ADVANCES IN SELECTION FOR FUNCTIONAL TRAITS

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Summary:

Functional traits

I have already mentioned some important advances in selection for functional traits, indicating periods of major changes. We currently are in a period of high-speed development and adoption of tools for selection on functional traits on an international scale (see an overview by Miglior in the proceedings of this convention). In my view, (international) evaluations for functional traits will be a major selection criterion in (international) dairy cattle breeding.

The major incentive is the socio-economic situation enforced by citizens (in their roles of voting politicians and buying and consuming products). I do not think that functional traits will become the dominant selection criterion; this role is for milk production traits. However, information on functional traits is a necessity for use in breeding – no or limited information on functional traits implies a limited use in breeding both at nucleus and at commercial level. The term 'secondary' these days is absolutely old-fashioned for the group of functional traits. This redefined role of functional traits undoubtedly has an effect on the construction of new genetics – genetic change in functional traits will be either less unfavourable or for the major functional traits becoming favourable.

Information on functional traits (i.e. predicted breeding values) for selection candidates still has relative (to production traits) low accuracy of selection. Predicted breeding values for individuals are still subject to relatively large standard errors and fluctuations over time when becoming more accurate. There is still (scientific and applied) research on methodology for recording and (statistical) evaluation of functional traits, and more progress is being made and expected to come. Major areas of more advances are also foreseen in (on line, individual) recording of traits in automatic milk recording systems and in animal genomics. For the next 10-15 years, conformation scoring on especially udder and locomotion of individual cows will still be a major source of information for breeding value estimation. Herd books on one hand will have to emphasize the importance of their role as suppliers of a primary source of functionality information for breeding value estimation for functional traits. But on the other hand, herd books will have to adopt recording procedures that support this role better and distinguish this more explicitly from recording other traits serving their role in trading and beauty-shows.

Introduction

Livestock production is a means to producing human food, other products for human consumption, and intermediates to be used as inputs for plant production. Livestock production also serves human interest in different other functions, like banking and social status. In general, livestock production is a means to create socio-economic human welfare and well being by converting resources (production factors labour, land and capital) to higher valued products.

In Western Europe, Holstein cattle around the time 1900 looked differently from Holstein cattle around 1950 and again differently from Holstein cattle around 2000. The fundamental reason for these differences is that human welfare and well being in different periods demand different functions for livestock. Going from one period to the other, breeding or genetic improvement, as a technological development, facilitates construction of genetics according to new (foreseen) socio-economic circumstances (see box). For example, as a consequence of a shift from aiming for food security to food quality and food safety, in the 1970-ies scientists started thinking about defining and routinely recording functional traits. Functional traits are those characteristics of an animal that increase efficiency not by higher output of products but by reduced costs of input (see Table 1). Results were first implemented in Scandinavian countries in the 1980-ies and we recently (since 1995) see an enhanced implementation of selection for functional traits on an international scale.

Genetic improvement schemes arise by initiatives of governments, industrial investors, or farmers' organisations. Farmers' organisations, like herd books, have played, and still play an important role in breeding. From different perspective, investments (in recording, housing potential breeding stock and evaluation) anticipate future benefits like sustainable food security, continued farm profits or appropriate returns on investment. Those that have control over the decisions in a genetic improvement scheme will try to optimise benefits given their specific perspective.

Breeding = socio-economic construction of genetics
The essence of technological development is to save on the input of production factors by setting up a new production function. By an alternative use, the saved production factors get a (market) price or an opportunity cost. Depending on many factors, for example the state of development of the country, key-issues in use of saved production factors are to increase food security or food quality, to enhance (economic and social) well-being of producer, consumer and citizen, or to increase sustainability of the system. Breeding goal definition involves deciding on the direction of a technological change: genetic improvement for which traits will lead to the specifically desired saving of production factors.

The aim of this paper is to place advances in selection for functional traits in an historic perspective and to highlight the role of herd books.

Table 1. Breeding goal traits for which it is advised that breeding organisations have information available (i.e. predicted breeding values) for selection candidates. (source: Proceedings International Workshop EU Concerted Action on Genetic Improvement of Functional Traits in cattle (GIFT); breeding goals and selection schemes, November 7-9th 1999, Wageningen.

Trait group	Trait
Production traits	
Milk production	Milk/carrier kg
	Fat kg or %
	Protein kg or %
	Milk quality
Beef production	Daily gain/final weight
	Dressing or Retail %
	Muscularity
	Fatness, marbling
Functional traits	
Calving ease	Direct effect
	Maternal effect
Still birth	
Udder health	Udder conformation
	Somatic Cell Score
	Clinical incidence
Female Fertility	Non-return rate
	Interval Calving – 1st insemination
Male Fertility	
Feet & Legs problems	Conformation
	Locomotion
	Clinical Incidence
Workability	Milk speed, ability, leakage
	Temperament/Character
Longevity	
Other diseases	
Persistency	
Metabolic stress/	Mature weight
Feed efficiency	Feed intake capacity
	Condition Score
	Energy Balance

Historic perspectives

In the 18th and 19th century, people keeping livestock were aware of the fact that offspring had characteristics similar to their parents. In Great Britain, pioneers like Blakewell used this knowledge to develop livestock 'breeds' with specific characteristics. These pioneers wrote overviews of the pedigree of their herds in books – herd books. The first official herd book for a cattle breed was established in 1822 for Durham cattle. However, underlying biological mechanisms of heritage were unknown. Only in the late 19th century, Mendel's laws or inheritance were re-invented, emphasizing the role of pedigree information in breeding. Following the work of Darwin on evolution of species, and following the work of Linnaeus on taxonomy, people started to classify livestock late 19th century, early 20th century.

