New Developments in Advanced Breeding Technologies and Phenotyping: SemenRate in UK & Canada

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Background

Advanced breeding technologies have revolutionised livestock food production. Genetic improvement has facilitated enormous productivity gains in farming. However, genetic potential remains a promise until genuine phenotypic progress is made. Many factors affect conception success and despite representing half of the reproductive equation, male factors can remain unmeasured or unknown. A single bull is often used to mate multiple females and in the case of artificial insemination (AI) where semen is collected, processed and frozen, potentially thousands of females worldwide (Statham et al., 2018, 2019).

Where semen or embryo quality falls below optimal, genetic promise can go unfulfilled. The use of sub-fertile bulls (those failing the pre-breeding soundness examination) or AI semen that has been damaged in processing, transport, storage, or handling is a contributing factor to this. The use of genomics offers specific opportunities for innovation in breeding low emission, net zero dairy and beef animals, but only if breeding is successful (Statham et al., 2017, 2020).

RAFT Solutions Ltd (RAFT) are a veterinary-led business based in North Yorkshire, sitting in a position to bridge the gap between industry and research to enable applied solutions to sustainable health and welfare in livestock animals. Alongside the research and advanced breeding aspect of the business, RAFT provide vet and farmer training as well as consultancy services.

RAFT's involvement in advanced breeding technologies has led to the establishment of an independent semen analysis service, SemenRate, with previous funding from InnovateUK. This service provides a multi-parametric assessment of both frozen and fresh semen using kinematic parameters from computer assisted semen analysis (CASA) alongside flow cytometry assays (Vincent et al., 2012; Sellem et al., 2015; Spilman et al., 2017). Many different factors affect conception success, including health & nutrition, so genetic promise may be unfulfilled if semen/embryo quality falls below optimal to achieve breeding targets.

Breeding for Sustainable Beef

A normal fertile bull is expected to impregnate 90 per cent of 50 normal, cycling, disease-free females within nine weeks, and impregnate 60 per cent of these in the first three weeks. Bulls of high fertility can achieve the same or better results. However, in a study of 319 bulls in the southeast of Scotland 33.4 per cent were found to be sub-fertile; reasons included lameness, poor scrotal circumference, scrotal enlargement, poor semen quality (motility or morphology) and poor serving ability (Eppink, 2005).

Before the service period, the pre-breeding evaluation of the bull should be performed by a veterinary surgeon who has undertaken and passed specific British Cattle Veterinary Association (BCVA) training in bull breeding soundness examinations. It allows a proactive approach to screening for sub-fertile bulls and includes the following:

- History and disease status
- Physical examination (including palpation of testes and measurement of scrotal circumference)
- Semen collection (artificial vagina or electro-ejaculator) and examination of motility and morphology of semen
- Serving assessment (synchronised heifers or farmer observation before visit)
- Special diagnostics (e.g. testicular ultrasound)

With only 65-85% of bulls being classed as satisfactory potential breeders at breeding soundness examinations, it is essential that bulls used in natural service are evaluated as thoroughly as possible prior to use with respect to natural service. Bulls should be capable of depositing high quality semen in the correct place. The BCVA bull pre-breeding soundness evaluation includes measurements such as scrotal circumference and percentage of morphologically normal sperm that have been shown to be correlated with fertility (Statham et al., 2019). The other components of the BCVA semen evaluation include assessment of mass motility (on a scale of 1-5) and individual progressive motility percentage.

Therefore, the use of validated, objective and repeatable measurement of semen motility & morphology such as CASA and flow cytometry should be considered as it is a powerful tool in objective measurements of semen motility (Vincent et al., 2012). Similarly using flow cytometry to determine morphologic differences offers objective analysis (Sellem et al., 2015). Increasing use of AI, embryo transfer, as well as ovum pick-up and in-vitro production of embryos, and especially the opportunity for sustainable breeding offered by sexed semen is a key driver for high quality genetics and checking semen quality. Being able to submit samples to a central independent semen laboratory, offering specialist referral support, may provide a solution to repeatable and objective semen motility evaluation, especially in proactively screening semen quality ahead of breeding programmes. The combination of CASA, flow cytometry and experienced referral laboratory support is the basis of the SemenRate service and central data hubs at the heart of this UK-Canada project described below.

Optimising reproductive success in beef cattle will also reduce greenhouse gas (GHG) emission intensity for beef. Good fertility performance is the cornerstone of a profitable and sustainable livestock business. Fertility drives productivity and in turn mitigates GHG emissions through reduced waste and optimising unproductive replacement youngstock inventories (Statham et al., 2017, 2020). Advanced breeding technologies offer a huge opportunity to achieve 'Net Zero' climate change targets in the beef industry.

