Excellence

NZQA Intended for teacher use only

Introduction
New Zealand's [NZ's] dairy farming industry is well known for its efficient calving and practices that increase milk production and farm income economically. To keep the advantage, dairy farmers use reproductive techniques to manage the fertility, genetic progress and calving timing. The two techniques I will be covering are Artificial insemination [AI] and embryo transfer [ET]. They enable genetic improvement, better management, and better economic returns. This report will explain how each method works, the equipment and biology involved, and justifies their use on NZ dairy farms.

Artificial insemination
AI is a process where semen from a genetically superior bull is collected, processed, and stored most often in frozen straws, before being deposited directly into the uterus of a cow using an insemination gun.

Equipment and Reproductive structures involved
AI involves depositing semen from selected high genetic bulls directly into the cow's reproductive tract during her fertile period. The equipment required includes:
A semen straw, stored in liquid nitrogen tanks An insemination gun for delivering semen Protective gloves, lubricant and other hygienic products Digital heat detection systems such as scratch cards

Heat detection
accurate heat detection is essential for both AI and ET success, where seasonal calving is standard. Signs of heat in cows include: standing to be mounted by other cows [most reliable], increased activity, restlessness and bellowing , Clear vaginal mucus [bull string] swollen and moist vulva, sniffing and licking other cows , following behaviour and chin resting.

Heat detection tools and techniques
Visual observation: checking herds at least twice daily, especially in early morning and evening.
Tail paint and chalk: applied to the tail , worn or rubbed paint indicates mounting and likely on heat.
Heat detection patches: Devices that change colour or pop when pressure is applied.

The reproductive structures involved are:
Vulva: entry point for the insemination gun. Vagina: Passage to the cervix
Cervix: structure that must be navigated carefully
In NZ most AI is preformed by trained technicians who visit farms during the breeding season [spring] to inseminate cows.

Steps of AI

1. Select a cow: choose a superior healthy fertile cow that is on heat [using previously explained methods] because AI is only successful when the cow is ovulating, the alternative is to use hormone protocols to synchronize cycling.
2. Obtain the cow: get the cow into a cattle crush where her head is held still in between bars for stability through the procedure. This is simply a safety measure.
3. Prepare equipment: as liste the equipment must be prepared, all of these tools must be clean and reliable to prevent infection and make sure the semen is alive and ready to fertilize the eggs in the cow.
4. Prepare semen: take the semen straw out of the nitrogen tank, thaw it in hot water for about 30-60 seconds [34-38c]. This needs to be done properly to reactivate the sperm without putting them at risk.
5. Prepare the vulva: Carefully clean the cows vulva with some sort of paper towel to remove dirt ot waste and reduce the risk of infection. This must be done because hygiene is crucial in AI steps to protect the cow.
6. Insert the gun using your arm into the rectum of the cow: wearing a long plastic glove of sum sort carefully insert your arm into the rectum to locate and prepare the cervix through the rectal wall, this is cause the cervix is deep in and hard to see.
7. Insert the gun: using your hand insert the gun into the vagina and gently guide it through the cervix using your hand in the rectum. Ensure not to force it in and aim to deposit the semen in the uterine body [past the cervix]. This must be done because if the semen is incorrectly placed the pregnancy will not likely happen.
8. Deposit the semen: Once the gun is in the correct place slowly press the plunger on the gun in to release the semen. By releasing it slowly it will reduce stress on the sperm and help it to spread out evenly.
9. Remove the gun and clean: carefully withdraw the gun and your arm then discard the used sheath and clean all of the equipment. Removing the gun will prevent damage to the cow.
10. Record the information: record the dare, the semen batch and the id of the cow for tracking and future insemination/pregnancy.

The timing of this process is important, the best time to inseminate a cow is approximately 12 hours after the cow is seen in heat, as this is when fertility is at its highest. This means that close observation of the herd is needed in order to spot oestrus symptoms like heightened activity and mounting behavouir[heat]. The process itself needs a high level of hygiene and precision, as the technician must guide the insemination gun through the cow's vagina and cervix to make sure the semen is placed at the uterine body. This is essential to maximise the chances of successful fertilization and minimize the risk of infection or injury to the animal.

