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ORIGINAL ARTICLE

Extinction probabilities of Hassawi cattle from Saudi Arabia using population viability analysis

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Abstract The sharp reduction in population size (N) of Hassawi cattle alarmed to estimate the possibility of extinction over a defined future time horizon. Two Hassawi cattle populations were considered for population viability analysis (PVA) in order to provide estimates of extinction probabilities (EPs). The EPs were estimated using Vortex® modeling program. The estimates of 2013 census and records on previous numbers were utilized in PVA models for two separated populations and their meta-population. The results of EPs and evolutionary growth rate were simulated for past and future, utilizing their demographic parameters and catastrophic events; like, feed scarcity, low production capability, crossbreeding and epidemic diseases. The simulated model concludes that the Hassawi cattle is facing extinction as the population size (N) and effective population size (N_e) were much less than those recommended to save endangerment. Therefore, the mimicked dynamic history of real Hassawi cattle population suggests that the assumed model was reasonable to mimic the likely fate faced by the Hassawi cattle population in the past. The future model concluded that the Hassawi cattle are indeed facing extinction after 21 years if assumptions of past model existed because both N and N_e were much lower than those recommended for escaping endangerment. Furthermore, PE increased with availability and severity of catastrophe events. The results of PVA and PEs should be considered into account to draw inferences about the expected future the Hassawi cattle dynamic because they are accurate data than those might extract from historical records. It is recommended that PVA may be considered in developing conservation strategy for the Hassawi cattle in order to conserve their valuable genetic resources, while the climate change is alarming.

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1. Introduction

Extinction is a process that starts with a downward trend in the number of breeding animals and ends with the loss of one breeding sex or both. The breeding animal number is the main criterion for assessing whether a species or a breed is endangered or in a situation of extinction. The condition numbers of less than 5000 breeding females, less than 20 breeding males and/or less than 10 breeding herds have been adopted (FAO, 1995; European Commission Union, 1992). The recommended solution to save such extinction is through a genetic conservation plan with better utilization and conservation of genetic resources.

The conservation start process may start by performing population viability analysis (PVA) (Simianer et al., 2003). PVA is a quantitative analysis that estimates the probability of extinction (PE) by incorporating environmental conditions, threats to persistence, and future management actions over defined time periods (Burgman et al., 1996; Gerber and González-Suárez, 2010). Many conservation geneticists have recommended PE estimates through a simulation of PVA performed on wild or domestic animals in captivity or nature conserved (Al-Atiyat, 2009; Pertoldi et al., 2014). In general, Shaffer (1993) mentioned that four factors, i.e., catastrophes, environment and demographic fluctuations, and genetic mutation drive a population into extinction. The catastrophic events usually occur at low probability but may drastically reduce the population size in a short time. The PE studies for domesticated breeds have provided insights into the best genetic conservation strategy (Reist-Marti et al., 2003; Al-Atiyat, 2009). In particular, the concern about the extinction of the indigenous domestic cattle breeds was emphasized by FAO (2000). The domesticated breeds are facing same living threats as those faced by wildlife species, in addition to artificial selection, crossbreeding and exotic breed replacement. The exotic breed replacement might be the major reason driving domesticated breeds of the developing countries into extinction (Garrick and Ruvinsky, 2014). Most of the developing countries are nearly crossing high producing exotics with indigenous animals to increase production. In the Kingdom of Saudi Arabia (KSA) also the number of exotic cattle/breeds is sharply increasing, with a sharp decrease in the number of indigenous cattle breeds (Al-Atiyat et al., 2015) and Saudi taurine cattle has become extinct, whereas Saudi indicus cattle is almost extinction (Al-Atiyat et al., 2015). In fact, the Saudi indicus cattle are two breeds, viz., Hassawi and Janoubi (ACSAD, 1988; Mohammed, 1997; Al-Atiyat et al., 2015). The number of Hassawi breed has steadily decreased over time in native areas of east parts of KSA. From genetic conservation point of view, the Hassawi cattle might be facing much rapid extinction than expected. The objective of this research was to simulate the extinction probabilities of Hassawi cattle breed of KSA in order to suggest the best conservation strategy.

2. Materials and methods

2.1. Data collection

The Hassawi cattle breed, Zebu (*Bos indicus*) cattle (for description refer to Mohammed, 1997; ACSAD, 1988; Al-Atiyat et al., 2015) (Fig. 1), is found in two populations in eastern parts of the Kingdom of Saudi Arabia (KSA). The two populations were in the Hofuf (Al-Hasa region; 5 farms with average 6–40 heads) and Qatif (2 farms with a total of 88 heads) cities reared under small-scale traditional production system. The total population was recorded during a survey conducted in 2013; while populations during different previous years were taken from statistical livestock records available with Saudi Agriculture Ministry (Saudi MOA, 2013; Table 1).

2.2. The PVA model

2.2.1. Estimation of extinction probability and model assumptions

Extinction probabilities (EPs) were estimated using population viability analysis (PVA) model of Lacy and Pollak (2015) using Vortex computer software. Vortex uses a Monte Carlo simulation of the effects of defined deterministic forces, and demographic, environmental and genetic stochastic events on the viability of living individuals. In brief, the program begins with creating individuals to form the starting population and then generates life cycle events on an annual basis (for explanations refer Lacy et al. (2015)).

The modeling scenarios required a set of input parameters of biological characteristics and stochastic events related to Hassawi cattle population (Table 2). Vortex simulated the populations by stepping through a series of events that describe an annual life cycle of a typical sexually reproducing organism, i.e., mate selection, reproduction, mortality, increment of age by one year, removals, supplementation, and then truncation to the carrying capacity. The input parameters of Hassawi cattle were derived from combination of published information (ACSAD, 1988; Mohammed, 1997; Al-Atiyat et al., 2015), supported with data collected from farmers and stakeholders. Breeding System was long-term polygynous, with new selection of mates each year, inbreeding depression using the lethal recessive alleles equivalent to 6.29 and 50% due to recessive lethal. Features of herd structure of different age classes as well as different sexes were specified for the Hassawi cattle populations. Stochastic events such as breeding success, progeny number, sex at birth and mortality rate were input data. The Catastrophe events were feed scarcity (drought), low production (exotic breed competition), crossbreeding and epidemic diseases. Each event was modeled as a separate type of catastrophe to simulate the effect on reduction in population size. The frequency of each type of studied catastrophe and the effects of the catastrophes on survival and reproduction was specified. Mortality figures that were used in the analysis are detailed in Table 2. The analyses were run for each starting population considering different mortality rates for each age class. Deterministic projections assumed no stochastic fluctuations, no inbreeding depression, no limitation of mates, no harvest, and no supplementation. In addition, mating was modeled as long-term polygynous. Initial population sizes of the real population (N = 188 animal) was set as carrying capacity. Vortex distributed the specified initial population among age–sex classes considering the mortality and reproductive schedule described initially for the model.

2.2.2. Simulation scenarios

A simulation model was used to compile the past population dynamics and future risk of extinction under similar