In the Netherlands, the first herd books were established in the period 1860-1880. The primary reason was not to facilitate breeding, like in Great Britain, but to facilitate trading of cattle. Americans were buying Dutch dairy cattle and required qualifying papers for trading in America. The newly established herd books certified the origin of traded cattle; at first, only herd or region of origin, later on also

pedigree information. The mayors of the villages had important roles in this period. In this period, no breed information was supplied, as breeds were not yet defined officially, except maybe some British breeds. Herd books primarily registered cattle, not breeds, and no breed characteristics were used as a criterion to allow cattle to be registered. Dutch dairy cattle showed large (regional) variation. In the provinces Holland and Friesland black and white cattle prevailed and American buyers were particularly interested in tall, open cows with high milk production.

In the next period (1890-1910) this changed drastically. Herd books changed their role by starting (besides registration of origin and pedigree) to classify the type of the animals. Animals were only allowed (for full registration) in the herd book when fulfilling established breed criteria for type. In fact, in this period herd books adopted the task of facilitating breed definition and obtained leading roles in selection programmes.

Early 20th century, technology for quantifying milk amount and fat content of milk was further developed and implemented on a routine basis. Availability of this data facilitated breeding to shift from qualitative to quantitative. In the period 1920-1940, theoretical thinking about quantitative plant and animal breeding progressed enormously. In this period, major theoretical concepts like genetic contributions of individual animals to genetic gain and inbreeding (Wright) and accuracy of selection (selection index theory; a.o. Hazel) were established. In a next period (1945-1970) in Western Europe, led by The Netherlands, the original dairy type of cattle was constructed to become a relatively beefy type of animal. Undoubtedly this had to do with socio-economic circumstances in that period (war and food crises). These circumstances were different in America, and here the dairy character of the imported animals was even further development to an outstanding milk-producing animal.

In the period 1950-1960, scientific advances in Europe and America established the conceptual thinking of breeding in a structured, programmed setting. Terms like ‘generation interval’ and ‘selection path’ were introduced (a.o. Lush, Skjervold, Robertson). As a next step, in the 1970-ties economic optimisation of breeding programmes was introduced (e.g. Brascamp). It is to be emphasized that artificial reproduction techniques formed an important incentive to these scientific developments. Artificial insemination also had an impact on the relative position of breeders. The number of bulls required for reproduction decreased and the impact of individual bulls (and thus their owners) increased. Later on, 1980ies, a similar development on the female side of selection occurred with the introduction of embryo transfer (and later on ovum pick up and in vitro fertilisation).

Over the whole period 1900-1960, type, milk amount and fat content were the major characteristics considered in cattle breeding, as these were the only characteristics measured routinely on a larger scale, especially for herd book cattle. However, this started to change with the development of technology for routinely measuring protein content in milk and milking speed (e.g. Politiek). The latter trait became important as a consequence of introduction of machine milking. In the 1970ies, as a consequence of changing social and economic circumstances (shift from aiming for food security to quality of product and production process, including welfare of the animals) scientists started thinking about defining and routinely recording functional traits in direct and indirect ways. Results were first implemented in Scandinavian countries in the 1980-ies and we recently (since 1995) see an enhanced adoption of selection for functional traits on an international scale. Meanwhile, the theoretical concept of mixed model equations was introduced (Henderson), which together with advances in computer technology formed the basis for modern genetic evaluation procedures. Major advances in breeding since the 1990-ies are facilitated by information and communication technology (ICT) and molecular techniques (genomics).

This is a nutshell overview of developments in more then an era. My major message is the interrelationship between breeding (breeding goals and selection programmes) and socio-economic circumstances. Both scientists and farmers’ organisations play a role in this interrelationship. Together

they shape the dynamics of society and breeding. In these dynamics, recently selection for functional traits has become a major feature.

Role of herd books

In my opinion, historically

- facilitating trading, and
- facilitating selection

are the primary tasks of herd books. Over time, a constant factor is that pedigree information is a primary source for both tasks. Without pedigree information no high quality breeding value estimation. Pedigree information provides the quality assurance of stock traded. However, tools applied to fulfil these roles have changed dramatically over time. Pedigree is not registered anymore in books, but in computers. The necessary animal identification is no longer based on drawing and describing the exterior, but is performed using ear-tags.

Cattle shows enhance the implementation of the (social) breed definition. We luckily still have cattle shows, but the discussion on the social functions they serve (breed definition, beauty-show, ranking on functionality) is lively. In the period 1980-95, conformation was a primary source of selection for functional traits, but this position is now to be shared with other direct recording sources of for example longevity and health of individual animals.

From about 1900 on, the herd book animals had unique features; origin (e.g. breeder), pedigree, type/conformation and possibly other performance parameters were known. However, this is no longer a unique quality of herd book animals anymore, but is common to a much larger group of (breeding) animals. This change has caused a major shift in the role and position of herd books. Conservatively trying to keep up an exclusive position for herd book animals, as breeding stock, does not seem justified.

Apart from the loss of unique features of their cattle, also the introduction of artificial reproduction techniques caused a change in the position of herd book animals and their owners. Less and less animals were required for reproduction, but individual impact of (proven) bulls and cows increased.

“A breed is a breed when enough people say it is a breed.” This is the primary definition underlying breed definitions throughout history. This also means, that when people change opinion or change direction of genetic improvement, a breed definition becomes dynamic. Breeds change, breeds disappear, and new breeds are established. Herd books should be flexible, ready to adopt breed definitions, or maybe better, ready to facilitate registration of breeds according to definitions used by farmers. The primary role of herd books throughout history has been to facilitate trading and breeding, not to become a trader or a breeder themselves.

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