Hormones of AI

1. Estrogen [oestrogen] is the hormone responsible for the visible signs of heat [estrus] within the cows. It rises just before ovulation and causes behaviours like restlessness, mounting, a swollen vulva and clear mucus discharge. These signs help farmers know the best timing for the procedure [AI] to take place. High levels of estrogen indicate that the cow is ready to mate and that the egg will soon be released. Timing AI during this estrogen peak increases the chances of successful

fertilisation.
2. Luteinizing Hormone [LH] is released just before the ovulation period. It plays a key role in triggering the release of the egg from the ovary. This surge in LH usually happens around the middle of the cow's estrous cycle. For AI to be successful, sperm must be present in the reproductive tract before or just as the LH surge happens so it will meet the egg shortly after it gets released. AI timing is often based on predicting this hormones rise.
3. Progesterone is a hormone that keeps pregnancy in the cow. It is high after the ovulation section of the cycle when the corpus luteum forms and prepares the uterus to support a fertilised egg. When the progesterone levels are high, the cow won't show signs of being on heat, and ovulation won't occur. For AI to work, progesterone levels must be low, this means the cow isn't pregnant and is entering a brand new cycle. Sometimes farmers use progesterone releasing devices or better known as a CIDR to control and synchronise the cycle for scheduled AI.
4. Gonadotropin releasing hormone [GNRH] is the hormone that stimulates the cow's brain to then release other hormones, like follicle stimulating hormone [FSH] and LH. It begins a reaction that leads to the development of a follicle and the eventually the release of an egg. In Ai procedures GNRH can be an injection to help control when the ovulation occurs. This will allow for easier and better timing of the insemination.
5. Prostaglandin [PGF2A] is the hormone used to reset the cows reproductive cycle. It creates the breakdown of the corpus luteum, which in result drops the progesterone levels.

Success depends on accurate heat synchronisation or detection, correct semen handling and placement during the procedure. The cows nutrition, health, and body condition. food quality varies depending on the seasons.

Disadvantages:
This Requires technicians, poor technique or mistiming of the procedure reduce the success rates. AI is labour intensive when it relies on visual heat detection on the farm. This doesn't maximise the reproductive output from cows [cows can only have one calf each per year], upfront equipment and training fees.

Justification for Use of AI in New Zealand
Number of cows in calving each year:
AI results in a high percentage of cows to become pregnant during the desired spring calving window, this is critical for matching the milk production. In managed herds, three week submission rates of 80%, six week in calf rates of 75-78% are reachable.
Genetic potential:
Nz farmers have access to semen from the some of the worlds best dairy genes. Farmers select parents based on breeding worth [BW], this combines traits like milk yield, fertility and the longevity.This increases rapid genetic gains.
Timing of calving:

Synchronisation protocols allow for tighter and better calving brackets, this is vital for managing food supply and labour over the NZ spring [season]. Early calving means cows have more time to recover from the birth and cycle back before the following mating. This supports high re productivity.
Economics of milk production:
Ai is cost effective for larger herds of cows. It reduces the need for bulls on farms, which saves costs and reduces the safety risks. The use of top genetics boosts, life time, milk yield and herd profitability.

AI is key to NZ's dairy industry. It makes precise reproduction, improved genes and is cost efficient. The timing of AI is carefully controlled, Hormonal synchronisation protocols inserts make it possible for farmers to get groups od cows ready for insemination so that they can go at the same time. This is a huge advantage throughout NZ's seasonal system, its vital that majority of the herds calves down in spring so they can make the most of the fresh produce. By synchronising the herd, it will increase the number of cows that can get inseminated quickly, this means more cows get pregnant earlier into the season. This is how you can get a tight calving pattern, where most calves are born together, when there's lots of produce to feed them. This means the calves will all arrive around about the same time this makes not only milking and feeding easier to manage but also maintains milk production and makes the most of the springs pasture growth. This ultimately, this planning is what keeps NZ's dairy farms productive, efficient and easier to control/run.

