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Review

Bio-economic models for efficient dairy cattle breeding

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The objective of this study was to define the main principles when the economic weights of traits are defined to be applicate in dairy cattle breeding. The competitive farming is a function of additive genetic values of traits weighted with economic values. For the calculation of economic values, the bio-economic models are mostly used. These models should reflect the production circumstances of evaluated production systems and be flexible to fit other production situations. Except of the production traits, the functional traits and traits for feed intake utilization are very important for the sustainable production. The environmental benefits (e. g. reduction of greenhouse gas emissions, welfare) should be mentioned as well. Results based on the bio-economic models provide the first information whether the breeding goal for cattle would be redefined. Moreover, flexibility of the bio-economic models enables to evaluate the breeding goals for different customer groups and for different cattle breeds. They are beneficial tools for comprehensive evaluation of the economic values for the most important traits in cattle and in sheep.

Keywords: bio-economic model, breeding, dairy cattle

1 Introduction

From the breeding point of view, the competitive farming is a function of additive genetic values of traits (breeding values) weighted with economic values (Wolfová et al., 2007). Generally, selection for milk production traits has traditionally received most emphasis in breeding programs of dairy cattle in many countries (e. g. Wolfová et al., 2007; Hietala et al., 2014). At present, breeding values and economic values for milk carrier, milk fat and milk protein yield of cows and bulls are the key breeding parameters in the Slovak dairy cattle population (Candrák and Lichanec, 2007). Nowadays, health traits (somatic cells count, longevity, claw disease incidence and clinical mastitis incidence) have strong impact on the profitability through effective utilisation of inputs, reduction of costs, improvement of milk price, and security of production. Therefore, more attention has been recently paid to their genetic improvement. In the turbulent economic conditions, the importance of traits has to be recalculated to obtain the real values. Based on the actual calculations of Krupová et al. (2016), current breeding objective and selection index for Slovak Pinzgau cattle should be redefined. The objective of this study was therefore to define the main bio-economic principles when the economic weights of traits are calculated and finally implicated in dairy cattle breeding.

2 Base principles applied in the bio-economic models

Calculation of economic importance of traits is obviously performed by the bio-economic models. In all models, production system should be defined with considering the profitability of all components. Omitting these principles would create a serious risk for genetic improvement (Kahi and Nitter, 2004). All input parameters can be modified to fit other production situations. The stationary state of the herd structure can be derived e.g. using the dynamic model – Markov chain procedure (Wolfová et al., 2007). The marginal economic values of trait are usually defined as the partial derivative of the profit function. To compare the economic importance of different traits, the marginal economic values are by first standardized when multiplying them by the genetic standard deviation of each trait and secondary, the relative economic values of traits are calculated.

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As the main criterion of economic efficiency for the modelled production system profit (Wolf et al., 2013) maximal revenues/minimal costs per production unit and biological efficiency (e. g. proteins) are used (Wolfová, 2006). All revenues and costs occurring in the herd during a year and in the life of progeny born in the herd should be discounted to the date of birth of progeny. For example, the annual discount rate of 1.0 and 5.0 % (Wolfová et al., 2007; Krupová et al., 2016) was applied to account for the delay in expression, and associated time value of money, of traits that influence revenues and costs in the life of the animal.

In the bio-economic model of Wolf et al. (2013), revenues are calculated from milk, breeding heifers, slaughtered cows and manure. Revenues from milk are there a function of milk yield, fat and protein content and somatic cell count (SCC) and the modified Wood function (Fox et al. 1990) is taken into consideration. As stated in Hietala et al. (2014), for these traits, a normal distribution is modelled which allowed a correct calculation of the average milk price for the given milk pricing system. SCC is frequently used to consider the quality payments to dairy producers. It is the main reason why the SCC is daily checked by farmers during milking and secondly this trait is included in the breeding goals and selection schemes of many dairy cattle breeds (Zavadilová et al., 2011).

Costs are calculated separately for feeding, housing, breeding and health. Feeding costs are calculated on the basis of daily net energy and protein requirements of the animal and on the price for feed with given dry mater, net energy and protein contents (Fox et al., 1990). From an environmental point of view, more efficient utilization of feed in dairy cattle is important. The need to improve feed efficiency in dairy production might increase in the near future due to continuously increasing requirements to mitigate the environmental impact of livestock production. It has been connected with a reduction in greenhouse emission through lower methane and manure outputs of animals, reflected in residual feed intake (RFI) traits (Hietala et al., 2014). Generally, RFI is defined as the difference between the actual daily dry matter intake and the predicted daily dry matter intake of an animal (Krupová et al., 2016). When the economic weights for RFI are calculated, the net energy and protein digestible in the intestine requirements for growth maintenance, milk production and pregnancy and the basis of the dry matter, net energy and protein content in the feed ration of the corresponding animal category are taken into consideration (Wolf et al., 2013). An option for achieving a direct genetic improvement in feed efficiency is selection for this trait. Some challenges and possibilities for RFI selection are connected with the limited availability of individual feed intake data due to costs associated with its collection (Krupová et al., 2016).

All other non-mentioned costs are usually accounted in bio-economic models as fixed costs per animal category per day (Wolfová et al. 2007). Improving of functional traits (health, reproduction and survival) is associated with a cost reduction (Gonzalez-Recio et al., 2014). Direct inclusion of health traits (mainly claw diseases and clinical mastitis incidence) in the breeding goal is expected to bring an extra economic benefit. E.g. effects of mastitis incidence on the loss of revenue due to discarding of milk during cow illness as well as additional costs for drugs, veterinary service and labour are considered when calculating the economic value for this trait (Wolfová et al., 2007). Clinical mastitis incidence is the major source of loss in dairy farms and in this term, SCC is used to monitor health status of the herd and can be used as an indirect selection tool for reducing mastitis incidence (Kahi and Nitter, 2004).

3 Conclusions

Based on the principles of bio-economic models described in this short review it can be summarised that enable well a comprehensive evaluation of biological and economical aspects of the animal production system. Generally, except the production traits, the functional traits and traits for effective feed intake utilization are very important for the sustainable and competitive animal production. Moreover, next to the economic also the environmental benefit, ensuring the animal welfare and finally the higher food security and sustainable development of the domestic agriculture should be mentioned. From the economical point of view, it would be important to study current breeding objective in cattle breeding programs. A well-defined breeding objective is the first condition for any improvement.

Results based on the bio-economic models provide the first information whether the breeding goal for cattle would be redefined. Moreover, flexibility of the bio-economic models enables to evaluate the breeding goals for different customer groups and for different cattle breeds. They are beneficial tools for comprehensive evaluation of the economic values for the most important traits in cattle and in sheep.

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