Turbo NTM

Key Performance Indicators

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The purpose of this project has been to improve the economy for the Nordic dairy farmer through better breeding schemes. The introduction of genomic selection has led to changes in dairy cattle breeding schemes. The design of breeding schemes has large effects on the genetic gain and the rate of inbreeding in the populations. Therefore it is important to routinely evaluate and ensure that the most optimal breeding schemes are used and thus the best bulls become fathers to the next generation of Nordic dairy cows.

The first part of this study reviewed the current literature in genomic cattle breeding schemes. In the second part an optimal genomic breeding scheme was described and discussed with regard to the current literature (Turbo NTM 2016). In the third part, key performance indicators were described based on the literature and in discussion with researcher from Aarhus University. The goal with the key performance indicators was to make practical useful performance indicators for dairy cow breeding schemes (See below).

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Key Performance Indicators

Topic	KPI
Phenotypes *Well-defined and unbiased phenotypes*	• Checklist with quality parameters for as accurate phenotypes as possible - Percentage of high quality phenotypes that are collected • Checklist to motivate and update farmers regarding phenotypes • Yearly track changes in genotyping herds for all traits • Yearly track changes in recording systems for all traits • Percentage of animals that have a phenotype registration for respective trait
Phenotypes *"Difficult to measure traits"*	• Yearly check traits that could be of interest for the breeding goal - Heritability - Correlation to other breeding goal traits - Cost per phenotype - Changes in recording strategies - New technologies
Genotyping *Reference population*	• Strategy for minimizing relationship of genotyped animals - Relationship between genotyped animals - Genotyped animals/bull • Plan for genotyping in the herds with high qulity phenotypes - Percentage of high quality phenotypes that are genotyped • Cost per genotype
Reproductive technologies *Multiple ovulation together with embryo transfer (MOET)*	• Yearly compared with OPU regarding profitability • Number of flushed donors • Genetic level at flushings (females and bulls)

	• Age and results at flushings • Born calves per donor • Number of embryos - Frozen and fresh • Time between flushing and transfer • Number of sires used • Action plan for ethical aspects • Checklist to motivate and update farmers regarding MOET
Reproductive technologies *Ovum pick-up (OPU)*	• Yearly compared with MOET regarding profitability • Number of OPU donors • Genetic level at OPU (females and bulls) • Born calves per donor • Time between session and transfer • Number of sires used • Age and results at session • Action plan for ethical aspects • Checklist to motivate and update farmers regarding OPU
Reference population *Size*	• Number of genotyped animals in the reference population (females and bulls) for all breeding goal traits • Number of animals contributing information to the reference population in the future total merit - Percentage of the population • Accuracy of all traits • Number of animals (females and bulls) added/year

Reference population *Composition*	• Relationship between animals - Production population, breeding animals and reference population • Number of tested daughters/sire • Variation in numbers of tested daughters/sire
Reference population *Regularly renewed*	• Age of reference population - Age structure in years per trait (females and males) • Average accuracy of all traits • Renewed regularly - Track how/when/why - Effect on accuracy
Reference population *Combining outside the Nordic countries*	• Yearly evaluated - Effect on accuracy - Genetic gain/cost • Yearly check recording strategies changes in different countries
Inbreeding *Inbreeding level*	• Rate of inbreeding (pedigree and genomic based) - Production population, breeding animals and reference population • Bull and female contribution • Yearly check new literature covering genomic information and inbreeding - Track changes (Genomic/pedigree)
Inbreeding *Control of lethal alleles*	• Plan to test, handle and control lethal alleles within and across breeds - Frequency in: population, breeding animals, reference population - Economic effect - Publish proved lethal alleles - Plan for usage of carriers in the breeding scheme • Yearly check law

Selection *Selection of breeding animals*	• Number of selected bulls - Genotyped → bought → reproductive start → large scale production • Number of selected females - Genotyped → contracted → reproductive start → large scale production - Average relationship in the different selection steps
Mating design	• Use minimum co-ancestry or minimizing the covariance between ancestral genetic contribution • Success rate with wanted matings - Time between semen released and enough breeding animals are inseminated • Variation in number of used sires - Mating programs - High index animals • Plan to handle and control lethal alleles - Mating programs - High index animals - Reproductive technology programs
Generation interval	• Bull and female generation interval - Reproductive technology program - High index mating program • Reproductive start for females and bulls • Semen quality and egg quality at certain ages (months) • Management checklist for animals in the AI-station – yearly evaluated