The quality of AI relies on careful semen selection from the worlds best parents[sires], this is evaluated by genetic indexes like BW and production worth [PW]. Strict handling protocols and skilled technicians also have an effect. Healthy well managed cows further improve conception rates or success, with industry targets, such as a 78% six week in calf rate, this is achievable in a well run herd. AI excels in increasing quantity of calving. A single elite bulls semen can impregnate thousands of cows throughout the season. The genetic gains made through AI are rapid, benefiting individual farms and the herd. This scale is unique in only AI, leading 80% of NZ's dairy cows to be bred using this procedure yearly.

The genetic potential for NZ dairy herds furthers through AI technology because farmers can access an international pool of elite sires instead of relying purely on local farm selections. The maintenance of genetic diversity is through the prevention of inbreeding makes sure continued advancement is happening while avoiding negative effects. The system remains in advancement since bulls undergo constant testing through calf performance metrics while farmers select desired traits in cows such as fertility, health and milk production. AI promotes a very good financial opportunity because it remains cost effective for farmer housing herds of about 50-500 cows while cutting the need to stay costly and the bulls that can be potentially dangerous are taken out of the equation. This also reduces disease transmission among the livestock on their farm. Using extended periods of genetic improvement dairy cows produce greater lifetime yields which will ultimately lead to an increase in farm profitability. The combination of timing, premium semen, mass cow insemination, consistent genetic progress and the cost efficiency makes AI the best breeding technique across all commercial dairy farms nationwide.

Embryo transfer [ET]

Equipment and reproductive structures involved: Et is more advanced technology then AI, used to multiply the genetics of elite cows. The equipment required for ET is more specialized than that for AI. It includes superovulation hormones such as FSH and prostaglandins, AI equipment for inseminating the donor, and catheters and flushing media for collecting embryos form the uterus. A microscope is essential for evaluating embryo quality, and a specialized embryo transfer pipette or gun is then used to deposit the embryos into selected cows. This process is more complex and requires a higher level of experience, expertise and training to ensure that the embryo viability and successful transfer, also the same vital carefulness of management regarding the donor and recipient animals.

Reproductive structures

In ET, the donors cows uterine horns are flushed to collet their embryos, normally 6-8 days after insemination when the embryos are at blastocyst stage. The transfer, the recipient cows cervix is carefully passed and the embryo is deposited into the uterine body close to the active corpus luteum. The placement is critical because the corpus luteum produces the progesterone which is needed for maintaining the early pregnancy. The handling of reproductive structures is crucial for the success of embryo collection and transfer.

Embryo transfer

1. Select the donor and recipient cows
   The donor cow should be elite. The recipient needs to be healthy and have a good enough fertility to carry the embryos.
2. synchronisation of the estrous cycles
   Using progesterone devices and prostaglandin injections to control the timing of heat in the donor and recipient cows. Both cows must be on the same reproductive cycles so the embryos match the uterus stage.
3. Superovulating the donor cow
   This starts by Injecting FSH over a 4 day period to make the donor develop multiple eggs instead of one[induce multiple follicle development]. This leads to the cow producing many embryos from a cow instead of simply one in a cycle.
4. Insemination of the donor cow
   AI happens 12-24 hours after the donor cow shows signs of heat, this is done specifically to then fertilise the eggs released during the superovulation.

5. Flush the embryos from the donor cows
   7 days after the insemination, embryos are flushed out of the uterus using a catheter. This is to collect the fertilised embryos before the implant.
6. Sort and evaluate/manage the embryos
   Inspect embryos under a microscope for quality and the development stage of them. Only high quality embryos are frozen or used.
7. Transfer the embryos into the recipients cows
   Put one embryo into each recipients cows uterus using a pipette, normally on the 7th day of her cycle. This will leave the embryo with the best chance of implantation and pregnancy.
8. Pregnancy check
   Using an ultrasound or palpation after 30 days. This is to confirm if the embryo transfer was successful or not.

