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ASSESSMENT OF GENETIC DIVERSITY AMONG THE TWELVE CHINESE MEAT GOAT BREEDS USING WEITZMAN APPROACH

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ABSTRACT

The genetic diversity of livestock breeds plays an important role in livestock production, but the significant loss of breeds is threatening genetic diversity of farm animal genetic resources (AnGR). The Weitzman approach which was accepted as a framework for assessment of genetic diversity on AnGR was exploited. In this study, Weitzman method was applied to set the priority of conservation by using genetic parameters of 12 Chinese meat goat breeds. Several measurement indexes of genetic diversity, involving total genetic diversity, contributions of each breed to the total diversity, marginal diversities, conservation potential, were calculated based on 11 microsatellite marker data of 12 Chinese meat goat breeds. The expected diversity of 12 goat breeds was 7132 which was 50.03% of the total genetic diversity. The mean extinction probability of 12 breeds was 0.375, where Hainan black goat was the highest, followed by Tibet goat, Haimen goat and Guizhou white goat. The marginal diversity of Hainan black goat in all breeds was the highest (-0.312), Fuqing goat was the lowest (-0.189). Hainan black goat had the greatest relative contribution to overall genetic diversity, followed by Maguan goat, Yichang white goat and Tibet goat. According to the trend of extinction, the conservation priorities of 12 breeds were Hainan black goat, Tibet goat, Guizhou white goat, Maguan goat, Chengdu ma goat, Haimen goat, Jianchang black goat, Anhui white goat, Fuqing goat, Yichang white goat, Shannan white goat and Matou goat**.** The Weitzman approach is a new idea to biodiversity resources protection, which is a reference for breed conservation and the decision-making of the relevant policy. We hope to provide objective and rational criteria and strategy for decision-making in conservation of Chinese meat goat breeds.

Key words: marginal diversity; conservation priority; goat; conservation potential.

INTRODUCTION

In recent years, with the development of conservation biology, the principle and method of genetic diversity have been gradually applied in the research and conservation of biological diversity，and consequently, conservation genetics, which is an interdisciplinary science that aims to apply genetic methods to the conservation and restoration of biodiversity, has become a very active field and direction in research of conservation biology (Eding and Meuwissen 2001). In the modern conservation biology, the genetics approach has received a great deal of attention. The importance of DNA molecule marker has been fully recognized in the areas including genetic management of endangered species, determination of clustering analysis and phylogenetic analysis (Naderi *et al*., 2008; Di *et al*., 2011). In order to enhance the rational utilization of biodiversity conservation, it is necessary to identify the breeds that should have conservation priority and the optimal fund should be allocated to each breed properly (Reist-Marti *et al*., 2003). The formulation of existing program for the conservation of livestock mainly depends on the commercial value and breed size, without considering the preservation of endangered genetic resources. With such huge biology resources, the particular interest is how to make decisions for investment policies to be applied to different breeds or populations to maximize benefits in terms of diversity conservation. Weitzman proposed a classical idea that marginal diversity is used for biodiversity conservation. It depends on the variation of breeds to confirm the conservation priority during a certain period of time (Weitzman, 1992; Weitzman, 1993). Many studies at home (Garcia *et al*., 2005; Pinent *et al*., 2005) and abroad (Liu *et al*., 2010; Wang *et al*., 2011) have proved this approach was helpful.

The domestic goat (*Capra hircus*) is one of the most important livestock species in animal husbandry (FAO 2007). China raises the largest number of goats in the world and has a valuable resource of goat breeds (FAO 2012). In our study, several measurement indexes of genetic diversity, involving genetic distance, extinction probability, breed contribution, current diversity, marginal diversity, conservation potential and the optimal fund allocation, were calculated among 12 Chinese meat goat breeds by using Weitzman approach.

MATERIALS AND METHODS

Materials: Blood samples from 514 animals were collected from 12 Chinese indigenous meat goat breeds (table 1) from Tibet, Guizhou, Shaanxi, Hubei, Anhui, Fujian, Yunnan, Sichuang, and Hainan of China. Samples for the indigenous breeds were collected from their conservation farms. Genomic DNA was extracted from all blood samples using a standard phenol-chloroform extraction method.

