semen	Female progenies with sexed semen with 90%, 80% and 75% sexing
1.	40%	20%	20	18, 16 and 15
2,	40%	15%	20	22, 20 and 19
3.	35%	20%	18	14, 12 and 11
4.	35%	15%	18	18, 16 and 15

Table 3. Showing the comparative production of female offsprings with normal conception rate of 55-60% and a corresponding fall of 15-20% upon shifting to sexed semen usage on a sample size of 100 heifers or buffaloes per lactation cycle

Sr. No.	Conception rate with normal semen	Fall in conception due to shifting to sexed semen usage	Female progenies with normal semen	Female progenies with sexed semen with 90%, 80% and 75% sexing
1.	60%	20%	30	36, 32 and 30
2,	60%	15%	30	40, 33 and 31
3.	55%	20%	28	31, 28 and 26
4.	55%	15%	28	36, 32 and 30

Next upon sexing capacity of 80% and 75%, this lowered figure of the number of female calves will be at values of 16 and 15, thereby meaning a further loss of 04 and 05 numbers of valuable female calves. No intelligent person on earth will venture to do this. Now we take the second case scenario of 40% conception rate and the fall of 15% upon the use of sexed variant. The outcome with normal semen will be 20 female calves again and with sexed semen, there will be 25 deliveries of which there will be 22 female calves at 90% sexing, at the higher side of it. At 80% and 75% sexing, the female calves will be 20 and 19 respectively. Overall, this means no perceptible increase with the outcome hovering a little above or little below the usual outcome with normal semen use. In case of third case scenario with 35% conception and 20% fall in conception upon use of sexed semen. With normal semen, the outcome will be 18 females (at the higher side of an average of 17.5) and with sexed semen; the outcome will be 15 deliveries out of which there will be 14, 12 and 11 calves at 90%, 80% and 75% sexing. In case of fourth case scenario with 35% conception and 15% fall in conception upon use of sexed semen; the resultant figures will be 18 female calves with normal semen and 18, 16 and 15 calves upon the use of sexed semen. This means the outcome landing at an unchanged figure of female calves or at the decreased value in figures upon the use of sexed semen. If we project these figures upon application on mega national scale; say, 100 million animals, the outcome will again be almost null or the decreased one as the case may be. Now let us assume that this technology is applicable on good conceivers i.e. heifers and buffaloes (Table 3) which usually have a natural conception rate of about 55-60%. Now, again we can divide this discussion in four case scenarios like just discussed above. Given the first case scenario of 60% conception rate and a corresponding fall of 20% upon the use of sexed semen; we get 30 female calves upon normal semen usage and 36, 32 and 30 female calves upon sexed semen usage with 90%, 80% and 75% sexing capability. In the second case scenario with 60% conception rate with normal semen and a corresponding fall of 15% upon the subjecting to use of sexed semen, we get 30 female progenies upon use of normal semen and 40, 33 and 31 female calves upon use of sexed semen with 90%, 80% and 75% sexing capacity. In the third case scenario of 55% conception rate with normal semen and a corresponding fall of 20% upon the use of sexed semen; we get 28 female calves (the higher side of an average of 27.5) with normal semen and 31, 28 and 26 female calves upon 90%, 80% and 75% sexing value of sexed semen. In case of fourth case scenario of 55% conception rate with normal semen and a corresponding fall of 15% upon resorting to use of sexed one; we get 28 female calves on using the normal semen and 36, 32 and 30 female progenies with 90%, 80% and 75% sexing quality of the sexed semen. This is a little above the normal value of 28 female calves with normal semen but the story has another chapter to be discussed and revealed just explained in the below paragraph. The cost of sexed semen is a very big concern. As we all know that sewing machines are nothing but the modified Coulter Counters or related machinery. The operational costs are very high. The machines involve highly advanced and sophisticated physics. It is not a child's play to handle such machines. The operational costs are super exorbitant. The output semen cost becomes very high. Moreover, there is lot of semen wastage. The output is between 20-30% of the input semen volume. So, automatically the cost has to go up. Roughly it should rise up to four to five times the price of the original semen. Coupled with the cost of operation which is nearly 10 U.S. dollars per a straw of the sexed semen produced; the actual cost rises to a very high figure, definitely beyond the reach of an ordinary Indian farmer. Even if the government comes with a heavy subsidy in pricing, then a valuable question arises as to whose is the money with which the government is offering such a price reduction? After all, a government never has its private money. All the money that a government can have is basically the public money or the money directly exhorted from the pockets of general masses only by the agency of heavy taxation of otherwise hard earnings of poor people generated with hard work and sweat and brow. So, ultimately it turns out that government ends up just profiting some wrong or inefficient multinationals by robbing the common Indian people of their valuable earnings. This is no business. This may be anything connected with

some sort of a crony capitalism but commerce and economics, it is certainly not. Production of sexed progenies is not a bad idea but certainly the approaches other than the one of sexing semen should also be given importance (Aulakh, 2018; Bryant, 1984; Zavos, 1991) and if such techniques are decisively more effective and advantageous than the sexed semen technology, they should be given importance and due place. This will certainly help the dairy farmers in practical normal field conditions right there on a dairy farm in Indian conditions.