Summary

1. Donor selection and superovulation, select a high genetic donor cow. Administer FSH [twice daily for 4-5] to induce multiple follicle development in the cows. Give prostaglandin[hormone] to synchronize estrus and regression of the corpus luteum.
2. Heat detection and insemination of the donor cow, detect heat in the donor cow [or synchronize using hormones]. Inseminate at the right time, normally more then once.
3. Embryo collecting/flushing, 6-7 days after the insemination restrain the donor cow. Insert a catheter into the uterus via the cervix. Recover embryos for inspection and grading under the microscope.
4. Recipient selection and synchronisation. Select healthy and recycling recipients. Using prostaglandin and or CIDRs synchronise the recipients estrous cycle to the donors cycle.
5. Embryo transfer process, Identify your chosen recipient in the correct reproductive stage [witch is the same or synchronised with the donors], Pass the transfer gun through the cervix and deposit embryo into the uterine body.
6. Monitoring and following up, observe the recipients for pregnancy and possible return to being on heat. Record all details for management and future breeding procedures.

Hormones relevant to this technique

1. Gonadotropin, releasing hormone [GnRH]
   Used in donor and recipient cows, the purpose of this is to control the ovulation timing or it helps initiate a new cycle. How it works, it can be used at the start of a synchronisation program or right before insemination to start ovulation.
2. Follicle stimulating hormone [FSH]
   used for the donor cow, the purpose is to stimulate the ovaries to produce multiple follicles or eggs instead of just one. How it works, its given as multiple small injections over a 4 day period during the cow's cycle. This encourages development of many oocytes for fertilisation.
3. Prostaglandin [PGF 2a]

Used in donor and recipient cows, the purpose is to cause regression of the corpus luteum [CL], leading to the start of a new cycle or synchronisation of heat. How it works, it ensures both donor and recipient cows are at the right stage of their estrous cycle. It is usually given around around day 9-12 of the cycle to trigger heat in 2-4 days.

4. Progesterone [often via CIDR- controlled internal drug release device]
   Used in recipient cows, it keeps the cow from coming onto heat to early in the process, it synchronises the uterine environment with the embryos development. It is inserted into the vagina for a total of 7 days, then it is removed to trigger the reaction of heat. This helps line up the recipients cycle with the donors embryo stage.

Hormonal control is critical, FSH stimulates the growth of multiple follicles, it increases the number of eggs released. Prostaglandin and GnRH synchronize the donor and recipients. Progesterone implants or CIDRs may be used to help maintain pregnancy in the recipients.

Success depends on

Success rely s on the donors response to super ovulation, some cows might not yield enough embryos. The quality of the semen and insemination timing also have major effects that determine the success of ET. The management and skill required to do this procedure regarding collection and transfer alter the rate of succession in a big way. The final point being that the health and management of the recipient cows must be up to standard.

Disadvantages

Et is costly, the hormones, veterinary services and sire management are expensive. Also ET is much more complex, it requires skilled personnel and extremely careful management.

Some donors do not respond well this means that the embryo yield is variable. There is increased stress on donor cows and repeated superovulation may affect the health of the cow. The recipient cows are needed this results in additional animals that must be catered for and managed.

<u>Justification for use in New Zealand</u>

ET multiples the reproductive output of elite cows, a single donor can produce 10-20 calves per year through multiple transfers, compared to one calf per year via AI. This is especially valuable for multiplying the genes of top elite cows.

Genetic potential:

Et allows for the most valuable cows to have a greater impact on the herds genetics. By combining the genes of elite sires, farmers can accelerate genetic progress.

