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Introduction

Artificial insemination (AI) is a powerful tool for increasing rates of genetic progress within fallow deer herds. However, it is not without certain costs to the farmer; both financial and time costs. In this paper, we compare the procedures and costs associated with the main types of AI used for fallow deer.

(1) The female reproductive tract

The female reproductive tract is composed of several distinct regions, each with a separate function (Figure 1).

(a) The **vagina** serves as the primary receptacle for semen following natural mating. Generally, the semen pools below the entry into the cervix (i.e. *os cervix*) and spermatozoa must pass through the *os cervix* into the cervix.

(b) The cervix is a rigid and high convoluted channel connecting the anterior vagina with the uterus. In fallow deer, the aperture through the cervix, which is about 5 cm long, is very small (<2-3 mm). It serves as a screen, allowing only viable spermatozoa to pass through. It is believed that various cervical secretions impede the progress of all but the most robust of spermatozoa.

(c) The uterus, which is divided into two distinct horns, is the main body of the reproductive tract that eventually encompasses the growing foetus. Placental

attachment can occur in either uterine horn. Each horn progressively narrows in diameter, to merge into the oviducts at the utero-tubal junction.

(d) The oviducts connect to the membrane (fimbria) that surrounds the ovaries. The egg (ovum) is collected, once shed from the ovary, by the fimbria and passed into the oviduct. From there, the ovum passes down into the uterus. Fertilisation normally occurs in the oviducts, but the embryo travels into the uterus prior to conception (maternal - embryonic attachment).

(e) The ovaries, although terminal to the oviducts, are usually sited alongside the horns or main-body of the uterus, as the entire uterus is coiled (Figure 1). In fallow deer, only one ovary ovulates at any one time.

(2) Vaginal insemination

Intravaginal semen deposition (sometimes referred to as "shot in the dark" insemination) most closely mimics natural insemination at copulation. Deposition of semen is generally timed to coincide with the onset of oestrus (i.e. about 48 hours after CIDR device removal), the time when copulation normally occurs.

However, spermatozoa have a number of barriers before reaching the oviducts, not the least of which are access through the *os cervix* and passage through the cervix. For this reason, natural ejaculates contain many millions (even billions) of spermatozoa. A fallow deer ejaculate may contain upwards of 2×10^9 (2 billion) spermatozoa to ensure an adequate number reach the oviducts. By contrast, artificial insemination seeks to reduce the total number of sperm used per insemination, in order to more widely distribute the genetic material from a single ejaculate.

Successful conceptions from intravaginal AI have been reported using 85 x 10^6 (85 million) motile spermatozoa per inseminate but it is likely that > 200 x 10^6 may be necessary for consistent results. Certainly, the use of fresh, rather than frozen-thawed, semen is more likely to achieve success in intravaginal AI programmes.

The advantages of intravaginal AI lies in low costs (no anaesthesia of does is required) and rapid operation (only a few seconds per doe). The main disadvantage lies in the expensive use of the semen resource.

(3) Intracervical insemination

Placement of semen beyond the *os cervix* and into the lumen of the cervix can be performed in fallow deer by using a lighted speculum. The procedure is quick and requires only manual restraint of does.

By overcoming the *os cervix* barrier, it is possible to reduce sperm dosages considerably over those used in intravaginal AI. However, for consistent success is seems necessary to use at least 50 x 10^6 motile spermatozoa, with a particular advantage using fresh over frozen-thawed semen.

Success rates of > 75% have been achieved using fresh semen as low as 12x10^6 sperm per inseminate, although the results have not been highly repeatable. Similarly, rates of > 70% have been achieved with frozen-thawed semen at 120x10^6 live sperm per inseminate (Jabbour *et al.*, 1991). It must be stressed that any semen used for cervical AI must be of high quality, particularly if it has been frozen.

The advantages of intracervical AI again lie in low cost and speed of operation. However, conceptions rates have been quite variable following this type of AI.

Both intravaginal and intracervical AI have the potential to become "do-it-yourself" procedures as they do not require the application of anaesthetic drugs to the does. However, our experience in NZ is that few farmers are interested in performing the AI themselves, and most commercial work has involved veterinary practitioners.

(4) **Laparoscopic intra-uterine inseminations**

Intra-uterine placement of semen is generally preferred for most species. By by-passing the cervix barrier, smaller numbers of spermatozoa can be used per inseminate. Furthermore, as semen is placed closer to the site of eventual fertilisation, sperm transport distances are dramatically reduced. This provides an opportunity to use semen of limited viability (e.g. poor post-thaw motility) with a reasonable chance of success.

In larger mammalian species (e.g. cow) the uterine lumen can be easily accessed via the cervix with the aid of rectal manipulation. However, for smaller species such as sheep and fallow deer, transcervical access is limited by small tract size. In these cases, laparoscopic procedures are generally adopted. This method involves visualisation of the reproductive tract via transabdominal placement of a fibre optic device (laparoscope) and injection of semen through the uterine wall and into the uterine lumen.

Laparoscopic techniques have proven to be very successful for fallow deer AI. The

main advantages include 100% success of semen placement in most cases, and the use of small dosages of spermatozoa ($< 25 \times 10^6$ per inseminate). Conception rates range from 50-80% but are generally more consistent than for intravaginal and intracervical techniques. However, anaesthetisation of does is essential for laparoscopic procedures, leading to increased veterinary costs relative to non-surgical techniques. Furthermore, laparoscopy is performed by trained professionals and can not, under any circumstance, be regarded as a "do-it-yourself" procedure. Thus, the overall costs of insemination per donor are considerably higher than for non-surgical AI.

Laparoscopic intra-uterine insemination of fallow does is generally performed 68-72 hours after removal of CIDR devices. The later timing relative to vaginal/cervical techniques relates to semen deposition closer to the site of fertilization. We would estimate that >90% of all fallow deer AI in the world involves the laparoscopic procedure.

(5) Transcervical intra-uterine insemination

There has been recent success in performing transcervical intra-uterine insemination in fallow deer, whereby the semen was deposited non-surgically through the lumen of the cervix. However, the procedure involved exteriorisation of the *os cervix* of fully anaesthetised does, and proved to be considerably slower than laparoscopic techniques. This technique has yet to prove more effective and of less risk than the laparoscopic technique.

Summary

: Intravaginal and intracervical insemination of fallow deer are low cost methods (probably $3-$10 per doe including oestrous synchronisation) but require large doses of high-viability semen and are prone to more variable success rates (30-75%).

: Laparoscopic intra-uterine insemination of fallow deer is a high cost method ($30-$80 per doe including oestrous synchronisation) but can successfully utilise smaller doses of semen and provides more consistent success rates (particularly when using cryopreserved semen).

: Transcervical techniques hold some promise but require further development to reduce the requirement for doe anaesthesia.

References

Jabbour, H.N., Veldhuizen, F.A., Green, G., Langridge, M. and Asher, G.W. (1991) Fertility of fallow deer (*Dama dama*) does following synchronisation of oestrus with CIDR devices or prostaglandin. Proceedings New Zealand Society of Animal Production 51: 147-151.

Figure 1: Schematic diagram of the reproductive tract of a fallow deer doe.