The analysis of marginal diversity and the research of a conservation program were studied which based on 15 microsatellite loci. These loci were screened from the set recommended by ISAG/FAO including McM527, ILSTS005, SRCRSP9, OarFCB20, SRCRSP5, TGLA53, ILSTS011, SRCRSP23, SPS113, SRCRSP7, INRA063, MAF209, BM1818, INRA132, MAF70 (Ling *et al*., 2012). PCR amplifications were performed in 12 μl reaction volumes containing 50 ng of genomic DNA, 0.025 μM of each primer, 250 μM of each dNTP, 1.25 units of *Taq* polymerase and 1× Magnesium-free PCR buffer (Takara, Japan). Amplifications were carried out using the GeneAmp PCR 9700 thermocycler (Applied Biosystems). Genotyping of PCR products was carried out on an ABI 3130xl automated capillary sequencer. The polymorphism parameters were obtained using Excel Microsatellite Toolkit Version 3.1 and POPGENE 1.31.

Table 1 Breed, resource and sample size of Chinese Indigenous Meat Goats

Breed	Code	Location	Sample size
Tibet goat	TB	Changdu City, Tibet	45
Guizhou white goat	GZ	Zunyi City, Guizhou;	38
Shannan white goat	SN	Ankang City, Shaanxi;	48
Yichang white goat	YC	Yichang City, Hubei	44
Matou goat	MT	Enshi City, Hubei	42
Haimen goat	HM	Nantong City, Hubei	46
Anhui white goat	AH	Feidong County, Anhui	39
Fuqing goat	FQ	Fuqing City，Fujian	42
Maguan goat	MG	Maguan County, Yunnan	45
Jianchang black goat	JC	Huili County, Sichuang	45
Chengdu ma goat	CD	Chengdu City, Sichuang	38
Hainan black goat	HN	Wenchang City, Hainan	42

The goal of this study was to develop a cost efficient conservation program for the diversity of those breeds through analyzing a set of measures indexes of genetic diversity. For the 12 breeds, allele distances were estimated based on 15 microsatellite loci.

Extinction probability: For each breed the degree of endangerment was calculated from the 5 indexes (x_i) as follows: species distribution area, total breed size, the trend of breed, economical importance and peculiarity. It was quantified as extinction probability (z_i) assuming a time horizon of 100 years, using different weights (w_i) (Ma and Wu, 2001). It was defined as: $D_i = \frac{\partial E(D)}{\partial z_i}$

Marginal diversity and conservation potential: The marginal diversity was calculated that reflects the change of expected diversity in the whole breed in case of an increase in the extinction probability of one breed(i). Thus it was defined as $D_i = \frac{\partial E(D)}{\partial z_i}$, where *E(D)* was the expected diversity of breed in an assuming time period.

In Weitzman's mind, "conservation potential (CP_i)" was so useful that to indicate the priority of a breed for conservation effectively. Thus CP_i was given by $CP_i = Z_i \times D_i$, where Z_i was the extinction probability, D_i was marginal diversity of breed(i).

RESULTS

Expected diversity and marginal diversity: The expected diversity of 12 goat breeds was 7132 which was 50.03% of the total genetic diversity. If we couldn't conserve the breeds, the expected diversity will reduce 49.97%, after a century. The extinction probabilities, relative contribution, marginal diversities and conservation potential of all breeds were expressed in Table 2.

The mean extinction probability of 12 breeds was 0.375, where Hainan black goat was the highest, followed by Tibet goat、Haimen goat and Guizhou white goat. The marginal diversity of Hainan black goat in all breeds was the highest (-0.312), Fuqing goat was the lowest (-0.189). Hainan black goat had the greatest relative contribution to overall genetic diversity, followed by Maguan goat, Yichang white goat and Tibet goat.