Breeding scheme *Evaluation*	• Genetic trends for total merit - Check genetic trends in main breeding goal traits - Within and across countries • Phenotypic trends in main breeding goal traits - Within and across countries - Females and bulls • Cost per dose of semen - Sold and produced • Yearly track law changes - Impact on breeding scheme • Action plan for ethical aspects - For example: gen editing, cloning

Key Performance Indicators - additional description

Phenotypes *Well-defined and unbiased phenotypes*	
Checklist with quality parameters for as accurate phenotypes as possible	Checklist with quality parameters for as accurate phenotypes as possible to achieve high quality of phenotypes.
Percentage of high quality phenotypes that are collected	(Animals with high quality phenotype)/(all animals with phenotype).
Yearly track changes in genotyping herds for all traits	Yearly track changes in genotyping herds for all traits.
Yearly track changes in recording systems for all traits	Yearly track changes in recording systems for all traits.
Checklist to motivate and update farmers regarding phenotypes	Motivate farmer so that they register the high quality phenotypes.
Phenotypes *"Difficult to measure traits"*	
Yearly check traits that could be of interest for the breeding goal	Yearly check traits that could be of interest for the breeding goal.
Heritability	Track heritability for new traits.
Changes in recording strategies	Track what have changed in recording herds.
Cost per phenotype	Cost for an animal registration for the new phenotype.
Correlation to other breeding goal traits	Correlation to other breeding goal traits.
New technologies	Track new technologies that could help to register the trait.

Genotyping *Reference population*	
Strategy for minimizing relationship of genotyped animals	Strategy for minimizing relationship of genotyped animals.
Relationship between genotyped animals	Track relationship with best available method between animals in the reference population.
Genotyped animals/bull	Track how many animals are genotyped per bull. What variation between bulls?
Percentage of best phenotypes that are genotyped	What percentage of high quality phenotype animals are also genotyped? (High quality phenotype animals)/ (High quality phenotype animals genotyped).
Cost per genotype	Cost for a genotype in the reference population.
Yearly evaluate for best payment solutions	Yearly check how to best combine genotyping for reference population and other usage of genotyping.
Reproductive technologies *Multiple ovulation together with embryo transfer (MOET)*	
Yearly compared with OPU regarding profitability	Yearly compared with OPU regarding profitability.
Number of flushed donors	Track how many donors in total that are flushed in the MOET breeding program per year.
Genetic level at flushing (females and bulls)	Genetic level at flushings for flushed donors and used bulls in the MOET breeding program.
Age and result at flushing	Track age and results at flushings.

Born calves per donor	Number of born calves per donor in the MOET breeding program.
Number of embryos –frozen and fresh	Number of embryos in the MOET breeding program: Total and per donor.
Time between flushing and transfer	Time between flushing and transfer. Variation in time between flushing and transfer?
Number of sires used	Number of sires used in the MOET breeding program.
Action plan for ethical aspects	Yearly updated action plan for ethical aspects. Positions and opinions for decisions.
Checklist to motivate and update farmers regarding MOET	Plan to update and motivate farmers so that animals with a high genetic valued are flushed.
Reproductive technologies *Ovum pick-up (OPU)*	
Yearly compared with MOET regarding profitability	Yearly compared with MOET regarding profitability.
Number of OPU donors	Track how many OPU donors in total that are flushed in the OPU breeding program.
Genetic level at OPU	Genetic level at sessions for donors and used bulls in the OPU breeding program.
Born calves per donor	Number of born calves per donor in the OPU breeding program.
Time between session and transfer	Time between session and transfer. Variation in time between flushing and session?
Number of sires used	Number of sires used in the OPU breeding program.
Age and results at sessions	Age and results at sessions.
Action plan for ethical aspects	Yearly updated action plan for ethical aspects. Positions and opinions for decisions.

Checklist to motivate and update farmers regarding OPU	Plan to update and motivate farmers so that animals with a high genetic valued are used in OPU breeding program.
Reference population *Size*	
Number of animals in the reference population (females and bulls) for all breeding goal traits	Number of animals in the reference population (females and bulls) for all breeding goal traits - All animals included - Animals with genotype - Animals included without genotype
Number of animals contributing information to the reference population in the future total merit - Percentage of the population	Number of animals contributing information to the reference population in the future total merit (Percentage of the population).
Accuracy of all traits	Accuracy of all traits in the breeding goal.
Number of animals (females and bulls) added/year	The number of added animals in the reference population - All animals included - Animals with genotype - Animals included without genotype
Reference population *Composition*	
Relationship between animals	Relationship between animals - Production population, breeding animals and reference population
Number of tested daughters/sire	Number of tested daughters per sire.