Timing of the calving:

Synchronising the donors and recipients allows for planned calving. This supports efficient herd management and helps make sure that calves from elite genes are born at the best times possible.
Economics of milk production:
ET is expensive, but the long term economic benefits far outweigh the costs because elite genetics are involved in the procedure. Calves from ET might have higher lifetime milk yields, better fertility and other desired traits. This justifies the investment for a higher value herd. But ET is generally not cost effective enough for the casual commercial dairy farm in NZ.

Embryo transfer represents the peak of reproductive technology procedures in the NZ dairying industry. It provides great control over elite genetics but comes with a more complex method and a bigger cost. The timing of ET must be managed with crucial care. Elite cows are superovulated using FSH to produce multiple eggs. Recipients are synchronised using progesterone and prostaglandin so embryos can be transferred at the right stage of the reproductive cycle in the cow. This hormonal control makes sure both donor and recipients are ready. This maximises the pregnancy rates and keeps the seasonal calving pattern which is crucial for pasture management.

Quality is critical throughout the ET process. Donors are chosen excellent genes and performance. Embryos are carefully graded under a microscope to make sure only viable ones are used. Recipients are selected for their health and ability to carry out pregnancy. The focus on quality at every step helps produce some of the best calves possible. Although the quantity of calves produced through ET is lower than AI it has a transformative effect at an elite level. A single top cow can produce 10-20 or more offspring per year through repeated flushes or the IVF method. This accelerates the multiplication of rare or highly desirable genetics much further than AI or natural mating could meet.

ET allows for rapid multiplication and combination of elite cow and bull genes. This will drive the production of future herd sires and the valuable breeding females. ET may not have the same wide impact as AI, it is a must for enhancing the genetics of nucleus herds and breeding sires that benefit the entire industry. Economically speaking ET is much more costly and more technically demanding then AI as we know. It requires major investments in hormones, vet expertise, management of the recipients and specialized equipment. But for the best cows. ET can provide major long term returns to farmers. This will include faster genetic gain, the creation of premium breeding stock and the potential to obtain higher prices for elite genes both locally and abroad. For majority of commercial farms the economics surrounding ET aren't favourable. But for high value breeding businesses and developing future sires, ET serves as a good tool for multiplying elite genes and maintaining NZ's lead in dairy breeding innovation.

<u>Hormone Involvement</u>

Changes in hormone use:
Estrous synchronisation, both AI and ET normally use prostaglandin GnRh and CIDRs to bring cows into heat at the same time. AI hormone use, is primarily for synchronising ovulation, reducing the need for visual detection and enabling a fixed timeline for insemination. ET hormone use, Donor cows are superovulated using FSH to produce multiple eggs, as well as prostaglandins or CIDRs for cycle synchronisation. Recipients receive synchronisation protocols to make sure the uterine is ready for the embryo implantation.

Advantages of hormonal involvement

It boosts the conception and submission rates, during the best time windows a far larger percentage of the herd can be inseminated or used for embryo transfer. It reduces labour, instead of consistently visually monitoring cows, farmers can plan and schedule their breeding. Consistent calving patterns, leads to more synchronised calving this improves the efficiency of labour allocation/management, nutrition and overall herd management.
Vital to ET, in order to maximise the number of offspring from elite cows superovulation is a must; without hormone control, donor and recipient cycles would not cycle appropriately. Cost of hormone use and drawbacks/risks, hormonal treatments FSH, GnRH, CIDRs, ect. All increase breeding expenses, especially for ET. Animal welfare must be considered like possible stress, side effects or multiple injections in specific protocols.

Disadvantages and risks surrounding hormonal use

Cost, hormonal treatments add to breeding costs, more so in ET. Animal welfare, some protocols involve multiple injections alongside potential stress or other side effects. Environmentally, excretion of synthetic hormones may have potential impacts if not managed carefully and correctly. Possible reduced fertility, excessive or poorly timed hormone use can reduce fertility and cause reproductive troubles.

Conclusion

While AI is suitable for all possible herds, ET is more strategic and can be used to multiply elite genetics, both have a vital role in maintaning the productivity, sustainability and profitability of the farm, these all help carry the NZ farming industry.