As shown in the derived maximum-likelihood tree (Fig.1), the 12 Chinese goat breeds were clustered into three groups. The Tibet goat (TB), with the most diversity distinct, was grouped first from the other Chinese goat breeds first. There were two clusters found among the remaining Chinese goats. The second cluster

was Shannan white goat (SN), Yichang white goat (YC), Guizhou white goat (GZ), Matou goat (MT), Anhui white goat (AH) and Haimen goat (HM). The third cluster was Fuqing goat (FQ), Jianchang black goat (JC), Chengdu ma goat (CD), Maguan goat MG, Hainan black goat (HN). In all breeds, the studies showed a strong correlation between marginal diversity and relative contribution ($r=0.824$, $p<0.01$) (Table 2 and Fig.1). While significant associations of extinction probability with relative contribution and marginal diversity were not observed in all breeds (Fig.1).

According to the trend of extinction, Hainan black goat stands top on the conservation priority list followed by Tibet goat, Haimen goat, Guizhou white goat and Anhui white goat. When the conservation potential was targeted, the conservation priorities of 12 breeds changed into Hainan black goat, Tibet goat, Guizhou white goat, Maguan goat, Chengdu ma goat, Haimen goat, Jianchang black goat, Anhui white goat, Fuqing goat, Yichang white goat, Shannan white goat and Matou goat**.**

Table 2. Extinction probability, marginal diversity, relative contribution and conservation potential of 12 goat breeds

Breed	Code	Extinction probality	Marginal diversity	Conservation potential	Relative contribution (%)
Tibet goat	TB	0.571	-0.263	0.173	8.28
Guizhou white goat	GZ	0.412	-0.295	0.141	7.41
Shannan white goat	SN	0.242	-0.223	0.066	7.83
Yichang white goat	YC	0.254	-0.211	0.072	8.36
Matou goat	MT	0.159	-0.208	0.053	7.41
Haimen goat	HM	0.502	-0.203	0.115	7.47
Anhui white goat	AH	0.412	-0.213	0.101	7.44
Fuqing goat	FQ	0.352	-0.189	0.08	7.53
Maguan goat	MG	0.352	-0.262	0.128	11.04
Jianchang black goat	JC	0.255	0.274	0.104	8.04
Chengdu ma goat	CD	0.382	-0.238	0.12	7.62
Hainan black goat	HN	0.603	-0.312	0.222	11.57

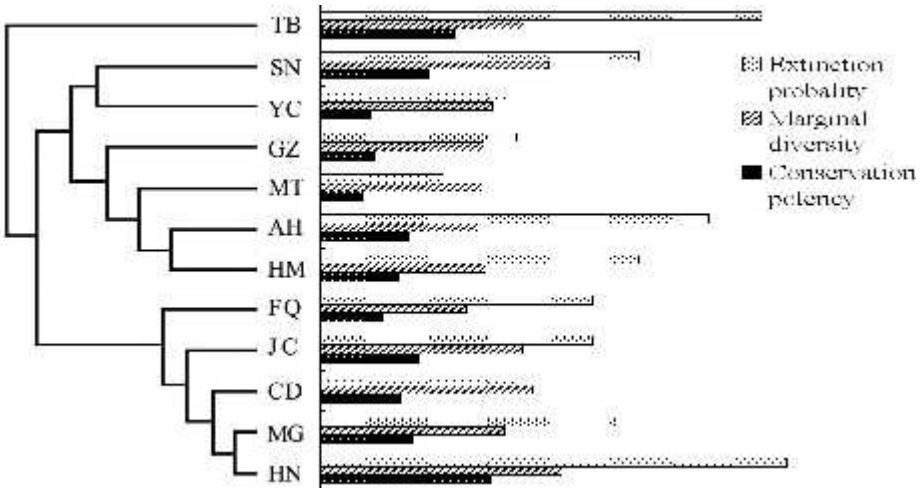

Fig.1 the drawing shows the NJ tree, extinction probability, marginal diversity and conservation potential, respectively.

DISCUSSION

Estimation of extinction probability: In this study, the actual extinction probability couldn't be calculated, without the exact information of each breed. Due to this reason, estimations of extinction trend were inevitably subjective. In order to reflect the trend of biodiversity objectively, the extinction probability were calculated based on species distribution area, total breed size, the trend of population, economical importance and peculiarity. Additionally, many factors influence the existence of endangered breed, involving whether the conservation program builds or not, inevitable disaster, war and information correctness, and so on.