Variation in numbers of tested daughters/sire	Variation in numbers of tested daughters per sire.
Reference population *Regularly renewed*	
Age of reference population - Age structure in years per trait (females and males)	Age of reference population - Age structure in years per trait (females and males)
Average accuracy of all traits	Track the average accuracy of all interesting traits.
Renewed regularly - Track how/when/why - Effect on accuracy	Track how, when and why the reference population is renewed. What was the effect on the accuracy?
Reference population *Combining outside the Nordic countries*	
Effect on accuracy	How much extra accuracy of breeding values?
Genetic gain/cost	How much extra gain compared to cost?
Yearly check recording strategies changes in different countries	Are there any new traits recorded? How are these recorded?
Average relationship in the different selection steps	Track effect of optimum contribution selection.

Inbreeding *Inbreeding level*	
Rate of inbreeding (pedigree and genomic based) - Production population, breeding animals and reference population	Rate of inbreeding (pedigree and genomic based) in production population, breeding animals and reference population. FAO upper guidance 1 % for a healthy population.
Bull and female contribution	Bull and female contribution to the inbreeding.
Yearly check new literature covering genomic information and inbreeding	To stay updated: check literature and talk to researcher about the topic.
Inbreeding *Control of lethal alleles*	
Plan to test, handle and control lethal alleles within and across breeds	Plan to test, handle and control for the different lethal alleles. Both within and across breeds to track them.
Plan for usage of carriers in the breeding scheme	Plan for usage of carriers in the breeding scheme
Frequency in: population, breeding animals, reference population	Track frequency in the population, breeding animals and reference population.
Economic effect	Estimated economic effect of the different lethal alleles.
Publish proved lethal alleles	Lethal alleles should be published so they can be avoided in the mating programs.

Selection *Selection of breeding animals*	
Number of selected bulls Genotyped → bought → reproductive start → large scale production	Number of selected bulls in the different steps to track differences over years. To see weak points and rooms for improvements.
Number of selected females and average relationship in the different selection steps Genotyped → contracted → reproductive start → large scale production	Number of selected females in the different steps to track differences over years. To see weak points and rooms for improvements. Track average relationship in the different selection steps.
Mating design *Mating design*	
Use minimum co-ancestry or minimizing the covariance between ancestral genetic.	Use minimum co-ancestry or minimizing the covariance between ancestral genetic.
Success rate with wanted matings - Time between semen released and enough breeding animals are inseminated	Successful/all suggestions in the mating program. How much genetic gain if not all are successful. What is the average time between semen start and required number of breeding animals are inseminated?
Variation in number of used sires	Is there variation in number of use sires? In mating programs and high index animals.
Plan to handle and control lethal alleles	In mating programs, high index animals and reproductive technologies.

Plan to handle and control lethal alleles - Mating programs - High index animals - Reproductive technology programs	Plan to handle and control lethal alleles in the mating program, high index animals and in the reproductive technology programs.
Generation interval	
Bull and female generation interval - Reproductive technology program and high index mating program	Bull and female generation interval. In the reproductive technology program and in the high index mating program.
Reproductive start for females and bulls	Track reproductive start for females and bulls.
Semen quality and egg quality at certain ages (months)	Track semen quality and egg quality at certain ages (months).
Management checklist for animals in the AI-station	Management checklist for best reproductive capacity.. For example feed plans, diseases, animals that fall off until reproductive start.
Breeding scheme *Evaluation*	
Genetic trends for total merit	Track trends for total merit.
Check genetic trends for all breeding goal traits - Within and across countries	Track trends for all breeding goal traits. Are there differences between countries?
Phenotypic trends in main breeding goal traits	Phenotypic trends in main breeding goal traits over time to check breeding scheme.

Cost per dose of semen - Sold and produced	Could in cases be a good KPI to evaluate efficiency of the breeding scheme. Check both sold and produced.
Yearly track law changes - Impact on breeding scheme	Check law changes that could have impact on the breeding scheme. For example: You have to register a certain phenotype correct which could affect quality.
Action plan for ethical aspects	Plan for ethical aspects to be able to argue for decisions. Some examples: gen editing, cloning.