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ANALYSIS

An approach to the optimal allocation of conservation funds to minimize loss of genetic diversity between livestock breeds

H. Simianer [a,*], S.B. Marti [b], J. Gibson [c], O. Hanotte [c], J.E.O. Rege [d]

[a] *Institute of Animal Breeding and Genetics, Georg-August-University Goettingen, Albrecht Thaer-Weg 3, 37075 Goettingen, Germany*
[b] *Institute for Agricultural Economics, Swiss Federal Institute of Technology, Sonneggstr. 33, ETH-Zentrum, 8092 Zurich, Switzerland*
[c] *International Livestock Research Institute, P.O. Box 30709, Nairobi, Kenya*
[d] *International Livestock Research Institute, P.O. Box 5689, Addis Ababa, Ethiopia*

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Abstract

About 30% of all farm animal breeds worldwide are at risk of extinction. To prevent this irreversible erosion of genetic diversity, the limited funds available for conservation need to be allocated in the most efficient way. Applying the diversity concept of Weitzman [Quart. J. Econ. CVII (1992) 363; Quart. J. Econ. CVIII (1993) 157] this paper presents a framework for the allocation of a given budget among a set of breeds such that the expected amount of between-breed diversity conserved is maximized. As a novel methodological contribution, a functional relationship between conservation funds spent in one population and the conservation effect in terms of reduced extinction probability is suggested. Based on arguments from population genetics, three different functions are derived, which may reflect the range of possible functions in typical conservation situations. The methodology is illustrated with an example of 23 African zebu and zenga cattle breeds. The results indicate that conservation funds should be spent on only three to nine of the 23 breeds, depending on the model used. Highest priority is given to breeds, for which the 'conservation potential', that is, the product of extinction probability and marginal diversity is maximum, and these are not necessarily the most endangered breeds. The methodology can be extended to the maximization of total utility, which incorporates diversity, as well as other direct use, and special value, characteristics. However, a number of essential input parameters such as extinction probabilities and economic values are lacking and realistic models for developing cost-efficient conservation strategies have to be derived. Given these lacking bits of information become available, the methodology suggested provides a breakthrough towards applicability of diversity-based approaches for decision taking in conservation programs.

Keywords: Diversity; Conservation; Allocation of resources; Cattle breeds

1. Introduction

Farm animal genetic diversity is threatened with extinction of breeds. Of the estimated 6400 breeds of farm animal species worldwide, about 30% are

* Corresponding author. Tel.: +49-551-39-5604; fax: +49-551-39-5587.
E-mail address: hsimian@gwdg.de (H. Simianer).

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endangered and 1% becomes extinct every year (Scherf, 2000).

The value of farm animal genetic diversity is multiform, comprising present production values as well as ecological and socio-cultural values. Option values are of specific interest, representing potential values of breeds under future, presently unknown conditions (Rege, 1999).

In many cases, the public has become aware that the loss of breeds and diversity within farm animal species is critical and that measures need to be taken to prevent, or at least slow down, this irreversible genetic erosion.

Financial and other resources to be invested into conservation are always limited. Therefore, these resources have to be spent in the most efficient and cost effective way. The need to develop a framework to allow rational decision-making in conservation programmes with regard to the question: 'what to conserve' has been a subject of research (Vane-Wright et al., 1991; Crozier, 1992). Weitzman (1993) has suggested the use of conserved diversity per unit of expenditure as measure of the efficiency of a conservation scheme.

An efficient use of conservation funds encompasses two levels of activity:

- To spend money within a breed such that the risk of extinction for this breed is immunized and the within-breed diversity is maintained.
- To distribute the total available amount of conservation funds among a subset of all endangered breeds such that the conserved diversity between breeds is maximized.

This study focuses on the second level of activity, i.e. the optimum allocation of resources among a defined set of breeds.

Although the study is largely based on the pioneering work of Weitzman (1992, 1993), the suggested approach is quite general and can be used with any measure of aggregate population distinctiveness that has the basic characteristics of a diversity.

Diversity can be derived from different types of raw data, which can be a genetic distance matrix (Weitzman, 1992, 1993; Solow et al., 1993; Thaon d'Arnoldi et al., 1998; Marti et al., 2003) or a set of weighted or unweighted characteristics, features or attributes (Faith, 1996; Weitzman, 1998; Nehring and Puppe, 2000) which may or may not reflect purely genetic properties of the considered unit. If, for example, the degree of adaptation of a species/breed to a certain environment is used as a feature to assess diversity, this feature is certainly not completely genetically determined. Although the present application is largely based on Weitzman's (1992, 1993) diversity concept, the core of the methodology should work with any reasonable diversity measure. The arguments will only make use of the 'non-negativity' and of the 'monotonicity' property in the methodological considerations.

The structure of the paper is as follows. Section 2 starts with the definition of the basic quantities. Computational aspects will be mentioned briefly. Based on arguments from population genetics, three models will be suggested, that link conservation expenditure to reduction in extinction probability. Examples for the applicability of the three models will be given and they will be compared in a small, illustrative example. Based on this achievement, it will be shown how the allocation of a fixed amount of conservation funds to a single breed out of a set of breeds affects expected diversity of the set. Finally, an algorithm is suggested, how a given budget can be allocated to a set of breeds, such that expected diversity is maximized.

The suggested methodology will be illustrated with a reasonably comprehensive set of African zebu and zenga type cattle breeds, which will be presented in Section 3.

The results will show, that optimum allocation of resources follows certain patterns, but is difficult to assess without a detailed model and reliable values of the required parameters.

In Section 5, strengths and shortcomings of the presented approach will be discussed and differences to alternative approaches, that have been suggested, will be highlighted. Also, a more general approach aiming at the maximization of the total 'utility' of the conserved set will be suggested. Finally, the main achievements of the paper will be pointed out and research needs to put this approach into practice will be indicated.