According to the research of livestock resource, there are 43 goat breeds existing in China (Qi *et al*., 2004), 12 of them were selected for analysis in the study. Among them, Hainan black goat, Tibet goat and Fuqing goat

belong to endangered resources. The extinction probabilities of Hainan black goat and Tibet goat, showed a high level in 12 goat breeds, were 0.603 and 0,571, respectively, and were consistent with the reality of breeds. The extinction probabilities of Haimen goat and Anhui white goat, 0.502 and 0.412, were higher than which of Fuqing goat (0.352). However, both of them weren't included in Chinese conservation program of livestock. It was indicated that when establishing a policy of conservation priority of genetic resources, it is important not only to reference the protection list, but to consider the other factors synthetically.

Decision-making of protected object: Due to differences in the significance of populations, the limited funds for species conservation should be used in most important species. Then, it is necessary to construct a priority conservation list of species, which suited to the nature realities and matched up with species protection objectives. In general, the species with excellent characteristics, such as high productivity, good quality of meat, egg, and milk, are not easy lost. Meanwhile, the reason of species in danger almost is they cannot bring high economic benefits to people. However, we should devote more care to the species in danger, because we cannot predict the demand for animal products in future. In addition, the value in history culture, ecology of species is the important factor worth considering.

FAO proposed that livestock breeds can be divided into Normal, Insecure, Vulnerable, Endangered, Critical and Extinct (FAO 2007). Regardless of overseas or domestic, each level or significance of endangered biology has an explicit concept. But it is difficult to grasp the standard, because no quantitative analysis is available. It is inevitably subjectivity to evaluate the threat variety, the conservation priority and their grade in one country or district. So it is necessary provide a couple of criteria or strategies objectively and rationally for decision-making in conservation of breed in a given area. Ruane (1999, 2000) proposed that the degree of extinction should be the standard in the conservation policy formulation. Obviously, Ruane's basis was not effective and scientific, considering some useful information neglected, such as variety genetic information, the feature and the economical importance. Conservation policy also needs to consider the contribution of each breed to biodiversity, the cost for conservation and the economical value. Barker (1994) proposed that the breed with higher contribution to biodiversity deserved more protection. In this research, Hainan black goat had the greatest contribution to genetic diversity (11.57%), followed by Maguan goat (11.04%), Yichang white goat (8.36%), Tibet goat(8.28%), Jianchang black goat(8.04%) and so on. However, relative contribution is not the best basis for the making of conservation policy, because the extinction probability was neglected in the method.

Marginal diversity approach proposed conservation potential as a great indicator for protection. Weitzman (1992) advised that this approach is the optimal tool for deciding the priority of breed conservation. This approach has proven helpful before in several studies in different species, involving Chinese sheep (Ma, 2005), Chinese pig (Zhao and Ma, 2007), Africa cattle (Canon *et al*., 2001), and European pig (Laval *et al*., 2000). The defects of this approach have already been observed by some scholars, also noted by Weitzman (1993), that the estimate of extinction probabilities is strongly subjective, and the within-breed component of variation isn't taken into consideration. Olliver and Foulley (2005) analyzed the within-breed component of variation by using expected heterozygosity, also assessed the within-breed and between-breed component of variation comprehensively. Some scientists suggested that extinction probability should be replaced by genetic extinction probability. Simianer *et al*. (2003, 2005) advised the maximum utility as the ultimate aim to formulate the program of funds allocation, which the maximum utility can be evaluated from within-breed diversity, variety's common characteristic and individual characteristic.

The object of protection was usually based on the endangered degree, so the strategy would make the number of the protection breed maximized. While the optimal conservation cannot come true with the lack of appropriate funds. Conservation policy should take the contribution of each breed to biodiversity, the cost for conservation, the economical value and so on into consideration comprehensively. In the rational policy of conservation, breeds with highly extinction probability, Karakul sheep and Hu sheep, are located in the back of the conservation policy, while tan sheep with low extinction probability obtains the preferable protection.

The optimal fund allocation to each breed of Chinese meat goat was made, based on the genetic diversity, the characteristic, regional distribution, and the economical importance. Marginal diversity approach is a new idea to biodiversity resources protection, which is a reference for breed conservation and the decision-making of the relevant policy.

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