UKRI: UK-Canada Breeding Project

UK Research and Innovation (UKRI) has pledged over £2.2m to seven agri-tech firms with Canadian partners to fund the development of new agricultural techniques that will help both countries meet their Net Zero emission targets. One of seven winning UK companies was RAFT alongside their Canadian partner Bow Valley Genetics, other UK technology partners and XL Vets groups in both countries.

RAFT have won funding for a 2-year project to further advance the already established SemenRate laboratory within the UK as well as setting up a new satellite laboratory in the west of Canada and a further site in the east to follow. Alongside the laboratory expansion is the development of new technologies to support the evolution of sustainable dairy and beef breeding.

Over the next two years the project partners will develop a group of advanced breeding technologies alongside a phenotyping database across the UK and Canada. This work will explore the role of germplasm quality and transport as part of achieving sustainable genetic progress and seek to establish phenotyping data across both countries in both sustainable dairy and beef breeding.

The technologies under development within the project include:

- Cytokine development: processing semen for AI removes the natural cytokines from the seminal fluid. These cytokines have been found to be important for fertilisation (Johnson et al., 2017). This work package aims to establish the cytokine profile for cattle, any variance between breeds and develop possible cytokine replacement treatments before or at insemination.

- Novel transport system for germplasm using hydrogels: the unique transport system would allow the movement of semen and embryos in countries where the cold chain has potential for disruption – lack of liquid nitrogen supply, long shipment distances etc.
- An objective, bull side semen analysis system (Jepson et al., 2019): this would provide veterinary surgeons performing pre-breeding soundness examinations with an objective assessment of semen motility and allow for any borderline samples collected to be referred to the established SemenRate laboratories for further analysis.

Each of the technologies will go through an alpha and beta testing phase with SemenRate within the project using the RAFT farm network as well as the XLVet network in both the UK and Canada. RAFT recently launched a new diagnostics data management company 'VetDx' at the Precision Livestock Farming (PLF) in Practice Conference held in at the York Biotech Centre in November last year. Veterinary Diagnostics Solutions (VetDx) is a joint venture between RAFT Solutions and human diagnostics data software specialists 'Personalised Diagnostics' (PDX) that will manage large scale collection, storage and interpretation of health & breeding information in a usable and flexible manner, protecting the confidentiality of individual data. This approach will be central to the development of the national data hubs at the centre of this project.

References

Eppink, E. (2005). A survey of bull Breeding Soundness Evaluations in the South East of Scotland. *Cattle Practice*, *13*, 205–209.

Jepson, A., Arlt, J., Statham, J., Spilman, M., Burton, K., Wood, T., Poon, W. C. K., & Martinez, V. A. (2019). High-throughput characterisation of bull semen motility using differential dynamic microscopy. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0202720

Johnson, M. L., Dasgupta, T., Gopichandran, N., Field, S. L., & Orsi, N. M. (2017). A Bayesian view of murine seminal cytokine networks. *PLOS ONE*, *12*(11), e0188897. https://doi.org/10.1371/journal.pone.0188897

Sellem, E., Broekhuijse, M. L. W. J., Chevrier, L., Camugli, S., Schmitt, E., Schibler, L., & Koenen, E. P. C. (2015). Use of combinations of in vitro quality assessments to predict fertility of bovine semen. *Theriogenology*, *84*(9), 1447-1454.e5. https://doi.org/10.1016/j.theriogenology.2015.07.035

Spilman, M. W., Burton, K. L., & Statham, J. M. E. (2017). 18 SEMENRATE: THE USE OF COMPUTER-ASSISTED SEMEN ANALYSIS AND FLOW CYTOMETRY FOR OBJECTIVE BOVINE SEMEN ANALYSIS IN THE UNITED KINGDOM. *Reproduction, Fertility and Development*, *29*(1), 116. https://doi.org/10.1071/RDv29n1Ab18

Statham, J., Burton, K., & Spilman, M. (2018). Semen analysis. In M. Diskin, P. Lonergan, D. Kenny, & S. Fair (Eds.), *International Bull Fertility Conference – Theory to Practice* (Vol. 12, Issue S1). Animal.

Statham, J., Burton, K., & Spilman, M. (2019). Looking after the bull: guide to management and assessment of fertility. *In Practice*, *41*(2), 69–83. https://doi.org/10.1136/inp.l363

Statham, J., Green, M., Husband, J., & Huxley, J. (2017). Climate change and cattle farming. *In Practice*, *39*(1), 10–19. https://doi.org/10.1136/inp.j195

Statham, J., Scott, H., Statham, S., Williams, A., & Sandars, D. (2020). *Dairy Cattle Health and Greenhouse Gas Emissions Study: UK, Chile and Kenya*. http://www.dairysustainabilityframework.org

Vincent, P., Underwood, S. L., Dolbec, C., Bouchard, N., Kroetsch, T., & Blondin, P. (2012). Bovine semen quality control in artificial insemination centers. *Animal Reproduction*, *9*(3), 153–165. https://doi.org/10.1002/9781118833971.ch74