The exotic question and sire choice: The exoticness of dairy herds is a big concern and fertilizing the cattle with the semen of sires of exotic breeds is not a fab but a business need in today's dairy farming. The good pedigree sire can provide you with the best of offsprings that will turn super heavy yielding on maturity and will take the dairy farm in good profits whereas, the bad yielding low exotic quality animals will only add up to the losses of the dairy farm upon reaching the lactation age. The problem with the sexed semen is that we can not have the sexed semen from the preferred sires of very high exotic standing because we all know that such semen from these bulls is already priced at very high value and if such semen is further subjected to the process of sexing, it will become further super costly. This will be beyond the reach of any dairy farmer worldwide even in U.S. or Europe etc and certainly for Indian dairy farmers, this will be simply out of reach. So, getting sexed semen simply means to compromise on the quality of sire exoticness. This will become a big hindrance in developing good quality herds on modern dairy farms.

Third of a century old technology still struggling to establish commercially: Flow cytometry is not a recent discovery but on the otherwise, it was developed on the initiative of Department of Agriculture, Government of USA (Johnson et al, 1989). There have been further developments and improvements but the basic characteristics of this have by and large remained the same. Overall, this is about a third of a century old technology. Had it been such a viable and fruitful outcome, it would have gotten established and accepted on its own with the farming community worldwide? This fact also goes against the factor of commercial and economic viability of the sexed semen on farm level and certainly dairy farmers are not modern commercial guinea pigs either.

The outcome concerns: There is an old saying that all that glitters is not gold. Often it turns out that too much shine just blinds the eyes. A very good and attractively packaged and well advertised product may not turn out so good in quality upon use. The million dollar question is that we should weigh all the ups and downs of a farming strategy to help our dairy farmers who are already facing a tough time and dairy sector is struggling to survive. The prices of feed materials are already up.

The costs of medicines, supplements and antibiotics have also flared. The milk prices are just stagnant. Moreover, there is danger of government opening up the national dairy sector to the import of milk and milk products. The competition is already very high and such an entry of multinational companies in the marketing arena of dairy will only worsen the things for Indian dairy farmers. The sexed semen could have helped the farmers greatly but there are certainly grave concerns about its application value and practical competitive effectiveness.

The measures to increase dairy productivity should be taken but an emphasis should also be focused on sexing techniques other than sexing semen and if such developments are found to contain better advantages and benefits for the dairy farmer, they should be preferably implemented instead of the techniques that have more publicity value and less of the practical application accolades.

Conclusion

Sexed semen is heavily advertised and publicized as a savior technology these days which has become a darling of the governments, lobbies and companies alike but it should be allowed after a critical examination of all its attributes, advantages and vices. From many years, we are listening to the roar of the advent of this technology and central government and various state governments in India have in fact promoted this on many occasions from at least last ten years or so but the farmers who were very much fascinated about this at a point of time, have turned in a way aversive to it. So, a balanced and steady headed approach should be adopted to allow or not its use on dairy farms and not a blind head down dive should be attempted. This will simply make the matters for Indian dairy farmers only worse. This has a message for our policy planners and executioners alike.

REFERENCES

Aulakh BS. 2018. A brief description and impact factor calculation about a sex fixing exercise in dairy animals undertaken in India. International Journal of Current Research. vol.10(8):72843-72847.

Aulakh BS. 2018. An exercise into sex fixing of progenies in dairy animals and calculating the impact factor of such a drug discovery with reference to Indian conditions. Journal of Animal Research. 2018; 8(3): 435-39.

Bryant F. 1984. Preparation of mono specific male-specific antibody and the use thereof for increasing the percentage of mammalian offspring of either sex. U.S. patent no.4,448,767.

Dejarnette J.M., Nebel R.L., Marshall C.E., Moreno J.F. 2008. Effect of sex sorted sperm dosage on conception rates in Holstein heifers and lactating cows. J. Dairy Sci. 91(5): 1778-85.

Funston R., Meyer T.L. 2012. Evaluating conventional and sexed semen in a beef heifer development program. The Professional Animal Scientist, 28: 560-563.

Garner D.L. and Seidel Jr. G.E. 2008. History of commercializing sexed semen for cattle. Therigenology, 69:886-895.

Gordon M.J. 1958. The control of sex. Scientific American. 199: 87.

Hafez ESE, 1982. Reproduction in farm animals. Reprint fifth edn. Lea and Fabiger. London. pp. 499.

Hunter RHF. 1982. Reproduction of farm animals. Longman. London, pp 138-139.

Inaba Y., Abe R., Geshi M., Matoba S., Nagai T., Somfai T. 2016. Sex sorting of spermatozoa affects development competence of in vitro fertilized oocytes in a bull dependent manner. Journal of Reproduction and Development. vol. 62(5): 451-456

Johnson L.A., Flook J.P., Hawk H.W. 1989. Sex preselection in rabbits: Live births from X and Y sperm separated by DNA and cell sexing. Biology & Reproduction. 41: 199-203

Seidel G.E. 2014. Update on sexed semen technology in cattle. The Animal, 8(s1): 160-164.

Zavos M. and Dawson K. A. 1991. Method for X and Y spermatozoa separation. U.S. patent no. 4,999,283.

****